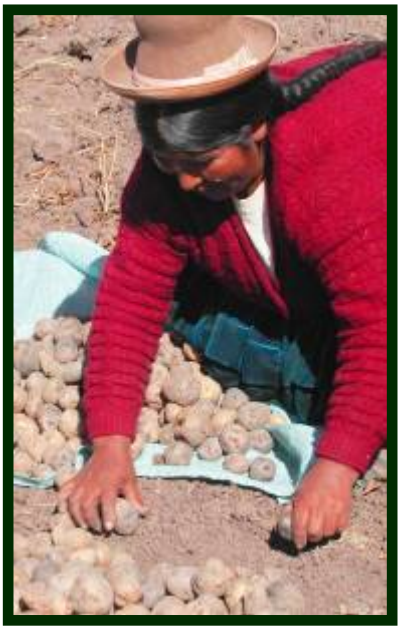
SANREM CRSP
2007 Annual Report



Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program

USAID FROM THE AMERICAN PEOPLE

VirginiaTech *Invent the Future*

SANREM CRSP

About the photographs

Front cover

Corn is a key crop in the high-altitude Chillanes region of Ecuador near Santa María, Peru. Photo by Associate Program Director Keith M. Moore.

Lemurs threatened by illegal forest clearing in Madagascar find refuge at a wildlife preserve. Photo by Program Director Theo Dillaha.

A Peruvian farmer in Santa María gathers potatoes that have been baked in an earth oven. Photo by Keith Moore.

Back cover

Daughters in a Bolivian farm family relax and share a smile after the harvest. Photo by Gender Equity Specialist Maria Elisa Christie.

SANREM CRSP
Annual Report 2007

Oct. 1, 2006 – Sept. 30, 2007

Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program

Report Coordinators
Theo A. Dillaha, Program Director
Keith M. Moore, Associate Program Director

This publication was made possible through the United States Agency for International Development (USAID) and the generous support of the American People under terms of USAID Cooperative Agreement EPP-A-00-04-00013-00.

SANREM CRSP Management Entity

Theo Dillaha, Program Director
Keith M. Moore, Associate Program Director
Maria Elisa Christie, Gender Equity Coordinator
S.K. De Datta, Administrative Principal Investigator, Associate Provost, Director OIRED
Michael Bertelsen, Economic Impact Assessment Coordinator, Associate Director OIRED
Deanne Estrada, Communications Coordinator
Peggy Lawson, Program Coordination Assistant

SANREM CRSP Board of Directors

Robert Bates, Washington State University
Jess Lowenberg-Deboer, Purdue University
Thomas Payne, University of Missouri
Alice Pell, Cornell University
Sharron Quisenberry, Virginia Tech
Mark Rosegrant, International Food Policy Research Institute
Alton Thompson, North Carolina A & T State University
Chris Kosnik, USAID
S.K. De Datta, Virginia Tech
Theo Dillaha, Virginia Tech

SANREM CRSP Technical Committee

Jeffrey Alwang, Virginia Tech
Devona Bell, Winrock International
Maria Elisa Christie, Virginia Tech
Elizabeth Jiménez, Universidad de la Cordillera
Andrew Manu, Iowa State
Saied Mostaghimi, Virginia Tech
Paul Mueller, North Carolina State University
Elinor Ostrom, Indiana University
Chris Pannkuk, Washington State
Manuel Reyes, North Carolina A&T University
Gerald Shively, Purdue University
Alex Travis, Cornell University
Corinne Valdivia, University of Missouri
Mike Bertelsen, Virginia Tech
S.K. De Datta, Virginia Tech
Theo Dillaha, Virginia Tech
Deanne Estrada, Virginia Tech
Keith M. Moore, Virginia Tech
Chris Kosnik, USAID

In Memoriam

Julia Pryde

The 2007 SANREM CRSP Annual Report is dedicated to Julia Kathleen Pryde. A land and water resources engineering graduate student at Virginia Tech, she was among those who died in the campus shootings on April 16.

As a researcher for SANREM CRSP's Long-term Research Award Activity 3, Julia traveled to Ecuador and Peru in 2006 to begin work on water quality modeling to estimate erosion from footpaths and unpaved roads in agricultural watersheds in the high Andes.

Mary Leigh Wolfe, co-Principal Investigator for the SANREM long-term program, worked with Julia on her research and was her adviser for undergraduate and master's studies in biological systems engineering at Virginia Tech. Julia showed maturity and wisdom beyond her years, Wolfe said. She stood out at her age because she already had a life plan and was taking steps to achieve it. She felt strongly about making things right for people and the environment.

Contents

Executive Summary

In the past year, the SANREM CRSP (Phase III) cultivated the Long-term Research Award (LTRA) program that has begun to generate new sustainable agriculture (SA) and natural resource management (NRM) knowledge and development impacts. The overall SANREM CRSP vision is to develop knowledge pertaining to SA and NRM interventions and strategies, organize that knowledge into an accessible online knowledgebase, place it in its proper development context, and disseminate the knowledge to decision makers. During this past year, the SANREM CRSP:

- managed and assessed five new long-term research activities
- reinforced capacity building activities
- completed the initial draft of a book on adaptive management of SA and NRM systems, and
- sustained Payments for Environmental Services (PES) workshops and sourcebook development.

The SANREM CRSP promotes stakeholder empowerment and improved livelihoods through the discovery, organization, and dissemination of SA and NRM knowledge. Our approach is participatory, engaging stakeholders at all levels in research problem formulation within priority areas of inquiry, focusing on multiple countries and/or regions to facilitate scaling research findings up and out. Program efforts are competitively driven and organized through a nested landscape systems approach. Gender sensitivity is integral to the SANREM approach and reinforced by gender-sensitive participant training programs that include degree and non-degree training plans. All activities link sustainable NRM with the economic concerns of local populations and the promotion of good governance.

Program Objectives

The objectives of the SANREM CRSP are to:

- increase scientific knowledge and technical innovations in SA and NRM
- improve knowledge management, education, and communication leading to behavioral changes in adaptation and adoption of new SA and NRM technologies and practices
- reform and strengthen SA and NRM governance, policies, and local institutions, and
- promote the functioning of sustainable resource-based local enterprises in national, regional, and global markets.

Program Outputs

The SANREM CRSP 2007 Annual Report is organized into four program areas: Long-term Research Activity reports, cross-cutting activities, SANREM Management Entity (ME) activities, and training and institutional capacity development. SANREM outputs for fiscal 2007:

- 81 long-term degree students (43 women and 38 men) 9,554 short-term training participants (including more than 3,500 women)
- 24 referred journal articles
- 3 books
- 6 book chapters
- 1 thesis
- 2 extension publications
- 6 working papers
- 2 websites
- 41 papers presented
- 39 electronic presentations
- 3 research briefs
- 4 news and magazine articles
- 4 newsletters
- 1 video
- 14 reports
- 1 abstract

Long-term Research Award Activities

The five Long-term Research Award (LTRA) activities were awarded between January and March 2006. These activities have blossomed through 2007, engaging U.S. and host country researchers, development agents, local officials and community members in their respective sites. Individual project progress was reviewed in summer 2007 by the External Evaluation Panel (EEP), and fine tuning of each project was initiated in response to EEP comments and suggestions. Highlights from each project are briefly summarized below.

LTRA-1: Decentralization Reforms and Property Rights: Potentials and Puzzles for Forest Sustainability and Livelihoods

Lead principal investigator (PI): Elinor Ostrom, Indiana University
Host countries: Kenya, Uganda, Mexico, Bolivia

This project aims to address the following development challenge: Decentralization and property rights reform policies created at the national level for large geographic domains often fail to account for the complexities of land use at the local level and can thus fall short of their goals of sustainable NRM and improving local livelihoods. This research is collecting and analyzing data from Uganda, Kenya, Mexico, and Bolivia to identify the institutional conditions and interactions that will deliver benefits equitably to local people while sustaining natural resources. Regional and global comparative research allows for identification of strategies within regions, and creates a learning environment among critical actors that may lead to more effective policy formation, implementation, monitoring, and enforcement. Project objectives are to:

- develop capacity within resource user groups at selected forest sites to enable differentiated actors (particularly women, the poor, and other marginalized groups) to identify, understand, and participate in forest governance, benefits, and policy processes
- develop capacity within key organizations in the forestry sector to understand the impact of policies on differentiated local actors and to adopt strategies for inclusion of such actors within broader policy processes, and
- develop effective monitoring techniques for use at the community level to assess the impact of decentralization and other property rights reforms on natural resources (including biodiversity) and livelihoods.

Activities this year focused on several areas.

- Researchers continued field visits in all four target countries, including data analysis, drafting of site reports, and follow-up training to present findings to stakeholders and identify additional activities. International Forest Resources and Institutions (IFRI) and household data collection has now been completed at Uganda Sites 2-3, Kenya Sites 2-4, and Bolivia Sites 2-3. Data collection for Mexico Sites 1-3 is almost complete. Final Poverty and Environment Network (PEN) surveys, which collect much more detailed household-level data, were conducted in five communities in Bolivia and 18 communities in Uganda.
- Interactive, post-site visit training was held at Uganda Sites 1-3, Kenya Site 1, and Bolivia Sites 1-3.
- A national-level, large representative sample (large-n) survey of forest communities was completed in Mexico and a similar survey initiated in Bolivia. Partners in Mexico completed a national survey of 146 forest communities in five states (Durango, Jalisco, Michoacan, Guerrero, Oaxaca). Bolivian partners continued work on their national-level survey. They developed a sampling framework and selected 150 communities for study; 13 communities have been completed.
- The scientific strategy and conceptual model behind the project were articulated.
- Researchers continued to synthesize findings related to the effects of decentralization on rights and decision making, and prepared for more focused analysis of findings in Year 3.
- Analyses related to the impacts of different policy regimes on gender were developed.

Following are the project's highlights.

- Preliminary results show that, as expected, institutional fit and congruence at multiple levels of governance are key in determining the outcomes of decentralization.
- Decentralization is not the universally beneficial policy it has been reputed to be; outcomes of decentralization are not consistent with findings depicted in the literature. Decentralization policies take varied forms that have varied effects. Instead of being a broad answer for all situations, decentralization policies need to be considered carefully by form and implementation in the context of local circumstances before being applied widely across countries and localities.
- In the four host countries, 1,816 individual, including user group members, local officials, and national-level policy makers, participated in training, workshops, and/or data collection. The degree of contact among organizations at different scales generated by this project has the potential to profoundly affect policy outcomes.

- Partners are working hard to interact with policymakers and practitioners and to ensure that the findings of the SANREM project have an impact. In Mexico, regular interaction has been conducted over the past year with the World Bank and World Wildlife Fund. The Bolivian team continues to collaborate with the U.S. Agency for International Development's Jatun Sach'a. The Kenya team has found great success with its Kakamega policy round table and hopes to hold additional round tables in its remaining sites.
- Communities want more involvement. Researchers in Uganda found that communities want to be able to lease forest land for community plantations; they want to establish buffer zones around forests to protect them; and they want increased involvement in monitoring, enforcement, and licensing. All of these are powers they have not received as a result of decentralization.

Project activities continue to proceed as planned. To accommodate EEP comments, the research team agreed to reduce the number of site visits by one in each country (a total of five sites each in Bolivia and Mexico, seven sites each in Kenya and Uganda). This change in the work plan will enable partners to focus more closely on analysis, synthesis, and dissemination.

LTRA-2: Developing a Participatory Socioeconomic Model for Food Security, Improved Rural Livelihoods, Watershed Management, and Biodiversity Conservation in Southern Africa

Lead PI: Alex Travis, Cornell University
Host country: Zambia

The goal of this project is to test and optimize a third generation model for biodiversity conservation that focuses on alleviating poverty and hunger, but uses markets to make SA and NRM strategies economically, socially, and environmentally preferred. The Community Markets for Conservation (COMACO) model, founded by the Wildlife Conservation Society in Zambia, is being assessed by the U.S. Agency for International Development (USAID) to see whether it is worthy and capable of being exported to other areas facing similar economic and environmental challenges.

Progress continues to be extremely strong on all objectives described in the proposal. All items listed in the work scopes for Years 1 and 2 have been started and/or completed, and research activities continue on all four objectives.

Research into the business structure of the community trading centers (CTC) of COMACO has identified major cost and profit centers within each CTC, making possible the reporting of business activities for each product and the development of cohesive business plans. Extension and training activities remain a major cost center and are unique to the model in that they would not be incurred by a business that focused purely on economic profit. Value-added products provide the major profits and are the key to economic self-sufficiency. Research into historical financial data was supplemented with collection of new data, including an inventory and audit. These provide us with the first business models for the costs associated with replicating this model for sustainable rural development having explicit ties to biodiversity conservation.

Notable research progress has translated into impact regarding the integration of new technologies into COMACO's activities. For example, the production of value-added food products at the Lundazi CTC has been evaluated. Significant issues regarding hygiene and safety have been identified and corrected. The addition of a soy extruder and soy "cow" or milk machine to COMACO's production instrumentation offer exciting new opportunities to expand markets and generate critically needed value-added products such as high-energy protein supplements that now must be imported at great expense for HIV patients. Yet scaling up for markets outside the Luangwa Valley imparts significant risks in terms of public health associated with packaged foods. Therefore, we performed research regarding current production practices, the types of food-borne pathogens that pose risks, as well as the quality control of these new products. To prevent problems associated with food production, we hosted two major training workshops for COMACO's Zambian staff on their own equipment in the best safe, hygienic food production practices and in product development. We printed posters and a children's coloring book to provide continual reminders in the home and workplace to implement these practices.

Large-scale experiments to quantify maximum soil yields over diverse agro-eco zones and to evaluate the efficacy of different soil amendments continue. Because of the scope of these efforts and through partnerships with Tropical Soil Biology and Fertility Institute (TSBF) and the Conservation Farming Unit, a host-nation organization, these findings should be applicable across much of southern Africa. Changes in land-use practices such as deforestation to facilitate the planting of short-term cotton crops on the plateau have been anecdotally correlated with increased runoff that this year contributed to extreme flooding in the alluvial areas of the valley – about half of experimental soil plots in these alluvial areas were lost to flooding. An in-depth watershed analysis involving both satellite imagery and on-ground runoff measurements is underway to quantify the contributions of specific agricultural and development practices to watershed management. Extensive data collection on village poultry practices has been coupled with training of more than 500 villagers in methods to improve poultry production. Market data on poultry sales suggested an increase in production of more than 50 percent in the trained areas as a result of our research and the implementation of corrective measures. Such data should be considered anecdotal until replication can be obtained. More extensive training of COMACO extension officers as veterinary para-professionals and the setup of a small field laboratory should result in longer-term improvements in diagnostic capability. The tremendous initial success of our poultry intervention has been leveraged into financial support from new sources, allowing SANREM researchers to partner with the International Rural Poultry Centre to extend these operations on a much larger scale.

Our social scientists have evaluated COMACO's extensive survey data, leading to new survey designs being implemented and analyzed regarding the effects of the COMACO intervention on social parameters such as education, health and nutrition. A large demographic survey has been completed, and the data are being analyzed. Numerous smaller surveys have also been completed. Quantification of COMACO's effects on biodiversity conservation has been greatly improved through the collection of data from control areas both before/after and within/without the intervention area. Data from Year 1 have been analyzed and suggest strongly positive effects for the COMACO intervention. Unfortunately for Zambia's wildlife-based tourism industry, analysis also revealed extreme depletion of wildlife in surrounding areas such as the Lukusuzi National Park. For example, comparing raw numbers alone, in an aerial survey of 5,329 square

kilometers in the COMACO core area, 1,019 animals were counted. In 9,061 km^2 of control areas, only 70 animals were counted. Statistical analysis and replication are needed over the next years to make valid comparisons. COMACO had already identified and mapped with a geographic information system (GIS) numerous professional poachers in the region surrounding the park. Training of poachers in alternative careers such as carpentry and beekeeping is underway and the efficacy/recidivism rate of the training program is being assessed. Should these efforts by COMACO be successful, our wildlife monitoring program will determine if wildlife populations are rebounding in the targeted areas. Year 2 wildlife surveys have revealed the same trend, with the COMACO core area having significantly higher wildlife populations than the surrounding control areas. However, continued monitoring will be required to determine if the differences are statistically significant; this is because of natural year-to-year sampling variations due to heterogeneous, non-uniform animal distributions, called clumping. A large-scale aerial survey of hippos in the Luangwa River has been performed, and the data are being analyzed.

Numerous miscellaneous items needed to support the research have been installed. In this regard, a very small aperture terminal (VSAT) broadband satellite Internet linkage has improved communications immensely between two of our main sites in Zambia and with our researchers in the United States. Its introduction represents a technology leap for the area, also providing an enormous improvement in COMACO's business operations. Progress made on all objectives has been above expectations. The only significant obstacles have been the floods mentioned above and described in greater detail below. These floods actually represent a critical research opportunity to help improve current development efforts by Western governments, pointing to the critical watershed studies needed to tie together activities on the plateau and in the valley. They also set the stage for efforts to foster a comprehensive ecosystem-scale management plan. A meeting in December brought together government officials and regional stakeholders to discuss land management and ecosystem interactions.

LTRA-3: Watershed-based Natural Resource Management in Small-scale Agriculture: Sloped Areas of the Andean Region

Lead PI: Jeff Alwang, Virginia Tech
Host countries: Ecuador, Bolivia

Long-term research for this project has proceeded according to plans with important activities well underway, some interesting preliminary findings, a well-designed and well-leveraged training program, and substantial networking with other researchers and policy makers in the area. Two research sites have been established: in Guaranda, Bolivar Province, Ecuador and in Tiraque, Cochabamba Province, Bolivia. Research is being conducted in farmer fields, at experiment stations in both countries, and by a network of researchers at U.S. and other universities. Main research partners are the national autonomous agricultural research institute in Ecuador (INIAP) and the autonomous agricultural research institute for Andean crops in Bolivia (PROINPA). Affiliated partners at host sites are Fundación Ecuatoriana de Estudios Ecológicos (ECOCIENCIA), Corporación para la Investigación, Capacitación y Apoyo Técnico para el Manejo Sustentable de los Ecosistemas Tropicales (ECOPAR) and Sistema de Información Geográfica Agropecuaria (SIGAGRO) in Ecuador; and Programa Manejo Integral de Cuencas (PROMIC) and Center for the Study of Economic and Social Reality (CERES) in Bolivia. The

international potato center (CIP) is also a partner. Coordinators at both sites have engaged local governments, farmer and community groups, and individual decision makers in the research planning and implementation process; the program is fully participatory.

Specific objectives of the long-term research are to:

- identify economic, social, political, and environmental conditions in the watersheds and understand the determinants of these conditions
- generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation (some alternatives might be new crops and new on- and off-farm income-generation strategies; others would be technical improvements to existing practices)
- create means of evaluating impacts of alternative actions, policies, and interventions on income generation, and social and environmental conditions (this will take individual responses such as changes in practices at the field, farm, and market scales, and aggregate them to the watershed level as well as create mapping between policy and other interventions and outcomes at the aggregate level), and
- build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital.

Our research plan involves phasing in activities. We began with participatory appraisals (PA) to identify key constraints and concerns. As a result of our findings, we designed physical and social science research to identify potential solutions to the constraints, including research on plant diseases, variety selection and testing, agronomic research on feasibility of alternative varieties, soil erosion rates and means of mitigating them. We are complementing the physical science with social science investigations of determinants of livelihood adoption, the profitability of livelihood alternatives, costs and benefits of enhanced NRM, and institutional considerations affecting governance in the watersheds. Because our goal is to build comprehensive physical and social models of the watershed, our research in the first two years of the project has focused on obtaining data and building the models. These models will be used in an adaptive watershed planning process to inform local decision makers about the impacts and consequences of alternative land-use plans. We have initiated a process of dialogue to build stakeholder ownership of the research products; participation also helps ensure that research is well-designed and relevant.

Research highlights are:

- completion of participatory appraisals in both sites
- completion of baseline surveys for both sites
- establishment of GIS for both sites
- a comprehensive soil survey for the Ecuador site, the analysis of which is yielding important information about the rate of soil erosion and its relationship to global carbon flows
- a protocol for assessment and monitoring of biodiversity for both sites and an analysis of biodiversity for the Ecuador site, and

- a first year of field-level agronomic research providing information on management techniques and the profitability of alternatives.

The analysis of the baseline survey of livelihoods for Ecuador shows highly diversified income-generation strategies, major differences in decision making and participation across our two working sites in Ecuador, and a disconnect between stated concerns for environmental quality and household level decisions. Data from the baseline are being used for more detailed household modeling of livelihood strategies and their impacts on the natural resource base.

Long-term training is proceeding at a pace beyond expectations. U.S. investigators have leveraged their SANREM funding base and involved far more students in SANREM research than would be possible if we relied exclusively on project funding. We have graduate students studying at U.S. universities: three in economics/social sciences, two in soil science, one in plant pathology, and one in biological systems engineering. Also, Victor Barrera, our coordinator for South America, is completing his Ph.D. in social sciences at Universidad Politécnica de Madrid in Spain. He is being funded by a separate grant to our partner INIAP, but SANREM is providing funds for his field research, which contributes to several of our objectives. The Ecuador and Bolivia sites both have made heavy use of *tesistas,* undergraduate students mainly in agricultural sciences and engineering, who need practical research experience to complete their degrees. These students represent a low-cost means of conducting research and an important component of our SANREM long-term training. A clear benefit of using *tesistas* is networking between the SANREM research team and the students' advisers.

Short-term training is proceeding according to plans. SANREM scientists have conducted a number of seminars and workshops for partner scientists, local governments, extension specialists, and farmers/citizens, among project beneficiaries. Several undergraduate and research interns have been engaged in the Ecuador site: eight from Virginia Tech, who were in Ecuador in May and June 2007; one from University of Denver, in Ecuador during November and December 2007; and one from Florida A&M University who conducted research in Ecuador in June 2007. These students are learning from their experience and also contributing to SANREM research, for their activities during their time in the country are closely coordinated with U.S. scientists.

LTRA-4: Adapting to Change in the Andean Highlands: Practices and Strategies to Address Climate and Market Risks in Vulnerable Agro-ecosystems

Lead PI: Corinne Valdivia, University of Missouri
Host countries: Bolivia, Peru

The overall research objective of this project is to assess and improve the capacity and capabilities of rural communities in the Andean highland (Altiplano) ecosystems of Bolivia and Peru to adapt to changes in climate and market drivers that may have reduced agricultural and natural resource sustainability and increased the region's risk of food insecurity. Three research sites comprising 10 rural communities were established in the Altiplano. Six research theme teams were established across regions, and three skills teams. Activities were coordinated through team investigator meetings in Peru, Bolivia, and across regions. A password-protected

website was established to facilitate communications and group discussions of working documents. Research design and experiment establishment activities took place in September and October 2006; monitoring instruments and approach were tested in February 2007; and monitoring and evaluations were conducted through June 2007, when harvests were completed in Bolivia. Assessments and farmer training continued in July and August in Peru. Extensive surveys and participatory evaluations were conducted in rural communities to assess quantitatively and qualitatively the initial status of communities in relation to their livelihoods, assets, practices and strategies, and to determine the effects of climate and market drivers. Demand identification and participatory assessments were completed in 14 rural communities. Baseline surveys and participatory mapping of changes in the landscape were completed with 12 communities across four regions. A baseline survey to capture livelihoods capital and practices included 450 households in Bolivia and Peru. In eight communities, first-year field studies were completed on soil characterization, alternative soil amendments, pest dynamics, biodiversity of potatoes and oca (*Oxalis tuberosa*), and testing of new quinoa varieties. The first phase in the process of linking local and new knowledge to produce practices and information alternatives to adapt to change took place in all regions. More than 120 events were held in Bolivia and Peru in this process. In Bolivia, 140 residents participated in farmer groups, and in Peru, 90 participated. A monitoring system to evaluate participation and the role of capital was implemented. Thirty-one students (17 female and 14 male) from Bolivia, Peru, and the United States are involved in field research, pursuing *licenciatura*, master's, and Ph.D.s in biological, physical, and social sciences. An international seminar on global change and climate, led by Universidad Mayor de San Andrés (UMSA) in La Paz in June 2007, showcased the SANREM CRSP and issues revolving around climate change and adaptation. Matching funding was secured for training students. UMSA secured a grant to expand the research program with farmers in Ancoraimes from the United Nations Development Program (UNPD) Bolivia Climate Change Small Donations project. The methodologies developed with the project were shared with CIP's ALTAGRO project and Save the Children. Proposals were developed for cross-cutting research in soils, watershed, knowledge to action, and gender, and funding was secured for graduate students in host countries.

Research highlights and products include:

- theme teams established for climate, biodiversity, pests and diseases, livelihoods and markets, and soils (skill team in participatory research methods and research on participation established to bridge knowledge systems and assess ability to act)
- working group on participatory methodologies developed, a plan for participatory assessments implemented, and a database created to capture information to monitor and evaluate participation through time in farmer research groups and information sharing
- completion of 450 household surveys spanning three regions – two in Bolivia, one in Peru – that capture data to analyze livelihood strategies, assets, land use and production systems, networks of information, shock events, and risk perceptions
- development and implementation of community participatory assessment and research methods to foster knowledge sharing and bridging, consistent with project development impact pathway – ability to act
- production of 64 geo-referenced maps depicting perceptions of change in natural resources, land use, cropping areas, and natural hazards/vulnerabilities of 10 communities

in the Altiplano of Bolivia as the starting point for assessment of alternatives for adaptation to changes in each participating community
- characterization of climate change and climate trends in the central and northern Altiplano
- first-year research on characterization of potato tuber moth and Andean potato weevil dynamics in rural communities completed, and training in Ancoraimes and Umala responding to community participatory assessments that identified these as major problems
- established collaborative relations with two Puno communities, developed co-learning resource management training, advocacy coalition training with communities and tours
- completed participatory assessment of a third region, Apolobamba, in Bolivia
- training in soil fertility, advocacy coalitions, and improved management of improved pastures in Puno in response to needs identified by collaborating communities
- assessment of local soil classification systems, the soil properties of the major soil types in each community, and the criteria used in these systems for classification and for land use decisions
- improved understanding of the effects of changes in climate and socioeconomic conditions on changes in cropping systems, soil organic matter, and soil fertility, especially related to changes in agricultural management of fallow periods at all research sites
- testing of management strategies for increasing soil organic matter and soil fertility in potato-based cropping systems in two regions, and
- three host country investigators traveled to the United States to begin doctoral programs and as part of master's degree training, and two graduate students traveled to Bolivia to conduct field research.

LTRA-5: Agro-forestry and Sustainable Vegetable Production in Southeast Asian Watersheds

Lead PI: Manuel Reyes, North Carolina Agricultural and Technical State University
Host countries: Philippines, Vietnam, Indonesia

Communities in many forest and vegetable-producing watersheds in Southeast Asia are suffering from poverty, and forest, soil and water resources degradation. The overall hypothesis of this research is: Integrating vegetable production in tree systems and trees in vegetable production systems will alleviate poverty and enhance environmental protection, ecosystem diversity, and sustainability on small farms in Southeast Asia. From extensive baseline studies, four villages were chosen for implementation of project activities. They are Ngia Trung commune, Binh Phuoc Province, Vietnam; Parakan Muncang and Hambaro, West Java Province, Indonesia; and Songko, Bukidnon Province, Philippines. The predominant agro-ecosystem at the Vietnam site is tree based. At the Indonesia site it is a multistory home garden system consisting of fruit and timber trees, annual rice and vegetable crops. At the Philippines an intensive vegetable-based system predominates.

ICRAF-Philippines scientist Agustin Mercado developed a net complementarity index (NCI) – a simple tool to assess vegetable-tree interaction. Using NCI, he found that optimum tree spacing for vegetable agro-forestry is 20 to 25 meters for three tree and four commercial vegetable species. Indigenous vegetable screenings were conducted in Vietnam, Indonesia, and the Philippines. Initial results show that many indigenous vegetables with medicinal and high nutritional content grow well under trees. Their NCIs are being determined in the Philippines. Low-cost drip irrigation experiments were well received by small-scale farmers, both women and men. Drip experiments commenced, and in Vietnam initial results showed that drip in cacao planted between cashew trees increased cashew yield. Vietnam is promoting cacao production, and results show that several cacao varieties are growing well between mono-cultured cashew trees. Test of a proposed human-powered prototype no-till planter was unsuccessful. It was concluded that human power is insufficient, and the prototype was modified for animal or small-motor power. Experiments on perennial cover crop *Arachis pintoi* planted between vegetables or under cashew trees for soil conservation, insect control and a nectar source for bees began in all countries.

Market baseline studies identified marketable vegetables and trees, and these vegetables and trees are the current focus of technological research. Marketing team has gathered sufficient knowledge on value chain. Marketing constraints faced by small scale farmers both women and men are lack of access to market information, inability to control market pricing, high transport cost, and poor post harvest handling.

The policy team conducted an extended baseline study and initial policy development. In the Philippines, the policy baseline study concluded that small-scale farmers, both women and men, can be effectively helped with policies developed locally, rather than nationally. This research has been supported by the local government in Lantapan, which has provided in-kind and financial support. This led to a memorandum of understanding signed by five agencies to develop incentive-based policies and mechanisms for payments for environmental services. In Vietnam, both national and local policies influence small-scale farmers, both women and men. Focus is on industrialized perennial crops like cashew and substitution of new perennials as market conditions dictate. Cacao was promoted by the local government as a new crop for diversification and income improvement, with vegetable production receiving very little attention.

The socioeconomic team developed an adoption monitoring feedback loop protocol for field- and farm-scale experiments and for collecting input, cost, and market data to calculate benefit/cost ratios of the experimental technologies, as well as to ascertain perceptions by small-scale farmers, both women and men, of vegetable agro-forestry technologies. The environmental impact team gathered substantial data to quantify the hydrologic effects of current land-use and management practices in the watersheds from the three countries using the Soil and Water Assessment Tool watershed model.

The gender team found that men are the dominant labor force in commercial crop production, while women predominate in raising subsistence crops, particularly in home gardens. The majority of the niches in the agricultural production cycle that require arduous work are mainly handled by males. More men than women control the following agricultural domains: farm-level

decision-making, including purchase of farm inputs and timing of harvest or marketing; involvement in farmers' organizations; and participation in agricultural training and extension services. Women's limited organizational and training involvement results from their preoccupation with unremunerated household duties, the scheduling of meetings or training at times when women are not available, and the perception that extension services are for men. Dominance in the agricultural marketing sphere varies by country.

Indonesian partners completed an indigenous vegetable production manual and indigenous vegetable cookbook, which supplement the comprehensive vegetable production manual published last year. Scientists with the Asian Vegetable Research and Development Center (AVRDC) completed an indigenous vegetable production guide for the Philippines. For each country, TMPEGS partnered with model small-scale farmers, both women and men, who are passionate advocates and practitioners of SANREM technologies. A video and booklet showcasing the Binahon family farm, "Taming the Land, the Wind and the Sun: The Story of the Binahon Agro-forestry Farm," was developed by the scaling-up team in the Philippines. The Indonesia site constructed a SANREM extension base camp on the property of Indonesia's model farmer. Many farmers, both women and men, have gathered and visited the camp, exchanging ideas with scientists and field technicians on vegetable agro-forestry systems. The Vietnam model farmer's field is the site of the vegetable-light intensity-tree experiment. The project website was launched.

Seventeen graduate students were supported by SANREM, and 23 non-degree training activities were conducted. Examples include participation of four partner scientists in the University of California's Beahrs Environmental Leadership Program; a Soil and Water Assessment Tool Modeling workshop in the Philippines; a no-tillage vegetable workshop in Indonesia; a soil quality workshop in Vietnam; low-cost drip irrigation workshops in three countries; and a farm field day in Lantapan, Philippines.

Several networking activities happened, with about 27 networking activities recorded. SANREM Program Director Theo Dillaha and SANREM Board Chair Alton Thompson visited partners in all countries. Furthermore, top administrators from partner universities in Vietnam, Indonesia, and the Philippines visited the United States and networked with personnel from federal agencies in Washington and administrators from North Carolina A&T and Virginia Tech.

Cross-cutting Activities

Our leading cross-cutting theme from the beginning has been gender. With the full initiation of our LTRA activities, gender has come to the fore as a critical research issue. Sex-disaggregated data collected across all projects and collaborative efforts to identify cross-cutting gender issues led to a session on gender at the SANREM annual meeting and a consequent research proposal addressing gendered networks and market access. Initial findings summarized for each project emphasize the multiple roles of women and men in sustainable livelihoods based on agriculture and NRM. It is important to recognize how these roles differ from setting to setting. For example, in some Andean communities, indigenous women are highly involved in the marketplace, while in others, men have the primary market role.

Another critical area where cross-cutting themes have been developing is in watershed modeling and assessment. This work, led by PI Conrad Heatwole, is addressing watershed management issues as identified in LTRAs 2, 3, 4, and 5. Initial research has focused on the impact of erosion from land cleared on the plateau and escarpment areas on siltation and wetland habitat in the Luangwa Valley, Zambia. Measurement instruments and protocols have also been established across other sites in the Andes and the Philippines.

Research proposals have also been developed for the coming year to investigate additional themes addressing issues such as linking knowledge to action and soil metagenomics. These cross-cutting activities are in addition to the common research being conducted by individual LTRAs. Nearly all of the LTRAs are working on common themes such as gender, governance, linking knowledge to action, soil and water resources, linking farmers to markets, and biodiversity.

Management Entity Activities

The SANREM Knowledgebase (SKB) is a web-based knowledge storage and retrieval database that organizes and provides access to all knowledge generated by the SANREM CRSP. The SKB is designed to provide practitioners in SA and NRM with pertinent information on best practices adaptable to site-specific conditions. The SKB is managed by the SANREM ME. Knowledge is contributed by the ME and SANREM CRSP Landscape System Coordinators, and Bridging Activity and LTRA PIs and their partners. The SKB is fully operational and allows researchers and practitioners to catalog and search SA and NRM information resources (books, reports, journal articles, videos, movies, presentations). As of September 2007, 2,162 information resources have been entered into the SKB, which is accessible at http://www.oired.vt.edu/sanremcrsp/menu_information/knowledgebase.php.

Training and Institutional Development

The SANREM ME, Bridging, and LTRAs contributed to short- and long-term training. Eighty-one students from 14 countries are involved in long-term degree training. Of those, 63 are from developing countries. The students are working on 27 Ph.D.s, 24 master's degrees, and 30 undergraduate degrees. Of the total, 43 students are female, and 38 are male.

SANREM supported 142 short-term training activities involving 9,554 people (more than one-third of them women) in 12 countries. There were 91 workshops, 18 short courses, 14 field days, 12 seminars, six focus groups, and one undergraduate internship program.

Long-term Research Award Activities

LTRA-1: Decentralization Reforms and Property Rights: Potentials and Puzzles for Forest Sustainability and Livelihoods

PIs: Elinor Ostrom, Indiana University
Krister Par Andersson, University of Colorado
Ruth Meinzen-Dick and Esther Mwangi, Consultative Group on International Agricultural Research (CGIAR) Systemwide Program on Collective Action and Property Rights (CAPRi)
Bruce Campbell and Marty Luckert, Center for International Forestry Research (CIFOR)

Host countries: Uganda, Kenya, Mexico, Bolivia

Executive Summary

This project aims to address the following development challenge: Decentralization and property rights reform policies formulated at the national level for large geographic domains often fail to account for the complexities involved in land use at the local level and can thus fall short of their goals of sustainable NRM and improving local livelihoods. This research is collecting and analyzing data from Uganda, Kenya, Mexico, and Bolivia to identify the institutional conditions and interactions that will deliver benefits equitably to local people while sustaining natural resources. Regional and global comparative research allows for identification of strategies within regions and creates a learning environment among critical actors that may lead to more effective policy formation, implementation, monitoring, and enforcement. The project's aims are:

- **Objective 1:** develop capacity within resource user groups at the selected forest sites to enable differentiated actors (particularly women, the poor, and other marginalized groups) to identify, understand, and participate in forest governance, benefits, and policy processes
- **Objective 2:** develop capacity within key organizations, especially government agencies and non-governmental organizations (NGOs) in the forestry sector to understand the effects of policies on differentiated local actors and to adopt strategies for inclusion of such actors within broader policy processes, and
- **Objective 3:** develop effective monitoring techniques for use by resource user groups and their partners (including NGOs and local agencies) at the community level to evaluate the effects of decentralization and other property rights reforms on natural resources (including biodiversity) and livelihoods.

Activities this year focused on:

- continuing field visits in the four target countries, including data analysis, drafting of site reports, and follow-up training to present findings to stakeholders and identify additional activities. International Forest Resources and Institutions (IFRI) and household data collection has been completed in Uganda Sites 2-3, Kenya Sites 2-4, and Bolivia Sites 2-3. Data collection for Mexico Sites 1-3 is almost complete. Final Poverty Environment

Network (PEN) surveys, which collect much more detailed household-level data, were conducted in five communities in Bolivia and 18 communities in Uganda.
- holding interactive, post-site visit training in Uganda Sites 1-3, Kenya Site 1, and Bolivia Sites 1-3
- completing a national-level, large-n survey of forest communities in Mexico and initiating a similar survey in Bolivia. Partners in Mexico completed the national survey of 146 forest communities in five states: Durango, Jalisco, Michoacan, Guerrero, and Oaxaca. Bolivian partners continued work on their national-level survey. They developed a sampling framework and selected 150 communities for study; 13 communities have been completed.
- articulating the scientific strategy and conceptual model behind the project
- continuing to synthesize findings related to the effects of decentralization on rights and decision making and preparing for more focused analysis of findings in Year 3, and
- developing analyses related to the impacts of different policy regimes on gender.

The following are project highlights.

- Preliminary results show that institutional "fit" and "congruence" at multiple levels of governance, as expected, are key in determining the outcomes of decentralization.
- Decentralization is not the universally beneficial policy it has been reputed to be; outcomes of decentralization are not consistent with findings depicted in the literature. Decentralization policies take varied forms that have varied effects. Instead of being a broad answer for all situations, decentralization policies need to be considered carefully by form and implementation in the context of local circumstances before being applied widely, across countries and localities.
- In the four host countries, 1,816 individuals, including user group members, local officials, and national-level policy makers, participated in training, workshops, and/or data collection. The degree of contact between organizations at different scales generated by this project has the potential to profoundly affect policy outcomes.
- Partners are working hard to interact with policymakers and practitioners, and to ensure that the findings of the SANREM project have an impact. In Mexico, there has been regular interaction over the past year with the World Bank and World Wildlife Fund. The Bolivian team continues to collaborate with the Jatun Sach'a Foundation. The Kenya team has found great success with its Kakamega policy round table and hopes to hold round tables in its remaining sites.
- Communities want more involvement. Researchers in Uganda have found that communities want to be able to lease forest land for community plantations; they want to establish buffer zones around forests to protect them; they want increased involvement in monitoring, enforcement, and licensing. All of these are powers they have not received through decentralization.

Project activities continue to proceed as planned. To accommodate comments from the EEP, the research team has agreed to reduce the number of site visits by one in each country for a total of five sites each in Bolivia and Mexico, and seven sites each in Kenya and Uganda. This change in the work plan will enable partners to focus more closely on analysis, synthesis, and dissemination.

Research Strategy and Development Objectives

Introduction

Decentralization and property rights reform policies formulated at the national level for large geographic domains often fail to account for the complexities involved in land use at the local level and can thus fall short of their goals of sustainable natural resource management and improved local livelihoods. In response to this development problem, the principal goal of this project is to improve forest and natural resource policy by developing and disseminating knowledge about the institutional conditions that make such policies more or less effective in delivering benefits equitably to local people while sustaining natural resources. We seek to achieve this goal by systematically characterizing how top-down public policy reforms, particularly decentralization reforms, affect local property rights and the implications of rights arrangements for particular groups (women, the poor, and marginalized who are dependent on forest resources). Our research analyzes the effects of forest decentralization from a local community perspective. We pay particular attention to the way in which property rights regimes and related local institutional arrangements may have been altered by changes in public policy at the national level. Specifically, we propose to accomplish the following objectives:

- **Objective 1:** to develop capacity within resource user groups at the selected forest sites to enable differentiated actors (particularly women, the poor, and other marginalized groups) to identify, understand, and participate in forest governance, benefits, and policy processes
- **Objective 2:** to develop capacity within key organizations (especially government agencies and NGOs) in the forestry sector to understand the impacts of policies on differentiated local actors and to adopt strategies for inclusion of such actors within broader policy processes, and
- **Objective 3:** to develop effective monitoring techniques for use by resource user groups and their partners (including NGOs and local-level agencies) at the community level to evaluate the effects of decentralization and other property rights reforms on natural resources (including biodiversity) and livelihoods.

Theoretical framework

Policy reforms such as decentralization do not automatically translate into new property rights regimes or immediately observable environmental outcomes. It is therefore crucial to analyze the processes in the middle of a causal chain linking policies with environmental outcomes. We propose that the effects of a policy change depend especially on the role played by local institutional[1] arrangements. Our research focuses on the institutional arrangements and incentives of local governance actors – local community leaders in particular – to explain their decisions and actions as well as the resultant outcomes for forests.

Our approach builds on the work of the new institutionalism school of political economy (North, 1990; Ostrom, 1990; Knight, 1992; Horn, 1995; Bates, 1998). New institutionalists seek to explain political behavior by examining the constraints imposed on individuals by institutions. Whereas early forms of institutionalism implied that institutional structures determined social or

[1] In this context, "institutions" are defined as systems of rules.

political outcomes, new institutional scholars have come to view institutional arrangements as moderating the effects of other variables. Our approach also emphasizes the value of considering institutions at multiple levels, drawing on earlier work that analyzes institutions as "two-level games" (Putnam, 1994), "nested action arenas" (Ostrom, 2005), or systems of multilevel governance (Hooghe and Marx, 2003). We recognize that institutional arrangements are nearly always made up of several layers of social orders, from local micro-interactional orders to international and transnational arrangements; and that the relationships of complementarity and contradiction between these layers are crucial.

We use these insights to analyze decentralized resource governance. Through this approach, we highlight the ways in which decentralization reforms are filtered by institutional arrangements to produce outcomes visible on the landscape. The existing set of multi-tiered institutional arrangements shapes the incentives that actors face and thus the patterns of interaction among resource users, various levels of government officials, and other actors. The relationship between actors and institutions is often complicated, for actors both respond to institutional incentives and enact these institutional arrangements continually. The key point in our approach is that the configuration of local institutional arrangements and their interactional dynamics shape the extent to which decentralization ultimately affects the environment.

One of the key challenges in our research is to isolate the effects of decentralization policies and other public policies on local decision making related to natural resources. The difficulty lies in the separation of decentralization from other processes that occur simultaneously and that also influence local decisions. We have a two-pronged approach to dealing with this challenge. First, we use our framework for institutional analysis, as laid out in the next section, to organize and clarify the conceptual linkages between public policies, property rights regimes, local institutional arrangements (such as rules governing resource access, voting rules, harvest rules), and the changing nature of natural resources. Second, we use this information to create a research design that offers insight into which variables matter in determining outcomes and which allow us to document complex interactions and draw lessons from them. We elaborate on both of these aspects below.

Institutional analysis framework

The institutional analysis employed in the project is structured by an adaptation of the Institutional Analysis and Development (IAD) framework (Figure 1). This framework helps the researcher organize the context-specific analysis of institutions and the incentives they generate (for reviews, see Ostrom, 2005, and Gibson *et al.*, 2005). In this analytical approach, we emphasize a contextually grounded analysis of local institutional arrangements and incentives. In other words, the effects of decentralization reforms are affected by a filter of institutional mediation. We view the decisions of local governance actors, including community members, authorities, local government officials, and NGOs, to be shaped by both national and local-level institutions, as illustrated by Figure 1. The local actors' incentive structures are composed of the perceived rewards and penalties from sociopolitical as well as financial or economic arenas. These incentives emerge from the patterns of interactions between local community leaders and a variety of actors, such as resource users, central government representatives, and private interest groups that operate under varying contextual conditions.

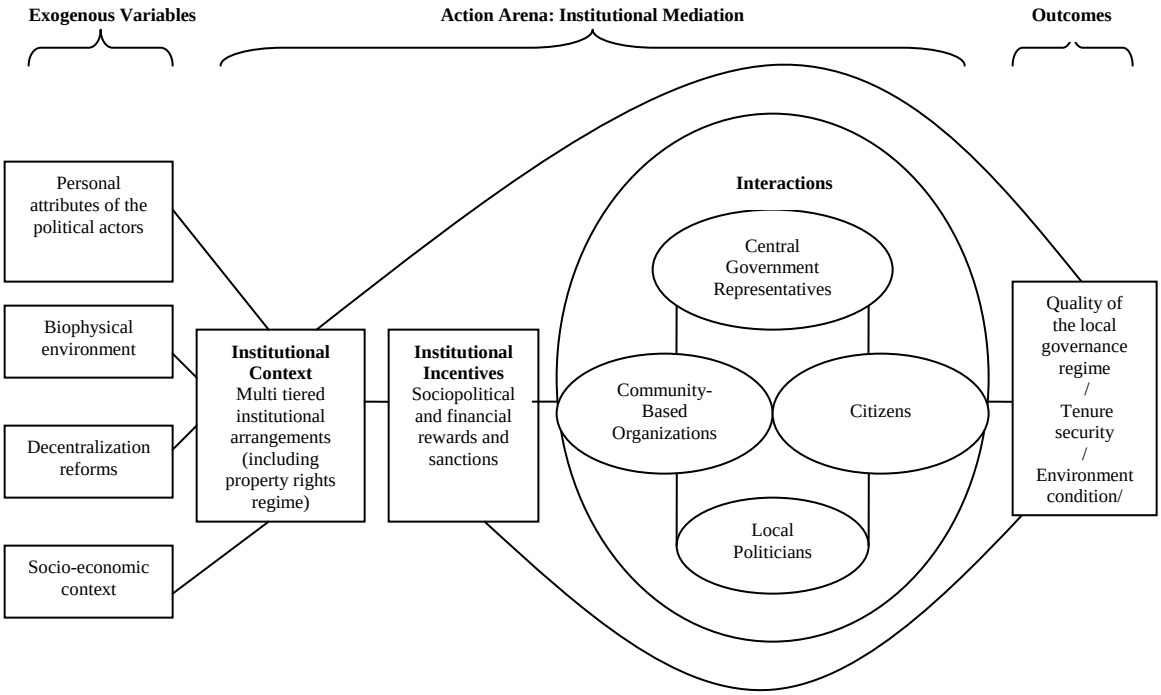


Figure 1: From Andersson, Laerhoven and Gordillo (forthcoming), adapted from Ostrom (2005)

The characteristics of these interactions in the local context will depend in part on local and national institutions: the particular mandate of local governments or communities, and their experience in governing in a particular policy domain, such as forestry, irrigation or fisheries. Following this logic, local community members will invest their time and resources into governance activities when they reap some rewards from doing so. Investing in governance activities may, for example, enhance or constrain their incomes from natural resources, the losses from intrusions, and their relationships with other governance actors.

All the relationships depicted in Figure 1 occur at multiple levels of governance: operational, collective choice, and constitutional. Note that governance level does not correspond to spatial level. In the current project we are particularly concerned with interactions between the community/watershed level and the national level, informed by patterns at the farm household/enterprise level, and each of these spatial levels may make rules at any of the three governance levels. The examples given above relate mostly to decision making at the operational level, which is where resource users interact and make day-to-day decisions such as what type of products to harvest on a certain day, where they will harvest, who they will ask for help, and how much they will harvest. These decisions at the operational level are influenced by governance processes at two superior levels of authority: the collective choice and constitutional levels. Figure 2 illustrates the multilevel dynamic of how decisions at one level are influenced by decisions at other levels of governance. The nested governance decisions in Figure 2 can be made by any or all of the actors in the action arena of Figure 1. That is, for any given level of spatial aggregation, including all systems of the SANREM framework – field, farm

household/enterprise, community/watershed, ecosystem, and policy/market – decisions can be made at the operational, collective choice, or constitutional level.

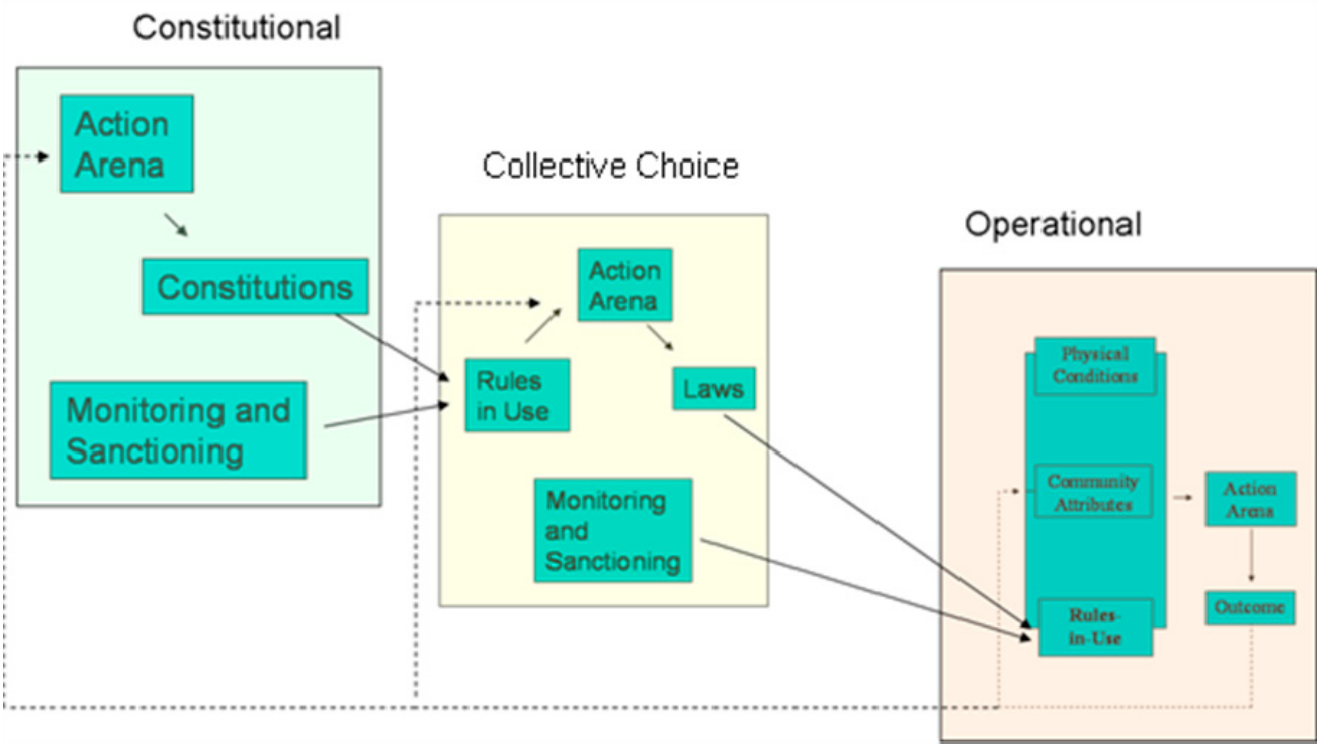


Figure 2: The nested nature of governance decisions. Adapted from McGinnis (2000)

At the collective choice level, policy makers decide the rules that constrain the resource users' harvesting decisions at the operational level. These rules may include who may or may not harvest resources, which areas are off limits for certain uses, and the maximum quantities that each family may harvest in a given year. The participants at this level of governance, the policy makers, are sometimes appointed by the community members themselves in a self-organized village council, and other times the participants are appointed by government officials. Whoever it is that makes the collective choice decisions, these decisions are influenced by rules created at the constitutional level of governance. At this highest level of governance, decisions are made about who is authorized to make collective choice rules, what means may be used in enforcement of these rules, and what sanctions may be applied to those who do not comply.

We use this framework to organize and clarify the conceptual linkages between public policies, property right regimes, local institutional arrangements, and the changing nature of natural resources. One of the most important tasks for the researchers in this stage of the research is to identify the ways and mechanisms that decentralization could plausibly influence local decision making. For example, who are the targeted actors to whom one should pay particular attention, what are their changed mandates, powers, and resources? Which particular processes are these actors likely to influence most, and which are they not very likely to influence at all? This first step of the analysis allows the members of the research team to agree on a common language, to discuss the most important theoretical and empirical work for analyzing the issues at hand, and to start formulating core hypotheses about causal processes.

The hypotheses emanating from the institutional analysis are then used to create a comparative research design that includes cases representing different degrees and types of decentralization. In our SANREM project, our research design includes two pairs of countries in two regions with varying degrees and types of decentralization, and relies on observations over time of the sites where we work. This design allows us to carry out a longitudinal, cross-sectional comparison of how communities respond to decentralization reforms. The combination of a carefully conducted institutional analysis, a solid comparative research design, and observations over time increases the likelihood of making sound scientific inferences.

Research strategy

Our research design allows us to test two critical aspects of our theoretical arguments. First, by selecting two pairs of countries with varying degrees of decentralization, we are able to examine the potential effect of this national-level policy on local-level decision making with regard to community governance activities. Second, by collecting data in multiple communities in each country, we can analyze the potential effects of varying institutional structures along with other local characteristics on community and household-level decision making. This allows us to test several highly policy-relevant hypotheses, as outlined in Table 1 below.

Core research question

What institutional conditions and interactions related to forest use in rural areas of developing countries will help deliver benefits equitably to local people while sustaining natural resources? Our main hypothesis is that the consequences for property rights in a decentralized governance situation are crucial to livelihoods and to sustainable natural resource management. From this central proposition, we derive several testable sub-hypotheses and several more specific research questions and sub-questions, outlined here and in Table 1 below.

The first research question looks at the effects of national decentralization policies on resource sustainability and the equity and efficiency of forest resource management at the local level. In particular, we look at the institutional conditions that make local actors more likely to invest in local forest governance institutions and in effective forest conservation. The second question looks at how decentralization policies change property rights to the forest, including identification of rules that influence forest user decisions and how these have changed under decentralization reforms, and the effects of decentralization policies on accountability and empowerment in resource systems. The third question examines the implications of decentralization for different groups, including women and forest-dwelling communities. Under this question, we further examine how community and household responses to policy changes are linked to gender and to poverty levels, and finally how community monitoring contributes to empowerment of rural communities and accountability of public officials to these communities. In other words, the project scrutinizes the differential effects of decentralization in detail, parsing what specifically is meant by decentralization in the various countries and determining what aspects of these policies have which repercussions. Decentralization encompasses a vast range of policies that need to be considered carefully in their effects at community and resource level.

Implications for research, action, and policy

To explicate the range of forms and effects of decentralization, the project employs a wide range of tools:

- doctoral dissertations
- journal article submissions
- site reports
- conference papers
- national advisory committee meetings
- national policy consultations
- regional policy exchanges
- on-the-ground training of resource users

Our focus on journal articles and doctoral dissertations speaks to our desire to contribute to scholarly debates on appropriate institutions for forest and natural resource management. Current understanding of decentralization processes, their outcomes, and what conditions those outcomes produce is evolving. Our cross-country study, using socioeconomic and biophysical methodologies and comprising analysis both cross case and within case, provides a unique opportunity to draw reliable insights on forest decentralization reforms.

In the policymaking and practice arena, we aim not only to share results and information in easy-to-use formats with both practitioners and resource users, but also to provide forums that will encourage feedback that in turn is incorporated into ongoing research. The national advisory committee (NAC) meetings represent forums where our research, its design and outcomes are periodically interrogated by individuals and groups that work in the forestry sector and who make and/or implement forest policy. In addition to these, we plan to hold national policy consultations, which will move beyond national advisory councils to include relevant actors in the policymaking arena to share our findings and get feedback of the relevance of our research. The national policy consultations will provide a broader audience from whom to learn which parts of our research are useful and how policymakers would use it. The regional exchanges will allow interactions between policymakers and other practitioners in each region (i.e., East Africa exchange and Latin America exchange). We anticipate that these regional exchanges will not only facilitate shared learning – Uganda, for example, is at a more advanced stage of implementing forest decentralization reforms, while Kenya has experimented with community management of some forests – but also other ongoing challenges in the forestry sector (see the case of degazetting, or lifting of protective regulations, in Uganda's Mabira forest).

But what will we learn that we plan to share with policy practitioners and other researchers? First, that decentralization reforms are not uniform and that they have uneven impacts. Second, that, holding ecological and cultural settings constant, these uneven impacts are conditioned by several factors, including the level and degree to which power, authority and resources are devolved; the range and security of rights to resources that is accorded to local communities; and the extent to which community preferences and needs are taken into account in decision making. Third, that mechanisms and strategies can be designed to ensure that such reforms are beneficial for poor rural men and women as well as for forest resource sustainability. In short, we plan to

share with policy makers, practitioners, and researchers that institutions matter, and how – that they are important for distributing benefits and ensuring accountability when such major reforms occur and that, with flexibility and learning, they can be designed to do so.

Table 1. SANREM-CRSP LTRA-1 Conceptual Model

Research Questions	*Sub-questions*	*Hypotheses*	*Methods*	*Products in the next 12-18 months*
1) How do decentralization policies made at the national policy level affect resource sustainability and the equity and efficiency of forest resource management at the local (farm and field) level?	1.1 Under what institutional conditions do local actors invest in forest governance institutions?	H1.The governance outcomes in the decentralized regime depend on the technical and financial resources of the local actor to whom responsibilities have been transferred	Using comparative case study analysis and large-n surveys (in Bolivia and Mexico), we will test whether a high level of schooling and income is associated with high performance of governance.	- A total of five doctoral dissertations that test, at least partially, this hypothesis by using existing IFRI data. These are students collaborating with the four LTR1 countries. - Preliminary findings from national surveys presented in a policy briefing at a national policy forum, in which NAC members and other policy makers will participate - A theoretical paper on the contribution of institutional theories to the study of decentralization of NR governance responsibilities
	1.2 What institutional factors make some local actors more effective in forest conservation than others?	H2. A transfer of governance rights, resources, and responsibilities will yield a higher rate of investment into forest governance activities when local communities are targeted rather than meso-level government organizations and when rights are perceived as secure.	Comparing Kenya (partial community devolution) with Uganda (municipality devolution) as well as Bolivia (municipality) with Mexico (community) we assess differences in relative investments in governance activities.	
2) How does decentralization alter forest property rights?	2.1 What are the main rules that influence forest user decisions and how have these changed with the decentralization reforms?	H3. In the decentralized regime local actors will relax conservation efforts to gain short-term payoffs through attracting outside actors' investments, leading to resource mining and degradation over time.	Longitudinal observations of forest communities in all four countries will be used to see whether there is less regulation on the ground after decentralization.	- A conceptual paper outlining how policy reforms affect the relationships between multiple levels of governance, especially as they pertain to the assignment of property rights, degree of accountability and empowerment that characterize these relationships. - One journal article analyzing the empirical results from tests described. - A methodological paper on the creation and use of forest
	2.2 How do rule changes attributed to decentralization affect the degree of accountability and empowerment	H4. The local actors' discount rates will help determine whether decentralization leads to a race to the bottom or a race to the top	Longitudinal, cross-section comparison of communities in each country to see whether communities with high discount rates invest less in governance and	

	within resource systems?		suffer more forest degradation after decentralization	condition indicators for comparative NRM studies - Site reports to summarize and describe community poverty status, their dependence on forest resources, the institutions that regulate forest access, their effectiveness and the role of gender relations
3) What are the implications of decentralization for different groups, including women and forest-dwelling communities? How can different interests be accommodated?	3.1 To what extent are community and household responses to policy changes linked to gender relationships and degrees of poverty within households and communities? 3.2 How does the use of the community monitoring contribute to the empowerment of rural communities and increased downward accountability of public officials to those rural communities?	H5. Forest resource management is more likely to be effective where decentralized forest management is sensitive to women's participation and includes women in decision making, rather than reinforcing existing inequalities. Outcomes will be more enhanced under devolution.	Cross-site, time series analysis of the relationship between women's participation in decision making and forest management outcomes. Within-case analyses will be used to identify the pathways and processes by which decentralization reforms improve (or inhibit) women's participation in forest decision making.	- A comparative empirical paper on gender roles in forest governance and the difference it makes for forest outcomes -A methodological paper comparing the use of household level data from PEN and from IFRI - An empirical paper on Bolivian indigenous people and the socioeconomic effects of forest management
		H6. Communities with high poverty rates will have higher discount rates of forest products and services	Cross-sectional tests of difference of means for proxy discount rates across income strata of communities in each country.	
		H7. Community-centered efforts to monitor and enforce rules related to forest significantly affect forest conditions	Using IFRI data base analyze whether community self-monitoring and enforcement is associated with superior user assessments of forests.	

Research Progress

Activities related to knowledge dissemination

a. Mexico. Submitted one article to *Forest Ecology* and a chapter of a book on political ecology in Mexico

b. Uganda.
   1. A research paper titled "Decentralized governance and ecological health: why local institutions fail to moderate deforestation in Mpigi District of Uganda" was accepted for publication
   2. The Uganda PEN study has been featured recently on CIFOR's Poverty Environment Network website, http://www.cifor.cgiar.org/pen/_ref/events/uganda.htm

c. Kenya. Three papers were written and presented to various audiences.
   1. "Internal Human Conflicts and Forest Conservation in Kenya," presented to the 2nd. Annual Conference of the Forestry Society of Kenya in Mombasa, August 2007. Paul Ongugo was elected to a two-year term as vice chair of the society.
   2. "Emerging Roles of Community Forest Associations in Participatory Forest Management," presented to the International Conference in Poverty Reduction and Forests: Tenure, Market and Policy Reforms, September 2007, Bangkok, Thailand.
   3. "Participatory Forest Management in Kenya: Is There Anything for the Poor?" presented to the International Conference in Poverty Reduction and Forests: Tenure, Market and Policy Reforms, September 2007, Bangkok.

d. Bolivia
   1. CERES team met to discuss decentralization and conducted thorough literature reviews on the subject.
   2. In July, presented preliminary results at the Association of Tropical Biology and Conservation (ATBC) conference, titled "Conflicts over natural resources in the Western Amazon: Implications for community forest management of non-timber forest products"
   3. In July, presented preliminary results in a poster session at the Federal University of Acre in Brazil
   4. In August, conducted four presentations for regional research organizations in Brazil, Bolivia, and Peru to disseminate preliminary research results and explain interactions with participating communities. Seminars were held at the Federal University of Acre in Brazil (18 participants), the Amazonian University of Pando in Bolivia (22 participants), the Institute for Humans, Agriculture and Ecology in Bolivia (20 participants), and the Amazon Conservation Association in Peru (15 participants).
   5. Preliminary results were disseminated by PENEWS to PEN partners and CIFOR scientists affiliated with the PEN project.

e. General
   1. Wrote and submitted two papers on gender and forest management for inclusion in the Conservation Biology meetings in July. One was written jointly by Kenyan and Ugandan teams and compares gendered access to forest resources in Mabira and Kakamega forests. The other was submitted by IFPRI and compares resource

management by user groups with different proportions of women and men in the four SANREM countries.

2. Paper presented by Nabanoga at the Society for Conservation Biology meeting in South Africa in July. Nabanoga's abstract won a travel award from the SCB's organizing committee.
3. The Kenya and Uganda teams are also working on a comparative analysis of decentralization effects between two ecologically similar sites –Kakamega and Mabira forests.
4. In March, held coordination meeting of gender component of study with SANREM's gender adviser, Maria Elisa Christie. Made plans to coordinate with Christie the submission of two articles to a special issue of *Society and Natural Resources* focused on gender.
5. Data cleaning completed and preliminary descriptive statistics generated for gender analysis. Preliminary report on gender and sustainability generated. The early results of data collected from 1993-2001 across 56 sites (i.e., 67 forests and 36 revisits in Africa; 36 forests and 18 revisits in Latin America) begin to show that perceptions of forest condition among forest user groups vary, with user groups in Kenya indicating the most degradation, Mexico the least, and Uganda and Bolivia in between.
6. In preparation for a paper analyzing the different forms that decentralization takes in the target countries, reports were received from all partners on decentralization in their respective countries.

Preliminary project-wide findings

While it is still early to draw detailed conclusions from the project, we can make some broad observations. The most notable is the degree to which institutional fit and congruence at multiple levels of governance are key in determining the outcomes of decentralization. Failure to account for compatibility of reforms with local-level institutions can create perverse, unanticipated effects. For example, in Bolivia, where the indigenous rights movement received such a boost with the election of the country's first indigenous president, researchers have seen evidence that indigenous groups who do not share the president's ethnicity have been further marginalized and their existing local institutions disrupted by reforms at the national level, creating opportunities for certain subgroups to benefit disproportionately. Reforms in Uganda have had varied on-the-ground impact because of incompatibilities in incentive structures and implementation strategies between the two national-level agencies – the National Forest Authority and the Uganda Wildlife Authority – responsible for forest management. While reform in Kenya is at an early stage, rules requiring group formation under longstanding pilot co-management programs have tended to exclude poorer households and widows from forest benefits. Also, there is lack of information at the local level on benefit structures, responsibilities, and processes under current reforms. Mexico finds that the success of forest monitoring and sanctioning activities by government agencies depends on the involvement of local governments and the cooperation of local communities.

Preliminary findings by country

Uganda

Our work with communities increased understanding of how to sustainably manage forests located on private and public lands, including:

- the role of local institutions in managing forests in a decentralized environment
- formation of bylaws by LC 1 Council to manage some forests as common property
- how to access funds to plant trees on both private property and land leased from government forest reserves to alleviate poverty, and
- the impact of decreasing access of local communities to forest resources due leasing forest land to private investors for pine plantation development.

A visit to Mabira forest underscored the importance of the forest to local users. We had a chance to speak with a women's crafts group, stick gatherers association, and carpenters associations. All groups seemed to derive some benefits from the forest. We also spoke with National Forest Authority officials, who were generally supportive of community activities in the area. However, the forest is still under threat. The community indicated that a stream passing through it is subject to pollution from the adjacent sugar factory. Plans to degazette the forest for development of sugar plantations have been suspended, but concerns remain about the security of the forest.

Similarly, our work with Work with District, the National Forestry Authority, community leaders, and community-based organizations has:

- helped to sensitize those organizations to their role in managing forests in a decentralized environment
- supported the implementation of bylaws made by local communities
- facilitated access to funds by local communities to plant trees on both private property and land leased from government forest reserves to alleviate poverty
- increased local community access to advisory services on planting and managing trees, and
- facilitated local community engagement in activities generating alternative incomes.

From PEN-Uganda. With respect to access rights to forests and specific forest products, there is a lot of confusion and variation about how people view their households' rights. There is also a lot of confusion within and among representatives of the Ugandan Wildlife Authority (UWA), the National Forest Authority (NFA), and the communities with which they work. In many cases, unless a clear collaborative forest management agreement has been established, households are negotiating access rights on an individual basis with UWA and NFA staff. This is likely leading to inequalities between households, further corruption within these organizations, and increased frequency of illegal harvesting by those who cannot pay the costs associated with securing legal access to forests and forest products.

Data from the first quarterly household survey have been entered, allowing for some very preliminary estimates of changes in the share of household income from forest products (Table

1). The analysis indicates that the contribution of forest products to household income has been stable in the Rwenzori field site, which is the area that did not undergo any governance reform. In the Bugoma site there has been a slight decline, and in the Budongo site, an increase in the contribution of forests to household incomes. The decline in Bugoma may be due to intensive forest clearing in that area; people have to travel further for forest access then they did in 2003. In Budongo, the increase may be due to more intensive harvesting of timber, one of the highest-value forest products in Uganda. In-migration from conflict-ridden West Nile province has brought many timber cutters to the area. Also, many tobacco-growing smallholders shifted to timber harvesting when British American Tobacco failed to buy their crops in 2004. These external processes, combined with significant changes in the incentives for both forest rangers in the Budongo field site and households living adjacent to the forest to limit illegal activities, have enabled local resource users to gain a larger share of income from forests.

Table 1: Share of Gross Household Income from Forests, 2003 and 2006

	Share of Income from Forests in 2003, percent[1]	Share of Income from Forests in 2006, percent[2]
Rwenzori Field Site	26	26
Bugoma Field Site	19	17
Budongo Field Site	9	13

1. Bush et al. 2004. *The Value of Uganda's Forests: A Livelihoods and Ecosystems Approach.* Kampala, Uganda: Wildlife Conservation Society.
2. Based on preliminary analysis of Jagger Dissertation gross income data for the three month period of July/August to September/October 2006.

Data on changes in forest cover and forest quality have not been analyzed yet. Based on qualitative observation, both forest cover and forest quality in Rwenzori field site appear to be relatively stable. Though forest clearing is ongoing, the area cleared is relatively small, and enforcement of activities within Rwenzori Mountains National Park is very strong. In Bugoma, forests are being cleared at a rapid rate for agricultural production. Even during the 10 months of this study, significant forest cover loss was observed. Forest quality is also declining in this area due to intensive pit-sawing by migrant laborers working for large sawn-wood producers based in Kampala. In the Budongo area, forest quality is declining due to pit-sawing by households living in communities immediately adjacent to the forest. Forest cover and quality outside the reserve are also declining due to agricultural expansion and timber production, though not as rapidly as in the Bugoma area.

Based on the preliminary findings, the general picture seems to be that Uganda's forest sector reform has had a mixed effect on local livelihoods and in general has negatively affected forest sustainability. The findings appear to contradict the majority of the literature, which predicts that decentralized forest governance leads to both improved livelihoods and more sustainable use of forests. Further analysis including econometric modeling will illuminate the conditions under which one or both of the desired outcomes of poverty reduction and sustainable forest management have been achieved. These findings will be important for informing the continued implementation of the forest sector reform in Uganda, as well as contributing to the recommendation and formulation of forest sector reforms in other countries across the low-income tropics.

Implication of decentralization on livelihood of local communities

- Access to forest resources by local communities have not significantly changed following decentralization.
- Prices for forest produce at the forest level are very low due to limited value addition and lack of collective marketing of forest produce.
- Where forest land has been leased to private investors, access to forest resources has declined. In such cases, women must travel long distances to collect firewood, forest foods, and herbal medicine.
- Collaborative forest management is still in the pilot stage and has limited scope.

What the communities want

- to be allowed to lease forest land for community plantation development
- to use the taungya system, in which local residents can grow crops during the early stages of plantation establishment, to manage a buffer zone around the forests not leased to private developers
- more involvement in monitoring and enforcement of forest rules, especially the forest adjacent to their land
- to be involved in allocating licenses for commercial harvesting of forest products

Condition of forest patches studied

- in the case of the Mbale forest, continued conversion of natural savannah woodland forest to pine plantations
- in the case of Kibale, increased conversion of forest land to agriculture in forest patches that are not gazetted

Opportunities

- strengthening of forest services in some districts
- availability of credit through micro-finance institutions to enable communities to start income-generating enterprises such as:
    - improved cattle and goat rearing
    - pineapple processing
    - growing of horticultural crops
    - upland rice cultivation

Constraints

- in Mbale and Malamagambo, limited land holdings and declining soil fertility
- in Kibale, increasing migration and resulting land conflicts
- in Kibale, insecure tenure
- declining access rights due to privatization of forest lands
- limited opportunities for value addition for forest produce

Conclusions

- There is limited impact of decentralization policy on the livelihood of local communities including women, the poor, and marginalized groups.
- Plantation development by private investors is reducing access of local communities to forest resources, similar to privatization of the commons. When resources become less accessible, women and the poor, who depend more on the forest for their livelihoods, are increasingly marginalized.

Recommendations

- continued capacity-building activities for both communities and local leaders
- work out strategies with policy makers to increase participation of local people in decision making at all levels of local governance – village, sub-county, district level – in the forest sector. For example, communities need to make decisions on permit allocation and use of revenue from permits in rehabilitating local infrastructure.

Kenya

A communication network was established among the SANREM team, local organizations, and resource users through chiefs and other leaders of groups such community forest associations.

There is also improved communication among actors at the local level. It came to the project's attention during reconnaissance visits that community members seemed unaware of the New Forest Act and its implications. The SANREM team organized community meetings in the three sites and invited stakeholders – government officials including the forester, the divisional forest extension officer, the ministries of agriculture and social services, the chiefs and assistant chiefs from all the locations – to discuss issues of forest governance. Local users were informed of changes in forest management in Kenya and the future role of the community.

A large number of community members in Aberdares and Tugen Hills are neither members of local organizations (forestry or non-forestry) nor participants in group activities. Some of the existing organizations had members from outside the settlements, which proved to be a big constraint, especially when trying to reach a large number of people within the settlements. It was also clear that impact from those sites may not be as high as in other areas because groups are more effective than individuals. We therefore encouraged community members from the two sites to form new groups or join existing ones to get involved effectively in the governance of forests adjacent to them. We informed them that groups will play an integral part of future forest governance under the new forest act and that it is important for them to join if they want to take part in decision making.

In Upper Imenti, a number of forest groups have formed associations that will eventually work closely with the Kenya Forest Service in governance. The community in Upper Imenti seems to be ahead of other forest-adjacent communities concerning the new act. They started forming groups a few years ago, and as a result, a few elitist groups have developed that want priority in sharing the benefits of decentralization. They also feel that they should make decisions on behalf of the community.

Property rights emerged as a major problem in the Aberdares and Tugen Hills sites. In Aberdares, the settlement was initially forest land that had been occupied by white settlers. The independent government led by the late President Jomo Kenyatta resettled squatters from different areas to this land. However, they were not issued deeds. Only recently did the former lands minister, who is from the area, issue a few members with deeds. In Tugen Hills, there are major problems involving squatters who believe that the forest is rightfully theirs and that they should live there. They claim that people resettled there are government beneficiaries, not the real "right holders."

The program has also noted that, though much study and research has been done at some sites, there was absolutely no feedback to stakeholders. Because the IFRI-SANREM project provides results to stakeholders, this has raised its profile at all sites where field research has been done. Both the local communities and other government officials expressed their concern for lack of feedback from other projects. It is therefore imperative to give results to the areas worked, thus aiding future research by other organizations or individuals and avoiding repetition.

Bolivia

In Site 3, the team found a population with low organizational capacity that is split between two residential zones. Because of a government program that provided housing to community members, most of the population have one residence near the regional center of Ivirgarzama and another two hours away by boat in the community itself. Furthermore, the residences in the community are spread out along the river, and the community members occupy only half of their territory. This is problematic because of pressures from new colonists, who have started to encroach on the sections of Yuracaré territory that are unoccupied or otherwise controlled by the Yuracaré. There are conflicts with the new colonists over who owns *de facto* rights to the territory and natural resources attached to them. Compared with neighboring areas, this territory is relatively wealthy in resources. However, according to estimates by project partner Jatun Sach'a, the forests are not particularly rich in timber. Jatun Sach'a is working with the community to prepare a forest management plan to address some of these problems as prescribed by forestry law and the national decentralization process. For members of the indigenous community in TIM Ivirgarzama, the main goal will be to consolidate their rights over those of the colonizers, who use the land for residences and to grow coca. The threat is that the number of colonists will increase and that cropland will extend into currently forested areas.

While it is too soon to draw meaningful conclusions from the national survey, the communities studied so far do not control significant forest areas and have not created designated municipal forest units (UFM) to manage what they do control. Because of this, the people charged with managing forests regard doing so as simply one other duty to complete. Only one community has a dedicated bureau to manage its forests. This means the communities surveyed so far do not generate high levels of money or interest related to forestry.

Summary

Local communities have not experienced benefits from decentralization for several reasons. First, some communities have no knowledge of the reforms and subsequently are unaware of the

opportunities that may lie in the reforms. As a consequence, research teams have conducted multi-stakeholder consultations, bringing together government officials, NGOs and local communities and their representatives to share information. From these processes some communities have begun to organize forest associations anticipated to improve bargaining power for negotiating access to forest resources and products. Second, even when communities are aware of the reforms, conflicts between indigenous groups and migrants/colonists can hinder access to forest resources. In such cases, the research team has enlisted relevant partners, for example, NGOs to work with communities to map out territory and to develop management plans and zoning informed by legal statutes on decentralization. Third, because local government is hard pressed to generate revenues, some forests have been leased out to private investors, locking out local communities from accessing resources. This reduction in access has increased the burden on some actors; for example, women have to walk farther to collect fuel wood and water. However, bylaws negotiated between local communities and officials have generated a shared understanding that forest be managed as common property to maintain community access and benefits. Fourth, even though people can have access to forests, prices of forest products are low, and there is limited organizing by resource users to enhance market access. Fifth, the roles, responsibilities, and authority among relevant forest management organizations are unclear and fragmented. Such ambiguity provides opportunities for corruption, illegal harvesting of forest products and concentration of benefits among those able to influence officials.

Activities specific to each project objective are listed below.

Objective 1: to develop capacity within resource user groups at the selected forest sites to enable differentiated actors to identify, understand, and participate in forest governance, benefits, and policy processes

The extent of progress along the development pathway specified in the targeting outcomes of programs (TOP) framework varies depending on country and community. All of the work discussed below has helped communities acquire analytical and forest management skills, aspirations (learning how to increase the productivity of the forest), knowledge (of policy processes, assistance available, and rights under current policy regimes) that will increase communities' capacity to participate.

Activities completed this year under Objective 1 and their respective outputs/results/impacts include the following.

1. A household survey database was developed to enable systematic data entry and is now in use by all partners. (farm household/enterprise, community/watershed levels)
2. Pre-site-visit trainings were held in Uganda Sites 2-4, Kenya Sites 2-4, Mexico Site 1, and Bolivia Site 3. Across the four countries, 75 individuals (community members, local officials) were trained in research methods. Another six students were trained as field assistants in Mexico and Bolivia.
3. Introductory meetings for larger audiences within the community were held in Uganda Sites 2-4 and Kenya Sites 2-4. Additional meetings were held in sub-locations around Kenya Sites 2 and 4. A total of 319 people attended these meetings. Community members were introduced to research goals, and Kenyan participants learned about the new Forest Act and decentralization policies.

4. Resource and recourse diagrams were created for Uganda Sites 2-3 and Kenya Sites 2-3. This activity allows stakeholders to engage in networking and increased communication while considering the flows of resources and information at a given site and identifying constraints on meeting local-level needs. (community/watershed, policy/market)
5. IFRI community and household data collection was completed in Uganda Sites 2-3, Kenya Sites 2-4, and Bolivia Sites 2-3. Data collection for Mexico Sites 1-3 is almost complete. (farm household/enterprise, community/watershed)
6. Site reports were completed for Kenya Sites 1-2, and a report for Site 3 is in progress. Site reports were also completed for Bolivia Sites 1-3. (community/watershed, policy/market)
7. A steering committee meeting was held in June. (policy/market).
8. Community members from Bolivia Sites 1-2 followed up on the SANREM site report received from the Bolivian research team by seeking support to implement the forest management plan from Jatun Sach'a. Increased understanding of the local situation through the SANREM study enabled them to participate more effectively in governance and policy issues and to counteract the fragmentary effects of national-level policies. (community/watershed, policy/market)
9. Final PEN surveys were conducted in five communities in Bolivia and 18 in Uganda. Results were presented at community meetings in both countries, attended by 146 community members in Bolivia (numbers are not available from the Uganda community meetings). The surveys in Bolivia were supplemented by participatory mapping exercises in each community intended to help community members gain a better understanding of land-use change over time. (farm household/enterprise, community/watershed)
10. PEN data in Uganda is being supplemented by a study of the sawn-wood value chain, for which 220 specialists were interviewed, and key informant interviews of nearly 40 important stakeholders in the forestry sector. (policy/market)
11. Interactive post-site visit training was held in Uganda Sites 1-3, Kenya Site 1, and Bolivia Sites 1-3. This training increased the capacity of community members to participate effectively in the policy process by increasing cooperation and networking among local communities, district forest services and local politicians. Details are included in the appendix. (farm household/enterprise, community/watershed)

The Bolivia team assisted with and participated in the International Workshop on Community Forestry with CIFOR and other international institutions April 23-27. With the help and support of CERES-SANREM, representatives of the Yuracaré territory also participated in the workshop. This gave community members an opportunity to communicate directly with international organizations about their situation and about the findings of the SANREM study site.

<u>Objective 2</u>: to develop capacity within key organizations in the forestry sector to understand the impacts of policies on differentiated local actors and to adopt strategies for inclusion of such actors within broader policy processes

The activities outlined below have increased contact between user groups and policy makers/practitioners, enabling increased awareness of the impacts of different policies at the local level (e.g., the impact on different property rights arrangements on behavior), knowledge of local customs and processes. The degree of advancement toward this objective varies widely depending on the country and community.

Activities completed this quarter under Objective 2 and their respective outputs/results/impacts include the following. Many of the objectives relevant here also relate to Objective 1 so are not repeated; however, they are listed in detail in the appendix.

1. As a result of the Uganda research team's SANREM work, officials in Kakindo Sub-county, the location of Site 2, proposed offering land to Makerere University to set up a model/demonstration for forests and agro-forestry technologies. This would give researchers a way to disseminate SANREM findings to local people (policy/market).
2. Partners in Mexico and Bolivia continue work on national-level forest community surveys. This will enable SANREM sites to be chosen as a representative sample of communities in both countries, making the results of the SANREM study more broadly useful in impacting forest management policies (policy/market, ecosystem, community/watershed).
    a. Partners in Mexico completed the national survey of 146 forest communities in five states (Durango, Jalisco, Michoacan, Guerrero, Oaxaca), and study sites were selected using criteria developed with Krister Andersson of University of Colorado.
    b. Bolivian partners likewise worked with Andersson to continue their national-level survey. They developed a sampling framework and selected 150 communities for study. The team will hold a one-day workshop/focus group interview in each community using a survey instrument comparable to that used in Mexico). Surveying has been completed in 13 communities.
3. The Bolivia team formed a support committee for the National Forest Council (Dirección Forestal Nacional) in coalition with other institutions.
4. National Advisory Council meetings were held in Mexico, Kenya, and Uganda; Bolivia maintained contact with NAC members and formalized cooperation agreements with some. This enabled the research teams to stay linked on a regular basis with policy makers and practitioners (policy/market).
5. In other networking activities, Kenya solidified ties with the USAID Mission and developed links with various organizations. Mexico further developed linkages with WWF and presented results of the national survey to several audiences including the World Bank and Comisión Nacional Forestal (Mexico's national forestry commission). Bolivia continued its ongoing collaboration with Jatun Sach'a and various state agencies. Uganda coordinated a visit to the troubled Mabira site along with the CAPRi program at IFPRI. (policy/market).

<u>Objective 3</u>: to develop effective monitoring techniques for use by resource user groups and their partners at the community level to assess the impacts of decentralization and other property rights reforms on natural resources and livelihoods

Activity on this objective will increase at the end of Year 3 and through Year 4, when we expect to focus on analysis, dissemination, and exchange across communities and regions. Nevertheless, several trainings have been conducted within communities and groups of policy makers that help achieve the aims of this objective.

Activities completed this year under Objective 3 and their respective outputs/results/impacts include interactive, post-site visit training in Uganda Sites 1-3, Kenya Site 1, and Bolivia Sites 1-3. This ongoing training will help increase the ability of communities to monitor policymaking and anticipate its effects on livelihoods (farm household/enterprise, community/watershed).

Extent to which project timeline is being met

Aside from minor delays, the project is on schedule. The household survey database took longer to complete than expected but is now in use by the host countries. Mexico has also experienced delays in completing all site visits, in part because of the national survey, but has a plan for completion along with other tasks in Year 3.

Obstacles encountered, actions taken, lessons learned

Uganda

Heavy rains and flooding delayed work in Site 4 on Lake Victoria. Activities in this site are expected to be completed early in Year 3. The research team noted budget challenges, which inhibit ongoing communication with communities after the site visit is completed.

PEN researchers have also encountered difficulty in obtaining secondary data from the National Forest Authority, the Forest Inspection Division that oversees the District Forest Services, and the Uganda Wildlife Authority. The reemergence of the rebel group the Allied Liberation Front in the study area has slowed some work. The combination of a weak U.S. dollar and high diesel prices raised research costs considerably. This affected sample sizes for the value chain analysis and access to remotely sensed data.

Finally, efforts to degazette the Mabira forest for conversion to sugar cane plantations have been of great concern to both researchers and to the communities in the area. As a result of public protest, degazetting plans have been suspended. Degazetting Mabira and allocating portions of it to private corporations would have undermined community access and livelihoods. It would also undermine the research and capacity building that the Uganda team has done at that site. The Uganda team will continue to monitor the situation.

Kenya

The Kenya team experienced challenges in competing with busy schedules to bring all NAC members together for meetings.

Some community members were unhappy about the length of the household survey, particularly in fertile agricultural areas where farmers equated the time spent on the survey to lost income. Also, because it is an election year and because of general tenure insecurity, some informants were suspicious of researcher motives. Researcher efforts have led to improved relationships with community members and leaders to facilitate data gathering.

Land conflicts in the Mount Elgon region delayed fieldwork there. The team plans to target this area in Year 3.

Bolivia

The Bolivia team experienced a significant setback when, due to computer failure, it lost a large database containing information from 1996 and including the current study. The team spent significant time trying to fix the problem and finally had to rebuild the database, reentering and re-cleaning the data. This has delayed analysis for all three SANREM sites.

Initiation of the national survey was somewhat delayed because of festivals in August. The surveyors also had problems with community access because the authorities in some communities refused to be interviewed. This necessitated making contacts in new communities. Due to all of this, surveyors needed an average of five days for each community to fill all forms. It is likely that this will be the minimum amount of time needed per community throughout the survey, for we started with the most accessible communities.

Degree and Non-degree Training Activities

LTRA-1 had six students involved in long-term degree training, all from host countries. Four women and two men were working on Ph.D.s. Short-term training involved 859 men and 957 women in 22 training workshops (see Degree and Short-Term Training Tables).

Publications, Presentations, Other Products

Activities this year produced eight academic papers, one book chapter, one workshop proceeding, one website feature, one newsletter feature, one poster session, and seven presentations (not including presentations made during community training workshops). See Publications, Presentations, and Other Products Table.

Networking Activities

Kenya

The SANREM team together with Esther Mwangi had a meeting with Bob Buzzard and Ms Wamalwa of the USAID Kenya Mission. The main objective was to discuss progress of activities and future collaboration. This opened the way for communication between the Kenyan SANREM team and USAID Kenya team.

The SANREM team at KEFRI included one partner from the private sector, the forest processing company Pan African Paper. The team also developed links with the Kenya Institute of Policy Research and Analysis (KIPRA) with which joint research is being developed. The team is holding discussions with Moi, Maseno and Egerton universities to initiate joint research activities.

Also in Kenya, a communication network was established among the SANREM team, the umbrella Forest Association, other organizations, and community members through local chiefs and leaders of the existing groups.

Mexico

The World Wide Fund for Nature expressed interest in a comparative study of approaches to conservation using two communities from the Monarch Butterfly Reserve, where UNAM collected data in 1999 and again in 2006. One of the two communities is Ejido El Paso, which was Mexico's first SANREM site.

Researchers presented findings of the national forest community survey to the North American Workshop on Forest Ecology (June 2007), the World Bank office in Mexico City (May 2007), the CONAFOR-World Bank meeting in Guadalajara (May 2007), and at the Expo-Forestal in Guadalajara (September 2007).

Bolivia

SANREM continued to collaborate with Jatun Sach'a on developing management plans for communities in the Yuracaré territory. The team also received a request from the forest superintendent in Cochabamba for advice on implementing indigenous management plans.

The team maintains consistent communication with members of different state agencies as a means of diffusing information discovered in the project.

Researchers presented preliminary results at the SANREM CRSP Annual Meeting in Cochabamba and led a field visit to the TIM Ivirgarzama community with Krister Andersson, Jacqui Bauer, and Keith Moore, including a presentation of results.

Uganda

The Uganda team organized a visit to Mabira forest in conjunction with CGIAR's CAPRi international policy workshop. Twelve policymakers and researchers from Kenya, Uganda, Ethiopia, India, Indonesia, Cambodia, and the Philippines participated in the visit, accompanied by journalists from three national and regional publications. Although the coverage focused primarily on the issue of degazetting, this raised awareness of different stakeholder interests and dependence on forest resources.

NAC workshop proceedings were distributed to National Forest Authority, National Forestry Resources Research Institute and Forestry Sector Support services.

Project Highlights

- **In the recently ended fiscal year, 1,816 individuals in the four host countries, including user group members, local officials, and national-level policy makers, participated in training, workshops, and/or data collection.** One of the driving hypotheses behind this project is that increased communication among organizations at different scales of governance will increase the capacity of policymakers to take into account both livelihoods and resource impacts; communication will also increase the capacity of community members to understand their rights and responsibilities and to participate in the process of making policies more effective. The degree of contact among organizations at different scales generated by this project has the potential to profoundly

affect policy outcomes. This potential is evidenced by the activities of the Yuracaré in Bolivia, who have met with local officials and representatives of national and international organizations, and who are using what they learned through the SANREM study to pursue support for their forest management plan and consolidate their rights to the forest in the face of threats from new settlers.

- **Partners are working hard to interact with policymakers and practitioners, and to ensure that the findings of the SANREM project have an impact.** Mexico has had regular interaction over the past year with organizations like the World Bank and World Wildlife Fund. The Bolivian team continues to collaborate with Jatun Sach'a. Kenya has found great success with its Kakamega policy round table and hopes to hold additional round tables in its remaining sites. Following discussion about findings in the site report, forest management goals, the potential for the forest to support livelihoods, and other topics, community members and local officials identified steps to take in cooperation with the Kenya Forest Service and Kenya Wildlife Service, including action to guarantee greater access to forest resources for the poor and other disadvantaged groups.
- **Communities want more involvement.** Researchers in Uganda found that communities want to be able to lease forest land for community plantations; they want to establish buffer zones around forests to protect them; and they want increased involvement in monitoring, enforcement, and licensing. All of these are powers they have not received as a result of decentralization.
- **Decentralization is not the universally beneficial policy it has been reputed to be; outcomes of decentralization are not consistent with findings depicted in the literature.** Decentralization policies take varied forms that have varied effects, from Uganda, where researchers see no significant changes in forest access for local communities following decentralization, to Bolivia, where certain indigenous groups have been given free rein while others struggle because decentralization and other national policies have disrupted local institutions. Instead of being a broad answer for all situations, decentralization policies need to be considered carefully in both form and implementation in the context of local circumstances before being applied widely across countries and localities.

LTRA-2: Developing a Participatory Socioeconomic Model for Food Security, Improved Rural Livelihoods, Watershed Management, and Biodiversity Conservation in Southern Africa

PIs: Alex Travis and Alfonso Torres, Cornell University
Dale Lewis, Wildlife Conservation Society-Zambia
Host country: Zambia

Executive Summary

The goal of this project is to test and optimize a third-generation markets-based model for biodiversity conservation that focuses on alleviating poverty and hunger using economically, socially, and environmentally sustainable agricultural and natural resource management strategies. The Community Markets for Conservation (COMACO) model, founded by the Wildlife Conservation Society in Zambia, is being assessed by SANREM to see whether it is worthy and capable of being exported to other areas facing similar economic and environmental challenges. The specific goals of the project are:

- **Objective 1:** to determine the extent to which the COMACO model can be economically self-sustaining and the effectiveness of the different COMACO model components
- **Objective 2:** to identify and integrate new technologies into the COMACO model to improve its profitability, food security and rural incomes
- **Objective 3:** to determine the extent to which the COMACO model provides self-sustaining social institutions and meaningful roles for COMACO participants, and
- **Objective 4:** to determine the extent to which the COMACO model improves biodiversity and watershed conservation.

Progress continues to be extremely strong on all objectives described in our proposal. All items listed in our work scopes for Years 1 and 2 have been started and/or completed, and research activities continue on all four objectives.

Research into the business structure of the community trading centers (CTC) of COMACO has resulted in identification of major cost and profit centers within each CTC, thereby making possible the reporting of business activities for each product and the development of cohesive business plans. Extension and training activities remain a major cost center and are unique to the model in that they would not be incurred by a business that focused purely on economic gain. Value-added products provide the major profits and are the key to economic self-sufficiency. Research into historical financial data was supplemented with collection of new data including an inventory and audit. These provide us with the first business models for the costs associated with replicating this model for sustainable rural development having explicit ties to biodiversity conservation.

Notable research progress has translated into impact regarding the integration of new technologies into COMACO's activities. For example, the production of value-added food products at the Lundazi CTC has been evaluated. Significant issues regarding hygiene and safety have been identified and corrected. The addition of a soy extruder and soy cow to COMACO's

production instrumentation offer exciting new opportunities to expand markets and generate critically needed value-added products such as high-energy protein supplements for HIV patients that currently must be imported at great expense. Yet the scaling up for markets outside the Luangwa Valley imparts significant risks in terms of public health associated with packaged foods. Therefore, we performed research regarding the current production practices, the types of food-borne pathogens that pose risks, as well as the quality control of these new products. To prevent problems associated with food production, we hosted two major training workshops for COMACO's Zambian staff on their own equipment in the best safe, hygienic food production practices and in product development. We prepared printed materials – posters and a children's coloring book – to provide continual reminders in the home and workplace to implement these practices.

Large-scale experiments to quantify crop yields over diverse agro-ecological zones and to evaluate the efficacy of different soil amendments continue. Because of the scope of these efforts, and through partnerships with TSBF and the Conservation Farming Unit (a host-nation organization), these findings should be applicable across much of southern Africa. Changes in land-use practices such as deforestation to facilitate the planting of short-term cotton crops on the plateau have been anecdotally correlated with increased runoff that this year contributed to extreme flooding in the alluvial areas of the valley (about 50 percent of experimental soil plots in these alluvial areas were lost to flooding). An in-depth watershed analysis involving both satellite imagery and on-ground runoff measurements is underway to quantify the contributions of specific agricultural and development practices to watershed management. Extensive data collection on village poultry practices has been coupled with training of more than 500 villagers in methods to improve poultry production. Market data on poultry sold suggested an increase in production of more than 50 percent in the trained areas as a result of our research and the implementation of corrective measures. Such data should be considered anecdotal until replication can be obtained. More extensive training of COMACO extension officers as veterinary para-professionals and the setup of a small field laboratory should result in longer-term improvements in diagnostic capability. The tremendous initial success of our poultry intervention has been leveraged into financial support from new sources, allowing SANREM researchers to partner with the International Rural Poultry Centre to extend these operations on a much larger scale.

Our social scientists have evaluated COMACO's extensive survey data, leading to new survey designs being implemented and analyzed regarding the effects of the COMACO intervention on social parameters such as education as well as health and nutrition. A large demographic survey has been completed, and the data are being analyzed. Numerous smaller surveys have also been completed. Quantification of COMACO's effects on biodiversity conservation has been greatly improved through the collection of data from control areas both before/after and within/without the intervention area. Data from Year 1 have been analyzed and suggest strongly positive effects for the COMACO intervention. Unfortunately for Zambia's wildlife-based tourism industry, they also revealed an extreme depletion of wildlife in surrounding areas such as the Lukusuzi National Park. For example, comparing raw count numbers alone, in 5,329 square kilometers of the COMACO core area, 1,019 animals were counted in an aerial survey. In 9,061 km^2 of control areas surveyed, only 70 animals were counted. Statistical analysis and replication need to be performed over the next years to make valid comparisons. COMACO had already identified and

mapped using GIS numerous professional poachers in the region surrounding this park. Training of these poachers in alternative careers such as carpentry and beekeeping is underway, and the efficacy/recidivism rate of the training program is being assessed. Should these efforts by COMACO be successful, our monitoring program will determine if wildlife populations are rebounding in the targeted areas. Year 2 wildlife surveys have revealed the same trend, with the COMACO core area having significantly higher wildlife populations than the surrounding control areas. However, continued monitoring will be required to determine if these differences are statistically significant because of natural year-to-year sampling variations due to heterogeneous, non-uniform animal distributions known as clumping. A large-scale aerial survey of hippos in the Luangwa River has been performed, and the data are currently being analyzed.

Numerous miscellaneous items needed to support the research have been installed. In this regard, a VSAT broadband Internet linkage has improved communications immensely between two of our main sites in Zambia and with our researchers in the United States. Introduction of this represents a technology leap for the area, providing an enormous improvement in COMACO's business operations as well. Progress made on all objectives has been above expectations; the only significant obstacles encountered have been the floods mentioned above and described in greater detail below. These floods actually represent a critical research opportunity to help improve current development efforts by Western governments in that they point to the critical watershed studies needed to tie together activities on the plateau and in the valley. They also set the stage for our efforts to help foster a comprehensive ecosystem-scale management plan. A meeting in December brought together government officials and regional stakeholders to discuss broad interactions.

Research Strategy and Development Objectives

The LTRA-2 project design seeks to use research in biophysical and social science to test and optimize the private enterprise economic model known as COMACO. This model links improvements in food security and rural livelihoods to SA and NRM practices in the Luangwa Valley, Zambia, with an overarching goal of conserving native biodiversity. Below, the current problem-setting is introduced, followed by a brief description of how the COMACO model attempts to alter SA and NRM practices to effect positive change. The LTRA-2 research strategy is designed to integrate into this model.

Current practices in the absence of COMACO

Farm commodity prices have been kept low by economic and sociologic forces that discourage better farming skills, leaving families in this region ill-prepared for the highly variable rainfall characteristic of this region, which often results in crop loss. Cash crops, such as cotton and tobacco, offer better short-term returns and are actively encouraged by large-scale outgrower schemes intended to provide economic assistance. Unfortunately, when cultivated under current practices, these crops typically mine nutrients from the soil, leading to increased land clearing (deforestation) without producing more food. The unsustainable practice of deforesting on the plateau is also suspected of contributing directly to severe flooding in the valley. In addition, under current practices these crops require extensive inputs such as pesticides and fertilizers that further reduce producer profits and conflict with other sources of family-level income generation

such as aquaculture. Poor livestock management and a range of social and gender issues also contribute to food insecurity and low household income. Among food-insecure families, surveys found that 42 percent illegally kill wild animals so they can barter the game meat for produce. This limits the development of other economic opportunities, and directly impacts existing safari and ecotourism markets that are a major source of income for communities, and the federal and regional governments. Figure 1 shows how unsustainable agricultural and natural resource management practices directly lead to additional unsustainable practices in a vicious cycle that ultimately results in widespread poverty and hunger in the area.

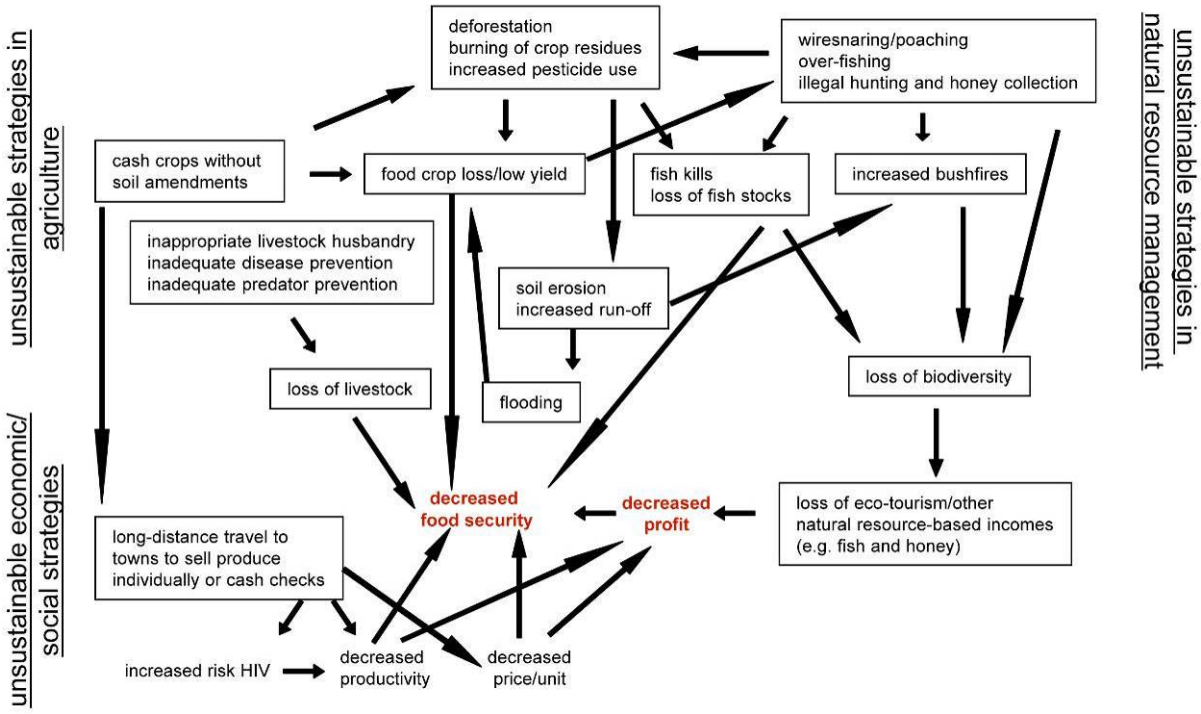


Figure 1: The problem setting

The COMACO model

COMACO seeks to improve biodiversity conservation through improvements in food security and livelihoods. This community-owned enterprise implements sustainable agricultural practices at the level of individual farms using extension support, marketing, and pricing strategies organized around COMACO's regional trading centers to increase small stakeholder profits. Figure 2 shows how this model attempts to make improved agricultural and natural resource management strategies sustainable by linking them directly to improvements in food security and rural livelihoods. Conservation of biodiversity resources leads to expanded economic opportunities such as honey production, improved fish yields, and consumptive and non-consumptive ecotourism.

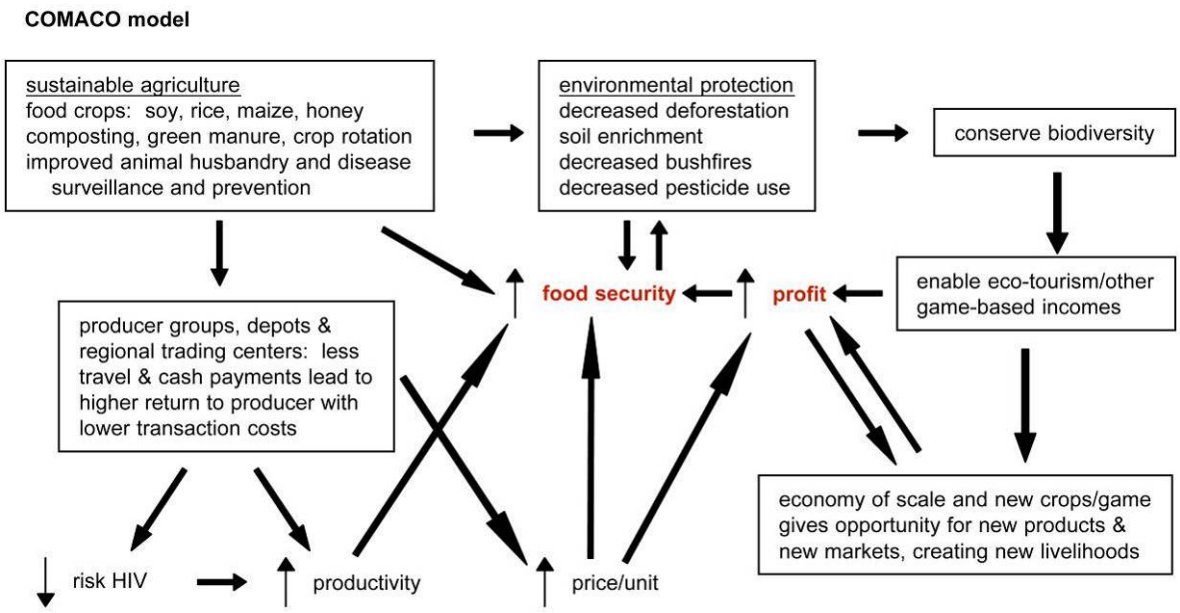


Figure 2: The COMACO model

SANREM-CRSP research

Scientists from Cornell, in conjunction with partners at the University of Zambia (UNZA), the Zambian Wildlife Authority (ZAWA), TSBF, the International Rural Poultry Centre (IRPC), and the Conservation Farming Unit (CFU), are performing social and biophysical research to test the COMACO model, and performing social and biophysical research that should lead to direct development impacts, positively affecting how COMACO performs its various interventions.

Overall hypothesis

A market-driven, community-based model designed to improve food security and rural livelihoods will lead to sustainable watershed and biodiversity conservation on a regional scale when based on environmentally and economically sound practices.

Our research has four main objectives. Specific research projects are described under each, with the dual goals of demonstrating how each individually connects to testing the model as a whole and how the results of each better inform other points of research. Where the different research topics integrate into the spatial framework of the COMACO model is shown in Figure 3. This diagram is greatly simplified. For example, social research is operating from family impacts such as gender equity, nutrition, and education through regional attitudes and policies such as education policy and infrastructure, and market testing.

Objective 1: to determine the extent to which the COMACO model can be economically self-sustaining and the effectiveness of the different COMACO model components

Economic assessments are being performed at various levels throughout the COMACO model to determine its potential for economic self-sufficiency. At household levels, are the COMACO interventions resulting in higher family incomes? At the regional level, SANREM research provided the first economic analyses of the Lundazi and Mfuwe community trading centers.

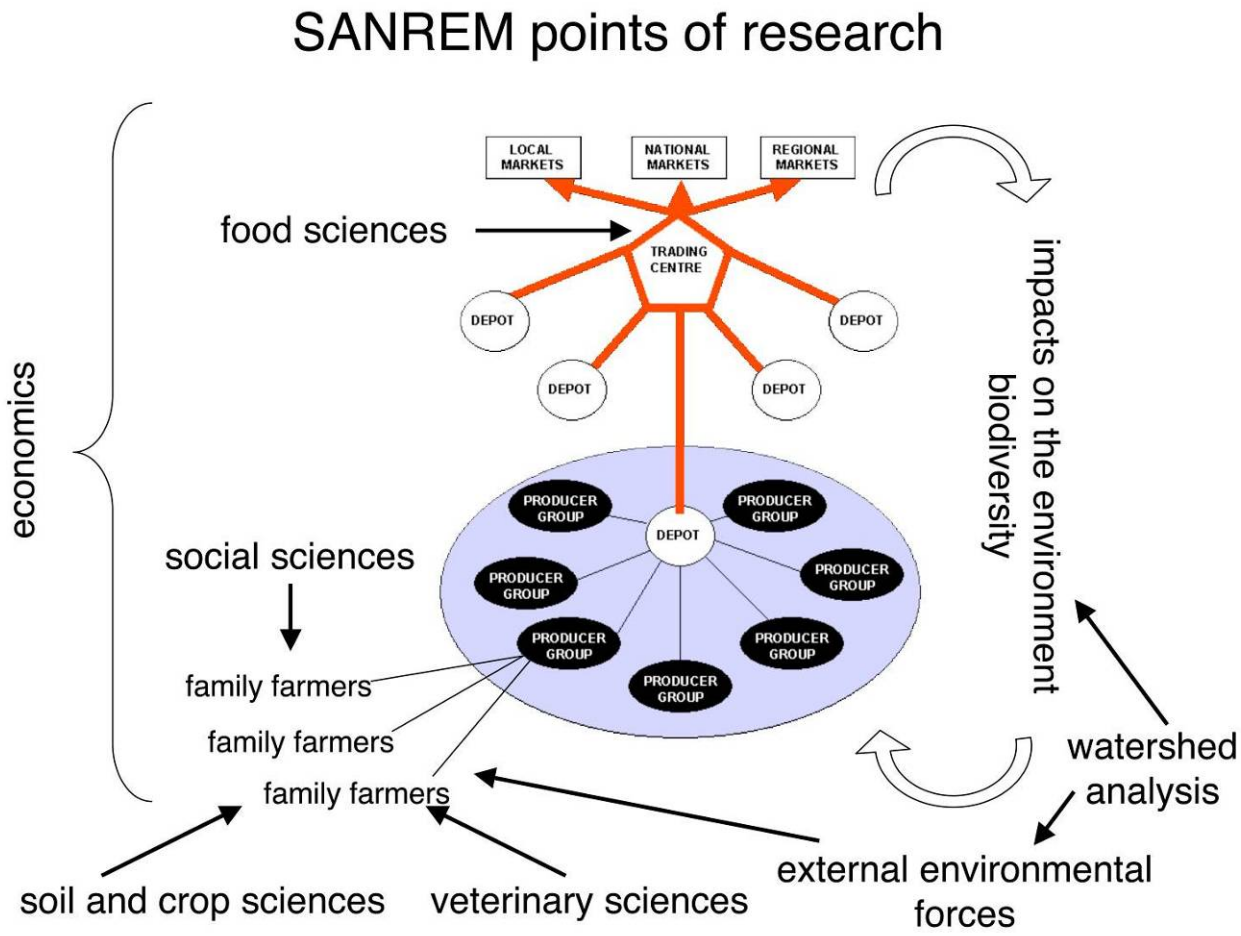


Figure 3: The research design

Previous business activities had not been tracked by product nor identified as profit-cost centers. SANREM provided business templates that are being used by COMACO to track its business

activities. This has enabled COMACO to generate its first five-year business plans in collaboration with the Haas School of Business at the University of California-Berkeley. These business assessments also identified the two major costs to the trading centers, both of which lie in the connection of the regional trading centers with farmers. Transportation costs are quite high because of the price of fuel and very poor road infrastructure. Also, COMACO's extension activities are another high cost that would not ordinarily be borne by a business run strictly for profit. Because COMACO seeks a triple bottom line of economic, social, and environmental improvements, the overall costs and benefits to the Luangwa Valley are being analyzed as an equation for the "cost of biodiversity conservation through the COMACO model." Objective 4 relies on data from all the objectives, including these business economic analyses. With business activities now organized, historical data collection has begun so that we can evaluate the costs that would be required to replicate the model. Because this is a post-hoc activity, the data are less reliable for the Lundazi CTC, which is older. Effects of a learning curve have been noted, with the newer trading center at Mfuwe costing significantly less to become operational. These data will allow us to document the feasibility of replicating COMACO elsewhere as a development model.

Objective 2: to identify and integrate new technologies into the COMACO model to improve its profitability, food security, and rural incomes

Food sciences

The major source of improved profits for COMACO is the value-added foodstuffs generated at the CTCs. These are in larger cities, have electricity, and have equipment and staff to polish and package rice; strain and package honey; and roast, shell, degerm, and crush peanuts for peanut butter. These products contribute substantially to the higher price per unit that COMACO offers for produce over its competitors. New equipment has recently come online, including a large extruder and a soy milk machine. Because it can generate a variety of extruded products, the former will be critical to enable profits for the planting of soybeans, as well as providing a means to generate money from broken rice that was previously considered wastage. By scaling up from farmers individually selling their produce to selling cooperatively through COMACO, the trading centers provide multiple sites for improving family profits. Not least of which, they provide access to wider regional and national markets. However, with these changes come new concerns. Namely, food production must now be performed with safety and hygiene as the highest priority. This is especially important for the production of high-energy protein supplement (HEPS), for which there is a wide market for the undernourished and HIV/AIDS patients. This product is now imported through relief agencies at high cost.

SANREM research identified multiple points where food production practices needed to be improved to facilitate hygienic production. After the physical facilities were altered to meet these recommendations, SANREM researchers organized a training workshop in hygienic food production and safety for COMACO's food production staffs from both the Lundazi and Mfuwe trading centers. New food-science research was carried out on how to overcome existing problems such as phase separation in peanut butter) and improve shelf life. Product development research was also initiated to take advantage of the extruder technology. Partnership between COMACO and the UNZA food lab has begun so that the food products' quality and safety can be tested in Zambia. This facility has now passed certification and signed a contract with the World Food Programme so that COMACO can now sell HEPS to that entity. This provides tremendous cost savings for relief efforts and directly improves the local economy. In this way, our food science research directly leads to new economic and social benefits of the model. Because markets link the SA and NRM practices to the improvements in family food security and incomes, the sciences also directly impact biodiversity conservation goals.

Soil sciences

SANREM research also is directed at the production practices that family farmers use. Farming in the plateau region of Zambia involves a system where forest is cleared and burned, and crops planted with few external inputs. This long-used system results in nutrient loss, increased erosion and loss of topsoil. COMACO trains farmers in conservation methods as a sustainable alternative. Key components of this approach are hand-dug basins where nutrients are concentrated and moisture retained, and retention of crop residues for weed control rather than burning them. Because COMACO covers a wide geographic area that encompasses several soil types with varying slopes and precipitation, it is essential to identify those components of conservation farming most beneficial in the different agro-ecological zones. Specific focus is

being placed on the nature of organic amendments most beneficial in the differing zones, then length of time required for maximum benefits. Our researchers are producing data that will directly improve the lives of individual farmers' families by raising crop yields and soil quality. Hundreds of experimental plots are being studied across the zones, which are found in much of southern Africa. In this way, the data produced will impact an area far wider than the Luangwa Valley. Our research team regularly interacts with the COMACO extension staff, helping them produce posters and training materials for field days at which entire villages are assembled for training in sustainable agricultural methods. Another important component of these days is providing a forum for families and villages to give feedback. Because a major drawback with most conservation farming schemes is the increased labor input required, farmers are encouraged to ask questions and share potential solutions. Our partnership and research with the CFU and TSBF also provide inputs from other areas within Zambia and across Africa. For example, work now is being done on a system that minimizes the tilling required from year to year for the management of the basins. Soil and crop sciences provide fundamental support at the level of individual families, but because improved farm practices help conserve topsoil and diminish the need for deforestation, they also provide landscape-scale impacts on the watershed and biodiversity conservation.

Veterinary sciences

Livestock production has undergone dramatic changes in eastern Zambia in recent decades. Cattle are gone from areas where they historically were common, because of the cessation of government-sponsored vaccination programs and coupled with increasing human populations in areas with endemic trypanosomiasis (the cause of sleeping sickness in humans and the livestock counterpart "nagana" in cattle). In addition to loss of draft power, livestock are a critically important coping mechanism. The area's sporadic rainfall often results in decreased crop yields. At these times, the sale of animals provides critically needed income. Poultry raising is extremely widespread, but SANREM research has identified that about 85 percent of chicks do not survive to sale or consumption. Predation, a mixture of infectious bacterial and parasitic diseases due to poor husbandry, and endemic Newcastle disease combine to severely reduce the poultry yield.

In just one summer, SANREM veterinary research performed a survey of existing practices as well as causes of morbidity and mortality, and developed a training program to easily and cheaply improve husbandry. Training was provided to more than 500 villagers, and poultry production rose in these villages by about 50 percent. However, these improved practices are not protective against Newcastle disease, which typically results in the loss of 70 percent to 100 percent of infected birds. Vaccinations against ND exist but have historically required maintenance of a "cold chain" from central stock to field use. Such vaccinations are not practical in the Luangwa Valley, which does not have electricity in most rural villages. Development of new thermostable vaccines has led to an opportunity to protect these birds and greatly improve family income and nutrition. In context of COMACO's desire to improve biodiversity conservation, increased poultry production would be predicted to decrease the need for bush meat for sale or consumption, as well as improving family incomes and nutrition. In the past year, we obtained additional outside funding to help partner with the IRPC (part of the Kyeema Foundation) to test the veterinary efficacy and economic efficacy of the thermostable vaccine. This trial is underway, and the analyses should indicate whether the approach is cost-effective. It

should be noted that gender-sensitive participatory appraisals and community selection of vaccination teams (one man and one woman) were the first steps in the vaccination trial, showing again how the biophysical sciences rest on social science activities.

In addition to poultry, veterinary research has now performed an analysis of current small ruminant husbandry practices in the Feira region. Feira is the site of COMACO's newest CTC and is a much drier location than the Mfuwe and Lundazi sites to the north. COMACO activities are much less advanced in this area but have identified goat production as potentially of great benefit. Unfortunately, goat production suffers almost as shocking a mortality rate as poultry –in this case, 60 percent to 70 percent of goats die before sale or consumption, mostly as young kids. A survey was performed of current practices, and a training manual was produced both for COMACO's extension officers ("training the trainers") and for the villagers themselves. More than 969 villagers were trained in improved goat production. From a market perspective, introduction of a "double-muscle" phenotype such as found in South African Boer goats would improve profitability. However, disease resistance in the native goats would have to be bred into the Boer goats by a hybridization program. This is a potentially important future research direction that is beyond the scope of our current funding.

Research leading to improvements in crop, poultry, and small ruminant production all should directly impact social indexes such as family incomes and nutrition. Also, sustainable production methods should lead to more sustainable use of natural resources. As just one example (see Figure 3), less deforestation will lead to improved soil retention and less downstream flooding, which itself will improve yields in those areas' farms, leading to improved food security and incomes. More trees also translate into more habitat for wildlife and bees. Increased wildlife populations should sustain more ecotourism, and less traffic into the bush should result in a decrease in bushfires, which is another source of deforestation. Honey production will benefit from both, for it is dependent on flowering trees. This is just one trail of connections that link our research components through this holistic approach that looks to effect positive economic, social, and environmental changes.

Objective 3: to determine the extent to which the COMACO model provides self-sustaining social institutions and meaningful roles for COMACO participants

As noted above, social sciences inform every aspect of our research, including the food, soil, and veterinary sciences. Indeed, social survey data have continually driven the evolution of the COMACO model, and numerous surveys are carried out by COMACO staff on a yearly basis. For example, the data from the original WCS baseline survey suggested that poaching with wire snares primarily occurred during the months when families were least food secure, and this drove the initial concept of trading snares for training in conservation farming and supplemental maize from the World Food Programme. To follow this original finding to the present, SANREM research has identified that one circumstance critically important to the success of the model in its current form is that the wire snares are not easy to replace (as opposed to the mining area known as the Copper Belt). Survey data have recently been used to demonstrate the relative profits of farming different kinds of crops, which can be used by the Community Resource Boards to modify planning for the next season and help COMACO as a whole see how income from cotton and tobacco compare with profits from food crops. Another example of how surveys are put into action came from surveys of hunters' experiences, which reflected a one-year

increase in wire snares in one area. This was directly attributable to introduction of solar fencing materials that were not properly stored or inventoried. These data were used to alter implementation of fencing programs in subsequent years. In addition to helping plan future activities, surveys also establish the compliance of farmers with sustainable practices regarding farming and poaching.

Social data is crucial to testing the model, because for it to be exported, it must be sustainable at the level of individual families and local, regional, and federal institutions. Therefore, the question of "buy-in" from the local population is of enormous importance. Demand to participate in COMACO certainly exceeds current training capacities. Thus the first indicator is positive: People want to join. The next aspect of buy-in is continued compliance with the SA and NRM practices that validate the market linkages. Preliminary data show that most people trained in conservation farming techniques continue to employ them even after supplemental maize distribution terminates. In fact, in many places farmers want the training and want to join even in the absence of supplemental training. However, many participants do not use all the components of conservation farming; rather, they choose one or more components, usually on the basis of their evaluation of labor inputs needed. This provides another example of how social and biophysical science activities merge: "Optimal" practices are not optimal if not followed, and if research can identify those activities that will yield the highest returns, then efforts can be tailored to where they will impart the greatest effects.

Current SANREM research is focusing on the impacts that COMACO is having on individual families. For example, are improvements in family income being used for education and improvements in childhood nutrition? What groups are benefiting from this additional income? SANREM researchers are interested in human capital formation and equity issues associated with COMACO activities. Because issues of equity are often overshadowed by preoccupation with average trends for entire communities, SANREM social work complements ongoing assessments of economic impact. In understanding the implications of this project on inequality, especially in children's schooling and health, we hope to shed light on issues of social stratification within vulnerable communities undergoing rapid economic change. This research is being done in the context of information gathered on educational policies that are not consistent between provinces in Zambia, which will prove informative regarding educational opportunities in these very poor rural villages.

Objective 4: to determine the extent to which the COMACO model improves biodiversity and watershed conservation

Watershed analysis

Our studies in Zambia have been significantly strengthened by a SANREM cross-cutting research project led by Conrad Heatwole of Virginia Tech. Deforestation is an unsustainable agricultural practice that has dramatically affected the canopy coverage of the plateau area and is becoming more common in the escarpment and valley floor. SANREM research is gathering quantifiable data on which to base models for how different land-use practices affect watershed qualities. For example, we predict that deforestation on the plateau will contribute directly to increased erosion and runoff that can result in increased water flows as the water works its way down to the Luangwa River. Increased siltation has been noted to cause substantial changes in

the morphology of the Luangwa River, making it wider and shallower. This can have important impacts on wildlife that use the river as habitat. Also, preliminary data suggest that wetlands in the escarpments and edges of the valley play significant roles in absorbing and ameliorating what can otherwise be rapid changes in water flows. This year, our soil science researchers lost up to 50 percent of their valley floor farm plots because of severe flooding. Watershed analysis provides a quantifiable way to assess whether land-use practices that are encouraged by development efforts on the plateau are actually having deleterious effects in the valley. Such data can help inform stakeholders across the valley to begin developing an ecosystem scale land-use strategy. SANREM will be hosting such a meeting in the coming months pending the availability of stakeholders to participate.

Biodiversity analysis

COMACO has introduced a series of complementary interventions that together focus on improving the human condition as a means to conserve biodiversity. SANREM research is evaluating whether the model is achieving these ambitious triple bottom-line goals. A multi-species approach is being pursued to investigate potential effects that COMACO is having on the conservation of wildlife species. Methodologies that evaluate multiple species are preferred to single-species counts for several reasons, including but not limited to the following.

- Many species have economic worth to both hunters and families and are therefore worth monitoring.
- COMACO activities or other externalities might inadvertently shift wildlife usage from one or more target species to other species.
- Assessment of changes in the populations of individual species might provide the first signs of new pressures on the ecosystem.
- COMACO seeks to change land-use practices on a broad scale, so its effects should be observed across species through habitat protection.

Aerial wildlife censuses will be carried out in the COMACO core area as well as two control areas where COMACO has not been active. The northern control is an area in which COMACO has had minimal activity but into which COMACO will soon extend. Its inclusion therefore accomplishes providing both a current non-COMACO control as well as multiple years of baseline data that will show how long it takes for the intervention to affect animal numbers. Assuming the continuation of data collection in the core area, this will provide information about animal movements and immigration. The eastern control is actually contained within Lukusuzi National Park. Of note, the first-year data from that park showed very few animals, suggesting that poaching has reduced populations there tremendously, even though direct habitat loss through deforestation has been minimal compared with that in surrounding areas. The northern control straddles the Luangwa River, so distance from permanent water and habitat/altitude are controlled compared with the core area.

In addition to these surveys, flights down the length of the Luangwa River from north of COMACO's intervention through the core area have been performed twice to count the hippo population and begin to map population distribution and densities. This is accomplished by careful aerial photography during daylight hours when hippos are invariably in the water. As noted above, perceived changes in river morphology can have dramatic influences on hippos,

crocodiles, and fish that rely on the river. This study will provide an excellent start to our understanding of potential changes. For example, the reduction in number of deep water pools – preferred hippo habitat – will result in crowding of these animals and is predicted to increase disease, decrease reproductive efficiency, increase the destruction of surrounding land habitat by the hippos that feed on land at night, and also affect species such as crocodiles that must share the habitat. This will also impact the ability of local farmers to use the river's fish as a resource for income and nutrition.

It is important to note that, in addition to those direct measurements, social data will also affect our evaluation of the success or failure of COMACO's biodiversity conservation impacts. We shall evaluate compliance with the cessation of poaching to determine whether patterns of consumptive animal use have actually altered because of COMACO, and we shall include indirect assessments (proxy data) of animal populations as well. Social surveys of safari hunters' experiences and Zambian Wildlife Authority officers (e.g., how many snares they encountered, how many poachers were seen, how much human activity was observed in protected areas) will provide outside observer data on compliance. Also, surveys of villagers will ask for data not only on their own snaring and illegal hunting practices, which would be subject to bias, but also on their perception of practices in neighboring villages, less subject to bias because they would not be in the same producer group.

Natural resource economic valuation

COMACO has been financed by a variety of donor organizations, including governmental and non-governmental sources. However, the best guarantee for this model to be sustainable in the long term would be for it to be able to support itself as a business. COMACO could continue to exist somewhere on the continuum from complete reliance on donor aid to complete self-sufficiency and attempt to demonstrate that it costs less to run this model than to provide aid for both relief and biodiversity conservation in the absence of COMACO's intervention. Yet the ability of the model to be replicated elsewhere would then be diminished because of the absence of such support in all areas in need of both habitat protection and humanitarian relief. The key to understanding how the model functions in terms of its triple bottom line is to generate an equation for the cost of biodiversity conservation through the COMACO model. Briefly, this will examine not only the hard economic data of revenues and costs generated by the CTCs, it will also incorporate data from quantitative analyses of outside benefits that COMACO provides. Because payments for ecosystem services and the social benefits of the intervention will vary widely from hard numbers to estimations, this equation will be presented in a tiered fashion so that readers, be they development practitioners, relief organizations, or academic reviewers, can easily dissect the components and evaluate their respective merits individually.

The first step in developing a benefit cost analysis of the COMACO model has been to carefully examine the project's activities in the Luangwa Valley and define the project's various impacts on local communities and the environment. Data are being collected on these many potential benefits and have benefited from a strong working relationship with ZAWA. The data also rely heavily on SANREM research being performed for all objectives, including economic analyses of costs and profits at the CTCs (Objective 1); quantification of changes in anti-poaching expenses such as patrols, trials, and incarceration (Objectives 3 and 4); changes in household food security and nutrition (Objectives 1, 2, and 3); changes in household income (Objectives 1,

2, and 3); profits from safari hunting and ecotourism (Objectives 1, 3, and 4); and estimations of benefits through ecosystem services such as watershed management and the value of wildlife. The watershed input will rely on erosion and runoff data –how much of a change in water flow is linked to deforestation? Hypothetically, if water flow in streams increases X percent due to deforestation and this translates into Y percent increased likelihood of flooding, then we can make informed estimates as to the value of crops lost in the valley due to deforestation on the plateau and escarpment. A contingent value survey will be administered to assess the values that tourists place on the presence and abundance of wildlife and ecosystem maintenance. This will be performed with assistance from ZAWA, which runs the North and South Luangwa National Parks.

Research Progress

Objective 1: to determine the extent to which the COMACO model can be economically self-sustaining and the effectiveness of the different COMACO model components.

1. Critical research accomplishments. Two different lines of research are represented within this objective. These are presented by topic alongside development impacts because the two are intimately related. Research accomplishments include:
    a. identification of CTC cost and profit centers
    b. identification of HEPS as a major commodity that could drive economic sustainability
    c. historical analyses of costs that were incurred to build and operate and staff the CTCs (allowing insight into the costs of replicating the model)
    d. collection of data regarding the costs of anti-poaching efforts in the Luangwa Valley, and
    e. surveys designed and currently being implemented regarding tourist willingness to pay, one metric for the value of biodiversity conservation.

2. System level. System level is broad, affecting families to the business as a whole. "Policy/market" is the best descriptor for system level.

3. Development impacts

    a. Business economic analyses

i). Analysis of current business practices and profitability. The COMACO model was developed in the absence of breaking out specific business costs and profits. One of the first points of SANREM research was the identification of individual cost and profit centers for each CTC. The CTCs differ slightly because they emphasize different crops and therefore different value-added products. Knowledge gained from this research enabled our team, led by John Fay, to help COMACO staff design comprehensive five-year business plans. SANREM research indicated that expanding markets for value-added products was essential for the COMACO model to achieve economic self-sufficiency. Progress at the Lundazi and Mfuwe CTCs has been investigated and found to be on target with outcomes predicted from Year 1 business modeling projections.

SANREM research identified HEPS as potentially a major market item with a high profit margin in that, if it can be produced locally, it will have competitive advantages over imported products given the poor road infrastructure and high costs of fuel. Large-scale permanent contracts are needed for this and a variety of products for COMACO to achieve self-sufficiency. Our team met with the World Food Program's logistics officer to map out a process for attaining the certification needed for selling to WFP, one of the main buyers of HEPS in southern Africa. This has now transpired and resulted in a recent order with WFP for 300 tons of HEPS. To engage in such large-scale production of food products, research and training provided by Cornell's food scientist, Carmen Moraru, was essential. Those activities are described in more detail below. New partnership with the UNZA food quality and testing laboratory has confirmed that COMACO is meeting product quality and safety guidelines. This has paved the way for sale of other products in addition to the HEPS. The linkages between different research disciplines underscore not only the holistic approach and needs of the model but also the close interactions of SANREM team members.

As a result of SANREM activities, production capabilities at Lundazi in particular have increased with the addition of both a soy cow and a soy extruder. This instrumentation made possible the production of HEPS as well as soy milk products and a variety of household foodstuffs. Soy milk sales will not become profitable (or possible on a large scale) in the absence of reliable clean water and a cold chain. Byproducts from all extruder-based activities and broken grains can be used for animal feed, offering further avenues for profit.

SANREM research has identified that general business operations have improved, becoming more process oriented, with full procedures in place for rice polishing and peanut butter processing. Research in Year 1 indicated that marketing practices as well as channels and outlets for sales needed to improve. As a result, there are now outlets in Lundazi, along the road from Lundazi to Chipata, and in Lusaka. Their operations and profitability are being assessed. SANREM research indicates that improved marketing is the key to COMACO's self-sufficiency, allowing the scaling up of the value-added products that are the major profit center. Billboards now going up in Lusaka emphasize the brand "It's Wild!" as being made by Zambians and for Zambia.

Business experts from the Haas School of Business are also partners now with SANREM in the analysis of current business practices and profitability of the COMACO model.

ii). Analysis of start-up costs for a CTC. A preliminary assessment of the start-up costs associated with the COMACO model linking sustainable rural development and biodiversity conservation has been completed. Start-up costs from December 2005 to present at the Lundazi CTC are about $1.087 million. This figure includes expenses associated with designing and refining the model for the CTC, which would not be necessary for additional CTCs. We will break these development costs out in the future. COMACO has been closely aligned and shares expenses with the WFP, therefore assumptions were necessary to back out WFP expenses from COMACO expenses.

Because of incomplete business records during the early years of the Lundazi center, its economic analysis is less accurate than that for the newer CTC at Mfuwe, which has benefited from SANREM financial templates generated during our initial Planning Award and during Year 1. The Mfuwe CTC, initiated in 2004, had more modest revenue over the past 12 months. It is focused on selling rice, honey, and produce in the local area to professionals and the tourist lodges across South Luangwa. First-year sales were about $31,500. Start-up expenses over that time, including headquarters support and operations, were about $299,000 after backing out WFP expenditures, with revenue of about $116,000. Start-up costs and quarterly sales will continue to be analyzed to determine whether the Mfuwe CTC is moving toward a break-even point or whether continual expansion of the model is keeping Mfuwe in a resource-intensive growth phase.

b. Quantification of the cost of biodiversity conservation through the COMACO model

This research will quantify the costs and benefits of the COMACO conservation model. Components of this analysis use the business economic analysis described previously (cost of CTCs, profits generated) and expand the analysis to different levels of potential positive externalities such as profits from safari hunting and ecotourism, decreased government expenses for anti-poaching and incarceration, value of ecosystem services, and reductions in external aid needed due to public health and social benefits.

Data collected by graduate student Sam Bell at the end of Year 1 from ZAWA have been analyzed regarding the number of poaching arrests before and during the COMACO intervention, the length of incarceration, and the associated costs. In addition to a temporal scale, mapping of arrest locations and poacher homes reveals insights into the spatial distribution of pressures on wildlife and gives a detailed indication of trends in effort/catch rate. This analysis will provide another perspective when examining the impact of COMACO on poaching in the area, in addition to the more obvious potential benefits to non-consumptive ecotourism and safari hunting.

A survey was developed and is currently being given to tourist visitors to the South Luangwa National Park. This instrument will provide data regarding "willingness to pay," which in turn will inform researchers about the actual non-consumptive value of wildlife (and therefore of their conservation). Also, this survey will be useful to ZAWA, informing the agency regarding its park management strategies. Such data will be viewed in conjunction with the straightforward values of wildlife used consumptively in safari trophy hunting.

4. Challenges and responses. All aspects are running according to or ahead of schedule. Financial data for the early years of the Lundazi CTC are not readily extractable, in large part because the COMACO model and the Lundazi CTC have co-evolved and utilized a wide variety of resources during that process. This has left unclear which of the early expenses were necessary should one attempt to replicate the model. Rather than make unneeded assumptions, we have concentrated instead on the costs associated with replicating the Lundazi CTC as it exists today. The Mfuwe CTC offers much more rigorous data for generation of a new CTC. The cost analysis of biodiversity conservation by means of the COMACO model requires data from the different national parks and ZAWA anti-poaching activities. Unfortunately, these are

not centralized and will take time to gather from appropriate regional offices. This was expected and planned for.

Objective 2: **to identify and integrate new technologies into the COMACO model to improve its profitability, food security, and rural incomes**

1. Critical research accomplishments. Several lines of research and host capacity building are represented within this aim. These are presented by topic alongside development impacts because the two are intimately related. Research accomplishments include:

a. identification of major needs for productive food processing (host capacity building through technical training workshops is reported as a development impact below)
b. research on extending safety, quality and shelf life begun
c. research identified major causes of grain breakage and economic loss
d. all soils and crops research projects underway
e. poultry husbandry and morbidity/mortality survey carried out
f. Newcastle disease vaccination trial initiated, and
g. goat husbandry and morbidity/mortality survey carried out.

2. System level. System level is again broad, ranging from farm household/enterprise for the poultry and goat work to farm/field for soil and crop sciences to policy/market for the food science work.

3. Development impacts.

a. Food safety and product development

Research during our site visit from the initial planning award identified several aspects of food production at the Lundazi CTC in need of dramatic improvement. These included implementation of sanitation measures, changes in the preparation and composition of specific products, changes in production line behaviors and facilities design/management, and use of different product packaging to improve food safety and lengthen shelf life. COMACO embraced these suggestions and implemented them during Year 1, resulting in immediate impact for our activities. Financial and operational research of COMACO's enhanced food production capabilities identified two major topics that required continued attention at Lundazi: capacity building for hygienic and safe food processing; and expanding the range of value-added foods processed by COMACO as a means for economic growth. Therefore, Carmen Moraru, a food scientist from Cornell, has performed research on current practices and potential problems, and prepared and presented major workshops on both hygienic and safe food processing and the development of new value-added food products. This training was essential for COMACO to get certification to sell HEPS and other products.

i). Hygienic and safe food processing. When preparing food products, the consistent application of best practices is essential. Training in the fundamental principles of bacterial contamination laid a foundation for practical teaching of appropriate hand-washing behavior. This was tested using a fluorescent reagent, Germ Glo, which is placed on the hands and used to compare various hand-washing techniques. An ultraviolet light showed which practices were optimal. This kit will be used to train new staff members in the future. Instruction in the hygienic maintenance of food-

preparation surfaces and instruments was also given and then tested using kits for the field detection of microbes such as *Salmonella spp*. and *Eschericia coli*. In collaboration with the Good Agricultural Practices Extension Group in the Department of Food Science at Cornell, Moraru developed both relevant signage and training materials for this workshop. Several other materials such as training brochures and coloring books for the children of staff and employees were also produced. A wide range of supplies critical for hygienic food production –lab coats, gloves, hair and beard covers, shoe covers, goggles –as well as the pathogen-testing kits for fast evaluation of potential microbial hazards were demonstrated and are being used for ongoing screening of processing facility hygienic status.

ii). Food processing and product development. Food product development, testing, and improvement are major areas in need of research and support. Issues such as phase separation of peanut butter have significant implications for sale, market access, and shelf life, as well as price per unit. Research involving the testing of products generated with different processing protocols led to implementation of specific changes such as diminishing the crushing of peanuts and improvements of emulsification. Experiments were set up and are underway to compare the effects of different production practices on shelf life. Similarly, rice processing is currently flawed because of a high percentage of grain breakage and inefficient husk removal. These factors combine to limit profitability. Research identified a design flaw in the rice polishing equipment being used. New products such as tofu and soy milk were also prepared and tested. A small focus group revealed that tofu might integrate easily into the local diet, but market analysis and product development are needed. We are also performing research to identify solutions for adding value through extrusion processing of some of the substandard quality grains such as broken rice, as well as the economical utilization of processing byproducts, which could be used as livestock or poultry feed. Adaptation of known processing methods to the nature and quality of the crops produced by COMACO and the existing processing conditions and abilities will require extensive research, which began during the workshop and continues. This research will lead to the development of a range of products for potential commercialization by COMACO.

When expanding to large commercial markets, food products must be tested routinely for quality control, including bacterial and fungal contamination (e.g. *Salmonella*, urease activity, presence of aflatoxin) and content (dry matter, protein). SANREM research had previously identified the lack of local capacity for product testing as a major obstacle limiting large-scale commercialization. A new partnership has now made it possible for these tests to take place at the UNZA food laboratory. Importantly, this new relationship affords several new host-nation capacity-building opportunities, for the university does not have many of the new technologies that COMACO does. Some possibilities for this relationship are in very early discussions and will be explored further (see Section VI below).

b. Soils and crop sciences

A second area in which we are injecting new technologies is research in soil and crop sciences. Conservation farming (CF) involves a set of practices including dry-season preparation of small planting basins using minimal tillage, no burning of crop residues, planting and nutrient application solely in the basins, and nitrogen-fixing crop rotations. CF is hypothesized to be a better farming system than the traditional *chitemene* system of slash-and-burn cultivation that has contributed to accelerated rates of soil erosion and degradation within the watershed due to

shorter fallow periods and longer cropping cycles caused by increased population pressures. The main goals of the soil science group (Johannes Lehmann, Peter Hobbs, and TSBF's Rob Delve and graduate student Lydiah Gatere) are to investigate under which environmental conditions CF works best, what are the reasons for better yields, what types of organic amendments (qualities) are best for improving production potential under CF, and how long it takes until CF achieves its greatest yield potential under farmer conditions.

i). Current soils research. Six hundred farmers with 1-year-old CF plots were selected along an environmental transect across three agro-ecological zones of Zambia: 500 farmers within Mambwe and Lundazi districts in low and medium rainfall regions and 100 more in Mpika district, a high rainfall area. Topographical land features and plot coordinates were measured with a global positioning system (GPS). Soil samples from the 600 experimental sites were collected for analysis of physical properties (texture, bulk density) and chemical properties (texture, pH, total carbon and nitrogen).

There are four main experimental treatments: 1) CF as managed by farmers, 2) conventional farming as managed by farmers, 3) CF supervised by researchers, and 4) CF supervised by researchers with different organic matter additions substituted by full commercial fertilization. These were planted in the selected sites where soil samples were taken. The CF plots in Treatments 3 and 4 were established on 1-year old CF plots, and the control plots (Treatments 1 and 2) were situated on adjacent farmers' fields. Maize was planted on these fields starting in November and December 2006. Rainfall was expected in Mpika and Lundazi by mid-November, but instead it started in mid-December. In Mfuwe the rain started in mid-November and was reliable. Unlike previous years, very few farmers had to replant.

Crop yields measurements were initiated in March 2007 by sampling cobs and stover separately. In the alluvial valley (Mfuwe) sites, floods and elephants damaged 55 percent of the plots, and another 5 percent were harvested by the farmers due to fear of termite and rat damage before yield data collection. Among the CF plots, those with fertilizer and compost had the highest yields, followed by biochar and fertilizer, then compost, and finally gliricidia (green manure). The farmer-managed CF plots (Treatment 1) were managed differently among the farmers with variable results, but the conventional plots (Treatment 2) had the lowest grain yield and total biomass. A second year of data will be collected during the third grant year from planting in November and December 2007. Tie-ins with the watershed analysis will indicate whether CF lessens erosion compared with conventional practices.

(ii). Development oriented activities. Within each region, three to five meetings were held with farmers to teach them the conservation farming system and to recruit them for field trials. The meetings explained the expectations of the research and what was asked of the farmers, including their making observations on the different treatments. Each farmer kept a plot map and plan for the season. Subsequent field days were held in the farmers' fields. COMACO extension personnel were also trained in the importance of CF as a means of soil and water conservation management in the Luangwa Valley watershed.

(iii). Effect of CF on yields over time. Concurrent with the above activities, the effects of CF on yields over time are being studied using a chronosequence (false-time series) approach. Fields

with different lengths of continuous practice of CF are being identified on the same soil type and under the same climate for assessment. Fields are located with differing conversion ages of CF adoption from one to 10 years with control fields that did not adopt CF in the same area where this technology has been promoted. In-depth interviews and site examination are being conducted. Soil samples and data on crop yields will also be collected to determine differences between treatments.

c. Livestock

i). Poultry. In Year 1, Erin McDonald, a Cornell veterinary student, received significant additional training from Benjamin Lucio and Beth Buckles in poultry medicine, husbandry, and pathology, enabling her to perform both survey-based and diagnostic research to evaluate causes of mortality in different villages. These data were used to produce a manual for the training of more than 500 villagers, about equal numbers of men and women. McDonald also trained six COMACO extension officers to serve as veterinary para-professionals able to assess clinical signs, evaluate husbandry conditions, and perform simple diagnostic and post mortem procedures. To support these activities, she set up and stocked a small laboratory at the Mfuwe CTC equipped for on-site parasitological and post-mortem animal examination. Based on her research findings, McDonald has written a series of lab protocols to be used for routine diagnostic needs expected to be encountered. Despite the fact that this first season of work was primarily designed to collect data on which to base future interventions, the training had an immediate effect. Based on interviews with poultry producers, COMACO's manager for the Mfuwe region reported that this research and training increased poultry survival by about 50 percent.

Because of this preliminary success, the AHEAD (Animal Health for the Environment and Development) program at WCS (not affiliated with COMACO) contributed $20,000 to extend this intervention greatly. IRPC contact Robyn Alders, in conjunction with SANREM researchers and COMACO staff, helped to implement a controlled trial to quantify the effects of using a thermostable vaccination against Newcastle disease in addition to, or apart from, the nutritional and husbandry practices instituted in Year 1 by McDonald. ND is endemic in the area and, regardless of husbandry practices, if it enters a village then typically 70 percent to 100 percent mortality can be expected. To maintain compliance with improved practices, we predict that one must protect against the complete loss of a flock by vaccinating against this disease. A participatory rural appraisal has already taken place to identify current attitudes and practices and to facilitate community selection of gender-equitable vaccination teams. These teams have already begun a vaccination program that has covered several thousand birds. Data compilation is beginning on village poultry populations as we near the end of the first dry season in this experiment. These data will test the efficacy of the vaccine and vaccine program as administered. Jon Conrad will then perform an economic analysis of the various interventions. His analysis will indicate the cost-effectiveness of vaccination compared with no vaccination, husbandry intervention versus no intervention, and combinations thereof. This work will be most rigorous if repeated over several years, which will help factor out the stochastic nature of ND epidemics in a particular region. IRPC is pursuing independent funds to extend its activities and potentially allow McDonald to return to Zambia at the completion of her veterinary training.

ii). Ruminants. In addition to poultry, SANREM research is now extending to goats and cattle in the Feira region, which is the site of the third and newest COMACO CTC. Tamika Lewis is supported by Cornell's Expanding Horizons program and received additional training in small ruminant husbandry, disease, and necropsy procedures. Lewis performed research regarding live goat market conditions in Lusaka, Zambia, and in neighboring countries, and government requirements for animal health and travel certifications. She and Alice Pell, an expert in both small ruminant husbandry and nutrition, then assessed the Feira CTC's potential to incorporate goats and cattle into its business model. They surveyed farms for local disease conditions and husbandry practices and found that goat mortality was about 66 percent before consumption or sale. Mortality of 0 percent would be expected with good practices. Lewis wrote two training manuals on goat husbandry. The first was used to train the trainers, 23 COMACO extension officers, in small ruminant husbandry and extension training methods. In conjunction with these officers, Lewis then trained more than 960 villagers in improved goat husbandry. SANREM research determined that the native goat does not offer much profit margin compared with breeds such as the heavily muscled South African Boer goat. Unfortunately, disease considerations make introduction implausible, for Boer bucks died within nine months from endemic disease suspected to be heartwater transmitted by ectoparasites. Native goats seem resistant to acute and peracute manifestations. Conversations with Zambian experts at the university and within government positions, as well as with Heifer International, suggested hybridization programs as a future line of research and capacity building important for economic success.

4. Challenges and responses. We have exceeded the expectations of our initial timeline and have greatly exceeded our initial proposal's extent by leveraging SANREM research and capacity-building successes into additional support and the recruitment of new partners. Plans to train Zambians in food safety and production at Cornell were altered because of more stringent federal homeland security guidelines. We have adapted by holding our training workshops in Zambia to cover these same topics while also addressing new opportunities afforded by the purchase of the soy extruder.

The major obstacle encountered to date has been the severe flooding in the alluvial regions of the valley, which destroyed conservation farming plots in the region. We suspect that this has been exacerbated by deforestation and erosion in the plateau and escarpment. This link will be investigated through the watershed analysis described below. Other constraints experienced were lack of consistent field workers, for COMACO could not renew the contracts of the previous field assistants from planting through harvest. Having permanent field assistants instead of relying on casual labor to monitor the plots, as well as weeding and guiding the farmers, would have helped improve results.

Objective 3: **to determine the extent to which the COMACO model provides self-sustaining social institutions and meaningful roles for COMACO participants**

1. Critical research accomplishments. Social research of several forms is presented within this objective. The results of social research are incorporated into the evolution of the COMACO model by its inherent design. Therefore, the development impact to COMACO is immediate because the data are used to inform COMACO practices. Moreover, these results inform researchers of potential inadequacies of the model that might hamper its ability to be replicated

elsewhere. Conversely, these results also confirm the nature and extent of potential benefits conferred, providing insight into which areas outside Zambia might benefit from introduction of such a model. For example, if farmers are not compliant with CF, why not? What can be done to improve compliance? Field days to answer these questions and provide training on improved practices are one link between the survey results and new COMACO practices. Because of this interwoven nature, critical research accomplishments are presented alongside the development impacts below. Research accomplishments include:

a. completion of repeated baseline survey to determine impacts on food security and incomes, and
b. completion of surveys regarding CF compliance, crop damage assessments, cotton income, outcomes of poacher transformation project, and snaring practices.

2. System level. System level is again broad, ranging from farm household/enterprise for the impacts on food security and family incomes to field for agricultural practices, policy/market for consumption practices, and a combination of farm household/enterprise with ecosystem scale for practices such as snaring that affect biodiversity conservation.

3. Development impacts. Eloundou-Enyegue and graduate student Vongai Kandiwa evaluated COMACO's extensive survey data and identified strengths and weaknesses. Great strengths include the COMACO extension network's ability to conduct surveys and enter data, and its very positive relationship with the community. Improving survey design and consolidation of new surveys were identified as means to improve the utility of future efforts. Project impacts have been felt through the improvement of COMACO's ongoing surveys that contribute to continual self-assessment. In Year 1, Kandiwa conducted her own surveys and had numerous participatory meetings with villagers to identify those effects of COMACO that affect family life indirectly. For example, how are potential improvements in family income and food security affecting the lives of families? Next year, Kandiwa will administer another survey to assess COMACO's effects on education and public health, including nutrition. Smaller surveys have been conducted regarding crop damage, compliance with CF methods, relative incomes from different crops, the activities and incomes of poachers and transformed poachers who have undergone training in alternative livelihoods, and surveys of hunters and farmers on snaring.

4. Challenges and responses. New work toward this objective is on time and continues to take place. Spreading out project activities across the year allows us to avoid logistical conflicts over issues such as need for in-country transportation. No major obstacles have been encountered regarding this objective.

Objective 4: to determine the extent to which the COMACO model improves biodiversity and watershed conservation

1. Critical research accomplishments. This objective has two main components, and significant expansion of watershed analysis has occurred during this year.

a. Biodiversity outcomes quantification

COMACO represents a novel approach to biodiversity conservation that focuses on improving food security and rural incomes through development that is intrinsically coupled to environmental sustainability. In addition to metrics for alleviating poverty and hunger, it is essential to the model that it succeeds in conserving biodiversity. In Year 1, we performed aerial wildlife censusing of the COMACO core areas as well as new controls. These will provide not only multiyear baseline data in areas where COMACO will be entering but also comparative control regions where COMACO is not active. In Year 2, we analyzed those data and found that the ungulate species amenable to aerial survey were all at stable or possibly slightly increasing numbers in the COMACO core area, whereas the control areas were largely devoid of these species. Interestingly, the Lukusuzi National Park also was largely devoid of wildlife, even though, as a national park, it has the highest degree of federal protection. COMACO's Poacher Transformation Program GPS data show that many of the commercial poachers live immediately adjacent to the park. Satellite imagery of existing canopy shows that the park has escaped the widespread deforestation seen nearby on the plateau, yet it has very little wildlife left. Together, these findings suggest that poaching pressures have resulted in the loss of these species but that appropriate habitat is still left in this area. If the Poacher Transformation Project can be successful, with a low recidivism rate and stable incomes for the participants over time, then this area would be a good candidate for reintroductions. Because of the nature of aerial surveying, we shall have to collect more data for the next several years before we can draw meaningful conclusions. To minimize variables, these surveys must be performed each September so that animal movements and vegetation are consistent and controlled. The second-year survey has been completed, and the results are similar to those of Year 1 in that the COMACO intervention area has substantially more animals than the controls. However, the numbers show a decline in the intervention area that would be consistent with expected with year-to-year variations in animal populations. Alternative explanations include sampling error, new pressures such as an impact by the flooding, a return to poaching, the introduction of disease, or increased predation by rising numbers of carnivores. As mentioned previously, given the unequal distributions noted, several years' worth of data will be needed to establish trends.

In addition to the aerial surveys of ungulates, we have conducted an aerial survey of hippos down the Luangwa River, not only in this part of the valley but for an extended distance to the north as well. The Luangwa River is famous for having the largest and most stable hippo population in Africa, yet local observations suggest that this population is under pressure from changes in the river itself. Significant increases in siltation have altered the course and character of the river. In general it appears to be getting more wide and shallow. Hippos are therefore being concentrated into the fewer remaining deep pools. Crowding of any species can increase stress, decrease reproductive success, and increase the transmission of disease, all potentially leading to declines in this great resource and prime tourism draw. Furthermore, crowding of a large-bodied species such as the hippo that are capable of transforming habitat can have profound impacts on other species sharing that habitat: loss of plant forage species, loss of fish species due to changes in turbidity in these pools, and loss of crocodiles due to changes in the fish and bank habitat. Study of this developing problem is in its early stages, but observations strongly suggest that a watershed analysis is just as essential for biodiversity conservation as it is for understanding the increasing severity of flooding of the alluvial farms in the valley. Current

images from the survey as well as from ENSO-Mosaic imaging are being compared against older satellite images to evaluate changes in river morphology. These comparisons are just underway and are an important component of watershed activities described below.

b. Watershed analysis

The extremely high rate of deforestation per capita suspected in eastern Zambia has been confirmed by canopy analysis of satellite images. This loss is greatest around Lundazi and is encroaching down the escarpment into the valley. Initial analyses suggest that between 1989 and 2002, more than 20 percent of woodland on the plateau and 9 percent within the valley were lost; ground observations show that this loss continues. Both COMACO's previous surveys and current SANREM studies suggest that outgrower agriculture development projects featuring cotton and, to a lesser extent, tobacco are driving this deforestation. Social survey results demonstrate that more than 90 percent of income on the plateau is now attributable to cotton. Unfortunately, in the absence of soil amendments or agro-forestry, the typical strategy is to deforest, plant one field, and immediately in the first season begin to deforest the next plot because, at best, profitable yields are obtained only in the first two or three years of planting.

Temporally correlated with these shifts in development policies and land-use strategies away from food-crop production toward cotton have been the observed changes in the Luangwa River and recent heavy flooding in the alluvial areas in the valley. We hypothesized that upstream land-use strategies might be contributing to these changes. In economic and social terms, this would suggest that the improvements in income on the plateau might be offset to an unknown degree by loss of income and a reduction of food security in the valley. In this scenario, deforestation and unsustainable agricultural practices would lead directly to significant reduction of wildlife, primarily due to loss of habitat and secondarily through increased poaching pressures due to food insecurity caused by crop loss or failure to plant appropriate amounts of food crops in favor of cotton.

An in-depth watershed analysis was determined to be essential to understand the complex inter-relationship between agricultural and economic practices and their social and conservation effects. This analysis could then contribute greatly to an ecosystem-scale management involving all regional stakeholders. Conrad Heatwole from Virginia Tech visited the study site to understand the situation on the ground, to ground-truth satellite imagery characterizations of land use, and to identify potential sites for hydrologic monitoring. Additional SANREM support for this proposal has recently been granted. Heatwole has now identified experimental areas and mapped out a study plan that will enable us to understand the functioning of the watershed as well as to quantify the hydrologic impacts such as upland erosion, silt loads in rivers, and flood risk of different land management scenarios at the watershed scale.

2. System level. System level is predominantly at the community/watershed/ecosystem level, although the impacts at that level are collectively based on the individual changes in behavior and attitudes at the level of families, fields and farms.

3. Development impacts. The data collected have not yet produced development impacts, for more time will be required to define significant differences in cause-and-effect relationships.

Data collected to date do suggest that biodiversity is substantially better in the COMACO core areas than in other areas, including national parks, that have not been influenced by COMACO.

4. Challenges and responses. The biodiversity conservation outcomes assessment is proceeding according to schedule, with additional studies being performed that go beyond what was in our original proposal. One challenge was that an area selected for a control at the southern end of the South Luangwa National Park has such uneven topography that it made aerial survey imprecise. This region was dropped from the study. We still have two other appropriate control areas in place to provide a rigorous comparison. Another obstacle has been the rise in price of aviation fuel. Our biodiversity outcomes assessment is critically dependent on aerial surveys because of the very large study areas and the types of species monitored. It will be difficult to continue with the same experimental paradigm if these costs increase further. The watershed analysis has been greatly strengthened by the expertise of Heatwole and has made tremendous progress to date.

Degree and Non-degree Training Activities

LTRA-2 had five students – four women and one man – in Ph.D. programs. Two of these were from host countries. Short-term training involved 4,522 participants in eight training workshops and four field days. Gender-disaggregated data were collected on 2,523 men and 1,599 women (see Degree and Short-Term Training Tables).

In addition to training of individuals, we have incorporated lessons from this long-term research project into several courses at Cornell. These are based in different departments across campus and across two colleges, showing both the diversity of the project and its broad applicability to issues of SA and NRM.

2006

Veterinary Medicine in Developing Nations (VetMed 615), 2 hours of lecture and discussion, and 1 hour of a panel discussion
Environmental Strategies (NTRSE 431), 2 hours of lecture and discussion
Environmental and Resource Economics (AEM 250) 1 hour of lecture

2007

Conservation Medicine (VetMed 754), 1 hour of lecture

Publications, Presentations, Other Products

One white paper for Zambian government officials, two training manuals, a coloring book, and two posters to reinforce hygienic practices were produced. Also, 16 invited seminars or posters have been presented, and two news stories have been written about our SANREM-CRSP activities.

Networking Activities

PI Travis met with the Zambian ambassador to the United States, Inonge Mbitkusita-Lewanika, in March 2007 and discussed the SANREM-CRSP project and the varied lines of research being carried out by Cornell researchers working in tandem with Zambian staff of COMACO. The ambassador was already aware of COMACO and was very impressed by its work but was not aware of Cornell's involvement through the USAID-funded SANREM-CRSP. She was

particularly excited by our research into relationships among different development and agricultural practices and social and environmental changes. We have maintained e-mail contact since then and hope that this relationship might facilitate improved communications with Zambian governmental institutions to improve host capacity building.

Co-PI Fay met with WFP Logistics Officer Felix Edwards in May 2007 in Lusaka to discuss the opportunity for COMACO to produce HEPS for WFP purchase. This provided information regarding the certification processes needed to demonstrate adequate quality control for certification. The food safety and hygiene workshop was an important step to ensure the safety of food production. With SANREM help, COMACO's products have passed their quality and safety tests at the UNZA food testing laboratory and are now certified. WFP has placed an order for 300 tons of HEPS from COMACO.

A new relationship has been developed with the UNZA's Department of Food Science and Technology laboratory. Nyambe Lisulo-Mkandawire is the COMACO contact person and is the head of the department. As explained above, COMACO products are now being tested for safety as well as content quality at the university. This is a standard commercial arrangement, but we are working to expand it into a true research and training collaboration. Lisulo-Mkandawire has suggested the possibility that COMACO allow university students to train at the Lundazi CTC because of its new equipment and products. This would significantly enhance the university's training program while bringing talented young Zambians from Lusaka out to Lundazi and COMACO. These discussions are at an early stage, but the PIs of this LTRA are enthusiastic about the possibilities given that this relationship clearly meets the SANREM goals of performing research, building host nation capacity, and injecting new technologies to make a major impact on the ground.

Improving our connections with local Zambian experts was a key accomplishment of our goat research team over the summer. As goats play a more prominent role in the business activities of the Feira CTC, collaboration with local experts at the university and NGOs will be critical. Contact was made with a wide range of noteworthy individuals from academia, government, and NGOs. Harrison Chitambo is a veterinarian with a Ph.D. in parasitology and was extremely informative regarding local causes of mortality in both goats and cattle. Francis Mulenga is the chief veterinary officer at the Ministry of Agriculture and was quite informative regarding livestock policy, local and trans-boundary diseases, and regional marketing practices and networks. Barnabas Chitalu of Heifer International gave an excellent description of that agency's programs and suggestions for hybridization schemes.

Project Highlights

Business

- Financial templates for accounting by product and yearly business results greatly improved COMACO CTC accounting.
- Identification of profit and cost centers enabled COMACO managers to understand the economics of their business, allowing them to determine cropping strategies and make projections and market accordingly.
- Five-year business plans were generated.

- Reconstruction of startup costs for each CTC gave first estimates for cost of replicating the COMACO model in other areas.
- Researchers demonstrated how improved quality control and product manufacturing at COMACO could lead to product certification and expanded market opportunities.
- Contact with WFP and establishment of certification process enabled COMACO's single largest contract to become realized once food safety training was performed.

Poultry

- examined current poultry husbandry and veterinary medical practices
- identified the major causes of poultry morbidity and mortality
- designed a training manual to assist villagers with poultry production
- trained more than 500 villagers in improved poultry husbandry
- trained six COMACO extension officers in rudimentary veterinary diagnostics and established a field laboratory at the Mfuwe Community Trading Center to perform routine veterinary diagnostics such as fecal flotations for parasites, gross post-mortem exams
- improved poultry numbers by 50 percent in the same region compared with the previous year, representing a tremendous increase in available dietary protein and family income, both of which should dramatically lessen the need for bush meat obtained through poaching
- leveraged poultry husbandry activities into an expanded program that vaccinated thousands of chickens and will form the basis for expanded research

Goats

- examined current goat husbandry, marketing, and veterinary medical practices; identified the major causes of morbidity and mortality; and developed recommendations for improved goat husbandry in the region
- identified the production strategies of cross-breeding that will be needed to confer the greatest profitability
- trained 23 COMACO extension officers and more than 960 villagers in improved goat husbandry

Soil and crop sciences

- examined the effects of different farming practices, focusing on the relative yields generated by different soil amendments in the different agro-eco zones of Zambia
- compiled preliminary data suggesting that conservation farming methods are superior to conventional practices
- compiled preliminary data suggesting that compost is superior to biochar as an amendment when used in conjunction with fertilizer; used together, provided an indication of maximum yield compared with compost alone

Food sciences

- examined the production practices for rice, honey, peanut butter, and peanut oil; identified shortcomings in hygienic food production and facilities maintenance practices; and developed appropriate technical and management measures to ensure production of safe, high- quality food products at the cooperative level
- through food science experiments, identified production methods that should extend shelf life and improve palatability while improving profits

Supporting technology

- established broadband Internet access at two locations by satellite linkage
- through that technology, facilitated future research collaboration between Zambian partners and scientists at Cornell and elsewhere, saving innumerable hours of travel and thousands of dollars in fuel costs

Social sciences

- demographic survey data being analyzed to provide insights into family impacts
- surveys of poacher transformation, snaring, and safari hunting providing assessments of compliance with sustainable NRM strategies

Biodiversity conservation

- performed first aerial surveys of control regions (game management areas where COMACO is not yet active), COMACO core and extended areas
- performed more detailed aerial surveys of hippo populations
- analyzed current and previous survey data suggesting that an ecosystem-scale management plan needs to be generated quickly so that differing development practices and family coping strategies currently employed do not result in the complete loss of wildlife outside the COMACO core area and do not lead to pressures that continue to impinge on the wildlife in the core area

Watershed analysis

- satellite imagery confirmed by ground-truthing, and watershed research priorities and experimental locations identified
- identification of watershed research priorities and experimental locations
- used watershed and biodiversity findings, in conjunction with COMACO business activities and social impacts, to lay foundation for an ecosystem-scale management plan

LTRA-3: Watershed-based Natural Resource Management in Small-scale Agriculture: Sloped Areas of the Andean Region

PIs: Jeffrey Alwang, Brian Benham, Darrell Bosch, Carola Haas, George Norton, and Mary Leigh Wolfe, Virginia Tech
Paul Backman and Jonathan Lynch, Pennsylvania State University
Duane Chapman, Cornell University
Willis Flowers, Florida A&M University
Sally Hamilton, University of Denver
Stan Wood, International Food Policy Research Institute (IFPRI)
Victor Hugo Barrera, INIAP, Ecuador
Mario Antonio Gandarillas, PROINPA, Bolivia

Host countries: Bolivia, Ecuador

Executive Summary

Long-term research on this project has proceeded according to plan, with all major activities well underway. Herein we report interesting preliminary findings, the development of a well-designed and well-leveraged training program, and substantial progress networking with other researchers and policymakers in the area.

Two research sites have been established – one in Guaranda, Bolivar Province, Ecuador; and the other in Tiraque, Cochabamba Province, Bolivia. Research is being conducted in farmer fields, at experiment stations in both countries, and by a network of researchers at U.S. and other universities. Main research partners are the national autonomous agricultural research institute in Ecuador (INIAP) and the autonomous agricultural research institute for Andean crops in Bolivia (PROINPA). Affiliated partners at host sites include ECOCIENCIA, ECOPAR, and SIGAGRO in Ecuador; and PROMIC and CERES in Bolivia. The international potato center (CIP) is also a partner. Coordinators at both sites have labored to engage local governments, farmer and community groups, and individual decision makers in the research planning and implementation process; the program is fully participatory.

Specific objectives of the long-term research are:

- **Objective 1:** to identify economic, social, political, and environmental conditions in the watersheds and understand the determinants of these conditions
- **Objective 2:** to generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation (some alternatives might be new crops and new on- and off-farm income-generation strategies; others would include technical improvements to existing practices)
- **Objective 3:** to create a means of evaluating the impacts of alternative actions, policies, and interventions on income generation, and social and environmental conditions (this will take individual responses such as changes in practices at the field and farm household/enterprise scales, and aggregate them to the watershed level; it will create a

mapping between policy and other interventions, and outcomes at the aggregate level), and

- **Objective 4:** to build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital.

Our research plan involves a phasing in of activities. We began with participatory appraisals (PA) to identify key constraints and concerns. As a result of our findings, we designed physical and social science research to identify potential solutions to the constraints, including research on plant diseases, variety selection and testing, agronomic research on feasibility of alternative varieties, soil erosion rates, and means of mitigation. We are complementing the physical science with social science investigations of determinants of livelihood adoption, the profitability of livelihood alternatives, costs and benefits of enhanced NRM, and institutional considerations affecting governance in the watersheds. Ultimately our goal is to build comprehensive physical and social models of the watershed, so our research in the first two years of the project has focused on obtaining data and building the models. These models will be used in an adaptive watershed planning process to inform local decision makers about the impacts and consequences of alternative land-use plans. We have initiated a process of dialogue to build stakeholder ownership of the research products; participation also helps ensure that research is well designed and relevant.

Research highlights include:

- completion of participatory appraisals in both sites
- completion of baseline surveys for both sites
- establishment of GIS for both sites
- a comprehensive soil survey for the Ecuador site, the analysis of which is yielding important information about the rate of soil erosion and its relationship to global carbon flows
- a protocol for assessment and monitoring of biodiversity for both sites and an analysis of biodiversity for the Ecuador site, and
- a first year of field-level agronomic research that is providing information on management techniques and the profitability of alternatives.

The analysis of the baseline survey of livelihoods for Ecuador shows highly diversified income-generation strategies, major differences in decision making and participation across our two working sites in Ecuador, and a disconnect between stated concerns for environmental quality and household-level decisions. Data from the baseline are being used for more detailed household modeling of livelihood strategies and their impacts on the natural resource base.

The participatory appraisals indicate that in all communities, soil fertility, erosion, and water quality are important concerns, but any effort to introduce watershed management will have to recognize the role of existing livelihood activities and interactions between household livelihood strategies and the environment. A major goal of the project is to increase incomes while enhancing the natural resource base, so analysis of livelihood strategies is important.

Our experiments aimed at investigating and identifying more sustainable agricultural practices will lead to increased profitability, less use of damaging and costly agrichemicals, enhanced nutrient management and methods for reducing erosion losses in highly sloped settings. In Bolivia, for example, enhanced integrated crop management is associated with as much as a 60 percent increase in yields compared with existing farmer practices. Cost of production information is being collected and analyzed for all our experiments; price data are currently being collected in the major markets.

Preliminary studies of marketing systems have helped identify key bottlenecks and alternative markets, which will possibly allow increased local capture of added value. In particular, a team of SANREM interns from Virginia Tech conducted an analysis of value-added chains in dairy markets and concluded that the markets are characterized by unequal access to information, domination by a small number of intermediaries, and lack of access for certain groups.

Research products are still in their preliminary stages. We have completed the following project working papers: an analysis of the baseline survey for Ecuador; a protocol for biodiversity monitoring; a biodiversity assessment for Bolivar, Ecuador; an assessment of governing and other institutions in Bolivar, Ecuador; and a draft of the participatory appraisal for Ecuador. In addition to these products, several presentations and abstracts by SANREM scientists have been made available, and the GIS for the two sites are available to other researchers.

Long-term training is proceeding at a pace beyond expectations. The U.S. investigators have leveraged their SANREM funding base and involved far more students in SANREM research than would be possible if we relied exclusively on project funding. Currently we have the following graduate students studying at U.S. universities: three in economics/social sciences, two in soil science, one in plant pathology, and one in biological systems engineering[2]. Also, Victor Barrera, our coordinator for South America, is completing a Ph.D. in social sciences at Universidad Politécnica de Madrid in Spain. He is being funded by a separate grant to our partner INIAP, but SANREM is providing funds for his field research, which contributes to several of our objectives. Both the Ecuador and Bolivia sites have made heavy use of *tesistas* – undergraduate students, mostly in agricultural sciences and engineering, who need practical research to complete their degrees. These students represent a low-cost means of conducting research and an important component of our SANREM long-term training. A clear benefit of the use of *tesistas* is the networking between the SANREM research team and the students' advisers.

Short-term training is proceeding according to plans. SANREM scientists have conducted a number of seminars and workshops for partner scientists, local governments, extension specialists, and farmer citizens, among project beneficiaries. Several undergraduate and research interns have been engaged in the Ecuador site: eight from Virginia Tech, who were in Ecuador in May and June 2007; one from University of Denver, who visited Ecuador in November and December 2007; and one from Florida A&M University, who conducted research in Ecuador in June 2007. Students are learning from their experience and also contributing to SANREM

[2] Julia Pryde, a graduate student in biological systems engineering at Virginia Tech, received her master's degree posthumously on May 11, 2007. She was a BSE student funded by SANREM who conducted research on the role of impermeable footpaths in contributing to soil erosion in Guaranda, Ecuador. She also coordinated the GIS system data collection with our GIS gatekeeper, ECOCIENCIA.

research, for activities during their time in the country are closely coordinated with U.S. scientists.

As noted above, our activities are heavily leveraged and, due to extensive networking, leveraging is likely to increase over time. In addition to the graduate students mentioned above, the undergraduate interns are partly supported by SANREM; other funding comes from college or university, departmental, and individual investigator sources. Research at Penn State and Virginia Tech is being supported through other grant and departmental funds. The Ecuador country team had a proposal approved by the Ecuadorian Secretaría Nacional de Ciencia y Tecnología (SENACYT). This funding, financed by petroleum surplus funds, was released beginning in May 2007 and amounts to $170,000 for this fiscal year. The money will be used to support field and experiment station research.

Research Strategy and Development Objectives

Introduction

The SANREM LTRA *Watershed-based Natural Resource Management in Small-scale Agriculture: Sloped Areas of the Andean Region* is working to address an important problem – households and communities in environmentally fragile Andean areas need alternatives to strengthen economic vitality through more productive livelihoods while ensuring environmental sustainability and social development. The research program's overall objective is to enable and support local capacity to plan policies and interventions that will raise incomes, improve social conditions, and protect and improve the environment in Guaranda, Ecuador, and Tiraque, Bolivia.

Several sub-objectives contribute to this overall objective: identify economic, social, political, and environmental conditions in the watersheds and understand the determinants of these conditions; generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation (some alternatives might be new crops and new on- and off-farm income-generation strategies; others would include technical improvements to existing practices); create a means of evaluating the impacts of alternative actions, policies, and interventions on income generation, and social and environmental conditions (this will take individual responses such as changes in practices at the field and farm household/enterprise scales, and aggregate them to the watershed level; it will create a mapping between policy and other interventions, and outcomes at the aggregate level); and build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital.

These research objectives will help us attain our development objectives within the framework for targeting outcomes of programs (TOP). Those goals are more effectively managing natural resources and ensuring sustainable use of natural resources in Chimbo, Ecuador, and Tiraque, Bolivia; diversifying economic activities through alternative natural resource-based livelihood strategies; and building social capital, enhancing local governance, and contributing to economic and social stability in resource-degraded, relatively remote rural areas.

Conceptual framework and research components

While the conceptual framework underlying our research program involves several components, it is built on a livelihoods approach to understanding human decisions. In our framework, household decisions are determined by the household's asset[3] (or capital) base; available alternatives; the institutional, policy, and social environments; exposure to risks; access to information; and the natural environment (Figure 1). Households allocate assets among activities to meet an objective such as utility maximization, profit maximization, risk minimization, or long-term well-being. This set of activities is known as a livelihood strategy. In our research program, household decisions about livelihoods, use of natural resources, and investments in natural resources will be investigated. Particular attention will be devoted to identifying the determinants of household decisions and how actions such as policy changes, local land-use plans and restrictions, and changes in incentives such as market prices affect these decisions.

We will see two broad types of impacts resulting from policy or institutional innovations in the watersheds: changes in a household's well-being and its asset position, and environmental impacts on soil quality and quantity, biodiversity, and runoff and water quality. The latter impacts will be felt at the field and farm level, but due to geographic inter-linkages implied by the watershed, they will be aggregated to the watershed level. Some local actions have impacts on a larger scale (runoff, carbon sequestration).

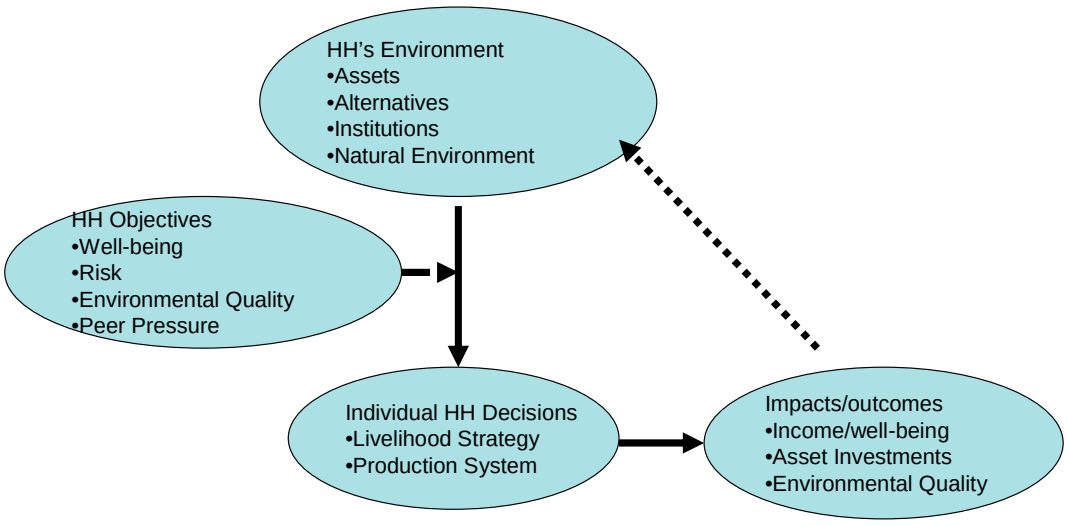


Figure 1: Household decisions and impacts

The watershed is affected by individual decisions that have cumulative impacts at the watershed and policy/market levels. We use a physical model of the watershed to create a mapping between the quantity, quality, and spatial distribution of human activity and space-related aggregate

[3] Assets are broadly defined to include financial assets (savings, access to credit), physical assets (ownership of farm equipment, other productive and non-productive durable goods), human capital (number of family members, levels of education, work experience), natural capital (access to land, quality of land, access to woodlands, water), location-specific capital (access to roads and markets, electricity, cellular services), and political and social capital.

outcomes such as runoff, water quality, and aquatic biodiversity. Economic models will measure aggregate impacts on economic well-being and markets. These models also simulate the impacts of alternative interventions (e.g., price policy, land-use regulations, land-use planning) on aggregate outcomes. The watershed planning model, comprising physical models of the watershed combined with models predicting how households will respond to changes in their environment, will be built, validated, and tested as a part of the research. These models will be used to inform local and regional decisions.

Acceptance of model findings requires buy-in of stakeholders, which will be facilitated by involving stakeholders in field research, and model and scenario development. We have taken an adaptive management approach to facilitate this buy-in.

Adaptive watershed management approach

The watershed management approach (Figure 2) is an adaptive management technique for achieving water quality and other environmental and economic goals in areas defined by watershed boundaries. Watershed boundaries are used because people's livelihoods are intimately tied to the integrity of water resources, previous cooperation on management of water resources is likely, and cooperating on water resources issues often leads to development of skills and cooperation needed to successfully address other development needs. The approach sequences the required monitoring, data analysis/assessment, planning, and implementation activities according to an annual schedule (e.g., monitoring in Year 1, data analysis/assessment and modeling in Year 2, plan development in Years 2 and 3, implementation in Years 3 and 4). The adaptive management cycle continues to work toward existing and new goals as they arise. Common elements of the approach include:

- definition of management units – large, small, or multiple watersheds
- definition of management cycles – time required to complete a monitoring, assessment, planning, and implementation cycle (typically four to five years)
- stakeholder involvement – agencies, organizations, and individuals interested in the water quality, ecosystem health, economic objectives, and strategies included in watershed management activities
- strategic monitoring – water quality, ecological health, and economic indicators monitored to measure the extent of problems and the stressors involved
- assessment – data analysis and professional judgment used to identify problems, sources, and stressors; water quality, environmental, and development goals are integral to assessments because they reflect criteria for achieving desired goals
- prioritization and targeting – areas within watersheds are ranked according to resource value, magnitude of problems, and other factors; specific sites are targeted for special management attention
- development of management strategies – realistic goals are set for the watershed, management strategies are then developed before allocating scarce resources
- watershed plans – these plans document the assessment results, goals, and chosen management strategies for the watershed; a plan is revised periodically (e.g., every five years); the plan also serves to educate the public on watershed-specific issues, and

- implementation – selected management strategies are implemented in the years between updates of the plan.

These elements are embedded in the different stages of the process presented in Figure 2.

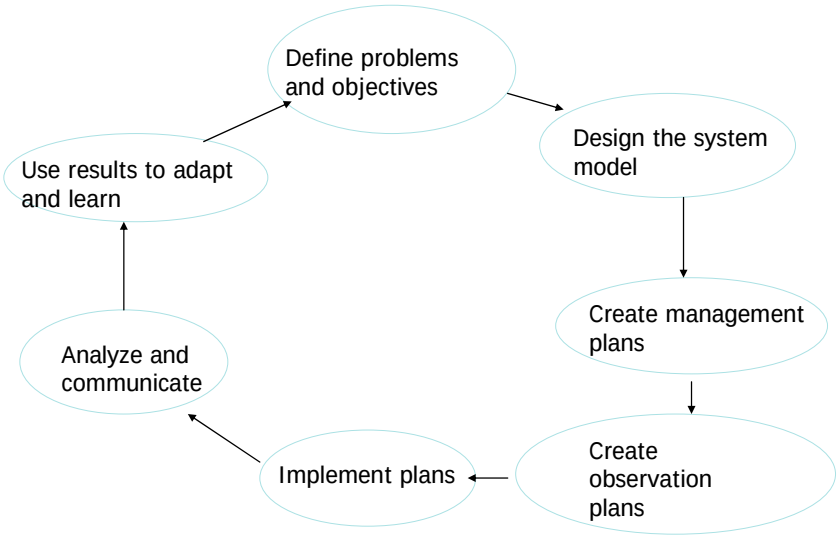


Figure 2: Adaptive watershed management

Methods and research components

Our research activities are divided into five components roughly corresponding to research Objectives 1-4. Activities involve a number of scientific disciplines – soil science, agricultural engineering, geography, plant pathology and agronomy, socioeconomics, ecology, biology – and in most cases the work is trans-disciplinary in nature. For example, social scientists and agronomists identified agronomic constraints faced by stakeholders; research was then designed with stakeholder input to address these constraints but with input from social scientists and bio-systems engineers who will use the research output for their modeling efforts. A schematic of the linkages between the different research components is presented in Figure 3.

Collaborative baseline development component. We invested significant resources into describing economic, social, and physical characteristics of the watersheds. Some of this description is being used to create an information baseline from which comparisons of changes will be made over time (e.g., socioeconomic baseline, assessment of biodiversity, aggregate information on soil loss and soil productivity). It will also be used to build our three basic models: physical production (soil and environmental attributes, productivity); models of household decisions (using data from socioeconomic baseline surveys plus geo-referenced data on agro-climatic conditions, distances to markets); and models of physical impacts of individual

and aggregate decisions (the relationship between activity on the landscape and outcomes such as aggregate soil loss, runoff, water quality).

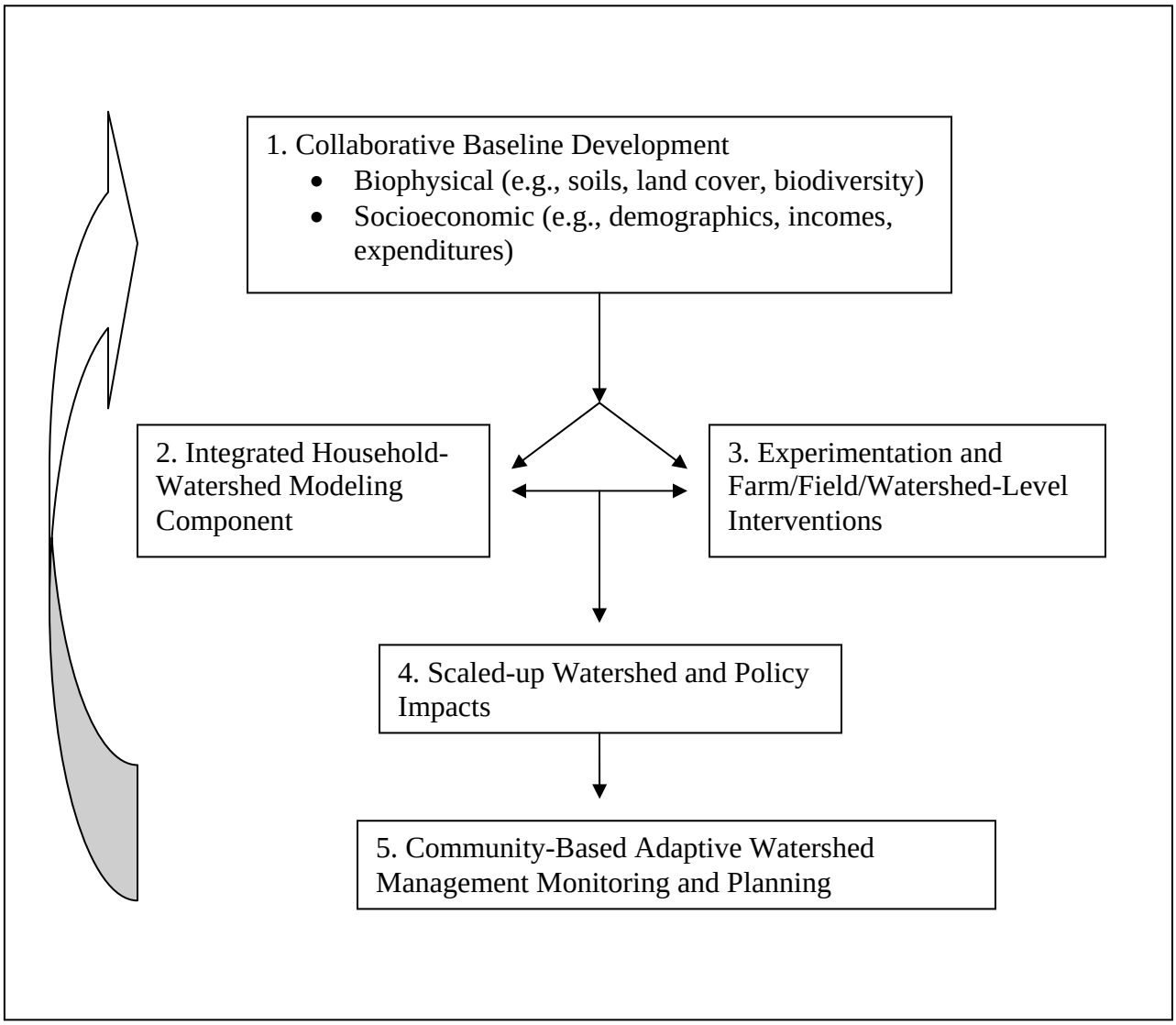


Figure 3: Research Components and Linkages

Integrated household-watershed modeling component. This research component uses information on livelihoods and outcomes but also agro-climatic data, access to infrastructure, and risk environment. We employ two broad means of modeling household decisions: a positive analysis using econometric techniques in a two-stage process, and a normative analysis using programming techniques. In the first stage we estimate the determinants of livelihood adoption using a multinomial logit or similar econometric technique; in the second stage we estimate the well-being impacts of this adoption, conditioned on the adoption decision. This positive analysis will be used to determine how households respond to changes in the physical, institutional, and social environment, and how these responses affect household well-being. It will also be used to determine the impacts of policy and institutional changes. The normative analysis incorporates information from the econometric analysis (how households will be expected to react to

changes), budgets on costs and resource requirements of different activities, and market price information. It creates predictions of responses to policy and other changes by representative household types (based on asset profiles) in a programming approach. These predictions are then aggregated and incorporated into the watershed model.

Experimentation and field/farm/watershed-level interventions. This research includes information on improved production practices (new varieties, inputs and management techniques), the relationship between practices and outcomes (income, soil loss, and on-farm productivity), alternative production and livelihood activities, and obstacles to adoption of new livelihood and production activities. It also includes an analysis of market functioning and barriers to participation in different, often higher-valued, markets. We also conduct case studies of small-scale value-added processing activities; these activities might affect livelihoods over time. The information on these alternatives is then incorporated into the household models to simulate how livelihood changes will result from changes in policy and watershed plans.

Scaled-up watershed-policy impacts. The inputs into the watershed models include much of the information generated above. The models will create a linkage between field- and farm-level activities and aggregate outcomes such as water quantity and quality, soil loss, sedimentation, and carbon flows. The watershed models will take information on the spatial distribution of natural conditions, rainfall, and human decisions, and will relate this information to aggregate outcomes. They will be used to simulate the aggregate impacts of alternative policies on outcomes of interest.

Community-based adaptive watershed management monitoring and planning component. To build local capacity to use the information created through the economic and watershed models, the stakeholders will be engaged in a participatory watershed planning process. This process will begin with a community visioning exercise whereby problems and concerns along with objectives are identified.

Each of the activities in our annual planning matrix can be located within each or several of these five components.

Research activities are conducted in laboratories in Ecuador, Bolivia, and U.S. participating universities, on-station, on farmer fields, and in participating communities. Physical science experiments are all conducted under standard scientific norms with replication and randomization. Social science activities include quantitative data analysis using data from random surveys, budget and cost analysis, and qualitative and participatory analysis. Research activities are conducted in a collaborative fashion, with U.S. and host-country scientists designing the experiments following discussions with stakeholders where appropriate. Many on-field experiments use stakeholder involvement to replicate farmer and decision maker behavior and to build confidence in study findings.

Research Progress

<u>Objective 1</u>: to identify economic, social, political, and environmental conditions in the watersheds, and understand the determinants of these conditions

Research to meet this objective is undertaken through Research Component 1 and includes the collection of spatial data, soil data, price and yield data, and analysis of soil data to understand the relationship between soil erosion and carbon retention. Data are also being collected to build the GIS and enable detailed physical modeling of the watershed. Data requirements for watershed modeling activities are substantial, and data collection is well underway in both countries.

Biophysical baseline – watershed boundaries

A major objective was to accurately define the boundaries of the study watersheds. Watershed boundaries are based on topographic maps. Typically, boundaries are generated from digital elevation models (DEMs). While several sources of DEMs are available, the quality of data varies, and mountainous areas such as the study watersheds provide additional challenges. A study was conducted to evaluate the accuracy of watershed boundaries derived from different sources of elevation data. The three sources of data were the Shuttle Radar Topography Mission (SRTM), the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), and a 1:50 000 topographic map, the most detailed data available for the study area in Ecuador.

The SRTM, developed jointly by NASA and the National Geospatial Intelligence Agency, provides elevation datasets for the globe at 3 arc second resolution, about 90 meters at the equator (U.S. Geological Survey, 2006). We obtained the 3 arc second SRTM DEM for Ecuador distributed by the CGIAR Consortium for Spatial Information (Jarvis *et al.*, 2006) during the summer of 2006. In November 2006, the SRTM data were updated covering the Ecuadorian region, and we obtained the new version. The 3 arc second SRTM dataset was transformed into the appropriate spheroid on which the 1956 Provisional South American Datum (PSAD56) is based. Then the data were projected into the PSAD56 Universal Transverse Mercator Zone 17 projection with a 90-m cell resolution. Significant voids are often encountered in SRTM data covering mountainous regions. Many data voids have been filled by CGIAR-CSE in post-processing. There is no universal method for projecting and interpolating SRTM datasets in mountainous regions.

ASTER is an advanced multispectral imager launched on NASA's Terra spacecraft in December 1999. ASTER covers a wide spectral region with 14 bands from the visible to the thermal infrared with high spatial, spectral, and radiometric resolution. The spatial resolution varies with wavelength: 15 m in the visible and near-infrared (VNIR), 30 m in the short-wave infrared (SWIR), and 90 m in the thermal infrared (TIR). The ASTER DEM product is generated using nadir-viewing (3N) and backward-viewing (3B) bands of an ASTER Level-1A image acquired by the VNIR sensor. The VNIR subsystem includes two independent telescope assemblies that facilitate the generation of stereoscopic data. The Band-3 stereo pair is acquired in the spectral range of 0.78 and 0.86 microns with a base-to-height ratio of 0.6 and an intersection angle of about 27.7°. There is a time lag of about one minute between the acquisition of the nadir and backward images.

Watershed boundaries were derived from the DEMs using automated procedures with the Watershed Delineator (written by the Environmental Systems Research Institute (ESRI) and the Texas Natural Resource Conservation Commission), an ArcGIS Extension that requires the Spatial Analyst extension to be installed as well. The GIS technique for watershed delineation consists of the following steps. First, the "Fill" tool was used to fill sinks in the elevation grid; this removed small imperfections in the data and enabled the "Flow Direction" tool (the second step) to run properly and create a grid of flow direction from each cell in the elevation grid to its steepest downslope neighbor. Then the "Flow Accumulation" tool was used to create a grid of accumulated flow to each cell from all other cells in the flow direction grid. The next step was to identify the watershed outlet grid, ensuring that was located directly over a grid cell from the drainage network. Finally, the "Watershed" tool was used to delineate the watershed for the specified outlet. Boundaries (in grid format) were defined. Using Spatial Analyst, the watershed boundary and the stream grids were then vectorized to produce polygon and polyline themes, respectively, for further analysis and comparison. The watershed boundary from the 1:50 000 topographic map was delineated by hand, then digitized by ECOCIENCIA personnel.

The three watershed boundaries were compared visually. Regression analyses were then conducted to compare each of the DEM-based watershed boundaries to the manually delineated boundary. For the regression analyses, a Cartesian coordinate system was used to compare the values of x at the same y location on the two boundaries to determine how similar they were. A total of 468 points, at constant intervals of 100 m, were utilized in each regression analysis for the complete watershed boundary. Then a t-test was conducted to determine if the differences in the x-values between one DEM-based boundary and the manual boundary were significantly different than the differences in x-values between the other DEM-based boundary and the manual boundary.

Visually, there were only small differences between the manually delineated and SRTM-based boundaries, while the ASTER-based boundary varied from the manually delineated one. The area of the watershed delineated manually is 13,061.3 hectares, while the SRTM-based and the ASTER-based watersheds are 0.66 percent and 2.6 percent larger, respectively. The regression analyses comparing the complete boundaries yielded an R^2 of 0.999 between the SRTM and manual boundaries and 0.988 for the ASTER and the manual boundaries. The t-test comparing DEMs indicated a significant difference ($p< 0.001$) in the distance differences. To determine the cause of the errors in the ASTER DEM, map algebra was used to define where the "Fill" tool had filled the sinks, finding that the errors in the stream network occurred where some especially large (60 to 100 m) fills had occurred. Then the ASTER-DEM was corrected and processed to obtain a new watershed boundary with almost no difference with the hand-drawn boundaries. Clearly, the accuracy of the watershed delineation depends on the accuracy of the available DEM.

ASTER data have several advantages, including low cost, high spatial resolution, and good correlation over vegetated areas. Disadvantages include mainly the potential masking by clouds. On the other hand, elevation models produced from SRTM data will be the highest resolution topographic dataset ever produced for the Earth's land surface. Therefore, an obvious advantage

of SRTM is the significant increase in spatial resolution and vertical accuracy over existing global elevation data, although the accuracy is clearly dependent on terrain vegetation that radar cannot penetrate. ASTER DEMs appear to be highly complementary to other types of satellite-derived data, such as SRTM. A fusion of DEMs from different sources (optics and radar) leads to improved results in comparison to the reference DEM.

The results of this investigation (Pryde *et al.*, 2007) were presented in June 2007 at the annual international meeting of the American Society of Agricultural and Biological Engineers in Minneapolis.

In-country GIS development

Ecuador

The team, led by ECOCIENCIA, elaborated historical maps of vegetative coverage from 1991 and 1999, and combined these with recent images from 2006, validated on the ground. Digital formatted information on basic land cover and land use for the Chimbo sub-watershed has been incorporated into the GIS. Additional layers include the hydrographic net, roads, population centers, altitude, land use and land cover, climate, and geomorphology. The baseline survey, conducted by INIAP in November and December 2006, has been digitized and incorporated into the GIS.

Bolivia

Basic maps of geology, geomorphology, slopes, erosiveness, and land use have been digitized and entered into the GIS, which is managed by PROMIC. Five zones for study in the sub-watershed have been identified; more intensive examination of soil erosion and degradation will occur in the subsequent project year using on-farm trials to generate geo-specific data. The information from the GIS was used in conjunction with field visits and other methods to create a detailed thematic map of risk of erosion (Figure 4). Samples were taken in the field to ensure that the map was an accurate reflection of conditions. This process was followed to obtain the map shown in Figure 5.

Soil erosion and carbon retention

Researchers are documenting the extent and severity of soil erosion in the region, paying particular attention to impacts on soil carbon retention, to understand the effects of land use on soil erosion and soil carbon content. The watershed in Ecuador is experiencing a classic syndrome of soil resource degradation driven by uncontrolled deforestation and crop cultivation in an area of high erosion risk, without soil conservation. The high-altitude soils of Alto Guanujo are fairly resistant to erosion and appear to be tolerating intensifying land use reasonably well. However, the older soils of Chillanes, many on slopes of 100 percent or more (i.e., a slope angle of 45 degrees or more), are suffering degradation that has already reduced productivity and will severely limit the agricultural base of the central watershed within the next two to three decades if unchecked. Rational land uses would be sustainable forestry or low impact agro-forestry and silvo-pastoral systems. Instead, the region has experienced massive deforestation over the past 40 years, resulting in loss of 80 percent of the original forest cover in areas around Chillanes. Cleared land is used for crop cultivation with no regard for soil conservation methods, resulting

Figure 4: Process used to produce risk map.

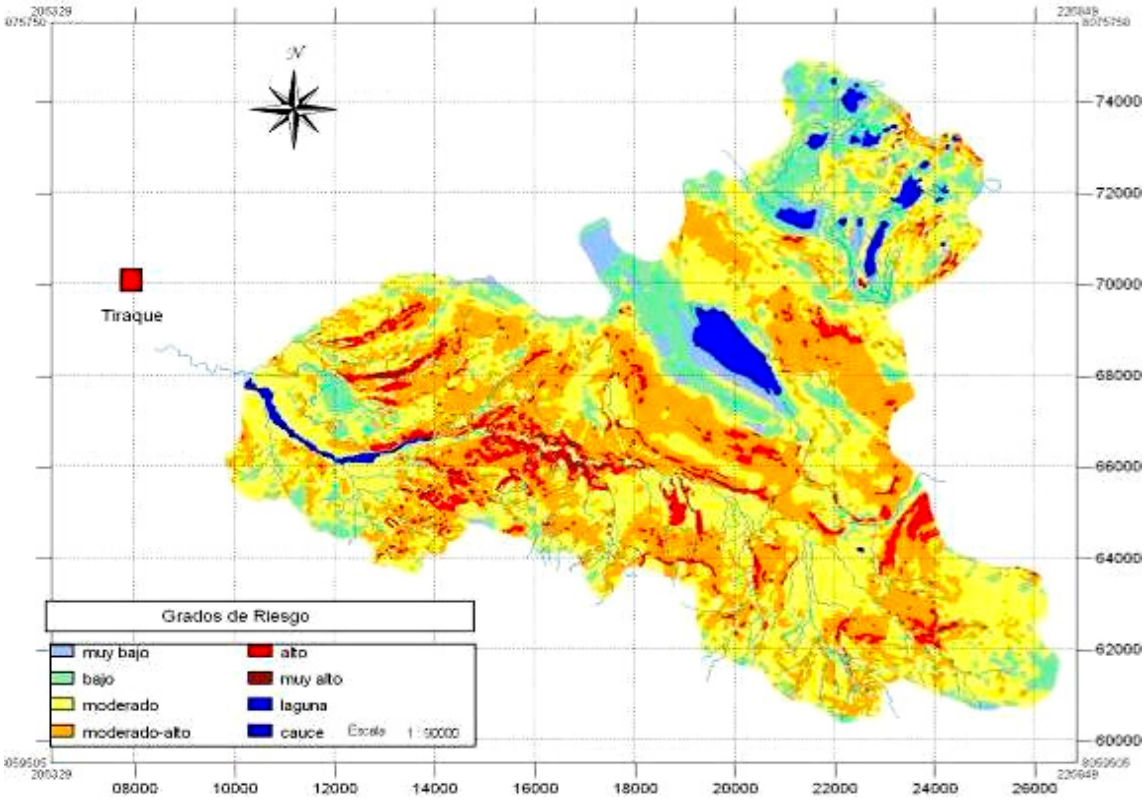


Figure 5: Risk map for Tiraque, Bolivia watershed

in loss of topsoil and soil nutrients, exposing infertile parent material or cemented horizons characteristic of volcanic soils of this region. Loss of forest and topsoil results in reduced soil water retention, more erosive runoff, and a vicious cycle of soil loss and water loss. Farmers report crop yields of only 5 percent to 10 percent of reasonable yield potential in this region, and that yields have dropped by half over the past 10 years. Fertilizer costs are growing and already account for more than one-third of production costs. Water has become scarcer due to reduced retention as well as reduced precipitation; this could be related to deforestation, which reduces transpiration and total water retention. Sampling confirmed this analysis, with intensive cropping associated with reduced soil fertility and soil depth.

Erosion assessment by ^{137}Cs analysis. All soil samples collected in 2006 were analyzed for ^{137}Cs radionuclide content to assess erosion by land use and location. This analysis was conducted at the Penn State Radiation Science and Engineering Center using High-purity Germanium Spectroscopy. Results indicate that the Chillanes region has experienced significantly lower levels of erosion compared with Alto Guanujo and Guaranda (Figure 6). This may be due to the longer amounts of time that land in Alto Guanujo and Guaranda have been in cultivation. We also observed more uniform ^{137}Cs concentrations in Chillanes with depth in the soil profile, which may be due to increased mixing from higher levels of biological activity at the low altitudes of Chillanes.

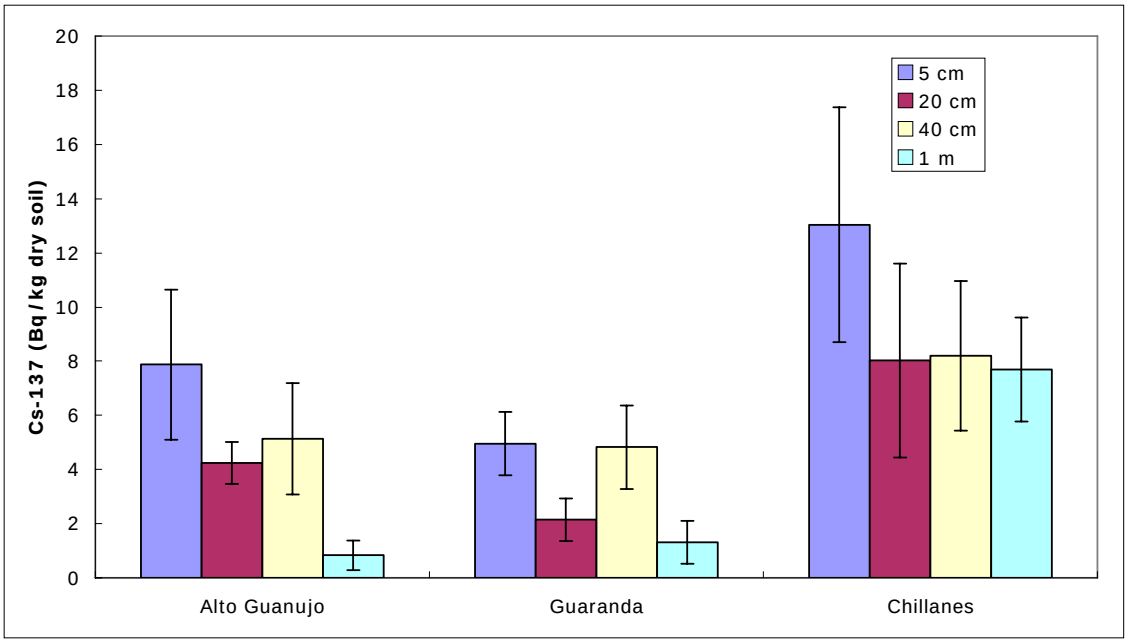


Figure 6: ^{137}Cs content in soil by location.
(Higher ^{137}Cs levels indicate lower levels of erosion over approximately the last 5 decades. Values shown are means ± standard error.)

Land-use effects on erosion were observed through the ^{137}Cs analysis (Table 1). Natural forest land showed by far the lowest levels of erosion. Paramo and pasture showed higher levels of erosion than expected. This may be due to effects of grazing pressure and rotations between annual crops and pastures. Soil samples were also collected in 2007 by Penn State graduate

students Amelia Henry and Raul Jaramillo and INIAP researcher Yamil Cartagena; these are currently being analyzed for ^{137}Cs content.

Although the cumulative erosion levels in Chillanes are currently among the lowest of the watershed, erosion pressure in Chillanes is by far the highest. The forests of Chillanes show the lowest levels of erosion of all samples collected, but annually cropped fields had erosion levels similar to those of Alto Guanujo. These results point to the destructive land-use practices of the Chillanes region that are causing rapid soil loss, for land in Chillanes has been in cultivation for much less time than in Alto Guanujo.

Table 1. Land-use effects on erosion determined by ^{137}Cs analysis

	Average ^{137}Cs at 5 cm depth (Bq/kg dry soil)
Annual	4.1
Forest	17.4
Paramo	3.1
Pasture	5.9
Tree plantation	4.0

Soil organic-matter content. All soil samples collected in 2006 and 2007 were analyzed for organic matter by the "loss on ignition" method (Figure 4). Average levels of soil organic matter ranged from 9.6 percent in Guaranda, to 12 percent in Alto Guanujo and 17 percent in Chillanes. These high levels of organic matter reflect the unique properties of Andisols, which is the dominant soil order of the Rio Chimbo watershed. Andisols are derived from volcanic matter that quickly forms the amorphous alumina silicate allophane. Allophane is highly reactive with carbon and therefore can adsorb and stabilize organic matter for many years. Soil organic matter is significantly reduced in all land-use treatments compared with natural forest land (Figure 7). These results indicate the importance of implementing soil conservation measures, both for soil health in the region as well as on a global scale for this valuable carbon-sequestering soil.

Soil fertility characterization. Although the Andisols are typically well-drained, high-carbon soils, allophane also strongly absorbs soil phosphorus, leading to reduced fertility. Soil phosphorus levels were characterized in all samples from 2006 and 2007 by Mehlich-3 analysis. Soil phosphorus in the top 5 cm of soil averaged 2.5 ppm in Alto Guanujo, 4.5 ppm in Guaranda, and 0.7 ppm in Chillanes. Levels of Mehlich-3 extracted phosphorus for optimum crop productivity should be 20-30 ppm. Soil phosphorus changes with depth showed dramatic stratification with depth in Alto Guanujo, variable changes with depth in Guaranda, and uniform but very low phosphorus levels with depth in Chillanes. Soil pH measured at all sites was on average 6.0, a moderate level for plant growth. Soil acidification was seen at shallower depths in all land-use categories except natural forest and those fields sampled from Alto Guanujo.

Physical soil characterization. Bulk density was measured at 20 cm from all sites sampled. No significant effect of land use on bulk density at 20 cm was observed, but the Chillanes region showed on average the lowest bulk density levels. To supplement this data, 15 soil pits were excavated to 1 m to measure bulk density at four different depths (Figure 8). These values are

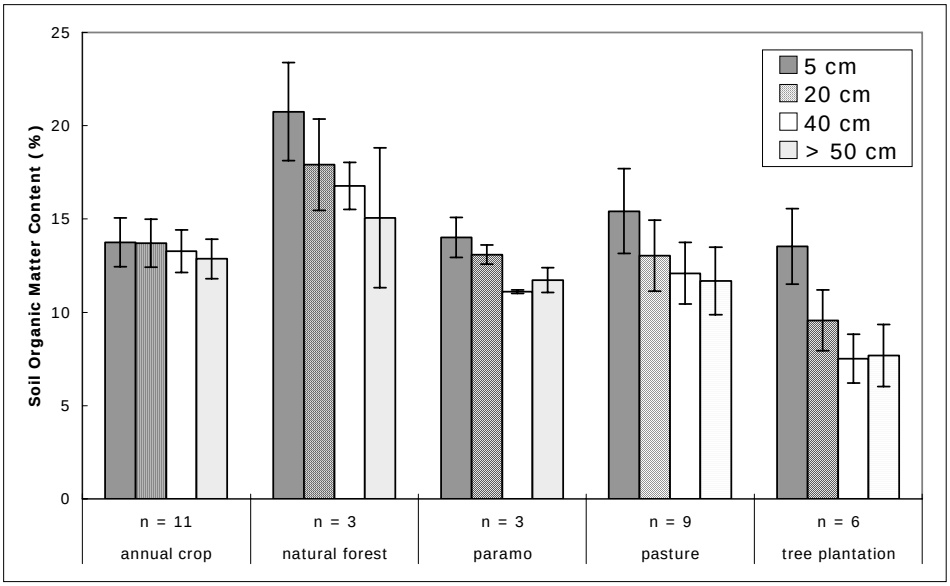


Figure 7: Soil organic-matter content by land use in all soil samples.
(Values shown are means ± standard error.)

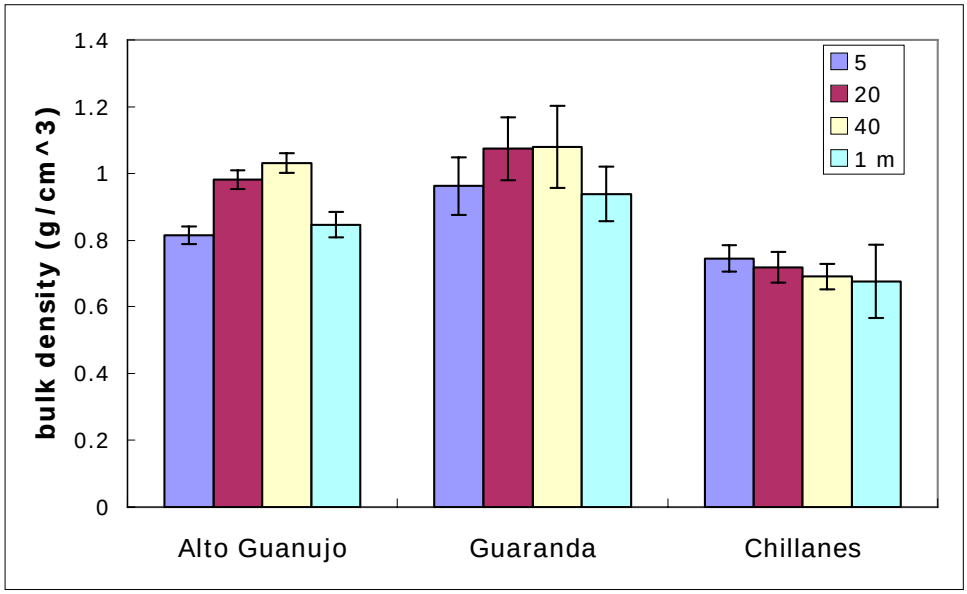


Figure 8: Bulk density with depth from 15 soil pits to 1-m.
(Values shown are means ± standard error.)

critical for extrapolating bulk density data to one meter at all sites, which will be used for calculating soil carbon storage levels.

Measurement and monitoring biodiversity. ECOCIENCIA has completed and published a protocol for biodiversity measurement and monitoring. This protocol is currently being implemented. An initial assessment has been completed, and a draft of the publication is available through the SANREM Knowledgebase. The main finding is that the study area in Ecuador characterized by significant biodiversity is threatened by human activities. Wooded

areas are fragmented, native vegetation continues to undergo stress, and threatened bird, mammal, and amphibious populations are common. More research is needed to understand the impacts of fragmentation, edge effects, and the relationship between sustainable biodiversity and introduction of non-native species.
The Bolivian partners want to apply the biodiversity measurement protocol to their own area; field visits have confirmed, contrary to initial perceptions, that biodiversity is extremely important. SANREM is providing resources so the ECOCIENCIA protocol can be adapted and tested in Tiraque, Bolivia.

This activity generates information on human responses and well-being outcomes, on how decisions are made (and gender roles in the process), and how community actions affect overall well-being and use of the natural-resource base.

Socioeconomic baseline

Collection of cost of production data. These data are needed to evaluate the profitability of alternatives, as inputs to the household and watershed models, and to understand the determinants of household livelihood strategy adoption. A protocol has been finalized for collection of these data for both Bolivia and Ecuador. The protocol uses both survey and non-survey techniques and has been used to collect cost of production for several crops in Ecuador. In both countries, cost of production data is being collected in all field experiments and participatory plots. Andy Sowell, an undergraduate intern from Virginia Tech, together with INIAP field staff, completed budgets for maize, beans, and potatoes. Yield data are being collected as the crops are harvested over the next few months. In Bolivia, prices are being collected at key markets, and information is being obtained from farmers about their concerns with respect to market access.

A process for evaluating market chains was tested in Ecuador in June 2007 by undergraduate interns Heather Weeks and Wendy Slusher from Virginia Tech and an Ecuadorean honors student. These students evaluated the various markets for fluid milk and dairy products in the Upper Guanujo watershed and conducted an analysis of market access. Main findings show that the milk markets are highly segmented and characterized by asymmetric information, price and market risk, and high transactions costs. Gender roles are highly differentiated; while women and girls are heavily engaged in on-farm production, sales and marketing are controlled by men.

Baseline socioeconomic surveys. These surveys provide a baseline by which project impacts can eventually be measured and will be used for the analysis of the determinants and impacts of alternative livelihood strategies. They also provide valuable inputs into the household and watershed models that will form the analytical foundation of our adaptive watershed management efforts. The Ecuador baseline survey has been completed, and a preliminary analysis of it has been undertaken. Surveys were taken of 286 families in the Alumbre micro-watershed (lower watershed) and the Illangama (upper watershed). Findings from the descriptive analysis indicate stark differences in conditions between the upper and lower watersheds, rather diverse livelihood strategies, and major differences in gender roles. Despite the high degree of soil degradation in both watersheds, fewer than 30 percent of farmers use or are aware of soil conservation methods.

This information is being used to estimate livelihood clusters, their determinants, and to generate estimates of production costs in support of other modeling efforts. A local undergraduate student is using data to support her thesis, "Characterization of the production systems in the Chimbo watershed."

The baseline survey in Bolivia suffered from delays but was implemented in July through September 2007. In February 2007, Virginia Tech experts consulted with the PROINPA and CERES partners responsible for implementing the baseline in Bolivia and made substantial revisions to the survey instrument and sampling frame. We decided that field application should begin after the past cropping cycle so that the agronomic information would clearly correspond to current conditions. Enumerators were trained in a lengthy session, and the survey was piloted before full-scale implementation. The survey contains observations from 400 households, 290 of these from the 14 communities in the watershed and 110 from four communities outside the watershed without cell-phone coverage[4]. Analysis of the data is ongoing.

Concurrent with the baseline survey, PROINPA conducted a social assessment of the communities and examined institutions for water management in the watershed.

Objective 2: to generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation

Research to meet this objective is undertaken through Research Component 3 and includes laboratory work to identify solutions to key agricultural pest problems, on-farm participatory evaluations of alternative crop varieties and farming techniques.

Laboratory experiments

Information is being sought on the optimal means of combating cacao pathogens for the lower Chimbo watershed in Ecuador[5]. Experimenters at Penn State tested the ability of *Bacillus* spp. to produce enzymes that could degrade pathogen cell walls. Of 69 isolates, 15 were chitinolytic, capable of degrading fungal cell walls. These 15 isolates were tested for their ability to colonize clonally propagated cacao ICS1 trees as well as to suppress disease in detached leaf assays.

All isolates were capable of colonizing cacao foliage when introduced with a polysilicon surfactant, but only a few elite isolates were capable of colonizing foliage at high population levels. Also, only a few of the elite isolates were capable of reducing disease in the detached leaf assay in the preliminary experiments. Phylogenetic analysis will be conducted to determine the taxonomic classification of these isolates. In addition, we began potted plant testing the elite Ecuadorian isolates at the INIAP station in Pichilingue, beginning in May 2007.

This preliminary research will be followed by field-level assays on elite bacterial endophytes and evaluation of an endophyte testing method for field use. We will conduct experiments to determine optimal methods for establishing efficacious levels of colonization and evaluate

[4] An important research endeavor planned for the next year is to examine the role of access to information on market choice, market participation and efficiency.

[5] The Ecuador site has two sub-sites (watersheds): the Upper Guanujo region (the "upper" watershed) and the area around the town of Chillanes (the "lower" watershed).

methods for determining levels of induced resistance by challenging leaves and stems with native pathogens.

Field experiments

As a part of the analysis of NRM options in the context of improved livelihoods, several field-level experiments have been established in each site.

Ecuador

Field experiments were established for nutrient management for maize-bean associations and other crop alternatives in the lower Chimbo watershed. Erosion measurement plots were established in Chillanes, Ecuador, to examine erosion under beans, maize, and pasture production systems. The experiments are set up in a randomized block design with three repetitions. Each erosion test plot is 15 m^2. In the first year, we measured daily rainfall, runoff volume, and weight of solid runoff. This experiment was established in March 2007, and bi-weekly data have been collected; yields of product also were taken at harvest in October 2007. Data will be used to estimate the relationship between management practices, rainfall, and soil erosion. As long-term sustainability of the agricultural system depends on maintaining a productive soil base, these experiments will assist the researchers and individual decision makers by identifying soil-conserving cultivation practices.

Seven field-level activities are being undertaken in both Ecuador sub-sites to examine soil nutrient requirements and nutrient flows. Because of variable agro-ecological conditions in the watersheds, specific recommendations for nutrient applications are required. Experiments were established to generate nutrient recommendations; the experimental design is complete random block design with three repetitions. The treatments are presented in Table 2, and data from these experiments are currently being analyzed.

Table 2: Treatments for nutrient recommendation experiments

Treatments		N	P_2O_5	K_2O	S	Mg
No.	**Nutrients**			**kg/ha**		
1	PKSMg	-	60	60	40	20
2	NKSMg	120	-	60	40	20
3	NPSMg	120	60	-	40	20
4	NPKMg	120	60	60	-	20
5	NPKS	120	60	60	40	-
6	NPKSMg	120	60	60	40	20
7	NPKSMgZn*	120	60	60	40	20
8	Agricultor	60	30	30	-	-

Additional research activities in Ecuador are designed to evaluate, in a participatory fashion, improved varieties for adoption in the areas. These include seed potato production, barley, chocho, quinoa, maize-beans associations, and blackberries. The latter experiment will assist in managing soil conservation. Demonstration plots and participatory experimental plots have been established in the communities of Culebrillas, El Carbon, Chinipampba, and Marcopamba in Illangama; and Bola de Oro and El Panecillo in Alumbre. The demonstration plots also include a

number of soil conservation practices including grass strips, contour plowing, natural and rock boundaries. Costs and yields associated with each variety and practice will be evaluated at the end of the growing season. Interviews with farmers and their families will be conducted to gain an understanding of taste and preferences for the varieties. Complementary market assessments are also being undertaken.

Although experimental data from this analysis are still being analyzed, the maize varieties are showing significant promise; they are short-season (thus lower the potential damage from drought) and high-yielding.

An additional analysis was conducted of the viability of alternative forage-livestock production and marketing systems for the Illangama watershed, where pasture/livestock systems are extremely common. These systems, however, are characterized by low levels of productivity, and efforts are clearly needed to improve them. The research examines two dimensions of the problem: quantity and quality of the forage and limitations to expanded use (number of animals) of existing forage. The second problem has been identified as more limiting; because of low profits associated with livestock production, pastures are slowly being converted to small grains, with concomitant environmental damages. Improvements in dairy marketing processes are necessary to promote intensification of dairy production in the area.

Bolivia

Several field experiments have commenced in the Tiraque watershed. In conjunction with local farmers, we are examining integrated crop management for potatoes, fava beans, and strawberries. Seven demonstration parcels for potatoes and six for fava beans were established to test yield differences between farmer practices and integrated crop management (ICM).Yield enhancements in ICM ranged from 38 percent to 64 percent, depending on the crop and location. Benefit-cost analyses of differences showed that ICM was superior. Differences were more pronounced in the upper portions of the watershed.

Eight experimental plots were established to determine the appropriateness of five new potential crops for the highland zone to fit into a potato rotation. Plots of maca (*Lepidium myenii*), kanawa (*Chenopodium pallidicaule*), forage oats (*Avena sativa*), quinoa (*Chenopodium quinoa*), and tarwi (*Lupinus mutabilis*) were established and evaluated for suitability at the high elevations of the watershed. Tarwi, quinoa, and kanawa were not deemed to be appropriate, having virtually no yields. Maca yields varied from 12.9 tons per hectare to 19.8 t/ha, which is comparable to yields in other locations and indicates the suitability of this product. The oats yields ranged from 43.7 to 143.7 t/ha (wet matter) and is also suitable for the conditions.

Strawberry trials have been established on seven farmer fields in six communities; three are in the lower zone and four in the middle-elevation zone. Preliminary evidence shows more potential for strawberry production in the lower parts of the watershed[6]; final judgment will follow the harvest. Subsequent research will examine barriers and market-related factors associated with commercialization processes.

[6] The Tiraque watershed has been divided for analysis purposes into four zones.

Timeline and problems encountered

Activities are proceeding as planned in Ecuador. In Bolivia, weather has not cooperated (El Niño phenomenon), and scientists are concerned about the representativeness of their results. Another concern is related to the seed-potato activities in the upper parts of the Tiraque watershed in Bolivia, where PROINPA is undertaking research on farming alternatives. This area is practically uncultivated, but population pressures are pushing farmers to use the land more intensively. The team would like to examine the possibility of more intensive use of lower lands combined with efforts to preserve land in its natural state in the uplands. The Penn State partners are actively involved in interactions with Ecuadorian collaborators. Activities in Bolivia are proceeding with less participation of U.S. scientists due to budgetary limitations. Slower ramping up of the Bolivian project was envisioned during project planning, but Bolivian counterparts continue to be frustrated by limited interactions with U.S. scientists.

Objective 3: create a means of evaluating the impacts of alternative actions, policies and interventions on income generation, and social and environmental conditions

This sub-objective will take individual responses (changes in practices at the field and farm household/enterprise scales) and aggregate them to the watershed level. It will create a mapping between policy and other interventions, and outcomes at the aggregate level.

Research for this objective is conducted under Research Components 2 and 4, combining socioeconomic and biophysical data through household and watershed modeling efforts to estimate impacts at the watershed level.

Household models

Robert Andrade and Catherine LaRochelle, students at Virginia Tech, have begun analyzing the baseline data to build household models. These models will be incorporated into the watershed models to help understand how people, erosion, and water quality are affected by policy and management instruments. An Ecuadorian undergraduate honors student is using the data to support her thesis, "Analysis of sustainable livelihoods of rural households within the Chimbo watershed." In both countries, market price data are being collected to support subsequent modeling efforts.

Livelihood strategies

In addition to using the baseline data to create coefficients for the household models, we are undertaking an econometric analysis of the data. This analysis will identify different typologies of households and their livelihood strategies; explore the determinants of adoption of each livelihood strategy; and examine the impacts of adoption on a variety of measures of household well-being. Analysis to date indicates a rich set of livelihoods even within the apparently homogeneous Illangama and Alumbre watersheds. Although agricultural practices are relatively similar in each sub-watershed, households show strong diversity in their relative dependence on different sources of income. Some are nearly entirely dependent on agricultural income, while

for many others, income from on-farm activities represents a relatively minor share of the household total.

This analysis, in conjunction with the household model, will highlight the different potential development pathways, constraints to entry into particular pathways, and the relationship between environmental conditions and outcomes and these pathways. Determinants will include assets and capital, household structure and human capital, and gender considerations. Andrade will conduct this analysis as a part of his master's thesis work and will deepen the analysis using participatory methods this summer in Ecuador.

Watershed modeling

The watershed visit to Ecuador in the summer of 2006 and subsequent literature review indicated that soil erosion and fertility are significant environmental stressors of SA livelihoods within the region. Footpaths and unpaved rural roads have been identified as possible causes for soil erosion and decreased fertility. These transportation routes can create both massive amounts of loose sediment during their construction and also impervious surfaces that increase surface water runoff impacts. Julia Pryde, a Virginia Tech master's student, developed a research plan to identify high-erosion risk areas created by footpaths and unpaved rural roads in mountainous agricultural watersheds. The plan included attempting to correlate particular rainfall, soil, and topographic features to stochastically predict water erosion from footpaths and unpaved rural roads. By identifying relative rates of sediment generation from unpaved roads and trails within the watershed, erosion-risk areas could be prioritized for intervention

Due to Pryde's death in April 2007, the work has not progressed. She had completed an extensive literature review related to erosion from footpaths and unpaved rural roads in mountainous areas, which we will pursue publishing. A new master's student joined the project in August 2007.

Conrad Heatwole of Virginia Tech has established a plan to identify further data needs and monitor weather and stream flows. He visited Ecuador and Bolivia in June 2007 to identify monitoring sites.

Timeline and problems encountered

Activities under this objective are being conducted in a timely fashion. Substantial inter-country exchanges have occurred. Alwang, Bosch (economists from Virginia Tech) and Barrera traveled to Bolivia in February 2007 to train partners in economic and watershed modeling, examine field research, and collaborate on research design. PROMIC personnel subsequently traveled to Quito to train INIAP scientists and other partners in principles of watershed management. Expertise is still lacking among our partners in the areas of watershed management, especially in cases where the process is participatory and based on physical models. We have faced challenges with sharing of data by the different research teams, but recent efforts at coordination have alleviated these problems.

Objective 4: build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital

This objective is undertaken under Research Component 5 and is critical to the overall project. This objective envisions use of science-based models to assist in the process of watershed management. It is important to integrate local stakeholders into the research planning process, for they will help validate model results and provide insights into the weaknesses and strengths of the modeling process. The project has always actively promoted local stakeholder participation.

Participatory watershed planning activities

In both Ecuador and Bolivia, ongoing local socialization activities are being conducted. Local farmers and community leaders are participating in several project activities. In both countries, the local governments are required by national law to design and institute land-use plans. This process, which requires detailed geographical data and will involve stakeholders across the watersheds, is an excellent means of further institutionalizing watershed planning. SANREM teams in both countries are providing technical input into land-use planning. They are doing so by providing access to thematic maps, conducting analysis of land-use potential based on the maps and their knowledge of agronomic potential, and identifying potentially harmful relationships between land use and environmental degradation in sensitive areas.

Ecuador

- Strong interactions have been established and maintained between the SANREM-INIAP team and the provincial government. An environmental interest area has been created in the Bolivar provincial government. This section of the government has been charged with working with the SANREM team to initiate adaptive management practices in the study watersheds.
- A number of working sessions have been held with the chamber of commerce for micro-enterprises in Chillanes.
- Two workshops have been held with beneficiaries in the Alumbre sub-watershed; an active interest group has been formed there.
- The provincial government is engaged with the SANREM team in using our expertise to strengthen its land-use plans.

Bolivia

- Seven ICM courses have been conducted in three Tiraque communities and have been widely attended by farmer groups. This training, while focused on technical agricultural themes, has familiarized the research team with the actors and built confidence within the watershed. Women have been active participants in these workshops, making up about 40 percent of the audiences.
- Participatory demonstration plots have been set up in the participating communities at low and middle elevations for sustainable management of potato, fava bean, and strawberry crops. In addition to generation of research information, these plots are being

used to build local ownership of the SANREM project, engage local farmers in the investigation package, and disseminate information on SA practices.
- Two workshops have been presented by the PROMIC-PROINPA team to demonstrate the utility of their thematic maps in designing a land-use plan for the watershed. The Department of Tiraque is required to produce a community land-use classification plan, and the community of Cebada Jich'ana has asked SANREM to assist in the process. During the workshops, participants evaluated the maps, verified their information on the ground, conducted transect walks, and helped to identify socioeconomic and other concerns important to the process.

Organizations and institutions

Researchers are evaluating organizations and institutions in the Chimbo watershed to learn the potential for alternative governance structures and producer associations. Robert Anderson, a SANREM intern from the University of Denver, spent six weeks in Ecuador and has completed a comprehensive assessment of local, regional and national institutions. He worked with INIAP and ECOPAR. His report has been finalized and has been entered in the SANREM Knowledgebase. His report includes several recommendations for broadening local participation, thus building ownership in the project. It also contains a comprehensive overview of institutions involved in water management in the Chimbo region. ECOPAR recently completed a companion paper that uses the baseline survey to evaluate perceptions of and interactions with local institutions. This paper, currently being revised, shows high levels of local participation, particularly in social and cultural groups, but less active involvement in governance and other institutions.

The following are major highlights of the institutional analysis in Ecuador.

- There are very few formally recognized community groups, particularly in the Illangama (upper) watershed. However, in the upper watershed, community activity is strong, with a culture that favors group decisions, participation, and consensus.
- In the Alumbre (lower) watershed, community organizations are relatively weak, and household participation in community activities is more limited.
- Women are much more likely to participate in community groups in the Alumbre compared with the Illangama watersheds.
- Very little correspondence was found between recognition of environmental problems – most people in both watersheds recognize damage to the environment – and adoption of resource-conserving practices.
- Weak linkages were found between local schools and provincial and national educational institutions.

An analysis of water management institutions is being conducted in Bolivia. Results are not yet available.

Timeline and problems encountered

Activities under this objective are being conducted in a timely fashion. In Bolivia, political instability at the national and local levels has slowed the ability to establish concrete relations with municipal authorities.

Degree and Non-degree Training Activities

The LTRA-3 group has made major headway in its training activities by aggressively identifying suitable candidates, promoting flexibility in program design, and leveraging funding from different sources. Nine graduate students are currently being trained: five men and four women. Four are from host countries. Four undergraduate honors students in Ecuador – two men, two women – and four from Bolivia are being trained.

Non-degree training has been eclectic, with 17 workshops, two short courses, and two field days focusing on environmentally beneficial agricultural management practices, biodiversity, adaptive watershed management, and watershed planning. These activities involved 317 men and 156 women. The SANREM internship program engaged 10 students – two men, eight women – in hands-on research in Ecuador and led to usable research output. (See Degree and Short-Term Training Tables for details.)

Publications, Presentations, Other Products

LTRA-3 has produced three reports, three working papers, six presentations, and one dataset over the past year.

Networking Activities

Leveraged funding

Several SANREM PIs have supplemented their SANREM funding with alternative resources. These supplemental funds are increasing the effectiveness of SANREM resources

Penn State

- USDA/ARS provided a total of $12,500 for support of our research program on sustainable and biologically based pest management in cacao in Ecuador. Funds were provided by the ARS international program leader, Eric Rosenquist, and channeled through a cooperative agreement with the Sustainable Perennial Crops laboratory in Beltsville, Md.
- In January 2007, the department of plant pathology provided one semester of tuition and a Ph.D. research assistant stipend for Rachel Melnick, our CRSP-funded sustainable cacao researcher, for a total of $12,442.
- Raul Jaramillo and Amelia Henry are supported by fellowships at Penn State, representing a leveraging of about $60,000 annually.

Virginia Tech

- The Department of Agricultural and Applied Economics is supporting Michael Castelhano, a master's degree candidate, with tuition plus an assistantship for a full year. SANREM paid his assistantship for spring 2007 and will fund his research on demand for potato attributes among producers in Tiraque, Bolivia. Total departmental funding is $22,000.

- The IPM CRSP is sharing two students with SANREM: Robert Andrade and Catherine LaRochelle, both of whom will conduct research on the watershed in Ecuador. The value of the IPM CRSP funding is about $24,000.
- The Department of Biological Systems Engineering is co-funding Javier Osorio, who is working on the Bolivia project. The approximate value of this funding is $15,000 annually.

Ecuador

- The Ecuador country team has had a proposal approved by Secretaría Nacional de Ciencia y Tecnología that will be financed by petroleum surplus funds. The approved amount is $170,000, which is being used to support SANREM research activities.

Other networking

- In Bolivar, Ecuador, meetings have been held with local and regional governmental authorities to sensitize people about the project and its goals, and to solicit inputs on project structure. Farmer groups have been formed in Cullebrillas comprising 20 men and four women, and in Bola de Oro comprising 17 men and five women.
- The Ecuador team participated in a climate-change workshop held by ECOCIENCIA and the Highlands Project in March 2007.
- The Ecuador team has been invited to participate in the process of land-use planning by the provincial government of Bolivar. Each province is expected to design and implement a land-use plan, and the SANREM team was selected to provide technical support.
- In Tiraque, Bolivia, the SANREM team was invited to provide technical support to its own land-use planning. In Bolivia, land-use plans are expected to be in place by 2009. This effort will support a master's thesis that will design a pilot land-use plan for Cebada Jichana, an indigenous community.
- A meeting was held during the visit of Alwang, Bosch, and Barrera (February 2007) with the municipal government in Tiraque, which fully supports the project.
- USAID-Ecuador met with the SANREM internship team at the beginning of the internship. Following completion of the internship, a half-day workshop was held with key USAID staff at which the interns presented their research results and highlights.
- Pryde, J.K., J. Osorio, M.L. Wolfe, C. Heatwole, B. Benham, and A. Cardenas. 2007. "Comparison of watershed boundaries derived from SRTM and ASTER digital elevation datasets and from a digitized topographic map." ASABE Paper No. 072093. St. Joseph, Mich.: ASABE. Presented by J. Osorio at the 2007 ASABE annual international meeting, Minneapolis, June 17-20. 10 pp.

Project Highlights

- Findings from the assessment of the soils in Ecuador confirm the importance of the project. The high-altitude soils of Alto Guanujo are fairly resistant to erosion and appear to be tolerating intensifying land use reasonably well. However, the older soils of Chillanes, many on a slope angle of 45 degrees or more, are suffering disastrous degradation that has already reduced productivity and will destroy the agricultural base of

the central watershed within two to three decades if unchecked. Soils of this type in this environment should be minimally disturbed and covered with vegetation at all times.

- The participatory assessment in Ecuador found remarkable agreement about the priorities for action in the Chimbo watershed: steps to increase productivity and profitability of agriculture, more diversified income streams on and off the farm, improved capacity to manage water resources, reforestation, and protection of biodiversity.
- Researchers found that soil organic-matter content in the Chimbo watershed generally decreased with increasing altitude, indicating the importance of conserving the soils at lower altitudes, for they represent greater carbon sequestration capacity but also high risk of degradation due increasing acreage under annual crop cultivation.
- Institutions in the Ecuador watershed suffer from many weaknesses, including lack of coordination, lack of clear demarcation of responsibility, and limited knowledge about how human actions affect the environment. Local leaders are beginning to appreciate the use of science-based management techniques, and the project is finding a welcome ear.
- The municipality in Tiraque will use the SANREM GIS and watershed modeling tools as inputs into its own process of land-use planning. This will increase the efficiency of the planning process.

LTRA-4: Adapting to Change in the Andes: Practices and Strategies to Address Climate and Market Risks in Vulnerable Agro-ecosystems

PIs: Corinne Valdivia, Leonie Marks, Peter Motavalli, and Jere Gilles, University of Missouri
Karen Garret, Kansas State University
Anji Seth, University of Connecticut
Cornelia Flora and Jan Flora, Iowa State University
Greg Forbes and Roberto Quiroz, CIP
Jorge Cusicanqui and Magali Garcia, Universidad Mayor de San Andrés, Bolivia
Elizabeth Jiménez, Universidad de La Cordillera, Bolivia
Miguel Angel Gonzales and Javier Aguilera, PROINPA, Bolivia
Celia Turín and Silvana Vargas, Universidad Nacional Agraria La Molina (UNALM), Peru
Carlos Laruta, Centro de Investigación y Promoción del Campesinado, Bolivia

Host countries: Bolivia, Peru

Executive Summary

The overall goal of this project is to assess and improve adaptive capacity and capabilities of rural communities in Andean highland (Altiplano) ecosystems of Bolivia and Peru to the challenges posed by climate and market change, drivers that may have reduced agricultural and natural-resource sustainability and increased the regions risk of food insecurity. Five objectives are implemented. Objective 1 studied the drivers' effect on livelihoods and ecosystem dynamics. Objective 2 elicited local knowledge about soils, water, pests, and biodiversity (the natural capital), and perceptions of the risks. New knowledge, information, and practices were developed with collaborating farmer groups (Objective 3), and market integration and negotiation strategies to increase well-being and value biodiversity were evaluated (Objective 4). Research with participatory approaches implemented to link local and new knowledge are expected to strengthen human, cultural, social, and political capitals, as well as capabilities leading to ability to act (Objective 5), changing knowledge, attitudes, skills, aspirations, and ultimately practice. This year's primary focus was to determine how the perceptions about drivers correspond with the research on changing the ecosystem at various scales and on livelihood strategies, while developing new knowledge to improve adaptive capacity (Objectives 3 and 4).

Fourteen communities in three regions of the Andes (Northern and Central Bolivian Altiplano and the Southern Peruvian Altiplano) participated in community assessments of landscape changes, developing 64 geo-referenced maps of natural resources, hazards, and biodiversity reflecting local knowledge and perceptions. Participatory research methods were implemented with 10 community research groups in all regions. Methods to evaluate the effectiveness of participatory research groups were implemented. Baseline surveys of 450 households in Bolivia and Peru were completed. Current knowledge (human and cultural capital) and practices were

elicited. Theme research teams focused on climate (trends, climate change, and local knowledge indicators), soils (local and scientific characterization, quality indicators, amendments), pests and diseases (perceptions of outbreak risk, dynamics, and modeling of disease and pest under climate change scenarios), biodiversity (census of varieties, gardens, and assessments of change in the landscape), and livelihoods and markets (capitals, activities and outcomes, networks, and market integration). Methodologies were developed to assess change and sources of risks by gender and life-cycle stages. These perceptions were combined with geographic information-system landscape maps to visualize change. Participatory activities to elicit local knowledge on climate, soils, pests and diseases, and native plants were combined with disciplinary research to understand the system dynamics and to design experiments on practices in soil amendments, new crops varieties, management of forages, and climate forecasts. A website was established to facilitate group discussions and communications. Research designs and establishment of field experiments with farmer groups took place in September and October 2006 in Bolivia (potato planting to experiment of soils amendments, biodiversity, traps to study Andean weevil, potato moth and quinoa pests), and weather stations. Participatory monitoring instruments were tested in February 2007; and monitoring and evaluations took place through July 2007. In Peru, assessments with communities to identify their strengths and constraints, using the community capitals framework, and surveys were undertaken until February 2007. Training and tours on identified knowledge needs through August focused on forage management improvements, soils, and water assessments. Our non-degree training activities are very large, reflecting our approach to bridging knowledge systems and researching the ability to act.

First-year field studies were completed in eight communities on soil characterization, alternative soil amendments, pest dynamics, biodiversity of potatoes and oca, and identification of new quinoa varieties. More than 120 events were held in Bolivia and Peru in this process. In Bolivia, 140 people participated in farmer groups, and 90 did so in Peru. A monitoring system to evaluate participation and the role of social, economic, cultural, natural, human, and political capitals was implemented. Thirty-one students – 17 women, 14 men – from Bolivia, Peru, and the United States are involved in field research, pursuing *licenciatura*, master's degrees, or Ph.D.s in biological, physical, and social sciences. The International Seminar on Global Change and Climate, led by UMSA in La Paz in June 2007, showcased the SANREM CRSP and issues revolving around climate change and adaptation. Matching funding was secured for training students. UMSA secured a grant to expand the research program with farmers in Ancoraimes from UNDP's Bolivia Climate Change Small Donations program. The methodologies developed with the project were shared with the CIP ALTAGRO project and Save the Children. The program developed proposals for cross-cutting research in soils, watershed, knowledge to action, and gender; and secured funding for graduate students and training in advocacy coalitions as a strategy for agency in host countries.

Research Strategy and Development Objectives

This project develops knowledge and practices to build resilient livelihoods and ecosystems in vulnerable rural communities of Andean agro-ecosystems in response to change in climate and markets. To accomplish this, we must understand the dynamics of current agro-ecosystems in order to identify knowledge, practices, and strategies that reduce vulnerability, value biodiversity, and build natural and human capital. This project engages in two dimensions, structural and transformative: structural by understanding the effects of markets and climate at

various scales in the ecosystem; and transformative through collaborative research processes with stakeholders to link knowledge with action to achieve adaptation at the individual, household, and group levels. The research conceptual model (Figure 1) captures these two dimensions.

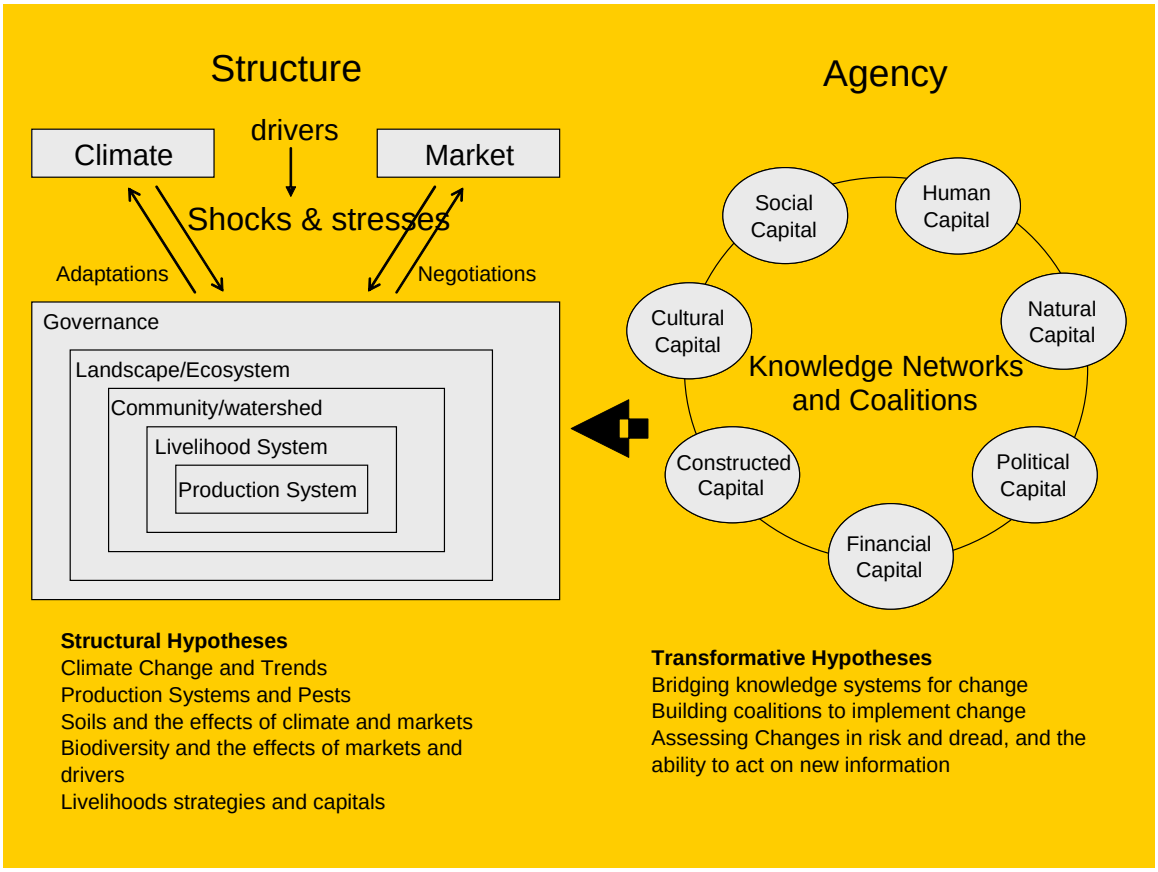


Figure 1: Research Conceptual Model

Critical to adaptation are an understanding of the effects of drivers at multiple scales in Altiplano ecosystems: market effects on decision making, climate effects on trends and changes in ecosystem biodiversity, and interaction effects on the outcomes of livelihood strategies. This understanding is essential in developing practices and strategies pursued in the agronomic and market-research programs, which seek to identify interventions that improve well-being and value biodiversity.

The specific objectives of this LTRA are:

- **Objective 1:** to characterize the dynamics of Altiplano agro-ecosystems at various scales to understand the impact of climate and markets as drivers of change
- **Objective 2:** to identify local knowledge and perceptions about production systems, landscape, and risks in order to assess the effect of climate and market change on livelihoods

- **Objective 3:** to develop practices and information strategies (networks to access new information) to address changing conditions and perceived risks
- **Objective 4:** to develop market access strategies and institutions that contribute to resilience, and
- **Objective 5:** to develop stakeholders' capacities and ability to act to reduce vulnerability and increase adaptation in the face of changing market and climate conditions.

Objective 1 studies the dynamics of the ecosystem, focusing on soils, climate, pests and diseases, biodiversity, livelihoods, and markets to determine how changing climates and markets have impacted agro-ecosystems and how these impacts have affected livelihood strategies. Objective 2 studies people's knowledge, perceptions of change, and experienced hazards. Both objectives provide information relevant to the TOP framework. Scientific and local knowledge gained under Objectives 1 and 2 informs research in Objectives 3 and 4, which focus on identifying adaptive practices and strategies necessary to build resilient livelihoods and ecosystems. Climate forecast information, soil management, crop alternatives, and pest management practices are developed. Objective 5 focuses on strengthening capacities and studies participation and its effect on stakeholders' ability to act.

The research strategy consists of development of knowledge in two dimensions using theme teams of multiple disciplines and integrating approaches. The project has developed five theme teams: climate, soils, pests and diseases, biodiversity-production systems, and livelihoods. A knowledge-to-action theme focuses on process and evaluation of ability to act. Multiple disciplines contribute to answering the questions in each theme, from understanding dynamics to adaptation practices and strategies. In the following paragraphs, we develop some examples.

Climate

Research describing climate conditions and trends over the past 30 years in the Altiplano allows us to make comparisons with the perceptions of decision makers at the household and community-watershed scales, identified with community participatory assessments and household surveys. These trends and conditions also feed into climate-change models for the Altiplano and will be used to predict medium (30 to 50 years) and 21st century climate change scenarios. Interdisciplinary research on local forecast indicators, assessing the links between climatology and farmer observations, is part of participatory research to build a common understanding of how climate variability is addressed and how climate information flows and is used. In tandem, participatory assessments and mapping of climate hazards are carried out by the social sciences and community participants, and are evaluated with communities along with climate forecast products in terms of effect on current production systems.

Local knowledge and new knowledge about climate predictions, and forecasting climate change scenarios are assessed in community meetings. On the one hand, the prediction models need to be evaluated with stakeholders in the climate prediction and change community; on the other hand, they must be shared with stakeholders at the local, regional, and national level to inform government policies that will benefit adaptation. Landscape research at the watershed level, especially imagery analysis and participatory mapping of change at the watershed/community scale, can contribute to a dialog about vulnerabilities and planning for resilience.

Pests and diseases

Field research on pests and diseases targets dynamics that depend on micro-regional local variability in altitude, temperature, location, and other characteristics. At a regional (ecosystems) scale, climate change scenarios are incorporated into models of disease and pests to predict changes in movement from low to high elevations as temperature and humidity change. Participatory evaluations of innovative methods for soil management of Andean potato weevil and potato tuber moth seek to identify practices that are compatible with the economic and labor realities of farmers. The purpose is to produce information that is relevant, appropriate to the decision makers' context, and consistent with their decision making process.

Soils

Disciplinary research is also undertaken to characterize soils and evaluate their quality under different fallow systems and changing management practices, which have been identified as responses to climate and markets. Soil quality indicators being developed are a proxy for biodiversity and will be included in the analysis of the consequences of farmers' adaptive strategies on their livelihoods and environment. This research links with a biotechnology project for soil metagenomics, to develop microbial indicators for soil degradation/quality. While characterization is done at the community/watershed scale, soil amendment experiments take place at the field level to enhance soil quality in order to buffer some of the shocks due to climate variability. Participatory and disciplinary research activities are elements of soil amendment practices researched and soil quality indicators developed at each site.

Biodiversity

To understand changes at the watershed/landscape scale, changes in the land-use patterns of households, crop varieties, land cover, and competition for resources are being assessed: at the field level with farmers to evaluate performance of current native varieties; at the community level to evaluate current varieties and changes through time; and at the municipality level to assess varieties of native potatoes using competitions. Also, we are identifying varieties that can be incorporated or recovered by planting gardens in communities and on farms to assess varietal performance; evaluating landscape changes through imagery analysis to support planning of future activities, and identifying varieties that can provide a more resilient landscape to projected changes based on medium-term climate-change scenarios and current climate trends. Imagery analysis as well as ground-truthing research and participatory mapping of changes in landscape focused on natural resources will provide a picture of the changes in vegetation, as well as the tools for discerning with communities the role of drivers in these changes.

Livelihoods and markets

Social and economic research focused on decision makers at the household and community levels identifies livelihood strategies and how climate and markets, along with changes in the environment, have shaped these. It assesses differences in strategies based on access and control of types of capital, as well as the structures under which decisions shaping the strategies are made. The purpose is to compare strategies and practices across communities and ecosystems.

This enables understanding of how the capital resources and capabilities of individuals, households, and community engender agency and adaptation. With the household economics approach, the differential impact of the strategies can be evaluated to determine how they benefit men and women. Assessments of practices under Objective 3 are linked with market strategies for inputs and outputs in Objective 4. Community participatory assessments with a gender perspective (Objectives 2 and 5) lead to identifying priorities and understanding differences. Economic portfolio research informs on market integration (or lack thereof) and the effect on income generation, food security, and vulnerability (Objectives 1, 2, and 4). Indicators of livelihood diversification and vulnerability, as well as of accumulation of assets, are some measures of economic and social well-being. These are combined with indicators of environmental well-being (natural capital) –soils and crop diversity, for example – to assess how the natural capital contributes to well-being and how decision makers invest in the natural capital. Risk perceptions (Objective 2) are studied in the context of livelihoods. Household surveys link livelihoods with perceptions of risk, types of capital, and ability to cope (Objective 5) with risk events. This research, as well as the research on perceptions of change, elicited through community participatory evaluations and mapping, provide a foundation on which knowledge about adaptation to climate and market changes can be developed, and about the ways in which information flows within and outside the communities.

Ability to act – knowledge to action

The research design incorporates agency as a dimension reflected on the right of the conceptual research model depicted in Figure 1. Within the sustainable livelihoods framework agency, defined as the ability to act, is the hinge articulating livelihoods with structures. At higher scales than community, it links people with markets and government institutions through collective action and stakeholder platforms. Throughout the project, research addresses who has the ability to act and how, including participants and non-participants in collaborating communities, through analysis of networks. It researches processes such as participation in research, capacity building, and collective project activities; and who is able to incorporate the new knowledge into decisions. Objective 3 identifies practices and information through participatory approaches and disciplinary research. The research on soils, pests, climate, and native crops builds on local knowledge and perceptions. Objective 4 identifies strategies that can improve bargaining power in commodity markets or reduce the perceived risks of decision makers by accessing credit and-or insurance. The identification of high-end income markets - niche markets for traditional cultivars – is one example. Strategies and institutions target improvement of bargaining or negotiation in markets that enhance Andean biodiversity and income, and are based on the lessons of research in Objective 1 through the assessment of how economic portfolios are influenced by market and climate changes, and who is vulnerable to changes. In this context, various approaches are studied. Advocacy coalition is explored as a mechanism to link actors at different levels with aligned incentives. Participatory market-chain approaches that develop stakeholder platforms are also studied. Analysis derived from Objective 1 on shocks and Objective 2 on perceived risks from climate markets and environmental change (such as increased pests) informs assessment of insurance markets for agriculture and the feasibility of micro-credit programs by different community strata. Various means of linking farmers with markets are evaluated in terms of participation and impact on ability to act. The sites permit comparisons under different market-access conditions, different commodities and mixes of traditional and commercial products, and the different forms of organization. Objective 5 is a

critical research and development objective. It is accomplished by examining different approaches to capacity development: participatory research, research groups, advocacy coalition, and stakeholder platforms. The development dimension consists of strengthening or developing the adaptive capacities of stakeholders. This involves degree and non-degree training as well as spaces for co-learning. Information is provided to decision makers at the household, regional, and national levels. These activities allow us to test a transformative hypothesis identifying the pathways through which knowledge becomes information for action. Our activities include collaborative approaches in themes that concern climate change and adaptation in rural areas with our research partners, policymakers, and development practitioners.

Consistent with the research design and strategy, Years 1 and 2 focused mostly on Objectives 1, 2, and 5. Objectives 3 and 4 require an understanding of the system and are a growing focus in Years 3 and 4. Objective 5 is accomplished throughout the life of the project; its final intended output is to assess the process of change.

Figure 1 also depicts the various scales at which the research tackles disciplinary and interdisciplinary research to reveal the effect of the drivers on ecosystem vulnerability. It also depicts the structural and transformative elements of the research.

Research hypotheses

The overall working hypothesis of LTR-4 is that bridging knowledge systems through participatory approaches designed to foster agency – the hinge between structure and livelihoods – will lead to adaptation where decision makers (individuals, households, groups, policymakers, implementers) are capable of negotiating and benefiting from climate and market changes. To test this overall working hypothesis, several disciplinary and trans-disciplinary questions (specific hypotheses in appendix) are posed and addressed by themes and teams.

The research strategy aims to address the following questions.

- Is climate changing in the Altiplano ecosystem?
- Do people perceive this change, and do they have the knowledge, capital resources, and capabilities to adapt?
- Are markets and their signals affecting the decisions of producers, and in turn are these decisions changing the landscape of the Altiplano? If so, are changes affecting the resilience of the environment?
- Are the changes in climate trends and variability, and their impact on livelihoods, combined with the market signals and responses, increasing adaptation or increasing vulnerability?
- Does an increase in livelihood well-being lead to improvements in biodiversity, or are the market signals perverse to the environment (if measured in biodiversity indicators)?
- Are there interaction effects between climate and market change that are leading to increases or decreases in livelihood and environmental resilience?
- How do people's perceptions of change, the risks they face, and the vulnerability they experience affect the livelihood strategies pursued, the various types of capital they access, and their ability to use information?

- Can scientists in collaboration with producers identify and-or develop technologies and interventions that address climate-change effects on soil degradation, pests and diseases, plant biodiversity loss, and vulnerability due to lack of information about climate?
- How does knowledge shape decisions, and how and when are people capable of using new information for decisions (collective action, groups, entrepreneurship)?
- Because the nature of the information is inherently probabilistic and-or is used in an uncertain decision making environment, do the new information and the participatory processes used in designing it reduce uncertainty?
- Does collaborative research with decision makers, where knowledge systems are shared through participatory approaches and through groups, engender knowledge that is relevant to the users (in their language and context) and guarantee necessary conditions for ability to act?

The overall research framework and design seek to identify – by the project's practices and-or strategies – who benefits, why, and how.

Several factors were considered in the selection of Altiplano ecosystems sites. The first set included physical characteristics such as altitude, rainfall, and temperature. The second dealt with relationship to markets in order to capture differences in the role of markets and policies in shaping livelihood strategies. All sites chosen shared the same culture and ethnicity.

Comparisons include access to and participation in markets, effects of climate trends in short-term strategies, and approaches to collaborative research between communities and organizations with differing principles of collaboration. Collaboration revolves around volunteer farmers groups in Umala and community organizations in Ancoraimes and Puno. While groups in Bolivia contribute to new research activities in soils, pests, biodiversity, and climate, in Peru the focus is on soils. Peru introduces knowledge already developed through co-learning and coalition building approaches. Finally, comparison of landscape changes across sites will evaluate how market and climate drivers have an effect on land use and vegetation cover.

Hypotheses, Objective 1: System dynamics and drivers

- Changes in climate have a negative impact on ongoing cropping systems, and traditional cropping systems are changing in the face of increased climate risks.

Methods. Conduct initial community participatory assessments of hazards and risks, using focus groups, group interviews, interaction with panels of local experts, followed by evaluation of observed climate trends over past 35 years using daily data from existing stations and evaluation of IPCC models to see if the models reflect trends. In addition, use satellite and aerial imagery to validate perceptions, and use weather information and stream gauging to develop a watershed model with climate scenarios. GIS mapping of pest and disease responses to climate will be generated.

- Changes in cropping systems and soil management practices from traditional agricultural management systems due to climate and markets will cause soil degradation, as evidenced by lower soil organic carbon, nitrogen, and other soil properties

Methods. Changes in cropping systems will be determined through baseline surveys and participatory assessments, as well as direct analysis of soil properties in farm fields with different management regimes (fallow length).

- Ongoing land-use cropping system practices that deviate from traditional practices result in lower soil organic C and N. These changes are in fallow periods, rotations, tillage, and changes (in Peru) from communal to private management. Changes in rotations and fallow uses in addition to manure use and plowing have resulted in lower soil organic C and N.

Methods. Perform direct analysis of C and N levels in farms with different types of management regimes from current to most traditional. Farms will be identified from baseline surveys. The baseline survey includes questions on land use, soil fertility, and production activities.

- Local perceptions of climatic conditions reflect the trends identified in climatology analysis of the locality.

Methods. Baseline surveys and focus groups with local experts provided us with perceptions. Our meteorologists will use available data to document actual weather trends, then will work with panels of local experts to reconcile the two if necessary. These trends will be compared with farmer perceptions obtained from focus groups and group interviews (Objective 2).

- Cropping system diversity has decreased in recent years in response to market incentives and out-migration.

Methods. Baseline household survey will provide details on cropping systems. T his will be supplemented by focus groups and community participatory assessments to recall changes in production systems over the past few decades.

- Best disease and pest management practices are changing in the farm systems of our study region, possibly due to climate change.

Methods. Focus groups and local expert panels will describe and evaluate local practices and recommended IPM practices to see whether they are becoming more or less effective in the face of climate and economic changes. On-farm and community research trials will compare traditional practices with recommended IPM practices, and a predictive model for late blight and Andean potato moth will be validated.

- Farm households having more crop diversity will have more stable levels of income and well-being than less diverse ones.

Methods. Conduct an assessment of household production diversity and income as a function of the number and type of crop species and crop variety diversity using a household survey and field measurements.

- Vulnerable households are less likely to be able to maintain biodiversity or improve natural resources.

Methods. Surveys will identify degree of vulnerability, and biodiversity will be directly measured. The natural capital indicators will be developed by the soil, crops, biodiversity, and production systems researchers and producers (Objective 1).

Hypotheses, Objective 2: Perceptions and risks

- Perceived climate hazards are the most significant risk facing households in the communities of the Altiplano.

Methods. Survey data, hazard risk mapping, and focus groups will rank relative risks. This will be used as the basis of risk assessment that looks at the relative level of risk posed by climate, markets, pests, and family health and well-being.

- Perceptions of risks will differ between local experts and other producers.

Methods. Network analysis using baseline survey (see previous hypothesis) supplemented by group interviews and ethnographic data will identify local experts in the areas of climate prediction, marketing, and production. Their perceptions of risk factors will be compared with those of other community members.

- Communities have local systems of soil classification and indicators that may differ from science-based indicators placing more emphasis on organic content.

Methods. Participatory workshops identified these classification schemes, and soil sample were taken in each soil type and evaluated for organic C and N.

Hypotheses, Objective 3: Practices and information

Achieving Objectives 1 and 2 will give us the information needed to develop new knowledge (human capital). Are there viable alternatives? Are these communicated beyond the group to others in the community and to other communities?

- Traditional (local knowledge-based) forecast methods are unable to predict current climate behavior.

Methods. A baseline survey will provide perceptions of this phenomenon. Local forecasters and experts identified in surveys and focus groups will make forecasts using traditional methods. Our meteorologists will make forecasts using their models, and the results will be discussed in workshops.

- The networks that producers use to access information to help in their decision making are not articulated to the networks through which experts, NGOs and government agencies try to disseminate information to producers.

Methods. A household survey will use basic network analysis techniques to look at the flow of information used in production decisions. Similarly, focus groups with extension workers and scientists will identify the networks used in information dissemination strategies.

- Soil management practices that build up organic matter will increase production and mitigate potential effects of climate change.

Methods. Conduct field trials in the different communities to determine the first-year and residual effects of existing and alternative soil amendments and other soil practices. Community focus groups will evaluate the treatments during the field trials. Soil and plant samples will be analyzed and yields collected to determine the effects of the treatments on crop performance and nutrition.

- Communities at higher altitudes will place a higher value on use of soil organic amendments compared with inorganic fertilizers.

Methods. Organize participatory workshops with community members, and conduct sampling and analysis of soil organic amendments used in each community.

- Climate forecast models in conjunction with input from local experts can help in the development of new production systems to deal with climate risk.

Methods. Models from the Intergovernmental Panel on Climate Change (IPCC) are evaluated by scientists and local experts at workshops. Mitigation and adaptation strategies are identified.

- Native varieties of potatoes may be used to enhance incomes and livelihoods.

Methods. Collections of potato varieties have been made. They will be evaluated by community members and the most promising included in the market development efforts under Objective 4.

- IPM packages for the potato weevil and potato moth can be optimized.

Methods. Farmer groups will design and carry out research on the components of current IPM packages and report results to the community.

Hypotheses, Objective 4: Strategies and institutions in market integration

- Vulnerable populations in rural communities lack reliable market access to outputs and inputs, as well as access to market information for their products.

Methods. Household survey information will compare market access by level of vulnerability measured in terms of access and control of labor and land, assets, credit, and networks.

- Urban markets exist for native varieties and cultivars of tubers and grains that are now used and valued only for home consumption.

Methods. Focus groups will examine the uses and desirable traits of native cultivars. Marketers and urban consumers will be surveyed to identify potential demand. Data from MAPA will be analyzed for the regions of study to identify existing links.

- Participation of a community in the Advocacy Coalition process will generate knowledge about value chains and demonstrable agency in accessing new markets.

Methods. Community members will be trained to conduct surveys of stakeholders related to potato marketing and be supported as they carry out these investigations. This

information will be returned to the community, and a marketing and production strategy will be identified.

Hypotheses, Objective 5: Capacities, capabilities, and ability to act

Development of capabilities and ability to act is based on the following conditions. First, the information generated must be relevant, in the language of the user, and must fit within the decision-making process of the potential user. Second, the decision maker must have the ability to act on the information. The latter depends on the types of capital, means, and opportunities available to the decision maker as well as the structure under which decisions are made.

- Social capital of producers will be increased during the life of the project, leading to out-scaling of site research findings between countries.

- Group formation and vulnerability affect member participation and dissemination of information throughout the community. Gender and life cycle differences exist in ability to participate in groups.

- Interaction between university researchers and stakeholders (NGOs, USAID, international organizations, government institutions focused on climate change) will increase as a result of this project and lead to up-scaling research findings in the area of climate change and adaptation.

- Networks of rural producers in Altiplano ecosystems will lead to out-scaling of research products.

Methods. Farmer research groups will be monitored for participation, linking it to capital measured in the surveys. Horizontal exchanges within watersheds and between Altiplano ecosystems will be carried out and evaluated. A second household survey will track information flows from participants to non-participants along with capital that contributes to changing knowledge, skills, attitudes, and practices.

- Community awareness of the mitigating effects of soil organic matter on increasing temperature and decreased rainfall can be raised through community workshops, demonstrations, and focus groups.

Methods. Conduct community workshops, demonstrations and establish focus groups with the field trials so they can observe the effects of increased soil organic matter on increased temperature and decreased rainfall.

Research Progress

Objective 1: to develop a shared understanding of the ecosystem and the social and economic drivers of change in highland vulnerable communities by identifying measures and indicators of ecosystem and livelihood well-being

This objective addresses multiple scales in order to focus on the interactions. It comprises five activities.

Critical research accomplishments

1. Quantitative and qualitative assessment of livelihoods, capitals, practices and strategies, ex-antes and ex-post.

Livelihood strategies, types of capital, land-use patterns, biodiversity, and the impacts of market and climate were studied using qualitative and quantitative approaches. Community participatory assessment methodologies were developed to identify demands and the perceptions of farmers about their current and past conditions. Bolivian researchers and students were trained in this method, which was implemented in the eight communities of Central and Northern Altiplano, and later in the municipality of Charazani, Apolobamba. Instruments to measure knowledge, abilities, skills, aspirations, and practices (KASAP), as well as assets and livelihood strategies, were developed and implemented in Bolivia and Peru. Methods to evaluate knowledge, skills, perceptions and ability to act were developed with PROINPA, UMSA, Universidad de la Cordillera in Bolivia and UNALM in Peru. The teams identified methods for participatory research, participatory evaluations, capacity building, knowledge sharing with farmer groups, and changes through the existence of the research program. A monitoring system to measure research participation was developed and implemented in Bolivia. This is now being implemented in Peru.

Criteria to evaluate soils and pests were developed in January with the theme teams and the participatory methods group in Bolivia. Climate and biodiversity of potatoes perceptions were elicited in group meetings. Two researchers were identified and trained to integrate findings on farmers' participation. Points in the research process when farmers will evaluate research in community experimental plots and farmer plots were identified for soils, biodiversity, and pest research activities, as well as for field days and training. Selected findings of studies conducted will be shared through workshops among regions, and summaries will be printed for distribution to all communities.

The Peru team developed surveys and KASAP protocols, and applied them in the communities of Apopata and Santa Maria. Participatory evaluations conducted with the communities were returned through visual aids. Demands for training workshops and field days were identified at these meetings. The UNALM team was trained by Jan and Cornelia Flora on advocacy coalition building. This approach will help to identify aspirations and assets to inform their planned activities. Community priorities included water, soils, and forages. Forty-nine families were interviewed in Santa María and 70 in Apopata. UNALM has built a strong collaborative relationship with the Universidad Nacional de Altiplano.

With help from Centro de Investigación y Promoción del Campesinado, participatory rural appraisals (PRAs) were conducted in Niño Corin and Amarete, two communities in the Charazani *municipio*, a high valley area within the Apolobamba conservation area. The goal was to assess vulnerabilities and the feasibility of extending SANREM research to this area. The two communities are inhabited by Quechua speakers, and the production system is characterized by small fragmented holdings on terraced slopes with wheat, peas, corn, and potatoes as the primary crops. After considering the observations of the EEP that we need to concentrate our efforts, we decided not to extend the project to this area. Including Charazani would require adding Quechua speakers to the team, and the isolation of the site would have made it an expensive place to

conduct research. It is at least seven hours' drive from La Paz. The production system differed enough from those in our other study communities to make knowledge transfer difficult.

Livelihoods survey results

Bolivia

To understand the relationships among livelihood strategies, types of capital, and current land use, interviews about production systems, market integration, and risk perceptions among 360 households in nine communities of Umala and Ancoraimes were conducted in September and October 2006. Codebook and preliminary analysis were presented to investigators at a meeting in February 2007. With the household survey database, the following studies are being prepared. Survey data informs initial conditions regarding practices, networks of information, and risk perceptions, as well as the type of soils, soil amendment practices, crop varieties, problems with pests and diseases, and land-use patterns. The characteristics of the production systems in Umala and Ancoraimes are assessed in relation to the drivers, climate, and markets. This study was to be completed by December 2007 by Alejandro Romero and Griselda Gonzales.

Preliminary results indicate three clearly identified agricultural systems in Umala and two in Ancoraimes. In Umala, the agricultural system with the highest income per capita specializes in livestock technologies, growing alfalfa, and selling sheep, cattle, and dairy products, mostly milk. Income is derived mostly from sales of milk, cattle, and potatoes. Households within this category also have the highest levels of human capital and the highest stocks of food reserves (chuño). Income from temporary migration is minimal. Households within the second type of agricultural production system have substantially fewer sheep and cattle, and their productive strategy is based on production and sale of potatoes. On average, households within this category have about half the income of the first category. A third production system relies on marketing of potatoes and milk. Households in this group on average earn the lowest income per capita and have the lowest levels of human capital; the largest share of income is from wages earned through temporary migration. The most important characteristic differentiating these three household production strategies is their capital stock of sheep and cattle.

In Ancoraimes, there are two household production systems that reflect distinct livelihood strategies based on differences in access to capital, especially natural capital. The main difference between groups is the income derived from temporary migration (human capital). The first system has higher income levels and human capital (number of adults, education and age). Their household production focuses on onions for market, a recently introduced crop. Households under the second system are characterized by substantially lower income per capita and human capital. Their livelihood strategy relies on greater crop diversification and access to income from temporary migration.

Assessment of the degree and characteristics of market integration and marketing strategies leads to two main conclusions. First, the importance of market access, measured by the share of effective income derived from selling agricultural products, defines distinct productions strategies. Second, recent shifts in demand for new crops and products have changed household portfolios in Bolivia's two study regions. The most significant changes are development of a local demand for dairy products in Umala and the introduction of onions as a cash crop in

Ancoraimes. In both cases, the extent to which households have taken advantage of these market opportunities depended on various factors, including human and social capital (measured by their participation in groups).

Household portfolio analysis of the baseline survey indicates that the communities of Umala in the Central Altiplano and Ancoraimes in the Northern Altiplano rely primarily on potato-based cropping systems, and a significant proportion of land is devoted to native pasture to support livestock. Other crops grown include barley, quinoa, fava beans, alfalfa, peas, oca, and isaño *(Tropaeolum tuberosum)*. In the lower elevation communities, cash crops and other income-generating activities such as dairy production are a larger proportion of farm activities. Tractors are the primary source of tillage in the lower-elevation communities, while animal and manual tillage are more common at higher elevations.

Within the typical rain-fed cropping system, a fallow period of varying length (average fallow period = 4 ± 2 years for Ancoraimes communities and 5 ± 3 years for Umala communities) is used to regenerate soil fertility. The highest proportion of organic soil amendments such as manure and chemical fertilizers such as urea and diammonium phosphate is applied to the potato crop. More chemical fertilizers are used in lower-elevation communities compared with the higher-elevation communities sampled in the survey. The organic soil amendments include manure from sheep, dairy cows, alpacas, llamas, and guinea pigs owned by the respective farm households. The availability of different organic amendments varied across the communities depending on the number and type of livestock in each community. For example, in Ancoraimes, alpaca and llama manures made up a higher proportion of organic amendments in the higher elevation communities, while sheep manure was more important at lower elevations.

Survey results suggest that cash crops such as potatoes and onions receive the highest proportion of chemical and organic soil amendments, highlighting the importance of livestock manure for soil fertility maintenance. Differences in crop and soil management were observed both between and within Umala and Ancoraimes, particularly due to the influence of whether the community was at lower or higher elevation. These differences, such as use of tractor, animal or manual tillage, may have an effect on long-term soil quality. Another important component of soil fertility maintenance is the use of fallow periods in the crop rotation. Results from the livelihood strategies, market integration, and land-use patterns will be shared with research groups in each community to discuss ongoing pressures of the drivers and potential alternatives. This will identify activities under Objectives 3 and 4, with approaches developed under Objective 5.

Peru

Findings to date in Puno communities indicate that changes in climate have had a negative impact on natural resources, their natural capital. A participatory risk analysis of natural resources identified the following concerns in order of importance: water, grasslands, soils, and animals. Farmer perceptions of climate hazards are that frosts are more frequent and stronger than 10 years ago; extreme temperatures have increased; the rainy season has shortened; and rainfall amounts have decreased. The volume of water resources has fallen dramatically. Due to a reduction in the fallow period, grasslands have less time to recover and are overgrazed. This is perceived to reduce humidity in the zone. Soils are used more intensely in Santa Maria, where the community depends on crops for food security. Shortened fallow periods are negatively

affecting soil fertility, with an increased use of chemical fertilizers. Local animal production systems are more resistant to climate variability even when animal diseases undermine their productivity. Santa Maria has a mixed farming system where crops are produced for consumption and livestock is sold. Apopata, on the other hand, does not have major crops and relies solely on the sale of livestock products such as wool, fiber, meat, and hides.

Aymara communities have integrated systems that involve much more than natural capital. Thus, to understand the impacts of climate and market, community and household decisions must be assessed jointly. To understand how strategies are conceived and which capital resources are involved, evaluations of KASAP about natural resources, climate, market, organization, institutional environment, and food security were carried out. In Santa Maria, local and technical knowledge incorporated improved skills in soil, grassland, and livestock management. Soils play a crucial role in potatoes, quinoa, and fava beans destined mainly for consumption but also for forage production. On average, a family has access to two plots for crop production and two for grazing. A recent increase in the number of families has reduced access to land, resulting in more intense use of soils. Knowledge and experience about the importance of fallow period is known, and concepts and techniques about soil conservation have been provided through training, but this knowledge is rarely put in practice because of land constraints. Moreover, when farming does not provide sufficient income, migration to nearby cities takes place, which reduces labor for farming. However, traditional social strategies to optimize the use of labor (*minka* and *ayni*) and land (*aynokas*) are still present in the community (cultural capital and social institutions). Apopata faces a similar situation with its grasslands. Increases in the number of families has resulted in a decrease of the area accessed, affecting rules of access, which results in degradation. Low prices for livestock products at small local markets force migration to cities and raise off-take and market supply. Social networks are weak due to the distance between households.

2. Evaluating climate variability in the Altiplano: Observational analysis of historical data.

The climate group has been working on a number of interrelated efforts. The Bolivian members led by M. Garcia (UMSA) have analyzed the historical station data to characterize recent climate and trends in the Bolivian Altiplano, while University of Connecticut members Anji. Seth and Ph.D. student J. Thibeault, have analyzed historical gridded observational datasets for the Altiplano region to verify the predictive power of climate model data (see Objective 3). Using data from weather stations in the Altiplano, which have at least 35 years of continuous observations, climate trends were analyzed using the Kendall Mann statistical test, and the results were mapped for the Altiplano. Results show an increasing trend in maximum temperature and no trend in annual precipitation (Table 1). These results were replicated by the gridded models. The trends in annual precipitation and minimum temperatures by proximity to Lake Titicaca are shown in Tables 2 and 3. There was a decline in precipitation and minimum temperatures close to the lake, but precipitation was unchanged and minimum temperatures increased in areas away from the lake. Evapo-transpiration increased across the Altiplano (Table 4). In the absence of a concurrent increase in precipitation, these changes will result in enhanced hydrological stress for rain-fed agriculture in the North Plateau. Glacial retreat may negatively impact some irrigation systems.

Table 1: Results of the statistical analysis of maximum temperatures using the Mann-Kendal test in selected Altiplano weather stations.

STATION	SIGNIFICANCE	VARIATION ºC/Year	STATION	SIGNIFICANCE	VARIATION ºC/Year
Copacabana	NS	0,009	Oruro	S (+)	0,014
Belen	NS	0,014			
El Alto	SS (+)	0,019			
Calacoto	SS (+)	0,02	Potosí	SS (+)	0,054
Viacha	SS (+)	0,03	ColchaK	SS (+)	0,008
Charaña	S (+)	0,02	Rio Mulatos	SS (+)	0,009
Ayo Ayo	NS	0,005	Uyuni	SS (+)	0,004
Patacamaya	NS	0,003			

NS: Not significant , **S**: Significant **SS**: Highly significant (**+**), positive trend, (**-**) negative trend. Copacabana and Belen are the stations closest to Ancoraimes and Patacamaya is closes to Umala.

Table 2: Results of the statistical analysis of annual precipitation using the Mann-Kendall test in the stations considered by the study.

STATION	SIGNIFICANCE	VARIATION mm/Yr.	STATION	SIGNIFICANCE	VARIATION mm/Yr.
Copacabana	SS (-)	-1,9	Oruro	S (+)	-1,0
Belen	S (-)	-0,6			
El Alto	S (+)	0,5			
Calacoto	S (+)	1,5	Potosí	S (-)	-1,2
Viacha	S (-)	-1,3	ColchaK	NS	-0,5
Charaña	NS	-0,2	Rio Mulatos	NS	-0,8
Ayo Ayo	S (+)	1,2	Uyuni	NS	-0,3
Patacamaya	NS	0,6			

NS: Not significant **S**: Significant **SS**: Highly significant (**+**) positive trend (**-**) negative trend Copacabana and Belen are the stations closest to Ancoraimes and Patacamaya is closest to Umala.

Table 3: Results of the statistical analysis of minimum temperatures using the Mann-Kendal test for stations considered in this study.

STATION	SIGNIFICANCE	VARIATION °C/Yr.	STATION	SIGNIFICANCE	VARIATION °C/Yr.
Copacabana	SS (-)	-0,024	Oruro	SS (+)	0,035
Belen	SS (-)	0,006			
El Alto	SS (-)	0,008			
Calacoto	SS (-)	-0,02	Potosí	SS (-)	-0,056
Viacha	SS (+)	0,03	ColchaK	SS (-)	-0,03
Charaña	SS (+)	0,02	Rio Mulatos	SS (-)	-0,043
Ayo Ayo	SS (+)	0,027	Uyuni	SS (-)	-0,05
Patacamaya	SS (+)	0,025			

NS: Not significant **S**: Significant **SS**: Highly significant (**+**) positive trend, (**-**) negative trend
Copacabana and Belen are the stations closest to Ancoraimes and Patacamaya is closest to Umala.

Preliminary analysis of the gridded observations in the context of large-scale climate variability confirms that wet episodes in the northwestern Altiplano are associated with mid- and upper-level winds from the east, which carry moisture from the Amazon basin; while dry episodes occur during periods of winds from the west. This mechanism relating winds and moisture transport to the western Altiplano is thought to be effective on a number of important timescales, e.g., dry and wet periods within a rainy season, the annual cycle of dry season and wet season, year-to-year variability in drought and wet years (Garreaud *et al.*, 2003) and has implications for observing and predicting sub-seasonal and inter-annual variability in rainfall in the region. A collaborative manuscript is in preparation for peer-reviewed publication on this topic.

Table 4: Results of the statistical analysis of reference evapo-transpiration using the Mann-Kendall test for stations considered in this study.

STATION	SIGNIFICANCE	VARIATION mm/Yr.	STATION	SIGNIFICANCE	VARIATION mm/Yr.
Copacabana	SS (+)	0,5	Oruro	NS	-0,14
Belen	SS (+)	0,6			
El Alto	SS (+)	0,8			
Calacoto	SS (+)	1,2	Potosí	SS (+)	2,35
Viacha	SS (+)	1,3	ColchaK	SS (+)	1,35
Charaña	S (+)	0,6	Rio Mulatos	SS (+)	1,43
Ayo Ayo	NS	-0,15	Uyuni	SS (+)	1,31
Patacamaya	NS	-0,13			

NS: Not significant **S**: Significant **SS**: Highly significant (**+**) positive trend (**-**) negative trend
Copacabana and Belen are the stations closest to Ancoraimes and Patacamaya is closest to Umala.

Seasonal forecasts and local indicators

To understand and document the use of local indicators for seasonal rainfall outlooks, the Bolivian climate group members led by Magali Garcia and with Jere Gilles interviewed individuals recognized as weather experts in their communities. With respect to perceived trends, the agriculturists observe that the growing season is changing and shortening, but they do not perceive that this shortening of the cycle is related to an increase in temperature. The analysis of station observations in Umala and Ancoraimes revealed no clear relationship between season total rainfall and date of onset, though the relationship between onset date and duration of rains is quite strong. Finally, local experts were asked to give their predictions for the 2006-2007 crop year, and at the end of the year they participated in workshops to evaluate their predictions. Preliminary results suggest that the predictions based on local indicators were quite accurate. In spite of a widespread belief that the reliability of local indicators has diminished, preliminary results suggest that they are still effective. This suggests that declining use of these indicators is related to changes in the production systems and to demographic and social factors.

Climate institutions and sources of information

Bolivia

Linking local and new knowledge to produce practices and information that provide alternatives for adapting to change requires an understanding of how this currently takes place. L. Rees under the supervision of Corinne Valdivia and Jere Gilles started work on this during the summer. Rees obtained a Brown Fellowship to conduct field research in Bolivia. Questions this activity seeks to answer are exploratory in nature: first, to identify whether institutions produce, use, or distribute climate information in accordance to their mission; second, to identify communication linkages between institutions; and third, to identify the Bolivian farmers' sources of information about climate and which sources are trusted. The hypothesis is that Bolivian farmers do not include scientific climate information in their production decisions because they do not have access to it. Understanding is critical in the process of linking knowledge systems. The status of knowledge about climate variability for the Altiplano and how it is conveyed make up one element of the process of linking knowledge systems. As new information about climatology, trends, and change are developed, pathways to access and trust this information in decision making are critical if our aim is to reduce the impact of climate hazards. In peasant communities, the relationship between agriculture and climate is much more intricate, and farmers are able to identify, with the aid of many different indicators, specific and important weather patterns. Farmers base their crop decisions and other production decisions on local knowledge systems, developed from years of observation, experience, and experiments. Farmers also access and incorporate new knowledge in their decisions. Networks for communicating information about the coming year's climate in the Altiplano are local and do not utilize scientific forecasts. The networks that forecast agencies use to communicate their forecasts do not include farmers either directly or indirectly through intermediaries.

Smallholder farmers rely on traditional systems of prediction rather than scientific ones. In Bolivia, an analysis of forecast communication networks showed nearly a complete disconnect between forecast agencies, mass media and farmers. Farmers used local networks and experts for the forecasts that they used in production decisions. Network analysis strategies provided an

understanding of local and non-local knowledge to rural households. It has long been recognized that the way that farmers organize and use technical knowledge is different than the way that agricultural experts do (Long and Long, 1992). One of the challenges facing extension workers and agricultural research systems is to create linkages between producer and expert knowledge systems. The gap between researcher, extension worker, and producer is even greater in developing nations.

Activities include quantitative analysis of survey data relating to farmers' climate information sources. This uses the household survey data for 360 families in the Altiplano. To date, descriptive analysis has been completed. A qualitative analysis of Bolivians' sources of climate information and level of trust in these sources (Ancoraimes and Umala) using focus group field research has been initiated. Tasks accomplished so far include development of questions about information sources of climate events and four focus groups organized in Umala (July 12, 2007) with selection criteria that included both women and men from high- and low-income groups. Four focus groups were organized in Ancoraimes (July 26, 2007) with similar criteria. These were conducted in Aymara and the interviews transcribed and translated to Spanish and English. A task to be completed in Year 3 is content analysis of those focus group transcriptions.

In the institutional field research, a protocol was developed and used to interview Bolivian climate information stakeholders: Bolivia's national service of meteorology and hydrology, regional government, civil defense, Bolivian Climate Change National Program, the ministries of planning and agriculture, UNDP, local community radio, Save the Children, and Oxfam International. Stakeholder interviews were summarized. Content analysis of summarized stakeholder interviews will be completed in Year 3. Preliminary findings to date indicate that farmers are most likely to consult local systems for climate information. The preliminary findings of the focus groups show variation on whether farmers use the radio to acquire climate information. It was evident that most farmers rely on local community networks for climate indicator information (local knowledge, human and cultural capital). They trust this source of climate information and have strong doubts about the information broadcast on the radio networks. Preliminary results indicate a disconnect between information sources and the end user: the farmer. There also appear to be differences between institutions on whether they are providing, using or distributing climate information in accordance with their mission.

3. Assessment of organic matter under current management regimes, perceptions of organic matter

Community participatory workshop results on soils

Participatory workshops were conducted in Ancoraimes and Umala in 2006 to determine the local soil classification system and the criteria used for classification by community members. During the workshops, community members drew soil maps for each community (see Figure 2 for an example of a soil map drawn for the community of San José Llanga) and identified

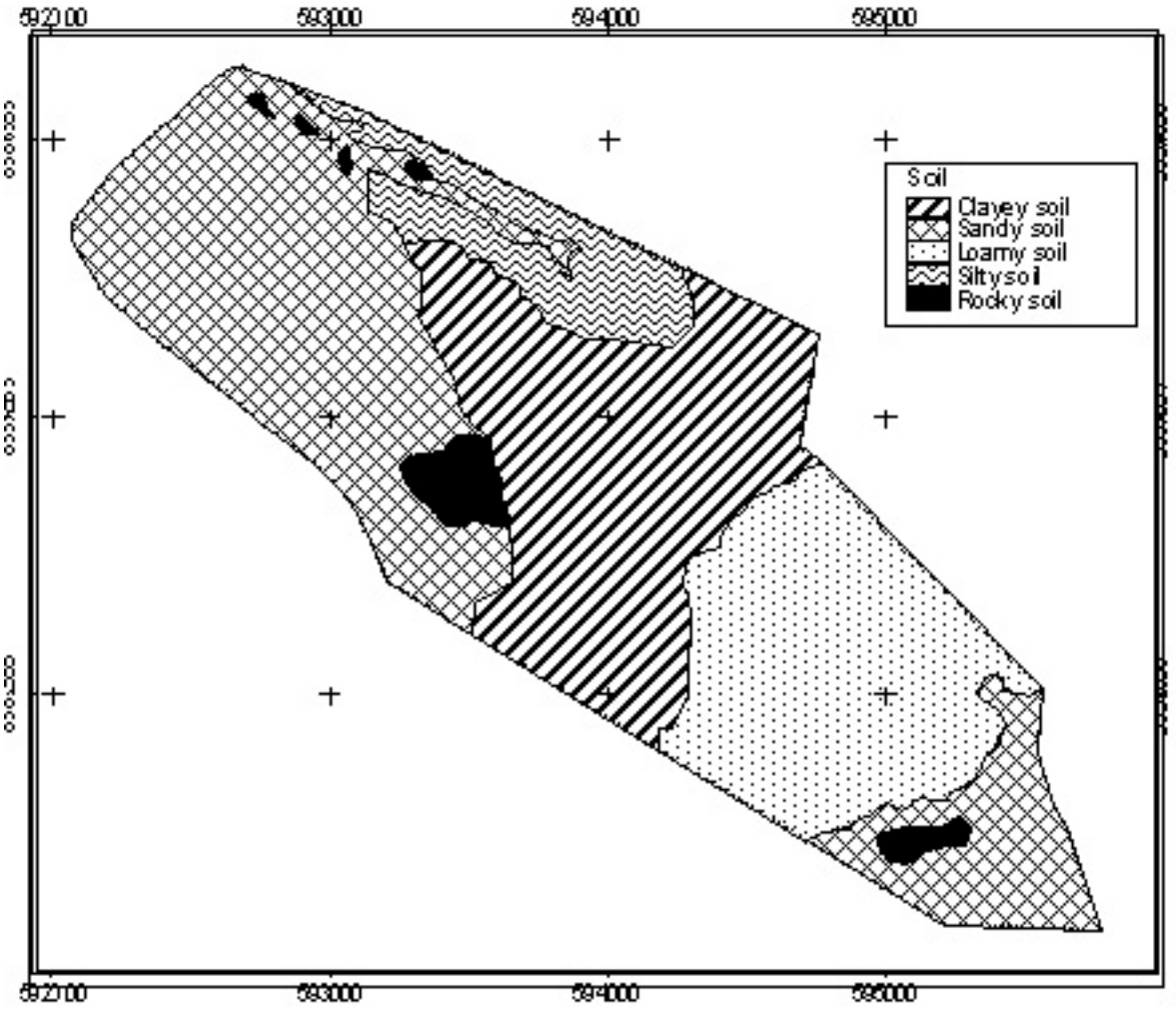


Figure 2: Map of the major soil types identified by members of the community of San José Llanga in Umala during a participatory workshop in 2006.

the characteristics and agricultural uses for each soil type. Participants identified three to seven soil types. The primary criteria for soil classification were texture, color, the presence of stones, and depth of the plow layer (human and natural capitals). In three of the four communities (except San Juan Circa) in which workshops were held in Umala, community members indicated that soil fertility had declined over the past 10 years due partly to decreased fallow periods. The primary effects of climate change that community members identified were dry conditions and stronger winds that have increased soil erosion, but these varied by soil type and by soil and crop management.

A Bolivian undergraduate student researched soil classification and completed extensive characterization of land use within the Ancoraimes communities using satellite imagery and remote sensing data. Initial results from this analysis indicate that the primary activities of the higher elevation communities center on livestock production, mainly of camelids (i.e., alpaca and llama) and sheep. In the lower communities, agricultural production of crops such as potatoes, onions, and fava beans is the primary activity. Farmers also have provided detailed descriptions

of the characteristics and uses for each soil type they have identified in their local classification system and how these uses have changed over the past 10 years due to climate change and other factors. Tables 5 and 6 provide a listing of the local soil classification system and local soil names in several communities in Ancoraimes and Umala, respectively. Community members generally noted no major changes in most of the specific soil types over time, but when changes were noted, those related to decreased soil fertility, lower soil water availability, loss of soil due to erosion, and increased incidence of pests in the soil (Tables 5 and 6).

Table 5: Local soil classification system used in communities in Ancoraimes.

Community	Relative Elevation	Soil Types	Local Name	Characteristics	Changes in Use*
Chinchaya	Low	Sandy	Cha'lla	Presence of sand; presence of small rocks	No change
		Clayey	--	Presence of fine particles; black and yellow color	No change
		Rocky	--	Presence of large rocks	No change
Karkapata	Medium	Loamy	Q'otapampa	Good soil with moisture	A lot of pests if onion and potato are planted
		Clayey	Q'enko	Very shallow soil so difficult to plant	No change
		Rocky soil (in the high part of the village)	--	Have large outcrops of rocks and have very little vegetation	No change
		Rocky soil (in the bottom part of the village)	--	Have erosion of soil from the high areas and there are rocks in the fields	No change

* Observed changes in use of soil over the last 10 years.

Table 6: Local soil classification system used in communities in Umala.

Community	Relative Elevation	Soil Types	Local Name	Characteristics	Changes in Use*
San José de Llanga	Low	Sandy	Cha'lla	Loose soil	No change
		Clayey	Ňeq'e	Very hard and heavy	It has become drier
		Silty	Kaima	Land with a lot of mud near the river	Before there was th'ola
		Saline	Qullpa	Land for grazing; soil is neither soft or hard	No change
		Rocky	Kala	Presence of large rocks	No change
San Juan Circa	Low	Sandy	Cha'lla	Loose soils with a light color	No change
		Clayey	Llinqi	Has a color of brown to black, it is dry and difficult to work	No change
		Rocky soil	K'ala chajua	Has rocks and some sand; the stones are about 30 cm in diameter; the surface soil is brown and the subsoil is reddish	No change
Vinto Coopani	High	White soil	Pajre oraque	Soft soil; spiney plants grow in it.	Before it was used for agriculture and now it is not.
		Clayey soil	Ňeq'e oraque	The surface soil can be cultivated but with erosion the soil becomes hard like cement	The soil used to be much stronger but it has been washed away.
		Sandy/clayey soil	Jach'oca	The soil has both clay and large stones	The moisture content is decreasing and there are more rocks.
		Hard clay soil	Karpa	Has clay that is used for making ceramics.	It has become less fertile.
Vinto Coopani	High	Sandy soil	Saj'e	Has little soil on the surface and below has gravel. It dries out quickly and is a very soil for production.	Used to be more fertile because it was maintained in fallow longer.
		Black soil	Chiar laqa	The clay is neither hard or soft	Used to be more fertile because it was maintained in fallow longer.
		Fine sand soil	Laqa Oraque	Good soil with the color of skin; it has very fine sand	It appears to have more rocks.
Kellhuiri	High	Sandy soil	Cha'lla	Has small rocks the color of coffee; loose	Decrease in production

Community	Relative Elevation	Soil Types	Local Name	Characteristics	Changes in Use*
				soil	
		Clayey soil	Ňeq'e	Does not have rocks; yellow-orange color; soil becomes hard when dry	No change
		Rocky soil	Khala	Big rocks; loose soil with a coffee color	No change
		Sandy/clayey soil	Jach'oca	Dark soil; very good soil	No change

* Observed changes in use of soil over the last 10 years.

Characterization of soils and organic amendments

Based on the local soil classification systems and soil maps (local knowledge, human and cultural capitals), geo-referenced soil samples were collected to a depth of 20 cm from farm fields representing the major soil types Umala and Ancoraimes. These fields were sampled in their first cropping year after being fallow. About two farm fields were sampled for each soil type. Soil bulk density was also determined using the core method; these data have yet to be compiled. The soil samples have been dried, ground, and sieved, and have been analyzed for texture, soil organic matter, electrical conductivity (EC), pH (0.01 M $CaCl_2$), Bray1 P, soil test K (1 M ammonium acetate, pH 7), exchangeable Ca and Mg, CEC and acidity that can be neutralized. Table 7 shows the results for soil samples collected in Umala representing the major soil types in each community. Soils were primarily classified in the sand, sandy loam, loam, and silt loam soil textural classes. Higher soil organic content appeared to relate primarily to higher silt and clay content and was generally lower as the proportion of sand increased (Table 7). A similar trend occurred with CEC. None of the soils sampled had cropping limitations due to salinity as determined by EC measurements. Measurements of soil acidity as indicated by soil pH and neutralizable acidity varied considerably (a pH range from 5.1 to 7.5), indicating a possible constraint for growth of some crops due to soil reaction. Soil test P and K levels were relatively high for unamended soils, but most of the soils would require amendments for maximum production. The clay soil (*Ňeq'e*) in Vinto Coopani had one of the lowest soil test P (3.0 mg P kg^{-1}) and K (159 mg K kg^{-1}) among the soils analyzed.

Geo-referenced samples of organic amendments were also collected from each community before the growing season in 2006 to determine the range in composition of these materials. Two or three samples of the same amendment type (e.g., cow and sheep manure) were collected from each community and had varying periods of composting and litter added. These samples have been analyzed for total organic C, N, P, K and micronutrient composition. The results are presented in Table 8. The C:N ratio of the manure samples collected from Umala did not generally differ and ranged from 13 to 24. In general, farmers indicated a preference for sheep manure over cow manure as a soil amendment, but very limited differences in nutrient composition were observed in the collected samples. An interesting difference among the communities was the elevated total Fe and Mn levels in sheep, cow, and alpaca manure from Chojñapata (Table 8).

Table 7. Selected soil properties of major soil types based on the local soil classification system used in communities in Umala.

		Particle size analysis									Exchangeable			
Community	Soil type	Sand	Silt	Clay	Textural class	Organic matter	pH_s	Neut. acidity	Soil test Bray1 P	Soil test K	Ca	Mg	CEC	EC
		%				%		$cmol_c\ kg^{-1}$	mg kg^{-1}				$cmol_c\ kg^{-1}$	$dS\ cm^{-1}$
San José de Llanga	Sandy/Cha'lla	88.8 ± 1.8*	6.3 ± 1.8	5.0 ± 0.0	Sand	0.3 ± 0.0	5.5 ± 0.6	0.8 ± 0.4	35.0 ± 3.6	166 ± 45	311 ± 90	44 ± 13	3.1 ± 0.3	0.1 ± 0.3
	Clayey/Ñeq'e	20.0 ± 0.0	55.0 ± 7.1	25.0 ± 7.1	Silt loam	2.4 ± 0.3	7.5 ± 0.1	0.0 ± 0.0	20.5 ± 5.0	424 ± 107.8	4520 ± 347	279 ± 45	26.0 ± 2.4	0.5 ± 0.0
	Silty/Kaima	41.3 ± 1.8	51.3 ± 1.8	7.5 ± 0.0	Silt loam	0.5 ± 0.0	7.5 ± 0.1	0.0 ± 0.0	14.8 ±0.4	158 ± 29	2337 ± 162	125 ± 20	13.1 ± 0.9	0.3 ± 0.1
San Juan Circa	Sandy/Cha'lla	52.5 ± 17.7	37.5 ± 14.1	10.0 ± 3.5	Loam	0.9 ± 0.4	6.0 ± 0.0	0.8 ± 0.4	22.8 ± 1.8	172 ± 58	1290 ± 336	181 ± 65	9.1 ± 2.7	0.1 ± 0.0
	Clayey/Llinqi	21.3 ± 1.8	52.5 ± 3.5	26.3 ± 5.3	Silt loam	2.7 ± 0.1	5.3 ± 0.2	4.0 ± 0.7	28.2 ± 7.4	438 ± 74	2299 ± 406	503 ± 82	20.8 ± 2.2	0.1 ± 0.0
	Rocky/K'ala chajua	67.5 ± 14.1	25.0 ± 10.6	7.5 ± 3.5	Sandy loam	1.4 ± 0.1	5.1 ± 0.1	2.8 ± 0.4	16.0 ± 0.7	259 ± 17	646 ± 89	159 ± 17	8.0 ± 0.3	0.1 ± 0.0
Vinto Coopani	Sandy/Cha'lla	51.3 ± 1.8	38.8 ± 1.8	10.0 ± 3.5	Loam	1.3 ± 0.1	5.7 ± 0.0	1.5 ± 0.0	46.8 ± 6.0	271 ± 17	1102 ± 168	148 ± 14	8.9 ± 0.9	0.3 ± 0.3
	Sandy/clayey soil/Jach'oca	68.8 ± 1.8	26.3 ± 1.8	5.0 ± 0.0	Sandy loam	1.2 ± 0.1	5.5 ± 0.1	1.8 ± 0.4	45.2 ± 1.1	240 ± 4	580 ± 70	70 ± 10	5.8 ± 0.1	0.2 ± 0.1
	Clayey/Ñeq'e oraque	33.8 ± 1.8	33.8 ± 1.8	32.5 ± 3.5	Clay loam	1.5 ± 0.1	6.9 ± 0.2	0.3 ± 0.4	3.0 ± 0.0	159 ± 48	3763 ± 241	578 ± 173	24.3 ± 3.1	0.2 ± 0.1
Kellhuiri	Sandy/Cha'lla	61.3 ± 1.8	32.5 ± 3.5	6.3 ± 1.8	Sandy loam	1.6 ± 0.4	5.5 ± 0.4	2.0 ±1.4	51.0 ± 19.1	243 ± 90	972 ± 294	101 ± 35	8.3 ± 0.1	0.2 ± 0.1
	Clayey/ Ñeq'e	38.8 ± 1.8	47.5 ± 0.0	13.8 ± 1.8	Loam	2.5 ± 0.7	6.3 ± 0.6	0.8 ± 1.1	38.2 ± 8.1	231 ± 35	2644 ± 75	160 ± 7	15.9 ± 0.8	0.3 ± 0.0

*Values represent the average ± standard deviation of two occurrences of the soil collected in each community. All fields sampled were going into their first year of cropping after varying fallow periods.

Table 8. Selected characteristics of composted manure samples collected in Ancoraimes and Umala communities in 2006.

Community	Manure type*	C:N ratio	Total organic C	Total N	Total P	Total K	Total Zn	Total Fe	Total Mn	Total Cu
			%				mg kg^{-1}			
Umala										
San José de Llanga	Cow	21	25.6	1.2	0.27	2.5	32.9	2827	104	7.3
	Sheep	13	22.3	1.7	0.38	2.6	37.8	2878	128	8.8
San Juan Circa	Cow	16	22.4	1.4	0.34	2.2	38.6	3742	200	7.2
	Sheep	20	30.1	1.5	0.32	2.2	38.0	2544	191	7.1
Vinto Coopani	Cow	24	28.3	1.2	0.28	1.5	35.5	4102	150	6.5
	Sheep	21	31.9	1.5	0.27	1.1	32.7	3318	168	7.1
Kellhuiri	Cow	19	31.7	1.7	0.36	1.6	36.5	3836	215	8.3
	Sheep	17	35.2	2.1	0.35	2.1	39.0	2714	182	7.9
Ancoraimes										
Chinchaya	Cow	--**	--**	1.5	0.27	1.6	47.2	5154	260	9.5
	Sheep	--	--	1.7	0.22	1.3	38.6	3099	231	9.2
Chojnapata	Cow	--	--	1.7	0.35	0.8	92.3	7223	1298	13.8
	Sheep	--	--	2.1	0.26	1.4	94.5	5991	1029	9.6
	Alpaca	--	--	1.8	0.25	0.6	81.7	4220	1538	11.0
	Llama	--	--	1.5	0.19	0.4	61.2	3820	797	8.8
	Guinea pig	--	--	1.5	0.40	1.2	68.5	5240	806	9.7

*Manure samples were collected from compost piles in each community and predominant source identified by community members.
**Analysis not yet completed

Table 9. Effects of changes in length of fallow period on selected soil properties of the sandy (cha'lla) soil in two communities in Umala.

Community	Fallow length	Total org. C	Total N	C:N ratio	pH_s	Neut. acidity	Soil test Bray1 P	Soil test K	Exchangeable Ca	Exchangeable Mg	CEC	EC
	- years -	---------- % --------				$cmol_c\ kg^{-1}$	---------- mg kg^{-1} ----------				$cmol_c\ kg^{-1}$	dS cm^{-1}
San José de Llanga	0*	0.47	0.014	35	6.25	0.25	21.8	150	436	68	3.4	0.1
	1	0.43	0.024	18	5.55	0.50	23.2	121	322	54	2.8	0.1
	20	0.45	0.032	14	5.90	0.50	22.5	142	341	56	3.0	0.2
	30	0.50	0.010	50	5.60	0.75	27.8	176	418	88	4.0	0.1
	$LSD_{(0.05)}$	0.03	0.004	9	0.54	NS	NS	NS	NS	NS	NS	NS
	P > F	0.018	0.001	0.001	0.066	0.381	0.522	0.220	0.413	0.326	0.421	0.479
San Juan Circa	0	0.81	0.091	9	5.85	0.75	20.2	184	1317	216	9.6	0.2
	1	0.62	0.054	11	5.55	1.00	24.8	140	852	140	6.8	0.2
	10	0.60	0.024	26	5.60	1.00	29.2	158	802	132	6.5	0.1
	30	0.56	0.030	18	6.25	0.25	24.8	141	700	117	5.0	0.1
	$LSD_{(0.05)}$	0.16	0.017	8	0.61	0.69	8.2	36	498	77	3.2	0.1
	P > F	0.039	0.001	0.014	0.099	0.107	0.150	0.078	0.086	0.075	0.066	0.121

*Fallow length of 0 years was an uncropped area.

An additional study, which is part of Ph.D. dissertation research for a Bolivian soil science student, was initiated to assess the effects of decreasing fallow periods in the crop rotation on soil degradation (i.e., on decreasing soil organic matter and other possible negative changes in soil characteristics). This study was undertaken because the results of initial surveys and participatory workshops in Umala and Ancoraimes indicated that one effect of climate change and other socioeconomic factors was a decrease in the length of fallow periods. Soil samples were taken from a number of fields of the same soil type but with different cropping histories to determine changes in soil properties at the beginning and end of the cropped phase of the rotation, then during the fallow period of varying length. The hypothesis is that the decrease in the fallow period reduces soil quality and that other factors, such as increasing use of tractors for primary tillage, may affect restoration of soil fertility during the fallow period. That is because farmers have identified that native vegetation such as th'ola (*Parastrephia lepidophylla* and *Baccharis incarum*) does not regrow as well in fallow areas with tractor-based tillage compared with animal-based tillage. Competing uses for th'ola in the Umala communities may also be affecting the effectiveness of the fallow period for soil fertility restoration. A potential follow-up study would identify multi-use plants that could be managed as part of an improved fallow system contributing to restoration of soil fertility as well as allowing for livestock grazing.

Initial results for the effects of varying fallow length on soil properties in two communities in Umala are shown in Soils - Table 5. This table compares analytical results from soil samples of the sandy (cha'lla) soil taken from non-farmed areas and farm fields with varying lengths of fallow. In general, soil organic C increased with increasing fallow length or was higher in the non-farmed versus the recently fallowed fields. Soil pH generally increased, and neutralizable acidity decreased with increasing fallow. Differences between other soil properties (i.e., soil test P and K, exchangeable Ca and Mg, CEC and EC) were observed only between the previously cropped and non-cropped areas) in San Juan Circa and not in San José Llanga (Table 9).

These results suggest that cultivation generally decreased soil fertility in certain soil characteristics, but the effect is not consistent in all communities. Fallow length may also be important in changing certain soil properties such as organic C and soil reaction that have been affected by cropping.

Soil samples of the sandy soil collected in San José Llanga in fallow fields underneath or between th'ola plants compared with cultivated fields of the same soil indicate some of the effects on soil properties as th'ola growing during the fallow period (Table 10). Directly underneath the th'ola plants, soil test P was higher than between the plants (Table 10). However, none of the other measured soil properties differed due to the sampling position in relation to fallow vegetation. Although leaf residues were visually observed to be higher directly under the plant, the effects of the plant may be wider spread due to wind dispersal of the leaves and the extent of root growth. In contrast, large differences in soil properties were observed in soils collected near the th'ola and during the first year of cropping. Soil total organic C, total N, pH, soil test K, exchangeable Ca and Mg and CEC were all higher in soil near th'ola (Table 10). This contribution of th'ola or other effects of fallow vegetation may be important for restoration of soil fertility during the fallow period.

Table 10. Selected soil properties of sandy (ch'alla) soil collected directly underneath or between th'ola plants or in farm fields during first year of cropping in San José de Llanga in Umala in 2006.

Location of sampling	Total organic C	Total N	pH_s	Neut. acidity	Soil test Bray1 P	Soil test K	Exchangeable Ca	Exchangeable Mg	Exchangeable CEC
	----------%----------			$cmol_c\ g^{-1}$	----------mg kg^{-1} ----------				$cmol_c\ kg^{-1}$
Beneath th'ola	1.82 ± 0.51	0.15 ± 0.02	7.2 ± 0.3	0.0 ± 0.0	44.5 ± 10.4	529 ± 162	3151 ± 610	208 ± 42	18.8 ± 3.7
Underneath th'ola	1.57 ± 0.20	0.15 ± 0.02	7.5 ± 0.1	0.0 ± 0.0	28.6 ± 5.6	365 ± 67	3484 ± 385	185 ± 16	19.9 ± 1.9
1st year cropping	0.45 ± 0.02	0.01 ± 0.01	5.5 ± 0.6	0.8 ± 0.4	35.0 ± 3.6	166 ± 45	311 ± 90	44 ± 13	3.1 ± 0.3

*Values represent the average ± standard deviation of three occurrences of the soil.

4. Identification of major plant pests, diseases, and incidence in recent years

Insect pests and diseases

In an extensive survey conducted by our SANREM team, the communities in Umala and Ancoraimes identified the Andean potato weevil (*Gorgojo de los Andes*) and potato tuber moth (*polilla*) as their major pests. In response to this assessment, we have developed participatory research to evaluate the population dynamics of these two insects in each of the communities. Two species of weevil (*Premnotrypes sp, Rhigopsidius piercei*) and three species of moth (*Phthorimaea operculella Z., Symmetrischema tangolias T., Paraschema detectendum P*) have been identified. We will combine the results from student theses with previous analyses of these two pests in Bolivia conducted by PROINPA staff and affiliates for publication in both English- and Spanish-language journals. This first step of understanding the dynamics of these pest species sets the stage for developing sustainable management techniques in collaboration with community members and with the economic and sociological perspectives of other SANREM team members. Preliminary results suggest a change in the behavior and population of potato weevils. Previous studies indicated that *Premnotrpes spp* was dominant, but nearly 90 percent of the species trapped were *Rigopsidisus piercie,* which has its origins in Argentina.

Students working at CIP are developing larger-scale assessments of potential climate-change effects on disease and pest management through Bolivia and Peru. Beginning with well-studied models of the effects of climatic variables on potato late blight, they are evaluating regional shifts in management requirements using GIS. This project has led to a new linkage with a U.S. Department of Agriculture project to assess the social and economic impacts of resistance gene deployment in Peru, Uganda, and China. We recently reviewed the problems in potato late blight management in the developing world (Forbes *et al.*, in review).

Pre-existing data from experiments evaluating the effects of potato diversity on potato late blight in Peru, Ecuador, and the United States have been synthesized, analyzing responses as a function of local climate (Garrett, Zúñiga, *et al.*, in review). As part of this study, a mathematical model

was developed for how climate and other factors impact the benefits of host diversity for disease management. Potato mixtures were found to be more valuable for disease management in climates with shorter seasons and therefore, presumably, lower regional inoculum loads. For example, potato production is seasonal and mixtures more useful in highland locations farther from the equator such as Huancayo, Peru, in contrast to year-round production in areas such as Quito, Ecuador. We also demonstrated that, under the assumptions of our mathematical model, mixtures will tend to be more useful at locations where epidemics are of intermediate duration and speed. That is, if epidemics are very slow, the effects of mixtures may not be noted, while if epidemics are so fast that plants are quickly wiped out, the benefits of mixtures may be limited. The speed of epidemics is strongly impacted by climate and will tend to change as climate changes.

The general utility of ecological genomic approaches for disease forecasting is being assessed based on plant responses to environmental stresses (Garrett, Hulbert, *et al.*, 2006), in addition to general ecologically based management approaches (Garrett and Cox, in press). In the long run, this may prove a promising approach for understanding plant resistance and the effects of soil microbial communities on disease and pest resistance.

5. Biodiversity (natural capital) in production systems

Oca, ollucu (*Ullucus tuberosus subsp. Tuberosus*), and quinoa are food crops beyond potatoes that were assessed in Umala and Ancoraimes. *In situ* characterizations of the use of biodiversity in potato and oca have been performed in two communities in Ancoraimes, including evaluations of the rate of loss of traditional varieties. In Umala, traditional potato varieties are being evaluated in participatory trials for a range of agronomic and other characteristics to provide recommendations for deployment of the most successful varieties and strategies for conservation. PROINPA organized a competition among communities in Umala to gather the greatest number of potato varieties. Four hundred people participated, and 114 varieties were collected. These were planted in demonstration fields in Vinto Coopani. The results of the trials will be provided to the participating communities and published in English- and Spanish-language journals.

Another student is completing a review of Bolivian research in agricultural biodiversity in the Altiplano for publication in both Spanish and English language journals. This will provide a synthesis of research that is currently not readily available as a baseline for conservation planning, future assessment, and optimal use of existing varieties.

System level

This objective includes research that links field, household, watershed/community, and ecosystems. Inter-scale relations are analyzed at the household and community level. Climate studies take place at multiple scales, soils at field, and across sites; dynamic of pests in fields comparing across sites, biodiversity in fields and gardens, depending on the site; and landscape driver relationships at community/watershed and ecosystem levels.

Development impact

This research provides the information on existing conditions to compare holistic and scientific knowledge, and identify commonalities. It provides the space for information sharing. This

directly informs KASAP and, through the participatory approaches, provides the settings for testing evaluation and possibly knowledge transformation. This informs Objectives 3 and 4 in terms of skills and practice.

Challenges and responses

Implementation of activities has been timely. Many activities are conducted through thesis research, which does increase the time required for data processing, presenting results, and the integration and synthesis of findings. The household survey took longer than anticipated to complete, clean, and process. Other delays included movement of funds at the beginning of the year, and road blockades due to political unrest that made it difficult to conduct research.

Objective 2: to understand how livelihood strategies are developed in response to farmer perceptions of the relative risks of these changes; and how these perceptions are linked to their assets

An initial participatory assessment of sources of vulnerability and perceptions of change in the landscape in the municipalities of Ancoraimes and Umala was completed in February 2007. A similar assessment was conducted in Apolobamba in April 2007. At these sites, families listed climate, declining soil fertility, and increased populations of pests as their major problems. These assessments provide a first picture of perceptions. This objective benefits from the information in these assessments and is a basis for further research activities indicated below.

Critical research accomplishments

1. Perceived risks and communication networks

Understanding of how livelihood strategies are shaped by farmer's perceptions of market and climate risks and what role do types of capital and assets play in shaping perception is undertaken to determine how types of capital and gender impact farmers' risk perceptions; what are the sources of dread, if these are gendered, and how economic factors affect dread; and how information on climate events, which is inherently probabilistic, is understood, trusted, and incorporated into a decision-making framework.

People assess risks using rules-based systems and association-based systems (experiential). People use both systems to assess risk (Slovic and Weber, 2002). When the results of associational- and rules-based systems conflict, it is more likely that people will assess risk based on the former criteria. In the case of the Altiplano, this will probably mean that, when results of traditional and expert forecasts conflict, farmers will use the traditional assessment model (Slovic *et al*., 2002). The research seeks to understand this relationship, for it is critical in developing inherently probabilistic information. Mass media have a role in providing forecast information, and their coverage of risk can influence perception and trust. Climate hazards and events are communicated often through media. Research on risk perceptions and communication has concentrated on the individual's cognitive mechanisms for processing risk and has ignored the social system that communicates risk to a person, for example, the networks used to access it. This research seeks to identify climate information pathways to support decision processes to increase climate-resilient strategies in the region.

Few studies on risk perception in Latin America exist (Renn and Rohrman, 2000; Sjoberg *et al.*, 2000), and those undertaken have focused on perceptions of health and safety risks. Few have addressed perceptions of ecological hazards (Willis *et al.*, 2005). The hypotheses tested are: There is an inverse relationship between types of capital (nature of the portfolio) and risk perceptions; women have higher risk perceptions and dread than men, even when there is equal control over assets; farmers who have better "insurance mechanisms" to deal with risks will feel lower dread; and farmers who have been exposed to more risk communication through their social systems will have lower dread.

Two methods are applied to address these hypotheses. In Bolivia's northern and central Altiplano, 360 households were interviewed, with women and men responding to questions regarding livelihood strategies, hazards experienced, types of capital, and perceptions of risk and dread. The second method is based on qualitative case-study research, involving focus groups. In July L. Rees and a Bolivian team conducted focus groups in both regions to understand how dread is defined and how hazards are dealt with, measuring differences by gender, life cycle and wealth.

To date, a descriptive analysis of risk perception has been conducted by household and by gender. In Year 3, the following will be accomplished: a mathematical model to measure how types of capital and gender relate with farmers' risk perceptions; and a model that depicts how sources of farmers' dread are explained through economic factors and gender roles. Preliminary results of the survey underscore the importance of environmental hazards, which rank the highest in risk perceptions. Overall, risk perceptions and dread appeared to be significantly different between municipalities and communities, where these are rankings of 0 to 5. There were also gender differences in risk perceptions

Risk communication is studied through content analysis of regional media. A database of 4,620 Associated Press articles was collected for Peru from 1988-2006, and 1,133 articles for Bolivia for the same period. These were imported into the Simstat software for content analysis. Activities to be completed in 2007-2008 include dictionaries created to define risks the news media may portray; and analysis performed using the dictionaries to determine how risks are reported by the media. To date, findings from the developed database of articles indicate a broad spectrum of risks discussed in the mass media that include political risks, natural hazards, and drug issues. Natural hazards identified for Bolivia include floods, earthquakes, volcanoes, and avalanches where floods have resulted in mudslides that claimed the lives of people traveling on public transportation.

Focus groups conducted in Bolivia on risk and dread perceptions of climate events (Ancoraimes and Umala) included the following completed tasks: developed a set of questions about risk perceptions, dread and coping strategies; organized four focus groups in the municipality of Umala (July 12, 2007) with high- and low-income women and men. The household survey database was used to identify economic conditions to define income levels. Four focus groups were organized in the municipality of Ancoraimes (July 26, 2007) using the same criteria for classification. Our field researcher, O. Yana, facilitated and translated Aymara transcriptions to Spanish, and L. Rees to English. The next activity, to be completed in Year 3, is the content analysis of focus group transcriptions. Preliminary analysis of the transcriptions of the focus

groups provided the following insights: Most farmers rely on climate indicators to help them make cropping decisions; however, some do listen to the radio for information. Most of the people do not trust the information they receive from the radio because it is not region specific. Most people indicate that there are very few things they can do for the prevention of a climate event. However, strategies mentioned were planting at different times, planting in different places, using chemicals, and creating vertical fallows. Some discussed coping mechanisms they use when they face a shock, such as use of food reserves, help requests at different governmental levels and institutions, and migration to find work in other regions.

Two studies are currently ongoing on the relationships among livelihood strategies, assets, and perceptions of risk. The first is a quantitative analysis of risk perceptions within a livelihoods framework. The community participatory assessments contributed to the development of this instrument. Questions included perceptions of risk and dread of the event by gender, along with those regarding types of capital, activities, and life cycle. Survey results show climate risks as the most important faced by households. We are testing the relationship between sources of risk, risk perceptions, and assets at the household level, as well as the differences between men and women in relation to risk perception and dread.

The household survey captured data on sources of market, climate, and technology information. Analysis of this data will be completed during Year 3 by Elizabeth Jimenez, G. Gonzales, Rees, and Valdivia. Household survey findings include climate hazards ranked by highest perceived risks, with drought first, followed by frost, flood, and climate change. Markets risks are perceived as high but rank seventh and ninth. These are also events over which respondents felt they had no control. In the case of dread, children getting sick ranks second after drought. Feeling of dread in general was greater among women than men with exception of floods. A second study, by Jimenez, Valdivia, and P. Ajata, aims to identify empirically the impact of risk perceptions on households' decision making and to inform the current debate on expanding financial services to rural agricultural producers in Bolivia. Preliminary results have shown that risk perceptions impact households' decision making, leading to the adoption of coping strategies reinforcing economic vulnerability. Such results suggest the need to design and experiment with schemes of agricultural insurance. This study is to be published in *Umbrales*, a Bolivian academic journal that will dedicate an issue to rural issues in Bolivia. Our project is partially sponsoring this publication through a collaborative agreement that Universidad de la Cordillera made with Centro de Investigaciones del Desarrollo Económico y Social, the oldest graduate social-sciences program in Bolivia.

Linking communications with risk perceptions requires participatory approaches that build on existing knowledge and knowledge systems. Results from the research activities listed above and on climatology and climate trends in Objective 1 will be shared with community groups. As part of the community participatory assessments, farmers developed geo-referenced maps of crop areas, land use, land-use changes, natural resources, and natural-resource changes, and a map depicting areas of vulnerability to climate events. The GIS unit at UMSA developed the geo-referenced maps, and a document was finalized in May. A method to share knowledge will be developed by the participatory methods skills team to return information to communities. In this case, a protocol will be developed in Year 3 to validate the maps with community groups and

include further information on climate trends and forecasts, local knowledge forecast indicators, and landscape imagery to develop a shared understanding of the implications for their regions.

2. Local perceptions of soil quality conditions and change

Workshops were conducted in Ancoraimes and Umala to identify the major current problems that communities are facing related to soil and crop management and how community members think they can be solved (for an example of a community prioritization map, see Figure 3). This information was used to orient research activities to develop alternative management practices undertaken to achieve Objective 3. Community members identified soil problems as one of several factors limiting their crop production. Among soil management problems identified were low soil quality and soil fertility, excessive water and wind-induced soil erosion, and inadequate soil management practices. Problems with soil fertility and quality were low nutrient content, stoniness, and high clay content making the soil hard to crop. Inadequate soil management practices cited were inappropriate tractor tillage, lack of a clear crop-rotation strategy, carelessness of incorporating manure, and overgrazing by sheep.

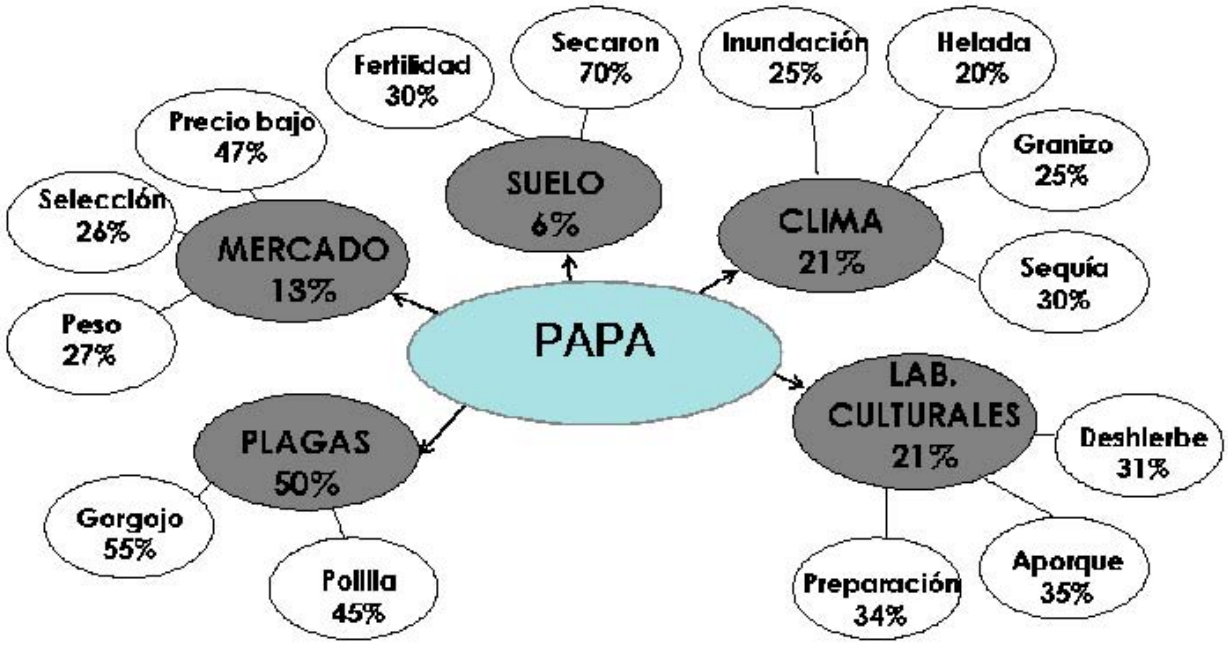


Figure 3: Map in Spanish of prioritization of problems in potato cultivation, drawn by members of the community of San José de Llanga in Umala during a participatory workshop in 2006.

Among the practices farmers recommended for addressing the different soil problems they identified were to add animal manure, green manure, and inorganic fertilizers; and to improve crop rotation and fallow periods to address problems related to low soil fertility. To control erosion, they recommended establishment of cover crops, drainage systems, and terraces if necessary. To improve soil management practices, they recommended better timing of soil preparation and maintenance of native th'ola (*Parastrephia lepidophylla and Baccharis incarum*) during the fallow period.

These survey results indicate that several factors limit crop production in communities in the Altiplano, including soil-related problems. Many soils have inherent limitations due to high clay content and excessive stoniness, and are located on steep slopes, which makes them more susceptible to erosion. Lack of sufficient soil fertility inputs and the impact of poor soil management practices have acted to degrade long-term soil quality and sustainability.

3. Community perceptions of climate

Workshops in January with groups of farmers in Ancoraimes and Umala on local forecast indicators yielded some excellent ideas about the way people perceive climate. First, farmers think that rains are coming later and there is less rain. This result does not seem to be the case when compared with long-term climate data. However, rises in temperature probably reduce the availability of moisture for crops (the same effect as less rain). And less soil moisture, carrying over through winter, may have negative impacts on quinoa and fava bean production. Second, the importance of winds for prediction of rainfall at certain times may provide a bridge between traditional and scientific forecast methods. The large-scale observations and models that A. Seth has been using seem to place heavy importance on the direction of winds. Third, the use and preservation of traditional forecast methods may be decreasing. During initial participatory meetings, people said their methods no longer worked, and many did not use them. However, at subsequent meetings people said they did use their forecast methods, and for the 2006-2007 crop year the predictions using traditional indicators were accurate. More investigation is needed ascertain the current status of these indicators. Belief in declining efficacy in traditional indicators may be due to the fact that there are fewer good years. The decline could also be due to changes in the production systems (i.e., tractor tillage, land fragmentation, off-farm employment) that make the traditional forecasts less useful because people no longer have as much freedom to alter time and place of planting and type of crop.

According to the long-term climate analysis, evapo-transpiration is increasing, and this may negatively affect crops such as quinoa and fava beans. However, farmers in Ancoraimes perceive drier years and shorter seasons, although rainfall has not changed. If the climate models are correct, the rainy season may begin later. These results support our underlying hypothesis that production systems are changing in response to climate change.

In Puno, farmers' perception about the effect of climate change on water, soils, grasslands, crops is that it contributes to an increase in the intensive use of natural resources. Farmers' perceptions are that water sources are drying and grasslands are decreasing due to the intensive radiation and frequent frosts. Soil fertility is decreasing due to shortened rainy season and increased radiation. In Santa Maria and Apopata, the response to climate-change perceptions is to improve soil fertility to increase production, as this requires more intensive use of natural resources. Information about climate and market are not available to both communities. Institutional support is important but also can generate internal conflicts within the community that may stress the environment.

4. Community perceptions of changes in diseases and pests

Gorgojo de los Andes is a pest identified both in Bolivia and Peru. Ranking of risk by community members in the household survey of Bolivian farmers, men and women, ranked pests as a moderate risk (3.48 average in scale from 1 to 5, with 5 being highest), while the perception of control is unsure for some (3.25), and dread of the event occurring is unsure (2.07). Perceptions of these risks have been gathered by gender, and data analysis is ongoing. Study about the perceptions of farmers with respect to pests will be conducted with workshops when the results on Andean weevil and the potato moth dynamics studies in the communities of Aroma and Umala are finalized. This activity will take place in Year 3.

System level

System level is an interaction of various scales as perceptions are hypothesized to be influenced by household-level capital, market and climate driver impacts/effects, and governance in terms of existing institutions that lead to insurance against shocks. Perceptions are assessed at the community/watershed and household/farm levels.

Development impact

Understanding differences between men and women about their perceptions of hazards and risks and their levels of dread felt will contribute to targeting knowledge and skills that can address these and improve their sense of agency. Results of this research inform how practices and strategies as well as information are targeted in Objectives 3 and 4. Research in the area of forecasts and communication about climate hazards, due to its probabilistic nature, will benefit from an understanding of how risks are perceived and hazards experienced to generate information products and processes that address this.

Challenges and responses

Several research activities carried out under this objective include thesis research, which has a longer time to completion. To reduce the time, we identify at the onset of the students' programs the area of the theme so they can contribute with literature reviews, and they receive short-term training in qualitative research to conduct focus groups and mapping, as was done this year. There are some issues with the community maps in terms of approach; these are being addressed and will inform the maps that will be developed in Peru during the third year. Unfortunately, Leonie Marks had to take leave from the university due to illness. As a result, Gilles and Valdivia are taking care of her research responsibilities under this objective.

Objective 3: link local and new knowledge to produce practices and information that provide alternatives for adapting to change

Critical research accomplishments

This objective develops specific interventions in soils, disease and pest management, biodiversity, crop varieties, forages, and dissemination strategies and networks to access new information and diffusion paths.

The Bolivian team met in January and February to develop the participatory assessment instruments and approaches used to measure changes in knowledge, attitudes, skills, abilities,

and practices, and these were selected and tested. Experiments were conducted with farmer groups, as well as with individuals experimenting on farm. Assessments were undertaken with farmer groups during emergence and harvest of potato and quinoa. Information on participation of individuals in all activities was monitored to determine who participates and how information flows from participant to non-participant farmers, with the aim of identifying who is key in the process of diffusion and information sharing. Farmer participation in meetings and other events such as field days and training courses were recorded. Discussion of results with farmer groups is a key phase in knowledge sharing and bridging to identify practices and strategies. The Peruvian team approach focuses on co-learning, where available knowledge such as management of improved forages is identified and shared on farm with community members. The Peruvian and Bolivian approaches to sharing new knowledge are compared under Objective 5, as different stages in the development and sharing of technologies and information are evaluated for uptake by participants and non-participants. Design of these methods falls under Objective 5, Implementation takes place with both practices and strategies (Objectives 3 and 4).

1. Soils

The focus of this effort to identify and develop alternatives for adapting to change was to develop practices to increase soil organic matter as a means to improve agricultural sustainability and buffer against impacts of climate change. Several possible strategies were identified in the Altiplano, including improved use of organic soil amendments and chemical fertilizers, better management of crop residues, use of green manures, development of managed fallow systems, and reduced tillage practices, thereby increasing biomass production and economic returns. To initiate this effort, we first examined the use of organic and inorganic soil amendments, including alternative organic sources such as household compost, on initial and successive crop response, changes in soil properties, and community perceptions of the relative agronomic effectiveness and cost of organic and inorganic soil amendments.

Field experiments

Field experiments were established in 2006 in four low- and high-elevation communities in Umala and three low- and high-elevation communities in Ancoraimes with community participation in selecting a representative site for each community. Initial soil samples were taken from all the sites before application of treatments and planting of potato. Treatments included a control, sheep and cow manures, compost, peat moss, Biofert (a commercial microbial activator soil amendment), urea and diammonium phosphate, and combinations of these different treatments. Samples of the organic amendments were collected for analysis. Agronomic measurements during the growing season included the emergence percentage, plant height, leaf area index, foliar cover, potato yields, and grades and tuber index. Petioles were also sampled to determine nutrient status. At the Umala sites, an additional study to compare petiole N results with results from the Cardy nitrate meter was also conducted to determine if this quick test method could be used to improve N fertility management. Additional soil samples were taken during the growing season to assess relative differences in nutrient content, water content, and porosity due to the treatments. Bulk density samples were taken before harvest to assess the effects of the treatments on soil physical properties. This experiment will be replicated during the next growing season, and an additional study will examine the residual effects of the treatments on the subsequent growth of a local grain crop such as quinoa or barley.

First-year results of the field trials in Umala and Ancoraimes indicate that mixtures of animal manures and chemical fertilizers generally resulted in the highest potato tuber yields (Figures 4 and 5). However, greater yield response to chemical fertilizer was observed in the Umala communities compared with those in Ancoraimes. The differences in incidences of frost and hail damage among the communities also had a significant effect on observed crop performance.

Some indication of the potential buffering effects of organic amendments on climate change such as increased temperature and lower rainfall is observed in Figure 6. This figure shows differences in soil water content in Cohani in Ancoraimes during the 2006-2007 growing season due to the effects of organic and inorganic soil amendments. In general, organic soil amendments such as sheep manure resulted in higher soil water content compared with the control and inorganic soil amendments. More controlled experiments are needed to determine the effects of adding these materials on decreasing shifts in temperature and soil water content due to the confounding effects of differences in plant growth when the amendments are added.

The field research in Umala and Ancoraimes is part of the undergraduate research of two Bolivian soil science students at the Universidad Mayor de San Andrés in La Paz.

Participatory evaluations

Community members were actively involved in evaluating the agronomic effectiveness and economic practicality of the fertility sources during and at the end of the growing season. Community members assessed which treatments they preferred at flowering time and harvest using their local criteria, which included plant biomass, number and size of tubers, plant height, uniformity, stem thickness, early maturation, and plant color. Also, they were given information on the relative costs of each fertility source in relation to the potato yields and were asked to select the treatments they preferred. In general, farmers selected the mixed chemical fertilizer and manure treatments.

In the communities in Ancoraimes, individual farmers also took one of the several fertility treatments represented in the field trial and grew potatoes under the management conditions in their own fields. This setup allowed farmers to compare the results of the fertility treatments across the range of management conditions that exist in the communities. In Umala, a field day was held in which farmers from several communities participated and heard talks by other farmers who presented information about their own experiences with the use of chemical fertilizers and organic soil amendments.

In Puno, natural resources under intensive use today are soils and pastures (grasslands and cultivated). Therefore, linking local and new technical knowledge to address farmer aspirations focused on training programs in the fabrication of organic fertilizers, pasture management, and conservation. The purpose was to exchange information about soil and pasture management, and to increase farmer knowledge that he or she can incorporate with existing strategies.

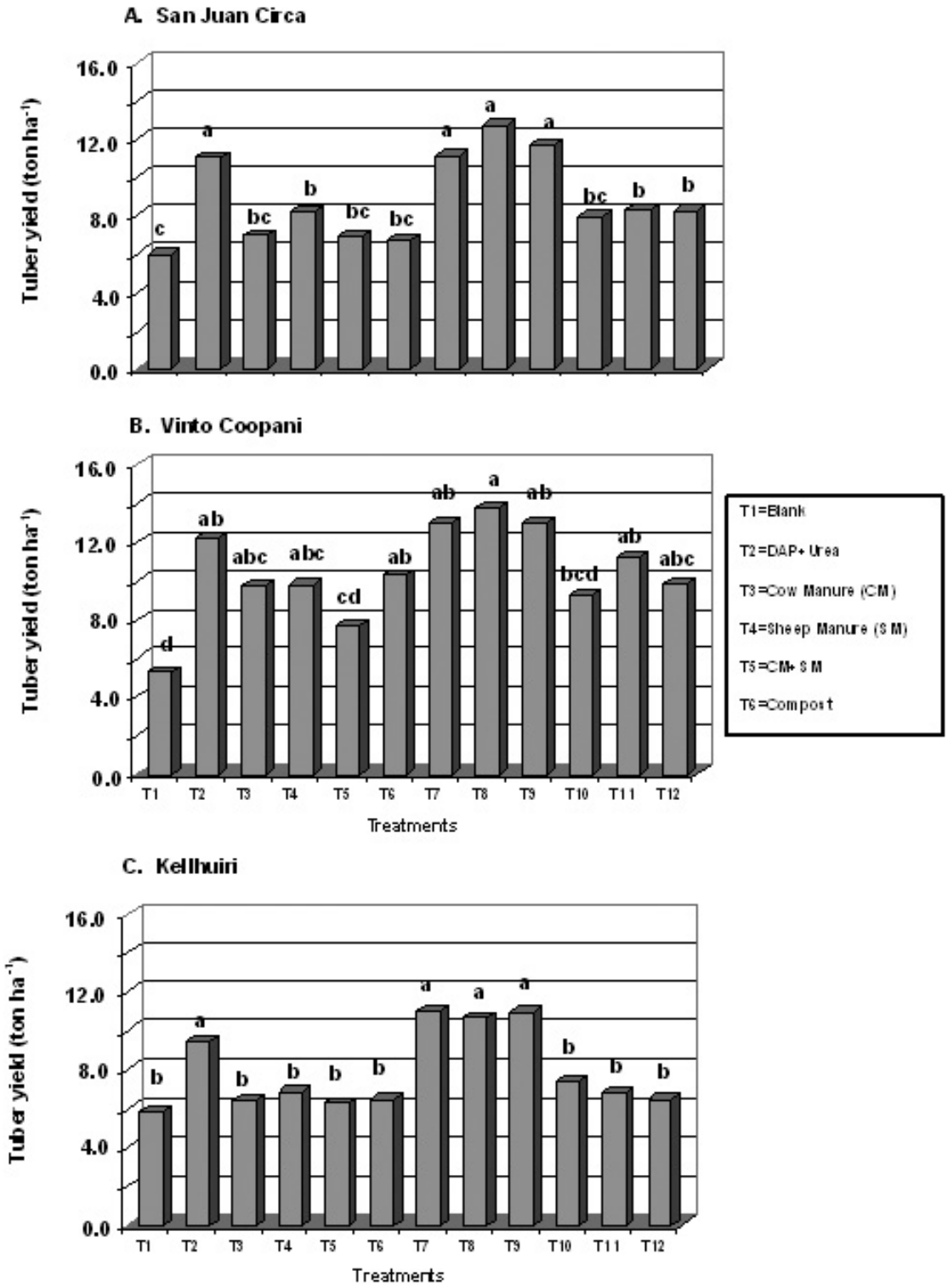


Figure 4: Potato tuber yields in 2007 due to application of organic and inorganic soil amendments in three communities in Umala. Letter indicates if means are significantly different based on $LSD_{(0.05)}$.

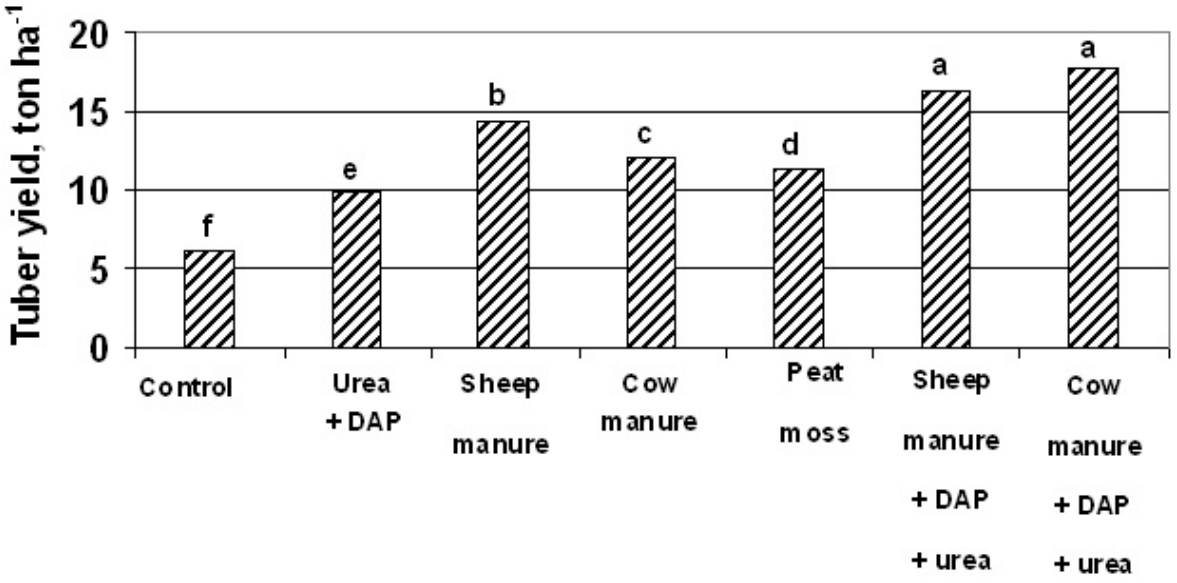


Figure 5: Potato tuber yields in 2007 due to application of organic and inorganic soil amendments in Cohani in Ancoraimes. Letter indicates if means are significantly different based on Duncan's Mean Range Test ($p < 0.05$).

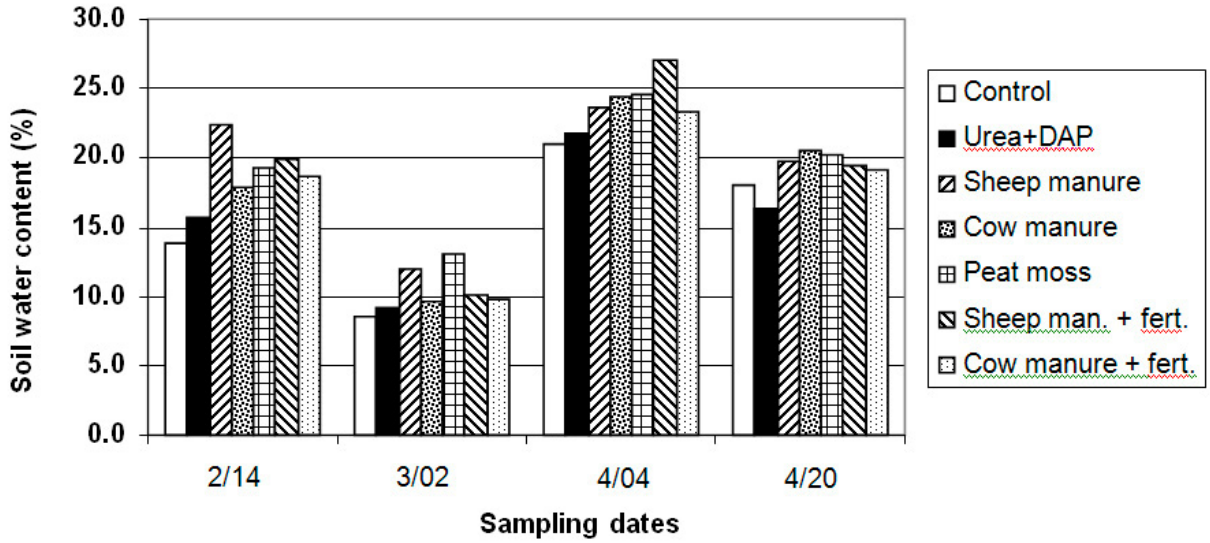


Figure 6: Soil water content to a depth of 30 cm during the 2006/2007 growing season in Cohani in Ancoraimes due to application of organic and inorganic soil amendments.

2. On-farm diversification – adapted and native varieties

Several introduced varieties of quinoa (*jacho grano, kurmi, ratuqui, surumi*, *sayana*) were compared with the local varieties in four communities. Drought conditions had an impact on the trials, but *jacho grano, kurmi,* and *suruni* showed the most potential in terms of yield; however, ranking among them varied by community. *Jacho grano* and *surumi* had the largest grains, and the local variety and *jacho grano* had the highest ranking in taste tests.

In Umala, 118 varieties of potatoes (natural and cultural capitals) were identified through a local competition. The characteristics of these varieties (morphology and habits) were analyzed using principal components analysis to place them into five groups. Of the 118 varieties catalogued, participatory evaluations suggested that 30 might have market potential, given their agronomic and cooking qualities. These varieties will be planted to study their characteristics in more detail. In Ancoraimes, evaluation of diversity of potatoes took place on farm. Student thesis field work was completed, and analysis is ongoing.

To assess the potential impact of new practices on the livelihoods of families in Umala and Ancoraimes, A. Romero was identified to pursue his master's degree with CIDES, focusing on the impacts of soil amendment practices, diversity of quinoa and potato varieties, and pest management. Data for the study have been collected through the household survey and is complemented by focus group interviews, which took place in August. This study takes place during the second year of field experiments in Umala and Ancoraimes. A livelihood framework will be used for impact assessment.

Information on climate conditions and forecasts: Integrating local and new knowledge
Evaluate Intergovernmental Panel on Climate Change (IPCC) Assessment Report Four (AR4) climate models for highland region. In examining the IPCC global coupled climate model integration for the 20th century, we are finding that the global models do capture the large-scale relationship between easterly winds and Altiplano precipitation on year-to-year time scales in the present climate. In the 21st century scenarios, the climate models tend to project a change toward more westerly winds, which would imply drier conditions in the Altiplano. Indeed, a few models show drier conditions in the future, but in general the models do not agree that more westerly winds will yield drier conditions; some models suggest wetter conditions even with westerly winds. In these models, the entire mechanism is changing in the future and must be explored in some detail. There is also some suggestion from the climate model projections that the drier conditions may be more likely in the early part of the rainy season. Clearly these results will have implications for highland agro-eco systems. However, the very preliminary nature of this work requires further and more rigorous analysis before direct discussions with farmer groups are warranted. The results of focus groups and interviews with local experts on climate prediction suggest that collaboration among local experts and meteorologists could lead to improved forecast models by using local evaluations.

3. Information dissemination networks

Our approach to participatory evaluation includes monitoring of those participating in the various research, capacity building and networking activities in the project. The household survey gathered information on current sources of information at the household level at the outset of the

research process. An ex-post survey will again capture KASAP, to determine how information is flowing from participants to non participants in the Bolivia regions.

System level

Information generated on climate corresponds to the various Altiplano ecosystems, while research on local indicators corresponds to knowledge and observations at the community/watershed and field scales. The soil management practices are field research, but evaluated at the community/watershed scale. The biodiversity research, on potato varieties, is conducted on two different scales, the municipality through competitions and the community /watershed through gardens. Information and dissemination networks encompass governance at the farm household level. Information networks focus on the community through the household surveys.

Development impact

The activities in this objective focus on changing P (practices in TOPS) but are designed to affect knowledge and abilities, as well as to evaluate what are the obstacles to implementation with the participatory methodologies been implemented in the project.

Challenges and responses

Problems with drought and pests impeded the complete evaluation of quinoa varieties and pest damage complicated the soil amendment trials. Field research, designed by the investigators is implemented by students for their theses. Integration of data across sites requires first completion of the thesis research, which in the case of *licenciatura* takes 12 months and a master's degree, 18 months. We are developing technical reports with the results of the thesis research. Some of the instruments for data collection were broken, and have been replaced. Coordination of the teams was facilitated in order to ensure comparable approaches at all sites in on-farm activities and in gathering the data to evaluate how information flows. We continue to support integration in the research and outreach.

Objective 4: develop market access through strategies and institutions that contribute to resilience, i.e., improved negotiation and valuing of biodiversity

Critical research accomplishments

1. Market access assessment

A household survey of 360 families is the source of data to analyze the role of markets in the composition of household economic portfolios and to analyze gender and market participation. Data entry, cleaning, and descriptive statistics were completed. This information was shared, along with the database, as inputs on socioeconomic characteristics, production systems, and land-use patterns contribute to soils, pests, climate, and biodiversity studies underway. A study of market access in Ancoraimes and Umala communities is ongoing with the survey data. Valdivia and Jiménez with graduate students G. Gonzales, Figueroa, and Rees are working on manuscripts for publication in Bolivia and a second for submission for Agricultural Economics Association meetings. A second study by Jiménez and Ajata aims to describe market access in the central and northern Altiplano using MAPA, the USAID Market Access and Poverty Alleviation project database. This study will be completed during Year 3. Collaboration with the

project and access to the database were secured this year. Women and bargaining power in market participation within the household (Ajata's thesis) is a third study with our database, where the central question is the role of human and other types of capital in bargaining power and market participation. She tests the role of education in empowerment, relating female head of household education market participation and indicators of well-being. To date, the household survey has been studied using cluster analysis. Preliminary findings point to education as an important factor in bargaining power, expressed as making joint participation in marketing by heads of household. The study focused on who is in charge of marketing products, with joint, male head of household, or female head of household as alternatives. Forty-two percent of households share in decisions about marketing. Human capital of male and female heads is higher in the group where joint decisions are made. Their degree of participation in groups is also higher, and so is their economic capital. This analysis is ongoing, and results are preliminary but point to a significant effect of female education.

2. Niche market assessment for native crops

Producers sell several varieties of potatoes in the Altiplano, as well as value-added traditional products such as chuño and tunta (processed freeze-dried potatoes). Producers in Umala, assisted by PROINPA, are improving quality of native potatoes to raise prices. Valdivia and M. Figueroa, master's degree student in agricultural economics student, are studying market institutions that facilitate access that simultaneously contribute to resilience. A case study of the Participatory Market Chain Approach (PMCA) and the Bolivian Andean Platform (BAP) started in June to understand how and when they increase bargaining power of potato producers. Central questions are: If and when does BAP, through the PMCA, contribute to an increase in income through marketing of native crops, supporting agricultural biodiversity? What types of farmer groups benefit from this strategy? Which households benefit, and who is excluded? Household data is used to identify the diversity of family conditions and the role of native crops in livelihood strategies. In-depth interviews were conducted with representative households of various income and lifecycle characteristics. In-depth interviews with stakeholders participating in the BAP were undertaken in June through August 2007 in La Paz. The questions raised with farmers included reasons for participating (or not) in the native varieties program and identifying the benefits, costs, barriers, and incentives for participation. The questions asked of stakeholders included how the institution/program benefits from improving market access for small-scale farmers. Farmers and stakeholders were asked to identify how producers access markets, who the market chain actors are, and institutional coordination. Key informant interviews included participant and non-participant farmers in the native potato program in three communities: Kellhuiri, Vinto Coopani, and Sirujiri. Stakeholders interviewed included ALTAGRO, PROINPA, Save the Children, Papa Andina, and the InnovAndes poverty alleviation project. Members of BAP included farmer organizations from Ancoraimes and Lahuachaca, NGOs working with them, and non-members of BAP. Institutional design is unique to each area. Development programs build their strategies on local institutions and knowledge, and traditional agricultural practices. Group size matters. Preliminary findings, comparing three producer organizations' participants in BAP, indicate that groups with smaller numbers of very engaged participants function better and achieve higher success than those with larger numbers where free ridership is experienced. Lack of incentives of any kind decreases interest to participate in native potato variety programs and platforms of discussion. The PMCA establishes BAP's rules. Transaction costs of participants in native potato improvement programs are higher for households where there is more than one

child, a single mother is the head of the family, the father is absent due to emigration, plots for cultivation are dispersed, crops diversification is low, land owned is limited in extension, only one member lives in the farm, and time is limited between farm and household activities. Transaction costs of participating in platforms such as BAP are higher for farmers than for stakeholders, because meetings are held in La Paz (one or two hours distance from rural areas).

3. Access to credit

The baseline survey in Bolivia provides information of current use of credit, as well as strategies to cope with shocks. G. Gonzales, master's student in rural development at CIDES, began in April with a review of supply and demand studies of financial services in rural areas in Bolivia, which continues with case studies in Umala and Ancoraimes. She will develop a profile of the supply of credit services and current demand them, focusing on case studies of existing supply and demand of credit for the production of quinoa and native potatoes. Preliminary results on the supply side show only 5 percent of the national supply for credit and micro-credit directed to agriculture. Micro-credit institutions offering services in rural towns have increased in recent years. These are aimed mostly at the services sector and small-scale retail, and do not cover agricultural production. At the household level, informal mechanisms are present. Household data at the research sites show that about 70 percent of heads of the household who have received a loan in the past five years obtained it through informal institutions. There are no studies on the nature and characteristics of informal financial institutions in the rural sector. Recent research concludes that the demand for credit in rural communities is aimed at investment in working capital, and demand for financial services other than credit – savings, for example – is largely absent. Focus groups conducted in Ancoraimes and Umala revealed two important preliminary conclusions. First, demand for credit aimed at investment appears not to exist. Producers perceive interest rates as too high, returns from investment are used to repay loans, thus "one ends up working for the bank." As part of her master's thesis, Gonzales is identifying the characteristics and extent of commercialization strategies at the household level in Umala and Ancoraimes using information from the database. She will link these results with current use of credit and visits to the communal banks created by peasant women and merchants in Patacamaya and Sicasica, both in our study sites. Her thesis will further this analysis and empirically assess the relationship between livelihood strategies, market strategies, market-related risks, and access to financial services.

Little information is available on recent creation of opportunities aimed at small-scale agricultural producers through the Banco de Desarrollo Productivo (Bank for Productive Development). Agricultural insurance appears to be a more appealing strategy. Jiménez participated in national-level discussions about agricultural insurance (Mesa Seguro Agropecuario) for small-scale producers in Bolivia. As part of this platform, she participated in a conference organized in Guatemala about access to financial services for small-scale producers. Participants concluded that minimum insurance against climate-related loss remains a major unresolved question in rural development. Provision of these services could be more effective if subsidy policies were combined with use of local institutions to reduce transactions costs.

4. Marketing strategies – advocacy coalition building

Market integration opportunities were identified with groups in Puno communities. In Santa María, a women's handcraft association, San Bartolomé, is interested in selling products through fair-trade markets. Apopata producers are seeking strategies to increase the prices of their products (wool, fiber, meat). The municipality created an office to set prices to benefit producers. In training activities with the project, a lesson learned by *comuneros* is that to reach their goals they need to be articulated with their municipality. Linking producers in Apopata with the handcraft group in Santa María is a strategy identified this year that will be studied in Year 3. Women of the handcraft association currently purchase wool at the Ilave market, and Apopata producers are seeking better prices for their products. Advocacy coalition training will be undertaken in the communities of Kellhuiri, Bolivia, and Santa María, Peru, to support producers' negotiation with stakeholders in the marketing chain. The research will focus on how advocacy coalition building can strengthen participation.

System level

Marketing scales regarding strategies consider two system levels, household and community/watershed, and how these two interact with markets and market institutions.

Development impact

Ongoing research on market participation will identify areas of constraint regarding the valuing of biodiversity of potato, quinoa and oca varieties in Bolivia, which will point to areas where capabilities need addressing. In a similar way, studies on access with alpaca fiber and value-added products focus on native animals of the Altiplano. The PMCA is an alternative being implemented in Bolivia and Peru to improve incomes and value biodiversity. Studies should lead to findings on how and when this facilitates negotiation and improves bargaining. Advocacy coalitions are being introduced to study how to address barriers.

Challenges and responses

Similar to other objectives, a significant number of research activities are undertaken with graduate research students at the master's level. In Bolivia, students were identified and started their projects in March 2007. In the United States, two students started their research in January and initiated field work from June through August. Students were given short training courses in statistics and quantitative methods in order to use the household survey. In Peru, students were identified in March to start training, and their research will begin in Year 3. This means that the research process takes more time to completion, but it will be within the time frame of the project. A challenge has been language skills, Aymara for the U.S. students and English for Bolivian and Peruvian students, which affects field research and access to the literature in their field. To address this, graduate students worked in teams during June through August, to strengthen skills and share strengths during the field research, and coordinate field work.

Objective 5: increase capacity for collaboration between communities and stakeholders, and ability to act: capabilities. Transformative processes in the research design

Critical research accomplishments

This objective focuses on our underlying approach: to strengthen capacities across stakeholders, especially investigators and decisions makers in rural communities, in research and development in the Andean region. The purpose is to increase capabilities, the ability to act, by strengthening networks and building coalitions of all stakeholders in the project. Inherent to this objective is research on participation to understand what capitals and types of groups (social and cultural capitals) lead to the circulation of information that informs decisions.

1. Team and stakeholder integration

The Bolivian team held several investigators meetings to coordinate research in the region, with two major meeting in December 2006 and February 2007 to share results of the baseline survey and to develop on-farm assessment methodologies with farmers of ongoing field experiments. Skills and theme groups were established in Bolivia to foster integration among PROINPA, UMSA and UC with institutions in the United States and Peru. The UNALM team in Peru built relations with faculty and former students of the Universidad Nacional del Altiplano (UNA) in Puno. This team carries out field activities in the communities. Two of the graduates are currently in the master's program in innovation for rural development at UNALM. Skills developed this year included livelihoods, participatory approaches, co-learning, and coalition building in collaboration with Iowa State University. Skills teams lead participatory research monitoring activities across sites, and theme teams coordinate research on specific topics. Skills include participatory research methods, research on participation, GIS, and landscapes. Themes include climate, pests, soils, biodiversity, livelihoods, and markets.

Stakeholders outside the rural communities were identified in Peru and Bolivia. In Bolivia, the second stakeholder meeting took place in July 2007, with discussion revolving around development of a climate adaptation platform for rural areas. USAID Title II implementers were invited, and survey instruments and research findings were shared with Save the Children. We coordinated with the Small Donations Program of United Nations Development Program Bolivia. A proposal by UMSA-SANREM CRSP was funded to support research in communities of Ancoraimes (see linkages). Other stakeholders in Bolivia include the Climate Change National Program, World Food Program, and MAPA. In Peru and Bolivia, we include ALTAGRO and Papa Andina. UNALM in Peru has developed relations with Centro de Investigación de Recursos Naturales y Medio Ambiente (CIRNMA), the government watershed agency Pronamachs, and Sierra Sur. PROINPA and UMSA organized field days in Umala and Ancoraimes to foster network building in and between regions. Two field days organized by participating communities in each Bolivian region were held in March and April. Non-participating community members and neighbouring communities were invited. In Peru, UNALM coordinated community leader visits to stakeholders and other communities in Santa María and Apopata. Activities to strengthen capacities in participatory interdisciplinary research, farmer and stakeholder networks, and advocacy coalitions, and formal training are reported in non-degree training.

2. Evaluation of impacts of participatory approaches: capitals, capabilities and agency

Different modes of research collaboration were established in each region in Year 2. In the central Altiplano with PROINPA, with different rules of participation, collaboration revolves around voluntary farmers groups; in the northern Altiplano, UMSA coordinated research and

capacity building through official community channels; in Peru, UNALM worked in collaboration with UNA initiating groups of participants from communities who are engaged in co-learning activities and coalition building. In Apolobamba, collaborating with CIPCA, participatory assessments were conducted with a producer association and a rural community.

To assess impact pathways, the project set up an evaluation protocol that includes a baseline survey, monitoring of participation through the various activities developed with collaborators in communities; and a second survey to measure changes in knowledge, attitudes, skills, and practices of participants and non-participants. This was established during Year 2 to compare approaches in terms of how capacities are strengthened within groups and how knowledge and skills are out-scaled to farmers who do not directly participate in the research at each site and between sites. In January and February 2007, Valdivia, V. Polar, Jiménez, and site coordinators in Bolivia met to identify the instruments. A monitoring and synthesis team was established in Bolivia. Meetings took place in Peru to coordinate this in July to implement a similar approach in Puno.

Assessment of participation in project activities was studied to identify barriers to involvement in participatory research. This year special attention was placed on women's participation. Major barriers to female participation were language (many women were not fluent in Spanish), time constraints, and lack of interest in some of the topics covered in the participatory programs. Women's participation in applied research is largely determined by gender division of labor within the household. To improve their participation in applied research, further training activities were suggested, including workshops and seminars aimed specifically at women's needs and interests. A study of participation by women in agricultural research, with emphasis on the experiences of participatory research in the SANREM project, is the focus of O. Yana's thesis research. She is assessing female participation in ongoing field research, which includes the participatory rural evaluations, the community participatory assessments, and ongoing on-farm trials. The second phase is to assess women's perceptions about their experiences with participation through case studies.

In August 2007, a University of Missouri-Universidad de la Cordillera team organized and conducted focus groups in two regions of Bolivia. The objective was to assess farmers' perspectives on four issues: women's participation in participatory research, access and use of financial services, past experiences with technology introduction, and perceptions of market- and climate-related risks by gender and income differences. Past experience with projects focused on technological interventions were mixed. Individual perceptions tend to emphasize the fact that past technologies promoted were not devised according to the community's long-term needs, a reason why many were not adopted.

Three workshops in Santa María and one in Apopata were carried out, providing information about the dynamics of productions systems. Tours were conducted to connect local and new knowledge. Local leaders visited other communal leaders, extension NGOs, and universities. *Comunero* networks with UNA, UNALM, and organizations like Care, Caritas, and Centro de Estudios y Promoción del Desarrollo increased. Community leaders visited UNALM in Lima and participated in a July 2007 seminar about achievements of the project.

Advocacy Coalitions processes were initiated in Santa María and Apopata. The Advocacy Coalitions Framework (ACF) is a new approach for the SANREM team in Peru and Bolivia. The process started in Peru. To initiate it, the Peru research team was trained by Jan Flora on ACF and participatory action research designed to build a community's social and political capital. Based on what was learned, the Peru team developed its work plan and formed a local technical team in Puno to lead ACF efforts. To date, the ACF process is further ahead in Santa María, where two workshops were held. The first included prioritization and analysis of problems ranked as important in a previous workshop, and election of a local research coalition team of eight community members (men and women), including the president and the lieutenant governor. This team coordinates with the local coalitions' technical team and reports results to the community. The workshop also covered analysis of historical trends in the use of land and water resources, and identification of key actors in management of resources in the community. The team learned that the majority of institutions that have worked in Santa María have been NGOs. Only one government institution, Pronamachs, was present. These external actors become the first set of institutions with which the community might build coalitions to address identified problems. Trust appears to exist between the community and NGOs, given their longer history of positive relationship, more so than with government institutions. The objective of the second workshop in Santa María was to initiate the coalition-building research process. Coalition teams (technical and community) defined the topics to be approached through ACF and were trained in this research process. Apopata completed its first workshop to prioritize identified problems, and formed local coalitions similar to Santa María's. The community analyzed water- and land-use historical trends and identified key external actors. Apopata has experienced less external intervention and was able to identify only two institutions: PISA, a research program on farming systems of the 1980s; and Pronamachs. The former researched soils; and the latter, soils, water management, and conservation.

3. Building capacities in multi- and interdisciplinary research

Formal degree training, non-degree training, and on-farm training are elements of capacity building planned and being implemented. A web-based team room hosted by Blackboard at Missouri has been developed to share ideas and progress on different themes, as well as in the integration process when interdisciplinary hypothesis are addressed. The site shares unpublished working papers and field reports to keep the team informed between conference calls and meetings. A characteristic of this project is that training and research are connected, for most of the students in host countries and the United States are conducting their thesis research with the project while receiving formal degree training. A second crucial characteristic is that research is connected across disciplines. For example, research examining soil management and quality issues has been cross-disciplinary, leading to several successful collaborations within and across SANREM projects. The use of information from the baseline survey and participatory workshops in Bolivia allowed for a better understanding of the major problems and priorities that the respective communities have and helped to provide a direction to the research, which may have a greater potential for positive impact on the communities to adapt to change in the past 10 years due to climate and socioeconomic factors. Collaborations have included several Bolivian private and public institutions such as UMSA and PROINPA, international institutions such as CIP, and U.S. educational institutions (Kansas State University, University of Connecticut, University of Missouri). Training of future Bolivian professionals has been a top priority, with the soils research effort and several undergraduate and graduate students involved. In addition,

discussions have been held among several of the participants from Bolivian, Peruvian, and international institutions for Year 3 research in Peru examining the effects of changing land-use and livestock practices on soil nutrient cycling and carbon sequestration.

System level

Capabilities are developed at three levels: household production system, community/watershed, and policy/market.

Development impact

Development of knowledge and skills and ability to act are key to adaptation. Activities implemented in this objective are methods approaches and skills that support Objectives 1 through 4, in terms of bridging knowledge systems and who is included. Skills and attitudes of those participating in the project as team members, their institution members, and stakeholders are assessed throughout the project. This year the monitoring system for studying participation, knowledge sharing, and constraints was implemented in Ancoraimes and Umala. Advocacy coalition training was developed in Puno. Exchanges are planned for the beginning of year three.

Challenges and responses

Participatory research demands time from stakeholders. Monitoring in Umala and Ancoraimes shows a lower rate of participation by women. Constraints related to participatory research are being addressed. Research also addresses constraints to participation due household characteristics (life cycle and labor), which include how groups share information with non participants. Many activities have demanded time from decision makers. The teams are coordinating in order to coordinate and reduce the time demands on farmers.

Degree and Non-degree Training Activities

Non-degree training

Many biophysical and social scientists are new to participatory research and research on participation. Training sessions were held in July 2006 on community participatory assessment protocols, mapping techniques, risk-vulnerability ranking; and in December and February on techniques for evaluation of KASAP in the many practices and strategies planned, as well as in monitoring of participation. Training was also undertaken in Peru under the leadership of UNALM on similar topics, for these skills are needed and often not learned in disciplinary training. Table 16 lists the activities the project has implemented. Sixteen meetings and workshops focused on skills development in livelihoods, coalition building, participatory community evaluations, mapping, enumerator training, and survey skills development. The teams in each country held almost 60 community events each since the beginning of field research in July 2006 until September 2007. Types of workshops included:

- sharing the project with potential communities
- assessment of demands
- mapping of community resources
- local climate indicators

- evaluation of experiments in the communities
- field days, and
- training tours.

Fourteen capacity training workshops on pests, quinoa and potato varieties, soil amendments, and forages were held in the Bolivian and Peruvian participating communities. Farmer and stakeholder networks and advocacy coalitions included two field days to build linkages between the participating and non-participating communities in each Bolivian region in March and April, and coalition building meetings in Peru in June and July. Fifty eight non-degree training activities were carried out in Peru at project sites and universities. These included exploratory meetings, attendance to communal meetings, field days, presentations, team meetings, and workshops, with a total participation of 569 men and 427 women. Five seminars were conducted with the support or collaboration of Iowa State University and University of Missouri. There were also two presentations, one in UNALM-Lima and the other in UNA-Puno. A seminar about Community Capital Framework was conducted by Jan Flora and Cornelia Flora for the UNA-Puno community, and one seminar about networks was conducted by Jere Gilles at UNA-Puno. In Bolivia, 57 non-degree training activities took place with 991 men and 570 women participating. An international seminar took place in Bolivia at the end of June, and a seminar was held at the USAID Mission in Bolivia.

Degree training

Table 17 lists 31 students, 14 at the *licenciatura* level conducting thesis research in rural communities; of those, nine are male and five are female. Twelve master's students are involved as graduate research assistants, most identified in August 2006 and March 2007; of those, nine are female and three are male. Their fields of study are economics, sociology, innovation, plant pathology, and agronomy. In the United States, five doctoral students – three female and two male – are involved in research in climatology, agricultural economics, rural sociology and soils.

UNALM investigators formed and trained a coalition team with young researchers who participating in the master's program in agricultural innovation for rural development at UNALM. One co-investigator left in August for Ph.D. work in rural sociology at Missouri. A seminar titled "Globalization, agriculture policies, and rural development" was taught by Jan Flora at the UNALM graduate school. Strengthening the sustainable development graduate programs is one of the training objectives.

With Karen Garret, students at UNALM, KSU, University of California- Davis, and ISU have developed a synthesis paper evaluating plant disease in the context of ecosystem services as part of a distributed graduate seminar recently funded through a competitive process by the U.S. National Center for Ecological Analysis and Synthesis (this is also an output in linkages developed through the project). The working draft of this synthesis is available on our SANREM project website (Cheatham *et al.*, in review). The editor in chief of the journal *Phytopathology* has encouraged submission of this manuscript. A Spanish-language version will be published in a special issue of the journal *Centro Agronómico Tropical de Investigación y Enseñanza.* Students at KSU also participated recently in development of a review of climate change effects on plant disease, published by Garret *et al.* (2006). Plant health instructor training modules were developed for use of the open-source programming environment R in ecology and epidemiology.

These are currently under peer review by the open-source online journal *Plant Health Instructor*, with the first module now accepted pending revision. The drafts under review can be viewed through links at http://www.k-state.edu/pdecology/RModules.html

Publications, Presentations, Other Products

LTRA-4 has produced 46 presentations, 18 working papers, 11 fact sheets, 11 articles, five abstracts, two posters, two websites, two databases, and two chapters. A working papers series is being developed to summarize preliminary research findings from graduate student research as well as field research that required more than one year.

Networking Activities

Collaboration was established with ALTAGRO, a development project implemented by CIP for the Andes of Bolivia and Peru, funded by the Canadian government. LTRA-4 contributed research protocols to capture livelihood strategies and measure impacts. This allows the project to access a larger database to analyze livelihood strategies in the Altiplano region. LTRA-4 is also researching specific development activities involving improvement and marketing of native potatoes.

Collaboration began between the University of Connecticut group and CIP on climate change modeling and downscaling. A. Posadas of CIP visited UConn to discuss the use of wavelet and multi-fractal techniques to downscale global model data for the Altiplano. UConn is preparing global model data for Posadas to analyze using these techniques. In addition, the analysis of global model scenarios for the Altiplano involves the SANREM CRSP in an international scientific effort to analyze and understand climate change using the World Climate Research Program (WCRP) Coupled Model Intercomparison Project (CMIP3) multi-model dataset.

A collaborative agreement was signed between SANREM CRSP LTRA-4, Universidad de la Cordillera, and the *Área de Desarrollo Rural* of CIDES' graduate program in social sciences at UMSA to support three scholarships in sustainable development in the CIDES master's program. The three supported students are graduate research assistants in market access. Cordillera will also support publication of one volume of the journal *Umbrales* and will include three scientific articles contributed by SANREM CRSP on market access and networks research.

Edith Fernandez Baca joined the project's researcher network. She leads advocacy coalition activities in the region. A network in Puno includes NGOs CIRNMA, Care, and Caritas. The team at UNA- Puno led by Professor E. Rivera of the social sciences school, now includes Professor Julio Choque, rangeland management, school of agronomy. Two members of Peru's research team participated in the May 1-14 Henry A. Wallace Scientific Conference in Costa Rica, presenting a poster titled, "Adaptación al Cambio Climático y de Mercado en Comunidades del Altiplano. Estudio de Caso de la Comunidad de Santa María" (C. Turín, Condor, P., Flora, C., and Flora, J.)

A proposal was submitted by UMSA to the UNDP Small Donations Program to support research on rural community adaptation to climate change. Four communities of the municipality of Ancoraimes were involved. Activities will involve 120 families participating directly in an

extension of ongoing research by our project. The total amount, $30,000, will allow our research to expand to more locations.

Travel support was provided for P. Cóndor and Cecilia Turín to participate in a Wallace conference workshop titled, “El enfoque de medios de vida sostenible para el desarrollo agricola y rural” (The Sustainable Livelihoods Approach in Agricultural and Rural Development). Each obtained a scholarship of $1,745 to attend, the result of collaboration with ISU.

L. Rees obtained a Dorris D. and Christine M. Brown Fellowship from Missouri to travel to Bolivia and conduct field work in Umala and Ancoraimes on risk perceptions and communication. She received an award of $4,500.

The project leveraged $50,000 from the Fulbright Program to fund Cecilia Turín’s doctoral training at Missouri, beginning in August 2007.

KSU’s proposal to the U.S. National Center for Ecological Analysis and Synthesis was the only selection for support of a distributed graduate seminar in spring semester 2007. Participants included students at CIP who are involved in SANREM. As a result of collaboration through SANREM, KSU was awarded $51,000 as part of a USDA-Linkage project with CIP to study economic and sociological impacts of resistance gene deployment in Peru, Uganda, and China.

Project Highlights

Highlights have been divided into two groups reflecting the scientists and the decision makers’ perspectives about system dynamics and climate and market drivers.

Decision-makers’ perspectives

- Community participatory assessments and surveys confirmed climate and water as principal concerns, along with soil fertility and incidence of pests and diseases.
- While climate hazards like drought, frosts, snow, and flood are perceived as higher in Umala, climate change is perceived as the highest hazard by Ancoraimes communities.
- Agricultural producers observed that the growing season is changing and shortening but do not attribute this to rising temperatures. Local expert predictions of 2006-2007 based on local knowledge indicators were quite accurate, suggesting these are still effective. Declining use is related to migration and changes in the production system.
- Study of the sources and trust of information found that farmers consult local knowledge systems for climate forecasts with the highest frequency. They listen to radio but have strong doubts about the forecasts broadcast.
- Farmer soil classification criteria include texture, color, presence of stones, and depth of the plow layer. Perceptions of decline in soil fertility over the past 10 years were attributed in part to decrease in fallow periods.
- Community participatory assessments identified Andean weevil and potato moth as major pests attacking production and post-harvest in Bolivian and Peruvian communities.
- Perceptions in focus groups about loans found that residents regarded such instruments as “working for the bank” because of the time required to repay the money.

- Advocacy coalition training was implemented in Puno communities to identify partners for marketing and for improving water and soil resources.
- Perceptions of control over risks and dread of risks consistently showed women as expressing less control and higher dread when analyzed by groups according to income and life cycle status, confirming the initial hypothesis.
- In Puno, farmer perceptions about the effect of climate change on water, soils, grasslands, and crops are that it contributes to increase the intensive use of natural resources; that water sources are drying, and that grasslands are decreasing due to intensive radiation and frequent frosts.

Scientific perspectives

- Changing climate. Analysis of 35 years of data find declines in precipitation and minimum temperatures close to Lake Titicaca in the northern Bolivian Altiplano, while precipitation was unchanged and minimum temperatures increased away from the lake in the central Altiplano.
- Desertification. Evapo-transpiration increased across the Altiplano. In the absence of concurrent increase in precipitation, this will result in enhanced hydrological stress for rain-fed agriculture in the north plateau.
- Confirmation that wet episodes in the northwestern Altiplano are associated with mid- and upper-level winds from the east that carry moisture from the Amazon basin, while dry episodes occur during periods of winds from the west.
- Analysis of data revealed a strong relationship between onset of rains and duration.
- Climate was responsible for 69 percent of respondents facing crop losses and 62 percent livestock losses in the central Altiplano, while 95 percent will lose crops and 85 percent livestock in northern Altiplano.
- Income in Ancoraimes' households is half that of Umala's. Their perceptions of crop and livestock price risks and risks of job loss are higher than Umala's, as well as loss of soil fertility and incidence of pests.
- Shocks have a greater impact in Ancoraimes, and migration is a significant coping mechanism, underscoring vulnerability.
- While Umala farmers resort less to migration, off-farm income is pursued in some degree by 20 percent to 45 percent of households in three income clusters identified.
- Savings are the main mechanism to cope with shocks in crops in Umala, while Ancoraimes households resorted to selling livestock or depleting invested capital. Between 25 percent and 30 percent of households borrow from others. Northern Bolivian Altiplano households use capital (animals) more often to smooth consumption, an indicator of vulnerability.
- Farmers perceive alternative high-value crops such as peas and onions to be a better means to increase food security. Two questions are posed: What role do high-value crops have on existing biodiversity; and how or if farmers benefit from linkages to high-income markets that value native varieties.
- Researchers reviewed and synthesized the most important observed and potential effects of climate change on plant disease risk, the potential for using new genomic tools for disease management, and sustainable responses to emerging diseases.

- Researchers reviewed status and needs to improve management of potato late blight in the developing world. This provides perspective on how potato late blight management strategies must be adapted in tropical areas compared with temperate studies.
- First-year study of pest dynamics identified two species of weevil and three of moth. Preliminary findings point to changes in behavior and population of potato weevils, with 90 percent being a species with origins in Argentina, a first step in understanding dynamics.
- Researchers completed interviews of organizations involved in production of climate forecasts, mitigation and adaptation to climate change, prevention of disasters, and food security to agencies involved in coping and adaptation policies.
- Male and female human capital is higher in households with joint marketing responsibilities and is correlated with higher incomes. Their degree of participation in groups (social capital) is higher, as is their economic capital.
- Market participation with native potatoes through groups points to positives as well as barriers. Small groups functioned better. Transactions costs of participation in groups are higher for families with less labor, small children, or a single head of household. Travel costs to participate in the platform are higher for farmers than other stakeholders.
- Oca, ollucu and quinoa along with native potato varieties were identified and studied on farm and in community gardens in two regions. Oca and ollucu were evaluated in Ancoraimes along with native potato varieties in farmer fields, while native potatoes and quinoa were in Umala.
- Through a competition in Umala municipality, 118 varieties were catalogued, planted, and evaluated by a farmer group. Thirty varieties were selected based on market potential; from these, five were chosen for the second round of on-farm experiments.
- Two of the four quinoa varieties were chosen as preferred varieties by farmer groups at the conclusion of first-year participatory research for further trials in the second year.
- Access to formal credit is not common; 70 percent is accessed from informal institutions.

Coincidences – bridging leading to Objectives 3 and 4

- According to long-term climate analysis, evapo-transpiration is increasing, and this may negatively affect crops such as quinoa and fava beans. However, farmers in Ancoraimes perceive drier years and shorter season, although rainfall has not changed. If the climate models are correct, rainy season may begin later. These results support our underlying hypothesis that production systems are changing in response to climate change.
- In the study of soil amendments trials, mixtures of chemical fertilizers with manures resulted in highest potato yields, with greater responses in Umala. Differences in incidence of frost and hail damage had a significant effect on yields. With loss of humidity due to warming, organic soil amendments such as sheep manure that resulted in higher water content compared with the control and with inorganic soil amendments would seem to be potential buffers. Further evaluations are being conducted.
- Examination of IPCC global coupled climate model integration for 20th century preliminary findings show that global models do capture the large-scale relationship between easterly winds and Altiplano precipitation on year-to-year time scales in the present climate. In 21st century projections, climate models tend to indicate a change toward more westerly winds, which would imply drier conditions in the Altiplano.

LTRA-5: Agro-forestry and Sustainable Vegetable Production in Southeast Asian Watersheds

PIs: Manuel Reyes, Charles Raczkowski, and Gudigopuram Reddy, North Carolina Agricultural and Technical State University
Robin Marsh, University of California-Berkeley
Ronald Morse and Conrad Heatwole, Virginia Tech
David Midmore, Central Queensland University
Howard-Yana Shapiro, Mars Inc. and University of California-Davis
Raghavan Srinivasan, Texas A&M University
Delia Catacutan, Rodel Lasco and Agustin Mercado, International Center for Research in Agro-forestry (ICRAF), Philippines
Joshi Laxman and Meine van Noordwijk, ICRAF, Indonesia
James Roshetko, ICRAF and Winrock International, Indonesia
Flordeliza Faustino, Liwayway Engle, Greg Luther, Ali Mubarik, and Manuel Palada, Asian Vegetable Research and Development Center (AVRDC), Taiwan
Ma. Elena Chiong-Javier, de la Salle University, Philippines
Victor Ella and Ma. Victoria Espaldon, University of Philippines-Los Baños
Dang Ha, Nong Lam University, Vietnam
Jean Saludadez, University of the Philippines Open University
Anas Susila, Bogor Agricultural University, Indonesia

Host countries: Indonesia, Philippines, Vietnam

Executive Summary

Communities in many forest and vegetable-producing watersheds in Southeast Asia are suffering from poverty and degradation of forest, soil, and water resources. The overall hypothesis of this research is: "Integrating vegetable production in tree systems and trees in vegetable production systems will alleviate poverty, and will enhance environmental protection, ecosystem diversity and sustainability on small farms in Southeast Asia." This research is being conducted by the TMPEGS team, which derives its name from its goals.

- **T**echnology: develop economically viable and ecologically-sound vegetable agro-forestry (VAF) systems
- **M**arkets: develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies
- **P**olicy: identify options and institutional frameworks that promote sustainability of vegetable agro-forestry production and reward environmental services
- **E**nvironmental and socioeconomic impacts: assess the short- and long-term environmental and socioeconomic impacts for farm families who adopt integrated vegetable agro-forestry systems
- **G**ender: provide mechanisms to ensure women's involvement in decision making, and sustainable production and marketing practices to improve their socioeconomic well-being within the vegetable agro-forestry system

- **S**caling-Up: build host-country capacity to manage and disseminate integrated vegetable agro-forestry

From extensive baseline studies, four villages were chosen for implementation of project activities. They are Ngia Trung commune, Binh Phuoc Province, Vietnam; Parakan Muncang and Hambaro, West Java Province, Indonesia; and Songko, Bukidnon Province, Philippines. The predominant agro-ecosystem at the Vietnam site is tree based. At the Indonesia sites, we work with multistory home garden systems consisting of fruit and timber trees with annual rice and vegetable cropping systems. At the Philippines site, an intensive vegetable-based system predominates.

The project is using the Net Complementarity Index (NCI), a simple tool developed by collaborating ICRAF-Philippines scientist Agustin Mercado to assess vegetable-tree interaction. Using the NCI, researchers found that optimum tree spacing for vegetable agro-forestry is 20 to 25 meters for three tree and four commercial vegetable species. Indigenous vegetable screenings have been conducted in Vietnam, Indonesia, and the Philippines. Initial results show that many indigenous vegetables with medicinal and high nutritional content grow well under trees. Their NCIs are being determined in the Philippines. Drip irrigation experiments commenced in Vietnam, and initial results show that drip irrigation in cacao planted between cashew trees increased cashew yield. Vietnam is promoting cacao production, and results show that several cacao varieties are growing well between mono-cultured cashew trees. Tests of a prototype human powered no-till planter for Southeast Asia showed that humans could not provide sufficient power. The prototype is being modified for animal or small motor power. Experiments on the perennial cover crop *Arachis pintoi* planted between vegetables or under cashew trees for soil conservation, insect control, and a nectar source for bees began in all countries.

Market baseline studies identified marketable vegetables and trees, which have become the current focus of technical research. The marketing team has gathered data on value chains and the principal constraints faced by small-scale male and female farmers: lack of access to market information, inability to control market pricing, high transport cost, and poor post-harvest handling.

The policy team conducted an extended policy baseline study and initial policy analysis. In the Philippines, it was concluded that small-scale male and female farmers can be effectively helped with policies that are locally, not nationally, developed. Local government in Lantapan has provided in-kind and financial support for the policy efforts. A memorandum of understanding was signed by five agencies to develop incentive-based policies and mechanisms of payments for environmental services. In Vietnam, both national and local policies influence small-scale male and female farmers. Focus is on industrialized perennial crops like cashew and substitution of new perennials as market conditions dictate. Cacao was promoted by the local government as a new crop for diversification and income improvement with vegetable production receiving very little attention.

The socioeconomic team agreed on an adoption monitoring feedback loop protocol to oversee on-farm and on-field experiments, including the collection of input, cost, and market data to calculate benefit/cost ratios of the experimental technologies, as well as to ascertain small-scale

farmers' perceptions of vegetable agro-forestry technologies. The environmental impact team has gathered substantial data to quantify the hydrologic impact of current land-use and management practices in the watersheds of the three countries using the Soil and Water Assessment Tool (SWAT) watershed model.

The gender team found that men are the dominant labor force in commercial crop production, while women dominate in raising subsistence crops, particularly in home gardens. The majority of the tasks in the agricultural production cycle that normally require arduous work are mainly handled by males. More men than women control the following agricultural domains: farm-level decision making, including purchase of farm inputs and timing of harvest or marketing; involvement in farmer organizations; and participation in agricultural training and extension services. Women's limited organizational and training involvement is due to their preoccupation with household duties, the holding of meetings or trainings during times when women are not available, and the perceived belief that extension services are for men. If the men lead in productive work, it is the women who reign in household and reproductive roles. These tasks consist mainly of unremunerated domestic chores like washing clothes and dishes, cooking meals, cleaning the house, and attending to child-care activities. Dominance in the agricultural marketing sphere varies by country.

Indonesian partners have completed an indigenous vegetable production manual and indigenous vegetable cookbook. They have supplemented the comprehensive vegetable production manual published last year. Scientists with the Asian Vegetable Research and Development Center (AVRDC) also completed an indigenous vegetable production guide for the Philippines. For each country, TMPEGS partnered with "model" male and female small-scale farmers who are passionate advocates and practitioners of SANREM technologies. A video and booklet, "Taming the Land, the Wind and the Sun: The Story of the Binahon Agro-forestry Farm," was developed by the scaling-up team in the Philippines. TMPEGS-Indonesia constructed a SANREM extension base camp on the property of SANREM's Indonesia model farmer. Many farmers, both women and men, have visited the camp and exchanged ideas with scientists and field technicians on vegetable agro-forestry systems. TMPEGS-Vietnam's model farmer field is the site of the vegetable light-intensity tree experiment.

The TMPEGS website (http://tmpegs.org/) was launched this year. It includes news and information on TMPEGS partners, trainees, activities, and reports.

Seventeen graduate students were supported by SANREM, and about 23 non-degree trainings were conducted. Principal training activities included participation of four TMPEGS scientists in the University of California's Beahrs Environmental Leadership Program; a SWAT modeling workshop in the Philippines; a no-tillage vegetable workshop in Indonesia; a soil quality workshop in Vietnam; low-cost drip irrigation workshops in three countries; and a farm field day in Lantapan, Philippines.

Twenty-seven project networking activities were recorded. Highlights included a visit by SANREM Program Director Theo Dillaha and SANREM Board Chair Alton Thompson with TMPEGS partners in all countries; and a visit by top administrators from partner universities in Vietnam, Indonesia, and the Philippines to the United States. The administrators networked with

personnel from U.S. federal agencies in Washington, D.C., and faculty and administrators at North Carolina A&T State University and Virginia Tech.

Research Strategy and Development Objectives

Communities in many forest and vegetable-producing watersheds in Southeast Asia are suffering from poverty and degradation of forest, soil, and water resources. The overall hypothesis of this research is: "Integrating vegetable production in tree systems and trees in vegetable production systems will alleviate poverty, and will enhance environmental protection, ecosystem diversity and sustainability on small farms in Southeast Asia." The project goes by the acronym TMPEGS based on its six main objectives.

- **T**echnology: develop economically viable and ecologically-sound vegetable agro-forestry (VAF) systems
- **M**arkets: develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies
- **P**olicy: identify options and institutional frameworks that promote sustainability of vegetable agro-forestry production and reward environmental services
- **E**nvironmental and socioeconomic impacts: assess the short- and long-term environmental and socioeconomic impacts for farm families who adopt integrated vegetable agro-forestry systems
- **G**ender: provide mechanisms to ensure women's involvement in decision making, and sustainable production and marketing practices to improve their socioeconomic well-being within the vegetable agro-forestry system
- **S**caling-Up: build host-country capacity to manage and disseminate integrated vegetable agro-forestry

Figure 1 shows the TMPEGS interdependence model. The hexagon is a tent with pegs at the six corners. Tent is dependent on each peg and their interdependent forces. Each peg represents a research objective. Successful hypothesis testing requires consideration of each objective as well as its interdependence.

Overview of individual research objectives

Research is conducted in Indonesia, Philippines and Vietnam. Each country has particular research protocols to test the overall hypothesis. However, they also have common research objectives including the following (details are provided in the section on work-plan elements):

- The technology peg aims to discover complementarities between vegetables and trees, and trees with trees. Can some vegetables enhance tree yields and can those trees enhance vegetable yields? It seeks to answer the question: "What combinations of vegetable and tree species optimize vegetable tree complementarity?" Various experiments are conducted to identify complementarities that may be achieved through technological innovations such as drip irrigation or reintroduction of shade-loving indigenous vegetables. Drip irrigation may enhance vegetable-tree complementarity by minimizing moisture competition between trees and vegetables. Indigenous vegetables can also

enhance complementarity by providing soil cover, hence soil conservation, while trees provide the shade that these vegetables need.

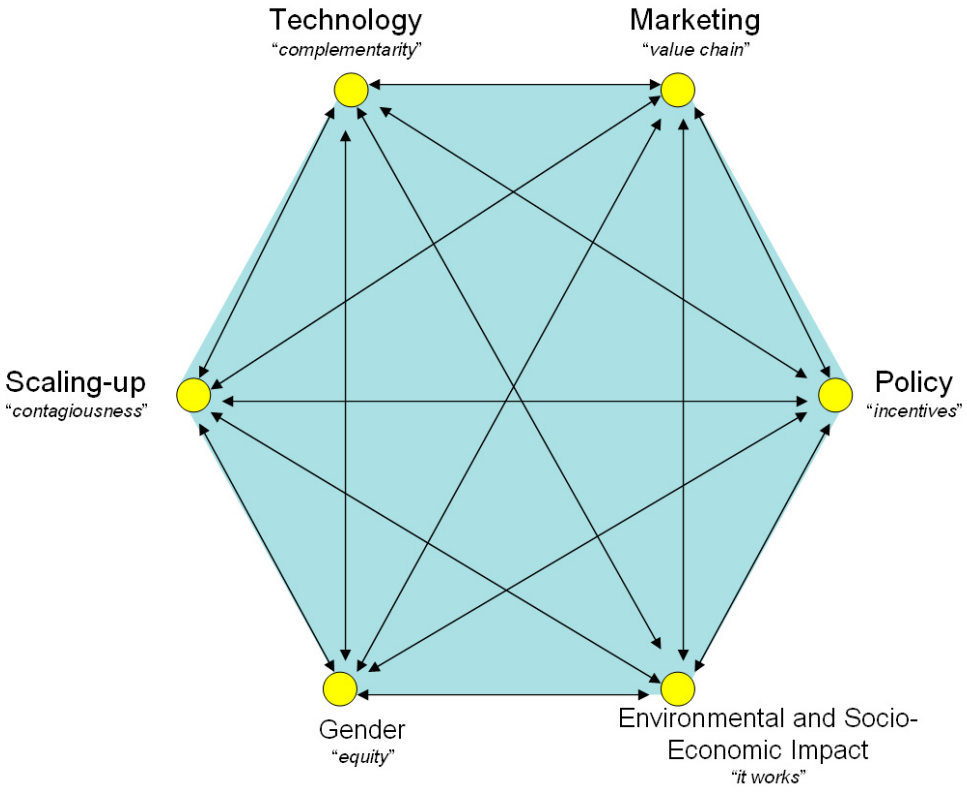


Figure 1: TMPEGS Interdependence Model

- The marketing peg aims to identify opportunities for greater profit along the value chain extending from production inputs to handling and sale of vegetables and tree products. It seeks to answer the questions: "What can be done to enhance income from timber, vegetables, or tree fruits? What opportunities exist to improve post-harvest handling to enhance vegetable or tree-fruit quality?" Transportation cost issues and the demand for indigenous vegetables are common to all three countries.
- The policy peg aims to identify incentives that promote investments in vegetable agro-forestry systems. Issues of concern include market inefficiencies, soil erosion and degradation impacts, and policymaking processes. This element seeks to answer the question: "What policy incentives promote wider adoption of vegetable agro-forestry systems by small-scale, male and female farmers?" These incentives can be incorporated into local, regional, or national government policies.
- The environmental and socioeconomic impact peg aims to measure whether the overall hypothesis works. The socioeconomic approach is a participatory development model with a monitoring feedback loop between small-scale farmers, both women and men (SSFWM), scientists, and other stakeholders. With respect to environmental impact, a water-quality model is being used to simulate and quantify hydrologic effects of current practices and compare them with hydrologic impacts of proposed vegetable agro-forestry

practices. It seeks to answer the questions: “Can VAF improve the quality of life of small-scale farmers? Will small-scale farmer incomes increase with VAF? Can VAF reduce the non-sustainable destructive hydrologic impacts of current practices?”

- The gender peg addresses equity. Alleviating poverty means that quality of life is improved for both women and men. This research aim ensures that women benefit from this project. It seeks to answer the question: “What alternative mechanisms can improve women’s involvement, socioeconomic status, and decision making in vegetable agro-forestry systems?” The research includes the investigation of gendered marketing networks and the different perspectives of men and women.
- Scaling-up aims for contagiousness. Once an innovation works, it needs to be disseminated to the full range of SSFWM. This research element seeks to answer the question: “How can innovations be efficiently spread geographically and to different levels of society?” Research is focused on training need assessments and the effectiveness of TMPEGS outreach activities such as workshops, seminars, and farm visits.

Peg interdependency

This section describes the interdependence of each TMPEGS peg on the others in the conceptual model (Figure 2), which shows a dynamic iterative process. The iterative flow is illustrated by solid and broken arrows. The solid arrow illustrates the predominant flow in the model. The initial baseline study helps to set technology development priorities. Various technologies and combinations are then tested. Potentially innovative technology needs to be considered from environmental and socioeconomic perspectives. Environmental and socioeconomic impact studies are conducted in conjunction with marketing, gender, and policy studies to identify institutional innovations. Successful technological and institutional innovations are then scaled up to other stakeholders, especially SSFWM.

Equally important as the solid arrow is the broken arrow, which highlights feedback mechanisms within the TMPEGS model. For example, the gender team may find that certain technologies favor men more than women or certain scaling-up strategies are biased toward men. If that is the case, the technology and scaling-up teams will modify their approaches to ensure gender equity. Another example of feedback is an economic study. If it is found that yield and vegetable quality increase due to drip irrigation, then benefit-cost studies will be conducted. If drip irrigation increases income significantly, then scaling-up strategies will be instituted. If not, the socioeconomic team will inform the technology team, and adjustments will be made in the drip irrigation approach. If no economical technology adjustment is feasible, then the drip component of the study will end. Other examples of interdependence are illustrated in subsequent sections.

Baseline study

Consideration of model interdependence began in Year 1 when TMPEGS conducted baseline and marketing surveys in all countries before designing research protocols. Findings from these surveys drove country-specific technology, marketing, policy, environmental and socio-economic, gender, and scaling-up research.

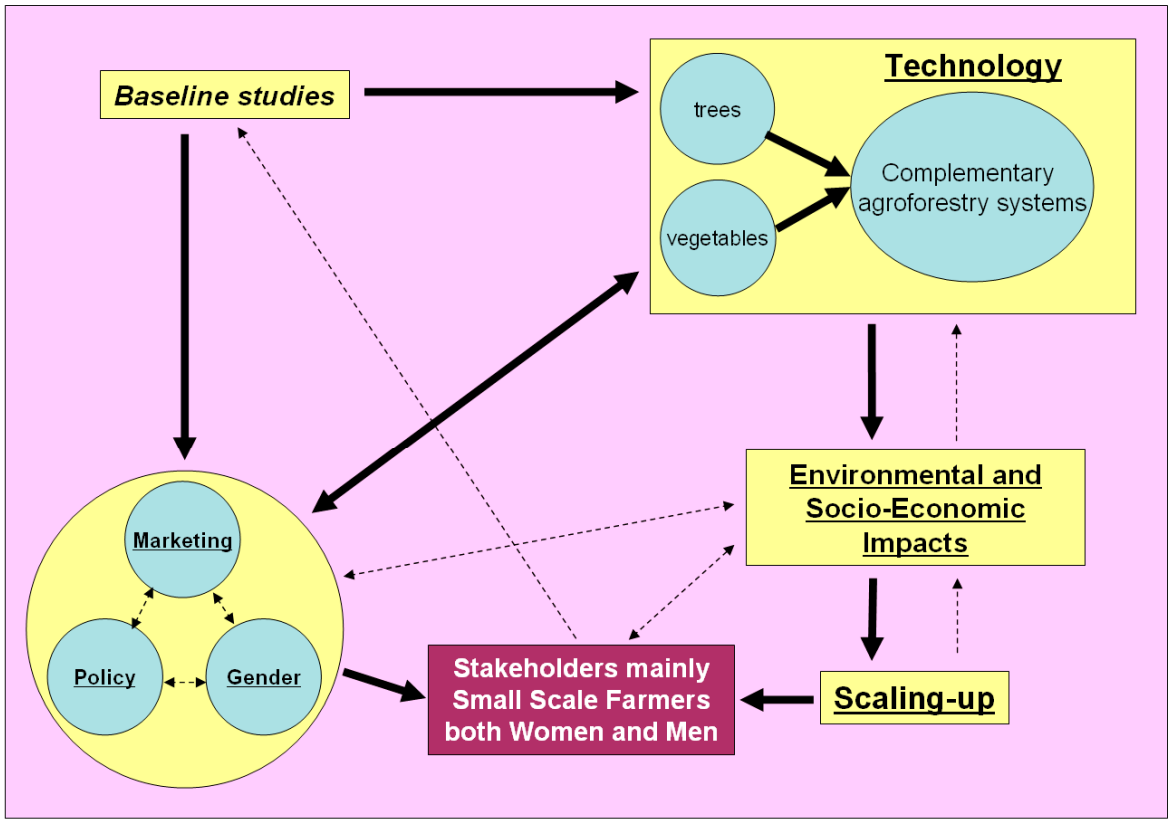


Figure 2: Conceptual Model of TMPEGS

The baseline studies gathered data on site characteristics (climate, predominant crops grown, soils, diseases, and management practices); marketable products; current policies on vegetable and tree production; socioeconomic status of stakeholders and villages; gender roles; and government extension programs. Following are examples of how the baseline study influenced technology research.

The baseline study showed that in the Vietnam study area, the predominant agro-ecosystem is tree-based (cashew) with potential for production of home garden vegetables in tree understory. At the Indonesian site, there is a multistory home garden system consisting of fruit and timber trees, and annual rice and vegetable crops. At the Philippines site, an intensive vegetable-based system predominates. These characteristics influenced decisions on which experiments to conduct.

Marketing baseline studies identified marketable vegetables and trees, which are the current focus of technology research. In Indonesia, growth and yield of 11 varieties of marketable commercial and indigenous vegetables are monitored in mixed timber and tree understory; and in the Philippines, yields of the five most marketable commercial vegetables and 25 indigenous vegetables planted parallel to trees are being monitored. In Vietnam, monoculture cashew plantations dominate the study area.

Policy baseline studies revealed government priorities. In Vietnam, the Vietnam Cacao Development Program aims to have 100,000 hectares of cacao by 2010. Hence, cacao was chosen for Vietnam's technology study. Planting of cacao between cashew rows is a major research focus. It was also found in Vietnam that some indigenous vegetables are marketable, excellent sources of micronutrients, and home production could improve family income by reducing off-farm purchases. Hence, performance of these indigenous vegetables under cashew understory is being studied. In the Philippines, the design life of a hydroelectric plant and irrigation reservoir is being shortened by soil loss from vegetable fields in its contributing watershed. Therefore, local government is encouraging soil conservation within its watershed. The potential of growing trees with vegetables for soil conservation is being encouraged.

Technology and other pegs

Technology influences other pegs. For example, if an indigenous vegetable-tree system is found to be complementary, then benefits accruing from such agro-forestry practice will be fed to the environmental and socioeconomic teams. The environment impact team will need data on agro-forestry management of distance between trees, vegetable density and cover, fertilization rates, tillage practice, kind of trees, rooting depth, growth period, yield, and many other parameters for environmental impact analysis using computer simulations. Simulation results will be used to quantify soil conservation and water quality benefits of the indigenous vegetable-tree systems. Yield and other data will be provided to the socioeconomic team for a benefit-cost analysis to see if such indigenous vegetable-tree systems improve SSFWM income.

Technology also feeds information to the marketing, gender, and policy teams. For example, technological successes may influence the type of policies to be recommended and the kind of incentives those policies will provide. Gender may be affected by technology, for example, a successful technology may impact men and women differently. Marketing research can also concentrate on technological breakthrough. For example, new markets may be researched on indigenous vegetables that thrive in VAF systems.

Marketing, policy, gender, scaling-up, and socioeconomic impact

Marketing, policy, and gender pegs frequently exchange information and findings. For example, in the Philippines, the marketing team informed the policy team that there are certain local government policies that favor wealthy vegetable growers, which is detrimental to SSFWM. Consequently, the policy team is seeking to determine the proper incentives to favor SSFWM. Also in the Philippines, the marketing team found that men are more involved in tree marketing, and women are more involved in vegetable marketing. This knowledge is used by both the gender and policy teams to formulate policies to promote gender equity.

The marketing, policy, and gender teams mainly feed the socioeconomic peg. The socioeconomic team synthesizes its research information to enhance equitable adoption of VAF system technology. The socioeconomic impact team combines findings from marketing, policy, and gender teams with those from the technology team to recommend technologically sound, socioeconomically acceptable, and environmental sustainable approaches to the scaling-up team. The scaling-up team devises strategies to be contagious. A successful VAF system methodology will be packaged for effective and fast distribution to many stakeholders, including national,

regional, and local governments; non-governmental organizations; and the private sector. Major emphasis will be on contagious packaging for SSFWM.

Work Plan

Sub-objective	Research Activity	Hypotheses	Methods
Technology			
T-1-1	Indigenous and Commercial Vegetables and Vegetable-Tree Complementarity	1. Several indigenous vegetables will yield well under trees 2. Yield of vegetables can be optimized by distance between planting 3. Reintroduction of indigenous vegetables will increase income and improve nutrition of small scale farmers both women and men 4. Some commercial vegetables yield better with trees	**Vietnam:** 1. Four indigenous vegetables (lemon grass, pineapple, rau ngot, & vetiver grass) will be monitored under cashew trees. Vegetable growth and yields will be monitored. 2. Indigenous vegetable yields (ginger, cu nang, nghe, lemon grass, bac ha, ngot, pineapple and sweet potato) will be monitored under cashew canopy, and between cashew tree rows, and no canopy. 3. Light intensity and yield of cu nang, a root crop, will be monitored under cacao–cashew, rubber, cashew, and natural forest. **Indonesia:** 1. Exploration, introduction, collection and characterization of local indigenous vegetables for vegetable agro-forestry were conducted in years 1 and 2. If Indonesian government permission is granted, the same studies will be repeated in year 3 for indigenous vegetable varieties recommended by AVRDC scientists. Indigenous vegetables seeds will come from AVRDC headquarters, Taiwan. 2. The performance of two promising indigenous vegetables characterized in years 1 and 2, will be measured under high density tree, medium density and no tree systems. 3. The effect of different planting distance on growth and yield of three indigenous vegetables (katuk, kenikir, and kemangi) will be monitored. **Philippines:** • Twenty five indigenous and five commercial vegetables are planted perpendicular to fully grown Eucalyptus trees. Complementarity of these vegetables as a function of distance from the Eucalyptus trees

Sub-objective	Research Activity	Hypotheses	Methods
			will be measured and analyzed.
T-1-2	Sunlight Intensity and Vegetable-Tree Complementarity	Vegetables have optimum yield responses to different intensities of sunlight	Each country will monitor responses of vegetables to varying light intensities. Their methodologies for measuring light, study layout, and kinds of vegetables and trees may vary. **Vietnam:** (four experiments and each experiment with at least 3 replications). The Vietnam site has a dense tree density (low light). The experiments are mainly with non-timber trees. 1. Four vegetables (lemon grass, pineapple, rau ngot, & vetiver grass) will be monitored under cashew trees. Light intensities under cashew canopy, vegetables growth and yield, and soil loss will be monitored. Sheet erosion will be estimated using point measurement method. 2. Light intensity, vegetable yields (ginger, cu nang, nghe, lemon grass, bac ha, ngot, pineapple and sweet potato) will be monitored under cashew canopy, between cashew tree rows, and no canopy. 3. Light intensity and vegetable cu nang (root crop) yield will be monitored under cacao–cashew, rubber, cashew, and natural forest. 4. Full light vegetable variety screenings of promising AVRDC vegetables at Nong Lam University farm. **Indonesia:** The Indonesian site is a mix of full light, medium light (low tree density), and low light (high tree density). The trees are a mix of many species. Ten vegetable species (honje, terubuk, katuk, kangkong, amaranth, chili, egg plant, yard long bean, green bean, & tomato) are nested in three light intensities on a completely randomized design with three replications. **Philippines:** The Philippine site is a vegetable growing region with mostly open space (full light). Twenty five indigenous and five commercial vegetables are planted perpendicular to fully grown Eucalyptus trees. Light intensities as a function of distance from the Eucalyptus trees and

Sub-objective	Research Activity	Hypotheses	Methods
			its impact on yield of different vegetables will be correlated. **Taiwan:** The purpose of the Taiwan site is for AVRDC scientists to study VAF complementarity in a more controlled experimental setting. It started December 2005 and is the first study at AVRDC headquarters on vegetable-tree systems. Light intensities penetrating from different trees and its impact on different vegetables is monitored and correlated.
T-1-3-1	Soil Moisture and Vegetable-Tree Complementarity	Drip irrigation will minimize water competition between tree and vegetable thus increases agro-forestry net complementarity.	Treatments: Replications (3) 1. No drip irrigation (control) 2. With drip irrigation Bell pepper will be planted in double row perpendicular to the tree rows of six years old *Eucalyptus torillana*. Conventional bell pepper management will be followed except for the application of drip irrigation as treatments.
T-1-3-1-1	Drip Irrigation: Will it Increase Yield and Income in Traditional Vegetable Production?	1. Drip irrigation will increase vegetable yield 2. Drip irrigation is an appropriate technology for increasing farmers' income in Nghia Trung, Vietnam; Nanggung, Indonesia, and Songco, Philippines	Several farmer fields (both women and men) with vegetable production will be selected. Selection criteria may vary from each country. Willingness of the farmer to partner, soil and topographic attributes, and location are common criteria to all countries. Farmers' field will be divided into drip irrigation and no irrigation plots. Vegetables to be tested will vary for each country. Quantity of water applied and frequency of water application will be based on farmers' perception with guidance from field assistants and scientists. At least four replications will be chosen for each country. The amount of water applied for each application will be measured. The socio-economist team will conduct a benefit-cost analysis and monitor adoption of drip technology. The drip irrigation system to be used was designed by the International Development Enterprise. The socio-economist team will conduct benefit-cost analysis and monitor adoption of drip technology. The team will account for cost of labor, drip irrigation kits, water, seeds, fertilizer and other items. They will also monitor how drip technology is being accepted by the villages

Sub-objective	Research Activity	Hypotheses	Methods
			and if it is being adopted.
T-1-3-1-2	Effect of Hydraulic Head and Slope on Water Distribution Uniformity of the International Development Enterprise Drip Irrigation System	With adequate hydraulic heads, the International Development Enterprise (IDE) '100 m^2 Easy Drip' drip irrigation system can achieve an irrigation uniformity coefficient of 0.9 and above at varying slopes.	The 'Easy Drip' drip irrigation kit developed by IDE and used in the TMPEGS drip irrigation research and demonstrations will be tested for water distribution uniformity under varying system heads and slope conditions. The experiments will be conducted at the hydraulic laboratory facilities of the College of Engineering and Agro-industrial Technology, University of the Philippines Los Baños. A drum reservoir served as water supply for the IDE drip system. A sub-main of 10 m and lateral-sub holder of 20 m with adjustable slope will be fabricated to enable slope variations during laboratory experiments. The drip system will be operated at pre-specified operating heads of 1 m, 1.5 m, 2 m and 2.5 m from the faucet for slopes of 0%, 10%, 20%, 30%, 40% and 50% for the sub-main and 0% slope for the laterals. The discharge in each emitter will be monitored under each chosen slope through direct volumetric measurements. The uniformity coefficient will be estimated using the Christiansen's coefficient of uniformity (CU, Christiansen, 1942; Zoldoske and Solomon 1988):
T-1-3-2	Effect of Tree Root Pruning on Vegetable-Tree Complementarity	Tree root pruning will minimize water competition between tree and vegetable thus increases vegetable agro-forestry net complementarity	Treatments: Replications (3) 1. No tree root pruning (control) 2. With tree root pruning Bell pepper will be planted in double row perpendicular to the tree rows of six years old *Eucalyptus torillana*. Conventional bell pepper management will be followed for both treatments. In tree root pruning, pruning is done by digging 1.2 m deep between the tree line and the bell pepper plot, and a plastic sheet is placed to avoid tree roots from re-penetrating back into the bell pepper plot.
T-1-4-1	Tree Roots Act as Safety Nets	1. Trees take up fertilizers leached from vegetable farms? 2. Trees increase fertilizer use efficiency in	Treatments: Replications (3) Tree species: *Eucalyptus torillana, Mysopsis eminii* Vegetable species: Bell pepper, Cabbage Application rate: With and without application of ^{15}N labeled fertilizer Experimental design and analyses

Sub-objective	Research Activity	Hypotheses	Methods
		vegetable farms?	These 6 treatments will be laid out in 2 x 2 x 2 factorial experiment in randomized complete block (RCB) design in 3 replications. Data on tree biomass, yield, and ^{15}N recoveries will be analyzed. ANOVA will be carried out and means comparison will be done using Tukey's HSD test at $P<0.05$. Data collection Tree biomass from all components, vegetable biomass from all components, ^{15}N recoveries from all tree and vegetable components, and soil ^{15}N recoveries from different depths will be collected.
T-1-4-2	Tree Roots Act as Nutrient Pumps	Trees take up nutrients from lower soil layers	Treatments: Replications (3) Tree species: *Eucalyptus torillana, Mysopsis eminii* Vegetable species: Bell pepper, Cabbage Injection depth: 20 cm and 60 cm Experimental design and analyses. These 6 treatments will be laid out in 2 x 2 x 2 factorial experiment in randomized complete block (RCB) design in 3 replications. Data on tree biomass, yield and ^{15}N recoveries will be analyzed. ANOVA will be carried out and means comparison will be done using Tukey's HSD test at $P<0.05$. Data collection. Tree biomass from all components, vegetable biomass from all components, ^{15}N recoveries from all tree and vegetable components. Soil ^{15}N recoveries from different depths.
T-1-4-3-1	Calibration Study of Phosphorus on Yard Long Bean in Nanggung Watershed	Yard long bean has an optimum phosphorus requirement for maximum yield	Treatments: Replications (3) Fertilizer application: Fertilizer rate: 100 kg/ha N and 135 kg/ha K_2O Pre plant: 100 % P, 50% N and K Side dress: 50% N and K (2 times), 3 and 6 weeks after planting, each of 25% Soil analysis: Preplant soil analysis: pH, EC, Cl-, NH4, NO3, P, K Mg, Ca P soil analysis, extract with the best extractant from correlation test

Sub-objective	Research Activity	Hypotheses	Methods
			This experiment is a split plot design with three replications. The main plot treatments are soil P status, with application of 0X, 1/4X, 1/2X, 3/4X dan X; X=2600 kg P_2O_5 ha^{-1}, one month before planting. The sub plot treatments are P fertilizer rate of 0, 45, 90, 135 dan 180 kg P_2O_5 ha^{-1} applied 1 week before planting. Total plot = 25 x 3 = 75 plot. Plot size = 1.5 x 4 m. The vegetable is yard long bean var. 777 (planted in double row, 50 cm between rows, 25 cm within row), direct seeded.
T-1-4-3-2	Optimization of N, P, K Fertilizer for Vegetables in Nanggung Watershed	Yard long bean and kangkong have optimum N, P, and K requirements for maximum yield	The vegetables are yard long bean var. 777 (planted in double row, 50 cm between rows, 25 cm within row, 2 seed per planting) and kangkong var grand (planted in four rows per plot, 25 cm between rows and 15 cm within rows, 10 seed per planting). Fertilizer application: 1. N fertilizer optimization. Fertilizer rate: 135 kg/ha P_2O_5 and 135 kg/ha K_2O Pre plant: 100 % P, 50% K, Side dress: 50% K (2 times), 3 and 6 weeks after planting, each of 25% 2. P fertilizer optimization. Fertilizer rate: 100 kg/ha N and 135 kg/ha K_2O, Pre plant: 50% N and K; Side dress: 50% N and K (2 times), 3 and 6 weeks after planting, each of 25% 3. K fertilizer optimization. Fertilizer rate: 100 kg/ha N and 135 kg/ha P_2O_5 Pre plant: 100 % P, 50% N; Side dress: 50% N (2 times), 3 and 6 weeks after planting, each of 25% 4. Soil analysis: Pre-plant soil analysis: pH, EC, Cl-, NH4, NO3, P, K Mg, Ca direct seeded.
T-1-5-1	Perennial Peanut as Soil Cover for Vegetable Production	1. Perennial peanut will be an economical cover crop for vegetables grown in Nghia Trung,	Perennial peanut will be established. A strip of about 10 inches will be tilled and different varieties of vegetables (chili, sweet pepper and tomato for Vietnam; yard long bean for Indonesia; and Chinese cabbage, tomato, and bell pepper for the Philippines) will be planted between strips of perennial peanut. The plot sizes will vary for each

Sub-objective	Research Activity	Hypotheses	Methods
		Vietnam; Nanggung, Indonesia; and Songco, Philippines? 2. Vegetables strip planted with perennial peanut will yield as well as with vegetables grown using traditional systems	country. Randomized complete block design with or without perennial peanut ground cover and with three replications. These experiments are parts of different studies. In Vietnam it is part of a vegetable screening study, in Indonesia an integrated pest management study, and in the Philippines a drip irrigation study.
T-1-5-1-1	Effects of Perennial Peanut and a Botanical Pesticide on Aphids and Their Natural Enemies on Yard-Long Bean	1. Perennial peanut will increase the population of aphid's natural enemies. 2. A botanical pesticide (*Tephrosia*), will decrease aphids in yard long bean. 3. A combination of '*Arachis pintoi*' and *Tephrosia*, will control aphid infestation in yard long bean	Perennial peanut will be established in farmer cooperator field. Plot size will be 10 x 10 m and the distance between plots within each block will be 15 m (these dimensions may be slightly reduced if local conditions require). The aphid, *Aphis craccivora*, and its major natural enemies will be sampled on yard-long bean. Among the natural enemies, at least the major ladybird beetle (Coleoptera: Coccinellidae) species will be sampled, but any other natural enemies that are relatively abundant will also be counted. The experiment will use a randomized complete block design with three or four replications (depending on the number that can be accommodated by local conditions). The trial will have four treatments: • Yard-long bean with bare ground, no pesticides • Yard-long bean with *Arachis pintoi* cover crop, no pesticides • Yard-long bean with bare ground, with *Tephrosia* botanical pesticide Yard-long bean with *Arachis pintoi* cover crop, with *Tephrosia* botanical pesticide
T-1-5-2	Developing No-Tillage Vegetable Planting Aids	No tillage planting aids to be developed and prototyped by TMPEGS will be beneficial and	Two types of no-till planting aids shall be designed, fabricated and tested. They are the drill and seeder. The planting aids shall be animal-drawn and motorized. The seeding rate, seeding germination, the operating cost and the projected maintenance cost of the two power

Sub-objective	Research Activity	Hypotheses	Methods
		increase income of small scale farmers both women and men in Songco, Philippines	sources shall be compared together with their ease of use, safety, and ease of fabrication.
T-2-1	Cacao under Cashew Canopy	Because of partial shade provided by cashew canopy, different cacao cultivars will grow well when planted between cashew rows	On-farm trials in 4 farms with 0.5 ha of cacao planted in existing cashew planting; 10 cacao cultivars. Experiment design: Randomized complete Block Design (RCBD) with 3 replications. On-farm trial with and with out drip irrigation in one farm; 10 cacao cultivar, RCBD with 3 replications.
T-2-1-1	Natural Termite Control in Young Cacao under Cashew Canopy	Vertiver will control termite in young cacao	On-farm trials in 2 farms with 600 cacao seedlings planted under 10 year old cashew will be implemented. One factor Randomized Complete Block Design (RCBD) with four treatments and three replications. The treatments are: 1. Farmers' technique (using chemical for controlling termite in young cacao) 2. Natural termite control using 100% vetiver biomass 3. Natural termite control using manure mixed with vetiver grass (50% vetiver biomass and 50% manure). 4. No control
T-2-1-2	Effect of Drip Irrigation in Cacao under Cashew Canopy	1. Drip irrigating cacao will benefit both cacao and cashew trees 2. Drip irrigating cacao planted between cashew trees is cost effective	1. On-farm trials will be conducted in 2 cacao plots one with and one without drip irrigation system. 2. Data will be collected during the dry season. 3. Inputs, cost for irrigation, materials, labor, and fertilizer use will be recorded. The experimental design is a paired t-test, with or without drip irrigation
T-2-2	Domestication of Indigenous Tree Vegetables and Medicinal Trees	Vegetable and medicinal trees will provide farmers with continuous supply of vegetables and medicines	Chinese malungay (Sauropus *androgynous*) will be raised using cuttings treated with Indole-3- butyric acid (IBA) at 150 ppm. Cuttings will be grown in clonal chamber, and transferred to a black plastic net shaded nursery. Seedlings will be hardened. The first experiment (type

Sub-objective	Research Activity	Hypotheses	Methods
		for common ailments	1) will look at their performance under tree based system by planting them 25 cm apart in 18 meters long plot perpendicular to the tree rows of *Eucalyptus torillana*. Apart from the collection of basic tree parameters, farmer participatory evaluation will also be used to rank 2-3 species. This ranking will form as basis for experiment 2. This second experiment will be done under farmers' management (type 3). A set of different tree vegetables (2-3 species) will be provided to farmers, and will be established based on their preference. Medicinal trees such as *Cinnamomum mindanensi* (Kalingag), *Cinchona pubescens* (Kenina), *Camella sinensis* (Tea), *Cinnamomum verum* (Cinnamon), and *Vitex negundo* (Lagundi) will be domesticated. These trees are known for their medicinal values. They will be propagated similar to the tree vegetables mentioned above and evaluated under farmer-managed experiment (type 3). Each farm represents a replication. For type 1, treatments will be in randomized complete block (RCB) design with three replications. For type 3, treatments will be in randomized complete (RCB) design. Each farm represents as replication. We aim at having 5-6 farmers, hence the replication.
T-2-3-1	Effects of Weed Management Methods in Cashew Production	1. It will be economical and practical for Nghia Trung farmers both women and men to change their 'clean week bare soil management' practice under cashew 2. Soil quality will improve if the 'clean weed-bare soil management' practice is changed	Three weed management practices in cashew planting will be assessed. On-farm trials will be implemented for the following weeding practices using a randomized complete block design with 3 replications: 1. No weeding 2. Mechanical weeding and no field cleaning before harvesting season 3. Weeding with herbicides and field cleaning before harvesting season

Sub-objective	Research Activity	Hypotheses	Methods
T-2-3-2	Vegetable Strips under Cashew Trees for Soil Erosion Control	1. Established of vegetative strips under cashew trees will significantly decrease erosion 2. Nghia Trung farmers both women and men will economically benefit if they change their current 'bare-soil cashew under story' with vegetated strips	Two farmer cooperators volunteered for this experiment. Vegetated strips of lemon grass, pineapple, rau ngot, and vetiver grass will be planted under cashew trees. The trial will have 5 plots (1 plot with out vegetables and 4 plots with vegetative/vegetable strips) with 3 replications. Plot size will be 5 by 10 m. The experimental design is a randomized complete block design with 3 replications.
Marketing			
M-1	Assessing Market Constraints and Potential for Indigenous Vegetables from Vegetable Agro-forestry Systems	No hypothesis: Service Objective: To provide information on major market constraints and potential for indigenous vegetables which are grown under VAF systems in Nghia Trung, Bu Dang district, Binh Phuoc province. The specific objectives are: 1. To identify consumer's knowledge and preference on local vegetables 2. To estimate the demand for major indigenous vegetables	1. A consumer survey will be conducted in Nghia Trung market, and in main market of Dong Xoai town, the capital of Binh Phuoc province. In each market, 5-6 retailers and 30 consumers will be interviewed using a prepared consumer survey questionnaire. Semi-structure questionnaire will be employed during the survey. 2. The survey will collect data on consumers' characteristics, their knowledge on local vegetables and their usage, consumers' preference on local vegetables that are being integrated into VAF system, and expected market demand. Major vegetables and root crops including lemon grass, sweet potato, ginger, Rau Ngot, Cu Nang, and bamboo shoot. Both, qualitative and quantitative data will be collected. 3. Major market constraints and potential for each vegetable will be identified from the survey and group discussions. 4. Data collected from the survey will be analyzed using descriptive statistics, analysis and simple regression analysis.

Sub-objective	Research Activity	Hypotheses	Methods
M-2-1	Farmers' Workshops on: Disseminating Vegetable Agro-forestry Baseline Survey Result and Technology and Recommendation to Improve the Quality and Quantity of Products from Vegetable Agro-forestry Systems	No hypothesis: Service Objectives: 1. To disseminate vegetable agro-forestry baseline survey and rapid market assessment result that have been conducted in years 1 and 2 2. To maintain farmers, market agents and other stakeholders' interest on SANREM project 3. To give input and feedback from the targeted participants regarding SANREM research finding 4. To identify the interest group on vegetable agro-forestry marketing development and create a marketing action plan	1. The participants will be farmers from Sukaluyu, Hambaro and Parakan Muncang villages. Each village can send 20 representatives to attend the workshop. Vegetable agro-forestry market agents and development agency officers will also be invited as well as village and sub-district officers. Total estimated participants are 80 persons 2. The workshop will be held in one village, Balai Desa Hambaro (tentative) for two days and conducted in February or March 2008 3. In the first session, the 'Marketing and Technology' team will present the research findings from the last 2 years of the project. And in the second session, participants will be grouped based on their interest of vegetable agro-forestry development 4. Vegetable agro-forestry development action plan will be created using PRA and lead by a facilitator
M-2-2	Farmers Comparison Study Trip to Good Practice of Vegetable Agro-	No hypothesis: Service Objectives: 1. To improve farmers' knowledge and skill in good management of	1. The site for comparison study will be decided based on information from market agents and other stakeholders. 2. Five representatives from each village project will be joined in the study. 3. The trips will be facilitated by marketing and technology team and

Sub-objective	Research Activity	Hypotheses	Methods
	forestry Management Site	vegetable agro-forestry systems 2. To encourage farmers by discussing and learning stories from successful farmers. 3. To get ideas and replicate the good practice management of successful vegetable agro-forestry farmers 4. To capture potential market, to collect marketing information and to see possibility in making collaboration	conducted at least in two locations. 4. Visit finding will be documented in the report and socialized to other farmers through focus group discussions
M-2-3	Post-Harvest Training on Vegetable Agro-forestry Products and Promotion of Indigenous Vegetables Species of Nanggung Sub-District	No hypothesis: Service Objectives: 1. To improve the marketable quality of vegetable agro-forestry products 2. To enhance farmers' knowledge and skill in post-harvest handling 3. To increase farmers' marketing role and skill in 'value-added creation' through training in improved	1. Farmers from interest groups will be trained by representative of market agents or other agencies with expertise on vegetable post harvest handling 2. Theoretical and practical training will be provided for two days 3. Indigenous vegetables species will be promoted through poster and leaflet in village and district levels

Sub-objective	Research Activity	Hypotheses	Methods
		post handling methods 4. To raise awareness amongst farmers and market actors	
M-3	Market Action Plan for TMPEGS-Philippines	No hypothesis: Service Objectives: 1. Validate market research findings with farmer/marketer stakeholders 2. Disseminate market findings to other stakeholder groups	1. Validate market research findings with farmer/marketer stakeholders, especially women marketers, and obtain their ideas for possible intervention. (The EEP query regarding how the entire project can "optimize the role of trees in the vegetable agro-forestry system" will be explored during the validation). 2. Disseminate market findings to other stakeholder groups particularly those that can utilize these for improving local market policies and programs and assist farmers and marketers. The issue of how to develop the market for agro-forestry products will be addressed. 3. Conduct participatory planning with women marketers to elicit prioritized courses of action/intervention that can be executed with the assistance of local organizations and/or external institutions.
Policy			
P	Developing Policy Options that Stimulate Investments in Vegetable Agro-forestry Systems by Smallholders in Southeast Asian Watersheds	Incentive-based policies stimulate investments in vegetable agro-forestry systems by smallholder farmers	*Philippines:* For the Philippines study, the research framework, process and methods are in figure 1 (Refer to work element 'P') *Vietnam:* For Vietnam, the study will focus on identifying and recommending policy options and institutional framework that promote sustainability of vegetable agro-forestry production among small farmers. Potentials and constraints for rewarding farmers for the environmental services provided through vegetable agro-forestry systems and sustainable farming practices will also be identified.

Sub-objective	Research Activity	Hypotheses	Methods
Environmental and Socio-Economic Impact			
E-1	Assessment of the Hydrologic Impacts of Vegetable Agro-forestry Systems in Southeast Asia	1. Conversion from conventional row crop production of vegetable to vegetable agro-forestry will: • Decrease downstream flooding risks (Indonesia, Philippines) • Increase dry weather base flows (Indonesia, Philippines) • Decrease nutrient losses in surface and subsurface flows (Indonesia, Philippines) • Decrease watershed sediment yields (Indonesia, Philippines) 2. Conversion from conventional agro-forestry with bare soil under trees to agro-forestry in which a soil cover is maintained via non-removal of leaves or growing of cover crops and/or	<u>SWAT Input Data:</u> Input data needed for SWAT modeling will be collected and prepared in GIS format for all study watersheds. More detailed data will be collected for research plots where surface runoff and sediment yields are measured. Required input data includes: climate (daily precipitation, temperature, etc.), soil properties, topography, crop cover, land-use, and management data. Satellite imagery will be used to obtain land cover and management at the watershed scale. Satellite imagery will be supplemented and verified with ground observations. Existing hydrologic records, if available, will be used for model calibration and validation. If existing hydrologic records are unavailable, limited hydrologic data will be collected. <u>Model Calibration and Validation:</u> If hydrologic records are available, the model will be calibrated and validated using independent sets of observed climatic and hydrologic data. If historical hydrologic records are not available for calibration (ungauged watersheds), the model will be parameterized using best professional judgment and used in an uncalibrated manner <u>Scenario Analysis:</u> The calibrated and validated model (or uncalibrated model for ungauged watersheds) will then be used to simulate runoff, nutrient and sediment loss, for various land use scenarios in the research watersheds in Indonesia, the Philippines, and Vietnam. Based on the simulation results, policy recommendations will consequently be formulated.

Sub-objective	Research Activity	Hypotheses	Methods
		vegetables will: • Decrease downstream flooding risks (Vietnam) • Increase dry weather base flows (Vietnam) • Decrease nutrient losses in surface and subsurface flows (Vietnam) • Decrease watershed sediment yields (Vietnam)	
E-2-1-1	Pesticide Use and Farmers' Health Cost in Cashew Production	Service: No hypothesis Objective: This study will investigate the impacts of pesticide exposure on cashew farmers' health in Nghia Trung village. The objectives of the study are to examine pesticide productivity, determine types of health impairments and estimate the health costs caused to farmers by pesticide use, and estimate farmers' willingness to pay for avoiding health impairment brought about	1. The Cobb-Douglas function will be used to examine pesticide productivity on cashew production. Production elasticity and level of pesticide use will be derived from the yield function model. 2. To quantify the health impairment of farmers with respect to personal characteristics of farmers and their use of pesticides, a health cost model will be estimated using data from health cost survey. 3. The random sampling method will be used to choose farmers for the farm household survey. A total number of 80 farmers will be interviewed in Nghia Trung village to gather detail information on pesticides use, health costs and other data needed for the estimation of pesticide productivity and health costs caused to farmers by pesticide use. Farmers will also be ask to express their willingness to pay for avoiding health impairment brought about by pesticide exposure.

Sub-objective	Research Activity	Hypotheses	Methods
		by pesticide exposure.	
E-2-1-2	Benefit Cost Analysis of Alternative Soil Erosion Control Practices in Cashew-Based Vegetable Agro-forestry System	Service no hypothesis. Objective: The objective of the study is to assess the effect of different soil erosion control measures applied by farmers on cashew yield and estimate the benefits and cost of these measures.	1. The random sampling method will be used to choose farmers for the farm household survey. 2. A total number of 80 farmers will be interviewed in Nghia Trung village to gather detail information on cashew production and soil erosion control practices. Constraints to the adoption of soil erosion measures will be identified from the household survey and focus group discussion. 3. A Cobb-Douglas function will be used to examine the impact of applying soil erosion control measure on cashew production. 4. Crop budget and benefit cost analysis will be conducted to assess the cost effectiveness of various soil erosion control measure. 5. A logic model will be employed to identify factors affecting the adopting soil erosion control measures by the farmers.
E-2-2	Socio-Economic Impact-Indonesia	Service: No hypothesis Objectives: 1. Identify vegetable cultivation technologies/practices within agro-forestry systems (Kebun) that are socially acceptable, affordable and economically profitable. Technologies must have B/C greater than zero using farm gate prices. 2. Provide information on adoption of	On farm trials in Hambaro and Parakan Muncang. 1. Inputs to include seeds, labor, fertilizers, pesticides, water: quantity and price to estimate costs, per ha. for smaller land size unit. 2. Calculation of benefit/cost ratios for various trials/experiment. Determine vegetable prices at farm gate, and throughout market chain with transportation costs included. How does benefit/cost change for farmers? 3. Include soil and water conservation benefits as available 4. Obtain farmers perceptions/feedback of vegetable trials via farmer visits to trials. 5. Farmer field days (all baseline farmers – 3 villages, to receive flyers announcing field days, farmer groups), 6. Specialized farmer training (e.g. drip irrigation), 7. Gender Awareness Workshop – women farmers, 8. Farmers' VAF Dissemination/Marketing Workshop – up to 80 farmers from Sukaluyu, Hambaro and Parakan Muncang villages (20/village, select from baseline farmers)

Sub-objective	Research Activity	Hypotheses	Methods
		recommended vegetable cultivation technologies	
E-2-3	Adoption of Integrated Vegetable Agro-forestry System among Smallholder Upland Farmers in the Philippines	Service: No hypothesis The general objective of the study is to determine the adoption behavior among smallholder upland farmers towards integrated vegetable agro-forestry system and to establish feedback mechanism between farmers and technologists. Specifically, it aims to: 1. Monitor technology adoption rate and innovativeness of smallholder upland farmers; 2. Assess income realized from technology adoption; 3. Determine the influence of technology adoption on women, men, and youth members of the household, including labor demand and food security, and on management of soil,	Participatory monitoring and evaluation using a semi-structured monitoring form shall be employed where farmer cooperators do self-recording and reporting of pertinent information relative to adoption of integrated vegetable agro-forestry system. Monitoring by researchers shall be done thrice a year (per cropping season). In addition, information received will be communicated in timely fashion to the technical field staff to facilitate adaptation to account for farmer adoption constraints.

Sub-objective	Research Activity	Hypotheses	Methods
		water and other natural resources; and 4. Identify problems met in technology adoption for immediate feedback to the SANREM technology team.	
Gender			
G	Exploring Alternative Mechanisms for Improving Women's Involvement, Status, and Voice in the vegetable agro-forestry System	1. Increased gender awareness among village leaders, sub-district officers, and TMPEGS members improves women's involvement, status, and voice in the Indonesian vegetable agro-forestry system. 2. Women's adoption and dissemination of technology improves their involvement, status, and voice in the Philippine vegetable agro-forestry system. 3. Existing women organizations and networks, linked by shared meaning systems defines women's participation in the	1. Indonesia: Gender awareness training workshops 2. Philippines: (a) Process documentation research utilizing onsite observation and in-depth interviews, and research dissemination workshop, (b) (b) Narrative analysis to answer the question what is/are the shared meaning system(s) of Songco women through which they organize their farm lives. Organization exists in people's accounts/stories. Stories are interpretations and constructions of oneself and one's world. People tell their stories/accounts in conversation. Transcribed Accounts will be analyzed using the Semio-Greimas Narrative Theory to derive the narrative structure (that tells meaning system and thereby organization. 3. Vietnam: Case studies, focus group discussions, and key informant interviews

Sub-objective	Research Activity	Hypotheses	Methods
		vegetable agro-forestry system. 4. Women's increased knowledge of the impacts of technology adoption and of the role of women's organization improves their involvement, status, and voice in the Vietnam VAF system. 5. Mechanisms developed jointly with women provide greater positive impacts on women's involvement, status, and voice in the VAF system.	
Scaling-up			
S	Integration of Vegetables and Agro-forestry Systems in Southeast Asian Watershed	1. Conduct training needs assessment or situation analysis to explore capacity building needs in the study areas in relation to managing VAF systems 2. Identify indicators and planning, monitoring and evaluation methods to measure impact and process of scaling-up.	1. Both horizontal scaling up (geographical spread and expansion to more people and communities within the same sector or stakeholder group) and vertical scaling up (expansion to stakeholders at different levels from grassroots organizations to decision makers at village, district, province and national level) will be undertaken 2. Participatory approach will be undertaken in the creation of learning and scaling up process.

Research Progress

Technology - complementarity

Agustin Mercado, coordinator, agro-forestry
Manuel Palada, coordinator, vegetable production
Le Van Du, Vietnam coordinator
Anas Susila, Indonesia coordinator
Agustin Mercado, Philippines coordinator

Objective
To develop economically viable and ecologically sound vegetable agro-forestry systems

Critical research accomplishments

1. Vietnam

Major tasks completed

- Report of the baseline survey was finalized and a working paper produced.
- Participatory on-farm trial on small-scale commercial vegetable cultivation with sweet potato greens, maize, onion, cucumber, and indigenous vegetables was conducted in the dry season 2007 on 200 m^2 open land of a collaborating farmer to assess the performance and efficiency of local commercial vegetables.
- Training on drip irrigation system on perennial crop was conducted, and a drip irrigation designed by TMPEGS-Vietnam was installed on 0.5 ha of cacao trees planted between cashew trees in March 2007. The field is farmer controlled. Amount of water applied and the yield of cashew and growth of young cacao are being monitored. Quantity of water applied and frequency of water application was based on farmers' perception with guidance from field assistants and scientists.
- On-farm trial on termite control in young cacao planting was set up with two collaborating farmers, each with 0.5 ha. The growth of cacao trees, rate of seedling loss due to termite attacks, and termite density are being monitored. Simultaneously with the termite control trial, on-farm trial on soil erosion control with lemongrass, ginger, saffron, vetiver grass, and natural vegetative strips have been set up on the same two collaborating farms.
- Trials with shade-tolerant indigenous root crop (cu nang: *Tacca pinnatifida Forst*) planted under forest trees, and cashew-cacao, cashew, and rubber plantation have been set up at the Mars station, on two collaborating farms, and at Nong Lam University.
- The extension center of Binh Phuoc province was consulted on the design of experiments with vegetables under cashew, and farmer field visits and training. *Arachis pintoi* has been planted on a small area at the Mars station and Nghia Trung village for generating planting material for the experiment on soil crop cover and vegetable with *Arachis pintoi*.
- Simultaneously with extension center experiment, an agreement was made with Mr. Thanh, one of the collaborating farmers, for on-farm trails for vegetables grown under cashew canopy under different light regimes. Experiments were to be set up in November 2007.

- To promote adoption of vegetable production in home gardens for reducing expenditures, and for improved family nutrition and health of poor and intermediate households, an assessment of vegetable production in home gardens of one collaborating farmer was conducted. Six farmers have been identified as collaborators for on-farm trials with drip irrigation for home garden vegetables. The vegetable drip trials are to be set up in January, 2008.
- Plan for participatory rapid appraisal on integrated pest management and integrated crop management was prepared and was to be conducted in December 2007 with support from AVRDC scientists Manuel Palada and Greg Luther.

Preliminary research findings

- Field assessment showed that most farmers in the study area have perennial cash crops (cashew and coffee, and rubber, black pepper, and fruit trees). Most home gardens have cashew trees. Vegetables are not abundant on the site. More than 80 percent of vegetables consumed by poor and intermediate households are purchased; only 15 percent are obtained from gardens or forests. The demand for integrating vegetables in existing cashew planting is mainly for home consumption and for local markets.
- At present there are agronomic obstacles for inter-cropping vegetables with the dominant perennials (cashew, coffee, pepper, rubber). These include labor, lack of suitable shade-tolerant vegetable varieties, and substantial financial and marketing constraints for commercial vegetable production, especially in the more remote and poorer hamlets. These constraints must be systemically addressed before recommending commercial vegetable production to SANREM target households. An evaluation of shade tolerant vegetables needs to be conducted. Integration of vegetables with cashew trees will be useful for soil conservation and for home consumption to improve small-scale farmer nutrition.
- *Experiment on termite control.* Cashew worm and termites are serious problem pests. The Vietnam technology team recommended integrated pest management work to control termites instead of minimum tillage research. On-farm trials on termite control in young cacao planting was set up in two collaborating farm and are being monitored by Nong Lam University researchers. The trial includes natural termite control with vetiver grass, no termite control, and farmers' termite control practice with pesticides. Two month after the treatment was implemented, the initial results showed that:
  - with the on-farm experiment at the field of farmer collaborator 1 (Mr. Tan) 30 percent of cacao seedlings were destroyed by termites in vetiver treatment, and 70 percent for others, including chemically treated cacao seedlings
  - with the on-farm experiment at the field of farmer collaborator 2 (Mr. Nhan), 25 percent of seedlings were destroyed by termites in control treatment (no vetiver, no chemical used), and
  - a termite population of 1-10 termite/8 dm^3 soil where cacao seedlings died.
- *Experiment on cacao varieties.* Cacao grows well under and between cashew rows planted by four collaborating farmers. Growth rate of 10 cacao cultivars and cashew yield are being monitored. Cashew yield is expected to increase as trees benefit from fertilizer and irrigation of cacao. Leaves of cacao are also expected to improve soil organic matter. During the harvest season in January-February 2007, higher cashew yield was recorded by one collaborating farmer who planted cacao under cashew.

- *Drip irrigation on perennial crop (cacao).* Drip irrigation designed by TMPEGS-Vietnam was installed on cacao trees planted between cashew trees in the fields of collaborating farmers. The young cacao grew well. The amount of water applied and the yield of cashew and growth of young cacao are being monitored. Quantity of water applied and frequency of water application was based on farmers' perception with guidance from field assistants and scientists. Initial data collected on cacao drip irrigation during the 2007 dry season revealed that a major benefit of the drip system for young cacao planting are savings in family labor and gasoline. Other possible benefits are increase in cashew yield due to cacao irrigation and fertilization, and excellent cacao growth due to shade provided by cashew trees. Cashew yield will be monitored in the coming harvesting season to compare cashew with and without cacao.
- *Drip irrigation with vegetables.* Drip irrigation may be a solution to alleviate water competition between trees and vegetables, improve water-use efficiency, and improve vegetable yield and quality. A paired-t study – used to compare mean differences between treatments when the observations have been obtained in pairs – will be conducted with and without drip treatments with six farmer partners. Besides agronomic benefits, cost effectiveness of drip technology for vegetable production will be studied.
- *Experiment at Mars station.* Several field visits to the Mars station were made by the team and international SANREM experts. The cacao experiment there seems unsuccessful. Soil at the Mars site is poor because it was improperly bulldozed, cleared, and contour graded. Hence, cacao trees are growing poorly. Water reservoirs were completed in 2005 but do not hold water for irrigation during the dry season. Cu nang and *Arachis pintoi* planted at the site in July 2007 died due to poor management, poor soil quality, and poor drainage. The initial plan was to set up a vegetable variety screening at the site. However, due to heavy work load and lack of personnel with experience in vegetable cultivation, staff at the site elected not to implement the vegetable variety screening.
- Agreement was made to set up vegetable screening and vegetable-under-cashew studies at the extension center farm of Binh Phuoc province. The experiment was to commence in November 2007. The extension center staff will also participate in farmer training, cross-field visits, and dissemination of VAF technologies. This collaboration is expected to build capacity and skill of extension center staff and help ensure the effectiveness of the scaling-up activities of this project.
- Cu nang and *Arachis pintoi* have been successfully growing at Nong Lam University and at Mr. Du's home trials. Planting material from these trials will be distributed to local farmers as a new vegetable crop (cu nang) and as soil cover (*Arachis pintoi*) to plant under cashew, cacao, or rubber. Cu nang is expected to provide good biomass for fertilizing perennial crops, and its roots could be processed into flour. Leaves may have bio-pesticide properties.
- An experiment with *Arachis pintoi* used as soil cover for several vegetables is being set up at Nong Lam University. The design of the experiment is a paired-t study, and the treatments are vegetables with and without the soil cover.
- In the experiment with vegetative strips for soil erosion control and home consumption, lemongrass, ginger, saffron, vetiver grass, and elephant grass are growing well. Soil quality and soil loss due to erosion will be measured by the "T" team at the end of the 2007 rainy season.

2. Indonesia

- Identification and characterization of indigenous vegetable from several land races was completed. The indigenous vegetables were kemangi (*Ocimum americanum*), katuk (*Sauropus androgynus*), honje (*Etlingera giseke*), kucai (*Allium tuberosum*), beluntas (*Pluchea indica*), kenikir (*Cosmos caudatus*), pegagan (*Centella asiatica*), and sambung nyawa (*Gynura procumbens).*
- All of the indigenous vegetables were collected from eight sub-districts in two counties: sub-districts Nanggung, Parung, Tamansari, and Cibinong (Bogor County, West Java Province); and sub-districts Pandegelang, Cadasari, Mandalawangi, and Cimanuk (Pandegelang County, Banten Province).
- Phosphorus rates for vegetable grown in the ultisol–Nanggung were determined. Some vegetables used in the experiment were amaranth (*Amaranthus* sp), kangkung (*Ipomoea aquatica*), eggplant (*Solanum melongena*), chili (*Capsicum annuum* L), tomato (*Lycopersicon esculentum*), green bean (*Pahaseolus vulgaris*), and yardlong bean (*Vigna unguilata*). This experiment was established as a preliminary database to build soil phosphorus status and as a quick reference to obtain phosphorus optimum rate in the acil soil, ultisol-Nanggung, of seven vegetable crops. This experiment will be followed by a correlation and calibration study to build phosphorus fertilization recommendations based on soil analyses. Proper fertilization enhances vegetable-tree complementarity.
- At a soil phosphorus concentration of 10.8 ppm (Bray-1) of ultisol, application of phosphorus fertilizer of up to 180 kg P_2O_5 ha^{-1} increased plant height of kangkung, eggplant, chili, tomato, yardlong bean, and green bean; and increased linearly the yield of amaranth, kangkung, eggplant, chili, tomato, and green bean.
- Correlation of soil phosphorus status and vegetable yield studies have been completed; however, the laboratory analyses are ongoing. This study will identify the soil extractant method that correlates best with vegetables yield.
- On-farm screening trials of vegetables grown in tree-based farming systems in West Java have began. This experiment will compare growth and yield of marketable vegetables at two different light levels within a tree-based farming system and with a no-shade traditional vegetable farming system; and analyze the cost of vegetable production under tree-based farming systems, and compare them with the cost of no-shade traditional farming systems. The experiment is ongoing; preliminary data have been collected and reported.
- Preparation for integrated pest management study on yardlong bean with and without soil cover has started. *Arachis pintoi* was propagated and planted on the plots.

.

3. Philippines

Assessment of existing VAF on tree-vegetable interaction

Data collection and analyses of the degree of tree-vegetable interaction of VAF systems on above-ground parameters such as spatial light transmission, spatial productivity of associated crop and tree biomass, canopy width, canopy height, and tree spacing were conducted in Songco, Lantapan, Bukidnon. This SANREM experimental site in the Philippines covers 21 farms, two agro-forestry systems, six tree species, eight vegetables, and four aspects. Based on the data collected, we identified three zones of tree-vegetable interactions: competition, complementarity, and neutral. On the basis of these three zones identified, we developed a Net Complementarity Index (NCI) as a simple tool to assess appropriate tree-vegetable integration. The NCI is equal to the degree of complementarity minus the degree of competition. The degree of complementarity is equal to the relative yield at the complementarity zone minus 1 multiplied by the distance of complementarity influence. The degree of competition is equal to 1 minus the relative yield at competition zone multiplied by the distance of influence of competition. Relative yield at complementary zone is equal to the yield at complementarity zone divided by neutral zone, and relative yield at competition zone is equal to the yield at competition zone divided by neutral zone.

With the data collected so far, we concluded that integration of trees on vegetable farms (integrate type) is feasible only if complementarity is greater than competition effect (net complementarity index is > 0) and the cumulative value of tree products is greater than the cumulative values of yield loss and crop displacement area (cropped area loss). NCI is a simple but powerful tool that can assess appropriate tree-vegetable integration in VAF systems. We also found that the optimum tree spacing or tree line (hedge spacing) in a VAF system can be achieved when two complementary zones at the optimum meet, which is 20 to 25 meters apart. Using NCI, we found that *Eucalyptus robusta*, *Eucalyptus torillana,* and *Acacia mangium* are suitable tree species for VAF systems, and cabbage, Chinese cabbage, cauliflower, and bell pepper are suitable vegetables.

We also found a positive relationship between tree height and NCI. As tree and canopy height increases, more light is available to vegetables, particularly immediately under the trees. Some vegetable farmers severely prune trees before planting vegetables. It was found that this practice has a negative effect if removal is greater than 40 percent. The amount of canopy left after pruning should be 60 percent to 80 percent in order not to compromise the complementarity effect. On the other hand, canopy width (trees with broad canopy) has a negative relationship with net complementarity, which indicates that trees with broad canopies are not appropriate for VAF systems. Common examples of broad-canopy trees are *Gmelina arborea* and mango. If broad-canopy trees cannot be avoided, regular pruning should be done.

Tree-vegetable matching

The on-farm experiment to evaluate different commercial and indigenous vegetables under tree-based systems has been established. To evaluate the varying degree of spatial and temporal interactions, the following vegetable species were planted perpendicular to rows of *Eucalyptus torillana*.

Fruit vegetables

1. Bell pepper	Capsicum *spp*
2. Tomato	Lycopersicon esculentum
3. Eggplant, talong	Solanum melongena
4. Okra	Abelmoschus esculentus
5. Yardlong bean, batong	Vigna unguiculata *ssp* sesquipedalis

Leafy vegetables

1. Jute, saluyot	Corchorus olitorius
2. Common cabbage	Brassica oleracea
3. Chinese cabbage	Brassica rapa *CVG*
4. Uray, bihod-bihod	Amaranthus spp
5. Alugbati	Basella alba

Tree and shrub vegetables

1. Bago	Gnetum gnemon
2. Katuray	Sesbania grandiflora
3. Alikway	Abelmuchos manihot
4. Malunggay	Moringa oleifera
5. Chinese malunggay	Sauropus androgynous
6. Roselle	Hibiscus sabdariffa

Root vegetable

1. Carrot	Daucus carota

Carrot, tomato, bell pepper, cabbage, and Chinese cabbage were the most commonly planted vegetable species in the area, as identified by the farmers on the baseline survey conducted in 2006. The rest were based on availability of seeds and planting materials, and adaptability in the site.

Except for the jute, basella, and amaranthus, data on plant height and stem diameter of these vegetables at 10 and 30 days after planting have already been collected and encoded in the computer for statistical analyses. Data on yield still must be collected.

Domesticating indigenous tree vegetables and medicinal trees

The on-farm experiment plots, which look at the performance of indigenous tree species under tree-based systems, have been established. The following indigenous tree vegetables and medicinal trees were planted perpendicular to rows of *Eucalyptus torillana*:

Tree vegetables

1. Bago	Gnetum gnemon
2. Katuray	Sesbania grandiflora
3. Lagikway	Abelmuchos manihot
4. Malunggay	Moringa oliefera
5. Chinese malunggay	Sauropus androgynous

Medicinal trees

1. Cinnamon	Cinnamomun verum
2. Kalingag	Cinamomun mindanensi
3. Kenina	Cinchona pubescens
4. Lagundi	Vitex negundo
5. Tea	Camella sinensis

Data on plant height and stem diameter of these tree vegetables and medicinal trees at 10 and 30 days after planting have been collected and encoded in the computer for statistical analyses. Data on yield is still to be collected.

The spatial effect of trees on the associated vegetable crops is already visible in the field, demonstrating the competition, complementarity, and neutral zones. While some vegetable crops

such as carrot are positively affected by the presence of trees, several vegetable crops were negatively affected, particularly the tree vegetables. But in general, the initial growth performance of the associated vegetable crops shows their adaptability in partial shading, moist soil, lower wind speed, and mild temperature under a tree-based system.

Local farmers are very interested in the research and results to date. Neighboring households have visited the site and asked for extra planting materials, particularly indigenous vegetables. If promoted and utilized, indigenous vegetables can diversify production systems, increase farmers' income, as well as provide valuable sources of food, nutrition, and medicine.

Effect of drip irrigation on VAF system net complementarity

The on-farm experimental plots that look at the effect of drip irrigation on vegetable agro-forestry's net complementarity have been established. Bell peppers were planted as test vegetables in double rows perpendicular to the tree rows of 6-year-old *Eucalyptus torillana.* Three treatments (no drip, with drip, tree root pruning) were laid out in a randomized complete block design with three replications. Baseline data on height, stem diameter, canopy width, and light interception by trees have been collected. Water discharged per minute for each drip is also collected. Precision irrigation is important because some vegetable species are sensitive to overwatering. At the same time, this optimizes efficient use of available water resources. Controlling water application at the base of each plant also reduces leaching and ensures a healthy canopy, which helps control soil erosion and increase yield.

Effect of trichoderma inoculation on the growth and yield of maize

On-farm experiments on the effect of inoculation with the bio-fungicide trichoderma were established to determine its effect on the growth and yield of maize in agro-forestry systems. Five treatments were laid out in a randomized complete block design with three replications. These treatments are: (T1) no inoculation as control, (T2) with trichoderma inoculation as recommended, (T3) with recommended fertilizer application with no trichoderma inoculation, (T4) with recommended rate of fertilizer application plus trichoderma inoculation, and (T5) with one-half rate of fertilizer recommendation plus trichoderma inoculation. This experiment was initiated in early September 2007, thus tangible results are yet to be seen. It aims to test tricoderma inoculation as a means of improving the growth and yield of maize while decreasing the rate of fertilizer application and enhancing maize-tree complementarity.

Fabrication and testing of no-tillage seed drill

A human-powered no-tillage seed drill was fabricated and tested using various cover crops. It was found that the seed drill pulled by a human was not feasible. Animal-drawn and small-motor drawn no-till seed drills will be fabricated and tested in Year 3. Fabrication and testing will be done based on studies at the International Wheat and Maize Improvement Center.

System level: Field

Development impact

Knowledge on vegetable agro-forestry has been disseminated through experiments, workshops and farm activities. Although there is no hard evidence collected yet, it has been observed that some small-scale farmers, both women and men, are valuing soil and water conservation more,

gaining skills in vegetable and tree integration and drip irrigation, aspiring to have a stable and increasing income and clean water while conserving soil and water resources, and capable of accessing high-yield indigenous vegetable cultivars and tree-vegetable-soil-water interaction technology.

Challenges and responses

1. Vietnam

- All activities are on schedule except the initial plan to set up a vegetable variety screening at the Mars site, which could not be implemented due to lack of personnel and experience in vegetable cultivation. To overcome this problem, the vegetables screening and vegetables under cashew experiments will now be conducted at the extension center of Binh Phuoc province. The experiment with *Arachis pintoi* as a cover crop planted with vegetables will be set up at Nong Lam University.

2. Indonesia

- Most project timelines were met except the experiment on *Arachis pintoi*. It takes longer than expected to establish this cover crop in the experimental plots. This is currently being done, and the expectation is that integrated pest management and *Arachis pintoi* cover crop study on yardlong bean will begin in early 2008.

3. Philippines

- Key activities scheduled within this quarter were implemented except for the establishment of the *Arachis pintoi* as negotiation for farm use is still ongoing. The search for an accessible and appropriate site for the cover crop has been tedious due to the specific characteristics of the area required for the research, hence the delay on establishment of this research. A site near the existing experiments has been identified, but negotiation is still underway.
- Many VAF farmers are unwilling to cooperate with vegetable productivity and tree performance trials on the suspicion that we are looking for "treasures." We regularly assure them that this is not our intention.
- Rains almost daily in the area this quarter affected implementation of field activities. This also requires additional maintenance and personnel, which has funding implications.
- Limited funds to conduct the experiments as well as the availability of needed materials (^{15}N labeled fertilizers) have been factors. Discussion had been initiated with the International Rice Research Institute, which charges about $30 for N, ^{15}N, and ^{13}C to conduct these analyses.

Marketing: Value chain

Miriam Nguyen, coordinator
Le Thanh Loan, Vietnam coordinator
Iwan Kurniawan, Indonesia coordinator
Maria Elena Chiong-Javier, Philippines coordinator

Objective: to develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies

Critical research accomplishments

Market surveys were conducted. The following are cross-cutting results.

- *Marketable commercial vegetables identified.* Marketable commercial vegetables preferred by small-scale farmers, both women and men, were identified in Indonesia and the Philippines. The Vietnam team found that perennial commercial crops were preferred over commercial vegetable crops because small-scale farmers cannot compete with commercial vegetable-growing provinces in Vietnam. Therefore, the Indonesian and the Philippines technology teams are experimenting with vegetables for commercial sale, while Vietnam technology team is experimenting on vegetables only for home consumption and soil conservation.
- *Indigenous vegetables with market potential identified.* Indigenous vegetables preferred by SSFWM and with good marketable potentials were identified in Vietnam, Indonesia, and the Philippines. Technology teams in the three countries are conducting experiments with these indigenous vegetables.
- *SSFWM vegetable market constraints identified.* Marketing constraints faced by farmers are lack of access to marketing information, inability to control market pricing, high transport cost, and poor post-harvest handling.

Country-specific research results

1. *Vietnam*

- It was found from the rapid market assessment survey that perennial crops were more valuable to farmers than annual crops. Cashew, rubber, durian with coffee, and pepper are the most preferred by farmers, with cacao vague to informants because the crop is new to them. On the other hand, the five most profitable and marketable diversified crops were durian, bamboo shoots, cassava, rambutan, and vegetables.
- Findings of the baseline study and market value-chain research indicate that it would not be wise for the project to pursue an income-enhancing strategy for SSFWM in Nghia Trung based on the originally proposed intensive vegetable-tree crop production model. There is need to facilitate on-farm research in diversified vegetable production at the home garden scale.
- Low use of technology, weak extension activities, inadequate supply of production inputs, poor marketing infrastructure, and weak market linkage and post-harvest performance hinder the development of agricultural markets in Nghia Trung.
- Cacao is a new crop with unknown prospects for production and marketing. On-farm trials and associated agronomic and marketing analysis are needed before extension of cacao to non-experimental households.
- Markets need significant intervention to empower SSFWM. Support on techniques and market price information, more efficient supply of input factors, extension activities, irrigation and marketing infrastructure are all needed.

- A pre-survey has been recently conducted in market outlets in Ho Chi Minh City's wet and open markets, supermarkets, and households; in Dong Xoai, the main town of Binh Phuoc province; and in Nghia Trung commune. Findings will be reported in Year 3.

2. Indonesia

- Based on the baseline study, the potential vegetable species or products for Nanggung farmers were identified. Most commercial vegetables grown in the area of study are yardlong bean, tomato, chili, green bean, mustard green, and cucumber.
- There were four market channels for selling vegetables.
- Problems faced by farmers that impact vegetable marketability are inadequate knowledge of on-farm procedures such as soil, pest, and disease management; limited knowledge of proper harvesting, handling, and grading of harvested vegetables; and lack of collective marketing.
- Market traders face irregular supply of products, low to medium quality of produce, and limited knowledge of storage and capital.
- Through support from SANREM, a farmer group already collectively sells its bananas based on market specifications to a large fresh-fruits wholesaler in Tangerang, which resulted to better pricing for the produce.
- Twenty traders and 150 households were surveyed for a consumer preference study. Results will be presented in Year 3.

3. Philippines

- The top five vegetables preferred by farmers for growing and marketing are cabbage, umbok (Chinese cabbage), potato, carrot, and tomato Preferred trees are eucalyptus, gmelina, falcata, jackfruit, and lanzones.
- While many farmers prefer to bring their vegetable produce directly to storage facilities in the city markets, most sell their supplies to the small-scale traders who take these to the marketplace.
- In general, the vegetable agro-forestry supply chains are for:
    - vegetables – farmer to producer to trader to storage facility to runner to classifier to shipper and finally to institutional buyer-consumer, and
    - forestry commodities – seeds, farmer to producer to consumer; and timber and fruits, farmer to producer to market intermediary to institutional buyer-consumer.
- The top three marketing constraints faced by vegetable farmers are lack of access to market information, inability to control market pricing, and high cost of hauling and trucking. For small-scale traders, constraints are lack of capital, inability to control the quality of goods, and inability to control market pricing. Meanwhile, the top three marketing constraints for agro-forestry products are undeveloped markets for timber and fruits, difficulty in selling timber posed by legal and permit requirements, and poor timber quality that affects pricing.
- Main insights derived from preliminary findings are:
    - there is a need to integrate trees in vegetable production and to motivate farmers to do so
    - marketing is an individual rather than a collective enterprise, and the marketer thrives through ingenious ways of linking him or her to the source of supplies

- the supply chains are not demand-driven but dominated and driven by intermediary buyers
- farmers do not appreciate consumers' market preferences, and
- any modification to increase farmers' share of downstream price of goods and to make the supply chain efficient must weigh the pros and cons of disrupting functional relationships among the different stakeholders in the chain.

System level: policy/market and farm household/enterprise

Development impact

The marketing peg aims to determine profit centers along the value chain extending from production inputs to handling and sale of vegetables or tree products. The goal is to decrease costs and increase benefits from each profit center, thereby increasing farmers' profits. Key profit centers have been identified by marketing team, and TMPEGS is concentrating research on these. For example, the technology team is conducting experiments for sustainable production of marketable commercial vegetables and tree products identified by the market team. The aim is to decrease input costs and increase yields of vegetables and trees produced. Furthermore, the marketing team has been disseminating market findings to farmers and traders. Farmers and traders are encouraged to improve efficiency of key profit centers. In Indonesia, a farmer group already sells its bananas based on market specifications to a large fresh-fruit wholesaler, which has resulted in better pricing.

Sufficient knowledge on the value chain has been gathered by the marketing team. Dissemination of this knowledge to SSFWM is the next step. For example, in Indonesia, workshops on proper post-harvest handling of vegetables will be conducted. Increased profit through improved vegetable quality will be monitored. The aim is for farmers to increase knowledge, realize benefits, acquire skills, aspire for high quality standards, and be enabled to supply products of the quality that the market demands. The result is vegetable and tree products of high quality commanding high prices.

Challenges and responses: Schedule is on time.

Policy: incentives

Delia Catacutan, coordinator
Dang Thanh Ha, Vietnam coordinator
Delia Catacutan, Philippines coordinator

Objective: to identify policy options and institutional frameworks that promote sustainability of vegetable agro-forestry production and reward environmental services

Critical research accomplishments

Two key activities were conducted: extended policy baseline study and initial policy development.

1. Extended policy baseline study

Philippines

A number of national policies related to tree growing and vegetable production exist, but despite their prominence and good intentions, disincentives and or gaps persist. Policy incentives often are expressed with ambiguity, making it difficult to interpret and implement at the local level. Apparently the policy milieu on vegetable farming and tree growing at the national level is less encouraging for small-scale farmers. National-level policies are undoubtedly indispensable, but their effectiveness needs further examination if they are to serve their purpose.
Recommendations are:

- national-level policies that are broad in scope and context are essential, but these need proper interpretation and further innovations to make them effectively applicable at the local level, and
- small-scale farmers both women and men, can be effectively helped with policies that are locally developed so that local people can take part in the formulation process

Vietnam

The government-supported agricultural development strategy in Binh Phuoc Province is focused on production of "strategic" industrial perennial crops and substitution of new perennials, as market conditions dictate. Cashew and rubber acreage have increased over the past few years as coffee and fruit trees have declined. All farmers in Nghia Trung are engaged in industrial perennials production and, to varying degrees, benefited from government support in the form of input supply and established market chains for these crops. Stakeholder interviews revealed that watershed protection and adoption of sustainable farming practices (soil erosion control, integrated fertilizer and pest management) will have significant environmental benefit to people in Dong Xoai, the capital of Binh Phuoc province; and downstream people. Previously, policies were directed toward the forest resources, but today they are more expanded to rural development and food security.

At the local level, the government promotes cacao as a new crop for diversification and income improvement. Vegetable production so far has not received attention from the Department of Agriculture and Rural. Development; therefore, there has been no extension program or activity on vegetable cultivation. The linkages between research and extension, as well as with research and policy decision, are quite weak in Binh Phuoc province. The research project needs to enhance these linkages for effectively promoting VAF technologies and sustainable farming practices.

2. Initial policy development

Philippines

Representatives of major stakeholder groups such as local government officials and farmers assessed their level of predictability, interest, and power in terms of natural resource management. All stakeholders have high level of interest. The stakeholders identified the guiding principles when formulating policies for VAF as incentive-based, inclusive rather than selective, effectively communicated, complemented with effective programs, and enforced immediately. Furthermore, the stakeholder groups were supportive and agreed to these actions: face-to-face

meeting with all stakeholder groups, and initial development of incentive-based policies for VAF.

Rapid hydrologic assessment (RHA) is a systematic process of appraising the hydrological situation and perceptions of key stakeholders with respect to the values and threats of natural resources. It can be used to appraise opportunities for negotiating land-use agreements that include rewards for the protection and rehabilitation of watershed functions in the uplands. Results of the RHA will be a basis for developing incentive-based policies for VAF systems. The following were accomplished for RHA research: desktop collection of biophysical and socioeconomic data, mapping of sub-watersheds within Lantapan, survey of local ecological and public-policy knowledge, multi-stakeholder site reconnaissance, and focus group discussion by stakeholder groups.

System level: policy/market

Development impact

The development impact of this study can be observed in the changes in knowledge and attitudes of research participants in a number of dialogues, seminars, and workshops, particularly local government officials, technicians, and other stakeholders such as irrigation and hydropower companies in the Philippines. The potential of VAF systems in improving rural livelihoods as well as in maintaining watershed functions are better understood and internalized, and the weaknesses of VAF- related policies and research, extension, and policy linkages have been recognized in the Philippines and Vietnam.

Philippines

Local government officials in Lantapan expressed strong interest to address this gap by developing a package of incentive-based policies for VAF. Local funding has been earmarked to initiate the development and implementation of VAF incentive-based policies in 2008. Some stakeholders obligated financial assistance, while others committed technical expertise and in-kind support such as maps and data. A memorandum of agreement was signed by five agencies to develop incentive-based policies and mechanisms for payments for environmental services.

Vietnam

The research team has established a good relationship and generated cooperation from local village leaders, the Department of Agricultural Research and Development, and the provincial extension center. Local decision makers are interested in VAF systems for improving income and nutrition of small farmers. The extension center of Binh Phuoc province is involved in VAF trials with vegetables under cashew and farmer field visits and training. This collaboration is expected to enhance the capability of the extension center staff and help to ensure the effectiveness of the scaling-up activities of the project.

Challenges and responses

Research activities were hampered by the conflicting schedules of research participants. Meetings and workshops are sometimes difficult to organize due to previous commitments and

priorities of individuals in the research setting. In the Philippines, some activities were postponed due to local government elections. In general, however, the planned activities were substantial.

In a social research setting, the variables are not controlled, and the research participants represent multiple perspectives, making it more challenging to capture their diverse interests. In addition, process- and participatory-oriented research is by nature time consuming and challenging in terms of consistency of contact and interaction with participants in the research arena. The real challenge is in maintaining credibility on the part of the researcher/facilitator and maintaining an atmosphere in which all participants feel their individual importance and contribution in the research setting.

Environmental and socioeconomic impact: "It works."

Victor Ella, environmental impact coordinator
Robin Marsh, socioeconomic impact coordinator
Nguyen Kim Loi, Vietnam environmental impact coordinator
Le Thanh Loan, Vietnam socioeconomic impact coordinator
Mahmud Raimadoya, Indonesia environmental impact coordinator
Suseno Budidarsono, Indonesia socioeconomic impact coordinator
Victor Ella, Philippines environmental impact coordinator
Anthony Penaso, Philippines socioeconomic impact coordinator

Objective: to assess the short- and long-term environmental and socioeconomic impacts for farm families of adopting integrated vegetable agro-forestry systems

Critical research accomplishments

1. Environment impact

- Year 2 of project implementation for the environmental impact Soil and Water Assessment Tool modeling components of this project was highlighted by capacity building in the form of non-degree training. A workshop on SWAT modeling was conducted in the Philippines in 2007. The SWAT modeling training was conducted at the University of the Philippines at Los Baños and International Rice Research Institute facilities from May 14 to 17 and was attended by 12 scientists from the Philippines, Indonesia, Vietnam, and Thailand. The training was coordinated by Victor B. Ella with overall program leader Manuel Reyes. The lectures were handled by R. Srinivasan from Texas A&M University. The training included lectures on the theoretical background of the SWAT model; introduction of the SWAT model and its applications; demonstration of SWAT model building; demonstration of SWAT model calibration, validation and simulation; and demonstration of other relevant software programs.
- In Indonesia, Philippines, and Vietnam, substantial secondary input data for SWAT modeling were collected in the past year. These include climatic, topographic, soils, and land-use data. Preparation of input data in appropriate format for SWAT modeling was also carried out. High-resolution satellite images for each project site in all three countries were purchased. More substantive SWAT modeling work will be performed in Year 3 of project implementation in all three countries.

- Modeling efforts have also been coordinated with Conrad Heatwole of Virginia Tech. He is coordinating the cross-cutting research on assessing hydrologic impacts of SANREM projects in several countries.

2. Socioeconomic impact

- During 2007, Robin Marsh of University of California-Berkeley provided substantial comments on the baseline reports from Vietnam and Indonesia, including the detailed market survey report from the Vietnam team led by Le Thanh Loan. She also formulated a set of specific research recommendations for the Vietnam coordinator, Dang Ha, based on baseline results and in line with SANREM objectives and the overall research design.
- In summer 2007, three SANREM partners participated in the Beahrs Environmental Leadership Program's certificate training course in Sustainable Environmental Management at the UC- Berkeley, co-directed by Marsh. In addition to attending the full three-week course, the three participants had an opportunity to exchange information and experiences on their respective SANREM projects, and to meet with Marsh individually and together regarding the socioeconomic monitoring and impact assessment methods that Marsh is coordinating in the three countries.
- Marsh traveled to Southeast Asia to work with SANREM professional teams in Indonesia and Vietnam, speak with local women and men farmers, and visit on-farm and on-station experiments. In collaboration with SANREM Vietnam and Indonesian teams, Marsh helped formulate the technology adoption monitoring feedback plan for the next 18 months and initiated discussion on the objectives, methodology, and timing for the impact assessment surveys and analysis toward the end of the project in 2009. She did not go to the Philippines; however, the adoption monitoring design was discussed with Anthony Penaso, Philippines coordinator for socioeconomic research, during the course at Berkeley and has been followed up. Marsh has ensured good compatibility in baseline, adoption monitoring, and impact assessment design across the three countries, which will greatly facilitate comparative analysis of project impacts.

System level: field

Development impact

The socioeconomic team's adoption monitoring with feedback plan is overseeing on-farm and on-field experiments to collect input, cost and market data to calculate benefit/cost ratios of the experimental technologies, as well as ascertain small-scale farmers' perceptions of these technologies. Furthermore, several visits to "adopting" farmers to monitor adoption or adaptation of any of the technologies are being conducted. This is in line with the TOP knowledge, attitudes, skills, aspirations, and capabilities. Goals of these visits are for SSFWM to gain knowledge of benefits, costs, and risks of adopting VAF; value conservation of natural resources; be able to calculate short- and long-term benefits and costs of introduced technologies; aspire to improve and practice various soil and water conservation technologies; and be capable of comprehending and advocating conservation technologies.

The environmental impact team, meanwhile, has been collecting data to assess the hydrologic impact of proposed VAF technologies in the research watersheds. The database will be used in

running the SWAT model, which will be used to quantify the environmental benefits of vegetable agro-forestry.

Challenges and responses

One challenge is that Marsh has not been allotted more time, making it difficult to ensure the necessary follow-up (zero staff time in Years 2 and 3). Marsh suggests a possible amendment to allocate two weeks in Year 3 to assist the teams in implementing monitoring plans and preparing for the impact assessment surveys in Year 4. Because additional funds are not available during Year 3, Marsh will be allocated more staff time in Year 4.

Gender: equity

Maria Elena Chiong-Javier, coordinator
Nguyen Duc Thanh, Vietnam coordinator
Trikoesoemaningtyas, Indonesian coordinator
Maria Elena Chiong-Javier, Philippines coordinator

Objective: to provide mechanisms to ensure women's involvement in decision making and sustainable production and marketing practices to improve their socioeconomic well-being within the vegetable agro-forestry system.

Critical research accomplishments

In all countries, gender data collected through the socioeconomic baseline surveys involving farm households in the study sites were analyzed and the findings incorporated in the survey reports. Also, the Philippines conducted a second survey that focused specifically on 50 women farmers, most of whom belong to the indigenous Talaandig group of Bukidnon. Salient findings from the gender analysis reveal the following.

- Men are the dominant labor force in commercial crop production, while women predominate in raising subsistence crops, particularly in home gardens. In the Indonesia and Philippines sites, most if not all niches in the agricultural production cycle that require arduous work are handled mainly by men; these include land preparation, planting, crop management and maintenance, fertilizer application and/or pest control, and harvesting. In Vietnam's case, husbands dominate only in planting, fertilizer application, and pest control; gender equality is observed in land preparation, crop management, and harvesting.
- More men than women control the agricultural domains of farm-level decision making, including purchase of farm inputs and timing of harvest or marketing; involvement in farmer organizations, associations, or cooperatives; and participation in agricultural training and extension services. Far fewer Indonesian women are involved in farming organizations compared with Vietnamese or Filipino women. Female participation in training, though generally low, is higher in the Philippines compared with Vietnam and Indonesia. Women's limited organizational and training involvement is due to such factors as their preoccupation with household duties, the holding of meeting or training during hours or times that disregard women's work and needs, and the perceived male orientation of many extension services.

- If the men lead in productive work, women reign in reproductive roles. The latter consists mainly of unremunerated domestic chores, particularly washing clothes and dishes, cooking meals at home and on the farm, cleaning the house, and child care.
- Dominance in the agricultural marketing sphere varies by country. In Vietnam, men and women generally share equally in the tasks of marketing farm produce. In contrast, marketing activities in Indonesia are predominantly handled by men, while in the Philippines these are usually handled by women. Albeit Filipino women exercise control over the actual sale of produce, both on farm or at the marketplace, the men still dominate in such post-harvest tasks as sorting, grading, and transport. Moreover, women's greater participation in marketing does not seem to translate easily into a greater say in farm expenditures.
- Limited data also indicate some gender differentials in the choice of agricultural crops to grow for the market and access to/control of land resource for production purposes. Furthermore, while women may help in planting and caring for trees, men dispose of timber and other tree products in the market.

After the surveys, collection of subsequent data to explore alternatives to improve women's status was designed and initiated using qualitative methods: on-site observation, key informant or in-depth interview, focus group discussion, case study, and-or interpretive approach.

In Vietnam, qualitative research was started to gather information on the structure and performance of the Nghia Trung women's association, the preparation of case studies on the role of women in the VAF system, and the identification of measures for monitoring and assessing the impacts of VAF technologies and training on women. The role of the women's association is believed to be strategic in ensuring women's participation through members who will collaborate in SA and NRM, and VAF extension training; and increasing the number of women participants in technology training, adoption and scaling up. The case studies will reveal the constraints women face in VAF technology adoption as well as the impact of such adoption on their lives.

For Indonesia, the gender analysis revealed the importance of meeting women's practical needs (resolving financial difficulties or low productivity, access to health care) over strategic needs (low competency and limited organizational participation). Because women felt strongly about their food provider role, the plan turned to addressing nutritional issues. Focus group discussion was conducted among 30 women belonging to two village groups to discuss local ways of utilizing indigenous vegetables, to learn the nutritional and medicinal values of such vegetables, to demonstrate new ways to cook nutritious foods using these vegetables, and to distribute a small recipe book on indigenous vegetables written by the gender team. Another focus group discussion was held to examine the role and dynamics of power in a women's organization before initiating a small income-generating project with selected women's groups, as well as to understand how to strengthen the organization.

In the Philippines, quantitative surveys were augmented with qualitative research. Because findings connected women and small-scale vegetable marketing, de la Salle University employed key informant interview and on-site observation to produce a case study of women biyahidors (small vegetable traders). This case study provided insights on the formation and interconnectedness of an informal alliance of six biyahidors, their motivations for engaging in

the trade, the features of their micro-enterprise, their business problems and strategies, the social benefits they derive from the network, and their needs and aspirations. Other pertinent survey data were fed to the technology team, facilitating inclusion of selected women farmers among trainees for specific technologies like drip irrigation. Forthcoming research has been designed to elicit the impacts of women's VAF training participation and technology adoption. It will utilize the process documentation research method that draws data from observation, key informant interview, and systematic data recording. The study's results will be disseminated and discussed with women's networks and alliances to draw out alternative mechanisms for improving women's involvement, status, and voice in the VAF system. University of the Philippines-Open University has been using and continues to apply the interpretive approach to gain a deeper understanding of how existing women's organization and networks, linked by a shared meaning system, define their participation in the Philippine VAF setup. This research supposes that organization exists in people's accounts or stories that are interpretations and constructions of oneself and one's world. These stories are told in conversations that are being recorded and transcribed. A narrative analysis of the transcripts of women's conversations, guided by the Semio-Greimas narrative theory, will be undertaken to derive the women's meaning system and thereby their organization.

System level: field, farm, policy/ governance

Development impacts

The necessary research activities for exploring alternative development pathways for women in the three VAF systems are expected to be completed in the coming year of project implementation. With the active involvement of informal or formal women's groups or associations, the findings will be translated into concrete actions in the final implementation year that can be pursued thereafter in the sites to realize the stated impact indicators in the gender TOP.

Challenges and responses

The project timeline for gender is generally proceeding on schedule. The gender teams in Vietnam, Indonesia, and the Philippines await the proposed SANREM-CRSP cross-cutting gender research led by Maria Elisa Christie, which focuses on gendered access to markets. This research is welcomed, for it will provide resources for delving into gendered market access through gendered networks; it could therefore expand the opportunities currently being considered for improving women's status and welfare in the VAF system. However, it could also disrupt the timetable for completing the teams' research plans for Year 3. The challenge to the teams is how to keep the interphasing smooth. Following a common research plan from the beginning will help to attain this.

Scaling up: "Contagiousness"

Ma. Victoria Espaldon, coordinator
Dang Thanh Ha, Vietnam coordinator
Anas Susila, Indonesia coordinator
Ma. Victoria Espaldon, Philippines coordinator

Objective: to build host country capacity to manage and disseminate integrated vegetable-agro-forestry systems

Critical research or service accomplishments

1. *Cross-cutting*

- Scientists from Vietnam, Indonesia, and the Philippines attended Soil and Water Assessment Tool, no-tillage vegetable and soil-quality workshops.
- Vietnam, Indonesia, and the Philippines identified farmers who are examples and proponents of SANREM technologies.
- Scientists from Vietnam, Indonesia, and the Philippines with a partner from Thailand organized the first Southeast Asian Soil and Water Assessment Tool conference to be held Jan. 5- 9, 2009, in Chiang Mai, Thailand (http://www2.mcc.cmu.ac.th/swat/index.php)
- Top administrators from Nong Lam University, Vietnam; Bogor Agricultural University, Indonesia; University of the Philippines-Los Baños; and Chiang Mai University, Thailand, visited personnel of U.S. federal agencies in Washington, D.C. (USAID, USDA, and National Science Foundation), National Association of State Universities and Land-Grant Colleges, American Council on Education, Mars Inc. scientists, and embassy staffs from Indonesia, the Philippines, and Thailand. Administrators also visited top officials from North Carolina A&T State University and Virginia Tech. NCA&T, Virginia Tech and Mars Inc. funded these visits

2. *Vietnam*

- A seminar by Robin Marsh to introduce the environmental leadership program at the UC-Berkeley, discuss results from field assessment, and identify possible technology interventions was conducted with 19 participants (nine men, 10 women).
- Training on soil quality and vegetable drip irrigation was conducted for 21 local farmers, village leaders, and representatives from the Department of Agricultural Rural Development (18 men, three women).
- Local farmers (five men, two women) participated in a field day and discussion on the design of field experiments to control termites on cacao and vegetable-natural vegetative strips for soil erosion control.
- A seminar introduced the concept of payments for environmental services to 16 NLU researchers and students (six men, 10 women).
- Through requests by Vietnamese farmers, an agreement was reached on an integrated crop management and integrated pest management workshop in November 2007 conducted by AVRDC scientists Manuel Palada and Greg Luther.
- SWAT training was conducted for five researchers of Nong Lam University.
- A soil quality workshop was conducted by Charles Raczkowski and G.B. Reddy.

3. *Indonesia*

- A SANREM experimental farm was established. Several small-scale farmers, both women and men, have visited the site. A SANREM field assistant is at the farm to assist and answer farmers' questions about vegetable agro-forestry.
- A no-tillage vegetable workshop was conducted by Ronald Morse and David Midmore.

- A drip irrigation workshop was held.

4. Philippines

- The Philippine work plan completed the baseline survey of 50 sample respondents from Brgy Songko, Lantapan, our study area. The baseline survey also included the training needs of farmers in the study area.
- A farmer field day on vegetable agro-forestry was successfully conducted with several small-scale farmers, both women and men, in attendance.
- Documentation of the Binahon Agro-forestry Farm owned and operated by Mr. and Mrs. Henry Binahon was completed, and a short documentary film, brochure, and story were developed. The farm illustrates a working model of vegetable agro-forestry, requirements for successful development of a farm, and the establishment of a small farm nursery employing VAF systems. Women play a significant role in the nursery establishment as well as in the marketing of the products. However, there is a need to define the roles of husband and wife in a family agro-forestry farm to optimize the socioeconomic, cultural, and environmental benefits of such a system. For example, it was found that the establishment of the nursery, the tree farm operation, and the integration of trees with vegetables are as important as linking and networking; for it is through networking that markets are identified and established. In the case of the Binahon farm, the wife is in charge of the farm operation, while the husband is more focused on attending meetings and conferences at which he is able to establish a network and reputation as a credible source of seedlings, other planting materials, and other services such as catering and accommodation for farmer training activities.
- A drip irrigation workshop was conducted.
- The evaluation report of the training course in drip irrigation for the target 50 farmers in Barangay Songko was completed using the pre- and post-test method for determining the effectiveness of the course. The results, however, are tentative and will be followed up by another interview after the implementation of the on-farm drip irrigation experiment.
- The Soil and Water Assessment Tool modeling workshop was conducted by R. Srinivasan.

System level: field, farm household/enterprise, policy/market

Development impact

Knowledge of vegetable agro-forestry has been disseminated through experiments, workshops, and farm activities. Although there is no hard evidence yet, it has been observed that some small-scale farmers, both women and men, are beginning to have an appreciation of vegetable agro-forestry, gaining skills in vegetable and tree production, aspiring to have a sustainable farming system, and trying to adopt vegetable agro-forestry in their biophysical and socio-cultural context.

Challenges and responses

The projects in Vietnam, Indonesia, and the Philippines are on time based on the projected timeline. It can also be considered a bit ahead in the Philippines, for part of what TMPEGS-Philippines conducted was planned to start by early October 2007. On obstacles encountered,

actions taken, and lessons learned, the Philippines team has not observed any constraints except the monthly financial reporting system, which seems too fast. Quarterly reporting may be more appropriate.

Degree and Non-degree Training Activities

LTRA-5 had 20 students involved in long-term degree training. Of those, 11 are women, nine are men, and 19 of the 20 are from host countries. Three are working on Ph.D.s, seven on master's degrees, and 10 on bachelor's degrees. Short-term training involved 287 men and 217 women in 12 workshops, four seminars, four focus groups, two field days, and one short course (see Degree and Short-Term Training Tables).

Publications, Presentations, Other Products

LTRA-5 researchers have produced seven working papers, 10 presentations, seven reports, four theses, a website, a poster, a fact sheet, a film, and a prototype of a human-powered no-till seeder.

Networking Activities

- SANREM Program Director Theo Dillaha, Virginia Tech, visited TMPEGS partners at Nong Lam University, Vietnam; Bogor Agricultural University and ICRAF (The World Vegetable Center), Indonesia; de la Salle University; University of the Philippines-Los Baños; University of the Philippines-Open University; Don Bosco Technical College; University of Sto. Thomas; Silliman University; and with ICRAF-Philippines.
- Alton Thompson, dean of the school of agriculture, North Carolina A&T State University, visited TMPEGS partners at Nong Lam University, Vietnam; Bogor Agricultural University, Indonesia; UP-Open University and UPLB; and Chiang Mai University, Thailand. A memorandum of understanding was signed among NCA&T and NLU, BAU, UPOU, UPLB, and CMU.
- Rector Tuyen, NLU, Vietnam; Chancellor Velasco, UPLB, Philippines; Vice-Rector Chozin, BAU, Indonesia; Associate Dean Attachai, CMU, Thailand; and Reyes visited several federal and educational agencies and officials from the Thai, Indonesian, and Philippine embassies in Washington, D.C.; and with officials of Mars Inc., and top administrators at NCA&T and Virginia Tech
- Reyes visited TMPEGS personnel in Vietnam, Indonesia, and the Philippines; met with small-scale farmers, both women and men; and strengthened relationships with SANREM-SEA-TMPEGS partners.
- Reyes visited the USAID Mission- Philippines. Unfortunately, USAID Mission- Vietnam personnel had to cancel their appointment, and USAID Missions- Indonesia was in transition to new leadership, hence Reyes was unable to meet with them.
- Le Thanh Loan, Vietnam; Gerhard Manurong, Indonesia; and Anthony Penaso and Christina Rodriguez, Philippines, participated in the Beahrs Environmental Leadership Program at UC- Berkeley. They established several contacts worldwide. These contacts are summarized in their trip report.
- Nguyen Kim Loi, Vietnam; Mahmud Raimadoya, Indonesia; Victor Ella, Philippines; and Attachai Jintrawett, Thailand, attended the Soil and Water Assessment Tool modeling workshop in the Philippines. They networked with each other and with R.

Srinivasan, SWAT international expert from the United States. This networking resulted in the organization of the first Southeast Asia SWAT Conference, to be held in Chiang Mai, Thailand, in January 2009.

- Le Van Du, Vietnam; Anas Susila, Indonesia; and Paul Catalan and Agustin Mercado, Philippines, attended the no-tillage vegetable workshop in Indonesia, conducted by Ronald Morse, Virginia Tech, and David Midmore. Australia. Networking was built among these scientists.
- Le Van Du and My, Vietnam; Anas Susila, Indonesia; and Caroline Duque, Philippines, attended the soil quality workshop in Vietnam, conducted by Charles Raczkowksi and G.B. Reddy of the United States. Networking was built among these scientists
- Country Coordinators Dang Thanh Ha, Vietnam; Anas D. Susila, Indonesia; and Delia C. Catacutan, Philippines, met with Reyes in Vietnam.

Vietnam

- Discussion with the extension center of Bin Phuoc province was held to plan for setting up experiment with vegetables under cashew, farmers' field and training.
- An agreement was made with one collaborating farmer to plan for setting up trials for vegetables grown under cashew canopy under different light regimes.
- Networking was strengthened with local stakeholders (representatives from Department of Agriculture and Rural Development, local village officials, representative of Women's Association, Farmers Association, and Youth Organization) in kickoff workshop, household survey, participatory market assessment, and group discussion.
- Nong Lam University researchers and Robin Marsh, UC-Berkeley, and David Midmore, Central Queensland University, networked during the visit of the two scientists in Vietnam.
- TMPEGS-Vietnam has supported a Danish student, Ramus Lybeack, to conduct his master's thesis in the study site in Vietnam.
- Dang Thanh Ha, Vietnam coordinator, participated in the global workshop in Lombok, Indonesia, on payments for environmental services and established several contacts there.

Indonesia

- A manual was completed on recipes for indigenous vegetables, and an indigenous vegetable cooking "bonding" time with women farmers sparked excellent relationships with the clientele.
- A vegetable agro-forestry extension camp was built in Hambaro village and has been visited and served several small-scale farmers, both women and men. It appears to be an excellent scaling-up model for Indonesia. Susila's SANREM-funded vegetable guide in Bahasa has been used in responding to fertilization questions in the site.
- TMPEGS-Indonesia was visited by Gerald "Jerry" Skiles, a marketing specialist volunteer from Winrock International under a farmer-to-farmers program. He provided assistance and shared his experience working with small-scale farmers during almost 20 years in Africa and gave input on developing a farm marketing association in Nanggung.

Philippines

- Through networking with Liwayway Engle and Flordeliza Faustino of AVRDC, and indigenous vegetables screening experiment at the Philippine site was established. AVRDC provided the seeds for the experiments and complemented the cost of field activities.
- AVRDC and ICRAF hosted a farmer field day on September 22, 2007, at SANREM's Philippine site. About 65 farmers, traders, technicians, and consumers from Lantapan attended the activity. Several SANREM researchers were also present.
- Discussions were initiated by ICRAF-Philippines with Peter Motavalli of the University of Missouri for possible research collaboration on the role of agro-forestry in rehabilitating degraded soils.
- A meeting with the new municipal mayor of Lantapan to introduce the project was completed.
- A meeting was held with the head of the Farmer's Information and Technology Services in Lantapan.
- Networking was done with the MagAgri Tayo, a TV program on agriculture.
- National Power Corp., a government-owned and operated corporation, adopted SANREM-TMPEGS activities into its annual work plan.
- TMPEGS-Philippines sought out NorMinVeggies, a private marketing arm of local vegetable producers from Lantapan, Bukidnon, with a bodega in Agora Market, Cagayan de Oro City, for assistance in its task of monitoring the prices of vegetable commodities.
- Agnes Rola visited the study site and spoke with municipal and provincial government officials, farmer partners, and the members of the water watchers group (Tigbantay Wahig).

Project Highlights

- Agustin Mercado (ICRAF-Philippines) developed the Net Complementarity Index (NCI), a simple tool to assess vegetable-tree interaction. A NCI greater than 1 means the vegetable-tree system has better vegetable yield compared with a traditional open-space vegetable production system. NCI may accelerate adoption of vegetable agro-forestry because NCI can show that addition of trees into traditional vegetable production systems may increase vegetable yield, at the same time providing benefits of environmental protection and income from trees.
- It was found that the optimum tree spacing in a VAF system can be achieved when two complementary zones at the optimum meet, which is 20 to 25 meters apart. Using NCI, it was found that *Eucalyptus robusta*, *Eucalyptus torillana,* and *Acacia mangium* are suitable tree species for VAF systems; and cabbage, Chinese cabbage, cauliflower, and bell pepper are suitable vegetables crops with NCI greater than 1.0.
- Research efforts continued on increasing NCI through experiments on tree-light intensity-vegetable combinations, reintroduction of indigenous vegetables, drip irrigation, tree root pruning, permanent cover crop, integrated pest management, and proper fertilization technologies. TMPEGS researchers hypothesized that any one of these technologies may increase NCI.
- Preliminary results in Vietnam showed that several varieties of cacao are growing very well when planted between cashew trees. Cacao is ranked as one of the top commodities

by Vietnam's government. Cacao has an excellent potential to increase income and diversify income source of small-scale cashew farmers, both women and men. Cacao also improves soil quality and has soil conservation qualities.

- Preliminary results in Vietnam showed that cacao planted between cashew trees and irrigated with a low-cost drip system is growing very well, and cashew yield is increasing. Irrigation efficiency significantly increased with the use of a drip system. Preliminary benefit/cost analysis showed a benefit/cost ratio higher than 1.0.
- Market baseline studies identified marketable vegetables and trees, and these are the current focus of technological research.
- Farmers and traders are encouraged to improve efficiency of key profit centers in a market value chain. For example, in Indonesia, a farmer group already sells its bananas based on market specifications and collectively to a big fresh-fruit wholesaler, which has resulted in a better pricing scheme for the produce.
- In Vietnam, local government promotes increased income and improved nutrition for small-scale farmers, both women and men. Indigenous vegetables may grow well in the cashew understory, is nutritious, and has some market. TMPEGS is therefore formulating policy incentives linking improved nutrition with indigenous vegetable production, the impact of which is to encourage adoption of VAF systems.
- Local government officials in Lantapan, Philippines, expressed strong interest in developing a package of incentive-based policies for vegetable agro-forestry. Local government funding has been earmarked to initiate this policy, the impact of which is to encourage adoption of VAF systems.
- Production was completed of the Binahon agro-forestry film and booklet. Mr. and Mrs. Binahon were strongly influenced by SANREM Phases I and II, and they developed an "ideal" agro-forestry system. The film and booklet have been used to showcase agro-forestry and its benefits to many small-scale farmers, both women and men.
- SANREM-TMPEGS led organization of first Southeast Asian Soil and Water Assessment Tool modeling international conference, to be held in January 2009 (http://www2.mcc.cmu.ac.th/swat/index.php). This is significant in advancing state-of-the-art watershed modeling technology for NRM in Southeast Asia.
- In Bahasa, a vegetable manual developed by Anas Susila has been used by many small-scale farmers, both women and men.
- Based on indigenous vegetables accession studies funded by SANREM, an accompanying indigenous vegetable manual was written by Bambang Purwoko. Furthermore, Trikoesoemaningtyas wrote an indigenous vegetable cookbook. These were distributed to SSFWM, encouraging them to adopt VAF system technology.
- In the Philippines, AVRDC has developed and distributed farming guides in English language on how to grow indigenous vegetables. The plan is to translate these guides into Visayan dialect for wider impact at the community level.
- The Philippines project site has generated a lot of interest. Neighboring households have visited and have asked for extra planting materials, particularly indigenous vegetables. If promoted and utilized, the VAF system can diversify production, increase farmer income, as well as provide valuable sources for nutritious food and medicine.

Cross-cutting Activities

Gender Equity

Introduction

A key SANREM CRSP objective is to address the role of gender in the development of sustainable solutions to agriculture and NRM problems. Gender equity has been a priority from the beginning and was a criterion in the selection of the five LTRAs. In the first two years, sex-disaggregated data collected through quantitative and qualitative methodologies has brought a gender lens to research activities, established some fundamentals, and raised questions to be pursued in the next stage. In 2007, members of the SANREM team made presentations on gender in Africa and South America. A session on gender was held at the SANREM CRSP annual meeting in Bolivia. Together with the development of a cross-cutting gender research proposal involving gendered networks and market access, this launched a new stage of collaboration on gender issues among LTRAs. These collective and individual efforts will allow SANREM CRSP to make interdisciplinary contributions to NRM research and policy in the near future as well as contribute to scholarship on gender issues in development.

Research, Papers, Presentations

While gender research is still in an initial phase, some information has been generated and questions identified. For instance, how do gender roles impact NRM and livelihoods? How do gender differences impact participation and research results? Are women's and men's perceptions of risk different, and if so, why? What are the factors that influence women's ability to benefit from market participation? Throughout the research, it became clear that generalizations cannot be made, for gender differences exist even between different regions and groups in a given country.

Several theses are underway that explore such issues. One is on intra-household perceptions of risks and experiences with hazards, shocks, and market integration. Another explores the factors that constrain or facilitate participation and access to information in participatory research by men and women. Impediments to women's participation included language barriers (many women speak their indigenous tongue but are not fluent in Spanish) and gender division of labor within households. Another project looks at women and bargaining power in market participation within the household, testing the role of education in empowerment, and relating female head of household education, market participation, and indicators of well-being. Another dimension of gender work focused on a study by Purdue University researchers in India on the role of gender in influencing patterns of agricultural input use and investment. Preliminary findings point to significant effects of women's education in bargaining power expressed through joint participation in marketing by heads of household.

The gender team in Southeast Asia found that men are the dominant labor force in commercial crop production, while women predominate in raising subsistence crops, particularly in home

gardens. More men than women control the following agricultural domains: farm-level decision making, including purchase of farm inputs and timing of harvest or marketing; involvement in farmer organizations; and participation in agricultural training and extension services. Women's limited organizational and training involvement is due in part to their preoccupation with household duties, the holding of meetings or trainings during times when women are not available, and the perceived belief that extension services are for men. Dominance in marketing of agricultural products varies by country. In Vietnam, male and female spouses generally share equally in the tasks of marketing farm produce. In contrast, marketing activities in Indonesia are predominantly handled by men, while in the Philippines these are usually handled by women. Albeit Filipino wives exercise control over the actual sale of produce both on farm or at the marketplace, their husbands still dominate in such post-harvest tasks as sorting, grading, and transport. Moreover, women's greater participation in marketing does not seem to translate easily to a greater say in farm expenditures.

For Indonesia, the gender analysis revealed the importance of meeting women's practical needs (resolving financial difficulties or low productivity, and access to health care) over strategic needs (low competency, limited organizational participation). Because the women also felt strongly about their food provider role, the plan turned to addressing nutritional issues. Focus group discussion was conducted addressing local ways of utilizing indigenous vegetables, and learning their nutritional and medicinal values. New ways to cook nutritious foods using these vegetables were demonstrated; furthermore, the gender team wrote and distributed a small recipe book on indigenous vegetables.

In several projects, community participatory assessments with a gender perspective led to identifying priorities and understanding differences. In one LTRA, a participatory rural appraisal took place to identify current poultry husbandry attitudes and practices, and to facilitate community selection of gender-equitable vaccination teams. In a study of group formation and vulnerability impact on member participation and dissemination of information throughout the community, it became clear that life cycle and gender differences affect ability to participate in groups. Perceptions of risk and dread were gathered by gender and will be analyzed in Year 3.

In Ecuador, a process for evaluating market chains was tested and showed that the milk markets are highly segmented and characterized by asymmetric information, price and market risk, and high transactions costs. It found that gender roles are highly differentiated; while women and girls are heavily engaged in on-farm production, much of the sales and marketing is controlled by men. Findings from the descriptive analysis also indicate stark differences in conditions between the upper and lower watersheds, rather diverse livelihood strategies, and major differences in gender roles, the latter linked to ethnicity. Constraints to entry into particular pathways and the relationship between environmental conditions will be determined by assets and capitals, household structure and human capital, gender considerations, and other factors.

Two papers on gender and forest management were written and submitted for inclusion in the conservation biology meetings in South Africa in July. One written jointly by Kenyan and Ugandan teams compares gendered access to forest resources in Mabira (Uganda) and Kakamega (Kenya) forests. The other, submitted by IFPRI, compares resource management by user groups with different proportions of women and men in the four SANREM countries (Kenya, Uganda,

Bolivia, Mexico). Another paper was prepared on gender in agro-forestry and sustainable vegetable production in the Southeast Asian Watershed; it looks at case studies of self-empowerment in the increasing number of women who are ensuring their families' survival by entering the sphere of micro-agricultural marketing and entrepreneurship. Other papers slated for joint publication include one on gender and resource ecology in rural Bolívar Province, Ecuador; and one investigating possible gender bias in short-term investment in agriculture. A presentation on the importance of gender in SA and NRM was made at a climate change conference in La Paz. The presentation was delivered in Spanish and is posted on the SANREM website.

Annual Meeting and Gender Collaboration

A gender session at the SANREM annual meeting in Cochabamba, Bolivia, allowed participants from all five LTRAs to share experiences and explore opportunities for gender research and cooperation across SANREM projects. In preparation for the annual meeting, each LTRA assigned a point person to support gender equity and coordinate with the ME on gender issues. Plans for a collective gender publication, including common research themes, were discussed.

The gender session at Cochabamba laid the groundwork for integrating gender as a cross-cutting research theme in the coming year and scaling up findings. A cross-cutting approach in different social and geographic contexts provides opportunities for collaborative and comparative efforts that build on existing research in all five LTRAs. The plan is to develop case studies using similar methodologies and research questions, and to exchange information on these at a gender seminar before the SANREM annual meeting in 2008. In the second year, participating LTRAs will compare the case studies and write papers for a collective publication, most likely a book.

All five LTRAs participated in the process of developing a cross-cutting proposal. The research aims to compare how gendered networks and coalitions affect the ability of groups to access and control natural resources, access appropriate markets, and capture value for their agricultural products. It will allow us to better understand how farmers manage resources and link to markets, what types of network characteristics contribute to securing sustainable livelihoods, and under what conditions these characteristics are most effective. It will significantly contribute to SANREM's ability to move knowledge to action and bring to light opportunities to benefit women during the current and future phase of the CRSP. Dissemination of findings through publications and policy briefs will aim to influence government policies and NGO partner programs to promote gender equity in sustainable development and livelihoods.

Gender Equity in Training and Research

All five LTRAs have done an excellent job achieving gender equity in long-term training activities, benefitting 38 male and 43 female students. Gender was one of the selection criteria for participation in short-term training, with more than 3,500 women and 5,000 men served in 142 SANREM events. As well, women compose the majority of the research teams across the five LTRAs. Whenever possible, interviews at the household level and focus groups with women and with women's organizations were carried out by women, facilitating greater access to women's perspectives and perceptions.

Watershed Modeling and Assessment

PI: Conrad Heatwole, Center for Watershed Studies and Biological Systems Engineering. Virginia Tech

Executive Summary

The goals of this activity are to enhance the impact of the SANREM CRSP mission by providing a cross-cutting program in watershed modeling and assessment and to provide technical support to LTRAs in assessing the water resources effects of alternative land management practices they are developing. Specific objectives are to:

- support NRM at a watershed and policy analysis scale by documenting landscape condition, quantifying natural resources, and defining land-cover and land-use change using geospatial imagery and analysis
- assess impacts of land-use practices and climate change on agricultural sustainability and NRM at a watershed scale, and
- design and implement low-cost community-based watershed monitoring program.

The period covered by this annual report was one of "seed funding," with initial focus directed to working with the LTR-2 project in Zambia. The efforts included specification and purchase of imagery to support land-use classification; spatial analysis to assess changes in the relative occurrence of fires in the project area; development of dataset to characterize Luangwa River tributaries; modeling analysis of probability of flooding and of sediment delivery as a response to changes in land use. Also, preliminary planning for the expansion of this cross-cutting activity into the other LTRAs was started in anticipation of the need to initiate monitoring programs in the fall before the rainy seasons at South America and Zambia project sites.

Project outputs for this past year include posters and presentations at conferences, and training for host country partners in hydrologic monitoring, GIS analysis, and watershed modeling. Networking has focused on working with existing partners of the LTRAs, although new contacts were made with the University of Zambia's soil science and geology departments.

Research Strategy and Development Objectives

Basic hydrologic data characterizing watershed response provides important information for quantifying the water resources of a community. Identifying, defining, and quantifying community resources are important steps in being able to 'manage' those resources. Hydrologic data is also critical for the calibration and evaluation of models that can be used to assess the long-term impact of climate and practice changes on the watershed. This activity relies on models, particularly the Soil and Water Assessment Tool (SWAT) model, to evaluate the biophysical conditions and response of a watershed to a variety of activities and stressors.

Objective 1: to support natural resource management at a watershed and policy analysis scale by documenting landscape condition, quantifying natural resources, and defining land-cover and land-use change using geospatial imagery and analysis

Hypothesis

High resolution imagery provides unique services to support watershed management at the community level across differing climatic zones, cultural practices, and cropping systems.

Methods

- acquire recent (high resolution) and historical imagery (aerial photos, satellite)
- digitize and classify (visual and digital analysis) to define land cover
- map and quantify areas in different LC/LU and change over time
- guide specification and purchase of satellite imagery to support individual LTRA project objectives
- assist in the collection of ground-truth data and classify imagery to support change detection and land-use mapping
- assist in the collection of ground-truth data and imagery classification for change detection in Bolivian Altiplano
- compare land-use classifications from Landsat, ALOS, and Quickbird imagery in Ecuador

Project partner collaboration will be to assist with field data collection for ground truthing current imagery, to lead interaction with communities to interpret historical images and document changes, and to provide imagery analysis as appropriate.

Objective 2: to assess impacts of land use practices and climate change on agricultural sustainability and natural resource management at a watershed scale

Hypothesis H.2a

Watershed modeling provides appropriate analysis to support watershed policy and management assessment in tropical and developing country conditions.

Hypothesis H.2b

The SWAT model is appropriate for representing landscapes and land-use practices in tropical and developing countries with conditions represented by small plots, steep slopes, and different climate, soils, and cropping systems.

Methods

- assemble base data to define watersheds (topography, soils, land cover, activities)
- collect hydrologic data from characteristic watersheds (weather, runoff, groundwater, irrigation use)
- select, parameterize, and evaluate models
- analyze response of land-use and climate change scenarios.

Objective 3: to design and implement a low-cost community-based watershed monitoring program

Hypothesis H.3a.

A community-based watershed monitoring program can provide data of suitable accuracy to support direct assessment of watershed hydrology, quantify ecosystem services, and support modeling analysis of landscape (watershed) response to management practices and climatic changes.

Hypothesis H.3b

Community-based watershed monitoring programs can increase knowledge of NRM issues, improve community stewardship of water (quantity and quality), and improve participation in NRM.

Methods

- design and implement monitoring plans for rainfall, stream flow, and sediment that provide appropriate representation of landscapes and land uses in project watersheds to support model development
- provide training for in-country personnel on instrumentation, installation and maintenance, quality assurance, data management and analysis.
- evaluate the accuracy of data of rainfall and stream flow collected by local observers as compared to data from reference instruments also installed in the watershed

Research Progress

Objective 1: to support natural resource management at a watershed and policy analysis scale by documenting landscape condition, quantifying natural resources, and defining land-cover and land-use change using geospatial imagery and analysis

Critical research accomplishments

A fundamental component of watershed characterization is the topographic information that defines surface features, flow paths, and slopes. The SRTM elevation data set, distributed by the U.S. Geological Survey, is extremely valuable because it provide worldwide coverage. The limitation is that the SRTM is currently available at a 90m grid spacing which is limiting when working with small catchments. Techniques for developing a refined grid through interpolation and use of supplemental stream information have been explored and can reliably be used to improve the resolution to 30m spacing.

High resolution satellite imagery can provide significant new tools and information to support natural resource management. Although the increased resolution also introduces challenges in typical classification, the fine resolution data itself reveals features that are desirable. The possibility of visual interpretation of these new data makes some types of classification simpler. Quickbird imagery over eastern Zambia (0.6m pan, 2.4m multispectral) and Landsat7 ETM+ from the same period were used together to derive land cover layers for the study region. Various classification approaches including different band combinations, training fields, and classification methods were compared in terms of classification accuracy. The error matrix and Kappa statistic for the approaches were calculated and accuracy of the classified images evaluated with randomly sampled reference data of 255 points. Using a combination of principal components and a vegetation index resulted in better classification accuracy than did a typical

false color infrared band combination. Different approaches in defining training fields and different classification algorithms did not result in significant differences in classification accuracy. The implication is that there is a maximum accuracy that can be achieved in working with the 30m Landsat data. One source of this limitation is the pixel mixing that occurs in small plot landscapes.

System level: watershed

Development impact

Appropriate methods are needed to effectively and consistently use available digital data sources in their support of watershed assessment for defining impacts of management practices and to define and quantify ecosystem services.

Objective 2: to assess the impacts of climate variation and land-use practices on agricultural sustainability and natural resource management at a watershed scale

Critical research accomplishments

Preliminary modeling studies compare the effect of different land-use scenarios for several tributaries to the Luangwa River originating from the plateau region around Lundazi in the Eastern Province of Zambia. The results demonstrate the potential negative impact of the increase in runoff and in erosion that can be expected to occur given continued expansion of agriculture into the hilly region.

System level: watershed

Development impact

Results from field observations and modeling analysis were used as input for a roundtable discussion of provincial, regional, government, and agency officials from Eastern Province, Zambia, on Dec 6, 2007. The goal of the roundtable was to identify policy and program directions for the region that will support NRM, biodiversity conservation, and sustainable livelihoods in the region.

Objective 3: to evaluate the accuracy and value of low-cost community-based monitoring of watershed hydrology

Critical research accomplishments

The deployment of a test case monitoring program in Zambia in March 2007, catching the end of the rainy season (December-April), was successful in collecting data using site training and simple measurement techniques. The deployment of a pressure sensor for flow gauging in streams also functioned as intended, providing 15-minute interval flow depths. Combined with the flow measurements to define the stage-discharge curve, the characterization of runoff using these low-cost, low-impact methods is supported as a readily implementable technique for assessing hydrologic response.

System level: watershed

Development impact: in progress

Challenges and responses

Implementing a monitoring program in three countries (Bolivia, Ecuador, Zambia) at five locations and eight watersheds in the fall of 2007 in preparation for the rainy season is a logistical challenge. Ensuring quality in the collection of flow data used to develop a stage-discharge curve for each of the monitoring sites will be a challenge of this program. Appropriate training, consistency in cooperators, and follow-up visits for quality assurance and training will be important for ensuring the validity and usefulness of the data collected.

Degree and Non-degree Training Activities

- Younggu Her (male, Korean) a Ph.D. student in biological systems engineering, Virginia Tech.
- Informal non-degree training in GIS and spatial analysis and in hydrologic monitoring for WCS-COMACO partners

Publications, Presentations, Other Products

Three papers and two posters were presented at international conferences.

Networking Activities

Primary partners are those currently involved with the LTRAs, but additional partners are identified as appropriate, particularly in national agencies involved with mapping and with collection of hydrologic and meteorological data. Contacts were made in Zambia with faculty at the University of Zambia (UNZA) in the soil science and the geology departments.

Project Highlights

- assisted in specifying and purchasing satellite imagery for seven LTRS project sites serving as a base map for project activities and land-use map for future modeling activities
- selected study watersheds in Luangwa River basin to define basic hydrologic response and to contrast the impact of cleared versus undisturbed (forested) areas using a paired watershed approach
- demonstrated through preliminary modeling analysis for three Luangwa River sub-watersheds that expanded land clearing in the national forests has implications for an increase in the probability of flooding
- developed monitoring methodologies that were tested in Zambia in spring 2007 and are being implemented in other project watersheds in fall 2007

Other Common Themes

Governance

All five LTRAs are dealing with governance issues. Their common thread is the development and application of knowledge to improve policies and policy performance. Of course, this is the overarching objective of LTRA-1 concerning decentralized forest management. LTRA-3 and LTRA-5 are addressing watershed management and how watershed management institutions can be improved through more informed policies. Policies that enhance the marketing of local products are the focus of LTRA-2 and LTRA-4. LTRA-1 began with the constitution of policy discussion bodies at the national level to guide and receive guidance from their research program.

Methodologically, the research programs are addressing these issues in a case-study format. LTRA-1, LTRA-3, and LTRA-4 are very explicit about conducting a "natural experiment" comparing policy formation and impact analyses across countries.

One of the primary findings of this work is that local communities both desire and benefit from more involvement in the management of their resources. In fact, LTRA-1 is learning that successful decentralization requires that local stakeholders gain greater access to management resources (financial, decision-making authority). Decentralization is not the universally beneficial policy it has been reputed to be. The form and implementation of policies need to be carefully considered. Other extra-local actors may benefit when decentralization removes national government controls but does not replace them with adequate local capacity for resource management and rule enforcement. LTRA-3, LTRA-4, and LTRA-5 are demonstrating that local engagement (i.e., active roles in local decision making) is creating greater commitment to improvement in management practices and local institutions.

The relationship between local and national policies is a particularly common theme as well. In Vietnam, a national cacao policy biases against locally based, more productive land uses. In the Philippines, national laws need to be adapted at the local level by locally generated policies that can better target local conditions. LTRA-4 is finding a disconnect between the local and national levels regarding climate change and forecasting, and is consequently building a platform of climate-change policy discussions from the local to the national levels.

Biodiversity

Biodiversity research is primarily conducted by LTRA-2, with governance aspects being studied in LTRA-1. A multi-species and a more targeted hippo survey are being used to investigate the potential effects of the COMACO program on wildlife in Zambia's Luangwa Valley. The wildlife survey counts controls for two areas outside the immediate COMACO zone of influence: the national park and an area north of COMACO activities. These surveys are GIS-based and have been conducted now for two years. A higher level of biodiversity has been found in COMACO areas than in the controls.

LTRA-1 has found that local communities in Uganda will be supportive of biodiversity conservation, but they need to be given active decision-making roles in buffer zone development. A biodiversity assessment (bird counts) has been conducted by LTRA-3 with the intent to assist in the management of remnant forests and building wildlife corridors at their Ecuadorian site. LTRA-4 has been concerned with the biodiversity of vegetative species, in particular indigenous potato and forage crops, and is making the link (as is LTRA-2) between biodiversity conservation and successful livelihood strategies.

The SANREM CRSP also supported USAID biodiversity activities in Madagascar by providing technical assistance to the Mission and partners seeking to restore wildlife corridors for lemurs in the illegally logged Didi forest preserve. SANREM also implemented an Associate Award from USAID-EGAT to develop training materials and to conduct a training program for USAID personnel on payments for environmental services programs. These two activities are described in more detail in the SANREM CRSP ME activities section of this annual report.

Linking Knowledge to Action

Our LTRA approaches to linking knowledge to action range from the standard extension and adoption studies (LTRA-2 and LTRA-5) to user group participation in the conception, development, and dissemination of technologies and new knowledge (LTRA-1, LTRA-3, LTRA-4). Common to all approaches are various forms of user group training such as seminars and workshops. Indeed, participatory approaches are used to engage users and their institutions meaningfully in the research programs. These have been quite useful in problem identification and diagnosis leading to new product development (LTRA-2) and improved technologies (LTRA-3, LTRA-4). Participatory approaches build a bridge between the knowledge systems of scientists and users that has practical application for farmer decision making. However, we have learned that the least vulnerable among the poor are more likely to participate than the more vulnerable (LTRA-4). To this end, the adoption studies before and after surveys.

LTRA-1 and LTRA-4 target not only direct users for the development and transfer of knowledge, they also focus on policymakers to help improve the context for institutions and practices at the regional and national levels through national advisory committees, regional and national policy roundtables, and advocacy coalition building. Inherent in the research design of LTRA-1, LTRA-3, and LTRA-4 is a focus on linking participatory processes and the value of the products produced through those processes. This has even become a focus for a cross-cutting research project involving researchers from LTRA-1, LTRA-3, LTRA-4, and LTRA-5.

Water Resources

There are two primary focuses on water resources management: improving water use effectiveness and efficiency (LTRA-3, LTRA-4, LTRA-5); and managing the impacts of rainfall and runoff (LTRA-2, LTRA-3, LTRA-4, LTRA-5). In fact, the latter has become a focus for a cross-cutting research project in watershed modeling involving all but LTRA-1. Priority issues involve monitoring the impacts of water in the landscape as these affect the quality of streams (LTRA-3), swamps, wetlands and rivers (LTRA-2) as they are affected by climatic trends (LTRA-4), deforestation (LTRA-2), vegetable agro-forestry systems (LTRA-5), and alternative landscape management practices (LTRA-3, LTRA-4). The hope is that lessons learned can be used to inform policymaking, particularly in LTRA-2 and LTRA-3. These research projects are

all using GIS and remote sensing satellite imagery to complement monitoring in the development and use of watershed models. In addition, LTRA-3 and LTRA-4 are using participatory techniques to enhance the value of the findings. Training in SWAT is a major emphasis in LTRA-5, building the capacity to evaluate vegetable forestry systems.

Drip irrigation is being used to improve water distribution and efficiency (LTRA-5). A particular focus is on minimizing competition for water between vegetables and trees in the vegetable agro-forestry system. LTRA-3 is investigating institutional arrangements to allocate irrigation water in both Ecuador and Bolivia, reviewing enabling legislation, and interviewing irrigation association members.

Soil Resources

LTRA-2, LTRA-3, LTRA-4, and LTRA-5 are all focusing on field-level soil management practices that increase soil fertility and organic matter. In Latin America and Southeast Asia, researchers are testing a range of techniques to reduce soil erosion: perennial peanuts, cacao, and veviter as cover crops (LTRA-5); grass strips (LTRA-3); farmer-recommended cover crops, drainage systems, and terraces (LTRA-4). While erosion was a problem in Zambia (LTRA-2), the focus has been more on conservation farming techniques to enhance soil fertility using manure, water catchment basins, and mulch. This research is testing these techniques across a wide range of agro-eco zones characteristic of the soils of southern Africa. LTRA-4 researchers, having determined that local techniques for soil quality management are indeed effective, now are seeking how to integrate this knowledge with relevant scientific improvements and develop methods for rapid soil-quality assessment.

In the Andes, LTRA-3 and LTRA-4 are grappling with the effect of human management and climate on soil organic matter. LTRA-4 is focusing on what interventions can buffer against climate change, specifically, reduced precipitation and changing frost-free periods. LTRA-3 is more concerned with explaining the anomaly of higher carbon levels at lower elevations to better understand the characteristics of appropriate sustainability practices.

Linking Farmers to Markets

Linking farmers to markets is an important focus for four of our LTRAs. Using case-study methodology, value chain analyses have been central to LTRA-3, LTRA-4, and LTRA-5 research strategies. Analyses have centered on both current crops and the potential for native varieties of potatoes (LTRA-4) and vegetables (LTRA-5). Transportation studies have been a particular emphasis of LTRA-5 and LTRA-3. Combined, these analyses have found that successful entry into new value chains requires better market information, lower transportation costs, and improved post-harvest handling. While market analyses have indicated new options, these do not appear to be within reach of the most vulnerable farmers (LTRA-4). LTRA-4 is innovating with an advocacy coalition approach to market integration that involves building networks and coalitions along the value chain. Gender differences in market participation have been found within indigenous Andean populations (LTRA-3). Market women have been found to be a dynamic force in the Philippines (LTRA-5). These findings and a strong interest in gender issues among researchers have lead to a cross-cutting research project on gender and market access.

Two of the LTRAs have been exploring the potential for value-added products. Product development and testing has been emphasized by LTRA-2 (soy extracts) and LTRA-3 (cheese). LTRA-3 is also initiating a study to determine the impact of cell-phone technology on the provision of up-to-date market information in the hope of addressing the lack of competitiveness in Ecuadorian markets.

Management Entity Activities

The Virginia Tech Management Entity (ME) provides overall administrative and intellectual leadership to all SANREM CRSP activities. This leadership is most clearly demonstrated in the financial management and program coordination of LTRA activities, management of the SANREM CRSP Knowledge and Information System (KIS), networking with information providers and users, promoting the SA and NRM, supporting SANREM CRSP researchers, and disseminating SANREM-generated knowledge to potential users. The ME also keeps abreast of innovations and new approaches in SA and NRM inquiry areas, nurtures innovative research and outreach activities, and circulates SA and NRM knowledge and information among partners and the public through the SANREM CRSP website, a quarterly newsletter, and research briefs.

SANREM Knowledgebase

The SANREM Knowledgebase (SKB) is a database of information resources (books, reports, journal articles, videos, movies, presentations) produced or identified, classified, and summarized by SANREM CRSP researchers. These experts are providing easy access to information resources relevant to SA and NRM. The SKB is also the repository for all SANREM CRSP-generated information resources. There are now 2,162 metadata entries, 250 of them the products of SANREM CRSP Phase III. This searchable database is organized by landscape system, as well as providing searchable fields such as title, creator/author, creation date, keywords, media type, time period, location, description (abstract), language, and SANREM Project Number (if appropriate). The SKB is on the SANREM CRSP website at http://www.oired.vt.edu/sanremcrsp/menu_information/knowledgebase.php.

Information technology development

Application developers from Agriculture, Human and Natural Resources Information Technology (AHNR-IT) at Virginia Tech have been assisting in the maintenance and enhancement of the SANREM Knowledgebase web application. The user interface has been improved this year with the addition of several features, including a search function to facilitate data entry and review, and the addition of components to better classify and search for information resources pertaining to ecosystem services.

The SKB was built using Apple's WebObjects development platform. WebObjects is a state-of-the-art Java-based application server particularly well suited for designing complex, high-traffic web applications. While WebObjects has been successfully employed by many different companies and institutions, its most visible use has been in the implementation of Apple's iTunes Music Store, which manages millions of downloads and purchases each year. In addition to

WebObjects, the SKB uses the Oracle Database Management System. Oracle is the industry leader in data storage systems and is used by the largest companies and institutions in the world to provide fast, secure, and reliable access to information. By using WebObjects in conjunction with Oracle, the SKB can provide fast, secure, and reliable data access to its clients.

Since becoming operational in 2005, the SKB has been continually evaluated and improved. It provides the ability for SANREM CRSP researchers to classify and catalog resources. A researcher is granted the ability to log in to the system by a SKB administrator and is given one of three levels of permission. The first level, cataloger, allows the researcher to enter resources or to view all resources in the system. To add a resource, the researcher first classifies it using a standard set of metadata. The Dublin Core Metadata Initiative (http://www.dublincore.net) has defined the metadata elements used in the SKB. The SANREM ME developed an expanded list of keywords pertaining to SA and NRM to guide and accelerate metadata entry and searches. The researcher also has the option of uploading non-copyrighted resources to a central server to allow Internet access. Resources can be any type of file (PDF, Word, images, video).

The second level of permission is reviewer. Reviewers have all the rights of catalogers, as well as the right to review and edit the metadata of other researchers. All resources submitted to the SKB by catalogers must be reviewed and approved for quality control before being published and made available to the public. Reviewers have the right to publish approved resources. Once a resource is published, it becomes available to the public through open access on the web. The final and highest level of permission is that of administrator. The administrator has all the rights of catalogers and reviewers, as well as the ability to add or deactivate users or change user permission levels.

The general public has the ability to search the database for published resources. These may be searched by a number of criteria, including title, keyword, creation date, GPS location, and date of data collection. Resources matching the given criteria are returned in a list from which they can be inspected and downloaded if appropriate. Data entry and searches are facilitated by the SKB Metadata Guide, Version 3 (Heatwole *et al.*, 2007): http://www.oired.vt.edu/sanremcrsp/documents/SKB.metadata.guide.V4.Oct.2007.pdf

Communications Program

The SANREM CRSP communications program disseminates pertinent SA and NRM information in multiple forms for various purposes. This program consists of:

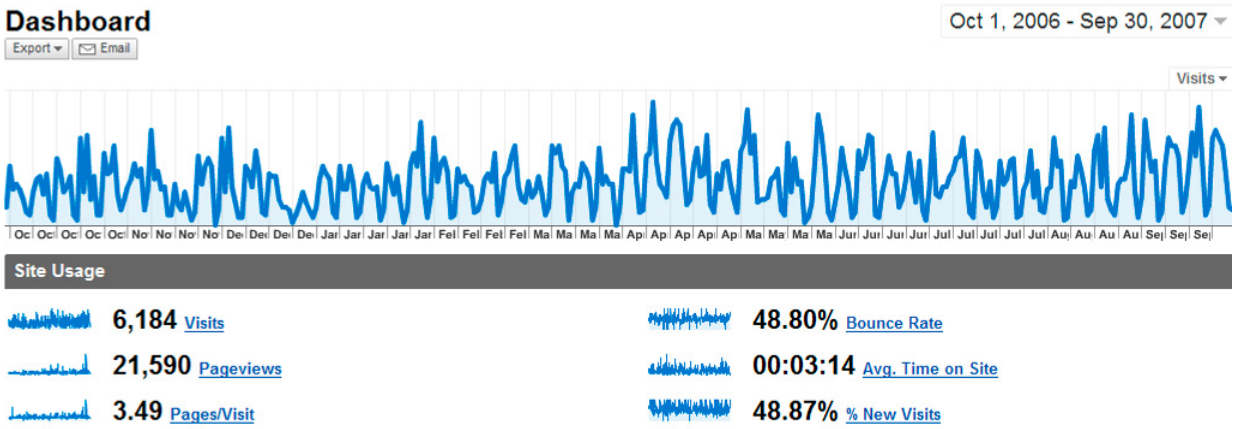
- the SANREM CRSP website channeling access to relevant information sources
- the SANREM CRSP Newsletter, an e-mail bulletin updating partners and other stakeholders on SANREM CRSP activities and accomplishments
- presentations and posters disseminating researchers' findings at seminars, conferences, and meetings
- working papers providing early release of SANREM CRSP research findings, and
- research briefs, which target development practitioners by highlighting technological and institutional innovations.

Website development and use

SANREM partners, development practitioners, policymakers, and other stakeholders public are informed of SANREM CRSP activities and announcements through the ME-maintained SANREM website, http://www.oired.vt.edu/sanremcrsp. Interest in the site has been growing over the past year, and it was recently redesigned to enhance user service and experience.

The SANREM ME tracks visitors to the website using Google Analytics, a free service that generates detailed statistics. The service shows how people find the site, how they explore it, and site visits over time. From the Dashboard – Google's collection of report summaries – data can be viewed in greater detail.

Google Analytics data for the SANREM CRSP website, FY2007



Visit: a period of interaction between a person's browser and a particular website, ending when the browser is closed or shut down, or when the user has been inactive on that site for 30 minutes

Pageview: an instance of a web page being loaded by a browser.

Pages/Visit: average number of pages viewed during each visit

Bounce rate: the percentage of single-page visits, i.e., the person left the site from the homepage

Avg. Time on Site: Time on site: how long a visitor is connected. Time on site can be misleading because visitors often leave browser windows open when they are not actually viewing or using a site

New visit: a computer accessing the website for the first time

Since the SANREM CRSP ME began using Google Analytics in September 2006 to track website activity, the number of visitors per month has nearly doubled, and the number of pages viewed per visit has increased by another 45 percent. These visits came from 119 countries and involved more than 3,000 visitors. Half of these visitors explored the services and information available on several pages. Of the website's more than 6,000 visits in fiscal 2007, three-fourths were from the United States. Nearly half of these visits were generated by search engines. About

a fourth were from direct traffic, that is, the visitor entered the URL directly; another fourth were from links on other sites.

Table: Annual growth in website visits (FY 2007)

Category	September 2006	September 2007	Year-to-year change
Visits	336	651	+ 94%
Pages/Visit	3.09	4.48	+ 45%

Table: Top 10 countries visiting SANREM CRSP website (FY 2007)

Country	Visits	Pages/Visit	Avg. Time on Site	New Visits
1. United States	4,733	3.82	00:03:31	38%
2. Philippines	193	2.24	00:02:03	81%
3. India	88	1.57	00:00.39	94%
4. Bolivia	85	3.60	00:03:18	62%
5. United Kingdom	82	2.18	00:01.54	91%
6. Canada	56	1.96	00:01:45	91%
7. Australia	49	2.86	00:01:37	84%
8. Germany	37	2.38	00:02:16	92%
9. Indonesia	37	3.22	00:04:44	59%
10. Thailand	36	4.03	00:05:08	78%

Information products

The ME publishes the SANREM newsletter and research briefs to promote and disseminate relevant SA and NRM messages and information. Research briefs provide concise summaries of peer-reviewed SANREM CRSP research findings and how SANREM research findings can be applied in the field. Research Briefs 6 through 8, building on work done in SANREM CRSP Phase II, were published in 2007 and are available online:

Rotational Grazing for Soil Carbon Sequestration (pdf)

Assessing the Scientific Knowledge Base for Ecoagriculture (pdf)

Surviving Vietnam's Coffee Boom and Bust (pdf)

The SANREM CRSP working papers series provides an early look at research in progress. Each paper has been internally reviewed but not yet refined for formal publication. These papers include work that the author is pursuing but has not yet reached conclusion, for example, preliminary baseline study reports, discussions of methodological or thematic issues, topical syntheses and literature reviews. The series was inaugurated this year with 11 entries available on the SANREM CRSP website.

"Market Value Chain Research: Case Study in Nghia Trung Commune, Bu Dang District, Binh Phuoc Province, Vietnam." Le Thanh Loan, Duong Thi Kim Lan, Dang Thanh Ha

"Diagnóstico Preliminar de la Biodiversidad en Las Microcuencas del Río Alumbre e Illangama, Afluentes del Río Chimbo, Provincia de Bolívar." Juan Andrés Calles López, David Salvador Peña, Irene Vásquez, María José Endara, María Alejandra Camacho, Cecilia Tobar

"Research Report: Socioeconomic Baseline Studies, Nghia Trung Village, Bu Dang District, Binh Phuoc Province, Vietnam." Dang Thanh Ha, Le Van Du, Duong Thi Kim Lan, Nguyen Thanh Loan, Tran Van My, Nguyen Duc Thanh

"An Analytical Agenda for the Study of Decentralized Resource Regimes." Krister Andersson, Elinor Ostrom

"The Issue of Spatial Scale in Hydro-Economic Modeling of Global and National Food and Water Systems to Address Sustainable Agriculture and Natural Resources Management." Kenneth Strzepek and Alyssa McCluskey

"Songco Women Biyahidors in Loversland Market: Self-Empowerment through Micro Vegetable Entrepreneurship." Maria Elena Chiong-Javier

"Socioeconomic Baseline Studies: Agroforestry and Sustainable Vegetables Production in Southeast Asian Watershed." Kusuma Wijaya, Suseno Budidarsono, James Roshetko

"Vegetable Agroforestry System: Baseline Survey Results in Songco, Lantapan, Bukidnon, Philippines, 2006." Miriam R. Nguyen, John Paul A. De Mesa, Agnes C. Rola

"Watershed-based Payment for Environmental Services in Asia." Marjorie Huang and Shyam K. Upadhyaya, Winrock International

"Paying for Watershed Services in Latin America: A Review of Current Initiatives." Douglas Southgate, Sven Wunder

"Regional Review of Payments for Watershed Services: Sub-Saharan Africa." Paul J. Ferraro

The SANREM CRSP newsletter is a bulletin that provides a quick update of activities, accomplishments, and future events in multimedia format: e-mail, on paper, and through the website. Issues of the newsletter appeared in February, May, and August 2007 and are available on the SANREM CRSP website at: http://www.oired.vt.edu/sanremcrsp/menu_information/newsletters.php. The newsletter is to be published quarterly in FY 2008.

Payments for Environmental Services Associate Award

In October 2006, the SANREM CRSP received an Associate Award titled "Global Assessment of Best Practices in Payments for Ecosystem Services (PES) Programs" to support USAID efforts in the area of payments for ecosystem services. Additional funding was provided to the BASIS CRSP, and this activity was cooperative between the SANREM and BASIS CRSPs. The objectives of the award were to:

- modify the SANREM Knowledgebase so it is more suitable for cataloging and locating PES resources
- conduct a literature review of payments for ecosystem services programs in developing countries, and enter information on the programs into the SKB
- incorporate information resources on PES into the SKB
- review PES activities in Latin America and the Caribbean, Africa, and Asia, and develop papers on PES activities and approaches in each region
- develop regional case studies to demonstrate approaches to PES in the different regions

- participate in the RUPES Global Event on Payments/Rewards for Environmental Services in Lombok, Indonesia, January 22-23, 2007, and present papers on regional approaches to PES
- assist the BASIS CRSP in development of a USAID PES sourcebook to be used to train USAID personnel in the principles of PES
- publish and maintain the sourcebook through the SANREM CRSP website
- with the BASIS CRSP, conduct a one-day PES policy seminar in October 2007 in Washington, D.C., for USAID personnel
- convert the PES policy seminar materials and presentations to a web-based distance learning tool, and
- disseminate the regional syntheses papers through publication in a journal.

The SKB was modified as planned, and information resources on 160 PES projects and 150 text resources were entered into the SKB. These resources are available through the SKB at http://www.oired.vt.edu/sanremcrsp/menu_information/SKB.php. A user guide for the PES portion of the SKB was developed and is available at: http://www.oired.vt.edu/sanremcrsp/documents/PES.Sourcebook.Oct.2007/PESKnowledgebaseQuery.pdf.

PES experts were recruited to develop the PES regional syntheses. They are:

- Africa. Paul Ferraro, associate professor of economics, department of economics, Andrew Young School of Policy Studies, Georgia State University
- Asia. Marjorie Huang and Shyam K. Upadhyaya, Winrock International
- Latin America. Douglas Southgate, professor of agricultural, environmental and development economics, Ohio State University; Sven Wunder, Centre for International Forestry Research (CIFOR), Brazil

The regional synthesis papers are available on the SANREM CRSP PES web page at: http://www.oired.vt.edu/sanremcrsp/menu_information/working_papers.php (Working Papers No. 06-07, 06-08, and 09-07). John Kerr and Rohit Jindal of the department of community, agriculture, recreation, and resource studies at Michigan State University also participated in review of the regional synthesis papers.

The *USAID PES Sourcebook,* published in October 2007, was developed by John Kerr and Rohit Jindal with assistance from Theo Dillaha of Virginia Tech. It is available at: http://www.oired.vt.edu/sanremcrsp/menu_research/PES.Sourcebook.Contents.php.

Technical Assistance to the USAID Madagascar Mission

In November 2004, Madagascar President Marc Ravolomanana discovered a logging road built by the Malaysian-owned Latitude Timber Co. This road construction and associated timber exploitation were in the Forestieres de Veriantsy et de Sahananto a l' interieur de la foret classee d'Ambohilero, Fkt Amboarabe, C/R de Didy. The main area of exploitation and road construction begins about 3.5 km southeast of Antsevabe within the primary evergreen forest of

the Ankeniheny-Zahamena biological corridor. According to local leaders, Latitude Timber began road construction and timber harvesting in April 2004, and all activities were stopped in November 2004 by order of the president. During these eight months of exploitation, Latitude Timber used heavy machinery to widen limited existing logging roads from less than 3 meters to greater than10m in places, to construct kilometers of new road, and to harvest timber by clear-cutting along the roads.

At the request of USAID Madagascar in 2005, SANREM researchers conducted an initial assessment of the illegal timber operation and developed recommendations for restoration of the forest. In early 2007, USAID Madagascar requested follow-up technical assistance; and in May 2007, SANREM sent a team of three scientists (Sarah Karpanty and Theo Dillaha of Virginia Tech, and Charles Welch of Duke University) to revisit the site, assess reforestation efforts, and update the restoration plan. Specific objectives of the project were to:

- assess passive restoration since the previous site visit
- assess the health of planted and nursery tree seedlings and to develop recommendations for planting the remaining seedlings to best provide habitat and movement corridors for key wildlife species
- evaluate the successes and limitations of restoration activities by USAID's MIARO program and Avotr'Ala, and to recommend additional practices as needed, and
- assess the socioeconomic impact of the road on Bemainty and Antsevabe, the two villages at opposite ends of the logging road.

The researchers reported the following conclusions.

- The forest is recovering through natural regeneration.
- The secondary and primary forest tree seedlings remaining in the nurseries on site should be planted under the canopies of existing or transplanted pioneer species to enhance their survival.
- Invasive species do not currently appear to be a problem. If non-native invasive species appear, they should be immediately eradicated to preserve the integrity of the forest system.
- Erosion, gullying, landslides, and bridge washouts have rendered the logging roads impassable to vehicles. This is an excellent development that works against further exploitation of the area. The road should not be repaired or maintained.
- There do not seem to be major downstream water-quality impacts at this time due to the road construction because of the natural buffering by the forest.
- National protocols are needed for construction of roads in forested and other natural areas. Revegetation and erosion-control activities should occur simultaneously with road construction, and provisions must be made to include natural corridors or bridges across the road for wildlife movement.
- Capacity-building for ecological restoration is a priority. Capacity-building must include professionals at all levels of Eaux et Foret and local villagers who are likely to be tasked with "sustainable exploitation" as part of management transfer agreements.
- Ambohilero is an unusual opportunity to observe and study passive restoration in Madagascar. The unique opportunity at Ambohilero is mostly a result of the isolated nature of the area and the low level of use by locals.

- The incursion of the illegal logging road into pristine rainforest habitat has important consequences for the endemic flora and fauna of this corridor region. A diversity of lemur species was observed in the timbered area, including *Indri indri, Propithecus diadema, Eulemur fulvus rufus, Avahi laniger, Microcebus murinus,* and *Cheirogaleus major*. Because of time constraints, systematic surveys to determine populations were not conducted. Two adult Propithecus diadema, identified by the International Union for Conservation of Nature and Natural Resources as critically endangered, were observed jumping vertically across a section of road where the roadbed was 30m wide; there was only shrubby vegetation for 15m on both sides of the main road before the lemurs could reach trees large enough to climb. More systematic studies are needed to understand how different species are affected by the road, for example, which species are capable of crossing it and how different species may avoid or be attracted to this new edge habitat.

Book on Adaptive Management of SA and NRM Systems

Smallholders around the world are confronted by the linked problems of poverty and environmental degradation. To address these multiple and complex factors, SANREM CRSP Landscape System and Technology Transfer coordinators are developing a guidebook for development practitioners. This book introduces an evolving adaptive management approach to SA and NRM systems. Its primary goal is to provide development practitioners with the knowledge, understanding, and tools to improve the innovative capacity of stakeholders. It also aims to encourage policymaker and donor support for local innovation and adaptive management. The book will be published in 2008.

Part I of the book provides an overview of complex adaptive systems and principles for adaptive management in the context of landscape systems. Part II is composed of six landscape system chapters and a chapter on stakeholder empowerment/capacity building. Each of these chapters:

- describes critical system components, their cause-effect relations and interactions
- highlights the timeframe(s) for component processes
- identifies links between system processes across temporal and spatial scales, and
- demonstrates how to act strategically to promote innovation.

Concrete examples will be used to illustrate systemic properties and principles of sustainable management, decision-making criteria, and links for scaling up, out, and down. Each chapter operates at two levels. At the first, each systems chapter describes the current state of agricultural and NRM science for each system; how system properties and processes are relevant to sustainable improvements in livelihoods and environmental services; and cross-scale linkages between systems that provide constraints and opportunities for development intervention impacts. At the second level, these chapters identify technologies and institutional practices that form a toolkit of innovation principles and options for adaptive management. Identification of these practical innovation principles will assist practitioners in project implementation and in scaling up and out of successful technological and institutional innovations. They will also help donors and project developers design successful and sustainable agricultural and NRM projects and programs that empower stakeholder innovation.

Part III of the book presents a set of case studies that demonstrate the application of landscape system adaptive management principles. Material for these chapters is being researched to provide holistic, multi-system and multi-scale presentations. They will show how the landscape systems/adaptive management approach can lead to successful sustainable management of agriculture and NRM systems. In particular, cross-scale interactions are highlighted that are critical to reducing poverty and improving long-term sustainability.

Training and Institutional Capacity Development

Long-term Degree Training

The SANREM CRSP uses degree training to strengthen the technical skills of researchers and teachers from U.S. and host country universities, national agricultural research services (NARS), NGOs, and relevant ministries. While developing a global knowledge base in U.S. universities, SANREM addresses specific host country SA and NRM questions, opportunities, and constraints. Twenty-four U.S. and host country universities institutions provided long-term training for 51 graduate students (27 Ph.D.s and 24 master's) and 30 undergraduate students associated with SANREM activities. Of these, 43 are women, and 38 are men. Sixty-three of these students are developing-country nationals studying at eight U.S. and 13 host country institutions (see Table of Degree Training Participants: FY 2007 in Appendix D).

Table 1: Long-term Degree Training Participants by Country, FY 2007

Country	Doctorate		Master's		Bachelor's		Total
	Men	Women	Men	Women	Men	Women	
Australia	1						1
Bolivia	3	1	2	4	10	5	25
Canada		2					2
Denmark			1				1
Ecuador	2		1	1	2	2	8
Indonesia	1		1	1	1	5	9
Kenya		1					1
Mali			1				1
Peru		1	2	3	1		7
Philippines	1	1	1	2			5
Uganda		1					1
USA	3	8	1	2			14
Vietnam			1		2	2	5
Zimbabwe		1					1
Total	11	16	11	13	16	14	81

Short-term Degree Training

Over the course of the year, SANREM CRSP partners held 142 short-term training events serving 9,554 people, including 3,780 women. Training events were held in 12 countries and often supported the initiation of the LTRAs. These numbers are underestimated because counts and distributions of men and women were not reported for all events.

Fourteen field days were held introducing new and alternative conservation technologies to 2,871 people, including 1,289 women. Twelve seminars addressed 214 people, 108 of them women. Of 517 participating in the 18 short courses, 178 were women. Ninety-one workshops were held serving 4,949 people, at least 2,173 of them women. Six focus groups involved 70 men and 44 women. Seven women and one man had internships among the SANREM CRSP participants. A full accounting of these training events is the table SANREM CRSP Non-Degree Training Participants: FY 2007 in Appendix D.

Table 2: Short-Term Training Participants by Country, FY 2007

Country	Women	Men	Total*
Bolivia	547	977	2,024
Ecuador	80	166	246
Indonesia	80	40	120
Kenya	173	200	373
Mexico	2	7	9
Peru	248	331	579
Philippines	86	162	248
Uganda	674	494	1,168
USA	5	8	13
Vietnam	49	83	132
Zambia	1,836	2,806	4,642
Total	3,780	5,274	9,554

* Total exceeds the number of men and women because sex disaggregated counts were not made for all training events.

Appendix A: Training Participants, FY 2007

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI (degree granting institution first)
						Start Date	End Date	Degree	SANREM CRSP	Non-SANREM CRSP	
Amy Duchelle	F	USA	Forestry	Bolivia	N	Aug-03	Jun-08	PhD	Y	Y	P. Pacheco (University of Florida)
Catherine LaRochelle	F	Canada	Agricultural economics	Bolivia	N	Sep-06	Aug-06	PhD	Y	Y	Alwang/Bosch (Virginia Tech)
Diego Pacheco	M	Bolivia	Political Science	Bolivia	N	Sep-05	May-08	PhD	Y	Y	E. Ostrom (Indiana University)
Jeanne Thibeault	F	USA	Geography/Climate	Bolivia	N	Sep-06	Sep-09	PHD	Y	Y	A. Seth (University of Connecticut)
Olga Yana (UC)	F	Bolivian	Sociology	Bolivia	N	Sep-06	Sep-06	MS	Y	Y	E. Jiménez (Universidad de la Cordillera)
Patricia Uberhuaga	F	Bolivia	Economist	Bolivia	N	Aug-05	Jul-08	PhD	Y	Y	P. Pacheco (The Royal Veterinary and Agricultural University-Denmark)
Porfidia Ajata (UC)	F	Bolivian	Economics	Bolivia	N	Sep-06	Oct-06	MS	Y	Y	E. Jiménez (Univ. Andina Simón Bolivar)
Javier Aguilera Alcón	M	Bolivian	Soil Science	Bolivia	N	Aug-06	Sep-10	Ph.D.	Y	Y	Peter Motavalli (U. of Missouri Columbia)
Griselda Gonzales	F	Bolivian	Rural Development	Bolivia	N	Apr-07	Apr-09	MS	Y	Y	E. Jiménez (CIDES – UMSA)
Alejandro Romero	M	Bolivian	Rural Development	Bolivia	N	Apr-07	Apr-09	MS	Y	Y	E. Jiménez (CIDES – UMSA)
Elvio Herrera Aruquipa	M	Bolivian	Soil Science	Bolivia	N	Oct-06	Sep-07	ING	Y	Y	R. Miranda (Univ. Mayor de San Andres)
Blas Mamani Vargas	M	Bolivian	Soil Science	Bolivia	N	Oct-06	Sep-07	ING	Y	Y	R. Miranda (Univ. Mayor de San Andres)
Milan Mamani	M	Bolivian	Biodiversity	Bolivia	N	Sep-06	Aug-07	ING	Y	Y	Miguel A. Gonzales (UMSA)
Eliceo Tangara	M	Bolivian	Soil Science	Bolivia	N	Sep-06	Sep-07	ING	Y	Y	Javier Aguilera (UMSA)
Claudia Jarandilla	F	Bolivian	Plant Pathology	Bolivia	N	Sep-06	Sep-07	ING	Y	Y	Miguel A. Gonzales (UMSA)
Miriam Gomez	F	Bolivian	Plant Pathology	Bolivia	N	Sep-06	Sep-07	ING	Y	Y	Miguel A. Gonzales (UMSA)
Nelly Calle Kantuta	F	Bolivian	Agronomy	Bolivia	N	Nov-06	Aug-07	ING	Y	Y	Peñaranda/Ruíz (UMSA)
Antonio Paz Arcani	M	Bolivian	Agronomy	Bolivia	N	Nov-06	Aug-07	ING	Y	Y	Peñaranda/Ruíz (UMSA)
Julio Sarmiento Vargas	M	Bolivian	Agronomy	Bolivia	N	Nov-06	Aug-07	ING	Y	Y	Cusicanqui/ Cruz (UMSA)
Dora Aguilar Endara	F	Bolivian	Agronomy	Bolivia	N	Nov-06	Aug-07	ING	Y	Y	Cusicanqui/ Cruz (UMSA)
Viviana Vera	F	Bolivian	Plant Pathology	Bolivia	N	Oct-07	Sep-08	ING	Y	Y	Miguel A. Gonzales (UMSA)
Juan Sipe	M	Bolivian	Soil Science	Bolivia	N	Oct-07	Sep-08	ING	Y	Y	Miguel A. Gonzales (UMSA)

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI (degree granting institution first)
						Start Date	End Date	Degree	SANREM CRSP	Non-SANREM CRSP	
Carlos Cladera	M	Bolivian	Soil Science	Bolivia	N	Oct-07	Sep-08	ING	Y	Y	Miguel A. Gonzales (UMSA)
Miguel Gonzales Aldana	M	Bolivian	Plant Pathology	Bolivia	N	May-07	May-09	MS	Y	Y	Karen Garrett (UNALM)
Justin Thomas	M	USA	Rural Sociology	Bolivia	N	Sep-07	Aug-07	PhD	Y	Y	J.Gilles (University of Missouri Columbia)
Nadezda Amaya	F	Bolivia	Economics	Bolivia	Y	Aug-07	Jun-06	MS	Y	N	Alwang (Virginia Tech)
José Carlos Claros	M	Bolivia	Agronomy	Bolivia	N	Sep-06	Sep-07	BS	Y	N	Botello (UMSS)
Richard Sánchez	M	Bolivia	Economics	Bolivia	N	Aug-07	Mar-08	BS	Y	N	Amaya/Botello (UNITEPC)
Javier Osorio	M	Bolivia	BSE	Bolivia/Ecuador	N	Jan-07	Dec-09	PhD	N	Y	Wolfe (Virginia Tech)
Guido Yactayo	M	Peru	BSE	Bolivia/Ecuador	N	Aug-07	May-09	MS	N	Y	Wolfe (Virginia Tech)
Johannes Postma	M	US	Horticulture	Bolivia/Ecuador	N	Jun-06	Jun-06	PhD	Y	Y	Lynch (Penn State)
Mike Castelhano	M	US	Economics	Ecuador	N	Aug-06	Jun-08	MS	Y	Y	Alwang (Virginia Tech)
Amelia Henry	F	US	Soils-Horticulture	Ecuador	N	Jun-06	Jun-08	PhD	Y	Y	Lynch (Penn State)
Raul Jaramillo	M	Ecuador	Soils-Horticulture	Ecuador	N	Jun-06	Jun-08	PhD	Y	Y	Lynch (Penn State)
Eugenia Núñez	F	Ecuador	Social Science	Ecuador	N	Jan-07	Jan-08	BS	Y	N	Barrera (Universidad de Bolivar)
Moazir Celleri	M	Ecuador	Social Science	Ecuador	N	Jan-07	Jan-08	BS	Y	N	Barrera (Universidad de Bolivar)
Edwin Chela	M	Ecuador	Soil Science	Ecuador	N	Jan-07	Jan-08	BS	Y	N	Valverde (Universidad de Bolivar)
Julia Pryde	F	US	Engineering	Ecuador	N	Apr-06	Sep-06	MS	Y	N	Wolfe (Virginia Tech)
María Figueroa	F	Ecuador	Agricultural Economics	Ecuador	N	Sep-06	Aug-08	MS	Y	Y	C. Valdivia (Univ. of Missouri Columbia)
Martha González	F	Ecuador	Social science	Ecuador	N	Aug-06	Sep-06	BS	Y	Y	Barrera (Universidad Estatal de Bolívar)
Rachel Melnick	F	US	Plant pathology	Ecuador	N	Jan-06	Sep-06	PhD	Y	Y	Paul Backman (Penn State)
Robert Andrade	M	Ecuador	Agricultural economics	Ecuador	N	Aug-06	Sep-06	MSc	Y	Y	Jeff Alwang (Virginia Tech)
Víctor Barrera	M	Ecuador	Social science	Ecuador	Y	May-06	Jun-06	PhD	Y	Y	Jeff Alwang (Univ. Politécnica de Madrid)
Edy Setyawan	M	Indonesian	Plant Protection	Indonesia	N	Aug-05	Dec-09	PhD	Y	Y	Rauf/Susila (Bogor Ag University)
Juang Kartika	F	Indonesian	Horticulture	Indonesia	N	Aug-07	Dec-07	MS	Y	Y	Anas Susila (Bogor Ag University)
Tisna Prasetyo	M	Indonesian	Horticulture	Indonesia	N	Aug-07	Dec-07	MS	Y	Y	Anas Susila (Bogor Ag University)
Didik Hermanto	M	Indonesian	Horticulture	Indonesia	N	Aug-07	Dec-07	BS	Y	Y	Purwoko (Bogor Agricultural University)
Prima Rahanita	F	Indonesia	Horticulture	Indonesia	N	Aug-07	Dec-07	BS	Y	Y	Anas Susila (Bogor Ag University)

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI (degree granting institution first)
						Start Date	End Date	Degree	SANREM CRSP	Non-SANREM CRSP	
Ratna Pambayun	F	Indonesia	Horticulture	Indonesia	N	Aug-07	Dec-07	BS	Y	Y	Purwoko (Bogor Agricultural University)
Novita Novaliana	F	Indonesia	Horticulture	Indonesia	N	Aug-07	Dec-07	BS	Y	Y	Purwoko (Bogor Agricultural University)
Mega Ayu Lestari	F	Indonesia	Horticulture	Indonesia	N	Aug-07	Dec-07	BS	Y	Y	Purwoko (Bogor Agricultural University)
Nia Kurniatusholihat	F	Indonesian	Horticulture	Indonesia	N	Aug-07	Aug-07	BS	Y	Y	Purwoko (Bogor Agricultural University)
Moussa Keïta	M	Mali	Local Development	Mali	N	Jan-04	Aug-07	MS	Y	Y	Moore/Cissé (Delta-C)
Gustavo Garcia Lopez	M	USA	Political Science	Mexico	N	Aug-05	Sep-09	PhD	Y	Y	E. Ostrom (Indiana University)
Jorge Pretel	M	Peruvian	Statistics	Peru	N	Mar-07	Sept '07	ING	Y	Y	Karen Garrett (UNALM)
Cecilia Turin Canchaya	F	Peruvian	Rural Sociology	Peru	N	Aug-07	Aug-07	Ph.D.	N	Y	J. Gilles (University of Missouri Columbia)
Clovis Bailon Flores	M	Peruvian	Agricultural innovation	Peru	N	Mar-07	Dec-08	MS	Y	Y	S. Vargas (Univ. Nacional del Altiplano)
Jenny Choque Flores	F	Peruvian	Agricultural innovation	Peru	N	Mar-07	Dec-08	MS	Y	Y	Jan Flora (Uni. Nacional del Altiplano)
Doris Bartolo	F	Peruvian	Agricultural innovation	Peru	N	Mar-07	Dec-08	MS	Y	Y	S. Vargas (Univ. Nacional del Altiplano)
Helen Villanueva	F	Peruvian	Biology	Peru	N	Nov '06	Nov-08	MS	Y	Y	Karen Garrett (UNM San Marcos)
Janice B. Sevilla	F	Filipino	Envi. Science	Philippines	N	Nov-06	Mar-09	M Sc.	Y	N	V. Espaldon (UPLB)
Laarni Lacandula	F	Filipino	Envi. Science	Philippines	N	Oct-06	Mar-07	PhD	Y	N	V. Espaldon (UPLB)
Charmaine T. Pailagao	F	Philippines	Environmental Science	Philippines	N	Apr-07	Sep-08	MS	Y	Y	Espaldon/Catacutan (UPLB)
Nathaniel Alibuyog	M	Philippines	Agricultural Engineering	Philippines	N	Oct-06	Sep-08	PhD	Y	Y	Victor Ella (UPLB)
Noel Gordolan	M	Philippines	Agricultural Engineering	Philippines	N	Oct-06	Aug-07	BS/MS	Y	Y	Victor Ella (UPLB)
Evelyn Lwanga	F	Uganda	Political Science	Uganda	N	Aug-01	May-07	PhD	Y	Y	E. Ostrom (Indiana University)
Pam Jagger	F	Canada	Political Science	Uganda	N	Sep-03	Sep-08	PhD	Y	Y	E. Ostrom (Indiana University)
Erin Frank	F	USA	Plant Pathology	USA	N	Aug-06	Sep-06	MSc	Y	Y	Karen Garrett (Kansas State University)
Lisa Rees	F	USA	Agricultural Economics	USA	N	Jun-06	Aug-09	PhD	Y	Y	Valdivia/Marks (Univ. of Missouri)
Shauna P. Dendy	F	USA	Plant Pathology	USA	N	Jun-06	Sep-09	PhD	Y	Y	Karen Garrett (Kansas State University)
Vuong Hoang Cuong	M	Vietnam	Agriculture Economics	Vietnam	N	Aug-06	Jan-07	Bs	Y	Y	DT Kim Lan (Nong Lam University)
Hoang Van Anh	M	Vietnam	Agriculture Economics	Vietnam	N	Aug-06	Jan-07	Bs	Y	Y	DT Kim Lan (Nong Lam University)
Huynh Van Lao	M	Vietnam	Agriculture Economics	Vietnam	N	Oct-05	Nov-07	MSc.	Y	Y	DT Ha (Nong Lam University)
Rasmus Lybaek	M	Denmark	Information & Media Studies	Vietnam	N	Oct-06	Dec-06	MSc.	Y	Y	DT Ha (Aarhus University, Denmark)

Student Name	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI (degree granting institution first)
						Start Date	End Date	Degree	SANREM CRSP	Non-SANREM CRSP	
Luong Thi Bich Van	F	Vietnam	Ag Economics	Vietnam	N	Sep-04	Dec-07	Bs	Y	Y	LV Du, DT Ha (Nong Lam University)
Pham Thi Kieu Trang	F	Vietnam	Ag Economics	Vietnam	N	Sep-04	Dec-07	Bs	Y	Y	ND Thanh, DT Ha (Nong Lam University)
Erin McDonald	F	USA	Veterinary Medicine	Zambia	N	Jun-05	May-08	DVM	Y	Y	Lucio/Torres (Cornell University)
Vongai Kandiwa	F	Zimbabwean	Development Sociology	Zambia	N	Sep-04	Jul-09	PhD	Y	Y	Eloundou-Enyegue (Cornell University)
Lydiah Gatere	F	Kenyan	Soil & Crop Sciences	Zambia	N	May-06	May-10	PhD	Y	N	Johannes Lehmann (Cornell University)
Samuel Bell	M	Australian	Applied Economics and Mgmt	Zambia	N	Sep-05	May-10	PhD	Y	N	Duane Chapman (Cornell University)
Buttke, Danielle	F	USA	Biomedical Sciences	Zambia	N	Aug-04	May-10	DVM	N	Y	Alexander Travis (Cornell University)

Non-degree training, FY 2007

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Bolivia						
Field Day	Oct-06	65 communities from Umala	At least 500		PROINPA	Competition about native potato varieties PROINPA and Umala municipality
Field Day	Feb-07	Farmers	31	8	PROINPA	Pasture improvement and pasture seed choice
Field Day	April-07	Men and women, farmers from Cohani.	16	0	Universidad Mayor de San Andrés	Learn about the different problems and needs of the community.
Field Day	April-07	Men and women, farmers from Calahuancane Baja	10	10	Universidad Mayor de San Andrés	Learn about the different problems and needs of the community.
Focus Group	July-07	Community members from Umala. Participants came from the following communities: Kellhuiri, Vinto Copani, San Juan Circa and San José Llanga	14	15	Universidad de la Cordillera	Training on data analysis using SPSS
Focus Group	July-07	Community members from Ancoraimes. Participants came from the follwoing communities: Chojñapata, Chinchaya, Calahuancani baja and Cohani	13	14	Universidad de la Cordillera	To identify perceptions on risks related to climatological changes, adoption of new Technologies, demand for financial services and women's participation in participatory research
Internships	Jan/Jul-07	US Undergraduate Students	1	7	Virginia Tech, U. Denver, PSU, INIAP.	Train participants in research methods, conduct research in field. (1-credit semester-long course at Virginia Tech, 6 weeks of field work in Ecuador)

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Short Course	Oct/Nov 06	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	32	18	PROINPA	To plant all field experiments and to train farmers in participatory research
Short course	Jan-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	33	11	PROINPA	Training on cultural practices about quinoa management
Short Course	Jan-07	Men and women, farmers from Calahuancane Baja.	8	8	Universidad Mayor de San Andrés	Train farmers to recognize the Andean weevil and the potato moth.
Short Course	Jan-07	Men and women, farmers from Chinchaya community.	18	22	Universidad Mayor de San Andrés	Train farmers to recognize theAndean weevil and the potato moth.
Short Course	Jan- 07	Masters and PhD students in Sustainable Agriculture at the National Agrarian University, La Molina, Peru	7	8	Credit course, toward PhD and Masters program in Sustainable Agriculture AG-7124 Globalizacion Politicas Agrarias y Desarrollo Rural	Students will understand the global setting, value chains and policies that impact the possibilities for agricultural alternatives in the Sierra, coast, and jungle regions of Peru.
Short course	Feb-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	29	11	PROINPA	Extractors naturals (potato and quinoa)
Short course	Feb-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa,	24	12	PROINPA	Potato management (plaguicides)

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
		Vinto Coopani and Kellhuiri communities)				
Short course	Feb-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	32	12	PROINPA	Training on cultural practices about quinoa management
Short Course	March-07	Men and women, farmers from Chojñapata	11	8	Universidad Mayor de San Andrés	Train farmers to recognize the Andean weevil and the potato moth.
Short Course	March-07	Men and women, farmers from Cohani	15	1	Universidad Mayor de San Andrés	Train farmers to recognize the Andean weevil and the potato moth.
Short course	Apr-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	26	9	PROINPA	Training on harvest and post harvest technologies in quinoa, potato and forage crops
Short course	May-07	Professionals at INIAP and others in Ecuador	35	15	Virginia Tech	Train participants in economic analysis and household modeling
Short course	May-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	26	9	PROINPA	Production costs (Potato)
Short Course	June-07	Graduate students working on markets and graduate students from PROINPA	1	5	Universidad de la Cordillera	Information regarding SANREM Project and research themes
Short course	Jul-07	Framers from Umala Municipality (San jose, San Juan Circa, Vinto Coopani,	28	8	PROINPA	Cost of potato and quinoa production

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
		Kellhuiri communities)				
Short Course	Sep-07	Graduate students working on markets	4	13	Universidad de la Cordillera	To identify perceptions on risks related to climatological changes, adoption of new Technologies, demand for financial services and women's participation in participatory research
Seminar	Sep-07	USAID officials and contractors in Bolivia	11	8	University of Missouri	Climate change in Altiplano, implications for development.
Workshop	Oct/Dec-06	Undergraduate students	1	1	CERES	To train students as field assistants
Workshop	Nov-06	SANREM Project Staff	12		PROINPA/PROMIC	Training in GIS
Workshop	Dec-06	PROINPA staff	3		PROINPA	Risk management
Workshop	Jan-07	Farmers from Chinchaya, Cohani, Calahuancane Chojñapata, San Jose, Kellhuiri, Vinto Coopani	24	12	MU, UMSA, PROINPA	On local forecast indicators to learn about which are used and how well these are performing.
Workshop	Jan/Sept-07	Community members in 5 communities in Pando, Bolivia	83	63	CIFOR-Bolivia	To train community members in the use of GPS units and compasses to enable participatory community mapping exercises
Workshop	Jan-Mar 2007	Local authorities in the Yuracare region	20		CERES, CIFOR	To present a general overview of the site report and Yuracare management plan to local officials
Workshop	Feb-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	21	8	PROINPA	Participatory evaluation of the field experiments (potato) Soils and biodiversity
Workshop	Feb-07	Men and women, farmers from Cohani	3	2	Universidad Mayor de San Andrés	Community Fertility Evaluation Assessment: Evaluate farmers perception about the

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
						participatory assessment about soil fertility
Workshop	Feb-07	Reasearchers from PROINPA UMSA and UC	4	5	PROINPA/UM/UC	Develop participatory assessment methods and instruments
Workshop	Feb-07	Researchers and farmers in Umala	25	20	PROINPA/UM/UC	Test instruments for participatory assessment
Workshop	Feb-07	Researchers and farmers in Kohani	7	8	UMSA/MU	Test and evaluate instruments for participatory assessment with farmers
Workshop	Feb-07	Policy makers, local officials in the Yuracare Territory, Bolivia	22	3	CERES	To present in detail the Yuracare forest management plan, developed by community members in cooperation with CERES
Workshop	Feb-07	PROINPA and SANREM partners	20	20	Virginia Tech, INIAP	Watershed management and economic analysis
Workshop	Feb/Mar-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	27	14	PROINPA	Planning Meetings
Workshop	Mar -07	Men and women, farmers from Calahuancane baja	9	6	Universidad Mayor de San Andrés	Participatory Assessment in Biodiversity: Evaluate farmers knowledge in the different potatoes varieties in the community and their uses, etc.
Workshop	Mar-07	Men and women, farmers from Chinchaya	6	6	Universidad Mayor de San Andrés	Community Fertility Evaluation Assessment: Evaluate farmers perception about the participatory assessment about soil fertility
Workshop	Mar-07	Men and women, farmers from Chinchaya	13	3	Universidad Mayor de San Andrés	Community Plagues Evaluation Assessment2: Evaluate farmers perception about the participatory assessment about soil fertility
Workshop	Mar-07	Men and women, farmers	12	1	Universidad Mayor de	Community Plagues Evaluation Assessment:

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
		from Chinchaya			San Andrés	Evaluate farmers knowledge about weevil of los Andes and the moth of potatoes
Workshop	Apr-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	29	19	PROINPA	Participatory evaluation of the field experiments (potato) Soils and biodiversity
Workshop	Apr-07	Farmers from Umala Municipality (San José de Llanga, San Juan Circa, Vinto Coopani and Kellhuiri communities)	33	11	PROINPA	Participatory evaluation of the field experiments (quinoa)
Workshop	Apr -07	Graduate students working on markets	1	5	Universidad de la Cordillera	Information regarding SANREM Project and research themes
Workshop	Apr-07	Men and women, farmers from Cohani.	10	2	Universidad Mayor de San Andrés	Community Participatory Assessment: Learn about the community aspects about agriculture, livestock, food security, natural resources, markets, information networks.
Workshop	Apri-07	Men and women, farmers from Calahuancane Baja.	8	0	Universidad Mayor de San Andrés	Community Participatory Assessment: Learn about the community aspects about agriculture, livestock, food security, natural resources, markets, information networks.
Workshop	Apr/May-07	Community members in TIM Ivirgarzama, Bolivia	17	21	CERES	To train community members in research methodology and give them an opportunity to participate and ask questions
Workshop	Apr/May-07	Foresters	2		CERES	To train 2 foresters in the IFRI data collection method
Workshop	May-07	Farmers from Kellhuiri community	12	4	PROINPA	Participatory evaluation of the field experiments (potato)

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
						Biodiversity
Workshops	May-07	Enumerators for baseline survey	5	5	PROINPA/CERES	Training in survey methods
Workshop	May-07	FARMERS	20	16	PROINPA/PROMIC	Enhanced pest management
Workshop	May-07	FARMERS	17	8	PROINPA/PROMIC	Enhanced pest management
Workshop	Jun-07	Farmers/PROMIC technicians	5	2	PROMIC	Soil sampling
Workshop	Jun-Sep 2007	Community members in TIM Ivirgarzama	13	20	CERES	To present findings from site visit and to train community members in data collection and use of GPS units
Workshop	Jul-07	Students/researchers	4	6	Universidad de la Cordillera	Training on data analysis using SPSS
Workshop	Jul-07	Farmers/PROMIC technicians	4	3	PROMIC	Soil sampling
Workshop	Aug-07	Framers from Umala Municipality (San jose, San Juan Circa, Vinto Coopani, Kellhuiri communities)	32	9	PROINPA	participatory evaluation of the quinoa grain
Workshop	Aug-07	Framers from Umala Municipality (San jose, San Juan Circa, Vinto Coopani, Kellhuiri communities)	28	12	PROINPA	Participatory culinary evaluation
Ecuador						
Field Day	Nov-06	Farmers	20	20	INIAP	Demonstrate soil conservation experiments
Short Course	Dec-06	Farmers	17	5	INIAP	Farmer field school in bean production
Workshops	Oct/Nov-06	Enumerators for baseline	5	5	INIAP	Training in survey methods

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
		survey				
Workshop	Oct-06	Farmers	20	4	INIAP	Integrated pest management for thrips in small-scale potato production
Workshop	Oct-06	Farmers	16	6	INIAP	Integrated pest management for thrips in small-scale potato production
Workshop	Nov-06	Farmers	20	5	INIAP	Soil fertility for potato production
Workshop	Feb-07	INIAP technicians	12	5	INIAP/ SANREM	Soil conservation
Workshop	Feb-07	Farmers	14	2	INIAP	Soil conservation
Workshop	Mar-07	Farmers	20	17	INIAP	Soil conservation
Workshop	Mar-07	Local government	13	10	INIAP/ SANREM	Leadership and gender
Workshop	Apr-07	Farmers/INIAP technicians	9	1	INIAP	Soil sampling
Indonesia						
Workshop	Mar-07	Farmers, scientists, and local government stafff		30	Bogor Agricultural Unversity Hambaro, SANREM farmer base camp, Indonesia	1) discussion on the local ways of utilization of indigenous vegetables (2) a class on nutritional and medicinal values of indigenous vegetables, and (3) cooking demonstration on new ways to cook nutritious foods from indigenous vegetables
Workshop	May-07	Farmers, VIP researchers, students, faculty	20	25	Bogor Agricultural University	To introduce concepts, methods, practice, and advantages of no-tillage vegetable technology
Workshop	May -07	Farmers, VIP researchers, students, faculty	20	25	Central Quensland University, NC A&TSU and Bogor Agricultural University and Hambaro Village,	Introduced drip irrigation and hands-on concept

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
					Indonesia	
Kenya						
Workshop	Fall 2006	User group assistants in Aberdares, Kenya	4	3	KEFRI	To train community members in IFRI data collection methods and to coordinate data collection and meetings with community members.
Workshop	Fall 2006	Community members and local officials in Aberdares, Kenya	29	26	KEFRI	To train community members on the details of the new Forest Act that aims to include community members in decision making on forest issues and general forest governance; also introduced participants to the IFRI and SANREM programs
Workshop	Jan-Mar 2007	Community members and local officials in Upper Imenti Forest, Kenya	12	18	KEFRI	To train community members and others about the new Forest Act that aims at including community members in decision making on forest issues and general forest governance; also introduced participants to the IFRI and SANREM programs
Workshop	Jan-Mar 2007	User group assistants in Upper Imenti Forest, Kenya	4	2	KEFRI	To train assistants in sampling techniques and household data collection methods
Workshop	May 2007	Community members and local officials in Kakamega, Kenya	18	12	KEFRI	To present findings from the site visit, learn more about community roles in forest management, and develop action steps for the future
Workshop	Jun-Sep 2007	User group assistants in Tugen Hills Forest, Kenya	8	3	KEFRI	To train assistants in sampling techniques and household data collection methods
Workshop	Jun-Sep 2007	Community members and local officials in Tugen	25	15	KEFRI	To train community members on the details of the new Forest Act that aims to include

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
		Hills, Kenya				community members in decision making on forest issues and general forest governance; also introduced participants to the IFRI and SANREM programs
Workshop	Jun-Sep 2007	Community members in Aberdares and Tugen Hills, Kenya	100	94	KEFRI	Additional meetings held in sublocations in Sites 1 and 3 to allow additional residents to learn about the project, the new Forest Act, and benefit sharing within the decentralized system.
Mexico						
Workshop	Jan-Mar 2007	Community members in Durango, Mexico	5		UNAM	To train community members in research methods
Workshop	March 2007	University students	2	2	UNAM	To train students as field assistants
Peru						
Field day	Dec 06	Farmers form SantaMaria	12	18	UNALM	Forage evaluation and management with emphasis on alfalfa
Field Day	May 07	Farmers from Apopata	11	10	UNALM	Description of grassland and animal management per family
Field day	Sep 07	Apopata households	25	10	UNALM (Jorge Gamarra)	Demonstrate how is the technical way to evaluate grasslands and to review the stocking rate concept
Seminar	Jan 07	UNALM community	7	8	ISU (Jan Flora)	Share experience on building coalition
Seminar	Mar 07	UNALM researchers	1	1	ISU (Cornelia Flora)	Reinforce of coalition building concepts
Seminar	Jun 07	University community UNA Puno	17	23	UNA-INACET	Share with university community the progress of project, and to received feedback
Seminar	Jul 07	University community, faculties, local NGO	8	11	UNALM-UNA/INACET – ISU	Share with university community concepts of Sustainable Livelihoods Approach, Community

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
					(Jan Flora, Cornelia Flora)	capital framework
Seminar	Sep 07	University community, faculties, local NGO	9	7	UNALM-UNA/INACET – MU (Jere Gilles)	Share with university community findings on networks on Bolivian Altiplano communities
Seminar	Sep-07	Students of the Anthropology program in Puno.	6	6	University of Missouri	Knowledge systems and the diffusion of technology
Short Course	May 07	Project reseracher	1	1	ISU-CATIE	Training on Sustainable livelihood approaches, capital of community framework and appreciative inquiry
Workshop	Oct-06	Farmers from Anccaca	3	1	UNALM	Community from upper lands identification and selection
Workshop	Nov-06	Farmers from Huacochullo	3	0	UNALM	Community from upper lands identification and selection
Workshop	Nov-06	Farmers from San Jose	2	0	UNALM	Community from upper lands identification and selection
Workshop	Nov-06	Farmers from Untave	29	14	UNALM	Community from upper lands identification and selection
Workshop	Dec 06	Famers from Santa Maria	8	8	UNALM	Data devolution and information validation from participatory workshop
Workshop	Dec 06	Puno team	3	5	UNALM	Survey analysis sensitization
Workshop	Dec 06	Farmers from Apopata	23	13	UNALM	Community from upper lands identification and selection
Workshop	Dec 06	Farmers from Huanacamaya	4	1	UNALM	Community from upper lands identification and selection
Workshop	Dec 06	Farmers from Yusta	2	2	UNALM	Community from upper lands identification and

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
						selection
Workshop	Jan 07	Puno team	2	0	UNALM	Training on participatory research
Workshop	Jan 07	UNALM researchers	1	2	ISU (Jan Flora & Edith Fernandez Baca)	Training on building coalition
Workshop	Feb 07	Farmers from Apopata	34	19	UNALM	Project presentation
Workshop	Feb 07	Farmers form Santa Maria	13	19	UNALM	Training in elaboration and use on organic fertilizer
Workshop	Feb 07	Local team	3	3	UNALM	Training on participatory methodologies
Workshop	Feb 07	Farmers from Apopata	23	9	UNALM	NNRR inventory and farmers perceptions of vulnerability respect to capital natural
Workshop	Mar 07	Farmers form Santa Maria	5	4	UNALM	Socialize the concept of coalition and form the committee that will attend coalitions activities in Santa Maria
Workshop	Mar 07	Farmers from Santa Maria	10	6	UNALM	Description of animal feeding system per family
Workshop	Apr 07	Local team	3	2	UNALM	Share data form workshop in Apopata
Workshop	Apr 07	Local team	3	2	UNALM	Training on animal feeding systems, bloat and presentation techniques
Workshop	Apr 07	Farmers form Santa Maria	13	14	UNALM	Evaluate animal feeding systems, training in bloat prevention, and silage preparation
Workshop	May 07	Farmers from Apopata	25	15	UNALM	Socialize the concept of coalition and form the committee that will attend coalitions activities in Apopata
Workshop	Ago 07	Local team	2	2	UNALM	Strengthen rural development concepts
Workshop	Sep 07	Apopata households	20	12	UNALM-UNA (Julio Choque)	Evaluate peat bogs location and condition

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Philippines						
Field Day	Sep-07	Farmers, Agricultural Technicians, Academe, Researchers	38	37	AVRDC, ICRAF	Demonstrate to stakeholders the potentials of VAF system Conduct participatory evaluation on farmers' preferred vegetables
Focus Group	May-07	Farmers from 9 barangays (village) covering Maagnao and Alanib sub-watersheds to the Manupali watersheds	13	1	ICRAF-Lantapan	Present initial results of LEK/PPEK survey Identify hotspots in Maagnao and Alanib sub-watersheds Understand the situation of natural resource use along the 2 rivers Identify the causes and effects Identify possible external interventions, and policy support to motivate farmers
Focus Group	Aug-07	Local policy makers: municipal and village council members	21	4	ICRAF-Lantapan	Discuss potential policy incentives for VAF
Focus Group	Aug-07	Banana plantation company staff: Mt. Kitanglad Agri-Ventures, Dole Skyland Philippines, HI-VAC company	10	5	ICRAF-Lantapan	Discuss potential policy incentives for VAF and PES mechanisms with local communities
Focus Group	Sep-07	Agricultural technicians, farmer leaders	9	5	ICRAF-Lantapan	Discuss potential policy incentives appropriate for VAF
Seminar	Apr-07	Staff of National Power Corporation, Watershed Mgt. Division	19	9	ICRAF-Lantapan	Present VAF-policy study Generate support for collaboration in terms of developing policy-incentives for VAF farmers in Lantapan
Workshop	Nov-06	Provincial & municipal legislators, Regional, provincial & local	19	8	ICRAF-Lantapan	Describe the natural resource conditions of the Manupali watershed Define the policy problem of VAF system

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
		department heads, Private sector – NIA/NPC, farmers, academe, researchers				Identify the policy principles, to support and promote VAF system
Workshop	Feb-07	Lantapan-LGU, BENRO, NIA, Postgraduate students	5	4	ICRAF-Lantapan	Understand stakeholders' roles and responsibilities Identify stakeholders' commitment Finalize work plan
Workshop	May-07	SANREM scientists from Indonesia, Philippines, Vietnam, Thailand and the United States; Faculty, research staff and graduate students from the Philippines	8	4	Host country: Philippines Resource Person: Dr. R. Srinivasan, Texas A&M University Coordinators: Dr. Victor B. Ella, University of the Philippines Los Banos and Dr. Manuel R. Reyes, North Carolina A&T University	To train the participants on SWAT modeling. In particular, the training aimed to acquaint the participants with the theoretical background of the SWAT model, input data requirements, model calibration, validation and sensitivity analysis and other relevant modeling techniques
Workshop	May-07	Farmers, Philippine researchers, and local government staff	20	9	Host country: Philippines, trainers: Manuel Palada, AVRDC, Victor Ella, UPLB and Manuel Reyes, NCA&T	To train participants on use of International Development Enterprise low-cost drip irrigation system
Uganda						
Workshop	Jan-Mar 2007	Local community members/ officials in Wakisi, Uganda	4		UFRIC	To provide additional site-specific training and provide opportunity for discussion between stakeholders

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Apr-May 2007	Community members and local officials in Kibale District, Uganda	31	12	UFRIC	To present research findings, chart roles and responsibilities of various stakeholders, and help participants understand the role of central government agencies in the forest sector following decentralization; also discussed the Tree Planting and the Local Government Acts
Workshop	Jun-Sep 2007	Community members and local officials in Luwero District, Uganda	23	10	UFRIC	To increase understanding of the impact of plantation development on resource access and health and the roles and responsibilities of different stakeholders under decentralization as well as discussing research results
Workshop	Jun-Sep 2007	Community members in 18 PEN communities in Uganda	432	648	CIFOR	To give an overview of the PEN study and its findings.
Workshop	Jan-Mar 2007	Community members and local officials in Kibale District, Uganda	4	4	UFRIC	To decrease conversion of forests to farm land and familiarize participants with research methods, addressing specific topics like forest sampling, the role of communities under decentralized forest management, tree management, and soil and water management.
USA						
Seminar	Aug-07	Rural Sociologists in USA	6	3	University of Missouri	Project Presentation
Short Course	Jun/Jul-07	Three scholars, one for each country	2	2	University of California-Berkeley	Bearh's Environmental Leadership Program: To acquire knowledge and skills on many facets of environmental leadership
Vietnam						
Field Day	May-07	NLU researchers, local collaborators in Nghia Tung	5	2	Nong Lam University	Discussion on the design of field experiments on termites control; vegetable/natural vegetative strips for soil erosion control;

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Seminar	Oct-06	NLU researchers, students	7	12	Nong Lam University	Report results of the baseline study, discussion on the design of the production constraints and issues, on-farm trials
Seminar	Oct-06	NLU researchers	9	10	Nong Lam University University of California, Berkeley Central Queensland University, Australia.	To introduce the environmental leadership program at the University of California, Berkeley to NLU researchers and staff; to discuss on results from the field assessment and identify possible technology interventions.
Seminar	Mar-07	NLU researchers, students	6	10	Nong Lam University	To introduce concepts and approach in RUPES/PES; discussion on its applicability in the study area.
Workshop	Apr-07	NLU researchers, village leaders, Leaders of the Farmer Association and Women Association	13	3	Nong Lam University	Field training on drip irrigation for local farmers, hands-on to set up drip system.
Workshop	Apr-07	NLU researchers, students	1	4	Nong Lam University	To provide guideline for the household survey on pesticides and health cost
Workshop	Jun-07	VIP researchers, Professors from North Carolina A&T State University	19	5	North Carolina A&T State University Nong Lam University	To introduce concepts and methods in soil quality measurement and management and practice soil quality test kits to VIP researchers
Workshop	Jun-07	Professors from NCA&T State University VIP researchers, Local farmers	18	3	Nong Lam University North Carolina A&T State University	To introduce methods in soil quality measurement and management and practice soil quality test kits to collaborating farmers
Workshop	Sep-07	NLU Researchers	5		Nong Lam University	To introduce SWAT-GIS modeling and analytical approach.
Zambia						

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field Day	January – March 2007	COMACO Rice farmers	434	555	WCS COMACO extension staff and trainers	Rice field selection, field preparation, planting and field management, harvesting and extraction of grain from the stocks; Introduction to soya beans production, nutritional values, varieties of soya beans, planting, spacing, seed rates, intercropping, harvesting, marketing, etc.
Field Day	April – July 2007	COMACO honey producer groups	552	372	WCS COMACO extension staff and trainers	TOT training on Introduction to Apiculture, bee biology, apiary selection and management, Honey harvesting; introduction to banana production, field preparations, water harvesting, planting, weed control, harvesting & marketing.
Field Day	June- July 2007	COMACO poultry groups	304	247	WCS COMACO extension staff & trainers	TOT Introduction to poultry production & management, nutrition and disease control
Field Day	August 2007	Organic cotton farmers	500		Edwin Abwino, WCS Organic Farming Extension Manager	Introduction of organic farming methods, training of more farmers, sustainable organic cotton production including a correct mix of other organic crops and vegetables.
Workshop	November 2006 to February 2007	COMACO trainers, extension staff & selected farmer groups	283	237	Lydiah Gatere, Cornell University	Field based training for soil management and composting trials
Workshop	April 2007	COMACO trainers, extension workers, depot managers	30	3	Beekeeping Specialist from Govt. Forestry department, DACO, Fisheries officers	TOT training on Introduction to Apiculture, bee biology, apiary selection and management, Honey harvesting; introduction to banana production, field preparations, water harvesting, planting, weed control, harvesting & marketing.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	June 2007	COMACO trainers, extension staff, depot managers	11	10	Brigitte Bagnol & Filomena Dos Anjos, IRPC	TOT in poultry management, disease prevention through vaccination, etc
Workshop	June 2007	COMACO trainers, extension staff, depot managers	20	3	Tamika Lewis, Cornell University	TOT Introduction to poultry production & management, nutrition and disease control
Workshop	July 2007	Trainers, extension workers, depot managers	20	3	Tamika Lewis, Cornell University	TOT training on introduction to goat keeping, basic animal husbandry, nutrition & management, assessing goat health and diseases.
Workshop	August 2007	COMACO Extension staff	5		Kasisi Agricultural training centre	TOT in sustainable agriculture with focus on organic farming methods
Workshop	August 2007	COMACO goat producers	558	406	WCS COMACO extension staff and trainers	TOT training on introduction to goat keeping, basic animal husbandry, nutrition & management, assessing goat health and diseases.
Workshop	July-September 2007	Transformed poachers	89		William Banda, WCS/COMACO Wildlife Extension manager	Improved livelihood skills, Marketing of finished goods, HIV/AIDS prevention, etc

Appendix B: Publications, Presentations, Other Products

Articles in refereed journals

Badini, O., C.O. Stöckle, J.W. Jones, R. Nelson, A. Kodio and M. Keita. 2007. A simulation-based analysis of productivity and soil carbon in response to time-controlled rotational grazing in the West African Sahel region. Agricultural Systems 94(1): 87-96.

Coxhead, I. and B. Demeke. 2004. Panel data evidence on upland agricultural land use in the Philippines: Can economic policy reforms reduce environmental damage? American Journal of Agricultural Economics 86(5): 1354-1360.

Coxhead, I. and S. Jayasuriya. 2004. Development strategy, poverty, and deforestation in the Philippines. Environment and Development Economics 9(5): 613-644.

Fisher, M. and G. Shively. 2007. Agricultural subsidies and forest pressure in Malawi's Miombo woodlands. Journal of Agricultural and Resource Economics 32(02): 349-362.

Fisher, M. M., G. E. Shively, S. Buccola. 2005. Activity choice, labor allocation, and forest use in Malawi. Land Economics 81(4): 503-517.

Fisher, M.M. and G.E. Shively. 2005. Can income programs reduce tropical forest pressure? Income shocks and forest use in Malawi. World Development 33(7): 1115-1128.

Flora, C.B. and A. Thiboumery. 2006. Community capitals: Poverty reduction and rural development in dry areas. Annals of Arid Zone 45(3-4): 239-253.

Garrett, K.A., S.H. Hulbert, J.E. Leach and S.E. Travers. 2006. Ecological genomics and epidemiology. European Journal of Plant Pathology 115:35-51.

Garrett, K.A., S.P. Dendy, E.E. Frank, M.N. Rouse and S.E. Travers. 2006. Climate change effects on plant disease: Genomes to ecosystems. Annual Review of Phytopathology 44:489-509.

Ha, D.T. and G.E. Shively. 2007. Coffee boom, coffee bust, and smallholder response in Vietnam's central highlands. Review of Development Economics. (Online Early Articles) doi:10.1111/j.1467-9361.2007.0039.x.

Ha, D.T. and G.E. Shively. 2005. Coffee vs. cacao: A case study from the Vietnamese Central Highlands. Journal of Natural Resources and Life Sciences Education 34:107-111.

Mahmoud, C., G. E. Shively. 2004. Agricultural diversification and integrated pest management in Bangladesh. Agricultural Economics 30(3):187-194.

Nazarea, V. 2006. Local knowledge and memory in biodiversity conservation. Annual Review of Anthropology 35: 317-335.

Ostrom, E. 2007. A diagnostic approach for going beyond panaceas. Proceedings of the National Academy of Sciences, 104(39): 15181-15187.

Ostrom, E., M.A. Janssen and J.M. Anderies. 2007. Going beyond panaceas. Proceedings of the National Academy of Sciences 104(39): 15176-15178.

Pimentel, D., P. Hepperly, J. Hanson, D. Douds, and R. Seidel. 2005. Environmental, energetic, and economic comparisons of organic and conventional farming systems. Bioscience 55(7): 573-582.

Rios, A. and G. Shively. 2006. Farm size and nonparametric efficiency measurements for coffee farms in Vietnam. Forests, Trees and Livelihoods 16(4): 397-412.

Roncoli, C., C. Jost, C. Perez, K. Moore, A. Ballo, S. Cissé and K. Ouattara. 2007. Carbon sequestration from common property resources: Lessons from community-based sustainable pasture management in north-central Mali. Agricultural Systems 94(1): 97-109.

Rouse, M.N., M.R. Cheatham, P.D. Esker, S.I .Cardenas, W. Pradel, R. Raymundo, A. Sparks, G.A. Forbes, T.R. Gordon and K.A. Garrett. 2007. Plant pathology in the context of ecosystem services. Phytopathology 97: S102.

Shively, G.E. 2004. Poverty and forest degradation: Introduction to the special issue. Environment and Development Economics 9(2):131-134.

Shively, G. E. 2006. Externalities and labour market linkages in a dynamic two-sector model of tropical agriculture. Environment and Development Economics 11(1): 59-75.

Shively, G.E. and I.A. Coxhead. 2004. Conducting economic policy analysis at a landscape level: examples from a dynamic model of a Philippine watershed. Agriculture, Ecosystems, and Environment, 104(1):159-170.

Shively, G.E. and M.M. Fisher. 2004. Smallholder labor and deforestation: A systems approach. American Journal of Agricultural Economics 86(5): 1361-1366.

Simon, D., D. McGregor, K. Nsiah-Gyabaah and D. Thompson. 2003. Poverty elimination, North-South research collaboration, and the politics of participatory development. Development in Practice 13(1): 40-56.

Yao, R.T. and G.E. Shively. 2007. Technical change and productive efficiency: Irrigated rice in the Philippines. Asian Economic Journal 21(2): 155-168.

Books

Coxhead, I. and G. Shively (eds.). 2005. *Land Use Change in Tropical Watersheds: Evidence, Causes, and Remedies.* Wallingford (UK): CAB International.

Nazarea, V., R. Guitarra, M. Pineiro, C. Guitarra, R.E. Rhoades and R. Alarcon. 2004. *Cuentos de la Creación y Resistencia.* Ediciones Abya-Yala: Quito, Ecuador. (Spanish)

Nazarea, V.D., J. Camacho, N. Parra. 2006. *Recipes for Life: Counsel, customs, and cuisine from the Andean hearth.* Ediciones Abya-Yala: Quito, Ecuador. (Spanish)

Rhoades, R., N. Gómez, J. Hidalgo, F. López, A. Vicuña (eds.). 2005. *El Cantón Cotacachi: Espacio y Sociedad.* Ediguias C. Limited: Quito, Ecuador. (Spanish)

Rhoades, R.E. (ed.). 2006. *Development with Identity: Community, Culture and Sustainability in the Andes.* CABI Publishing: Wallingford, UK.

Rhoades, R. E. (ed.). 2006. *Desarrollo con Identidad: Comunidad, Cultura, y Sustentabilidad en los Andes.* Ediciones Abya-Yala: Quito, Ecuador. (Spanish)

Book chapters

Coxhead, I. 2005. International trade and the natural resource curse in Southeast Asia: Does China's growth threaten regional development? In: Resosudarmo, B. (ed.). The Politics and Economics of Indonesia's Natural Resources, 77-91. Singapore: ISEAS.

Coxhead, I. 2007. Globalization and the poverty-environment link in Asian Agriculture. In: Balisacan, A. and N. Fuwa (eds.). Agricultural Development in Asia: Ideas, Paradigms, and Policies. Singapore: ISEAS (in press).

Coxhead, I. 2004. Interactions between economic policies and institutions in water allocation and use: Theory and evidence from a Philippine watershed. In: A.C. Rola, H.A Francisco and J.P.T. Liguton (eds). Winning the Water War: Watersheds, Water Policies and Water Institutions. Makati, Philippines: PIDS/PCARRD.

Coxhead, I. and S. Jayasuriya. 2005. Trade liberalization, resource degradation and industrial pollution in developing countries. In: S. Jayasuriya, (ed.): Trade Theory and Analytical Models: Essays in Honour of Professor Peter Lloyd, Vol. 1, 257-281. Chelthenham, UK, and Northampton, MA, USA: Edward Elgar.

Forbes, G.A., N.J. Grünwald, E.S.G. Mizubuti, J.L. Andrade-Piedra and K.A. Garrett. 2007. Potato late blight in developing countries. In: Peters, R. (ed.) Current Concepts in Potato Disease Management. Kerala, India: Research Signpost (In press).

Garrett, K.A. and C.M. Cox. 2008. Applied biodiversity science: Managing emerging diseases in agriculture and linked natural systems using ecological principles. In: R. Ostfeld, F. Keesing, V. Eviner (eds) Cary Conference XI: Infectious disease ecology: the effects of ecosystems on disease and
of disease on ecosystems. Princeton University Press (In press - February 2008).

Gregory, S., A.W. Allen, M. Baker, K. Boyer, T.A. Dillaha, and J. Elliott. 2007. Realistic expectations about the timing between conservation implementation and environmental effects—lessons learned from long-term research. In: M. Schnepf and Craig Cox (eds.) Managing Agricultural Landscapes for Environmental Quality: Strengthening the Science Base. Soil and Water Conservation Society, Ankeny, Iowa.

Pagiola, S., M.D. Angeles and G. Shively. 2005. Using payments for environmental services (PES) to assist in Watershed Management. In: Coxhead, I., G. E. Shively, Eds. 2005. Land use change in tropical watersheds: Evidence, causes, and remedies, 163-175. Cambridge, MA, USA: CABI Publishing.

Rhoades, R. 2007. Mama Cotacachi: History, local perceptions, and social impacts of climate change and glacier retreat in the Ecuadorian Andes. In: Orlove, B. (ed.). Darkening Peaks: Mountain Glacier Retreat in Social and Biological Contexts. Berkeley: University of California Press.

Rodriguez, R. and D. Southgate. 2006. Local resolution of watershed management trade-offs: The case of Cotacachi. In: R. Rhoades (ed.). 2006. Development with Identity: Community, Culture, and Sustainability in the Andes, 219-235. Wallingford, UK: CAB International.

Shively, G. and C. Zelek. 2005. Linking economic policies and environmental outcomes at a watershed scale. In: Coxhead, Ian and Gerald Shively (Eds.). 2005. Land Use Change in Tropical Watersheds: Evidence, Causes, and Remedies, 147-162. Wallingford (UK): CAB International.

Theses and dissertations

Adiong-Verbal, X.F. 2006. Multiple role performance of upland women farmers: Socioeconomic characteristics and perceived consequences. Masters' Thesis. Manila: De La Salle University.

Demeke, B. 2005. Essays on environmental and development policy analysis in developing countries. Ph.D. dissertation. Madison, WI: University of Wisconsin-Madison, Department of Agricultural and Applied Economics.

Salazar, M. 2006. An economic analysis of smallholder coffee production in Guatemala, Honduras, Nicaragua, and Vietnam. M.S. Thesis. West Lafayette, IN: Purdue University, Department of Agricultural Economics.

Tran, N.A. 2007. Measuring the efficiency of coffee producers in Vietnam. MS thesis. West Lafayette, IN.: Department of Agricultural Economics, Purdue University.

Yao, R. 2005. Impacts of irrigation development on agricultural productivity, resource allocation and income distribution: A longitudinal analysis from Palawan, the Philippines. M.S. Thesis. West Lafayette, IN: Purdue University, Department of Agricultural Economics.

SANREM research briefs

SANREM CRSP 2006. Developing social infrastructure for effective NRM. SANREM CRSP Research Brief No. 1. Blacksburg, VA: SANREM CRSP - OIRED - VT

SANREM CRSP 2006. Modeling tool improves watershed analysis. SANREM CRSP Research Brief No. 2. Blacksburg, Virginia: SANREM CRSP - OIRED - VT

SANREM CRSP 2006. Lowland irrigation practices benefit upland farms. SANREM CRSP Research Brief No. 3. Blacksburg, Virginia: SANREM CRSP - OIRED - VT

SANREM CRSP 2006. Understanding alternatives to forest use in Malawi. SANREM CRSP Research Brief No. 4. Blacksburg, Virginia: SANREM CRSP - OIRED - VT

SANREM CRSP 2006. Subsistence farmers move into the market. SANREM CRSP Research Brief No. 5. Blacksburg, Virginia: SANREM CRSP - OIRED - VT

SANREM CRSP 2006. Rotational grazing for soil carbon sequestration. SANREM CRSP Research Brief No. 6. Blacksburg, Virginia: SANREM CRSP - OIRED - VT

SANREM CRSP 2006. Assessing the scientific knowledge base for ecoagriculture. SANREM CRSP Research Brief No. 7. Blacksburg, Virginia: SANREM CRSP - OIRED – VT

SANREM CRSP 2007. Surviving Vietnam's coffee boom and bust. SANREM CRSP Research Brief No. 8. Blacksburg, Virginia: SANREM CRSP - OIRED - VT

Extension publications (large)

Cornell University. 2006. Poultry health and management: A guide to raising healthy village poultry. Wildlife Conservation Society.

Coxhead, I. and B. Demeke. 2005. Poverty and environmental damage in Philippine agriculture: Do trade policies matter?. Philippine Institute for Development Studies, Development Research News XXII (4) (July-August), pp. 1-6. Philippine Institute for Development Studies.

Heatwole, C.D., M. Obenhaus, C.B. Heatwole, T.A. Dillaha and K.M. Moore. 2005. SANREM Knowledgebase Metadata Guide (Versions 1, 2, and 3). Blacksburg, VA: SANREM CRSP - OIRED - VT.

Nong Lam University Team. 2007. Drip irrigation training in Nghia Trung Village, Bu Dang District, Binh Phuoc Province, Vietnam. Ho Chi Minh City, Vietnam: Nong Lam University.

Susila, A. 2006. Panduan budidaya tanaman sayuran. Bogor, Indonesia: Bogor Agricultural University.

Fact sheets (small extention publications)

Obonyo-Kamau, E., P. Ongugo and A. Kyomughisha. 2006. The role of community-based organizations on sustainable management of Kakamega Forest. Kenya Forestry Research Institute Research Brief.

Conference proceedings and papers

Jervis, M.H. (ed.). 2006. Taller experiencias de manejo de cuencas hídricas en el Ecuador. Quito, Ecuador: Fundación Antisana (Spanish)

Manu, A. 2005. Simulating urban growth patterns of a developing country city using computational neural networks. In: Proceedings of the Seventh Biannual Africa GIS Conference, Tshwane (Pretoria), South Africa

Moore, K.M., S. Cissé and A. Touré. 2006. Building social infrastructure for decentralized NRM. In: Dixon, J., C. Neely, C. Lightfoot, M. Avila, D. Baker, C. Holding and C. King (eds.). Farming Systems and Poverty: Making a Difference. Proceedings of the 18th International Symposium of the International Farming Systems Association: A Global Learning Opportunity, Rome, Italy, 31 October - 4 November 2005

Rhoades, R. 2005. Are traditional mountain governance principles still relevant in a global world? In: Taylor, L. and A. Ryall (eds.). Governance and Decision-Making in Mountain Areas. Proceedings of the Fifth Mountain Communities Conference, Banff, Alberta, Canada, 4-8 June 2005

Twumasi, Y.A., A. Manu, T.L. Coleman. 2005. Remote sensing and GIS application in Coastal Zone Management: A case study of Ghana. In: Proceedings of the Seventh Biannual GIS Conference, Tsewane (Pretoria), South Africa

Working papers

Anderson, R. 2007. An institutional analysis of the Chimbo River watershed.

Andersson, K. and E. Ostrom. 2007. An analytical agenda for the study of decentralized resource regimes. SANREM CRSP Working Paper No. 01-07.

Calles, J. A. 2007. Bioindicadores terrestres y acuáticos para las microcuencas de los ríos Illangama y Alumbre, provincia Bolívar. (Spanish)

Cárdenas Chávez, A. 2007. Análisis de paisaje: Cobertura vegetal y uso del suelo e indicadores biofísicos: Tasas de cambio, representatividad y fragmentación microcuencas Illangama y Alumbre. (Spanish)

Chiong-Javier, M.E. 2007. Songco women biyahidors in Loverslane Market: Self-empowerment through micro vegetable entrepreneurship. SANREM CRSP Working Paper No. 03-07.

Demeke, B. and I. Coxhead. 2006. Modeling spatially differentiated environmental policy in a Philippine watershed: Tradeoffs between environmental protection and poverty reduction. Manuscript, Penn. State U. and U. Wisconsin-Madison, presented at AAEA meetings, July 2006.

Ha, D.T., V.D. Le , T.K.L. Duong and T. Nguyen. 2006. Socioeconomic baseline case study: Nghia Trung Village, Bu Dang District, Binh Phuoc Province, Vietnam. SANREM CRSP Working Paper No. 03-06.

Herrera, E., R. Miranda, P. Motavalli and M. Peñaranda. 2007. Efecto de aplicación de abonos orgánicos y químicos sobre la fertilidad del suelo en el cultivo de la papa (Solanum tuberosum) en el Altiplano Norte de la Paz. Prácticas y Estrategias en Respuesta a Riesgos Climáticos y de Mercado en Agroecosistemas Vulnerables de la Región Andina, Documento No. 12. Facultad de Agronomía, Universidad Mayor de San Andrés, La Paz, Bolivia. (Spanish)

Le, T.L.,T.K.L. Duong and D.T. Ha. 2006. Market value chain research: Case study in Nghia Trung Commune, Bu Dang District, Binh Phuoc Province, Vietnam. SANREM CRSP Working Paper No. 01-06.

López, J.A.C. and D.S. Peña. 2006. Diagnóstico preliminar de la biodiversidad en las microcuencas del Río Alumbre e Illangama, afluentes del Río Chimbo, Provincia de Bolívar. SANREM CRSP Working Paper No. 02-06. (Spanish)

Mamani, B., R. Miranda, P. Montavalli and J. Cusicanqui. 2007. Caracterización de suelos según su Índice de fertilidad y capacidad de uso en El Municipio de Ancoraimes. Prácticas y Estrategias en Respuesta a Riesgos Climáticos y de Mercado en Agroecosistemas Vulnerables de la Región Andina, Documento No. 13, Facultad de Agronomía, Universidad Mayor de San Andrés, La Paz, Bolivia. (Spanish)

Nguyen, M.R., J.P.A. De Mesa and A.C. Rola. 2007. Vegetable agroforestry system: Baseline survey results in Songco, Lantapan, Bukidnon, Philippines, 2006. SANREM CRSP Working Paper No. 05-07.

Strzepek, K. and A. McCluskey. 2007. The issue of spatial scale in hydro-economic modeling of global and national food and water systems to address sustainable agriculture and natural resources management. SANREM CRSP Working Paper No. 02-07.

Wijaya, K., S. Budidarsono and J. Roshetko. 2007. Socioeconomic baseline studies: Agro-forestry and sustainable vegetables production in Southeast Asian watershed. SANREM CRSP Working Paper No. 04-07.

World Wide Web sites and documents

TMPEGS. 2007. Technology, Marketing, Policy, Environmental and Economic Social Impact, Gender, Scaling-up Website. Available at: http://tmpegs.org/.

SANREM CRSP. 2005. SANREM CRSP Website. Available at: http://www.oired.vt.edu/sanremcrsp/.

Universidad de la Cordillera. 2007. Proyecto SANREM - MU. Available at: http://ucordillera.edu.bo/SANREM/. (Spanish)

University of Missouri. 2007. Adapting to change in the Andean Highlands: Practices and strategies to address climate and market risks in vulnerable agro-ecosystems. Available at: http://sanrem.missouri.edu.

SANREM CRSP. 2007. Payments for Environmental Resources Website. Available at: http://www.oired.vt.edu/sanremcrsp/PES.php.

Papers and seminars presented

Aguilera, J. 2006. Adaptacion al cambio en zonas de altura: Prácticas e estrategias para afrontar riesgos de clima y de mercado en agro-ecosistemas vulnerables. Presented at the PROINPA annual meeting, August 2007, Cochabamba, Bolivia. (Spanish)

Ali, M. 2006. AVRDC- The World Vegetable Center: Role of horticulture in poverty alleviation . Presented at North Carolina A&T State University, Greensboro, NC, April 2006.

Bhagowalia, P., S. Chen and G. Shively. 2007. Short-term investments in agriculture: Is there a gender bias?. Paper presented at the annual meeting of the American Agricultural Economics Association, Portland, OR, 31 July 2007.

Christie, M. E. 2007. La importancia de la temática de género en el Manejo de los Recursos Naturales y la Agricultura Sostenible en un escenario de cambios globales. Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007. (Spanish)

Coxhead, I. 2006. Globalization and the poverty-environment link in Asian Agriculture: Theoretical exploration and a Vietnam case study. Paper presented at the World Congress of Environmental and Resource Economics, Kyoto, Japan, 3-7 July 2006.

Demeke, B. and I. Coxhead. 2006. The effect of national policies and labor markets on land use decisions in developing countries: an application of maximum simulated likelihood to a system of censored acreages with panel data. Paper presented at the American Agricultural Economics Association Annual Meeting, Long Beach, California, 23-26 July 2006.

Fisher, M. and G. Shively. 2006. Agricultural subsidies and forest pressure in Malawi's Miombo Woodlands. Paper presented at the Third World Congress of Environmental and Resource Economists, Kyoto, Japan, 3-7 July 2006.

Flora, C. 2007. Social capital and community problem solving: Combining local and scientific knowledge to fight invasive species. Presented at the International Working Conference on Community Management of Biosecurity, Sanur, Bali, Indonesia, 24-26 May 2007.

Flora, C.B. 2007. Social capital and community problem solving: Combining local and scientific knowledge to fight invasive species. Presented at the International Working Conference 'Community management of biosecurity' A partnership research enterprise between the Cooperative Research Centre for National Plant Biosecurity (CRC NPBS Australia), University of Mahasaraswati (Indonesia), and Charles Darwin University (Australia), Sanur, Bali, Indonesia, 24-26 May 2007.

Garret, K.A. 2007. Climate change, biodiversity, and ecosystem services: The view from Plant Pathology. Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007.

Her, Younggu, and C. D. Heatwole. 2007. Land use classification in Zambia using Quickbird and Landsat imagery. ASABE Paper No. 072017. St. Joseph, Mich: ASABE.

Her, Younggu, and C. Heatwole. 2007. Evaluating landuse impacts on water balance and soil erosion in Eastern Zambia using SWAT. ASABE Paper No. 072096. St. Joseph, Mich: ASABE.

Jiménez, E. 2007. Peasant economies and rural financial services in Bolivia. Presented at the Seminario Sobre Intercambio de Experiencias en Servicios Financieros Rurales, Guatemala City, Guatemala, 7-10 August 2007. (Spanish)

Lehmann, J. 2006. Bio-char: Soil ecological and carbon balance studies. Presented at the Biochar as a Soil Amendment Workshop at the World Congress of Soil Science Meeting, Philadelphia, Pa., 14 July 2006.

Lewis, D. 2006. Markets, food security and conservation: A model for rural development in Zambia. Presented at the Biodiversity Conservation in Agriculture Symposium, Punta Cana, Dominican Republic, 31 May - 2 June 2006.

Manu, A., Y.A. Twumasi, and T.L. Coleman. 2006. Is it global warming or the effect of urbanization? The rise in air temperature in two cities of Ghana. Paper presented at the Fifth International Federation of Surveyors Regional Conference for Africa, Accra, Ghana, 8-11 March 2006.

McDonald, E. 2006. Biodiversity conservation in Zambia. Presented at the seminar for the Expanding Horizons Program of Cornell University, Ithaca, NY, 7 December 2006.

Midmore, D. 2007. Microirrigation. Presented at the drip irrigation workshop held in Bogor Agricultural University, Bogor, Indonesia, May 2007.

Moore, K.M. 2007. Integrating scale and disciplinary perspectives: Managing for change in complex adaptive systems. Paper presented at the Rural Sociological Society Annual Meeting, Santa Clara, California, August 2007.

Moore, K.M. and T.A. Dillaha. 2006. Developing an adaptive management approach for small holder innovation. Paper presented at the Rural Sociological Society Annual Meeting, Louisville, KY, 10-13 August 2006.

Moraru, C. 2007. A Cornell initiative to promote food security and rural livelihoods in Zambia: The food processing component. Presented at a seminar to Cornell's Food Science Department, Ithaca, NY, 25 September 2007.

Osofsky, S. 2007. Case studies from Africa: The value of the 'One Health' entry point for facilitating conservation and development. Presented at a seminar at the American Veterinary Medical Association 144th Annual Convention as part of the "One World, One Health, One Medicine: Emerging Global Animal Health Threats' panel, Washington, DC, 16 July 2007.

Osofsky, S. 2007. Moving conservation and development ahead: Progress at the intersection of program and policy. Presented at the seminar at the USAID/DC Ecoagriculture Working Group Meeting, Washington, DC, 17 May 2007.

Osofsky, S. 2007. The value of the 'One Health' entry point for facilitating conservation and development: Case studies from Africa. Presented at the National Foreign Affairs Training Center, Foreign Service Institute, Arlington, Va., 30 August 2007.

Osofsky, S. 2007. The wildlife/domestic animal/human health interface and implications for conservation and development at the landscape scale. Presented at a seminar at the Envirovet Summer Institute 2007 Short Course in Terrestrial and Aquatic Wildlife and Ecosystem Health, White Oak Conservation Center, Yulee, Florida, 29-30 June 2007.

Osofsky, S. 2007. The wildlife/livestock/human health interface and implications for conservation and development at the landscape scale. Presented at the seminar at the national veterinary meeting, "Special Species Symposium" held at Cornell University, Ithaca, NY, 22 April 2007.

Osofsky, S. 2007. The wildlife/livestock/human health interface and its relevance to CBNRM in Southern Africa. Presented at the Africa Biodiversity Collaborative Group and US AID FRAME meeting on "Community-Based Natural Resource Management: Impacts and Lessons Learned" held at the World Wildlife Fund, Washington, DC, 7 May 2007.

Pryde, J.K., J. Osorio, M.L. Wolfe, C. Heatwole, B. Benham and A. Cardenas. 2007. Comparison of watershed boundaries derived from SRTM and ASTER digital elevation datasets and from a digitized topographic map. Presented at the 2007 ASABE Annual International Meeting, Minneapolis Convention Center, Minneapolis, MN, 17-20 June 2007.

Reyes, M.R. 2006. Agroforestry and sustainable vegetable production in Southeast Asian watersheds. Presented at the International Annual Meeting of the American Society of Agricultural and Biological Engineers, Portland, Or., 11 July 2006.

Rios, A. R., G. Shively. 2005. Farm size and nonparametric efficiency measurements for coffee farms in Vietnam. Selected Paper prepared for presentation at the American Agricultural Economics AssociationAnnual Meeting, Providence, Rhode Island, July 24-27, 2005.

Sarukhan, J. and L. Merino. 2007. Challenges to sustainable forest management and stewardship in Mexico. Paper presented at the 6th North American Forest Ecology Workshop, Vancouver, BC, 18-20 June 2007.

Seth, A. 2007. Implications of climate change for the Andean Highlands. Presented at the Environmental Engineering Seminar, University of Connecticut, Storrs, CT, 27 April 2007.

Southgate D., T. Haab and F. Rodriguez. 2005. Payments to the rural poor for the sake of conserving tropical watersheds: A contingent valuation analysis in Ecuador. Presented at annual meeting of Association of Environmental and Resource Economists, Providence, Rhode Island, 19 May 2005.

Travis, A. 2006. Achieving biodiversity conservation through food security and rural livelihoods in Zambia. Presented as part of the Agroecological Perspectives for Sustainable Development series to the Cornell International Institute for Food, Agriculture and Development CIIFAD), Ithaca, NY, 13 September 2006.

Travis, A. 2007. Achieving biodiversity conservation through food security and rural livelihoods in Zambia: The COMACO model. Presented at the seminar at the national veterinary meeting, "Special Species Symposium" held at Cornell University, Ithaca, NY, 22 April 2007.

Travis, A. 2007. Diverse approaches to wildlife conservation: From animal stem cells to rural business development in Zambia (and how a Rotary Graduate Fellowship changed my life). Presented at a seminar to the Ithaca Rotary club, Ithaca, NY, 8 August 2007.

Travis, A. 2007. From the bench to the bush: New approaches to wildlife conservation. Presented at a seminar at the Cornell College of Veterinary Medicine Reunions, Ithaca, NY, 8 June 2007.

Tsuwani, Y.A., A. Manu, T.L. Coleman and A. Osei. 2006. Use of geospatial information management as a decision support tool in land use planning: A case of Ghana. Paper presented at the Fifth International Federation of Surveyors Regional Conference for Africa, Accra, Ghana, 8-11 March 2006.

Turin, C and P. Condor. 2006. Presentación proyecto SANREM. Adaptación de estrategias de manejo de RRNN al cambio climático y de mercado en agroecosistemas del Altiplano. Taller Stakeholders Puno. 18 Agosto 2006. (Spanish)

Turin, C. and P. Condor. 2007. Presentación avances proyecto SANREM: Programa Peru. Seminario Proyecto SANREM - Prácticas y Estrategias de Adaptación a los Cambios Climáticos y de Mercado en Agroecosistemas Vulnerables del Altiplano, La Paz, Bolivia, 29 Junio - 3 Julio 2007. (Spanish)

Valdivia, C. 2007. Adapting to change in the Andean Highlands: Practices and Strategies to Address Climate and Market Risks in Vulnerable Agro-Ecosystems . Valdivia, C. 2007. Climate Variability Household Vulnerability and Adaptation to Change in Andean Ecosystems. Department of Agricultural Economics Seminar Series. October 6. University of Missouri Columbia.

Waller, J. 2007. Utilizing an untapped resource; Manure use in the Bolivian Altiplano as a means to increase overall production. Waller, J. 2007. Utilizing an Untapped Resource; Manure Use in The Bolivian Altiplano as a Means to Increase Overall Production. Undergraduate research project, as part of Plant Sci 4950, based on the SANREM Project “Adapting to Change in the HIghlands”.

Yao, R.T., G.E. Shively and W.A. Masters. 2005. How successful are government interventions in food markets? Insights from the Philippine rice market. Selected paper presented at the annual meeting of the American Agricultural Economics Association held in Providence, Rhode Island, July 24-27, 2005.

Electronic presentations

Aguilera, J. 2006. Breve descripción de las características de Umala: Area de intervención del proyecto SANREM CRSP. Presented at the SANREM CRSP Investigators Meeting, Universidad de la Cordillera, La Paz, Bolivia, September 2006. (Spanish)

Aguilera, J. 2006. Taller de identificacion de demandas tecnologicas en cuatro comunidades del Municipio de Umala: Resultados preliminares . Presented at the SANREM CRSP Investigators Meeting, Universidad de la Cordillera, La Paz, Bolivia, September 2006. (Spanish)

Alwang, J. 2007. Contribuciones de ciencias económicas a la investigación agropecuaria. (Spanish)

Anji Seth. 2007. Understanding climate variability and change in the Altiplano. Seth, A., J. Thibeault and M. Garcia. 2007. Understanding climate variability and change in the Altiplano. Presented at the International Seminar on Global Change and its Effects on the Agricultural Systems of the Andean Zone. 28-29 June. La Paz, Bolivia.

Bambang, P. 2007. Collection and characterization of several indigenous vegetables in Indonesia. Presented at the second annual TMPEGS-Indonesia meeting, Bogor, Indonesia, May 2007.

Barragán, C. 2006. Análisis de vulnerabilidad a la inseguridad alimentaria nutricional. Presented at the First Stakeholder Meeting of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 28 April 2006. (Spanish)

Barrera, V., INIAP. 2007. Manejo de recursos naturales para agricultura de pequeña escala basado en cuencas hidrográficas: El caso de la subcuenca del río Chimbo. (Spanish)

Bosch, D. 2007. Manejo integrado de cuencas hidrográficas . (Spanish)

Carvajal, M.A. 2006. Presentación institucional del CIPCA, Centro de Investigación y Promoción del Campesinado. . Presented at the Scientists Team Retreat of SANREM CRSP Adapting to Change in Andean Ecosystems, Batallas, Bolivia, 26-27 April 2006. (Spanish)

Catacutan, D. 2006. TMPEGS Project presentation to the Municipal Council of Lantapan and the village government of Songco.

Chiong-Javier, M.E. 2006. Women's role in agricultural production and its health consequences. Presented at De La Salle University, the Philippines.

Cortez, R. 2006. Rural income program. Cortez, R. 2006. ADRA Title II Rural Income Program. Presented at the First Stakeholder Meeting of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 28 April 2006. (Spanish)

Cusicanqui, J. 2006. Presentación institucional - Instituto de Investigaciones Agropecuarias UMSA. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 24-26 April 2006. (Spanish)

De Datta, S.K., T.A. Dillaha, and T. Williams. 2007. Trends in USAID support for CRSPs and other university involvement in U.S. foreign assistance. Presented at the ASA-CSSA-SSSA International Annual Meetings, New Orleans, LA, Nov. 4-8, 2007.

Dillaha, T.A. 2007. Future Assessment of the CRSPs. Presented at the Annual CRSP Council Meeting, Portland, OR, August 1-3, 2007.

Dillaha, T.A. 2007. Global Assessment of Best Practices in Payments for Environmental Services. Presented at the Soil and Water Conservation Society International Meeting, Tampa, FL, July 22-25, 2007.

Dillaha, T.A. 2007. Monitoring Changes in Hydrologic Response Due to Land Management Changes at the Watershed Scale: Time Lag and Other Issues. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/presentation/Day1/session2/TheoDillaha.pdf

Dillaha, T.A. 2007. PES Knowledgebase - Overview and Demonstration of a New Tool. Presented at the Pro-Poor Payments for Ecosystem Services USAID PES Policy Seminar, Virginia Tech Northern Virginia Center, Falls Church, Oct. 4, 2007. Available at: http://www.oired.vt.edu/sanremcrsp/documents/PES.Sourcebook.Oct.2007/PolicySeminarPPTs/DillahaKnowledgebase.pps

Dillaha, T.A. 2007. Regional Differences and Similarities in PES Programs for Hydrologic Services. Presented at the Pro-Poor Payments for Ecosystem Services USAID PES Policy Seminar, Virginia Tech Northern Virginia Center, Falls Church, Oct. 4, 2007. Available at: http://www.oired.vt.edu/sanremcrsp/documents/PES.Sourcebook.Oct.2007/PolicySeminarPPTs/DillahaRegionalSynth.pps.

Du, L.V. 2007. Agroforestry and sustainable vegetable production case study: Nghia Trung Village, Bu Dang District, Binh Phuoc Province, Vietnam. Presented at the Vegetable No-tillage workshop, Bogor Agricultural University, Bahasa, Indonesia, May 2007.

E. Jiménez. 2007. Peasant Economies and rural financial services in Bolivia. Jimenez, E. 2007. Peasant economies and rural financial services in Bolivia. Presented at the Semiario Sobre Intercambio de Experiencias en Servicios Financieros Rurales. Guatemaly City, Guatemala. 7-10 August. 2007. (Spanish)

Ella, V. 2007. Irrigation water management: Basic principles and applications. Presented at the vegetable drip irrigation training held in Songco, Lantapan, Bukidnon, Philippines, May 2007.

Ferraro, P. 2007. Ferraro, Regional Synthesis Africa. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/presentation/Day2/session%202/PaulFerraro.pdf

Ferraro, P. 2007. PES Design and Policy Issues-Part II. Presented at the Pro-Poor Payments for Ecosystem Services USAID PES Policy Seminar, Virginia Tech Northern Virginia Center, Falls Church, Oct. 4, 2007. Available at: http://www.oired.vt.edu/sanremcrsp/documents/PES.Sourcebook.Oct.2007/PolicySeminarPPTs/FerraroDesignIssuesII.pps.

Flora, C. 2007. Marco de los capitales para la sustentabilidad de comunidades frágiles en los Andes . Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007. (Spanish)

Flora, C.B. and J.L. Flora. 2006. Coaliciones de persuasión, los capitales y investigación - acción participativa. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz Bolivia, 24-26 April 2006. (Spanish)

Flora, J., C.B. Flora and M.A. Gotrett. 2007. Globalización, modos de vida, y comunidad rural en América Latina. Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP:
Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007. (Spanish)

Garrett, K.A. 2006. Fitopatología "intercropping" y mezclas - Climate Change, biodiversity and ecosystem services: The view from Plant Pathology. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz Bolivia, 24-26 April 2006. (Spanish)

Gilles, J.L. 2006. Redes, conocimientos y tomas de decisiones. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 24-26 April 2006. (Spanish)

Gilles, J.L. 2007. Perceptions, networks, knowledge and climate. Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007.

Gregory, S., A.W. Allen, M. Baker, K. Boyer, T.A. Dillaha, and J. Elliott. 2007. Realistic expectations about the timing between conservation implementation and environmental effects—lessons learned from long-term research [or what scale of change is possible over what period of time]. Presented at the Managing Agricultural Landscapes for Environmental Quality: Strengthening the Science Base. A workshop organized by the Soil and Water Conservation Society, Westin Crown Center Hotel, Kansas City, Missouri, October 11-13, 2006.

Ha, D.T. 2006. An overview of the work plan for the Vietnam TMPEGS Team. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Ha, D.T. 2006. Introduction to the TMPEGS study site in Vietnam - Nghia Trung village. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Ha, D.T. and Nong Lam University Team. 2006. Research plan for the market survey and market value-chain analysis. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Ha, D.T. and Nong Lam University Team. 2007. Baseline studies: Key findings in Vietnam. Presente d at the second annual TMPEGS- Vietnam meeting, Nong Lam University, Ho Chi Minh City, Vietnam, June 2007.

Ha, D.T., P.H.D. Phouc and L.V. Du. 2006. Research Framework and planning for the baseline study of the Vietnam TMPEGS team. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Hepperly, P. 2006. Soil quality and nutritional quality. Fourth International Agroecology Symposium, University of Chapingo, Texcoco, Mexico. (Spanish)

Herrera, E.A. 2007. Efecto de la aplicación de abonos orgánicos y químicos sobre la fertilidad del suelo en el cultivo de la papa (Solanum tuberosum) . (Spanish)

Huang, M. 2007. PES in Asia: Trends, Lessons Learned, Best Practices, and Knowledge Gaps. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/presentation/Day2/session%202/MargieHuang.pdf

Kerr, J. and R. Jindal. 2007. PES Design and Policy Issues-Part I. Presented at the Pro-Poor Payments for Ecosystem Services USAID PES Policy Seminar, Virginia Tech Northern Virginia Center, Falls Church, Oct. 4, 2007. Available at: http://www.oired.vt.edu/sanremcrsp/documents/PES.Sourcebook.Oct.2007/PolicySeminarPPTs/Kerr-JindalDesignIssuesI.pps.

Kurniawan, I. 2006. Agroforestry & sustainable vegetable production in South East Asian watersheds-SANREM (1st year): Case study: Nanggung sub district, Bogor, Indonesia: Objective 2: Markets. Presented at the TMPEGS-Indonesia organizational meeting, October 2006.

Kurniawan, I. 2007. Evaluate collective action strategy to enhance market access for VAF's farmers in Nanggung subdistrict, West Java: A case study on banana marketing. Presented at the second annual TMPEGS-Indonesia meeting, Bogor, Indonesia, May 2007.

Le, V.D., H.D.P. Pham and V.M. Tran. 2006. Research planning of the Vietnam TMPEGS team for technology research. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Luther, G. 2006. Agroforestry and sustainable vegetable production in Southeast Asian Watersheds. Presented at the SE Asia IPM-CRSP Project Workshop: Ecologically Based Participatory IPM for Southeast Asia, Cipanas, Indonesia.

Luther, G. 2006. Pest and pest managment participatory appraisal: Nanggung, West Java, Indonesia, 11-12 September 2006.

Luther, G. and A. Rauf. 2007. Integrated pest management in vegetable agro-forestry systems: The IPM component for SANREM CRSP-Indonesia. Presented at the 2007 second annual meeting of TMPEGS-Indonesia, May 2007 .

Manurung, G., J. Roshetko, N. Nurlaila and N. Astutiningsih. 2007. Vegetable priority species, current practices and species management improvement in agroforestry system. Presented at the second annual TMPEGS-Indonesia LTRP 5 meeting, Bogor, Indonesia, May 2007.

Marks, L.A. 2006. Research methods in risk analysis. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 24-26 April 2006.

Marsh, R. 2006. Beahr Environmental Leadership Prograom - Celebrating 6 Years (2001-2006). Presented at Nong Lam University, Ho Chi Minh City.

Mercado, A. 2006. Vegetable agroforestry systems research activities. Vegetable Agroforestry Workshop, Philippines.

Mercado, Jr., A.R. 2007. Tree vegetable interaction in vegetable agroforestry systems progress report. Presented at the no-tillage vegetable workshop held in Bogor Agricultural University, Bogor, Indonesia, May 2007.

Merino, L., A.E. Martinez, A. Arias and A. Garcia. 2007. Comunidades forestales en México: Resultados preliminares de nuestra encuesta nacional. Presented at the launching of the book Los Bosques Comunitarios de México: Manejo para Paisajes Sostenibles, by D. Bray, L. Merino, and D. Barry at the World Bank offices, Division of Environment and Development, Mexico City, Mexico, 9 May 2007. (Spanish)

Midmore, D. 2007. Resource requirements for optimal crop production and minimal environmental impact . Presented at the no-tillage vegetable workshop held in Bogor Agricultural University, Bogor, Indonesia, May 2007.

Miranda, R. 2007. Enmiendas orgánicas e inorgánicas y la fertilidad del suelo en el cultivo de la papa (Solanum tuberosum). (Spanish)

Moore, K.M. 2006. Building local networks and social infrastructure for natural resources management governance. Presented at North Carolina A & T State University, Greensboro, NC.

Moore, K.M. 2006. Inciting social capital formation: A SANREM CRSP approach in West Africa. Presented at Makerere University, Kampala, Uganda.

Moore, K.M. 2007. Social capital: Lessons from West Africa. Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007.

Moore, K.M. 2007. Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program(SANREM CRSP). Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007.

Motavalli, P. 2006. Adapting to change: Changes in community perceptions and management of soil quality and soil organic matter. Motavalli, P.P. 2006. Presentation to NCR-59 Working Group, Illinois.

Motavalli, P. 2007. Managing soil organic matter for sustainable agriculture and mitigation of the effects of climate change. Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007.

Mubarik, A. 2006. AVRDC- The World Vegetables Center's vision of the role of horticulture in poverty alleviation. Presented at North Carolina A & T State University, Greensboro, NC.

Nazarea, V. 2005. Countering through remembrance: Folk varieties, heirloom seeds and the promise of resilience. Presented at Ecological Threats in the 21st Century Conference, Oxford University, Oxford, UK, 4 July 2005.

Nazarea, V. 2005. Native perspectives on plant germplasm conservation. Presented at Society for Advancement of Native Americans and Chicanos in Science, Denver, Co., 30 September 2005.

Nguyen, V.L., D.T. Ha and V.M. Tran. 2006. Environmental and socio-economic impacts - Research framework and planning. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Nhat, T.T.H. 2006. Research plan for gender-role of women in vegetable production and agroforestry enterprise. Paper presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Nong Lam University Team. 2007. Summary of gender baseline study in Nghia Trung, Vietnam. Presented at the second annual TMPEGS-Vietnam meeting, Nong Lam University, Ho Chi Minh City, Vietnam, June 2007.

Palada, M.C. 2006. AVRDC- The World Vegetable Center's research & development on good agricultural practices for safe vegetable production.

Palada, M.C. 2007. IDE low-cost drip irrigation for vegetable production: A Farmer's Guide. Presented at the Training Course on Drip Irrigation for Vegetable Crops, Songco, Philippines, 24-25 May 2007.

Palada, M.C. 2007. Low-cost drip irrigation systems for smallholder vegetable farmers: Technology transfer- Cambodia. Presentation at a training course on drip irrigation for vegetable crops, Sonco, Philippines, 24-25 May 2007.

PROINPA. 2006. Manejo de recursos naturales basado en cuencas en agricultura de pequeña escala: Áreas de ladera de la Región Andina. (Spanish)

PROMIC/PROINPA. 2007. Proyecto: Manejo de recursos naturales en la agricultura a pequeña escala basada en cuencas. (Spanish)

Raczkowski, C.W. 2007. Measuring soil physical properties to assess soil quality.

Raimadoya, M. 2007. E : Environment. Presented at the second annual TMPEGS-Indonesia meeting, Bogor, Indonesia, 31 May 2007 .

Reddy, G.B. 2007. Vietnam workshop on soil quality: Soil biology and chemistry.

Reyes, M.R. 2006. Introduction to the SANREM Project: Agroforestry and sustainable vegetable production in Southeast Asia watersheds. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Reyes, M.R. 2007. Agroforestry and sustainable vegetable production in Southeast Asian watersheds: Second oral report to USAID-Philippines. Presented to USAID-MISSIONS-Philippines, 28 May 2007.

Reyes, M.R. 2007. Field experiments on vegetable agroforestry, indigenous vegetables, drip irrigation, integrated pest management, and no-tillage in the Philippines, Indonesia and Vietnam. Presented during the second annual meeting of LTRP 5 in Bogor Agriculture University, Bogor, Indonesia.

Rhoades, R.E. 2005. Cotacachi: A case study in governance and decentralization. Presented at International Conference on Mountain Governance and Decentralization: Banf Centre, Canada, 4-8 June 2005.

Seth, A. 2006. Climate change: Why worry?. Presented at the First Scientific Team Retreat of SANREM CRSP Adapting to Change in Andean Ecosystems, Batallas, Bolivia, 26-27 April 2006.

Seth, A. 2007. Global climate change: An introduction and results from the IPCC Fourth Assessment Report (AR4). Presented at the International Seminar on Global Change and its Effects on the Agricultural Systems of the Andean Zone, La Paz, Bolivia, 28-29 June 2007.

Seth, A., J. Thibeault and M. García. 2007. Andean highlands: Implications of climate change. Presented at the Environmental Engineering Seminar Series, University of Connecticutt, 27 April 2007.

Shapiro, H. 2006. Agroforestry and sustainable vegetable production in Southeast Asia watersheds: An introduction to sustainable Cocoa. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Shapiro, H. 2006. The story of sustainable cocoa: Reducing poverty, improving lives, protecting the environment one chocolate bar at a time. Presented at North Carolina A & T State University, Greensboro, NC.

Southgate, D. 2007. Regional Synthesis Latin America. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/presentation/Day2/session%202/DaugSauthgate.pdf.

Suseno B., W. Kusuma and J.Roshetko. 2007. Socio-economic baseline study: Case study: Nanggung sub-district, Bogor, Indonesia. Presented at the second annual TMPEGS-Indonesia meeting, Bogor, Indonesia, May 2007.

Susila, A. 2006. General vegetable production: transplant production. Presented at the Farmer Group Training, Nanggung, Indonesia.

Tangara, E. 2007. Efecto de fertilizantes orgánicos y inorgánicos en el cultivo de la papa (Solanum tuberosum L.) en cuatro comunidades del Altiplano central de Bolivia. (Spanish)

Thinh, P.T. 2006. Policy research framework for the Vietnam TMPEGS Team. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Trikoesoemaningtyas and H. Puspitawati. 2007. Facilitating women's participation.

Tuan, V.D. 2006. A study on the impact of cocoa agro-forestry ecosystem on social economy and environment in a hillside location in Nghia Trung village, Bu Dang district of Binh Phuoc province. Presented at the Vietnam Kick-off Workshop: Agroforestry and Sustainable Vegetable Production in the Southeast Asian Watersheds, Nong Lam University, Ho Chi Minh City, 12 May 2006.

Turín, C. and S. Vargas. 2006. Presentación institucional del Instituto de La Pequeña Producción Sustentable, UNLAM. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz Bolivia, 24-26 April 2006. (Spanish)

Turin, C., P. Condor, C. Flora and J. Flora. 2007. Adaptación al cambio climático y de mercado en comunidades del Altiplano: Estudio de caso de la comunidad de Santa María. Presented at the V Conferencia Científica Interamericana Henry A. Wallace Enfoque de Medios de Vida Sostenibles para
el Desarrollo Agrícola y Rural, CATIE, Costa Rica, 13-17 May 2007. (Spanish)

Valdivia, C. 2006. Metodologías en el estudio de prácticas y estrategias en respuesta a los riesgos climáticos y del mercado en agroecosistemas vulnerables. Presented at the First Scientific Workshop of SANREM CRSP: Adapting to Change in Andean Ecosystems, La Paz, Bolivia, 24-26 April 2006. (Spanish)

Valdivia, C. 2006. Prácticas y estrategias en respuesta a los riesgos climáticos y del mercado en agroecosistemas vulnerables. Presented at the First Stakeholder Meeting of the SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 26-28 April 2006. (Spanish)

Valdivia, C. 2007. Encuesta de línea base estrategias de vida, capitales y prácticas: Municipios de Umala y Ancoraimes, Departamento de La Paz, Bolivia, ciclo 2005-2006. Presented at the Investigators SANREM CRSP Bolivia Seminar: Metodologías participativas, investigación interdiscipliaria y medición de impactos en el corto y mediano plazo, Universidad Mayor San Andrés, La Paz, Bolivia, 9 February 2007. (Spanish)

Valdivia, C. 2007. Estrategias de vida y resiliencia: La interacción clima-mercados, experiencia de los Andes . Presented at the Segundo Seminario Internacional de Investigación SANREM CRSP: Cambios globales y su efecto sobre los sistemas agropecuarios de la zona andina, La Paz, Bolivia, 28-29 June 2007. (Spanish)

Valdivia, C. and J. Gilles. 2007. Practices and strategies to address climate and market risks in vulnerable ecosystems, panel on collective action, participation and Agricultural research . Presented at the Rural Sociological Society 7th Annual Meeting, Santa Clara, CA, 2007.

Valdivia, C. and J.L. Gilles. 2006. Adaptación al cambio en los Andes. Presented at the First Scientific Workshop of SANREM CRSP: Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz Bolivia, 24-26 April 2006. (Spanish)

Valdivia, C. and J.L. Gilles. 2006. Marco administrativo y financiero del proyecto. Presented at the First Scientific Workshop of SANREM CRSP: Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz Bolivia, 24-26 April 2006.

Vargas B. and B. Mamani. 2007. Caracterización de suelos según su índice de fertilidad y capacidad de uso en el municipio de Ancoraimes. (Spanish)

Vásquez, A. 2006. Programa de seguridad alimentaria (PL-480 título II) USAID/Bolivia. Presented at the First Scientific Workshop of SANREM CRSP Adapting to Change in Andean Ecosystems, Hotel Presidente, La Paz, Bolivia, 24-26 April 2006. (Spanish)

Wunder, S. 2007. Hot potatoes in the Payments for Environmental Services debate. Presented at the USAID PES Seminar, Washington, DC, July 13, 2007. Available at: http://www.oired.vt.edu/sanremcrsp/menu_research/PES.PolicySeminar.Oct.2007.php.

Wunder, S. 2007. PES and Poverty Alleviation. Presented at the Pro-Poor Payments for Ecosystem Services USAID PES Policy Seminar, Virginia Tech Northern Virginia Center, Falls Church, Oct. 4, 2007. Available at: http://www.oired.vt.edu/sanremcrsp/documents/PES.Sourcebook.Oct.2007/PolicySeminarPPTs/WunderPovertyAlleviation.pps.

Abstracts

Dillaha, T.A. 2007. Monitoring Changes in Hydrologic Response Due to Land Management Changes at the Watershed Scale: Time Lag and Other Issues. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/2.2.pdf.

Dillaha, T.A., K.M. Moore, S.K. De Datta and M. Bertelsen. 2006. Sustainable Agriculture and Natural Resources Management Collaborative Research Support Program. Journal of Soil and Water Conservation 61(3): 183-184.

Duchelle, A., P. Cronkleton and K. Kainer. 2007. Natural resource conflicts in the Western Amazon: Implications for community management of non-timber forest products . Presented at the Association of Tropical Biology and Conservation (ATBC) Conference, Morelia, Mexico, 15-19 July 2007.

Ferraro, P. 2007. Ferraro, Regional Synthesis Africa. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/7.1.pdf.

Huang, M. 2007. PES in Asia: Trends, Lessons Learned, Best Practices, and Knowledge Gaps. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/7.2.pdf.

Motavalli, P.P., J. Aguilera, C. Valdivia, M. Garcia, E. Jimenez, J.A. Cusicanqui and R. Miranda. 2007. Changes in soil organic C and N due to climate change and socioeconomic factors in potato-based cropping systems in the Bolivian Highlands.

Obonyo, E., P. Ongugo, J. Mogoi, J. Njuguna. 2007. Exclusion, poverty and inequality in decentralized Kenyan forests: Bridging the divide. Abstract submitted to the 2008 Conference of the International Association for the Study of the Commons.

Ongugo, P., J. Mogoi and J. Njuguna. 2007. Internal human conflicts, forest conservation and sustainable development: The case of 5 forests in Kenya. Abstract submitted to the 2008 Conference of the International Association for the Study of the Commons.

Southgate, D. 2007. Regional Synthesis Latin America. Presented at the Global Event for Payments/Rewards for Environmental Services, Lombok, Indonesia, January 22-23, 2007. Available at: http://www.worldagroforestry.org/sea/portals/2/lombok/material/7.3.pdf.

Sparks. A. H., P. Ester, and K. A. Garrett. 2007. Teaching modules for epidemiological concepts in the R programming environment. Sparks. A. H., P. Ester, and K. A. Garrett. 2007. Teaching modules for epidemiological concepts in the R programming environment. Phytopathology 97:S110.

Posters

Abaye O., M. El Hadj and K.M. Moore. 2007. Improved pasture resources in the Madiama Commune of Mali, West Africa: Working with women groups at the village level. Poster. Presented to the Commission on Outreach and International Affairs and at the Outreach NOW 2007 Planning Committee Conference, Virginia Tech, Blacksburg, Va., 24 September 2007.

Abaye, O., M. El Hadj and K.M. Moore. 2007. Improved pasture resources in Madiama Commune, Mali, West Africa: Working with women's groups at the village level. Poster. Poster presented at the Outreach Now 2007 Conference, Blacksburg, Virginia, September 2007.

Gatere, L. 2007. Conservation farming steps for hand-hoe farmers. Poster.

Heatwole, C.D., Y. Her, D. Lewis, A.J. Travis, T.A. Dillaha. 2007. Conservation planning for biodiversity conservation in the Luangwa River watershed, Zambia. Poster presented at the 2007 Annual Meeting of the SWCS, Tampa, Florida. Ankeny, Iowa: SWCS

Her, Younggu, and C.D. Heatwole. 2007. Impact of land use on hydrology of the Luangwa River. Poster presented at the Deans Forum on the Environment, Feb 26, 2007. Blacksburg: Virginia Tech.

Moraru, C. 2007. Here's how to wash your hands correctly! Poster. Ithaca, NY: National GAPs Program at Cornell University

Moraru, C. 2007. Please wash your hands often. Poster. Ithaca, NY: National GAPs Program at Cornell University

Perdew, J. and G. Shively. 2007. The role of pest management techniques in Indonesian cocoa production. Poster. Presented at the annual meeting of the American Agricultural Economics Association, Portland, OR, 31 July 2007.

Seth, A., J. Thibeault and M. Garcia. 2007. Climate variability and change in the Andean highlands. Poster. Presented at American Association of Geographers Annual Meeting, San Francisco, CA, 17-21 April 2007.

Newsletters

Duchelle, A. 2007. Resolving conflict and promoting certification in Bolivian brazil nut stands. PENEWS 2007-1 (March). Bogor, Indonesia: CIFOR.

SANREM CRSP. 2007. SANREM CRSP Newsletter. August 2007. OIRED, Virginia Tech. Blacksburg, Virginia.

SANREM CRSP. 2007. SANREM CRSP Newsletter. May 2007. OIRED, Virginia Tech. Blacksburg, Virginia.

SANREM CRSP. 2007. SANREM CRSP News. February 2007. OIRED, Virginia Tech. Blacksburg, Virginia.

SANREM CRSP. 2006. SANREM CRSP News. September 2006. OIRED, Virginia Tech. Blacksburg, Virginia.

SANREM CRSP. 2006. SANREM CRSP News. March 2006. OIRED, Virginia Tech. Blacksburg, Virginia.

SANREM CRSP. 2005. SANREM CRSP News. September 2005. Blacksburg, Virginia: OIRED - Virginia Tech.

Videotapes

Espaldon, M.V. 2007. Taming the land, the wind and the sun: The story of the Binahon Agroforestry Farm.

Nazarea, V. D. 2005. Conservation with a small c.

Magazine and newspaper articles

Bowman, B. 2006. Plans for no till roller free for down loading. The New Farm, 12 May 2006. Available at: http://www.newfarm.org/depts/notill/features/2006/0506/drawings.shtml.

Hepperly, P. 2005. Twelve reasons to make and use compost. The New Farm, 11 August 2005. Available: http://www.newfarm.org/columns/research_paul/2005/aug05/12_reasons.shtml.

Hepperly, P. 2005. New reasons to perfect organic no till. Dr. Paul's Research Perspectives. The New Farm, 8 December 2005. Available: http://www.newfarm.org/columns/research_paul/2005/1205/fert.shtml.

Hepperly, P. 2006. SANREM: Sustainable Agriculture and Natural Resource Managment: A new dawn for longer-term thinking. Dr. Paul's Research Perspectives. The New Farm, 16 February 2006. Available: http://www.newfarm.org/columns/research_paul/2006/0206/sanrem.shtml.

Ramanujan, K. 2007. Cornell gets U.S. grant to teach Zambians farming alternatives that reduce poverty and protect wildlife. Cornell Chronicle 8 February 2007.

Ramanujan, K. 2007. Profits, not poaching, is message Cornell scientists are aiming at Zambian farmers.

Schatz, J. 2007. A cheaper plan to stop poaching: Give them real jobs (a new program in Zambia teaches former poachers new ways to make a living in order to support conservation goals). The Christian Science Monitor.

Winter, M. 2006. Biodiversity conservation in Zambia: Food security looks like the answer.

Other reports

Astutiningsih, N. and G. Manurung. 2006. Management of vegetable priority species based on their important characteristics for household and market demand in Nanggung Sub District. Badung, Indonesia: Program Study of Biology, School of Life Sciences and Technology, Bandung Institute of Technology.

Cárdenas, F.M. and V.H. Barrera. 2006. Diagnóstico rural participativo desde la equidad de género, social y ambiental en la subcuenca hidrografica des Río Chimbo, Provincia de Bolívar, Ecuador. Quito, Ecuador: INIAP. (Spanish)

Chávez, A.C., J.C. López and D.S. Peña. 2006. Diseño metodológico para la Evaluación y Monitoreo de la Biodiversidad en las microcuencas hidrográficas de los ríos Illangama y Alumbre de la provincia de Bolívar. EcoCiencia. (Spanish)

Chiong-Javier, E. 2007. Songco women biyahidors in Loverslane market: Self-Empowerment through micro vegetable entrepreneurship. Manila, Philippines: De La Salle University.

Chiong-Javier, E. and E. Catacutan. 2005. Results of rapid stakeholder consultation in Lantapan, Bukidnon, Philippines. Manila, Philippines: De La Salle University / Nairobi, Kenya: The World Agroforestry Center (ICRAF).

Ha, D.T. 2005. Report of the preliminary assessment of the study area in Nghia Trung Commune, Bu Dang District, Binh Phuoc Province, Vietnam. Ho Chi Minh City, Vietnam: Nong Lam University.

Ha, D.T., V.D. Le, T.K.L. Duong, T.L. Nguyen, V.M. Tran and D.T. Nguyen. 2006. Socio-economic baseline studies case study: Nghia Trung Village, Bu Dang District, Binh Phuoc Province, Vietnam. Ho Chi Minh City, Vietnam: Nong Lam University.

Jagger, P. 2007. Negotiating livelihoods and sustainability after Uganda's forest sector governance reform. Poverty Environment Network (PEN). Indonesia: CIFOR.

Karpanty, S., T.A. Dillaha, and C. Welsh. 2007. Action Plan for Restoration at Ambohilero Forest, Madagascar, and Similar Areas of Degradation. Final Report Submitted to USAID-Madagascar. SANREM CRSP, Office of International Research, Education, and Development, Virginia Tech, Blacksburg. 47 p.

Kurniawan, I. 2006. First year annual marketing report of agroforestry and sustainable production in Southeast Asian Watershed, Case Study: Nanggung Sub-district, Bogor. Bogor, Indonesia: ICRAF and Winrock International.

Kurniawan, I. and J. Roshetko. 2007. Marketing-Indonesia case study. Nairobi, Kenya: The World Agroforestry Center (ICRAF).

Le, T.L., T.K.L. Duong and D.T. Ha. 2007. Market value chain research: Case study in Nghia Trung commune, Bu Dang district, Binh Phuoc province, Vietnam. Ho Chi Minh City, Vietnam: Nong Lam University.

López, J.A.C. and D.S. Peña. 2006. Diagnóstico preliminar de la biodiversidad en las microcuencas del río Alumbre e Illangama, afluentes del río Chimbo, provincia de Bolívar. Quito, Ecuador: EcoCiencia. (Spanish)

Ongugo, P., E. Obonyo, V. Oeba, J. Mogoi, D. Omedo. 2007. SANREM CRSP project: Kakamega site report. Kenya Forest Resources and Institutions program.

Roshetko, J. and A. Susila. 2005. Preliminary survey of agroforestry and sustainable vegetable production and marketing in Nanggung Sub District, West Java. Nairobi, Kenya: World Agroforestry Centre (ICRAF), Winrock International and Department of Agronomy & Horticulture-Faculty of Agriculture-Bogor Agriculture University .

Setiawan, N.N. and G. Manurung. 2006. Baseline study on vegetable priority species, current practices, and gender roles in vegetable agroforestry system in Nanggung Sub District. Badung, Indonesia: Program Study of Biology, School of Life Sciences and Technology, Bandung Institute of Technology.

Suseno, B. and Arief. 2007. Technology adoption on vegetable agroforestry system in Nanggung: Monitoring study & impact study design. Nairobi, Kenya: World Agroforestry Center (ICRAF).

Trikoesoemaningtyas, H. Puspitawati and T. Herawati. 2007. Gender baseline studies: Agroforestry and sustainable vegetable production in southeast Asian watershed: Case study: Nanggung Sub-District, Bogor, Indonesia. Bahasa, Indonesia: Bogor Agricultural University.

Tukan, J.C.M. and J.M. Roshetko. 2006. Agroforestry and sustainable vegetable production and marketing in Nanggung Subdistrict, West Java: Marketing survey report. Bogor, Indonesia: ICRAF and Winrock International.

Wijaya, K., S. Budidarsono and J. Roshetko. 2006. Socio-economic Baseline studies: Agroforestry and Sustainable Vegetables Production in Southeast Asian Watershed. SANREM CRSP Research Report. ICRAF Southeast Asia.

Winrock International. 2007. Community-based wetland co-management in Bangladesh. Winrock International.

Appendix C: USAID Common Indicators for SANREM CRSP

Indicator	Documentation (list each relevant item by indicator category)
New technologies/management practices under research	• Community Trading Centres (CTC) now operating with tracking of profit and cost centers • Food production now performed in hygienic fashion • food products now tested for safety and quality • food processing methodologies being tested for improvements in phase separation and extending safe shelf life • conservation farming technologies being tested (soil amendments, time frame for maximum benefits) • new husbandry practices for poultry and goat production • resistance to frosty pod and witches broom diseases in cacao (2) • nematicidal plants (1) • soil quality indicator methods • soil amendments • climate trends for Altiplano regions • participatory management approaches to link local and new knowledge • approaches to increase agency (ability to act) on new information • information kits to predict dynamics of change in pests/diseases due to climate change • management of native potato varieties, oca and quinoa • coalition building for adaptation and for market integration • development of the concept of 'net complementarity index' (NCI) for vegetable-tree interactions • researching on technologies that will enhance net complementarity
Technologies or management practices being field tested	• conservation farming methods • effects of COMACO's market linkages on biodiversity conservation • alternative productivity management techniques (maiz, beans and other crops—6)

	• erosion management practices (6) • Soil amendment practices • varieties of native potatoes • information formats for climate, markets, pests and disease dynamics • landscape maps for planning • participatory approaches to link to markets • perennial peanut (Arachis pintoi) for permanent crop cover in vegetable agroforestry systems • developing low cost drip irrigation for cacao-cashew production system • determining irrigation uniformity coefficient under varying slopes and hydraulic heads for the low cost drip system developed by International Development Enterprise • determining the response of indigenous and commercial vegetables under different light intensities • developing an animal or small motor powered no-tillage implement for vegetable production
Partner organizations benefiting from SANREM assistance	• Center for the Study of Economic and Social Reality (CERES), Bolivia • Uganda Forest Resources and Institutions Center, Makarere University • Kenya Forest Resources and Institutions program • Consejo Civil Mexicano para la Silvicultura Sostenible • Universidad Nacional Autonoma de Mexico • Tropical Soil Biology and Fertility (part of CIAT) • International Rural Poultry Centre • PROINPA (Bolivia) • PROMIC (Bolivia) • INIAP (Ecuador) • Sig Agro (Ecuador) • EcoCiencia (Ecuador) • ECOPAR (Ecuador) • Universidad Mayor San Andres (Bolivia) • Universidad de la Cordillera (Bolivia) • Universidad Nacional Agraria La Molina (Peru) • Universidad Nacional del Altiplano (Peru) • PROINPA Foundation (Bolivia); • CIPCA (Bolivia) • ALTAGRO • Bogor Agricultural Unversity

	• Hambaro village farmer association, Indonesia • University of the Philippines-Los Banos • Nong Lam University • University of the Philippines-Open University • Tigbantay Wahig (Lantapan, Philippines) • National Power Corporation (NPC) Philippines
Producer organizations, water user associations, trade and business associations & community based organizations assisted	• Nakalanga Development Association (Mukono District, Uganda) • Nakalanga Environment Conservation Association (Mukono District, Uganda) • Meru Forest Environment and Conservation Protection Association (Upper Imenti Forest, Kenya) • Kenya Tourism Board • Yuracare indigenous population in 3 sites, Bolivia • Acta Fundacional AFIN (national association of indigenous forest product producers), Bolivia • Community Markets for Conservation (COMACO)-Zambia • Illangama and Alumbre Watershed Management Committees, Bolivar Province (Ecuador) • Tiraque Water Users Association (Bolivia) • Anacoraimes community association (Bolivia) • Umala community associations (Bolivia) • Santa Maria community associations (Peru) • Apopata community associations (Peru) • Eleven rural communities in Bolivia and Peru where participatory research groups have been formed or strengthened; two rural communities where participatory assessments were developed;
Technologies made available for transfer as a result of SANREM assistance	• Binahon agroforestry farm video and booklet are being used in the Philippines to illustrate the Binahon's successful approach in sustainable resource management
Policy reforms analyzed with SANREM assistance	• Aberdares Forest, Kenya—community members heretofore unaware of the New Forest Act trained by SANREM partners in its details, including their rights and responsibilities • educational policies in Zambia, differences between provinces (provides a policy background for analysis of SANREM impacts on childhood education) • dairy policy in Ecuador • watershed management policies in Bolivia and Ecuador
Policy reforms presented for legislation or decree as a result of SANREM	• Kibaale District, Uganda—community agreed to enforce law that prohibits farmers from clearing

Assistance	forest within 100m of river banks following training by UFRIC • Mukono District, Uganda—local government agreed to establish forest committees to liaise with local communities about forest laws • Kakamega Forest, Kenya—participants in a post-site visit round table (including the Provincial Forest Officer and forest user groups) agreed to include a clause in user group agreements allowing poor and disadvantaged community members to join groups even if they can't afford membership fees • Local government officials in Lantapan, Philippines expressed strong interest to address developing a package of incentive-based policies for vegetable agroforestry. Local funding has been earmarked to initiate this policy
Analytical studies of policies or institutions disseminated	--

Appendix D: Acronyms

A	aspirations
A	attitudes
ACF	Advocacy Coalitions Framework
ADRA	Adventist Development and Relief Agency International Title II USAID
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVRDC-WVC	Asian Vegetable Research and Development Center – The World Vegetable Center
BAP	Bolivian Andean Platform
C	capabilities
CAPRi	collective action and property rights
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza
CEFS	Center for Environmental Farming Systems
CERES	Center for the Study of Economic and Social Reality
CF, CFU	conservation farming, conservation farming unit
CGIAR	Consultative Group on International Agricultural Research
CI	Conservation International
CIDES	Centro de Investigaciones del Desarrollo Económico y Social
CIFOR	Center for International Forestry Research
CIP	Centro Internacional de la Papa (international potato center)
CIPCA	Centro de Investigación y Promoción del Campesinado
CIRNMA	Centro de Investigacion de Recursos Naturales y Medio Ambiente
COMACO	Community Markets for Conservation
CPA	community participatory assessments
CRC	collaborating research centers
CRSP	Collaborative Research Support Program
CTC	community trading center
DEM	digital elevation model
DLSU	de la Salle University
ECOCIENCIA	Fundación Ecuatoriana de Estudios Ecológicos
ECOPAR	Corporación para la Investigación, Capacitación y Apoyo Técnico para el Manejo Sustentable de los Ecosistemas Tropicales
ESRI	Environmental Systems Research Institute
FFH	Food for the Hungry, Title II USAID
GIS	geographic information system
GPS	global positioning system
HEPS	high energy protein supplement
I	TMPEGS-Indonesia; sometimes Indonesia
IAD	Institutional Analysis and Development framework
ICM	integrated crop management
ICRAF-WAC	International Center for Research in Agro-foresrty – The World Agro-forestry Center
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute

IFRI	International Forestry Resources and Institutions research program
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias
IPCC	Intergovernmental Panel on Climate Change
IPM	integrated pest management
IRPC	International Rural Poultry Centre
ISU	Iowa State University
K	knowledge
KASAC	knowledge, attitudes, skills, aspirations, capabilities
KASAP	knowledge, attitudes, skills, aspirations, practices
KEFRI	Kenya Forestry Research Institute
KSU	Kansas State University
MAPA	USAID Market Access and Poverty Alleviation Project
MARD	Ministry of Agricultural Research and Development
MM	Manupali Model
MU	University of Missouri-Columbia
NAC	national advisory council or committee
NARS	national agricultural research services
NCI	Net Complementarity Index
NCSU	North Carolina State University
ND	Newcastle disease
NGO	non-governmental organization
NLU	Nong Lam University
NRM	natural resource management
P	TMPEGS-Philippines; sometimes Philippines
PA	participatory appraisal
PEN	Poverty and Environment Network (at CIFOR)
PES	payments for environmental services
PI	principal investigator
PMCA	Participatory Market Chain Approach
PR	participatory research
PRA	participatory rural appraisal
PROINPA	Fundación PROINPA (Promoción e Investigación de Productos Andinos)
PROMIC	Programa Manejo Integral de Cuencas
PWES	payments for watershed environmental services
RHA	rapid hydrologic assessment
RMA	rapid market assessment
S	skills
SA	sustainable agriculture
SANREM	sustainable agriculture and natural resource management
SEA	Southeast Asia
SIGAGRO	Sistema de Información Geográfica Agropecuaria
SSFWM	small-scale farmers, both women and men
SRTM	Shuttle Radar Topography Mission
STC	Save the Children, Title II USAID
SWAT	Soil and Water Assessment Tool

TMPEGS	Technology, Marketing, Policy, Environmental and Socioeconomic impact, Gender, Scaling-up
TOP	targeting outcomes of programs
TSBF	Tropical Soil Biology and Fertility Institute
UConn	University of Connecticut
UC	University of California
UC	Universidad de la Cordillera
UFRIC	Uganda Forestry Resources and Institutions Center
UMSA	Universidad Mayor San Andrés
UNA	Universidad Nacional del Altiplano
UNALM IPPS	Universidad Nacional Agraria la Molina Instituto de la Pequeña Producción Sustentable
UNAM	Universidad Nacional Autónoma de México
UNAM-IIS	Instituto de Investigaciones Sociales of the Universidad Nacional Autónoma de Mexico
UNDP	United Nations Development Program
UNZA	University of Zambia
UPLB	University of the Philippines at Los Baños
USAID	United States Agency for International Development
USGS	United States Geological Survey
V	TMPEGS-Vietnam; sometimes Vietnam
VAF	vegetable agro-forestry
VIDIN	vegetable agro-forestry, introduction of indigenous and improved vegetables, drip irrigation, integrated pest management, no-tillage technologies
VSAT	very small aperture terminal
VT	Virginia Tech
WCS	Wildlife Conservation Society
WFP	World Food Program
WTA	willingness to accept
WTP	willingness to pay
ZAWA	Zambian Wildlife Authority

SANREM CRSP
Office of International Research, Education, and Development (OIRED)
Virginia Tech
526 Prices Fork Road, Blacksburg, Va. 24061-0378
Phone: (540) 231-1230. Fax: (540) 231-1402
http://www.oired.vt.edu/sanremcrsp/

USAID
FROM THE AMERICAN PEOPLE

SANREM CRSP

VirginiaTech
Invent the Future