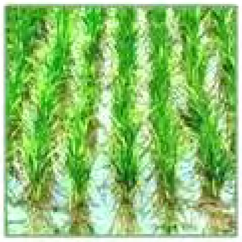

SANRED CRSP Annual Report 2008

October 1, 2007-September 30, 2008

USAID Cooperative Agreement EPP-A-00-04-00013-00

Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

SANREM CRSP

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SANREM CRSP Annual Report 2008

October 1, 2007 – September 30, 2008

Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program

Report coordinators

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

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Contents

1.Figures and tables

Figures

Tables

2. Executive summary

The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) promotes stakeholder empowerment and improved livelihoods through the discovery, organization, and dissemination of sustainable agriculture (SA) and natural resource management (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 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.

Knowledge dissemination

SANREM CRSP training, publications, and other knowledge dissemination products in Fiscal Year 2008 include the following. See Appendix B.

- 98 long-term degree students (53 women and 45 men)
- 11,118 short-term training participants (including 5,690 women)
- 14 refereed journal articles
- 4 book chapters
- 3 theses
- 25 extension publications
- 15 working papers
- 4 websites
- 10 conference proceedings and papers
- 9 papers presented
- 65 electronic presentations

- 3 research briefs
- 5 newsletters
- 15 reports
- 50 posters
- 4 abstracts

Long-term Research Award activities

The five Long-term Research Award (LTRA) activities were awarded between January and March 2006. In Fiscal Year 2008, these activities engaged U.S. and host country researchers, development agents, local officials, and community members in their respective sites. Highlights from each project are 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 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, interactions, and strategies that will deliver benefits equitably to local people while sustaining natural resources. Regional and global comparative research creates a learning environment among critical actors that may lead to more effective policy formation, implementation, monitoring, and enforcement. The project has three main objectives.

- **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

- **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

Project activities

- Data analysis, drafting of site reports, and follow-up training to present findings to stakeholders and identify additional activities were completed in the four target countries. International Forest Resources and Institutions (IFRI) and household data collection were completed in five sites in Mexico and Bolivia, seven sites in Uganda, and six sites in Kenya. A seventh site in Kenya was delayed due to local political unrest, but the team has identified an alternative site that will be completed early in FY 2009.
- Data collection is also complete for national-level surveys in Bolivia and Mexico, each involving roughly 150 communities.
- Poverty and Environment Network (PEN) studies, which collect much more detailed household-level data than the SANREM household surveys, were conducted in Bolivia (two studies, five communities) and Uganda (one study, 18 communities).
- Interactive, post-site visit training was held in Uganda and Kenya.
- Researchers continued to synthesize findings related to the effects of decentralization on rights and decision making, and to prepare for more focused analysis of findings in the final year of the project.
- The first of two regional exchange meetings was held between stakeholders in Kenya and Uganda.

Project highlights

- The most significant project finding to date is that 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.
- At the 12th Biennial Conference of the International Association for the Study of the Commons, partners in Uganda won the prize for the paper that provides the best case-study analysis. Their paper, “Multi-Stakeholder Governance in Land and Forestry in Uganda: Conflict Mitigation, Scale, Knowledge and Collective Action,” presented findings from the Wakisi site (Site 1, Mabira).
- Findings from Mexico’s national survey were used for a report on the conditions and dynamics of community forests in the country. This report was financed by the Food and Agriculture Organization of the United Nations (FAO) to serve as a base for a new joint project of the World Bank and the Mexican government on community forestry.

- The role of women in the two regions appears to vary significantly, with no female-dominated community groups found in the Latin American countries but numerous well-established women's groups in Kenya and Uganda.
- Bolivian researchers have immersed themselves in analyzing and learning from the data collected, sharing findings with communities through "community folders" and in the process writing 10 papers using SANREM and PEN data.
- Partners continue to interact with policymakers and practitioners to ensure that the findings of the SANREM project have impact. The Bolivia team continues to collaborate with the Jatun Sach'a Foundation. The Kenya team has developed connections with numerous forestry-related actors, including the National Museums of Kenya, Maseno and Moi universities, Action Aid, and Nature Kenya. As part of the effort to bring numerous actors together, a regional exchange meeting between Uganda and Kenya allowed representatives from user groups, government agencies, NGOs, and SANREM partners to exchange lessons and experiences, and to develop ideas to improve governance reforms in the future.
- Since the beginning of the project, 2,436 individuals in the four host countries, including user group members, local officials, and national-level policymakers, have 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.
- Results continue to confirm the finding that institutional "fit" and "congruence" at multiple levels of governance, as expected, are key in determining the outcomes of decentralization.

Project activities continue to proceed as planned. Political unrest in Bolivia and Kenya caused delays in both countries, but the Bolivia team nevertheless completed data collection, and the Kenya team will complete its seven sites early in FY 2009.

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" biodiversity conservation model that seeks to use markets to link improvements in rural livelihoods and food security with biodiversity conservation objectives. The Community Markets for Conservation (COMACO) model endeavors to operate on a triple bottom line of being economically, socially, and environmentally sustainable. SANREM research is involved in testing this ecosystem scale activity to identify strengths and weaknesses, and to define the sets of conditions under which it can operate so that the model could potentially be replicated elsewhere. SANREM researchers also are involved in host-country capacity building so that their work can be translated into on-the-ground impacts that improve the operations of the model. The project has four main objectives.

- **OBJECTIVE 1:** determine the extent to which the COMACO model can be economically self-sustaining and the effectiveness of the different COMACO model components
- **OBJECTIVE 2:** integrate new technologies into the COMACO model by applying food, soil, and veterinary sciences
- **OBJECTIVE 3:** determine the extent to which the COMACO model provides self-sustaining social institutions and meaningful roles for COMACO participants
- **OBJECTIVE 4:** determine the extent to which the COMACO model improves biodiversity and watershed conservation

Project activities

- economic analysis of the COMACO business model
- agronomic field trials studying the effects of alternative soil amendments on crop yields in both researcher and farmer controlled plots.
- collection of socioeconomic data on COMACO participants
- census of wildlife in COMACO and non-COMACO areas
- introduction of improved peanut butter processing technologies
- improved food hygiene and safety training and practices
- a “willingness to pay” survey assessed the value of wildlife for tourism
- assessment of potential carbon sequestration payments for COMACO members who sequester carbon due to conservation farming practices utilized and preservation of existing forests

Project highlights

- The business economic analysis showed a 12-month net operating loss through March 31, 2008, of 349 million kwacha (about $75,000 at an exchange rate of 4,665 ZMK/USD) or about $2.14 per participating family. COMACO progress to an economic break-even point is being hampered by continual expansion, costs associated with the training of participants in sustainable practices, data collection to assess their own impacts, and high fuel costs.
- Research on soil and crop sciences quantifying the optimal soil amendments for different agro-ecological zones, slopes, and soils continues. Preliminary results indicate that yields with biochar fertilizer treatment are about 22 percent and 160 percent higher respectively than with cow manure and farmer-managed compost treatments.
- Modification of existing peanut butter processing practices led to significant improvements in phase separation of peanut butter, affecting both quality and shelf life.

- Workshops on hygiene and food safety in collaboration with the Food Science Department at the University of Zambia and resulting improvements in food safety resulted in the receipt of a major COMACO contract for production of a high energy protein supplement (HEPS) used to combat malnutrition and to strengthen patients with HIV/AIDS. Previously, HEPS was imported from South Africa and other countries.
- Preliminary census numbers indicate that wildlife population densities (hippopotamuses and ungulates) are up significantly in COMACO versus non-COMACO (control) areas. COMACO has grown so quickly, its effects are now being felt in these control areas. This underscores the widespread influence and growth of the model as well as the need for a true ecosystem-scale management strategy.
- Potential values in terms of global carbon and avoided deforestation markets have been identified by SANREM researchers and could be used by COMACO to diversify and increase its revenue streams.

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

Lead PI

Jeffrey Alwang, Virginia Tech

Host countries

Ecuador, Bolivia

Research is being conducted at two research sites – Guaranda, Bolivar Province, Ecuador; and Tiraque, Cochabamba Province, Bolivia – in farmer fields, at experiment stations in both countries, and by a network of researchers at U.S. and other universities. Research partners include the national autonomous agricultural research institute in Ecuador (INIAP) and the autonomous agricultural research foundation for Andean crops in Bolivia (PROINPA). Host country partners include Fundación Ecuatoriana de Estudios Ecológicos (ECOCIENCIA) and Sistema de Información Geográfica y Agropecuaria (SIGAGRO) in Ecuador; and Programa Manejo Integral de Cuencas (PROMIC), Center for the Study of Economic and Social Reality (CERES), and Universidad Mayor de San Simón (UMSS) in Bolivia. Coordinators at both sites have engaged local governments, farmer and community groups, and individual decision makers in research planning and implementation. The program is fully participatory, and research findings are influencing decisions at the field, farm, and watershed levels. The project has four main objectives.

- **OBJECTIVE 1**: identify economic, social, political, and environmental conditions in the watersheds and understand the determinants of these conditions
- **OBJECTIVE 2**: generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation. Some alternatives include new crops, on- and off-farm income-generation strategies, and technical improvements to existing practices.

- **OBJECTIVE 3**: create a means of evaluating the impact of alternative actions, policies, and interventions on income generation, and social and environmental conditions. This sub-objective takes individual responses (changes in practices at the field, farm, and market scales) and aggregates them to the watershed scale.
- **OBJECTIVE 4**: build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital

Researchers began their work with participatory appraisals to identify key constraints and concerns. They used these findings to design physical and social science research to identify solutions to the constraints, including research on plant diseases, variety selection and testing, agronomic research on feasibility of alternative varieties, and soil erosion rates and means of mitigating them. The project complements physical science with social science investigation of determinants of livelihood adoption, profitability of livelihood activities, costs and benefits of enhanced NRM, and institutional considerations affecting governance in the watersheds. Physical and socioeconomic findings have been built into physical and social models of the watershed, which have been calibrated and are being used to simulate policies. In the first two years of study, researchers focused on obtaining data and building the models; in the past year these models have been run and tested. Results are being used in an adaptive watershed planning process to inform local decision makers about the effects and consequences of alternative land-use plans. The project has engaged stakeholders at all phases of research to gain their confidence in the process.

Project activities

- completion of participatory appraisals in both sites
- completion and analysis of baseline surveys for both sites
- establishment of a geographic information system (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 in both sites
- field-level agronomic research that is providing information on management techniques and the profitability of alternatives
- development, calibration, and testing of mathematical models of the watershed

Project highlights

- Analysis of the baseline survey of livelihoods for Ecuador shows highly diversified income-generation strategies, major differences in decision making and participation across the two working sites in Ecuador, and a disconnect between stated concerns for environmental quality and household-level decisions. In Bolivia, livelihood strategies are far less diverse, and opportunities outside agriculture are limited. However, several livelihood alternatives that make better use of household and community assets have been identified in both Ecuador and Bolivia.

- In all research communities, soil fertility, crop pests, erosion, and water quality are important concerns, but any effort to introduce watershed management practices needs to recognize interactions between household livelihood activities and the environment. The project has completed experiments to validate more SA practices associated with increased profitability, less use of damaging and costly agrochemicals, enhanced nutrient management, and reduced 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.
- Analyses of marketing systems have helped to identify key bottlenecks and alternative markets. In Ecuador, researchers identified actions to improve access to higher-value milk markets. The project found that the markets are characterized by unequal access to information, domination by a few intermediaries, and lack of access for certain groups. In Bolivia, researchers documented the important role that women play in potato markets and are examining how enhanced information might enable these women to improve their positions.
- Long-term training has proceeded 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 have been possible if relying exclusively on project funding.
- The project finished two graduate students at the master's degree level and one Ph.D. at U.S. universities. Three more students are expected to finish before September 2009[1]. Victor Barrera, the project's coordinator for South America, has completed his Ph.D. in social sciences at Universidad Politécnica de Madrid in Spain. Both the Ecuador and Bolivia sites have made heavy use of *tesistas*, undergraduate students in agricultural sciences and engineering who need a practical research experience to complete their degrees. These students represent a low-cost means of conducting research and an important component of SANREM's long-term training. A clear benefit of the use of *tesistas* is the networking that takes place between the SANREM research team and the students' advisors.
- Short-term training is proceeding according to plans. SANREM scientists have conducted seminars and workshops for partner scientists, local governments, extension specialists, and farmers/citizens among project beneficiaries. The SANREM undergraduate internship paid for nine students to conduct research in Ecuador in 2007, and four students are slated for summer 2009. Three partners from Ecuador and Bolivia visited Virginia Tech in 2008 for monthlong training on watershed modeling. Virginia Tech researchers conducted a series of workshops in Ecuador and Bolivia on watershed modeling and adaptive watershed management.
- The project's activities were heavily leveraged. In addition to the graduate students mentioned above, the undergraduate interns are partly supported by SANREM with other funding from college, university, departmental, and individual sources. The Ecuador team received funding for a proposal to the Ecuadorian Secretaría Nacional de Ciencia y Tecnología. This funding, released beginning in May 2007, amounts to $100,000 for FY 2007 and $120,000 for FY 2008. Researchers are also collaborating closely with the

[1] In addition, Julia Pryde, a graduate student in biological systems engineering at Virginia Tech, received her master's degree posthumously on May 11, 2007.

SANREM cross-cutting initiatives: watershed monitoring, soil quality, soil metagenomics, knowledge to action, and gender.

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 goal of LTRA-4 is to improve the capabilities of rural communities in Andean highland (Altiplano) ecosystems to adapt to climate, market, and social changes. These changes challenge agricultural production, natural-resource sustainability, and livelihood wellbeing due to alterations in the dynamics of the ecosystem that translate into production system risks and income uncertainties. Developing an understanding of how these changes have affected these ecosystems from a scientific and producer perspective is the first step toward developing adaptive strategies. Based on this understanding of the systems, the project has now completed its second year of participatory research and training efforts to address these challenges in the areas of plant varieties, soil amendments, pest management, production strategies, and marketing. These efforts should ultimately change knowledge, attitudes, skills, aspirations, and finally, practice.

Research focused on a second year of field trials and data collection in 10 communities of the Altiplano. Various participatory experiments were conducted in the central and north Altiplano communities in Bolivia, and new soils and pests experiments began in Peru. Landscape research started this year in the northern Altiplano of Bolivia. Co-learning activities and advocacy coalition research continued in Peruvian Altiplano communities, while skills were transferred to Bolivian colleagues. Disciplinary and interdisciplinary research continued on soils, pests and diseases, climate, biodiversity, livelihoods, and institutions. The project has five main objectives.

- **OBJECTIVE 1**: characterize the dynamics of Altiplano agro-ecosystems at various scales in order to understand the impact of climate and markets as drivers of change
- **OBJECTIVE 2**: 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**: develop practices and information strategies (networks to access new information) to address changing conditions and perceived risks
- **OBJECTIVE 4**: develop market access strategies and institutions that contribute to resilience

- **OBJECTIVE 5**: develop stakeholders' capacities and abilities to act to reduce vulnerability and increase adaptation in the face of changing market and climate conditions

Project activities

- validation of climate models for the Altiplano
- assessment of climate change impacts and risks
- field trials of short-season quinoa varieties
- assessment of stakeholder perceptions of climate change risks
- soil amendment experiments
- managed rotation experiments
- investigation of pest (potato moth and potato beetle) population dynamics

Project highlights

- Climate models were validated by comparing them with past observations. These analyses indicate higher rates of evapotranspiration, a weaker early rainy season, and less frequent but more intense rains in the rest of the rainy season.
- Climate change has affected conventional crop production strategies that use natural indicators to decide when, where, and what to plant. Climate change has also affected early planting of high-protein crops such as quinoa and fava beans. For this reason, researchers have been conducting trials on short-season quinoa varieties.
- Climate change appears to increase the incidence of crop pests and diseases.
- Families with more diversified livelihood strategies were found to be less concerned with climate risk. Families involved in both market and non-market exchanges maintain a greater diversity of potatoes than families involved in only one exchange, either market or non-market.
- Soil amendment research is focused on buffering the effects of climate change as well as on soil fertility and productivity. This research included assessment of soil degradation due to changes in fallow length on soil carbon and nitrogen fractions, and C and N mineralization potential; field trials in which several soil fertility practices were compared through quantitative measurements and participatory assessments of experiments by community members; and determination of the effects of soil organic amendments on soil water-holding capacity and heat buffering capacity. Increasing fallow length was found to significantly increase total soil organic C and improve soil fertility in Umala communities.
- Experiments were initiated in Peru to compare impacts on soil quality of *aynokas* (collectively managed rotation systems) and private plots. Soil samples were collected in Umala to link with the soils metagenomics research.
- Researchers continued monitoring the dynamics of insect pests to provide data for modeling the incidence of potato moth and potato weevil. An analysis of the impact of various climate-change scenarios on the incidence of potato blight with emphasis on the Andes and East Africa was completed. Integrated pest management trials are ongoing in Peru (Santa Maria) and Bolivia (Ancoraimes).

- Advocacy Coalitions (AC) is a methodology to strengthen or build the social networks of a community linking it with outside organizations and developing the skills of elected group leaders to interview, research, and build collaborations to make things happen. Advocacy Coalitions were implemented in Peru for the past two years and in Bolivia this year. Bolivian collaborators were trained in AC in Peru, and AC research continues in Apopata, Peru. These activities are being facilitated by the field team in Puno, overseen by El Instituto de la Pequeña Producción Sustentable at La Universidad Nacional Agraria La Molina. The information and knowledge shared by the research team has been used to identify activities or to start negotiating cooperation agreements among the community and external actors who seek to improve capacities in the community to address priorities defined at the beginning of the AC process.
- Participatory research evaluations continued. Both the research and the process of involving farmers in the development of new knowledge was evaluated and compared across sites. A database linking who participates and why with the baseline on livelihood strategies, practices, and perceptions is now functioning with the second-year data of evaluations introduced.
- *Bofedales* (peat bogs) were identified as the main natural capital livelihood resource for alpaca producers in this Altiplano ecosystem.
- Reports, presentations, and posters prepared by the research teams in Peru and Bolivia were disseminated at the annual LTRA-4 and SANREM meetings and other professional conferences.

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

Lead PI

Manuel Reyes, North Carolina Agricultural and Technical State University (NCA&T)

Host countries

Philippines, Vietnam, Indonesia

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 six objectives.

- **OBJECTIVE 1:** <u>Technology</u> – develop economically viable and ecologically sound vegetable agroforestry (VAF) systems
- **OBJECTIVE 2:** <u>Markets</u> – develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies
- **OBJECTIVE 3:** <u>Policy</u> – identify options and institutional frameworks that promote sustainability of vegetable agroforestry production and reward environmental services

- **OBJECTIVE 4:** Environmental and socioeconomic impacts – assess the short- and long-term environmental and socioeconomic impacts for farm families who adopt integrated VAF systems
- **OBJECTIVE 5:** Gender – provide mechanisms to ensure women's involvement in decision making and sustainable production and marketing practices to improve their socioeconomic wellbeing within the VAF system
- **OBJECTIVE 6:** Scaling up – build host-country capacity to manage and disseminate integrated VAF

Project activities

- field research on competition and complementarities between trees and vegetables in VAF systems.
- investigation of water application uniformity in International Development Enterprise (IDE) low-cost drip irrigation systems
- research on vegetable yield response to drip irrigation
- VAF technology adoption research
- investigation of women's access to markets
- assessment of effects of government policy on VAF adoption
- cacao variety field trials in Vietnam
- field research on response of cacao seedling to irrigation and shading in cashew plantation understory
- development of fertilizer recommendations for common Indonesian vegetables

Project highlights

- Integrating trees into vegetable systems increased yields of some vegetables by as much as 53 percent. Net complimentary indices, which measure the benefit of vegetable-tree systems, were developed for some vegetable-tree combinations. Responses of vegetables to varying light intensities indicated that some vegetables grow best in full sunlight, some in medium sunlight, and some in low sunlight. One study found that pruning more than 40 percent of tree canopy reduced vegetable yield. Another study concluded that tree-vegetable competition is nonexistent during the early tree establishment stage and that yields of vegetables increased by 29 percent to 53 percent when the trees were two years old. Malunggay, an indigenous tree vegetable, was found to grow well in acid soils at high elevations. Trees benefited from vegetables as well.
- Tree root pruning and plastic barriers between pruned roots and the vegetables resulted in a 75 percent increase in chili yield.
- In response to a tomato leaf curl virus plague in Northern Mindanao, 15 leaf curl virus-resistant tomato strains were tested and several strains identified that performed well. An extensive evaluation of the water application uniformity of the International Development Enterprise (IDE) low-cost drip irrigation system as a function of operating head and slope was completed. This research resulted in the publication of IDE-drip design guidelines for steep slopes and accelerated redesign of IDE's drip kit to achieve better water

application uniformity. Experiments on IDE-drip with a chili tree system indicated that IDE-drip will likely minimize vegetable-tree moisture competition.

- IDE-drip irrigation systems in home vegetable gardens improved vegetable quality, produced higher yields and resulted in substantial labor savings compared with conventional hand irrigation. TMPEGS is still determining whether drip irrigation is cost effective.
- There is evidence across the three countries that women farmers undertake marketing activities and seek to improve their economic status for the sake of family, especially children's welfare. Family-oriented goals, rather than desire for personal empowerment, motivate them to become market players. TMPEGS is optimistic that market-oriented women's networks could enable and facilitate women farmers' marketing of agricultural crops produced in family farms.
- Policy environments for VAF are supportive in Indonesia and the Philippines. However, VAF policies have tended to benefit rich farmers more than poor ones. Hence, there is a need to alert government policymakers to revise VAF policies to address this bias. Incentives for good environmental practices should be negotiated at local rather than national levels. Whether effective policy action will emanate from national or local government is dependent on the policy environment of the country and the policy being enacted.
- In Vietnam, cacao varieties suitable to integrate with cashew trees have been identified. Improved cacao tree growth was observed when cacao seedlings were planted in the understories of mature cashews, with growth further enhanced by drip irrigation.
- Vetiver grass was found to be effective in protecting cacao seedlings from termites, a major cacao pest in some areas in Vietnam. Growing vetiver grass together with applying vetiver mulch on the seedlings was an effective natural method that can control termite attacks.
- Cacao integration in cashew systems has the potential to increase producer income by 100 percent compared with current cashew-only systems.
- Preventive spraying of cashew trees with insecticides in the Nghia Trung village area had no significant impact on cashew yield. In addition, initial results on the use of herbicides to control weeds in cashew plantations decreased cashew yields. Furthermore, most farmers who used pesticides reported health problems such as headache and fatigue, and they spent an average of $9 more in annual health costs compared with farmers who did not use pesticides.
- A SANREM-funded research station and extension training center (SANREM base camp) was established in Nanggung, Indonesia. The SANREM base camp targets small-scale farmers, both women and men, and demonstrates the benefits of optimizing fertilizer applications. Indonesian scientists determined optimum fertilizer rates for several marketable commercial and indigenous vegetables. Base camp activities have:
    - identified indigenous vegetable varieties suitable for Nanggung conditions
    - identified vegetables growing well under shade, and
    - demonstrated that vermicost is an excellent medium for chili pepper transplant production.
- Brochures on fertilizer application recommendations and management have been development for common Indonesian vegetables.

- Most Indonesian village officials were found to acknowledge the importance of women's participation in social, production, and marketing activities. Hence, a program on revolving credit was developed for women's groups, and post-harvest training (mainly for women) for the vegetable katuk was provided.
- A cookbook for indigenous vegetables was developed to help expand markets through increased consumer demand for indigenous vegetables. It was enthusiastically received by the Nanggung village women.
- Analysis of environmental destruction caused by conventional vegetable production practices in the Philippines was found to be at alarming rates. The Soil and Water Assessment Tool (SWAT) model predicted potential soil erosion in cropped areas 157 times higher than in forested areas**.** However, many vegetable farmers are practicing soil conservation methods that can be traced to past SANREM training and education programs, and their actual soil loss is substantially less.
- As an incentive to adopt VAF system practices, the local government will supply subsidized IDE-drip irrigation systems to farmers. TMPEGS research on VAF systems led the local government developing a municipal ordinance, "Providing an Incentive-support System to Encourage Adoption and Investment in Sustainable Farming Systems in Lantapan, Bukidnon," based on that research. SANREM analysis of agricultural employment in Mindanao shows a consistent decline in agricultural wages, bringing them lower than non-agricultural wage rates. This will affect the forms and rates of technology adoption.
- Philippine scientists have been preparing training manuals and training materials on VAF, drip irrigation, and indigenous vegetables. It was found that innovations such as publication of techno-guides and pamphlets, video documentation of farming practices, and many more strategies enhanced the farmers' awareness and knowledge of VAF systems.
- TMPEGS supported 10 students in long-term degree training. Short-term training involved 271 men and 161 women through five workshops, eight seminars, nine focus groups, and one working group meeting.

Cross-cutting research activities

Gender

Lead PI

Maria Elisa Christie, Virginia Tech

Host countries

Bolivia, Ecuador, Peru, Philippines, Vietnam, Indonesia, Zambia

The goal of the SANREM gender initiative is to determine how the gendered nature of networks linking women to markets affects the quality of information they receive and their bargaining power in the household and the market. As markets emerge and change, producers join together to improve their exchange capabilities. This project compares how gendered networks and collations affect the ability of groups to access and control natural resources and markets to capture value for their agricultural and forest products. The specific proposition is whether women producers' participation in networks consisting primarily of women increases their access to markets. Specific objectives are to:

- increase women's awareness of markets and access to quality information
- identify gaps in networks and implications of findings to empower women to better access markets and increase bargaining power
- increase women's bargaining power through participatory research methodologies that affect social, human, and political capitals, and
- recommend interventions to NGOs, government, and researchers to empower women through training and reorientation of production and marketing initiatives.

Activity highlights

- In one Bolivian site, when women were exclusively responsible for potato sales, households had higher incomes; the lowest income households were those in which only men sold the crop.
- In Ecuador, while men are twice as likely as women to market household agricultural production, women dominate small-scale dairy market production, and men from other communities dominate the market intermediary role.
- In another Bolivian site, women are mostly responsible for marketing because of their negotiating skills and bargaining power with wholesalers who are also women.
- In Southeast Asia, farm women's involvement in marketing their products appears most active in the Philippines study site, where it is sanctioned by both women and men as an appropriate role for women to undertake alone and without spouse partnership. In contrast, women's market participation in the Indonesian site is unusual and not normative. In Vietnam, the situation falls somewhere in between, with husbands sharing equally in decisions about women's role in markets and which traders to use.

Watershed management

Lead PI

Conrad Heatwole, Virginia Tech

Host countries

Bolivia, Ecuador, Zambia, Philippines, Indonesia, Vietnam

The goal of this activity is to enhance the impact of the SANREM CRSP mission by supporting and strengthening the LTRAs and providing technical support and a cross-cutting focus in watershed modeling and assessment. Objectives are to:

- support NRM at a watershed and policy analysis scale by documenting landscape conditions, quantifying natural resources, and defining land-cover and land-use changes 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 programs.

The primary effort in this first year of project implementation has been the installation of field instrumentation for watershed hydrologic monitoring, and specification and purchase of imagery to support land use classification in LTRA project sites in Bolivia, Ecuador, Zambia, Philippines, Indonesia, and Vietnam.

Activity highlights

- In Bolivia, Ecuador, and Zambia:
  - 21 stream gauging stations (pressure sensors and staff gauge) were installed
  - 7 weather stations were installed and are operating
  - 16 recording rain gauges (tipping buckets) were installed
  - initial data was gathered on flow rates at each station
  - training was done on flow monitoring using the salinity tracer method and flow meter for project teams at each location, and
  - base imagery was acquired for 8 project watersheds.
- Satellite imagery was acquired for land use classification in Philippines, Indonesia, and Vietnam.
- Preliminary results of community monitoring are positive. Observers are engaged and enthusiastic in their participation. The quality of the data is good and provides valuable verification of the automated stations and logged data from sensors.
- Education and training are key elements of all site visits: reviewing basic concepts of watershed management, watershed hydrology and monitoring for water balance assessment; and providing instruction on the installation, operation, and maintenance of different types of monitoring instrumentation.
- Basic hydrologic data was collected from all sites and will be used in characterizing watershed response to alternative land management scenarios.
- Support was provided to individual LTRAs in their watershed management impact assessment activities and coordination of impact assessment activities across sites.

Knowledge to action

Lead PI

Esther Mwangi, Kennedy School of Governance, Harvard University

Host countries

Bolivia, Uganda, Kenya, Ecuador, Vietnam, Philippines

The overall goal of the knowledge-to-action cross-cutting activity is to identify the conditions under which research knowledge can influence the practice and behavior of policymakers, practitioners, and resource users. The activity will systematize the recording and analysis of different strategies and processes used by LTRAs 1, 3, 4, and 5 to influence policy and practice to gain an understanding of what strategies worked (or did not) and how research-policy linkages can be enhanced to improve decision making at multiple levels of governance. Research questions addressed by this activity include:

- What strategies have the research projects used to try and link their research to policymakers and resource users? Have those strategies been effective? Why or why not?
- Who are the participants or actors in the research-action arena? Who is included or excluded, and why? How might who participates influence outcomes?
- How do participants in the research-action arena think about research? Do they value research? For what purposes? How do they envision that it may help or hinder them in their daily work?
- What factors influence learning by participants in the resource-action arena? What constraints do they face? What factors influence their actions and priorities?
- How have resource users and policymakers used research findings from these projects in their daily lives and strategic planning? What institutional and other constraints have they faced?
- What kinds of knowledge systems lead to more action and policy responses? Under what conditions can successful knowledge-action efforts be promoted?
- What can be done to improve the knowledge-action link? Specifically, what kinds of insights can the SANREM experience provide to researchers regarding elements of sequencing, timing, and delivery of their knowledge-to-action strategies to ensure maximum impact?

Activity highlights

- The reception of research interventions by local people, resource users, local leaders, government officials, and policymakers has been positive. In the Philippines and Vietnam, for instance, the interest is driven by a genuine concern to access markets for agricultural produce, an important opportunity for improving the livelihoods of the rural poor. In Bolivia and Ecuador (in the watershed management project), while Ecuadorian leaders are aware of the relationships between water quality and land use, they are unsure of how to induce changes in land use and are eager for relevant policy options. On the other hand, Bolivian leaders are only remotely aware of the linkages. In Uganda, the involvement of significant stakeholders in the research partnership as well as consultative interactions between policymakers and practitioners resulted in a reduction of illegal timber harvesting.
- In Uganda, the involvement of stakeholders in research activities and processes has improved communication among actors in the forest sector. Stakeholders are now more appreciative of the magnitude of the problems involved in implementing the forest decentralization policy. However, limited resources of practitioners, including a limited mandate, bureaucratic bottlenecks, and the longer-term nature of solutions, constrain their ability to effect change as well as the pace of change.

Soil quality

Lead PI

Peter Motavalli, University of Missouri

Host countries

Bolivia, Zambia, Indonesia, Philippines

The goal of this activity is to identify effective, low-cost methods that can be used to evaluate soil quality in developing country conditions. Soil quality assessment is a process by which soil resources are evaluated on the basis of soil function. The need for an effective, low-cost method to evaluate soil quality is important in developing countries because soil degradation is a major impediment to sustainable crop growth. Specific objectives are to:

- assess community perceptions and indicators of soil quality, including differences in perceptions of soil quality due to gender, environment, and socioeconomic factors, and
- determine the efficacy of spectroscopic-based (i.e., near-infrared, mid-infrared, and visible range) analytical methods to evaluate soil organic matter fractions and soil quality in degraded and non-degraded soils in a wide range of environments.

Activity highlights

- prepared soil quality survey instruments for community members and agricultural professionals to assess community perceptions and indicators of soil quality, as well as the ideal characteristics of a rapid soil quality test
- conducted background research on laboratory and field procedures for soil quality assessment
- worked closely with the soil metagenomics cross-cutting research activity to identify appropriate field sites for assessing soil quality using both our methods and the soil metagenomics approach
- evaluated several analytical methods for determining changes in soil quality due to soil degradation. Soils evaluated were from a long-term experiment in the United States with different tillage and fertility treatments and from soils collected in Bolivia with different cropping histories. Further testing will be conducted with soils from Zambia, Indonesia, and the Philippines.
    - The potassium permanganate ($KMnO_4$) test for labile carbon (C) shows some promise because it is rapid, relatively low in cost, and can be distributed as a field kit either with a portable spectrometer or with a color chart. However, it was difficult to obtain $KMnO_4$ in Bolivia.
    - The near infrared (NIR) procedure allowed for prediction of several soil C fractions, including the $KMnO_4$ C test, but the portable field instrument may be cost prohibitive for resource poor countries.

Soil metagenomics

Lead PI

Karen Garrett, Kansas State University

Host countries

Bolivia, Zambia

The goal of this research is to determine if soil metagenomics can be used as a quick and reliable indicator of soil quality for developing country soils. Soil metagenomics utilizes molecular techniques to isolate soil DNA and characterize the genetic structural and functional composition of soil biota through comparison of identified DNA with clone libraries. This activity was initiated in response to and supports a USAID biotechnology earmark. The activity objectives are to:

- use pyrosequencing and metagenomic tools to characterize soil microbial communities from soils representing a range of levels of degradation
- identify microbial taxa that are indicators for levels of degradation, especially those that may indicate that the process of degradation has begun but is still reversible, and
- link soil community structure to both the general soil biophysical context and the social science context to understand human impacts and drivers of human decision making for soil management.

Activity highlights

- Four graduate students are currently receiving training through this project.
- The activity sponsored a soil metagenomics workshop at Universidad Mayor de San Andrés (UMSA) in La Paz, Bolivia. There were 47 participants from the university and NGO communities.

SANREM CRSP Management Entity activities

Program review and assessment activities

The SANREM CRSP underwent three major external reviews during FY 2008: a technical program review by the SANREM CRSP External Evaluation Panel (EEP); an administrative management review (AMR) by a USAID-contracted AMR team; and a USAID review. The purpose of the EEP review was to evaluate the scientific progress of SANREM during its first three and a half years. The purpose of the AMR was to evaluate the administrative management practices of both the ME and its sub-awardees. The USAID review was to determine if SANREM would be continued for another five years and if Virginia Tech would continue as the Management Entity (ME). SANREM received positive results from both the EEP review and the AMR, which are summarized below. Based on the continued relevance of SANREM activities to USAID applied research needs, the results of the EEP and AMR reviews, and other considerations, the USAID review recommended that SANREM be renewed for another five years beginning Oct. 1, 2009, at a annual funding level of $3 million.

EEP review

The EEP review was conducted between May 2007 and January 2008. The EEP review was to be used by USAID in determining whether to renew SANREM CRSP for Phase IV. The specific objectives of the EEP review were to evaluate programmatic focus and effective scientific balance of research toward achievement of objectives; identify inadequate performances; identify activities that are irrelevant or marginal to CRSP objectives; consider effective balance between research and training for development of institutional research capability; assess the balance of domestic versus overseas research in terms of effectiveness in removing constraints in developing countries; evaluate the cost-effectiveness of the entire CRSP operation in terms of actual cost of doing business versus costs of alternatives that may be less expensive, more efficient, and more effective; and examine ways of disseminating research results and determining the appropriateness of the research.

EEP review summary

Based on the scientific progress achieved during the first three and a half years of Phase III of the SANREM CRSP, the EEP recommended that the program be extended for an additional five-year research phase. The EEP review team recognized the impressive SANREM knowledge generation and dissemination activities, the excellent graduate training, and the researchers' and ME's commitment to engage in multidisciplinary research. SANREM was judged to be a suitable instrument to capitalize on the strong disciplinary knowledgebase and development research expertise at U.S. universities in addressing complicated issues of developing country contexts through an inter- and trans-disciplinary approach. The EEP commended the SANREM ME and researchers for their proactive responses to EEP suggestions. The EEP also recommended the establishment (funding permitting) of cross-cutting research activities related to soils, water, biodiversity and ecosystem services, governance, institutions, and gender. The ME and SANREM Technical Committee implemented a cross-cutting research activities program when funding became available.

Administrative management review

The SANREM AMR review was conducted between October 2007 and May 2008. The AMR panel was asked by USAID to complete two basic tasks:

- to determine if a review of the original proposal, the annual reports, the EEP reports and the report of the AMR show a record of good performance during the first three years of implementation, and
- based on this evaluation, to state the performance level they would expect during the remaining two years of this award and during any five-year extension of the activity.

AMR summary

With regard to the two basic tasks assigned to the panel, the conclusions are that:

- SANREM has had good performance during the first three and a half years of operation; and more importantly, because of its flexibility and judicious practice of adaptive management, the ME has made adjustments along the way that have steadily increased the efficiency and effectiveness of management of the SANREM CRSP; and
- given the promise of significant results, the admirable adaptive management approach of the ME, its strong partnership with and leadership of the LTRAs, and its good record during the first three and a half years, SANREM likely will operate at an even higher level of performance during the remaining year and a half and during the next five-year extension of the activity.

SANREM Knowledgebase (SKB)

The 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 SA and NRM practitioners with pertinent information on best practices adaptable to site-specific conditions. The SKB is managed by the SANREM CRSP ME, and knowledge is contributed by the ME and SANREM researchers. The SKB allows researchers and practitioners to catalog and search SA and NRM information resources, including books, reports, journal articles, videos, movies, and presentations. As of September 2008, 2,515 information resources had been entered into the SKB, which is accessible online at:
http://www.oired.vt.edu/sanremcrsp/menu_information/SKB.php.

Training and institutional development

The SANREM ME and LTRA activities contributed to both short- and long-term training. Long-term degree training involved 98 students – 53 women, 45 men – from 17 countries. Of those students, 79 are from developing countries. The students are working on 32 Ph.D.s, 36 master's, and 30 undergraduate degrees.

SANREM supported 156 short-term training activities involving 11,118 people – more than half of them women – in 11 countries. There were 103 workshops, 20 short courses, 13 field days, nine seminars, 10 focus groups, and one study tour.

See Appendix A.

3. Long-term Research Award activities

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

Principal investigators (PIs)

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

Host countries

Uganda, Kenya, Mexico, Bolivia

Research objectives

- **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
- **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

The following are among the project's activities this year.

- Field visits were completed in the four target countries, including data analysis, drafting of site reports, and followup training to present findings to stakeholders and identify additional activities. IFRI and household data collection has been completed in five sites in Mexico and Bolivia, seven sites in Uganda, and six sites in Kenya. A seventh site in Kenya was delayed due to local political unrest, but the team has identified an alternative site that will be completed early in FY 2009.

- Data collection is also complete for national level surveys in Bolivia and Mexico (each involving roughly 150 communities).
- PEN studies, which collect much more detailed household-level data than the SANREM household surveys, were conducted in Bolivia (two studies, five communities) and Uganda (one study, 18 communities).
- Interactive, post-site visit training was held in Uganda and Kenya.
- 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 the final year of the project.
- The first of two regional exchange meetings were held between stakeholders in Kenya and Uganda.

The following are project highlights.

- Partners in Uganda won the prize for the paper that provides the best case study analysis for their paper "Multi-Stakeholder Governance in Land and Forestry in Uganda: Conflict Mitigation, Scale, Knowledge and Collective Action" at the 12th Biennial Conference of the International Association for the Study of the Commons. This paper presented findings from the Wakisi site (Site 1, Mabira).
- Findings from Mexico's national survey were used for a report on the conditions and dynamics of community forests of the country. This report was financed by FAO with the purpose to serve as a base of a new joint project of the World Bank and the Mexican government on community forestry.
- The role of women in the two regions appears to vary significantly, with no female-dominated community groups found in the Latin American countries but numerous well-established women's groups in Kenya and Uganda.
- Bolivian researchers have immersed themselves in analyzing and learning from the data collected, sharing findings with communities through "community folders" and in the process of writing 10 papers using SANREM and PEN data.
- Partners continue to work hard to interact with policymakers and practitioners, and to ensure that the findings of the SANREM project have an impact. The Bolivian team continues to collaborate with the private non-profit Jatun Sach'a Foundation. The Kenya team has developed connections with numerous forestry-related actors, including the National Museums of Kenya, Maseno and Moi universities, Action Aid, and Nature Kenya. As part of the effort to bring numerous actors together, a regional exchange meeting between Uganda and Kenya allowed representatives from user groups, government agencies, NGOs, and SANREM partners to exchange lessons and experiences and to develop ideas to improve governance reforms in the future.
- In the four host countries since the beginning of the project, 2,436 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.

- Results continue to confirm the finding 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.

Project activities continue to proceed as planned. Political unrest in Bolivia and Kenya has created delays in both countries, but the Bolivia team nevertheless completed data collection, and the Kenya team will complete its seven sites early in FY 2009.

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 NRM and improving 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:** 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 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
- **OBJECTIVE 3:** 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 impact 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[2] 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 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 multitiered 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 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, and 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.

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[2] In this context, “institutions” are defined as systems of rules.

Institutional analysis framework

The institutional analysis employed in the project is structured by an adaptation of the Institutional Analysis and Development (IAD) framework (Figure 3-1). 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 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 3-1. 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 among local community leaders and a variety of actors, such as resource users, central government representatives, and private interest groups who operate under varying contextual conditions.

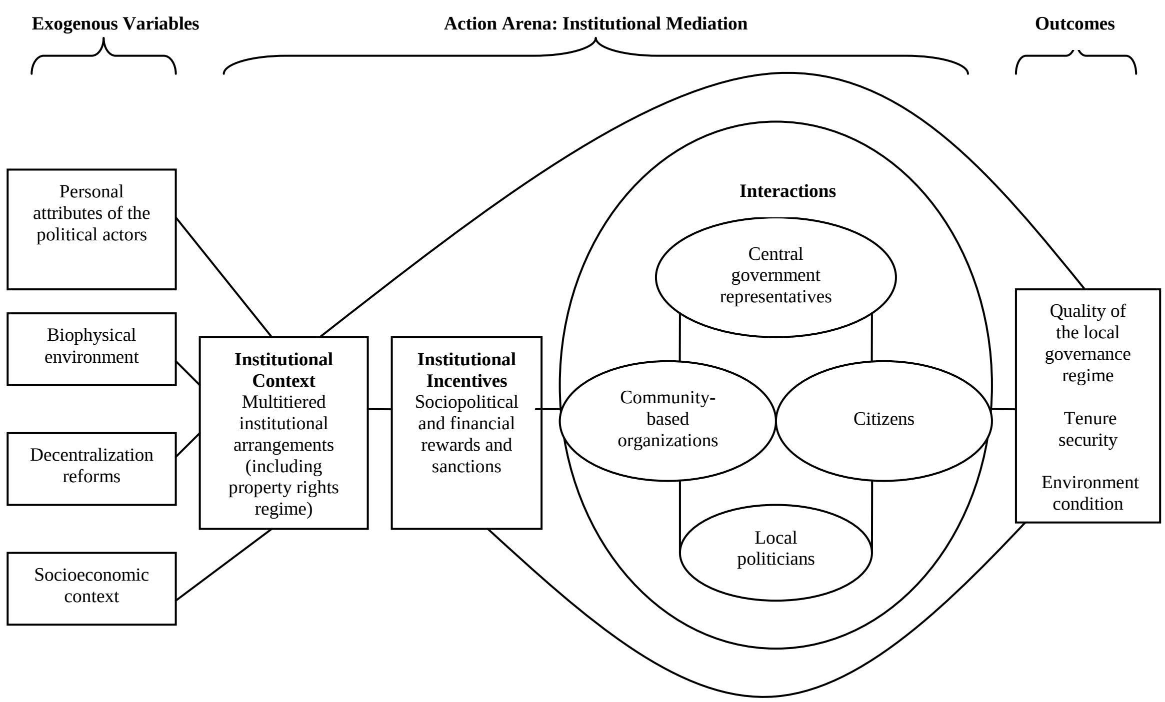

Figure 3-1. From Andersson, Laerhoven, and Gordillo (forthcoming), adapted from Ostrom (2005)

We propose that the characteristics of these interactions in the local context will depend in part on local-level institutions as well as national-level institutions, particularly the mandate given to local governments or communities and their experience with 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 3-2 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

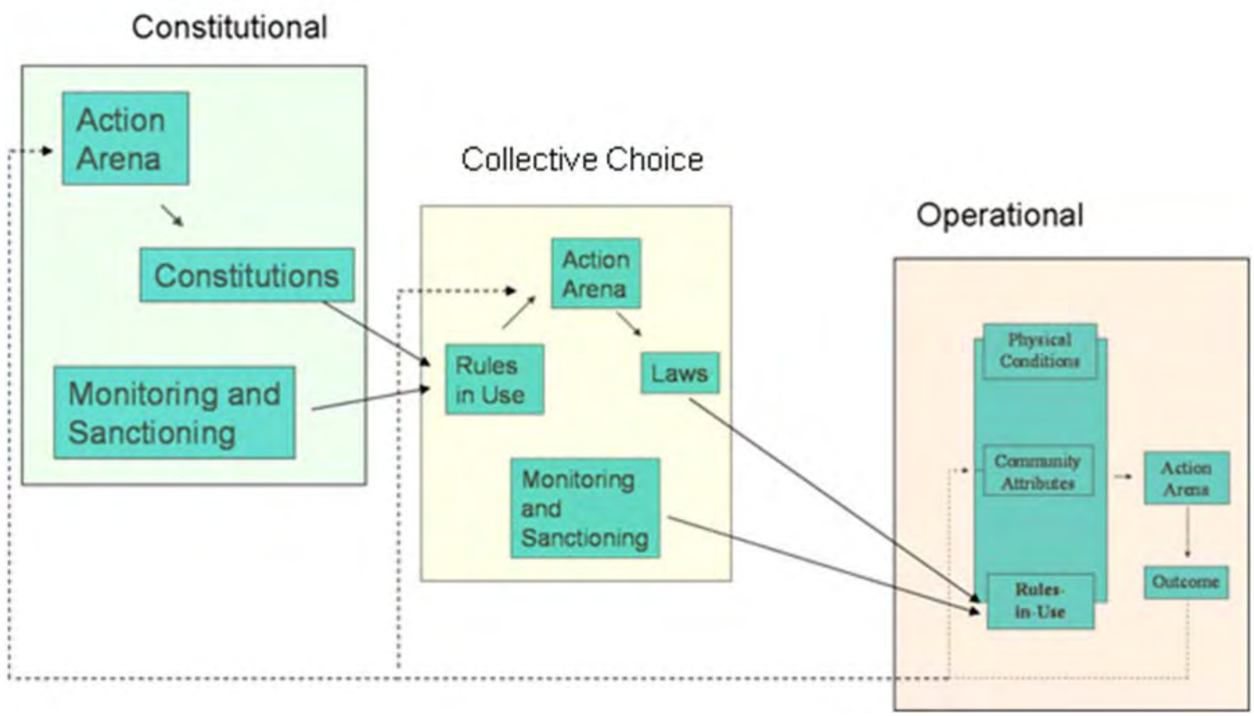

Figure 3-2. The nested nature of governance decisions, adapted from McGinnis (2000)

products to harvest on a certain day, where they will harvest, whom 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 3-2 illustrates the multilevel dynamic of how decisions at one level are influenced by those at other levels of governance. The nested governance decisions in Figure 3-2 can be made by any or all of the actors in the action arena of Figure 3-1. That is, for any given level of spatial aggregation, including all systems of the SANREM framework – field, farm household/enterprise, community/watershed, ecosystem, policy/market – decisions can be made at the operational, collective choice, or constitutional level.

At the collective choice level, policymakers 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 policymakers, are sometimes appointed by the community members themselves in a self-organized village council; at other times the participants are appointed by government officials. Whoever makes the collective choice decisions, these are influenced by rules created at the constitutional level of governance. At this highest level, 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 among public policies, property right regimes, local institutional arrangements, and the changing character of natural resources. One of the most important tasks for the researchers in this stage 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, and 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 to draw on 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, crosssectional 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 in our analysis.

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 regards to community governance activities. Second, by collecting data in multiple communities in each country, we are in a position to 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 3-1 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 (NRM). From this central proposition, we derive several testable sub-hypotheses and several more specific research questions and sub-questions, outlined here and in Table 3-1 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 forest governance institutions and in effective forest conservation. The second question looks at how decentralization policies change property rights to the forest, including identifying the 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 out what specifically is meant by decentralization in the various countries and determining what aspects of these policies have what repercussions. Decentralization encompasses a vast range of policies that need to be considered carefully in their effects at the community and resource level.

Implications for research, action, and policy

In an effort 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 current 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, we also aim 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 our NACs 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 which to learn what parts of our research are useful and how policymakers would plan to use it. The regional exchanges will allow interactions between policymakers and other practitioners in each region, that is, East Africa and Latin America. We anticipate that these regional exchanges will facilitate not only shared learning about decentralization – 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 for managing other ongoing challenges in the forestry sector as well (see the case of degazetting Mabira forest in Uganda).

But what will we learn that we plan to share with policymakers, practitioners, and other researchers? First, that decentralization reforms are not uniform and that they have uneven impacts. Second, holding ecological and cultural settings constant, that these uneven impacts are conditioned by several factors, which include the level and degree to which power, authority and resources are devolved; the range and security of rights to resources 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 try and 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 policymakers, 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 3-1. 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 LTRA-1 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 among multiple levels of governance, especially as they pertain to the assignment of property rights, and 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 condition indicators for comparative NRM studies. - Site reports to
	2.2 How do rule changes attributed to decentralization affect the degree of accountability and empowerment within resource systems?	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 will be used to see whether those with high discount rates invest less in governance and suffer more forest degradation after decentralization.	

				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 database, analyze whether community self-monitoring and enforcement is associated with superior user assessments of forests.	

Research progress by objective

Project-wide findings

A gender-based analysis of previously collected IFRI data from the four countries showed that Kenya and Uganda have male-dominated, mixed, and female-dominated user groups; Bolivia and Mexico have no female-dominated groups. It also found that the presence of more female members in user groups is associated with less investment in some forest improvements (maybe due to resource constraints), more restrictive rules on forest use, lower monitoring and enforcement, and less conflict.

As reflected in some of the country-specific findings below, institutional fit and congruence at multiple levels of governance continue to be key in determining the outcomes of decentralization. Failure to account for compatibility of reforms with local-level institutions can create perverse, unanticipated effects, or alternatively have no effect at all despite stated goals of improved livelihoods and resources. In Bolivia, as previously in Uganda, researchers found that forest health has declined after decentralization compared with forests where decentralization has not been implemented. Researchers continue to detect a lack of information at the local level on benefit structures, responsibilities, and processes under current reforms. However, as in Kenya, communities informed of their rights can take the initiative in forming associations and in pursuing income-producing activities that are compatible with forest conservation. Clearly, close attention needs to be paid to the details of planning and implementation if decentralization is to have the positive effects it is reputed to bring.

Findings by country

Uganda

In a paper that won the award for best case study at the biennial meeting of the International Association for the Study of the Commons, Ugandan scholars studied Mabira forest (Site #1), and found that collaborative forest management initiatives, constrained by expectations of demonstrable impact within limited timeframes, lack the flexibility and adaptive capacity necessary for social learning. They further found that forest condition is declining both within and outside of protected forest boundaries: The average diameter breast height (DBH) was just 19cm, much lower than the 40cm DBH expected in this ecosystem. The team also found just 32 species of trees, a sharp decline from the 119 species recorded in 1980 and 142 species recorded in 1968. Overall, they observe that

> “[a]t this time, local institutions have little incentive to maintain large-scale forest patches solely to mitigate environmental impacts. They do not want to put forth the effort on behalf of the state or international organizations that only produce costs at any level of the enduring administrative hierarchy. Here is a case where robust local institutions could actually “degrade” the global forest commons from the perspective of conservationists, while successfully maintaining the flow of forest products to local users.”

They conclude that sustainable, multi-stakeholder goals are more achievable when designed to allow for adaptive governance at multiple levels, rather than turning to simple devolution. They apply this concern directly to the new Forest Act (2003), which focused narrowly on forests rather than on promoting (or maintaining) land-use patterns appropriate to the biome in general.

The following are other site-specific findings in Uganda.

- The collaborative resource management committee is working very effectively together with Uganda Wildlife Authority in Kapkwai forest, Mt. Elgon Forest reserve (Site 6).
- Collaborative resource management has collapsed in Bufuma forest in Mt. Elgon forest reserve.
    - Both sites are managed by the Uganda Wildlife Authority, but there is more population pressure in Bufuma than in Kapkwai.
    - The relationship between Uganda Wildlife Authority officials and local communities is poor in Bufuma but good in Kapkwai.
    - There is increasing commercialization of products harvested in both sites.
    - The share of monetary benefits to both communities from park revenue is limited.
- Residents of Nkenga in Gombe (Site 7) would like to manage Kizzikibi forest reserve through collaborative forest management arrangement with the National Forest Authority to reduce the increasing rate of illegal harvesting and encroachment on the forest.
- Local residents of Nkenga and the Mpigi district officials believe that NFA is more corrupt than the former Forest Department and is less likely to effectively protect the forests in the district.

Kenya

Results from the analysis of data collected before July 2008 showed that women were not well represented among the executive members of the 10 associations analyzed. Of the total number of officials across the associations surveyed, only 28 percent were female. Only 17 percent of the associations had ever elected a woman as chair or president; these cases had all occurred within the last five years.

Interestingly, more than 50 percent of both male and female household heads had never had any contact with government forest agents, a statistic that raises questions about both the reach of government attempts at decentralization and the involvement in forest management activities at the household level.

There were also interesting disparities in the reasons given by men and women for joining forest groups. Sixty-seven percent of men cited better forest management and future benefits as their reason for joining an association, compared with 75 percent of women. Men also cited increased access to forest products (22 percent) and access to other benefits (11 percent) as other reasons; no women cited these. In contrast, 25 percent of women said they joined the association because they felt it was their duty to protect the forest for the community and the future; none of the male respondents cited this reason. These differences highlight the need for decentralization efforts to target women specifically, to ensure both that they have equal access to benefits and that their differential values are incorporated into reforms.

Communities are now getting more involved in forest decision making and forest business because the new Forest Act allows them to take more part in decision making regarding the forest through the community forest associations. Arabuko Sokoke (Site 6) is a good example of a location where this is happening. Many community members, especially in the participatory forest management (PFM) pilot sites, have been made aware of their new rights and are exercising them through participation in the preparation of management plans and harvesting levels for the pilot forests. Forests are also being opened to communities that can harvest products to generate income. This has resulted in more community members taking part in activities that do not interfere with conservation activities but that contribute to income generation such as butterfly farming, beekeeping and honey harvesting, ecotourism, making of wood carvings for sale to tourists, and sale of seed and seedlings.

Meanwhile, although forest managers are expected to collaborate and take the lead on PFM activities with community members, they are not adequately equipped to take up the role. Some are also reluctant to hand over some of their powers to the communities, and most are classical foresters who have not been trained in PFM.

Results from two sites, Arabuko-Sokoke and Ramogi, indicate that the economic condition of the community members is very low. In Ramogi, the agricultural output from the land is low, and fishing, the main economic activity, has been hampered by the hyacinth that has blocked Lake Victoria and reduced the fish population. The community's dependence on the forest is also high.

There are few conservation efforts in Ramogi, and it is only recently that the National Museum of Kenya has initiated an ecotourism project with community members in collaboration with other organizations. Arabuko Sokoke has many organizations working towards its conservation efforts. The community forest associations in the area are also strong and have been working on participatory forest management and activities over the last few years.

Mau forest, Site 7, is one of the major water towers in the country. It provides water to most of the major rivers in the country. Lakes Nakuru and Victoria, among others, are directly supplied with water from rivers arising from Mau. But Mau forest has undergone massive deforestation and huge excisions for settlements, leading to a reduction of water in many parts of the country. As a result, there has been a huge national and international outcry over the massive deforestation.

Bolivia

A preliminary analysis by CERES of IFRI and household surveys explored perceptions of forest conditions before and after decentralization, based on data collected 10 years ago and again in 2008. An original hypothesis of LTRA-1 was that higher participation at multiple governance levels should be positively related to sustainable forest management; however, the preliminary analysis showed that, in highland communities where decentralization reforms have not been implemented, forest conditions have been better than where reforms have taken place (and where theoretically participation is higher). Furthermore, the team found that communities showing worsening forest conditions have more heterogeneous actors than those with improving forest conditions. Data are still being analyzed; the team should have more information on these findings soon.

Results of the PEN quarterly household-level income analysis demonstrated greater forest income dependency among extractivist households in Pando, Bolivia, compared with Acre, Brazil. This included the relatively large contribution of Brazil nut income to households in Pando. Forest-based income was 58 percent of the total share among households sampled in Pando, with Brazil nuts alone contributing 43 percent. Conversely, in Acre, forest-based income was 25 percent of the share among households sampled, with Brazil nuts contributing only 10 percent. The study also found that "unclear property rights, coupled with the dominant role of the Brazil nut in the Pando household economy, create an extremely high degree of conflict during the harvest season – primarily theft of nuts. Conversely, a secure land tenure system in Acre … has resulted in less conflict" (Duchelle, "Natural resource conflicts in the Western Amazon: Implications for community forest management").

Mexico

- The team in Mexico found that, as a result of emigration, women are increasingly occupying posts in local governance structure, which increases the duties they must address in their already busy lives.
- The team also found that some migrants are returning to their communities and tend to be given posts with heavy responsibilities as a way to "make them pay" for the years outside the communities. This pattern poses difficulties to the continuity of community projects, including forest management.
- Both household surveys and national survey results show that forest contribution to family income is very limited; that the main uses in most forest communities in Mexico are domestic uses (fire wood, grasses); and that some of these extended forest uses compete with the conservation of the forest cover.
- The analysis of the forest data showed conservation of forest cover in the four cases where the data have been gathered; nevertheless, major sources of pressure on the forests (e.g., presence of forest pests) were detected even in cases where community commercial logging does not take place.
- The analysis of the forest data shows a high biodiversity, presence of key species, and maintenance of the typical structure of the forest in the two communities with cloud forests where IFRI cases have been implemented. In one of them, Comaltepec, commercial logging has taken place continually since 1950s.

Accomplishments by objective

Activities specific to each project objective are listed below.

OBJECTIVE 1: 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 (TOPS) 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 during Year 3 under Objective 1 and their respective outputs/results/impacts include the following.

- Pre-site-visit trainings were held in Uganda Sites 5-7, Kenya Sites 5-7, Mexico Site 4-5, and Bolivia Site 4-5. Across the four countries, at least 39 individuals (community members, local officials) were trained in research methods. Another five students were trained as field assistants in Mexico.
  (community/watershed, policy/market)
- Introductory meetings for larger audiences within the community were held in Bolivia Site 5, Uganda Site 7, and Kenya Sites 5-6 (including three separate trainings at different locations in Site 6). More than 300 people attended these meetings. Community members were introduced to research goals, conservation and decentralization policies.
  (community/watershed, policy/market)
- Resource and recourse diagrams were created for Uganda Sites 5-6 and Kenya Sites 4-6. 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 needs.
  (community/watershed, policy/market)
- IFRI community and household data collection was completed in Uganda Sites 4-7, Kenya Sites 5-6, Mexico Sites 1-5, and Bolivia Sites 4-7. Kenya has been delayed due to unrest in Mt. Elgon, location of Site 7. However, the team has selected an alternate site and will complete data collection early in FY2009.
  (farm household/enterprise, community/watershed)
- Data from the Uganda PEN study and Bolivia PEN study 2 have been entered and cleaned and are being analyzed.
- Site reports were completed for Kenya Site 3, Bolivia Sites 5-6, and Uganda Site 4.
  (community/watershed, policy/market)
- A steering committee meeting was held in February.
  (policy/market)
- Interactive post-site-visit training was held in Uganda Sites 4 and 7, and Kenya Sites 5-7. 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. The Kenya team has also forged strong links with the Ogiek community, an endangered indigenous group in Mau forest (Site 7), and held additional training in Site 6 on participatory forest management. At least 114 people participated. Details are included in the appendix.
  (farm household/enterprise, community/watershed)
- Partners in Kenya and Uganda held a regional exchange meeting to discuss lessons learned and ways to improve governance reforms in both countries. The two-day meeting

was attended by five members of the national advisory councils, six members of the Kenya and Uganda research teams, three Mpigi District (Uganda Site 7) technical and political leaders, three user group representatives (from Sites 1, 2, and 4 in Uganda), and representatives of the Forest Sector Support Department of the Ministry of Water and Environment, the Mukono District Forest Services, and the National Forestry Research Institute (Uganda). A similar meeting will take place between Mexico and Bolivia in FY 2009.
(policy/market)

- Dissemination of findings continues through policy briefs on sacred forests and property rights in Kenya, the role of various actors in forest decentralization in Uganda, and other means.
- In Uganda, a controversial plan to degazette Mabira forest that had been suspended appears to have been resumed. The Uganda team is focusing effort on communicating research results to policymakers, activists, and the community of interest at large to inform decision making.

OBJECTIVE 2: 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 effects of different policies at the local level (e.g., the impact on different property rights arrangements on behavior) and knowledge of local customs and processes. The degree of advancement toward this objective varies widely depending on the country and community.

Activities completed this year under Objective 2 and their respective outputs/results/impacts include the following. Many of the tasks relevant here also relate to Objective 1 so are not repeated.

- Partners in Mexico and Bolivia have completed national-level forest community surveys, including 146 forest communities in Mexico and 149 in Bolivia.
  (policy/market, ecosystem, community/watershed)
- National advisory council members from Kenya and Uganda participated in the regional exchange meeting held in August.
- Uganda and Kenya partners are planning to form a network with a group of East African scientists to strengthen participatory approaches in NRM in the region. A meeting organized by the Association for Strengthening Agricultural Research in Eastern and Central Africa was convened in Uganda toward this objective.
- The Kenya team displayed at the Kenya Forestry Research Institute (KEFRI) open day in June at Gede, Malindi, attended by more than 500 people from various organizations and the general public.
- The Kenya team also held meetings with policymakers and other government officials in Sites 5, 6, and 7, thus creating or strengthening networks. They have linked community members to government departments that play a role in improving their livelihoods. The SANREM team was also able to establish lines of communication with other actors

working directly with the communities, such as National Museums of Kenya, Dominion Group, Maseno and Moi universities, Birdlife International, and Nature Kenya.

- In Site 5 (Ramogi), the Kenya team has enabled or helped sustain links between various actors and the community, including government departments and organizations like National Museums of Kenya, Research Program on Sustainable Use of Dryland Biodiversity, Tourist Trust Fund, Dominion Group, Maseno and Moi universities, and Got Ramogi Community Forest Conservation Trust.
- The Kenya team also held meetings with CARE Kenya, Plan Kenya, and Action Aid. A new partner, Friends of Lake Victoria, was added to the project.
- The Bolivia team along with Krister Andersson held training in institutional analysis in the context of community forestry for the national advisory committee. Attendees included academics, practitioners, and representatives from the public sector and NGOs. Eight people attended, one woman and seven men, including representatives from the Autonomous University Gabriel Rene Moreno-Santa Cruz, University of Fridbourg (Germany), BOLFOR II (a phase of the Bolivia Sustainable Forest Management Project), Jatun Sach'a, and the National Forest Department and its superintendent. It was suggested that the group hold similar meetings in the future to continue the discussion, to build a common understanding, and to accommodate the different interests in community forestry across Bolivia.
- The Bolivia team continues to work closely with and receive support from the private conservation group PROMETA and Jatun Sach'a. CERES's record of working with communities to improve their technical learning, production, and general capacity for forest management contributes to the willingness of these organizations to provide support. Maintaining relationships with Jatun Sach'a and others has been challenging because of high levels of political unrest in the country.
- At the request of the forestry superintendent of Cochabamba, the team also assisted with a workshop about the new rule regarding community forest managers.
- As mentioned above, Uganda Forestry Resources and Institutions Center (UFRIC) hosted a policy round table with Indiana University graduate student Pamela Jagger to present the findings of her study. Attendees included representatives from Makerere University, various NGOs, community-based organizations involved in forest management, and the Uganda Wildlife Authority.
- Researchers in Uganda also discussed their research and findings with the chief game warden at Mt. Elgon National Park (near Sites 6 and 7) and with the director of natural forest management for the National Forest Authority and the acting chairperson of the authority's board of directors (re: Gombe, Site 7).
- A representative from the Uganda Wildlife Authority was closely involved with the training held in Site 4 as well as activities around Sites 5 and 6.
- Numerous papers have been completed or are in process, with several being presented to various groups in all countries. These are detailed above under "knowledge dissemination."

OBJECTIVE 3: 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 as dedicated cross-community trainings are implemented in FY2009. Nevertheless, several trainings have already taken place that help achieve the aims of this objective.

Uganda and Kenya have both implemented extensive post-site-visit training. UFRIC held capacity-building training in Gombe (Site 7), attended by 11 people including four representatives of the local council and one government official. The group discussed the need to conserve Kizzikibi forest reserve as it was when the team first visited in 2001; the role of communities and stakeholders under decentralized forest management; lobbying and negotiating for collaborative forest management arrangements; enhancing household incomes from non-forest activities; and forest monitoring. All of these skills increase the ability of the community to anticipate and adapt to changes.

UFRIC also held training to strengthen leadership and management capabilities in the local communities of Mugomba and Mujanjabula (located within Site 4), which are involved in collaborative forest management. A total of 40 people were trained. This group included Rakai district officials involved in natural resource management, local councilors, and forest association members.

The Uganda team also held a second post-site visit, capacity-building training in Malamagambo/Sango Bay (Site 4). A total of 33 were trained, including local councilors and forest association members. The training focused on sharing of experiences between the National Forest Authority and Uganda Wildlife Authority related to community participation: comparing collaborative resource management under UWA-managed national park and collaborative forest management under NFA-managed forest reserves.

The Kenya team has linked community members in Sites 5-7 to government departments that play a role in improving their livelihoods. The team has also forged strong links with the endangered Ogiek community in Mau forest.

Kenya researchers held additional training for community members on participatory forest management and for government officials on management of natural resources at Gede (one of the blocks of Arabuko forest, Site 6) in the hall owned by the community forest association. A total of 30 people trained.

This ongoing training will help to increase communication among actors at multiple levels of governance, enhance the ability of communities to monitor policymaking and anticipate its effects on livelihoods, and familiarize policymakers with community-level concerns (farm household/enterprise, community/watershed).

Extent to which project timeline is being met

Aside from minor delays, the project is on schedule. Kenya and Bolivia have both experienced delays because of political unrest, but Bolivia has nevertheless completed all sites. The Kenya team, although delayed, will complete its last site early in FY2009.

Obstacles encountered, actions taken, lessons learned

Three of the four country research center surveys (Bolivia, Mexico, Uganda) have reported data entry problems with the IFRI database. Our database manager has been working closely with partners to resolve the problems, but data entry has been delayed. We had indicated that no Year 4 funds would be issued unless all data were received, but we may need to reexamine this policy if problems are not resolved soon.

IFPRI found that data constraints in reconciling user group-level and forest-level data limited quantitative analysis that could be done on gender issues using preexisting data. Adding data from the next round may help to give enough degrees of freedom for analysis of forest-level outcomes for a future paper.

Kenya

Although the post-election violence has been resolved, there are still underlying tensions in some areas of the sites, and some people have not returned to their homes. This has delayed partner activities, especially round-table and NAC meetings. However, we hope to keep on schedule, for efforts to bring various communities together are going well.

The introductory meetings and data collection of the planned seventh site, Mt. Elgon, was put off for some time due to land and ethnic clashes caused by the Sabaot Land Defense Force. An alternative site, Kedowa in the Mau forest complex, has been chosen as an alternative site, and field work will be completed early in the final year of the grant.

Convening national advisory council meetings and round tables has been difficult because most people are in the process of recovering and resettling in their workplaces after the post-election violence. Some community members are also just returning to their homes from the Internally Displaced Persons camps. The regional meeting scheduled in Jinja, Uganda, in August helped in bridging this gap, for some key members of the advisory council attended the meeting.

Bolivia

PEN researcher Amy Duchelle was unable to present preliminary results of the paper, “Conservation in an Amazonian tri-national frontier: drivers of land cover change in community managed forests” at the IV National Bolivia Forestry Conference in Cobija in September due to severe local political unrest at the time.

Mexico

Mexico continues to struggle to submit reports and other materials on time, but the team has nevertheless completed data collection on schedule. Data are expected to be submitted soon.

Degree and non-degree training activities

LTRA-1 had six students involved in long-term degree training. Four women and two men were working on Ph.Ds. Short-term training involved 363 men and 168 women in 20 training workshops. See Appendix A.

Publications, presentations, other products

Activities this year produced nine academic papers, 15 presentations (not including presentations made during community training workshops), two abstracts, and two policy briefs. See Appendix B.

Activities related to knowledge dissemination

Bolivia

- CERES team produced "community folders" for sites 3, 5, and 6 to share data collected and findings with each community studied. For Site 3, the team also put together a "community journal" in cooperation with Jatun Sach'a, another project funded through USAID. These documents outline concerns and findings in lay language for resident use, provide feedback to the communities and give them information about their forests and institutions.
- Work continues on several papers:
    - "Decentralization and municipal governance of forests," which analyzes the results of the national survey. An early version was presented at the 4th Meeting on Forests Sept. 3-7.
    - "Empowering rural communities in lowlands for improvement of forest resource management," accepted for a seminar sponsored by ForLive on forests and communities.
    - "Poverty, inequality and decentralization in Bolivian municipalities, 1995-2008" will be used in a course by Consejo Latinoamericano de Ciencias Sociales.
    - "Political participation of women in Bolivian municipalities"
    - "Management indicators and forest management capacity: An analysis of efficiency and its determinants in Bolivian municipalities"
    - Masters theses dealing with 1) forest management and the politics of decentralization and 2) institutional changes in Chiquiaca (Site 7)
    - Two papers are in progress related to PEN Study 2 (researcher Patricia Uberhuaga).
        - Analysis of outcomes of the forest decentralization process at household level, specifically looking at the effectiveness of such reforms in poverty alleviation.
        - Analysis of forest environmental income and forest economic dependency in the Bolivian lowlands. This paper is intended to evaluate the variation in

    dependency levels among households, based on an econometric model that is being developed.
  - A second paper on the effects of decentralization in Bolivia on poverty alleviation is in progress.
- A paper based on Bolivia PEN Study 1 titled "Natural resource conflicts in the Western Amazon: Implications for community management of non-timber forest products" was presented at the International Association for the Study of the Commons.
- Preliminary research results of PEN Study 1 were presented at National Science Foundation Interdisciplinary Graduate Education Research Trainee sustainability meeting at University of Alaska-Fairbanks in October 2007.
- PEN results related to research on Brazil nuts were also presented by PEN researcher Duchelle, acting as a guest lecturer in a community forest management class at the University of Florida. The class was attended by 30 students and two faculty members.

Uganda

- J. Bahati, A. Banana, and W. Gombya-Ssembajjwe won the prize for the paper that provides the best case study analysis: "Multi-Stakeholder Governance in Land and Forestry in Uganda: Conflict Mitigation, Scale, Knowledge and Collective Action." Presented at the 12th Biennial Conference of the International Association for the Study of the Commons (IASC), the paper provided findings from the Wakisi site (Site 1, Mabira).
- A policy brief developed to explain the roles of various actors in the forest sector was distributed in various places.
- A policy round table was held to present the findings of Indiana University graduate student Pamela Jagger. Attendees included representatives from Makerere University, various NGOs, community-based organizations involved in forest management, and the Uganda Wildlife Authority. The presentation gave various stakeholders an opportunity to discuss the successes and failures of Uganda's decentralization policy.
- A draft paper drawn from the Uganda PEN study is in progress exploring the effects of decentralization reforms on livelihoods. The tentative findings have been presented at:
  - Indiana University, SANREM workshop, February 2008
  - Purdue University, West Lafeyette, Ind., Department of Agricultural Economics, March 2008
  - Rights and Resources Group, Washington, March 2008
  - Workshop on Forest Governance and Decentralization in Africa, South Africa, April 2008, and
  - SANREM CRSP annual meeting.
- Another paper from the Uganda PEN study addressing the impacts of heterogeneous perceptions on access rights was also presented at IASC.
- A third paper from the Uganda PEN study compares the IFRI and PEN methods of collecting and analyzing household data. A draft was presented at a meeting of PEN researchers in January and at IASC.

Kenya

- A flyer on community participation in forest management was distributed in Arabuko-Sokoke (Site 6) and to policymakers.
- Four papers were presented at IASC:
    - "Emerging Roles of Community Forest Associations in Participatory Forest Management"
    - "Internal Human Conflicts and Forest Conservation in Kenya"
    - "Security of tenure in natural resource management: An insight into property rights," and
    - "Exclusion, poverty and inequality in decentralized Kenyan forests: Bridging the divide."

Mexico

- Two presentations were given at IASC:
    - "Local institutions, social organization and forest management in Mexico," and
    - "Trends and impacts of migration in the community social organization of common property in the forestal communities of Mexico."
- Results of the national survey and the study sponsored by FAO were presented to FAO, World Bank officers (responsible for development and environment projects in Mexico and Central America), and officers of the Comisión Nacional Forestal, in April 2008.
- The team presented the same results for:
    - the general director and three sub-directors of the National Forestry Commission in May
    - "G-Bosques," an association of two national forest communities federations in August
    - Commission of Forestry and Commission on Environment of the Congress of the country, also in August, and
    - the World Bank Group working in Latin America in September.

General/cross-country

- Project partners made 12 presentations related to SANREM at the 12th Biennial Conference of IASC, including one prizewinning paper by UFRIC. Most papers and presentations are mentioned by country above, but some dealt with the project as a whole:
    - "Forest decentralization: Racing to the bottom, to the top, or not in a hurry to go anywhere at all?" and
    - "Examining decentralization from a property rights perspective."
- A paper titled "Resource, recourse and decisions: incentive structures in forest decentralization and governance in E. Africa" comparing decentralization in Kenya and Uganda was presented by Abwoli Banana at the workshop on Forest Governance and Decentralization in Africa in Durban, South Africa. The paper was coordinated by UFRIC, KEFRI, and IFPRI.

- A regional meeting between Kenya and Uganda brought together five members of the national advisory councils, six members of the Kenya and Uganda research teams, three Mpigi District (Uganda Site 7) technical and political leaders, three user group representatives (from Sites 1, 2, and 4 in Uganda), and representatives of the Forest Sector Support Department of the Ministry of Water and Environment, the Mukono District Forest Services, and the National Forestry Research Institute (Uganda). Attendees—including practitioners, community user groups, and researchers—discussed experiences and lessons learned, identifying ways to improve implementation of reforms in both countries.
- An analysis of gender dimensions of user groups and forest conservation in four countries was completed based on previous rounds of IFRI data. A paper based on this analysis titled "Gender and Forest Conservation: Cases from East Africa and Latin America" was presented at IASC in July and at Sustainability Science Seminar, Harvard University, in September. The same paper is also under review for inclusion as a working paper at Harvard's Center for International Development.

Networking activities

Kenya

The Kenya team has been very active in networking this year. They displayed at the KEFRI open day in June at an event attended by more than 500 people. Along with Uganda, they participated in plans to form a network of East African scientists to strengthen participatory approaches to NRM. A meeting organized by the Association for Strengthening Agricultural Research in Eastern and Central Africa was convened in Uganda toward this objective. The team also met with policymakers and government officials related to Sites 5-7. They have been working to numerous degrees with actors including:

- National Museums of Kenya
- Dominion Group
- Maseno and Moi universities
- Birdlife International
- Nature Kenya
- Research Program on Sustainable Use of Dryland Biodiversity
- Tourist Trust Fund
- Got Ramogi Community Forest Conservation Trust
- CARE Kenya
- Plan Kenya
- Action Aid, and
- Friends of Lake Victoria.

Mexico

Findings from the national survey were used for a report on the conditions and dynamics of community forests of the country during the federal administration, 2000-2006, and the impacts of public policy. This report was financed by FAO with the purpose to serve as a base of a new joint project of the World Bank and the Mexican government on community forestry. Leticia Merino was invited by the organizers of the IASC 2008 conference at the University of Gloucestershire, England, to give a lecture to the students of this university on forest policies in developing countries.

The team also made presentations on the findings of the national survey to "G-Bosques," an NGO; the World Bank Group in Latin America; the Commission of Forestry and the Commission on Environment of Mexico's legislature; and the National Forestry Commission.

Bolivia

The team continues to work closely with and receive support from PROMETA and Jatun Sach'a, and have assisted with trainings regarding community forestry at the request of the forestry superintendent of Cochabamba.

Uganda

UFRIC hosted a policy round table attended by representatives from Makerere University, various NGOs, community-based organizations involved in forest management, and the Uganda Wildlife Authority. Researchers also discussed their research and findings with the chief game warden at the Mt. Elgon National Park near Sites 6 and 7, and with the director of natural forest management for the National Forest Authority and the acting chairperson of the forest authority's board of directors (re: Gombe, Site 7). A representative from the Uganda Wildlife Authority was closely involved with the training held in Site 4 as well as activities around Sites 5 and 6.

A regional meeting between Kenya and Uganda brought together five members of the national advisory councils, six members of the Kenya and Uganda research teams, three Mpigi District (Uganda Site 7) technical and political leaders, three user group representatives (from Sites 1, 2, and 4 in Uganda), and representatives of the Forest Sector Support Department of the Ministry of Water and Environment, the Mukono District Forest Services, and the National Forestry Research Institute (Uganda). Attendees – including practitioners, community user groups, and researchers – discussed experiences and lessons learned, identifying ways to improve implementation of reforms in both countries.

Along with Kenya, they participated in plans to form a network of East African scientists to strengthen participatory approaches to NRM. (See above under Kenya for details.)

Project highlights

- Partners in Uganda won the prize for the paper that provides the best case-study analysis for “Multi-Stakeholder Governance in Land and Forestry in Uganda: Conflict Mitigation, Scale, Knowledge and Collective Action” at the 12th Biennial Conference of IASC. This paper presented findings from the controversial Mabira site (Site 1).
- Findings from Mexico’s national survey were used for a report on the conditions and dynamics of community forests of the country. The report was financed by FAO with the purpose to serve as a base of a new joint project of the World Bank and the Mexican government on community forestry.
- The role of women in the two regions appears to vary significantly, with no female-dominated community groups found in the Latin American countries but numerous well-established women’s groups in Kenya and Uganda. This can have implications for the ability of women to have a sufficient voice in natural resource issues.
- Bolivian researchers have immersed themselves in analyzing and learning from the data collected, sharing findings with communities through community folders and are in the process of writing 10 papers using SANREM and PEN data.
- Partners continue to work hard to interact with policymakers and practitioners, and to ensure that the findings of the SANREM project have an impact. The Bolivian team continues to collaborate with the Jatun Sach’a Foundation. The Kenya team has developed connections with numerous forestry-related actors including the National Museums of Kenya, Maseno and Moi universities, Action Aid, and Nature Kenya. As part of the effort to bring numerous actors together, a regional exchange meeting between Uganda and Kenya allowed representatives from user groups, government agencies, NGOs, and SANREM partners to exchange lessons and experiences, and to develop ideas to improve governance reforms in the future.
- In the four host countries since the beginning of the project, 2,436 individuals, including user group members, local officials, and national-level policymakers, 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.
- Results continue to confirm the finding 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.

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

PIs

Alex Travis, Alfonso Torres, Johannes Lehmann, Peter Hobbs, and Parfait Eloundou-Enyegue, Cornell University
Dale Lewis, Wildlife Conservation Society-Zambia
Robert Delve, Tropical Soil Biology and Fertility Institute, International Centre for Tropical Agriculture

Host country

Zambia

Research objectives

- **OBJECTIVE 1:** determine the extent to which the COMACO model can be economically self-sustaining and the effectiveness of the different COMACO model components
- **OBJECTIVE 2:** integrate new technologies into the COMACO model by applying food, soil, and veterinary sciences
- **OBJECTIVE 3:** determine the extent to which the COMACO model provides self-sustaining social institutions and meaningful roles for COMACO participants
- **OBJECTIVE 4:** determine the extent to which the COMACO model improves biodiversity and watershed conservation

Research strategy and development objectives

The LTRA-2 project design seeks to use biophysical and social science research to test and optimize a private enterprise economic model known as Community Markets for Conservation (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. The current problem setting is introduced below, 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 area’s highly variable rainfall, 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. Also, 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. Of 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 affects the safari and eco-tourism markets that are a major source of income for communities as well as the federal and regional governments. Unsustainable agricultural and natural resource management practices lead directly to additional unsustainable practices in a vicious cycle that ultimately results in widespread poverty and hunger in the area.

The COMACO model

COMACO seeks 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 stakeholders' profits. Figure 3-3 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 eco-tourism.

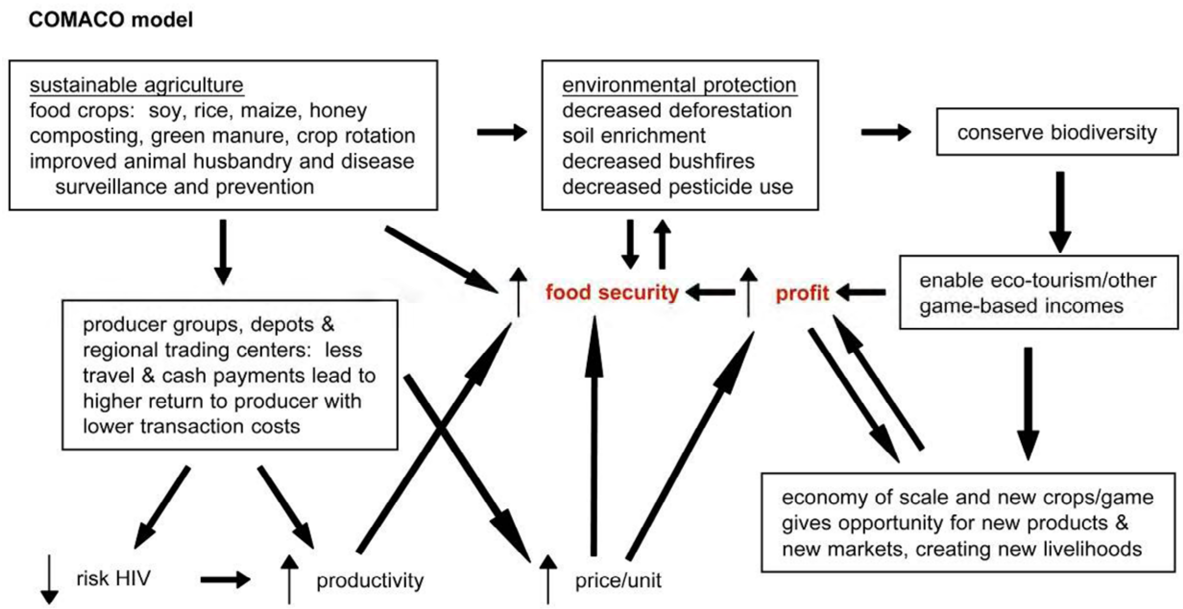

Figure 3-3. The COMACO model

SANREM CRSP research

Scientists from Cornell, in conjunction with partners at the University of Zambia (UNZA), the Zambian Wildlife Authority (ZAWA), Tropical Soil Biology and Fertility Institute (TSBF), the International Rural Poultry Centre (IRPC), and the Conservation Farming Unit (CFU), are conducting social and biophysical research to test the COMACO model and 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 they connect individually 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 3-4. This diagram is greatly simplified. For example, social research is operating from family impacts (e.g., gender equity, nutrition, education) through regional attitudes and policies (e.g., education policy and infrastructure, market testing).

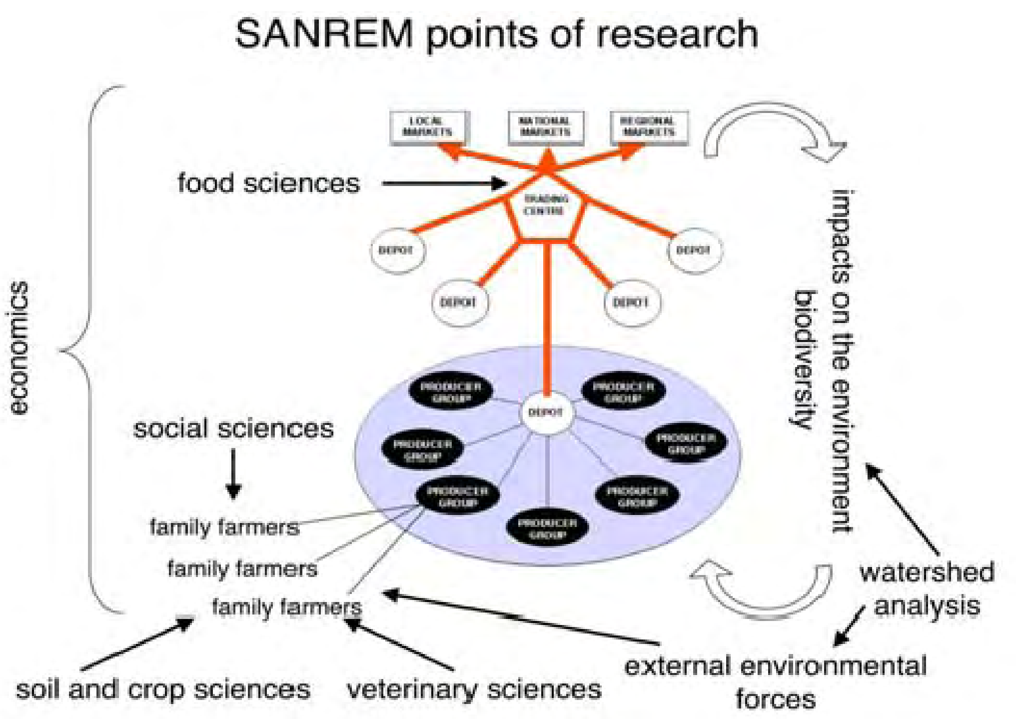

Figure 3-4. The research design

OBJECTIVE 1: 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 Regional Trading Centres. Previous business activities had not been tracked per 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 the rural farmers. Transportation costs are quite high because of the price of fuel and very poor road infrastructure. In addition, 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 trading center, which is older. Effects of a learning curve have been noted, with the newer Mfuwe Regional Trading Centre 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: 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 regional trading centers. 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 than 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 ensure profits from the planting of soybeans, as well as provide 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 HEPS, for which there is a wide market for the undernourished and HIV/AIDS patients. This supplement 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, which was taken by 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 the 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 laboratory has begun so that the food products' quality and safety can be tested in Zambia. That facility has now passed certification, and a contract has been signed so that COMACO can now sell HEPS to the World Food Programme. 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 improvements in family food security and incomes, the food sciences also directly affect 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 traditional system results in nutrient loss and increased erosion and loss of topsoil. COMACO trains farmers in conservation farming 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 geographically covers a wide area that encompasses several soil types with varying slopes and precipitation, it is essential to identify those components of conservation farming that are most beneficial in the different agro-ecological zones. Specific focus is being placed on the nature of organic amendments that are most beneficial in the differing zones and the length of time required to achieve maximum benefits. Our researchers are producing data that will directly improve the lives of individual farmers' families by increasing crop yields and soil quality. Hundreds of experimental plots are being studied across zones representative of much of southern Africa. In this way, the data produced will affect an area far wider than the Luangwa Valley.

Our research team regularly interacts with the COMACO extension staff, helping them produce posters and teaching materials for field days for which entire villages are assembled for training in sustainable agricultural methods. Another important component of these days is establishing a forum for families and villages to provide feedback. Because the increased labor required is a major drawback with most conservation farming schemes, 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 for 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 the past decades. Cattle are gone from areas where they historically were common, in part 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 providing 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 production is extremely widespread, but SANREM research has identified that about 85 percent of chicks hatched 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 yield from this activity.

In one summer alone, SANREM veterinary research performed a survey of existing practices and 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 approximately 50 percent. However, these improved practices are not protective against Newcastle disease, which typically results in the loss of 70 percent to all of infected birds. Vaccinations against the disease 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, improvements of poultry production would be predicted to decrease the need for bushmeat for sale or consumption, as well as improve 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 and economic efficacy of use 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, the site of COMACO's newest regional trading center, 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 do poultry – in this case, 60 percent to 70 percent of goats die before sale or consumption, mostly as young kids. A survey was made 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 crops and production of poultry and small ruminants all should directly impact social indices such as family incomes and nutrition. In addition, improved production methods should lead to more sustainable use of natural resources. As just one example, less deforestation will lead to improved soil retention and less downstream flooding, which itself will improve yields in those 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 eco-tourism, and less traffic into the bush should result in a decrease in bushfires, another source of deforestation. Honey production will benefit from both, for it is dependent on flowering trees in the forests. 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: 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 annually. For example, the data from the original WCS baseline survey suggested that poaching with wire snares primarily occurred during months when families were least food secure. 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.

Survey data have recently been used to demonstrate the relative profits of different kinds of crops, information that can be used by community resource boards to modify planning for the next season and can 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 data on hunters' experiences, reflecting 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 issue of "buy-in" from the local population is of enormous importance. Demand to participate in COMACO certainly exceeds current training capacities. Therefore, 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 ends. 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 required labor inputs. This is 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 utilized by families 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 evaluations 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 very poor rural villages.

OBJECTIVE 4: 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 contributes 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 have caused substantial changes in the morphology of the Luangwa River, making it wider and shallower. This can have a significant effect on wildlife that utilizes the river as habitat. In addition, 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 some 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 over 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 censuses of wildlife 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 both providing a current non-COMACO control as well as yielding 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 completely contained within

Lukusuzi National Park. Of note, 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 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, predicted to increase disease, decrease reproductive efficiency, increase the destruction of surrounding land habitat by the hippos that feed on land at night, and affect species such as crocodiles that must share the habitat. This will also affect the ability of local farmers to use the river's fish for additional income and nutrition.

It is important to note that, in addition to these direct measurements, social data will also affect our evaluation of the success or failure of COMACO's biodiversity conservation efforts. 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 the experiences of safari hunters 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. In addition, surveys of villagers will ask not only for data on their own snaring and illegal hunting practices, which would be subject to bias, but also for information on their perceptions of practices by 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, both for relief and for biodiversity conservation, in the absence of COMACO's intervention. Yet the ability to replicate the model elsewhere would then be diminished because of the absence of such support in all areas needing 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 regional trading centers but will also incorporate data from quantitative analyses of outside benefits that COMACO provides. Because payment 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 improvements and have benefited from a strong working relationship with the Zambian Wildlife Authority. The data also rely heavily on SANREM research being performed for all objectives, including:

- economic analyses of costs and profits at the regional trading centers (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 eco-tourism (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 greater 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 operates the North and South Luangwa National Parks.

Research progress by objective

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

Critical research accomplishments

Research was performed to evaluate the economic performance of the COMACO regional trading centers. COMACO still has a net operating loss as noted above, which would be greater if depreciation and amortization costs were included. As noted, the expansion of the model is a continual economic drain as costs for transportation, extension training, and certification increase. However, COMACO serves social and environmental missions as well, and these benefits can be substantial (and are being calculated as part of a natural resources economic analysis in Objective 4). Even if considered solely from a business perspective, the amount of operating deficit is relatively small, about $2.50 per participating head of household annually or an even lower rate if calculated in comparison with the number of members of each family participating. Factors facilitating COMACO's efforts for economic self-sufficiency include development of high-quality products with newly diversified outlets for selling rice, peanut butter, groundnuts, honey, and soy-based foods. The global food crisis also made Zambian rice more competitive in terms of price with imported rice from Asia, mainly Thailand.

An important additional revenue stream that SANREM research has identified is carbon markets, including compliance markets of the Kyoto Protocol and voluntary markets. A high-level feasibility study has been completed and is being evaluated by COMACO and WCS.

Finally, 2008 research included the provision of three discussion concept notes that were distributed to Zambian provincial ministers in December 2007. The topics of the papers included:

- market opportunities arising from COMACO's impact on community organizations and land-use practices as additional avenues for sustaining COMACO
- economic costs of food aid relief – past, present and future scenarios for Luangwa Valley, and
- private-sector models for poverty reduction – fact or fantasy?

System levels

Enterprise, policy/market

Development impact

The financial analysis has helped COMACO to better understand its position regarding financial sustainability. While progress has been made, ongoing development of volume, quality products, and sales outlets needs to continue to reach financial self-sufficiency. Also, previous evaluation regarding cost to establish a trading center has helped COMACO evaluate options and requirements for establishing a future center in the north-northwest of Luangwa Valley. The analysis of COMACO's ability to leverage carbon markets has helped it to better understand the potential for a future significant revenue stream and also the steps required to access such markets. Further research is required as this market evolves through the post-2012 climate regime negotiations. Finally, the concept papers derived SANREM-related research on topics important to COMACO and the Luangwa Valley were used for a high-level discussion sponsored by the Norwegian Embassy with NGOs, environmental groups, and key Zambian governmental ministers.

Challenges and responses

These studies are continuing as planned and are on schedule. No new obstacles have been encountered, and additional topics identified by our research have been incorporated.

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

Critical research accomplishments

Major research efforts have been undertaken on this objective in Year 3. In the case of food sciences and veterinary sciences, the research has already translated into development impacts, and soils research is poised to do so in Year 4 of the funding period.

Soils and crop sciences

The main goal of the soil science group is to investigate:

- under which environmental conditions conservation farming (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.

This year, about 300 farmers along an environmental gradient (annual rainfall 500-1,200mm) covering the three agro-ecological zones of Zambia participated in the second experimental season. The same farmers were maintained from the first season (2006-07) with the same treatments on the same plots.

The treatments were:

- CF as managed by farmers
- no CF as practiced and managed by farmers, and
- CF supervised by researchers with organic matter additions being *Gliricidia Spp* leaves, manure, biochar + inorganic fertilizer, manure + inorganic fertilizer. Maize was planted on these fields starting in November and December 2007.

Crop yield determination started in March 2008 by sampling cobs and stover separately. Ninety percent of the farmers' fields were harvested. This season, progressive farmers with the trials were engaged as the supervisors to help monitor the experimental plots in activities such as planting, weeding, and guiding. Among the CF plots, those with fertilizer and manure and/or fertilizer and biochar were the best across the region. The farmer-managed CF plots were directed differently among the farmers with variable results, but the traditional plots had the lowest grain yield and total biomass.

A collaborative study with Karen Garrett from Kansas State University was carried out from the same plots in which soils were collected for a metagenomics analysis to serve as an indicator of soil degradation. Another collaborative study is taking place with the Conservation Farming Unit. This study is a "false chronosequence," which means that plots that have been farmed under CF conditions for various lengths of time are being evaluated in the current year to establish whether the time spent under CF affects crop yields.

Food sciences

In food sciences, research has been done to optimize the quality and shelf life of peanut butter and has resulted in an improved product. The addition of a soy extruder and necessary training in its safe and hygienic use and in product development of extruded foods have resulted in COMACO's ability to manufacture HEPS. Expanding on the capacity-building workshops in Year 2, COMACO has continued to pass quality and safety tests, enabling it to carry through on a contract for 300 tons of HEPS this year.

Veterinary sciences

Based on data gathered from Year 1, we devised and instituted training to improve poultry production practices at the household level. Although this did result in improved production, these advancements did not protect against the endemic Newcastle disease (ND) virus. In conjunction with IRPC and WCS' AHEAD program, we instituted a community-based research effort to test the veterinary and economic effectiveness of a vaccination program against ND. Communities within the same chiefdom were divided into control and test villages. Gender-balanced vaccination teams were identified by the communities and trained on how, when, and under what conditions to vaccinate. Data collection forms were standardized, and instruction in their use was given. Based on the experience of the IRPC in other nations in eastern and southern Africa and SANREM social surveys done in the Luangwa Valley in Year 2, a general plan of several vaccination cycles annually implemented. Data have been collected and are being analyzed. Because of the stochastic nature of ND outbreaks, data must be collected over one to two years before they can reliably be interpreted. However, preliminary results suggest veterinary efficacy, in that households that vaccinated tended to have larger flocks. The economic analysis of the costs and benefits of this intervention requires further data collection.

System levels

Farm, enterprise, field

Development impact

Soils and crop sciences

The samples and data collected from this year will be analyzed in Year 4. Thus our major translation into impact will come next year. That being said, both Cornell scientists and COMACO extension officers have been using advancements in conservation farming to educate local farmers in more productive, sustainable practices. Within each agro-ecological zone, field meetings and visitations of various plots were held with farmers to help them understand the system and also to involve them in the trials. The discussion forums explained the expectations of the research and what was required of the farmers, which included making observations on the different treatments. Each farmer kept a plot map and plan for the season. Subsequent forums were held in the farmers' fields. This structure inherently helps farmers learn to quantify the results of their efforts so that they can monitor and evaluate their future yields beyond the current trials.

COMACO extension staff were also trained in the importance of conservation farming (CF) as a means of soil and water conservation management in the Luangwa Valley watershed. As noted in earlier reports, CF as practiced by COMACO involves dry season preparation of land; no burning of crop residues, using them instead to suppress weeds and return nutrients to the soil; no-till or minimum-till planting; crop rotation with nitrogen-fixing crops; intercropping; composting in the planting basins; and diversified crop production. Adoption of these sustainable methods is having an enormous impact on farming practices and therefore food security and rural incomes in the Luangwa Valley. Attempts to switch to a no-till method have focused on design and construction of seed planters that will be tested in the coming year.

Food sciences

The improvements in peanut butter have led to larger and improved contracts with Zambian stores and have widened market potential for these products. The HEPS contract not only provides COMACO with a market and a profitable product, it also could mean significant savings for the Zambian government and international aid organizations that would otherwise have to import the product at great cost and with a large carbon footprint. Perhaps one of the greatest impacts of our food science research and host nation capacity building is an institutional change at COMACO geared toward safe production and continued internal capacity for food science research. COMACO now has a relationship with the food sciences lab at the University of Zambia and has hired one of its graduates permanently as a food technologist to assist the production line in developing new products and providing quality control.

Cornell food science researchers have facilitated an interaction between COMACO and General Mills that has blossomed into a relationship between these organizations. General Mills is now providing COMACO with a second extruder so it can further scale up production. Furthermore, a Cornell student studying for a master of professional studies degree in food sciences will have an eight-week internship at a General Mills facility in the United States. After learning how to use an extruder identical to the one being set up in Zambia, the student can go to Zambia and help train COMACO personnel on its use, best production practices, and product development potential. General Mills has also agreed to train COMACO’s food technologist on the use of the extruder in the United States.

Although data are still being collected, the vaccination program should provide immediate short-term impacts in improving poultry production, leading to increased incomes, improved food security, and a higher nutritional plane. Should the program prove to be economically self-sustaining, it will also provide impacts on a longer-term basis. For example, protection against ND will allow farmers to more reliably gauge production, essential for contract work with local lodges and other businesses. Plans to develop new trading centers in the north and west of the valley are now including plans for their participants to prioritize larger-scale poultry production. These markets will synergize with crop byproducts and extruder capabilities in the form of poultry feed and supplements.

Challenges and responses

Two major challenges were encountered in the veterinary research. These resulted from our commitment to make all the research involve simultaneous host-nation capacity building. That is, instead of using vaccination teams of Westerners, our efforts involved the training of community vaccination teams. It is imperative that sick birds not be vaccinated. The sick animals will not receive protection, will die, and the families will then have a tendency to blame the vaccine as the proximate cause of death. Nevertheless, despite training, data collected from one area suggest that this occurred. This is a well-established risk with the strategy, and the IRPC has encountered the problem before. Another challenge encountered was the impact of the extremely high local infection rate with HIV/AIDS. One of the personnel in charge of data collection from two control villages became very ill, and those data were not collected for one cycle. Efforts this past summer were made to address both issues – improving vaccinator understanding as well as emphasizing and improving accurate data collection. A veterinary student from Cornell was put in the field to work with a new COMACO staff member dedicated to these projects.

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

Critical research accomplishments

SANREM social researchers developed new ties with the University of Zambia, which led to the inclusion of a University of Zambia student in our gender research. COMACO has routinely performed monitoring and evaluation of their household impacts with a large survey of its participants in comparison with non-participants living in the same areas. SANREM researchers worked with COMACO to improve the rigor and scope of its survey. We also helped to train independent enumerators to carry out the survey in a rigorous fashion. Sections on childhood education and access to healthcare were expanded, and new sections on intra-household decision making, personal safety, aspirations, housing conditions, sanitation, and assets were added. These data have just been collected from the primary study area, and the survey is currently being extended to include new villagers (a “pre-COMACO” group) in the vicinity of the new regional trading center at Nyimba. As COMACO begins work in this area, these data will provide an important baseline comparison to evaluate the impact of COMACO’s activities.

System levels

Farm/household, enterprise, policy/market

Development impact

The modifications to the survey will improve COMACO’s ability to evaluate the impact of its activities. Data from the new SANREM-initiated research is being entered into databases for analysis. This is an important step on the path to impact. These data will be analyzed in the coming months. We anticipate learning how COMACO is affecting individual families, particularly women and children.

Challenges and responses

There are no unanticipated challenges to report.

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

Critical research accomplishments

Our natural resource economic assessment of the costs and benefits of COMACO's activities has continued, with a major "willingness to pay" survey being carried out on tourists in the South Luangwa National Park and the nearby bush camps. Data are being analyzed and show that, in terms of national park entrance fees, tourists would be willing to pay not only for improved mega-fauna populations but also for small and intermediate-size species. Data regarding other potential benefits such as reduced poacher arrests, trials, and incarcerations continue to be collected. Household data are being collected by SANREM research, as described in Objective 3, as well as by SANREM-assisted COMACO survey research.

A major aerial survey of hippo populations in the Luangwa Valley has been completed (activity performed in Years 2 and 3). Data from this survey are being tallied and GIS mapped down to the level of individual pods so that the total number and distribution of Africa's largest hippo population can be understood. These data are essential to understand the potential effects of changes in river morphology on these animals and the potential downstream effects of these large mammals on forest habitat, crocodile and fish populations. Our other aerial survey is focused on the COMACO core area in comparison with two non-COMACO controls (one that straddles the Luangwa River to the north of the core area, the other that covers Lukusuzi National Park). In Year 2, these data showed few animals in the non-COMACO areas and declining numbers in the core area. Year-to-year variation and sampling errors dictate that such evaluations be carried out over a period of years to have true value. In Year 2, an added variable was felt in the form of severe flooding in the valley that disrupted normal animal distribution patterns. Data from Year 3's survey show marked increases in the core intervention area, which reinforce the need to draw on several years of data before trying to interpret trends.

Because of the expected variation with this methodology, we have grouped the individual species into two guilds: primary poaching targets and secondary poaching targets. The former is composed of large-bodied ungulates that typically travel to waterholes on a daily basis, making them susceptible to snares placed on those trails. Examples of these species include kudu, roan, eland, hartebeest, and wildebeest. The latter group is composed of smaller-bodied species such as impala, puku, and warthog. Comparisons of these guilds from pre-COMACO years with current years suggest a statistically significant increase in the numbers of the primary poaching target guild and a stable population of the secondary poaching targets.

System levels

Policy/market, ecosystem

Development impact

Data from the willingness-to-pay survey can inform COMACO regarding its efforts to save individual species from poaching pressures and can inform ZAWA officers so they can optimize their price structure for national park admissions and organize their own targeted conservation efforts. For example, the item considered most valuable by tourists in the South Luangwa National Park was a hypothetical rhinoceros reintroduction program similar to an actual program in the North Luangwa National Park. Thus, ZAWA might gain information useful for its own planning. The wildlife population assessments will similarly provide important data to determine the efficacy of the model in terms of this environmental bottom line. The net stabilization or increase in numbers of different wildlife species has been incorporated into the COMACO business approach through a growing development of two community bush camps. These now have entered international markets and had more than 180 Western tourists this past dry season, providing a small but important tangible demonstration of local value deriving from the conservation mission.

The data regarding the ecosystem services benefits, the indirect benefits of sustainable practices to the local government and national authority structures, and the value of wildlife populations will help complete the strictly business economic assessment to give an idea of the total costs of biodiversity conservation using the COMACO model. These data will constitute a significant component of our ultimate evaluation regarding the value of replicating the COMACO model as a combined rural development and wildlife conservation strategy.

Challenges and responses

One challenge to the aerial survey of herbivore species is that COMACO has grown swiftly to include the areas that were initially designed to be non-COMACO controls. From a scientific perspective, this loss is unfortunate and cannot be recovered; for example, moving farther away would change the habitat and pressures of human populations too greatly to be of any relevance as controls. However, from a practical perspective, we can still compare these areas to see whether COMACO's introduction will result in a restoration of wildlife populations of an equivalent value to the core area. Also, the potential benefits of COMACO's expansion to the human inhabitants of those areas and to the ecosystem clearly outweigh the scientific loss.

Degree and non-degree training activities

LTRA-2 had eight students involved in long-term degree training: four from host countries and four from the United States or other developed countries. Of those, six are women and two are men. Two women and one man are working on Ph.D.s. Short-term training involved 3,263 men and 3,963 women in 12 training programs. See Appendix A.

Publications, presentations, other products

Activities this year produced two refereed journal articles, one extension training poster, two conference proceedings and papers, four working papers, seven presentations (not including presentations made during community training workshops), two posters, and four other educational lectures to Cornell students. See Appendix B.

Networking activities

Networking has taken several forms during the past year. Notably, SANREM research has led COMACO into a long-term relationship with the University of Zambia regarding food quality and safety testing. Moreover, SANREM's focus on food safety and hygienic production, as well as product refinement and development, has led COMACO to expand its staff expertise to hire a recent University of Zambia graduate as a food technologist. These developments have helped to engage the private sector as well. General Mills has provided COMACO with funds for a second extruder. General Mills sent its personnel to inspect COMACO's food production at the Mfuwe and Lundazi trading centers, and these visits went so well that COMACO's food technologist and a master's degree student from Cornell are both going to General Mills to train on an extruder identical to the one being purchased for Lundazi. After this internship, the student and the COMACO technologist will go to the Lundazi trading center to implement their new knowledge.

Networking with the officers of ZAWA has continued and grown into a legitimate partnership in which data are freely being shared. This is an important development because access to these data provides an independent source of evaluating COMACO's impact on poaching.

Project highlights

Business economics

- Historical analyses have quantified the cost of equipping and staffing a trading center from startup. These data are being used to assess projected costs for replicating the community trading center model as COMACO scales up and out.
- Analyses of yearly operations have identified the profit and cost centers associated with each trading center. For example, the addition of value through processing and packaging provides the majority of profit for COMACO, and the reduction of transportation costs, when possible, will reduce costs. Together, these realizations have been used to improve operational efficiency and shape the long-term business plans for each center. Optimizing the centers' activities can help offset built-in costs that are inherent to COMACO's triple bottom-line mission but retard the ability to reach a purely economic break-even point.
- The transfer of business accounting skills has had a significant impact on COMACO's ability to monitor its own financial progress.
- Based on the recommendations of SANREM researchers, COMACO has assembled an advisory board of Zambian and international professionals. These individuals meet to provide their expertise to help COMACO grow as a business and enter new markets successfully.

Food sciences

- "It's Wild!" brand peanut butter has increased market contracts and increased profit due to studies on lipid emulsification and particle size, as well as experiments with product packaging, which together have improved the quality and shelf life.
- Host capacity building in safe, hygienic food production has resulted in significant changes in COMACO's practices, operations, and path to economic self-sufficiency. Development of the relationship with the University of Zambia food laboratory, the hiring of a food technologist on the staff, the scaling up to include two extruders, and the size and value of new contracts for diversified products all have resulted from and/or built on SANREM research and capacity building.

Veterinary sciences

- Preliminary data show that poultry production can increase and be stabilized through a community-operated vaccination program against endemic Newcastle Disease. Improvements of household poultry production should improve family income, food security, and nutrition.

Natural resource economic valuation

- "Willingness to pay" survey results quantified the value of different classes of wildlife and different conservation activities. These results provide an economic value for wildlife conservation and help to inform ZAWA conservation activities and practices such as gate prices.

Biodiversity conservation

- Aerial survey data suggest that species that are the primary target of snaring are increasing in number and that smaller species that are secondary targets have stable numbers. Our data verify that COMACO is achieving impacts on local wildlife populations by targeting both snaring and professional poachers, fulfilling one of its three main goals of conserving biodiversity.

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

PIs

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Host countries

Bolivia, Ecuador

Research objectives

- **OBJECTIVE 1**: identify economic, social, political, and environmental conditions in the watersheds and understand the determinants of these conditions
- **OBJECTIVE 2**: generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation. Some alternatives include new crops, on- and off-farm income-generation strategies, and technical improvements to existing practices.
- **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 takes individual responses (changes in practices at the field, farm, and market scales) and aggregates them to the watershed scale.
- **OBJECTIVE 4**: build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital

Research strategy and development objectives

Introduction

SANREM's LTRA-3, 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 to 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, 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 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 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.
- build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital

These research objectives will help us attain our TOPS framework development objectives, which are:

- more effective management of natural resources and sustainable use of natural resources in Chimbo, Ecuador; and Tiraque, Bolivia
- diversify economic activities through alternative natural resource-based livelihood strategies, and
- build social capital, enhance local governance, and contribute to economic and social stability in resource-degraded, relatively remote rural areas.

Conceptual framework and research components

The conceptual framework underlying our research program involves several components, but 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 and access to information; and the natural environment (Figure 3-5). Households allocate assets among activities to meet an objective (utility maximization, profit maximization, risk minimization, long-term wellbeing). 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

[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 and water), location-specific capital (access to roads and markets, electricity, cellular services), and political and social capital.

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 household wellbeing 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, will be aggregated to the watershed level. Some local actions have impacts on a larger scale (run-off, carbon sequestration).

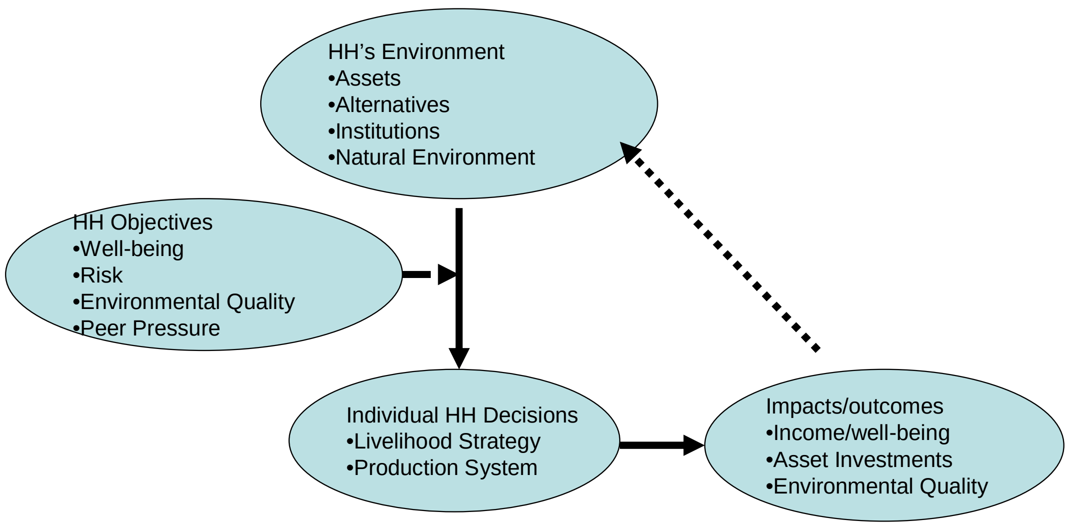


Figure 3-5. Household decisions and impacts

The watershed is affected by individual decisions, and these decisions 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 outcomes such as run-off, water quality, and aquatic biodiversity. Economic models will measure aggregate impacts on economic wellbeing 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 adopted an adaptive management approach to facilitate this buy-in.

Adaptive watershed management approach

The watershed management approach (Figure 3-6) 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, and implementation in Years 3 and 4). The adaptive management cycle continues to work toward achieving existing and new goals as they arise. Common elements of this approach are:

- *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* – including agencies, organizations, and individuals interested in the water quality, ecosystem health, economic objectives, and management strategies 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 and management strategies are then developed before allocating scarce resources
- *watershed plans* – these 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 3-6.

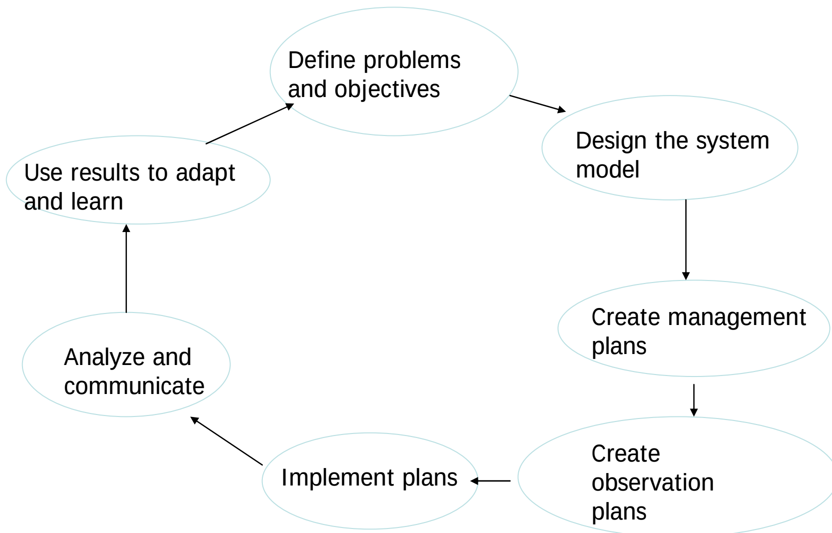


Figure 3-6. Adaptive watershed management

Methods and research components

Our research activities are divided into five components roughly corresponding to research Objectives 1-4 (above). Activities involve a number of scientific disciplines – soil science, agricultural engineering, geography, plant pathology and agronomy, socioeconomics, ecology and 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 biosystems engineers who will use the research output for their modeling efforts. A schematic of the linkages among the different research components is presented in Figure 3-7.

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)
- 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).

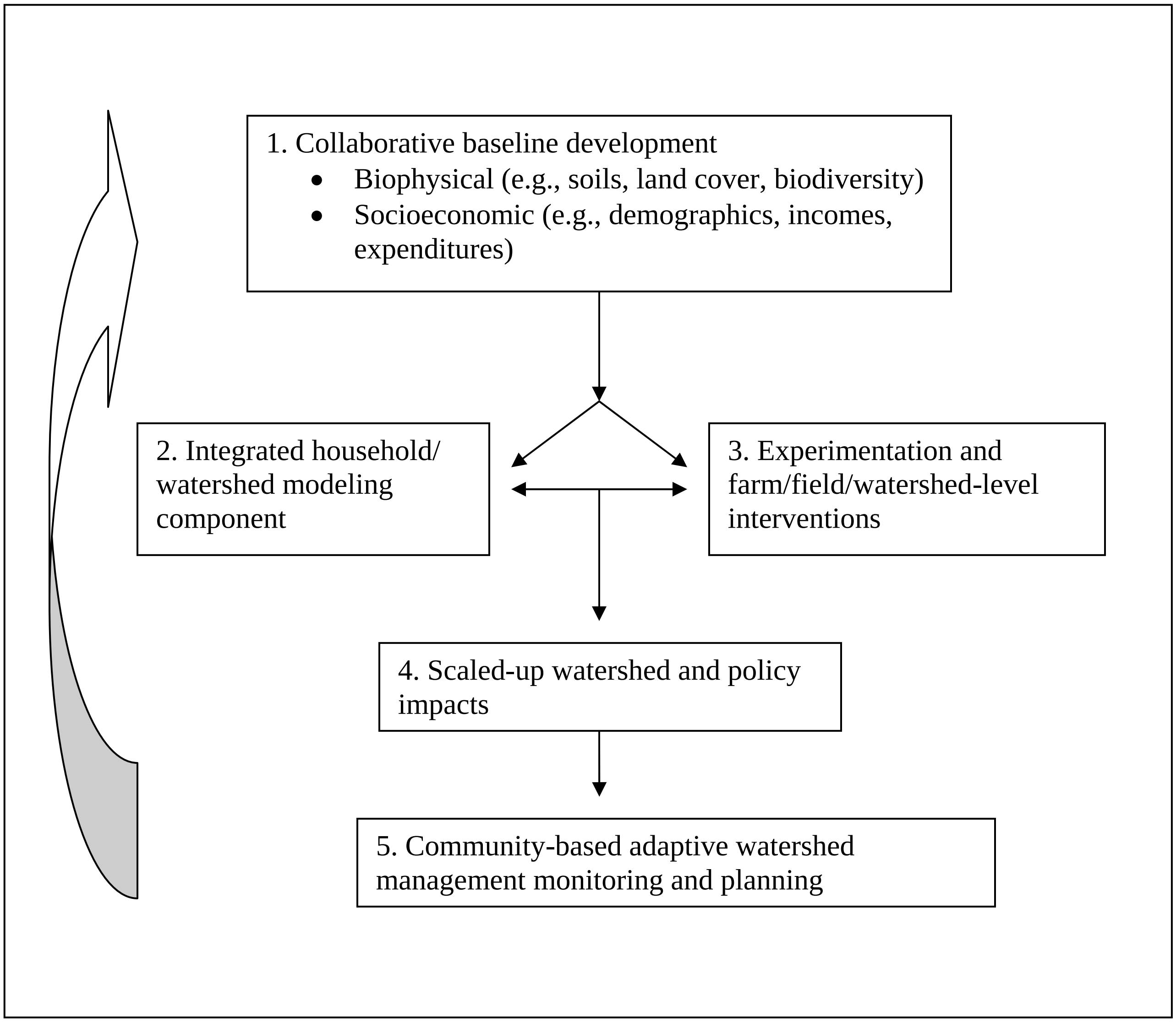


Figure 3-7. Research components and linkages

Integrated household-watershed modeling component

This research component uses information on livelihoods and outcomes but also agro-climatic data, access to infrastructure, and the 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 wellbeing. 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 base 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, in watershed plans, etc.

Scaled-up watershed-policy impacts

The inputs into the watershed models include much of the information generated above, and 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 in U.S. participating universities, on-station, in 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 information 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 by objective

OBJECTIVE 1: identify economic, social, political and environmental conditions in the watersheds and understand the determinants of these conditions

Research to meet this objective includes collection and analysis of data on watershed characteristics including agro-climatic and geophysical conditions; household-level data on household characteristics, assets, living conditions, and livelihoods; soils and their relationship to outcomes such as soil erosion, nematodes and pathogens, and carbon retention; and environmental conditions. Data are fed into GIS and are being used in our physical modeling of the watershed. The data also help establish a baseline that is being used to measure and monitor changes over time.

Critical research accomplishments

- For each site we have completed GIS, which includes information on soil characteristics, slope and elevation, rainfall, land use and soil cover, water sources such as streams and rivers, the transportation network and other infrastructure. Other variab
- les are included depending on their availability. For instance, the Ecuador GIS contains information on market locations, while the Bolivian GIS has information on access to cellular telephone signals. Our baseline survey data have also been included in the GIS for both sites.
- We have documented the extent and severity of soil erosion in the region, with particular attention to impacts on soil carbon retention and to understand the effects of land use on soil erosion, soil carbon content, and soil productivity. For example, in Ecuador we know that the soils in the upper watershed, although more highly prone to erosion, are far less degraded than the soils in the lower watershed. We have established test plots on which we are measuring erosiveness under different management practices. The data from these plots are being used as input into our watershed models, which have produced aggregated estimates of erosion lost (in Bolivia).
- In Bolivia, we have documented that several species of nematodes are causing key damage to several of the most important cash crops. Research plots evaluating biofumigant rotation crops have been established to reduce their impact. Similarly, biological control systems are being evaluated with very positive effects to control foliage pathogens in several key crops in Bolivia and Ecuador.
- A protocol for measuring and monitoring biological diversity has been created and applied at both sites. Research this year shows that biological diversity in the Bolivian site is quite high, with a number of important mammal and bird species.
- We have established a monitoring system for aquatic biodiversity in the Ecuador site as a means of measuring water quality; in the current year are working to identify indicator species and establish a school-based monitoring system in Bolivia. Water quality in the rivers in our Ecuador site is relatively good, but several threats to that quality have been identified. The use of macro-invertebrates as indicator species appears to be justified.
- A system has been established for collecting cost of production data and monitoring product prices in local markets. Prices and their variability are critical determinants of

profitability and livelihood success. Before the project, no information on cost of production or product prices was available to the researchers or decision makers, and nothing was known about how prices vary over space and time.
- Baseline surveys of socioeconomic data have been completed and analyzed in both sites. We now have a solid understanding of livelihood strategies, farming practices, income and wellbeing outcomes, and gender relations for households in Ecuador and Bolivia.

System levels

Watershed, market, governance

Development impact

- All of these activities increase knowledge and awareness.
- The GIS will be used for several purposes: establishment of a baseline and regular updating to facilitate monitoring of change; data storage and management; and visual presentation of research results. Ability to present data and research findings in visual fashion is expected to increase research uptake. Also, the use of GIS data to inform local decisions will help establish a process of evidence-based decision making in areas where most public decisions are made without good evidence of their impacts.
- Biodiversity monitoring enhances the information about how actions in the watershed affect environmental outcomes. Participatory monitoring is being used to collect this information, and participation is increasing local awareness of biodiversity and its value. Biodiversity indicators are being included as a part of curriculum in local schools. Information on the impacts of actions on biodiversity will be used to evaluate land-use plans and local decisions.
- Ability to monitor prices in local markets will enhance decision making at the local level. Individual producers will be better aware of costs and potential profits. It is estimated that increased information will lead to welfare gains of 10 percent to 20 percent for households in the watersheds. This enables more informed actions on the part of individual decision makers.
- Baseline surveys allow for comprehensive monitoring of program impacts. This will increase efficiency in future planning.

Challenges and responses

The information base for our GIS was limited in both countries, and the project expended more resources than previously expected in collecting data on soil types, rainfall, etc. Collaboration with cross-cutting initiative on watershed monitoring facilitated our response by helping identify data sources and providing resources for data gathering, particularly weather and stream-flow data. In Ecuador, government funds allowed for expanded collection of weather and biodiversity data. A persistent problem we face in Bolivia is gaining the confidence and trust of local decision makers, especially political leadership. We have undertaken special efforts to engage these politicians in the process and are beginning to see some fruits of this labor.

Research progress

In-country GIS development

As noted, the GIS have been completed for each country and are being used to organize data, input data into modeling, and present results to decision makers. These achievements have been documented in earlier reports, so we will highlight just a few accomplishments.

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, geomorphology.
- Digital elevation models (DEMs) were obtained and additional analysis done.
- The baseline survey has been digitized and incorporated into the GIS.
- The GIS is being used to produce information for the household analysis (e.g., distances to towns, markets, water sources) and the watershed models.

Bolivia

- Basic maps of geology, geomorphology, slopes, erosiveness, and land use have been digitized and entered into the GIS, which is managed by PROMIC.
- DEMs have been obtained and additional analysis done.
- 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 3-8). Samples were taken in the field to ensure that the map was an accurate reflection of conditions.
- Regarding land use, satellite images have been obtained and classified; additional work is being done to refine classifications (Figure 3-9).
- We now have 14 years of daily weather data from the Tiraque, Bolivia, watershed.
- Five zones for study in the sub-watershed have been identified. More intensive examination of soil erosion and degradation has occurred, and the data from our field trials (below) are being incorporated into the GIS.
- The baseline survey has been digitized and incorporated into the GIS.
- The GIS is being used to produce information for the household analysis (especially important for our purposes is the coverage of cellular phones, which is being used to estimate the impacts of information on household decision processes) and the watershed models.

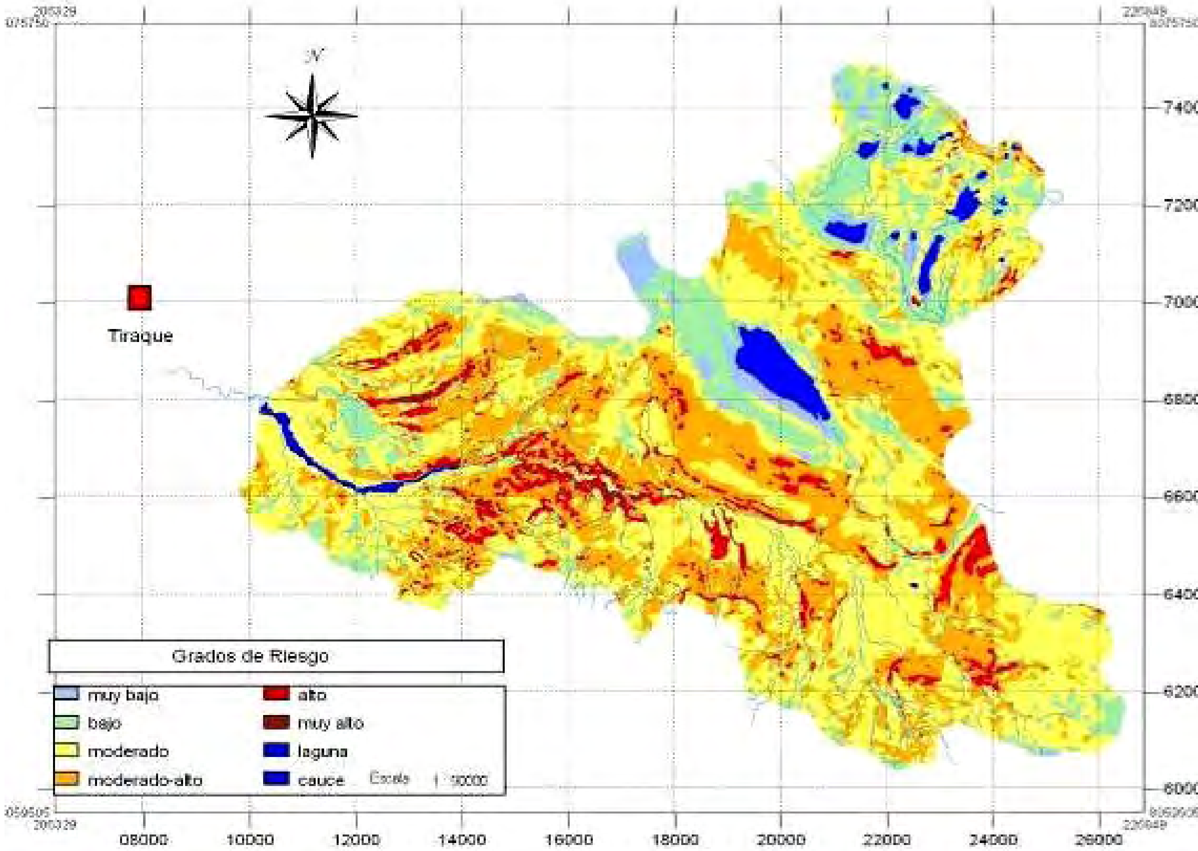


Figure 3-8. Risk of soil erosion, Tiraque, Bolivia, watershed

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 (the Illangama sub-watershed) are fairly resistant to erosion and appear to be tolerating intensifying land use reasonably well. However, the older soils of Chillanes (the Alumbre sub-watershed), 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. The region has experienced massive deforestation over the past 40 years, resulting in loss of about 80 percent of the original forest cover in areas around Chillanes. Farmers report that crop yields, which are only 5 percent to 10 percent of yield potential in this region, have dropped by half over the past 10 years. Fertilizer costs are growing and already account for more than a third of production costs. Water has become scarcer due to reduced water retention as well as reduced precipitation. This could be related to deforestation, which reduces transpiration and total water retention in the watershed. Sampling confirmed this analysis, with intensive cropping being associated with reduced soil fertility and soil depth.

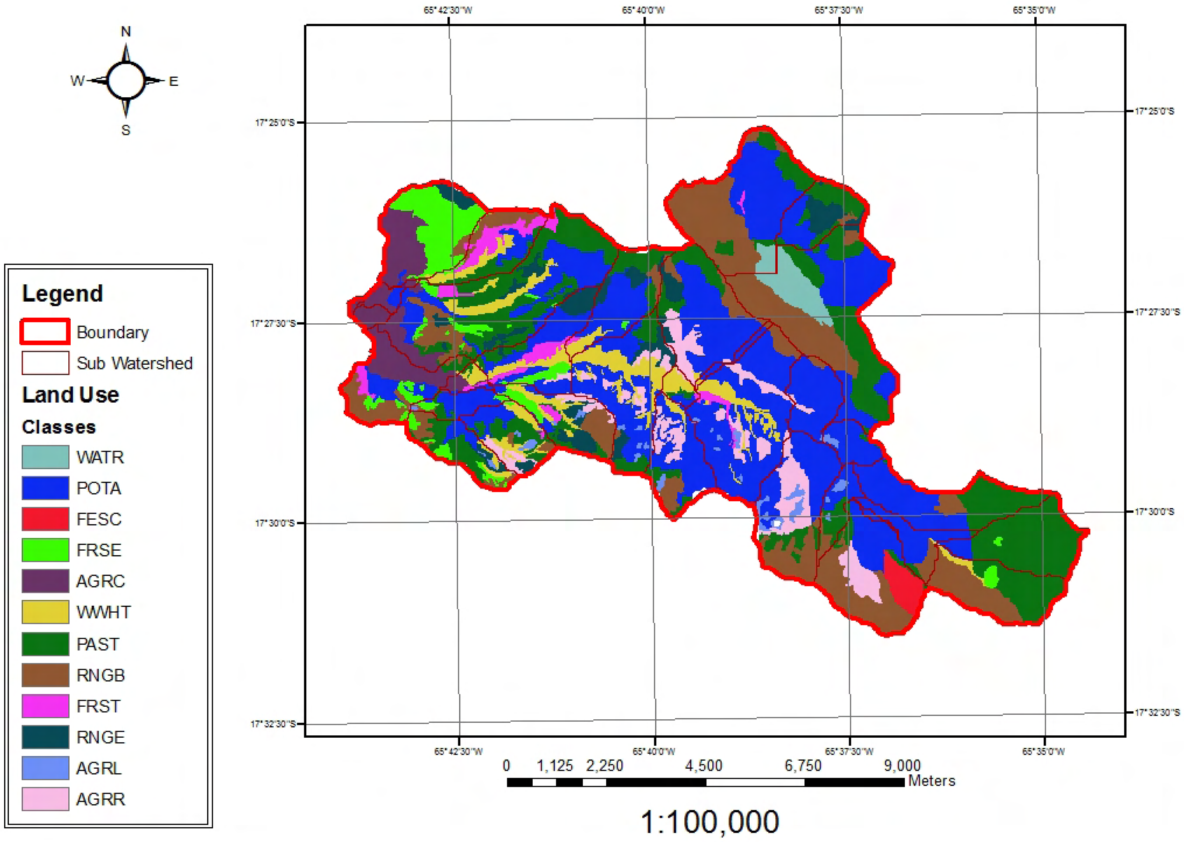


Figure 3-9. Land-use map for Tiraque, Bolivia, watershed

We have documented the extent and severity of soil erosion in the region, with particular attention to impacts on soil carbon retention and to understand the effects of land use on soil erosion and soil carbon content.

Erosion assessment by Cs-137 analysis

All soil samples collected in 2006 were analyzed for Cs-137 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. 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 Cs-137 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.

Land-use effects on erosion were observed through the Cs-137 analysis. Natural forest land showed by far the lowest levels of erosion. Páramo 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 samples have been analyzed for Cs-137 content.

Radiocarbon dating to determine soil age

Previously, we conducted soil carbon and Cs-137 analyses on samples from the Rio Chimbo watershed to examine the relationship between carbon storage and erosion with respect to land use. We observed that the low-altitude location Chillanes showed high levels of soil carbon but also strikingly high erosion levels (low Cs-137 concentrations), especially compared with the high-altitude site Alto Guanujo. We attributed the high level of erosion at Chillanes to unsustainable farming practices, where crops are grown on steep slopes with no soil cover between seasons, compared with a long-standing crop rotation system put into place by Quechua communities in Alto Guanujo. The Cs-137 method determines cumulative erosion levels but does not distinguish actual rates of erosion among sites. We hypothesized that, because land in Chillanes has been put into cultivation only recently, the rate of erosion (tons soil loss per year) far exceeds that of Alto Guanujo. To test this hypothesis, soil age at both sites was determined using radiocarbon dating. We expected soil at Chillanes to be much younger than that of Alto Guanujo.

Table 3-2. Radiocarbon dating results from 12 sites in the Rio Chimbo watershed

Values shown are in radiocarbon years before present (BP) or percent modern carbon (pMC), depending on the amount of C-14 the sample contained relative to the 1950 C-14 standard.

Site	Location	Crop	Conventional radiocarbon age	Unit
20	Alto Guanujo	páramo	50	BP
2	Alto Guanujo	pasture	70	BP
25	Alto Guanujo	pasture	40	BP
27	Alto Guanujo	pasture	250	BP
17	Chillanes	pasture	340	BP
12	Chillanes	pasture	40	BP
1	Alto Guanujo	páramo	103.6	pMC
23	Alto Guanujo	páramo	101.7	pMC
11	Chillanes	forest	103.8	pMC
14	Chillanes	forest	104.3	pMC
15	Chillanes	forest	105.9	pMC
28	Chillanes	pasture	100.3	pMC

We submitted soil samples from 12 sites in the watershed for radiocarbon dating. These samples were from Alto Guanujo and Chillanes, under either pasture or natural (páramo or forest) land use, and at a soil depth of 5 to 20 cm. Samples were analyzed for C-14 content either radiometrically or by accelerator mass spectrometry, depending on the sample size and carbon content. C-14 content can be used to determine age of a soil sample because it is continually generated by cosmic rays and can be compared with a modern C-14 standard.

Results from the soil radiocarbon dating are presented in Table 3-2. All results reflect minimum age dates, which means that the age is as young as the sample could possibly be. For soil ages determined in radiocarbon years before present (BP), a calibration curve can be used to estimated the actual year that the carbon in the sample originated (Figure 3-10). Results expressed in percent modern carbon (pMC) had more carbon than the 1950 C-14 standard, which is due to thermo-nuclear bomb testing in the 1950s. Presence of this “extra” C-14 generally indicates that the material analyzed was part of a system that was respiring carbon after the onset of the testing in the 1950s.

We are currently analyzing this data to relate it to our previous Cs-137 and soil carbon results. Some of these C-14 results are unexpected. For example, we expected the Chillanes samples to be the youngest, but soil in the pasture sample at Site 17 in Chillanes was 340 BP—the oldest among all samples submitted. It may be that mixing of layers of different age by soil biota (a process that is more prevalent at the warmer, lower altitudes in Chillanes) explains these results. Alternatively, erosion at Chillanes may have been so great that much older soil from deeper layers was exposed. This line of reasoning is supported by the Cs-137 results, which for that sample were among the few with undetectable Cs-137 levels indicating large erosion levels. Our next step is to consult a soil scientist with experience in radiocarbon dating to interpret these results.

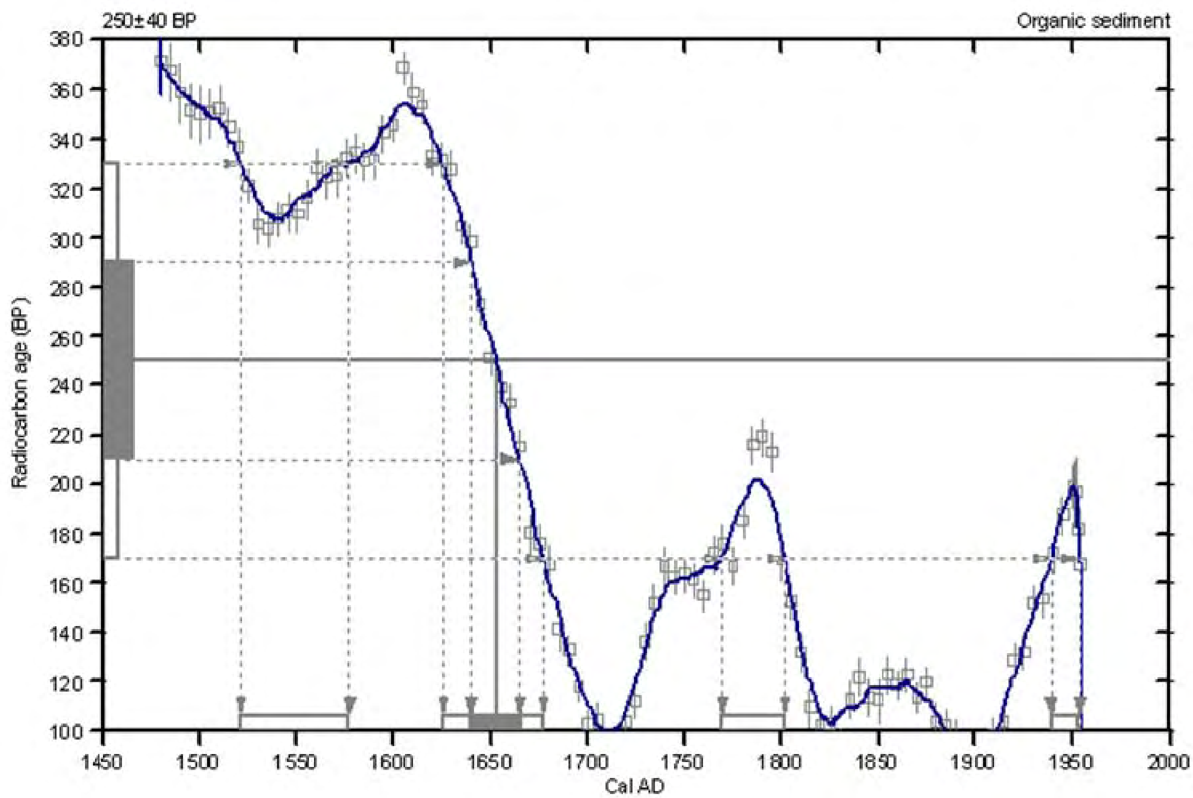


Figure 3-10. Relationship between radiocarbon years and calendar years from Site 27, a pasture sample from Alto Guanujo

C-14 analysis determined the sample age to be 250 radiocarbon years before present, which indicates that the carbon in this sample originated around 1650 AD.

Although average soil carbon concentrations in g C kg^{-1} soil were highest in Chillanes, average carbon storage on a m^{-3} soil volume basis was highest in Alto Guanujo (Figure 3-11) due to differences in soil bulk density (compaction). Carbon in the litter layer contributed minimally (<2 %) to total soil carbon storage. These soil carbon values are similar to previously reported carbon levels in Chilean andisols under forest, tree plantation, and pasture (Huygens et al., 2005) but slightly lower than those reported in pastures and coffee plantations in the Colombian Andes (Hoyos and Comerford, 2005).

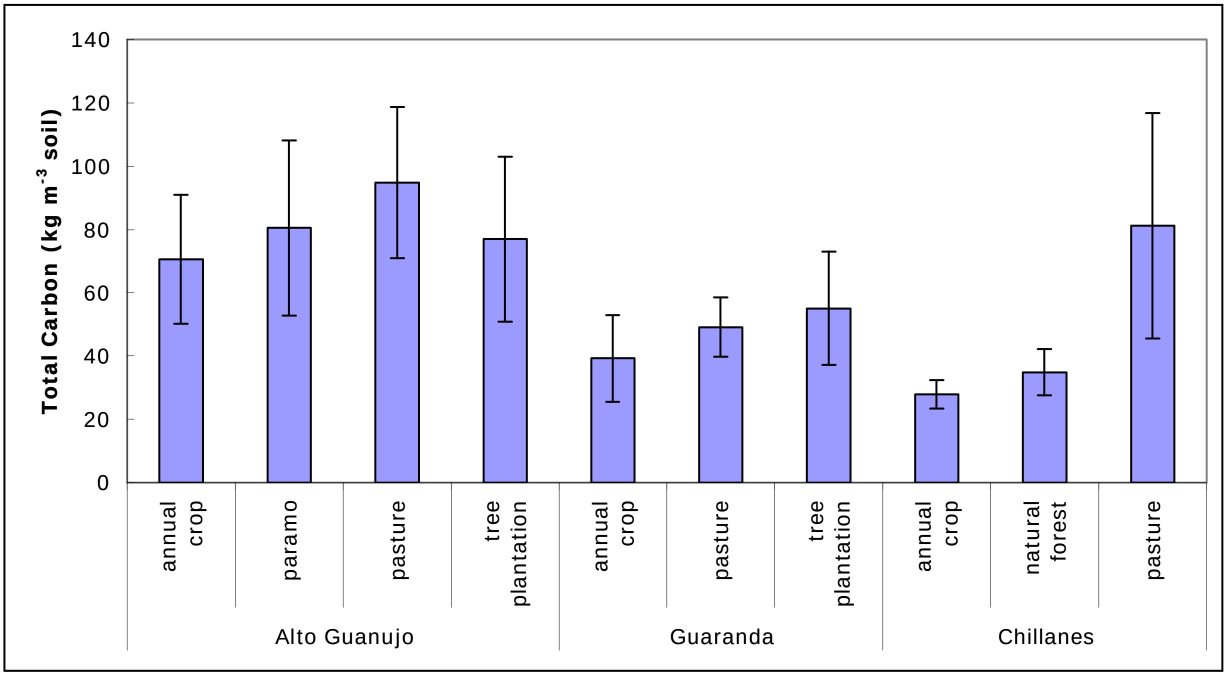


Figure 3-11. Total carbon storage at each location by land use

Biodiversity assessment for the Jatun Mayu watershed, Cochabamba, Bolivia

This activity was realized with the coordination of the Center for Genetics and Biodiversity, Faculty of Science, UMSS. All three levels of the Tiraque watershed were transected and evaluated between November 2007 and February 2008. The methodology established by ECOCIENCIA, our Ecuadorian partner, was applied with the following results.

- Vegetative biodiversity. We encountered 241 species; the lower zone of the watershed has the most biodiversity. Many species with medicinal value were encountered.
- Insect biodiversity. We encountered 68 insect species in five orders. We focused on lepidopterans and coleopterans as indicators of environmental quality.
- Reptilian biodiversity. We identified eight amphibian species in five families and seven reptile species in four families. Three endemic species were identified (two reptiles and one amphibian).
- Avian biodiversity. Sixty-six species from 25 families were identified, with the lower zone having the greatest diversity.
- Mammalian biodiversity. Eight small and six large mammal species were identified in the watershed.

The study has been completed and is being shared with the local authorities and schools.

Water quality measurement using aquatic bio-indicators (macro-invertebrate) in Ecuador

Water is a key resource and is under pressure and pollution due to human use for different activities and increased population. In the Ecuadorian Andes these pressure are reflected by the increase in conflicts over its use and its pollution. In Illangama, the main source of water is runoff from Chimborazo Mountain and the surrounding páramos (highlands). In Alumbre, water supply and quality depends mainly on the remaining forest. In both cases, human activities such as agriculture and livestock have produced pollution of the páramo and high deforestation. The objectives are: 1) to establish the reference condition of water bodies using bio-indicators; 2) to determine water quality from the sub-watersheds using water quality indexes based on bio-indicators; and 3) to describe effects of soil use and anthropic activities on water quality.

Table 3-3. Sites, coordinates and altitudes for the physical, chemical, and biological monitoring, Bolívar-Ecuador, 2008

Sub-watershed	Place	Coordinate*		Altitude (m)
		Y	X	
Illangama	Páramo de Arenales 1	9841617	731046	4176
Illangama	Páramo de Arenales 2	9841716	730740	4172
Illangama	Páramo de Arenales 3	9840742	730662	4135
Illangama	Río Culebrillas 1	9833155	735762	4205
Illangama	Río Culebrillas 2	9829875	733238	3689
Illangama	Río Culebrillas 3	9830788	731457	3369
Illangama	Quebrada Arrayacu 1	9833070	730195	3330
Illangama	Quebrada Arrayacu 2	9834860	730072	3455
Illangama	Puente Quindigua	9832708	730387	3274
Illangama	Río Illangama	9829150	726329	2865
Alumbre	Pacay	9781612	715219	2267
Alumbre	Quebrada Panecillo	9787373	720304	1942
Alumbre	Bosque Tiquibuzo	9776144	712045	2441
Alumbre	Quebrada Encillado	9784402	717865	2368

*UTM - PSAD56 -18S

During 2008 we sampled five stream localities in the Illangama watershed and four in the Alumbre watershed. We now have two years of macro-invertebrate data for these sites (Table 3-3). The personnel of ECOCIENCIA are preparing a report detailing the results so far of this project. We are applying two metrics to evaluate water quality. One was developed for Colombia, the other for high altitude streams in Peru and Bolivia. To very briefly summarize our data so far, the Alumbre streams have on average better water quality than the Illangama streams. This is probably due to the fact that Alumbre streams have better vegetative cover along their banks, while Illangama streams have only páramo vegetation, which allows domestic animals free access to the streams. However, none of the streams are severely polluted, according to the metrics of stream macro invertebrates.

Results show that the rivers are still in good condition besides. The BMWP/Col and ABI indices show that water quality is relatively good (Table 3-4). The physical-chemical parameters show that the water quality in the micro-basins is good. Regarding the microbiological analysis, the values showed pollution with fecals and animals in most of the rivers tested, surpassing acceptable limits.

The presence of native fish (*Astroblepus* sp.) and macro-invertebrates is evidence that the water quality is still acceptable in the area. However, deforestation is evident, and this could affect water quality over time. Without doubt the most serious problem is the disposal of wastewaters from Chillanes to the river without treatment. From San Juan Pamba the water flows to the Alumbre river and finally to the Chimbo River. As a consequence, measures at the sub-watershed to protect the remaining forest are necessary, such as establishment of stream bank protection and fencing of strategic areas for water provision. The data gathered about aquatic micro invertebrates in the area are the first done and will be references for future studies in the area and others in the Ecuadorian Andean area.

Table 3-4. Quality of water using BMWP/Col and ABI indexes. Bolívar-Ecuador, 2008

Sub-watershed	Sitio	BMWP/Col*	Quality	ABI**	Quality
Illangama	Culebrillas 1	86	Acceptable	78	Very good
Illangama	Culebrillas 2	98	Acceptable	100	Very good
Illangama	P. arenales 1	44	Doubtful	54	Good
Illangama	P. arenales 2	58	Doubtful	65	Good
Illangama	P. Quindigua	101	Good	89	Very good
Illangama	Qda. Arrayacu	77	Acceptable	77	Very good
Alumbre	Tiquibuzo	213	Good	161	Very good
Alumbre	Panecillo	140	Good	140	Very good
Alumbre	Pacay	101	Good	84	Good

*quality good >100 and quality very critical <15:
** Illangama: very good >68 and very bad <10; Alumbre: very good >112 and very bad < 17

Participatory monitoring of water flows in the Illangama and Alumbre sub-watersheds

In Ecuador, we monitor atmospheric events in the zone using automatic weather stations, located strategically in the watershed basin. Sites for the weather stations were chosen based on life zones, vegetation surplus, water supply, and ecosystems. These study sites provide information needed for our models and to characterize conditions over time. The seven weather stations have automatic sensors that register average values every 15 minutes of precipitation, intensity (amount of rain), temperatures (maximum, average, and minimum), relative humidity, wind (speed and direction), atmospheric pressure, and solar radiation (Table 3-5).

Table 3-5. Average values of atmospheric phenomena, Bolivar-Ecuador, 2008

Station	Sub-watershed	P (MM)	T (°C)	RH (%)	SW (M/S)	WA (Ø)	PA (MBAR)	SR (W/M^2)
WEC1	Illangama	5.0	8.4	90.6	1.12	179.1	687.2	114.3
WEC2	Illangama	4.0	1.7	96.6	-	-	-	133.0
WEC3	Illangama	6.6	7.0	-	-	-	-	-
WEC4	Illangama	3.9	9.1	-	-	-	-	-
WEC11	Alumbre	7.1	13.8	94.9	0.44	191.9	775.1	155.4
WEC12	Alumbre	5.9	13.1	-	-	-	-	-
WEC13	Alumbre	7.6	13.4	-	-	-	-	-

P=precipitation; T=temperature; RH=relative humidity; SW=speed of the wind; WA=address of the wind; AP=atmospheric pressure; SR=solar radiation.

For the water flow study, sensors are being used to register the pressure exerted by drainage on a 15-minute basis; these data are compared with data from barometric sensors that also register data every 15 minutes. The difference shows the real pressure exerted by the river. Information on volume in the rivers is shown in Table 3-6. It is important to indicate that the precision of the data is increased with the number of gaugings, and it is possible to calibrate a linear regression between the height of the water level in the river (registered by the sensor) and the water volume.

Stakeholders in the watershed participate in this monitoring of climatic and water flow conditions. This participatory monitoring is an initial step toward quantification of the hydric resources. It permits modeling of the sub-watersheds and helps define high-priority actions of conservation and rehabilitation. Water monitoring with participation of the communities has stimulated interest in hydric resources and challenges to them. It engages communities in the management and conservation process.

Table 3-6. Average values of the volume of water in rivers registered in Illangama and Alumbre, Bolivar-Ecuador, 2008

Station	Sub-watershed	Drainage	Place	Volume (M^3/S) (dry time)
EC01	Illangama	Río Illangama	Quindigua central	0.05
EC02	Illangama	Q. Arrayan Yacu	Quindigua central	0.65
EC03	Illangama	Q. Chaupipogyo	Cullebrillas	0.02
EC04	Illangama	Río Illangama	Paltabamba	1.16
EC11	Del Alumbre	Río Guayabal	Guayabal	0.02
EC12	Del Alumbre	Río Guayabal	Pacay	0.06
EC13	Del Alumbre	Q. San Juanpamba	Chillanes	0.11

OBJECTIVE 2: generate and validate environmentally sustainable alternatives to improve production systems and enhance income generation. Some alternatives include new crops, on- and off-farm income-generation strategies, and technical improvements to existing practices

Research to meet this objective includes laboratory work to identify solution to key agricultural pest problems, on-farm participatory evaluations of alternative crop varieties and farming techniques, analysis of market chains and performance of agricultural markets, and measurement of economic gains/losses from existing and new technologies.

Critical research accomplishments

- We have information on the relationship between management practices and cropping patterns and soil loss for Ecuador and Bolivia. We have two complete years for the upper and lower Chimbo watersheds in Ecuador and one year for Bolivia but are able to characterize the relationship of interest.
- We have completed an assessment of the milk marketing chain in Ecuador and have identified a number of important obstacles to participation in higher-value markets. Policies are currently being considered to increase access to these higher-value markets. In Bolivia, we are about halfway through the assessment of access to higher-valued potato marketing chains.
- Several strategies have been identified for managing plant pests and diseases using lower-impact techniques, such as biological control, biofumigant cover crops, and other integrated management practices. We have conducted laboratory experiments and experiments in farmer fields to identify means of controlling cacao diseases, diseases of other Andean fruits, and diseases in conventional crops (potatoes, maize, beans).
- We have identified a number of crops and production practices of existing crops that are favorable in terms of income generation and lower impact on the environment.

System levels

Production and pest control research is being conducted at the field and farm scales; research on livelihood and crop production alternatives is being conducted at the field, farm, and market scales.

Development impact

- Each of these research themes will permit enhanced decision making at the farm and community level. At the farm level, we can raise incomes by 20 percent to 30 percent through adoption of improved management techniques. At the community level, land use planning will be enhanced by knowledge of the relationship between practices and soil loss.
- Access to higher-value chains can raise incomes in the area and create the economic space needed to implement conservation practices. Public actions to increase access will build local capacity to take similar decisions in the future.
- In Bolivia, information from our field experiments is being incorporated into farm plans.

Challenges and responses

Activities are proceeding as planned. In Bolivia, weather has not cooperated (El Nino phenomenon) and scientists are concerned about the representativeness of their results following two years of field trials. The research in Bolivia intentionally lagged behind that of Ecuador, but this year both sites have enjoyed the active collaboration of research partners.

Research progress

As noted, we are evaluating soil and productivity losses due to water erosion in production systems.

Ecuador

The most serious form of soil degradation is soil loss caused by erosion. This, in turn, depends on environmental conditions and management practices. Our study is the first to characterize the relationship between management practices and soil loss. The study had the following objectives: 1) determine the amount of soil lost as a result of superficial drainage in prominent production systems; 2) calculate the superficial drainage; and 3) calculate the level of macro- and micronutrients lost by this phenomenon.

Table 3-7. Indicators of soil loss by runoff. Alumbre sub-watershed, Bolivar-Ecuador, 2008

Treatments	Volume of accumulated precipitation M^3/ha	Volume of runoff water M^3/ha	Volume of infiltrated water M^3/ha	Eroded soil T/ha	Eroded ground lamina MM
Pasture	4740.00	49.51 b	4690.54 a	0.48 c	0.04
Corn	4740.00	119.55 a	4620.45 b	17.78 a	1.77
Bean	4740.00	164.14 a	4575.86 b	4.66 b	0.46

The farmer field plot was in a pilot property in the sub-watershed of the Alumbre River. Three treatments were considered in a random bloc design) maize, beans, natural pasture) with three repetitions. Each experimental unit was isolated with a metallic structure and protected in its upper limits to avoid water entrance from above. A wedge rain gauge was place to register rainfall on a daily basis. Tanks were used to collect runoff water with sediments, and aliquots were taken to quantify accumulated sediments. These sediments were analyzed for macro- and micronutrient content.

We have information on total precipitation, runoff water, water infiltrated, and eroded ground lamina (Table 3-7). These indicators correspond to the evaluation of the first productive cycle of natural pasture, maize, and bean. Greater surface runoff was registered in beans and maize production systems; the maize system displayed the most soil loss; and in natural pasture (*Pennisetum clandestinum*) least runoff was observed.

Table 3-8. Loss of macro- and micronutrients from water erosion, Alumbre sub-watershed, Bolivar-Ecuador, 2008

Elements		Production system		
		Pasture (kg/ha)	Corn (kg/ha)	Bean (kg/ha)
Macronutrients	N	0.136	4.400	0.988
	P	0.034	0.768	0.194
	K	0.013	0.489	0.105
	S	0.021	1.395	0.193
	Ca	0.095	4.470	1.147
	Mg	0.048	1.517	0.169
Micronutrients	Zn	0.015	0.306	0.051
	Cu	0.001	0.051	0.012
	Fe	0.302	12.686	3.165
	Mn	0.006	0.229	0.047
	B	0.239	0.002	0.410

Maize also is associated with the highest loss of macro- and micronutrients. Calcium, nitrogen, magnesium, and iron levels suffered the greatest losses from erosion (Table 3-8). This greater loss of soil and associated nutrients is due to the prolonged duration of the productive cycle in maize. An additional factor that contributes to greater erosion is cultivation for weeding and urea application during the productive cycle.

We also estimated the economic loss associated with erosion under an assumption of constant prices and production costs. In 10 years, the present value of the losses in the productive systems would be between $346.50 and $2,851.72 per hectare, depending on the product (Table 3-9).

Table 3-9. Present value of the losses in the productivity as a result of the hydric erosion, Alumbre sub-watershed, Bolivar-Ecuador, 2008

Item	Corn	Bean	Pasture
Initial depth of the arable layer (cm)	20.00	20.00	20.00
Yield (kg/ha/year)	864.00	724.00	6,600.00
Costs ($/ha/year)	338.00	364.00	85.00
Income (/4 ha)	345.60	289.60	70.00
Loss of the ground lamina (cm)	0.0178	0.0047	0.0005
Present value of the economic losses by hydric erosion in a period of 10 years	-$2,581.72	-$346.50	$50.10

This information is being used as input into our watershed models to understand how practices affect aggregate soil losses in the watershed and the economic costs associated with soil loss.

Bolivia

In our Bolivia site in the Tiraque region, we have established a number of trials in the upper zone to determine erosion losses associated with different vegetative covers. The following treatments were established:

Trial 1
Treatment 1. Native coverage
Treatment 2. Potato cultivated in rows up and down the slope, new land
Treatment 3. Potato cultivated in contours, new land
Treatment 4. Potato on recently fallowed land

Trial 2
Treatment 5. Native coverage
Treatment 6. New coverage on fallow land

We are collecting runoff water on a daily basis to determine volume of runoff, sediment, and total erosion loss per parcel. We have 629 observations from 15 plots (Table 3-10). The differences across treatments appear to be substantial, but the data are still undergoing analysis. In 2007-2008, abnormally heavy rainfall interfered with our trials.

Table 3-10. Measures of soil loss by treatment, Tiraque, Bolivia

Trial 1			Trial 2		
Treatment	**Soil erosion (kg/ha)**	**Total runoff (mm)**	**Treatment**	**Soil erosion (kg/ha)**	**Total runoff (mm)**
T1	2,418.19	41.75	T5	3,305.72	54.08
T2	2,658.94	104.13	T6	3,141.33	44.36
T3	2,371.70	24.04			
T4	1,354.05	24.44			

We also are evaluating nutrient balances associated with different farming practices, different varieties, and different management systems.

In Bolivar province, Ecuador, maize is the most widespread crop, with a surface of 25,000 hectares. Because of low yields and a fragile environment, we encourage site-specific and season-specific fertilization rates (MNSE). This methodology seeks to provide nutrients optimally based on plant needs. The objectives for this study were to quantify the potential yield and the limiting nutrients for maize; and to evaluate the agronomic and economic performance of MNSE. Three field plots with seven treatments were established in a complete bloc design (Table 3-11), where the localities represented the repetitions. All the treatments include soil conservation farming practices already identified as being suitable for Bolivar province.

Table 3-11. Description of treatments in study, Alumbre sub-watershed, Bolívar-Ecuador, 2008

Treat.	Fertilization levels					Sowing densities plants/ha
	N	P_2O_5	K_2O	S	Mg	
1	140	70	20	20	10	60,606 (25 cm x 66 cm) - 1 plants/site
2	140	70	20	20	10	60,606 (50 cm x 66 cm) - 2 plants/site
3	140	70	20	20	10	50,000 (25 cm x 80 cm) - 1 plants/site
4	140	70	20	20	10	50,000 (50 cm x 80 cm) - 2 plants/site
5	0	70	20	20	10	50,000 (50 cm x 80 cm) - 2 plants/site
6	140	0	20	20	10	50,000 (50 cm x 80 cm) - 2 plants/site
7	Farmers' fertilization					48,000 (72 cm x 95 cm) - 3 plants/site

Results show that the best treatments for grain yield are treatments 1, 2, 3, and 4, corresponding to fertilization of 140 kg of N/ha, 70 kg of P205/ha, 20 kg of K20/ha, 20 kg of S/ha, and 10 kg of Mg/ha with a plant density of 60,606 plants/ha (treatments 1 and 2) and 50,000 plants/ha (treatments 3 and 4), Table 3-12. Producers evaluated the treatments and decided that the best treatment was the one with 140 kg of N/ha, 70 kg of P_20_5/ha, 20 kg of K_20/ha, 20 kg of S/ha, and 10 kg of Mg/ha with a sowing density of 60,606 (25 cm x 66 cm).

Table 3-12. Averages and Tukey test for the indicators evaluated, Alumbre sub-watershed, Bolívar-Ecuador, 2008

Treat.	Fertilization levels					Harvested plants per hectare	Grain yield t/ha
	N	P_2O_5	K_2O	S	Mg		
1	140	70	20	20	10	55,682 a	2.51 a
2	140	70	20	20	10	55,555 a	2.52 a
3	140	70	20	20	10	48,125 b	2.65 a
4	140	70	20	20	10	47,292 b	2.41 a
5	0	70	20	20	10	43,125 b	1.86 ab
6	140	0	20	20	10	45,938 b	2.05 ab
7	Farmers' fertilization					34,972 c	1.28 b

Different letters indicate significant differences ($p <= 0.05$).

We also find that nitrogen is a key limiting nutrient; phosphorus, potassium, sulfur, and magnesium did not significantly influence maize yields. In all the treatments, the application of nitrogen to the soil considerably increased the extraction of nitrogen, phosphorus, potassium, sulfur, and magnesium. The application of phosphorus, potassium, sulfur, and magnesium did not alter the extraction of these elements in the aerial part of the maize plants. The distribution of the nutrients in the maize plant was:

- N – 50 percent in the grain, 3 percent in the maize-cob, 47 percent in the residues
- P –59 percent in the grain, 2 percent in the maize-cob, 39 percent in the residues
- K –12 percent in the grain, 3 percent in the maize-cob, 85 percent in the residues, and
- Mg –32 percent in the grain, 2 percent in the maize-cob, 66 percent in the residues.

Economic analysis of alternative production systems

Ecuador

We conducted meetings in our communities to define the target production systems. The objective was to focus our research on selected practices to understand how conditions could best be improved. Through participatory procedures, we identified BMPs (see Table 3-13) for improvement and conservation of natural resources. The technological alternatives essentially oriented to the conservation and management of soil and to improve the life strategies of the producing families.

Table 3-13. Technologies selected for implementation in Chimbo watershed, Bolívar-Ecuador, 2008

Illangama	Alumbre
• *Drainage ditches and grass strips* • *Enhanced rotations: nature pasture, potato, barley, bean, quinoa* • *Natural fences* • *Intercropping chocho and pasture* • *Timed plantings* • *Enhancement of associated cropping systems: maize-bean and maize-broad-bean.* • *Improved pastures with the use of mixtures with annual rye grass, bluegrass, perennial white and red clover, rye grass biennial and rye grass.*	• Strip cultivation: wheat, maize, beans • Terraced cultivation of vegetables • Natural fences • Contour planting of fruit trees • Low intensity farming of maize and beans • Establishment of improved pastures with the use of mixtures with annual rye grass, bluegrass, perennial white and red clover, rye grass biennial and rye grass • Crop rotation: maize, climbing beans, bush beans • Contour strips

We also used participatory methods and our GIS data to identify areas in the watershed of greatest vulnerability (Figure 3-12) where we sought to implement our BMP (Figure 3-13). We have an intervention plan in each of the 12 pilot units in which the information is being taken from all the implemented components. These data will be analyzed in the coming year to identify the most promising BMP for the area.

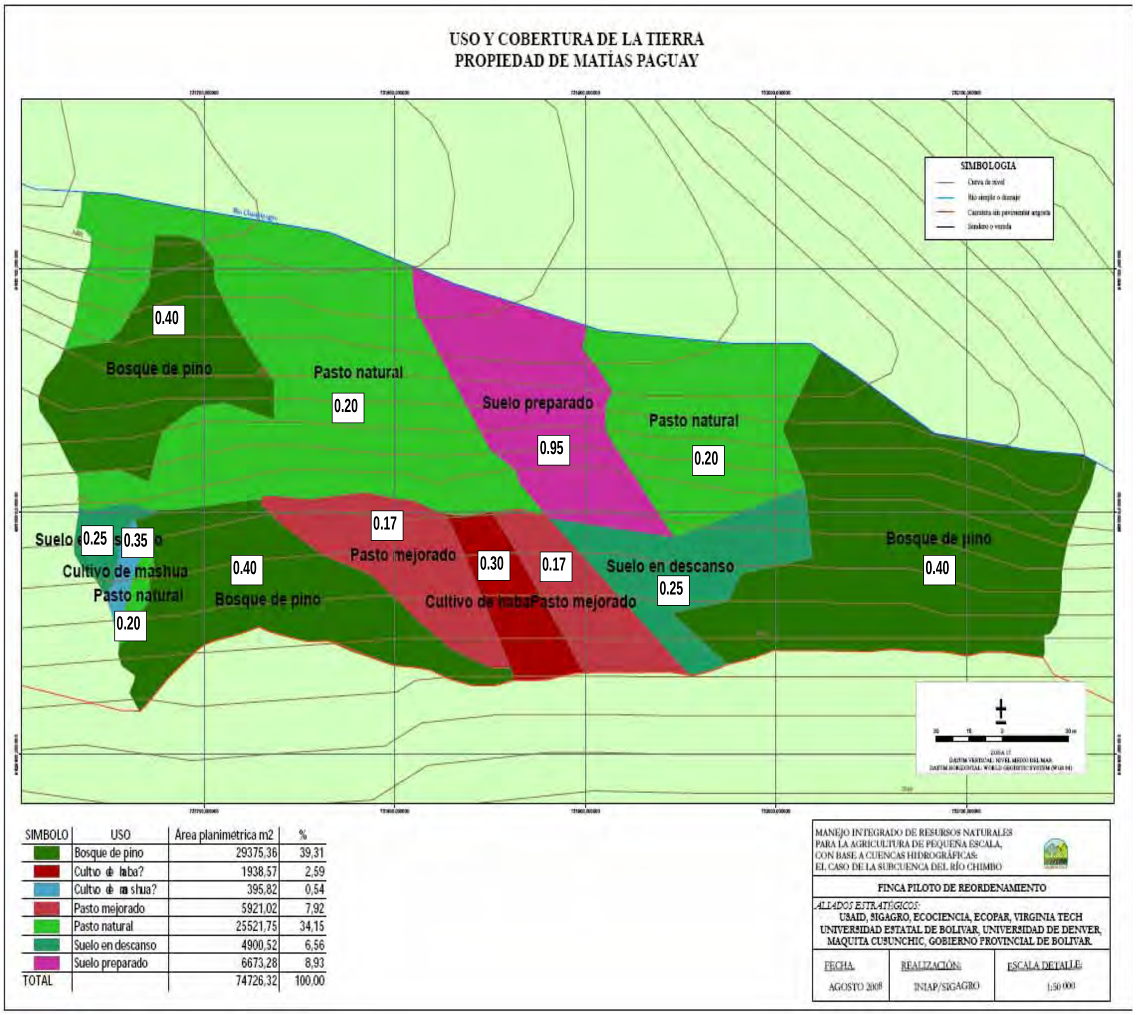


Figure 3-12. Map of soil use and analysis of physical and environmental vulnerability in a pilot unit of the community of Marcopamba, Bolivar-Ecuador, 2008

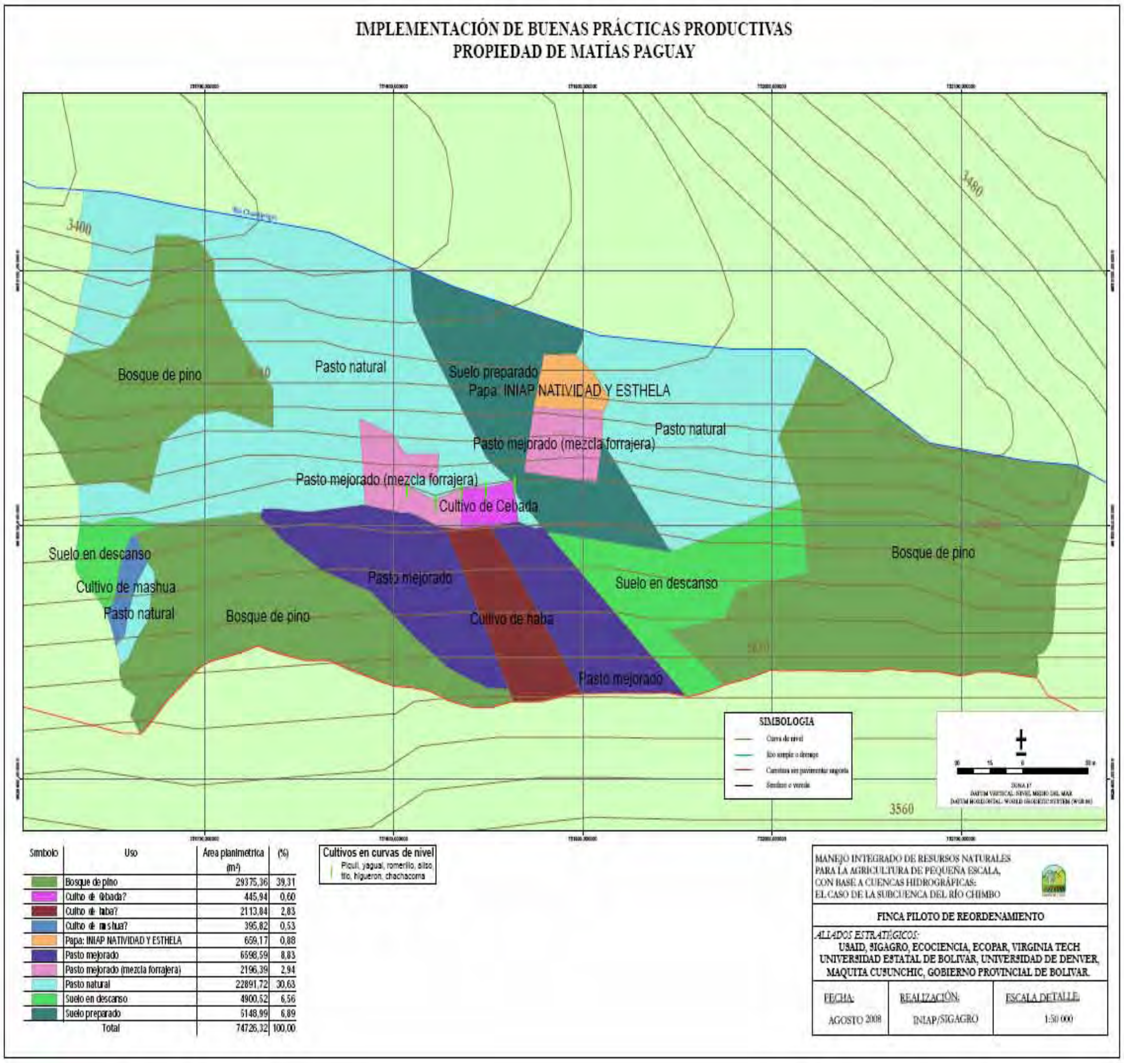


Figure 3-13. Planning best management practices (BMP) in a pilot unit of the community of Marcopamba, Illangama sub-watershed, Bolivar-Ecuador, 2008

<u>Bolivia</u>

Fava beans, potato, temperate tree fruits, strawberries, maca, quinoa. We have identified from field trials the most suitable fava bean variety (*habilla de altura*). This variety is being included in our evaluation of income-earning potential by households. We have evaluated a number of maca production systems, varying planting density and elevation, and now know that maca is a high-yielding crop that can play an important role in efforts to diversify incomes, especially in the middle portion of the watershed. Yields of nearly 3,000 kg/hectare are possible with planting densities of 2.5 kg/hectare. Farmer groups have been established to promote production and coordinate marketing of this important crop. Quinoa test plots have shown highly variable yields, and we need to do more work before we can recommend this product as a food security supplement. Management of yield variability caused by nematodes and diseases is under evaluation at several sites and in several crops using bio-intensive pest management.

We had hoped that production of strawberry seedlings would provide an alternative source of income for farmers in the mid-elevation of the watershed, but two-plus years of experimentation have been disappointing, mainly due to the cold conditions in the area. We believe that the only viable alternative is production in greenhouses and are looking for low-cost suppliers. Our study of the seedling market indicates that substantial demand exists for the product, and many producers in the medium-elevation of the watershed have water resources needed for greenhouse production. However, virus- and pathogen-free seedlings are in competition with lower priced questionable seedlings.

Analyze marketing system to identify obstacles to participation in higher-valued markets. Entrance by producers into higher-value chains may represent a means of increasing incomes through rather modest actions. We identified two potential value chains – milk and dairy in Ecuador and potatoes in Bolivia – and sought to analyze obstacles to participation in higher-return paths within the chains. Further analysis of the chains will allow the establishment of strategies that optimize benefits to participants.

In Ecuador, semi-structured interviews were conducted with producers (141), intermediaries (10) agrochemical and veterinarian products sellers (5) and final consumers of artisan cheese (15). Also, six case studies were done at the producer level to characterize milk and artisan cheese production processes. We used cluster analysis, simple descriptive statistics and test of mean differences.

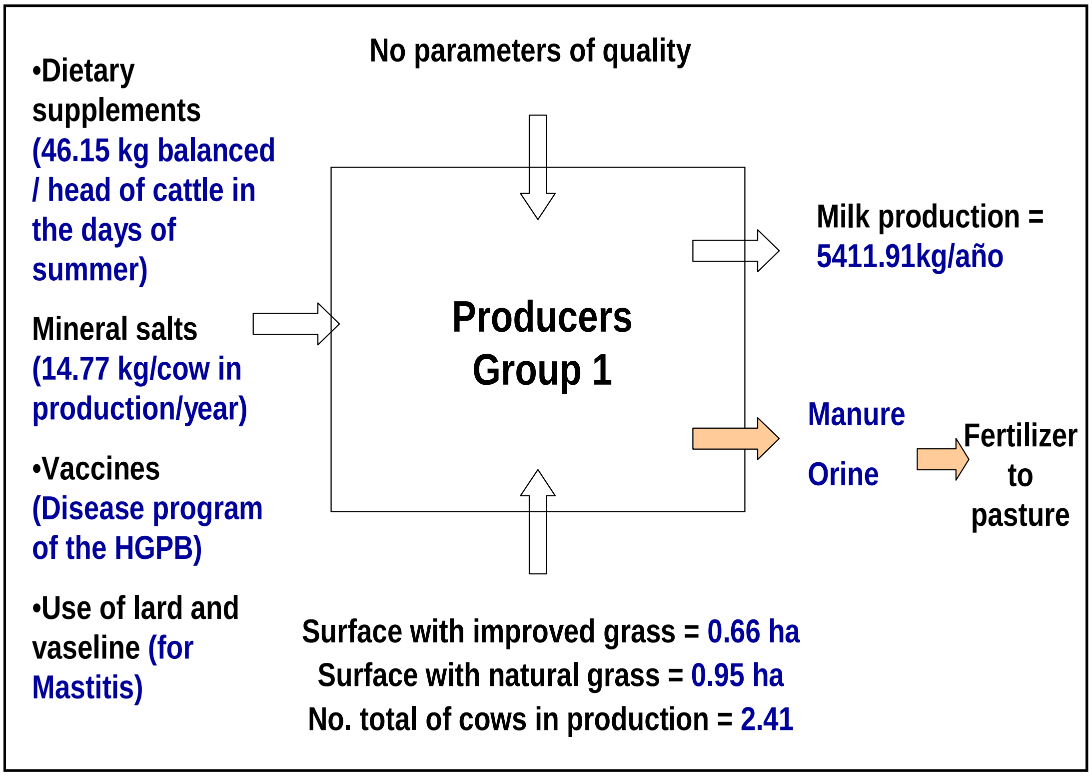
We identified two groups of milk producers and artisan cheese (Table 3-14); 86 percent are within Group 1 and 14 percent in Group 2. The producers of Group 2 use improved practices, own larger land surfaces, use more improved pasture, have larger herds, and depend mainly on incomes from dairy (rather than other on- and off-farm livelihoods). Those in Group 1 are small-scale producers.

Table 3-14. Characterization of groups of milk producers, Illangama sub-watershed, Bolivar-Ecuador, 2008

Indicators	Average	
	Group 1	Group 2
Age of the family head	41.69	51.17
Years of study of the family head	2.91	2.00
Total surface of the farm (ha)	2.69	8.21
Total surface with natural grass (ha)	0.95	1.69
Total surface with improved grass (ha)	0.66	3.78
Total number of bovines	6.85	13.33
Total number of cows in production	2.41	4.83
Milk production (kg/year)	5,411.91	11,720.56
Cheese production (kg/year)	439.44	912.22
Gross income by milk cattle ranch (USD/year)	659.17	1,368.33
Gross income by family (USD/year)	2,812.18	7,061.33
Income by agricultural activities outside the farm (USD/year)	79.75	0.00
Income by activities with salary (USD/year)	428.40	863.33
Economic value of production means (USD))	59.01	658.50

The characterization of milk production by each group is shown in Table 3-14. Group 1 producers use more nutritional supplements, especially during the dry season when on-farm feed availability falls. Milk production depends on available feed (given the genetic quality of the stock), which is usually natural grass with low nutritional quality. Some Group 1 producers also own small areas where they have introduced improved pastures, and by all indications the improved nutrition from these grasses has positive impacts on milk production, but the producers lack the land and financial resources to expand their areas of improved pasture. Group 2 producers have larger extensions of improved pasture and indicate that the amount they have covers the nutritional necessity during the dry season. As a result, this group of producers is able to save resources otherwise spent on nutritional supplements.

In both cases, however, sanitary norms are not adhered to and quality is a major problem. For both groups, 6 kg of milk are required to produce 1 kg of cheese. One of the main disadvantages in the commercialization process is the dispersion of the producers and the low production for artisan cheese, especially the producers of Group 1 (2.27 kg/day). These small-scale producers directly commercialize their cheese because intermediaries demand larger amount of products than they can supply (Figure 3-15).



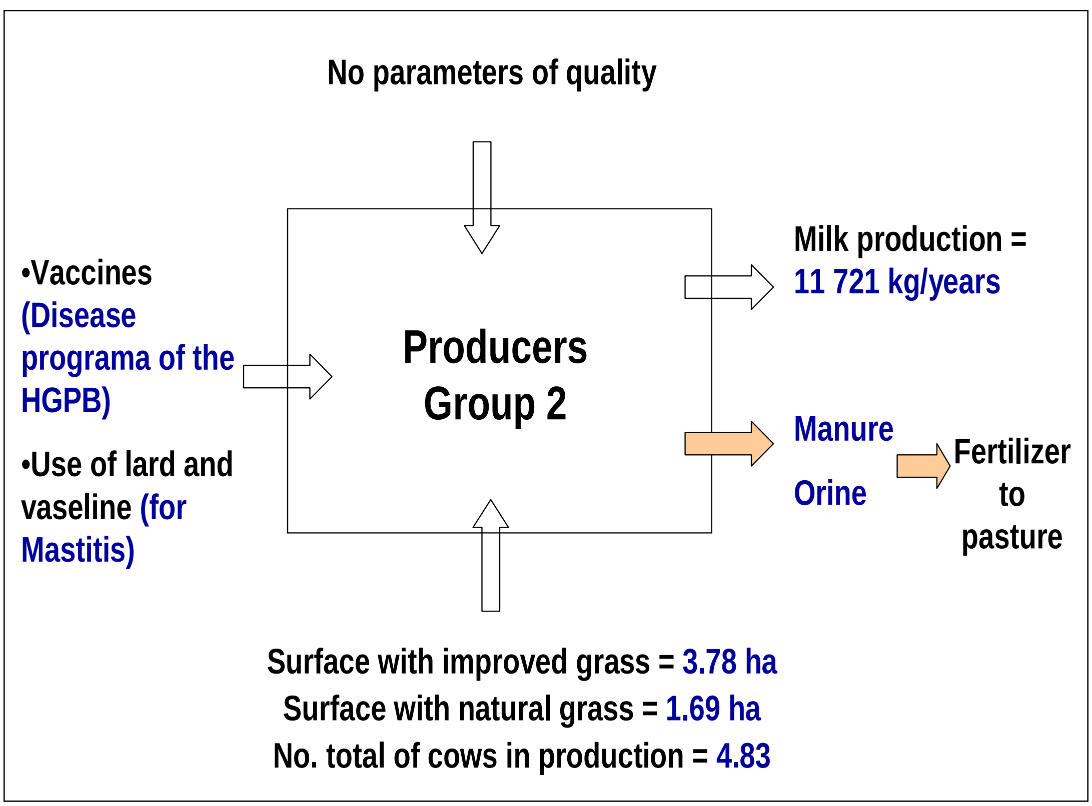


Figure 3-14. Characterization of the technical function of milk production, sub-watershed of the Illangama River, Bolivar-Ecuador, 2008

The price received for cheese oscillates between $1.32 and 1.43 per kilogram, but final consumers pay between $2.60 and $2.86. Due to the prices the producers can get by selling directly, the Group 1 producers accumulate the cheese all the week and exchange it on the days they go to the market to supply themselves with food. The production cost of a kilogram of cheese is $1.28. This implies that from the price at the farm to the final consumer, the value of cheese nearly doubles.

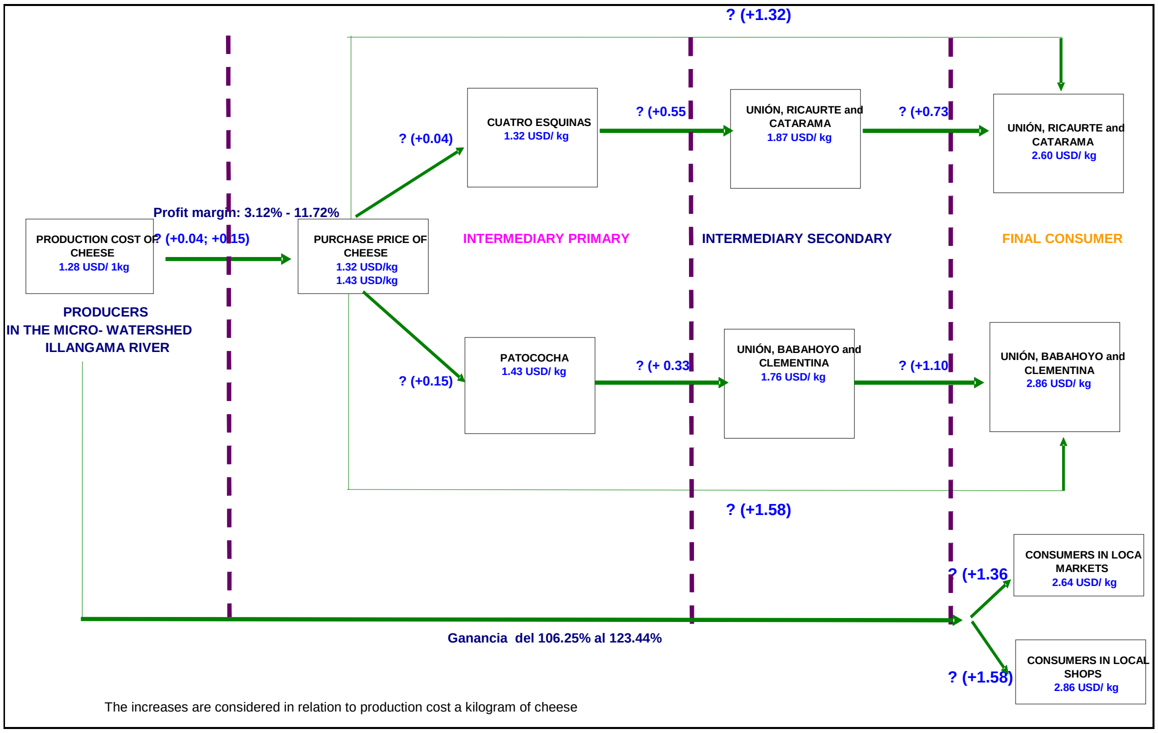


Figure 3-15. Value chain for artisan cheese production, sub-watershed of the Illangama River, Bolívar-Ecuador, 2008

Biocontrol of fruit pests. Fruits in Ecuador and Bolivia face severe disease constraints due to climatic conditions and other factors. Current control methods rely on heavy use of pesticides, which imply high costs (and low profits) and potential damage to the environment. SANREM has invested significant resources into identifying lower-cost and environmentally friendly pest control techniques. For stone fruits, we have provided natural competitors that can totally prevent crown gall disease.

Post-harvest experiments. Nine endospore-forming bacteria (seven collected from unmanaged apple orchards and two from vegetables) have been found and evaluated for their ability to suppress the bitter rot pathogen *Colletotrichum acutatum* on apple fruit. Effectiveness of the bacteria in combination with or without AgSil (potassium silicate) was also tested. Tree-ripe Rome beauty fruit were harvested from trees receiving a standard fungicide program. Following harvest, fruits were washed in a 1 percent bleach solution and rinsed twice with tap water. Isolates of *C. acutatum* were obtained from infected fruit and maintained on potato dextrose agar (PDA). The bacterial isolates were grown in tryptic soy broth at 24C for seven days. Bacterial cells were pelleted using a Sorvall RT7 centrifuge at 2,800 rpm for 20 minutes, resuspended in

0.1 M potassium phosphate buffer, and the concentration was adjusted to log 8 CFU/mL. Fruits were spray-inoculated with bacterial isolates using hand-held spray bottles, placed on cardboard packing trays, and stored at 34C. One week later, fruits were wounded (2mm by 2mm deep) with a sterile nail. Wounds were inoculated with a 20 µL bacterial suspension (log 8CFU/mL). Within one hour wounds were challenge-inoculated with a 20 µL suspension of *C. acutatum* conidia. One hour after challenge, respective wounds were inoculated with 20 µL of a 2 percent AgSil solution. Wounded fruits were randomly placed on molded cardboard packing trays (20 fruit per tray) so that each tray contained representatives from each treatment. Individual fruit served as one replicate with 18 replications per treatment, and trays served as blocks. Trays were stored on plastic shelving at 20 C in a controlled atmosphere chamber. Fruit were evaluated for disease severity one week after pathogen inoculation.

All bacterial treatments except isolate BacJ alone significantly reduced lesion area compared with unsprayed controls (Table 3-15). AgSil alone was not effective, for it was not significantly different from the unsprayed control. The presence of AgSil did not have a significant effect when combined with most isolates except with A1-1. A 68 percent reduction in lesion area compared with unsprayed controls was observed on fruit treated with the isolate alone; however, only a 30 percent reduction resulted when combined with AgSil. Isolate A3-6 was most effective, resulting in 89 percent reduction in lesion area compared with unsprayed controls and 90 percent compared with AgSil treated controls.

Table 3-15. Suppression of bitter rot lesion area by endospore-forming bacteria isolated from apple and vegetables

	Mean lesion area (MM^2)[z]	
Treatment/ Bacterial isolate	**Bacteria alone**	**Bacteria + 2% AgSil**[y]
Untreated control	268 a[x]	300 a
A1-1	87 c	211 b
FO-20	151 bc	198 bc
BT8	153 bc	176 bcd
BacJ	195 ab	137 cd
A2-4	143 bc	195 bc
A3-F1	111 bc	154 bcd
A3-1	87 c	160 bcd
A3-6	30 d	29 e
A3-2	119 bc	119 d

[z] Lesion diameters were measured vertically and horizontally across the wound site. The average diameter was used to calculate the total diseased area (πr^2) on each fruit.
[y] Rates are based on product recommendations.
[x] Within columns, means with the same letter are not significantly different at P=0.05 as determined by the Tukey-Kramer test.

Fuji fruit were used to assess bacterial colonization. Fruit samples were collected one week after each bacterial inoculation. The level of applied bacterial populations was determined using conventional microbiological methods. Plugs (#9 core borer) were removed from fruit samples and triturated in a stomacher blender to disrupt the plant tissue. From the resulting supernatant (50 µl) was dilution plated in triplicate onto YED. The remaining supernatant was heated at 75 C for 15 minutes to select the endosporic population from the total population. This supernatant was plated as above. All plates were incubated for 24 hours, and bacteria will be enumerated. Results indicated that AgSil did not significantly affect fruit surface colonization by any of the tested bacterial isolates (Figure 3-16).

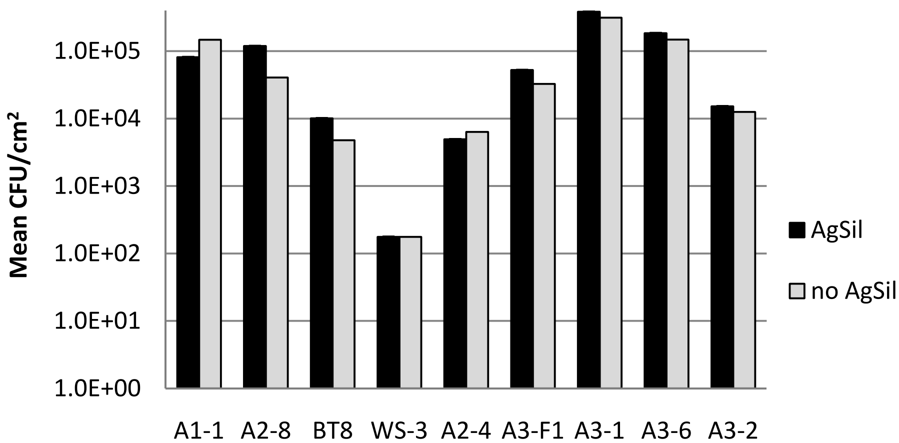


Figure 3-16. Influence of AgSil® on the colonization bacterial isolates on Fuji fruit

Field experiments. Field trials were conducted at the Penn State University Fruit Research and Extension Center in Biglerville, Pa. To evaluate the timing of bacterial application on preharvest and postharvest disease severity, branches of four varieties – Rome Beauty, Golden Delicious, Gala, and Gold Rush – were tagged and utilized for preharvest applications of bacterial isolates and a source of fruit for postharvest applications. Preharvest applications of four bacterial isolates were applied at 10^8 CFU/ml to leaves and apples on eight branches (replicates): one application in May, two applications in May and July, and one postharvest application. At the time of bacterial inoculation for preharvest treatments, the last fully expanded leaf was marked with tape. Starting in May, apple scab and rust disease severity was assessed weekly until terminal bud occurred and new susceptible tissue was no longer available. To evaluate apple scab, percentage of leaf area diseased was estimated on all leaves (occurring after the tape) on two shoots per branch using a 7-point rating scale where 0 = No visible symptoms, 1 < 2 percent, 2= 2 percent to 7 percent, 3=7 percent to 15 percent, 4=15 percent to 25 percent, 5=25 percent to 40 percent, 6=40 percent to 60 percent, and 7>60 percent. Results indicate that isolates FLS-5 and A1-1 were able to suppress apple scab disease severity throughout the growing season (Figure 3-17). Further analyses are necessary to determine the significance of disease reduction and to test for treatment interactions.

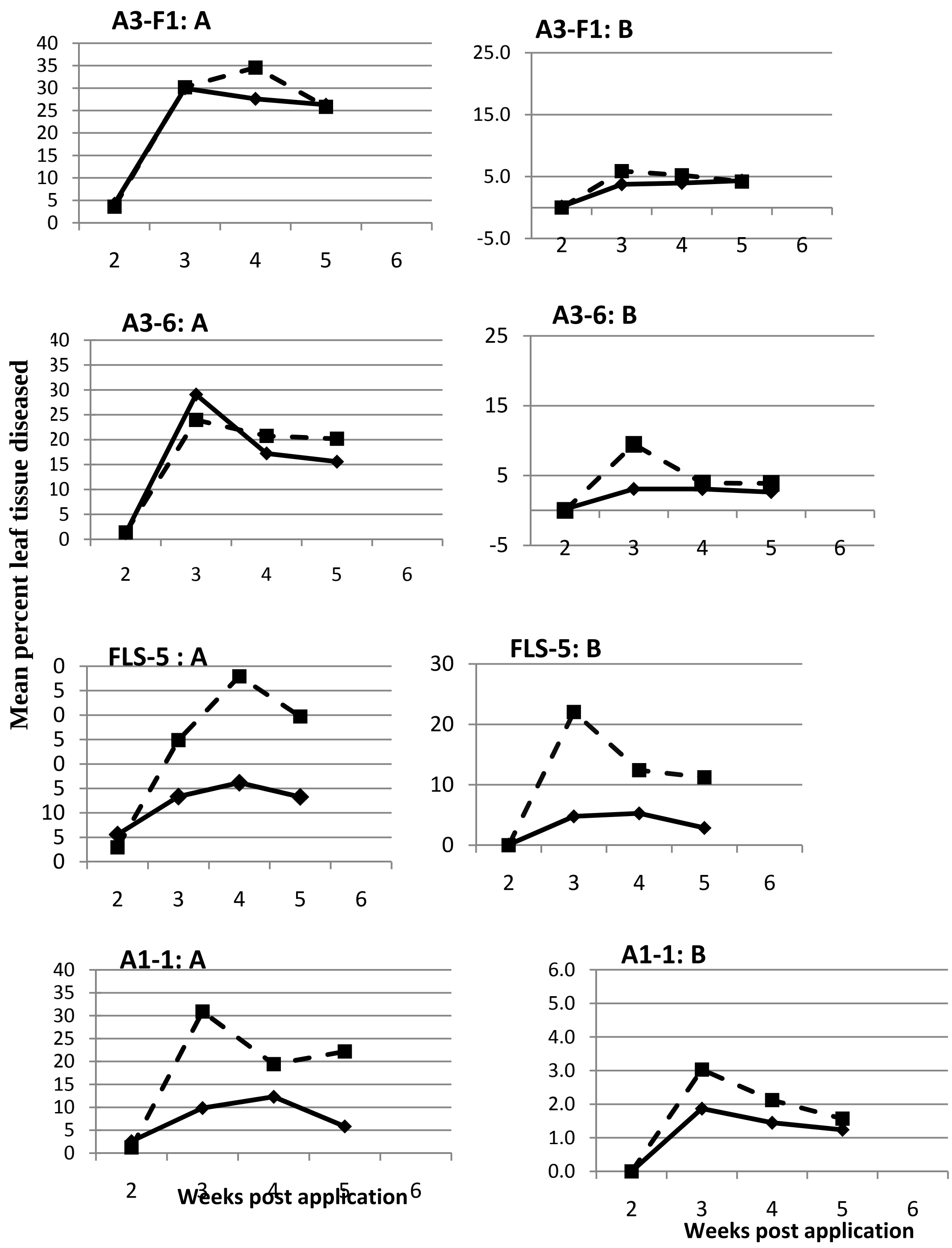


Figure 3-17. Effect of bacterial isolates on apple scab disease severity on branch inoculated Rome Beauty and Golden Delicious trees.*

Disease assays in two research plots; (A) and university drive (B). Solid lines represent branches treated with the bacterial isolate, and dashed lines represent the non-treated control.

*There were no significant differences in disease severity on Rome Beauty and Golden Delicious, so the data were pooled.

Depending on the variety, fruit will be harvested in September to October. Upon harvest, fruit will be rated for apple scab, flyspeck, and sooty blotch disease severity and incidence. Fruit collected from the postharvest application treatment will be spray-inoculated with four bacterial isolates at 10^8 CFU/mL. One week after harvest, fruit from all treatments will be wounded and challenged with 10^4 conidia/mL of the bitter rot pathogen *C. acutatum*. Similar tests developed by PROINPA in Cochabamba, Bolivia, confirm these results, and procedures are being adapted to Bolivian conditions.

Field experiments have been established to evaluate alternative control strategies in Bolivia. The use of green manure crops is being evaluated for suppression of nematodes. There are virtually no organo-chemicals still registered for nematode control in the United States or Bolivia. Crops of mustards, radish, and arugula are known to produce cyanogenic products that kill nematodes when the crop is tilled into the soil and allowed to decompose. These experiments are being established for evaluation in early 2009. The use of bacteria to control foliage diseases in fava bean and potato is being evaluated. These experiments were established in September, and will be evaluated in the spring. The use of non-pathogenic agrobacterium radiobacter for control of crown gall in peach is also being evaluated. This particular treatment is the primary control for crown gall in the United States.

Biocontrol, Bolivia. We have identified the following isolates of endophyte bacteria: 53 from cereals, 32 from fava beans, and 25 from potato. Our first evaluation was of effects relative to *Alternaria fabae*. Of 55 isolates evaluated, only one was highly efficient (1A9a), but we have selected three for evaluation on farmer fields. During the current year, we are evaluating isolates against chocolate spot in fava bean (*Botritys fabae*). We have identified 23 isolates from the following: *Penicillium*, *Aspergillus,* and *Cladosporium*.

We are also examining the response of nematodes to biofumigants. These techniques include solarization, use of plastic as an inhibiting mulch, and incorporation of biofumigation plant material into the soil. We have two trials currently in place. First-year results are very promising.

Biological control of cacao pests, Ecuador. Diseases are the most important factors limiting production of *Theobroma cacao* in South America. Because of high disease pressure and environmental concerns, biological control is a pertinent area of research for cacao disease management. In this work, we evaluated the ability of four *Bacillus spp.* isolated from vegetable crops for their ability to colonize *T. cacao* seedlings and reduce the severity of black pod rot (*Phytophthora capsici*). Of the *Bacillus spp.* tested, application of *B. cereus* isolates BT8 from tomato or BP24 from potato, together with the polysilicon surfactant Silwet L-77 (0.24 percent/volume) resulted in long-term (>68 days) stable colonization of cacao leaves. Further investigation revealed that foliar colonization by BT8 and BP24 was primarily epiphytic, with endophytic populations typically representing 5 percent to 15 percent of total foliar bacteria. Significant reductions of disease severity (P 6 0.05) on cacao leaf disks challenged with *P. capsici* were recorded from after day 26, and through 68 days following colonization with BT8. No bacterial colonists were observed in or on leaves that developed after bacteria application, suggesting that the bacteria were not capable of systemic movement through vascular tissues. These newly developed non-colonized leaves from colonized plants exhibited disease suppression, which supports a probable disease suppression mechanism of induced systemic resistance for the BT8 isolate. (See Melnick, Zidack, Bailey, Maximova, Guiltinan, and Backman (2008) for more detail on this series of trials.)

Diagnosis of decision-making institutions in small-scale irrigation systems, Bolivia. Our Bolivian site is challenged by conflicts related to water access and allocation of water rights within small-scale irrigation systems. We are undertaking a diagnosis of institutions and how decisions are made in these systems. This diagnosis includes: identification of all the systems in the watershed; a diagnosis of challenges and decision-making processes, based on a participatory exercise; and alternatives for solution to access and decision-making problems. To date, we have identified and geo-referenced all of the sites and have undertaken group exercises in three selected systems. In these group interviews we engage participants in discussions about how decisions are made, who is responsible for which tasks, and how disputes are resolved.

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 takes individual responses (changes in practices at the field, farm, and market scales) and aggregates them to the watershed scale. It will also create a mapping between policy (and other interventions) and outcomes at the aggregate level

Critical research accomplishments

- We currently have calibrated watershed models for both our Ecuador and Bolivia sites. These models are being used to estimate watershed-level runoff and impacts on water quality of alternative land-use patterns. The simulations we are running are being used to evaluate alternatives and as input into community decision making. In Ecuador, we have had a number of workshops with local government authorities to examine how projected changes in land use will effect erosion, runoff, and water quality
- Household data have been thoroughly analyzed in both sites, and a comprehensive analysis of the determinants of livelihood strategies has been completed for the Ecuador data. This analysis was completed by Robert Andrade as a part of his master’s thesis in agricultural and applied economics at Virginia Tech. We now have information on the relative benefits (and impacts on household livelihood choices) of a variety of interventions, including more access to adult education, increased irrigation, and improved access to credit. These results are being used to simulate changes in strategies as policies are adopted by local governments and, when used in conjunction with the watershed models, will show how policy affects land use, which in turn affects erosion and water quality in the area.
- We identified four livelihood groups in the Illangama sub-watershed and three in Alumbre. The groups defined for Illangama are: Group 1 (37 percent), depend on agriculture, livestock, and off-farm income; Group 2 (38 percent), depend on agriculture, livestock, and incomes from off-farm labor; Group 3 (9 percent), depend on agriculture, livestock, and incomes from own business; and Group 4 (16 percent), depend on agriculture and incomes from social help and migration. For the Alumbre sub-watershed the results are: Group 1 (40 percent), depend on agriculture, livestock, and incomes from own business or off-farm labor; Group 2 (35 percent), depend on agriculture and incomes from off-farm agricultural work and social help; Group 3 (25 percent), depend on

agriculture and incomes from off-farm labor and migration. Households in most of these livelihood groups generate income through off-farm labor.

- Data on farmer risk perceptions and its impact on potato variety selection was collected and analyzed for our Bolivian sites. Data collection and analysis were completed by Michael Castelhano as a part of his master's thesis in agricultural and applied economics at Virginia Tech. Results show that disease resistance has an important impact on variety selection but that taste and marketability of the potato are most important. Results will be used to help inform breeding research at PROINPA.

System levels

The watershed model uses data from the field and the farm scale to aggregate to changes at the watershed scale. It is our principal cross-scale evaluation tool. Livelihood work is being done at the farm, market, and watershed scales. We use the results from the livelihood analysis to simulate impacts of change at the policy level.

Development impact

- Having the ability to use models to simulate land-use changes represents a huge step forward in evidence-based decision making at local levels in both of our countries. Our collaborative research process has built confidence in the research process and leads to greater acceptance of research findings. This has a major impact on uptake and incorporation into policy decisions. It fosters both knowledge and capabilities to make decisions; we have yet to see how much impact it has on actions. The importance of working watershed models can not be overstated: We now possess the bedrock upon which we can make informed decisions about the watershed.
- The household data analysis helps create an environment of better-informed decision making. The results are being incorporated this year into the watershed models and are also being used on their own to understand how policy can change household decisions. In Bolivia in particular, good evidence on social conditions is lacking; we now have information on these conditions and can analyze how policy affects these conditions.
- The information on farmer risk perceptions and their determinants will be used to create more cost-effective breeding programs and will also inform extension efforts.

Challenges and responses

Activities under this objective are being conducted in a timely fashion. The watershed models are very data-intensive. The necessary data had to be gathered from a variety of sources, and in some cases primary data needed to be collected (e.g., rainfall for the Ecuador site). This has led to some delays, but they were unavoidable. In both countries, our research partners have done yeoman's work in assisting with data identification and collection. We have also strengthened in-country capacity to do fairly technical modeling (see below), and this capacity helps us by sensitizing host-country partners to our data needs and allowing them to better understand the utility of the data. Collection of household data in Bolivia was slowed by community suspicions and objections by the local government, but these problems were alleviated in 2007, and our data set is now complete.

Research progress

Watershed modeling

We have now applied the SWAT model (the soil and water assessment tool) to both the Ecuador and Bolivia watershed (figures 3-18, 3-19, and 3-20). It is difficult to overstate the importance of this outcome: We now have the basis on which we can apply the adaptive management framework in a developing country. We have begun to incorporate the livelihood study results into our watershed model and can use the models to simulate changes in management and land use. We also are applying a field-scale model (GLEAMS) to selected individual management systems to provide more detailed input to SWAT. All this information will be used to evaluate water quantity and quality impacts of different livelihood scenarios.

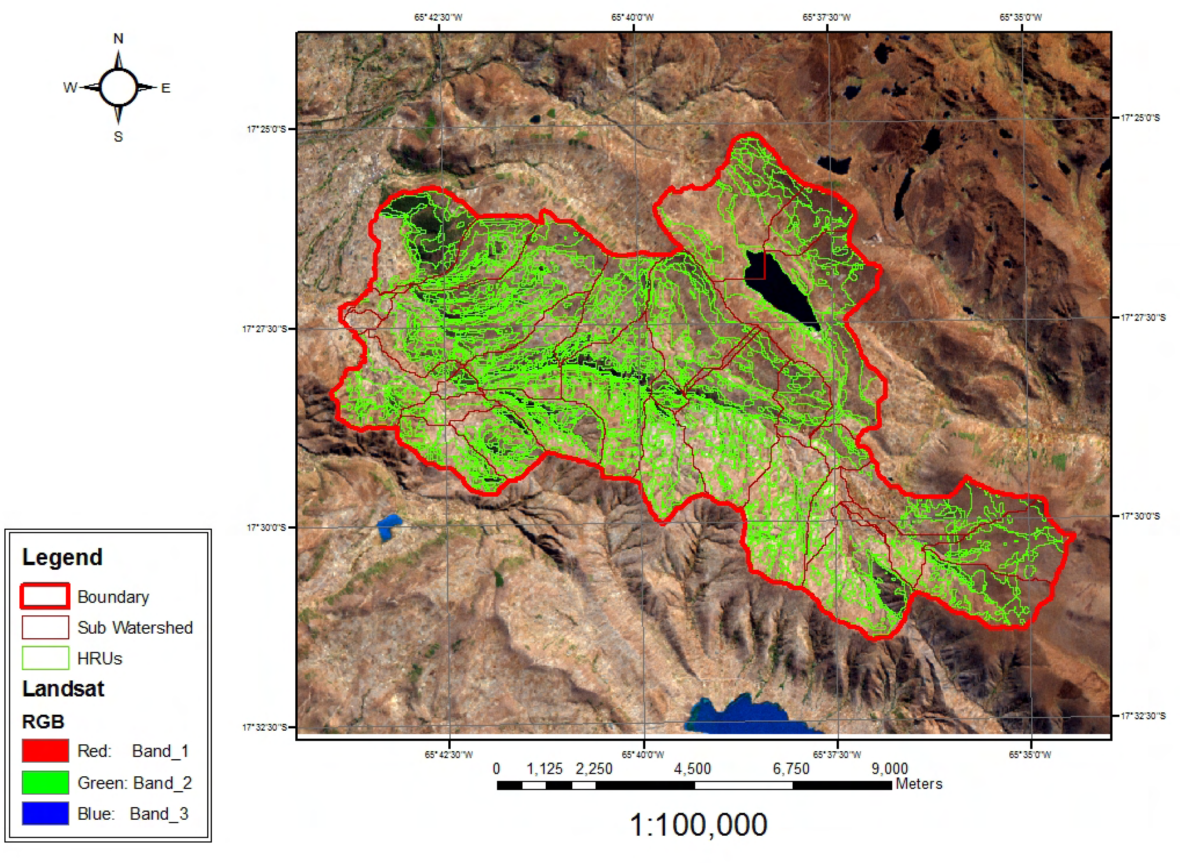


Figure 3-18. Sub-watersheds and hydrological response units over a LANDSAT image of the Jatun Mayu River Watershed, Bolivia

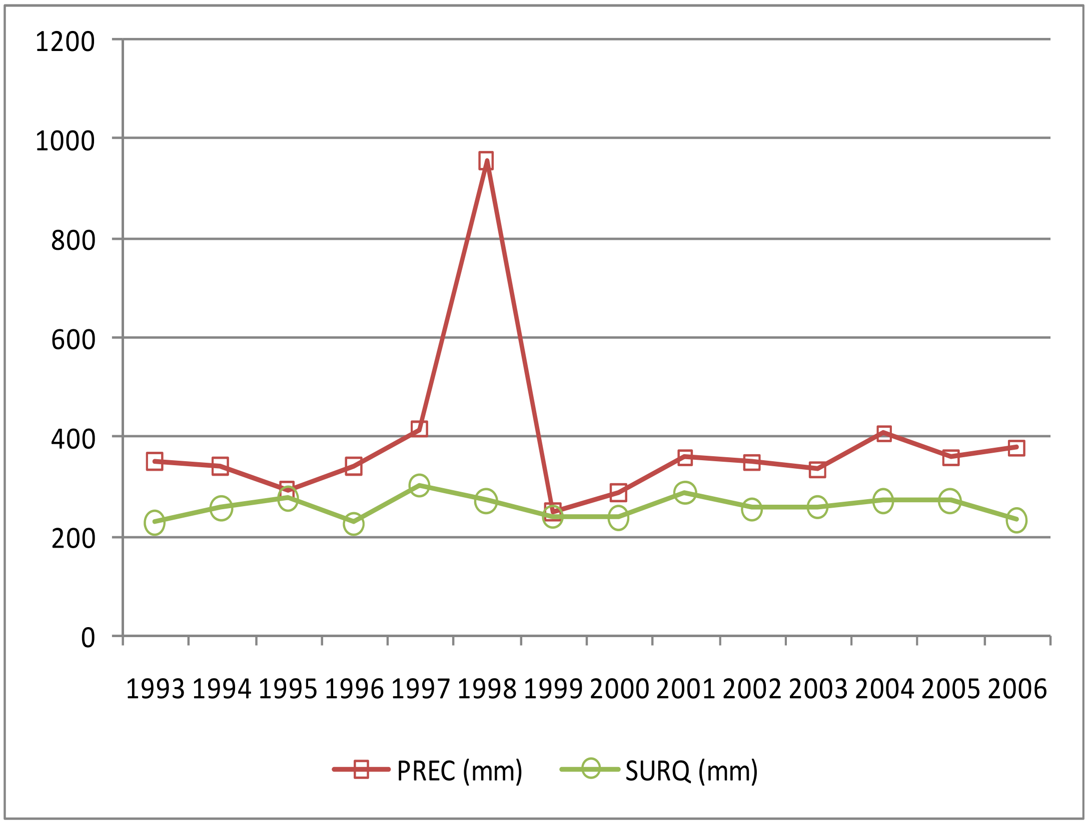


Figure 3-19. Precipitation and SWAT-simulated runoff (mm/year) for the Jatun Mayu River Watershed, Bolivia

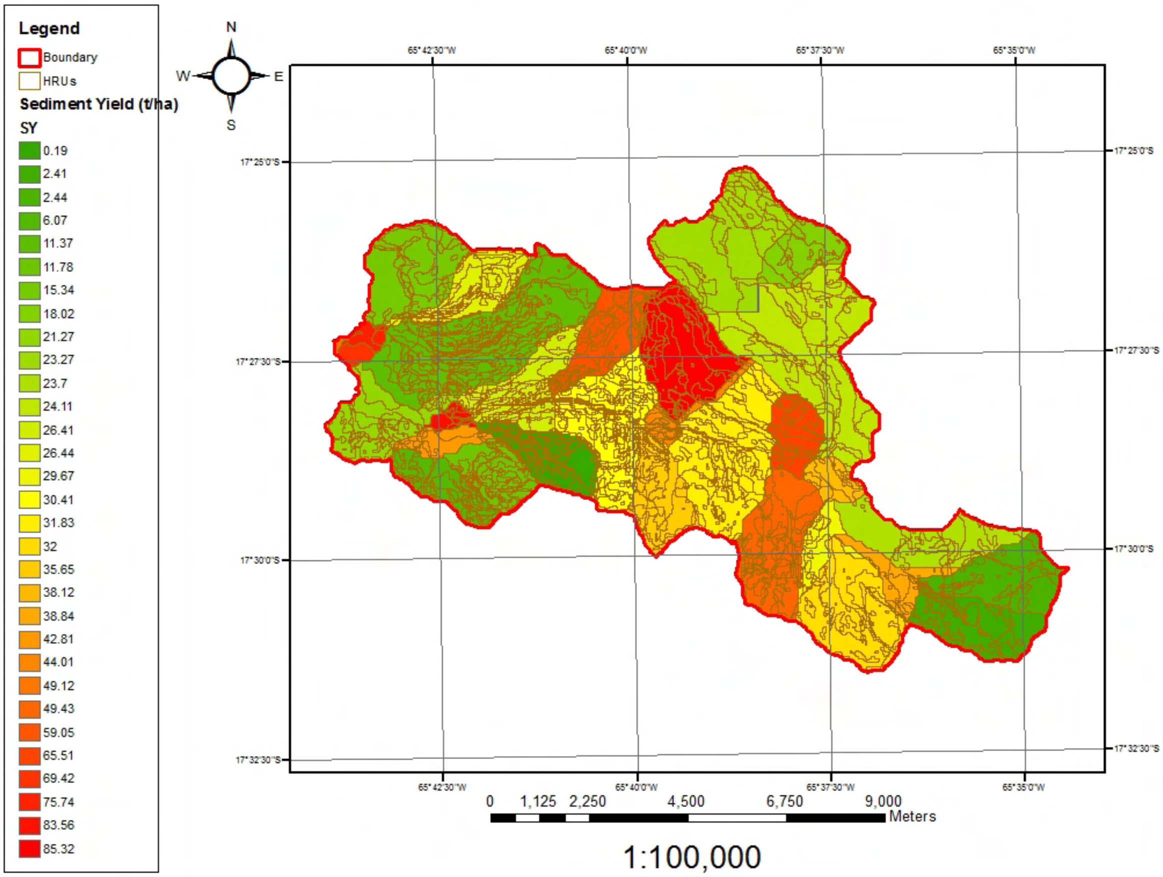


Figure 3-20. SWAT-simulated sediment yield (t/ha) for 1993 for the Jatun Mayu River Watershed

Household data collection and analysis

Households in rural Ecuador face different challenges, but poverty is incredibly widespread. Uneven and limited distribution of assets presents challenges to efforts to improve economic conditions in the watersheds. Inadequate access to critical assets such as land and financial capital induces households to overexploit their resources and to implement livelihood strategies that best use the meager assets they have. One goal of this project is to identify new or improved livelihood activities that raise incomes and place less stress on the environment. These strategies, such as entering higher-valued dairy markets, may be characterized by new capital and asset requirements. They also may be characterized by increased participation in off-farm activities. Assets, access to markets, capabilities, information, and other factors all affect the means by which households earn their livelihoods. They also, together with the livelihood strategy, determine welfare levels.

The general objective of this analysis of livelihood strategies is to identify successful livelihood strategies and analyze factors affecting adoption of such strategies. To achieve this objective, we describe and characterize the livelihood strategies realized by residents, identify the determinants of adoption of alternative livelihood strategies, establish the relationship between livelihood choices and household wellbeing, and estimate changes in wellbeing from policy change.

Methods used to investigate household livelihoods and their determinants are largely quantitative:

- Identify livelihood strategies using a clustering protocol and hierarchical cluster methods
- Estimate impacts of variables that affect the probability of livelihood adoption using a multinomial logit model
- Correct for selectivity bias while measuring the impact of livelihood strategy adoption on household well-being
- Use results from econometric models to examine impacts of policy change in education and irrigation on livelihood adoption and wellbeing

Data come from surveys of 286 households as a part of the SANREM baseline conducted during September and November 2006 in the upstream Illangama (117) and the downstream Alumbre sub-watersheds (169).

Cluster analysis

To identify livelihood clusters, we used a hierarchical clustering method. In this method, the squared Euclidean distance was used to define similarities among households. Using this metric, low Euclidean distance implied that groupings were more alike, and high Euclidean distance implied greater dissimilarity. Ward's method was used as the agglomerative linkage. This method links households with the lowest increase in the error sum of squares. We created our clusters based on allocation of household assets: labor (among activities) and land (into different crops and livestock).

The four main livelihood clusters are diversified households, those engaged in agricultural markets, rural non-farm economy, and agricultural subsistence and wage work.

Just over a quarter of the households in the Chimbo watershed adopt the diversified livelihood strategy (1). These households do not receive more than 70 percent of their income from any single activity and mainly get income from agriculture and off-farm activities. These households divide their farm land relatively equally between pastures and crops. Diversified households participate frequently in civil society and have family members that migrate. Most of these households are indigenous, thus the livelihood is more common in the upper Illangama watershed.

Table 3-16. Livelihood clusters and their attributes

Variables	Livelihood 1. Diversified households	Livelihood 2. Engaged in agricultural markets	Livelihood 3. Rural non-farm economy	Livelihood 4. Agricultural subsistence and wage work
% Households in cluster	27	37	17	19
Agriculture income share %	0.45	0.87	0.12	0.39
Agriculture wage share %	0.02	0.03	0.14	0.57
Off farm income share %	0.53	0.10	0.74	0.05
Own surface with title %	0.84	0.87	0.77	0.77
Watershed Alumbre %	0.46	0.37	0.98	0.85
Land size (ha)	3.82	6.79	3.59	3.64
Irrigation access %	0.23	0.33	0.06	0.09
Value physical assets $	2008	2348	856	496
Credit access %	0.08	0.03	0.12	0.00
Distance to closest river (km)	1.12	0.86	2.05	1.58
Distance to closest city (km)	7.21	7.58	3.61	5.17
Participation in civil society orgs %	0.60	0.55	0.26	0.38
Family members that migrate %	0.71	0.39	0.54	0.13
Mestizo households %	0.31	0.25	0.64	0.53
Household head male %	0.88	0.90	0.82	0.72
Secondary education or plus %	0.65	0.65	0.66	0.45
Expenditures per capita $	325	432	280	219
Ratio of food expenditures-income	0.17	0.14	0.17	0.22

Livelihood 2, encompassing those households engaged in agricultural markets, is the most common in our sample, more than one-third. Households engaged in this livelihood get about 90 percent of their income from agricultural production, and they dedicate a relatively high percentage of land to commercial crops (roots and a mixture of grains and legumes). This group of farmers owns the more land and physical assets, and one-third of the farms have irrigation access. They intensively use pesticides and fertilizer for production and have the highest percentage of producers that have received technical training. Households in this livelihood have, on average, the highest levels of income and expenditure in the watershed.

The smallest livelihood cluster encompasses households that dedicate their labor to off-farm activities (Livelihood 3). Households in this group receive almost 80 percent of income from activities not related to their own farms. Almost all the households within this livelihood are from Alumbre and are near the main city. They own smallest amounts of natural and physical assets, and one-quarter of the total land is untitled. Households that engage in this livelihood cluster are among the poorest in the two sub-watersheds.

Our final cluster (Livelihood 4) comprises households with relatively small landholdings and where two-thirds of household income is derived from agricultural wages and one-third from agriculture. Income and expenditures per capita are, on average, less than $1 a day, so households in this cluster are, on average, extremely poor. Almost all the producers in this group are from Alumbre. They possess less land and fewer productive assets than households in the other groups. The cluster is also, on average, the least well educated and has fewest migrating family members.

This description of livelihood groups provides insights into how they will respond to the SANREM project, the new technologies it will introduce, and changes in land-use plans. Livelihood 2 and, to a lesser extent, Livelihood 1 will likely benefit most from new production technologies and practices; they have resources and know-how to adopt new practices. Livelihoods 3 and 4 are more likely to benefit from off-farm innovations, for example, new dairy value-added processes or marketing opportunities. The clusters also provide a basis of further analysis: What factors determine in which cluster a household finds itself? And what factors are associated with changes in livelihood strategies?

Determinants of livelihood changes

The Ecuador household data has been analyzed to estimate determinants of livelihood strategies and risk preferences. The livelihood analysis has identified different typologies of households and their livelihood strategies (see above); explored the determinants of changes in livelihood strategies; and examined the impacts of adoption on a variety of measures of household wellbeing. Analysis indicates a rich set of livelihoods even within the apparently homogeneous Illangama and Alumbre watersheds. Although agricultural practices are relatively similar within each sub-watershed, households show strong diversity in their relative dependence on different sources of income, indicating flexibility in adaptation to conditions. 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. These differences indicate that they will respond in different ways to changes in policy and land-use guidelines.

A two-step sample selection model (following Bourguignon, Fournier, and Gurgand, 2005) first estimated the probability of entering a livelihood cluster (using multinomial logit) and in the second step estimated a selectivity corrected model with household wellbeing (consumption expenditures or income per capita) as the dependent variable.

More formally, the model can be seen as follows. Consider the following model of household wellbeing:

(1) $\ln y_{ik}=\Omega\beta_k+u_i$,

where y_{ik} is the wellbeing (income or expenditure per capita) for household i in the kth livelihood, and Ω is a vector of regressors. The essential problem is that we do not observe y_{ik} for strategies (out of a universe of M such strategies) that household i does not employ; we only see the household in a single livelihood. Define y^*_k to be a latent variable for unobserved income in the kth strategy and express:

(2) $y^*_k=\xi\lambda_k+\eta_k$.

Outcome K is chosen if $y^*_k > \max(y^*_j)$ for $j\neq k$ (that is, selection of livelihood strategy j is the best the household can do). Define $\varepsilon_k=\max(y^*_j-y^*_k)$ for $j\neq k$. Then $\varepsilon_k=\max(\xi\lambda_j+\eta_j-\xi\lambda_k-\eta_k)$, which leads to a multinomial logit specification of the determinants of livelihood choice under assumptions laid out above. Because livelihood choice and wellbeing outcomes are jointly determined, we need to account for selection into the livelihood choice. Standard method in a binary case is to use Heckman's correction when estimating Equation 1. A generalization of the Heckman correction accounting for the multinomial nature of the choice was used here to estimate the determinants of livelihood choice and, conditioned on this choice, the impacts on household wellbeing. The variables in the multinomial logit model are shown in Table 3-17.

Table 3-17. Variables in multinomial logit estimation of the determinants of livelihood choice

Variables	**Description**
Livelihoods (dependent var.)	Livelihood strategy chosen
Farm surface	Total farm size in hectares
Irrigation	Whether or not the farm has irrigation access
Physical assets	Total estimated value in dollars of productive tools, small livestock, and cattle
Education	Whether or not the individual in the household with highest level of education attained secondary education
Soil productivity	Measure of soil quality (GIS)
Age and square age	Head of household age
Household size	Number of members who are part of the household
Dependency ratio	Percentage of members below 18 and above 71 years old
Watershed	Whether or not the households are located in the Alumbre sub-watershed
Altitude	Altitude location of the household in kilometers
Distance to rivers	Distance to the closest river in kilometers (GIS)
Distance to towns	Distance to the closest town where usually are located the closest school (GIS)
Distance to cities	Distance to the closest main city where usually are located the markets (GIS)

The results show that several assets are critical determinants of how households select livelihoods. Access to land, access to water resources, markets, and higher educational attainment all affect the choice of livelihood. Households with fewer assets are "pushed" into less remunerative livelihoods, and increased education, access to credit, and more irrigation all will affect livelihood choice.

These estimates were used to simulate three policy interventions: increased access to education, increased access to credit, and more irrigation. It was found that education access has the strongest impact on household wellbeing because it works in two ways: It moves households into more lucrative activities and, conditioned on the choice of activity, increases wellbeing on its own. Access to credit also had a strong effect, but this effect was mainly in the second stage: Access does not affect what households do but allows them to better utilize existing assets within a livelihood strategy.

This analysis highlights the different potential development pathways, constraints to entry into particular pathways, and the relationship between environmental conditions and environmental outcomes and the pathways. Determinants will include assets and capitals, household structure and human capital, gender considerations, and other factors.

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

This objective is a critical component of the overall project, which envisions use of science-based models to assist in the process of adaptive 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. Several activities were undertaken this year to help achieve the objective and raise awareness among stakeholders of adaptive management.

Critical research accomplishments

- Professionals and community members in Ecuador have been trained in the adaptive watershed management process. Brian Benham (Virginia Tech) conducted two daylong watershed management workshops for local government officials and other stakeholders in the watershed. The workshops addressed six steps in watershed management planning: Building Stakeholder Partnerships; Watershed Characterization – Approach and Data Needs; Developing Water Quality Goals and Identifying Possible Solutions; Designing a Watershed Management Implementation Program; Implementing a Watershed Management Plan; and Measuring Progress and Making Adjustments. The community workshop on Jan. 23, 2008, Juan Calles and Adriana Cárdenas (ECOCIENCIA), and Wills Flowers (Florida A&M). Community stakeholders were engaged throughout.
- Professionals in both sites have been trained in watershed modeling. Training occurred in two phases: In February 2008, Ecuadorians Adriana Cardenas of ECOCIENCIA and Carlos Montufar of SIGAGRO, and Bolivian Ana Karina Saavedra of PROMIC participated in a five-week training session at Virginia Tech. They engaged in a hands-on

process that involved theory, models, and model applications. Each brought to Blacksburg the requisite data from their sites and applied these data to the models in question. Training was led by Mary Leigh Wolfe, Brian Benham, and Conrad Heatwole of the university's biological systems engineering department. A second training session was held in Cochabamba, Bolivia, where Wolfe, Heatwole, and Benham conducted a four-day water quality modeling workshop for professionals from government agencies, NGOs, and universities. The workshops provided participants with hands-on training in the background and application of the following models: GWLF – Generalized Watershed Loading Function; GLEAMS -- Groundwater Loading Effects of Agricultural Management Systems; and SWAT – Soil and Water Assessment Tool.

- Participatory watershed planning activities have been established and are ongoing in both sites.

System levels

This work is governance level (local policy) using inputs from research conducted at other scales.

Development impact

This is a critical component of our progress in bringing knowledge to action. It builds capacity to make better-informed decisions and increases the likelihood that decision makers will accept and use the information

Challenges and responses

The major constraint has been difficulty in attaining cooperation in Bolivia. Political tensions have created friction between our researchers, who are viewed by many in the watershed as outsiders, and the local political leadership. We have attempted to overcome these problems through efforts to engage local stakeholders in hands-on work. For example, our partner PROMIC created a number of farm-level land-use plans for individual farmers. These plans have been enthusiastically accepted, and more farmers want them than we can deliver. This has led to better acceptance of our team in the area.

Research progress

Watershed planning, Ecuador

Two daylong watershed management workshops were conducted for government and NGO professionals in Ecuador. Each workshop addressed six steps in watershed management planning.

- Building Stakeholder Partnerships
- Watershed Characterization – Approach and Data Needs
- Developing Water Quality Goals and Identifying Possible Solutions
- Designing a Watershed Management Implementation Program
- Implementing a Watershed Management Plan

- Measuring Progress and Making Adjustments

After completing the workshop, participants should be able to describe the following concepts:

- typical steps involved in conducting a watershed-scale study to assess the potential pollutants contributing to degraded water quality
- typical steps involved in developing a watershed-scale plan to address the offending pollutants
- how BMPs control non-point source pollution
- The role of watershed stakeholders in the watershed management planning process

The Jan. 21 and 22 workshops drew 44 participants. Workshop resource materials were provided to all participants. Those presentations made in English were simultaneously translated. Extensive interaction and discussion occurred during both workshops. Feedback about the workshops has been and continues to be very positive.

A community workshop was held on Jan. 23 and was very beneficial and eye-opening. ECOCIENCIA and Florida A&M scientists teamed up to conduct the workshop. The community stakeholders were very engaged throughout the workshop. A technique for engaging stakeholders learned during the earlier workshops was used. The technique requires stakeholder to illustrate their perception of their watershed by drawing a picture of their watershed. Stakeholders then trade the pictures and discuss commonalities and differences. This exercise promotes dialogue among stakeholders and gives watershed management professionals insights that can be used to more effectively educate and communicate with stakeholders.

Watershed modeling, Bolivia

A four-day water-quality modeling workshop was conducted in Cochabamba, Bolivia, for professionals from government agencies, NGOs, and universities. The workshops provided participants with hands-on training in the background and application of the following models:

- GWLF – Generalized Watershed Loading Function
- GLEAMS – Groundwater Loading Effects of Agricultural Management Systems
- SWAT – Soil and Water Assessment Tool

After completing this workshop, participants should be able to describe:

- the role of modeling in watershed management
- basic modeling concepts, and
- approaches for modeling hydrologic, erosion, and nutrient processes.

In addition, workshop participants gained experience in applying selected models.
Thirteen people participated in the workshop. Extensive workshop resource materials were provided to all participants. Those presentations made in English (some were made in Spanish) were translated by PROINPA and PROMIC staff. Extensive interaction and discussion occurred during the workshops. Feedback about the workshops was positive.

Degree and non-degree training activities

The LTRA-3 group has made major headway in its training activities by aggressively identifying suitable candidates, by promoting flexibility in program design and by leveraging funding from different sources. We have completed five graduate students (four men, one woman) at U.S. or European universities, six undergraduate honors theses at host-country universities (four men, two women), and are currently supporting five graduate students (one man, four women) at U.S. universities, four undergraduates (one man, two women) and three graduate students (three men) at host-country universities.

Non-degree training has been eclectic. The majority has focused on environmentally beneficial agricultural management practices, with other activities related to biodiversity, adaptive watershed management, and watershed planning. While the balance has been toward participation of males, special efforts have been undertaken to promote participation by females.

Degree training

Victor Barrera (Ecuador) completed his Ph.D. at Universidad Politécnica de Madrid in Spain in 2008.

Robert Andrade (Ecuador) completed his master's training in agricultural economics at Virginia Tech in 2008.

Michael Castelhano (Bolivia) completed his master's in agricultural economics at Virginia Tech in 2008.

Amelia Henry (Ecuador) completed her Ph.D. in plant biology at Penn State University in 2008.

Raul Jaramillo Velasquez (Ecuador) completed his Ph.D. in horticulture at Penn State in 2008.

Rachel Melnick (Ecuador) is in her third year of studies toward a Ph.D. in plant pathology at Penn State with partial funding from SANREM. She is working on development of alternative fungal disease management technologies for cacao, particularly biological control.

Catherine LaRochelle (Ecuador) is in her third year of studies toward a Ph.D. in agricultural economics at Virginia Tech. She is currently reviewing literature on relationships among risk, farmer decisions, and environmental impacts. She is being funded by SANREM and other projects.

Anissa Polatewich (Bolivia) is in her third year of studies toward a Ph.D. in plant pathology at Penn State with partial funding from SANREM. She is working on development of alternative biological controls for fruits and is collaborating on control of vegetable pests.

Javier Osorio (Bolivia) is in his third year of Ph.D. training in biological systems engineering at Virginia Tech. He is assembling GIS data for the Tiraque (Bolivia) watershed model.

Nadezda Amaya (Bolivia) is in her second year of master's training in agricultural and applied economics at Virginia Tech. She is examining how information affects potato marketing decisions in Bolivia and the role of gender in these decisions.

See Appendix A.

Publications, presentations, other products

See Appendix B.

Networking activities

The Ecuadorian team has developed a project proposal, which has been presented to the Ministry of Environment of the Government of Ecuador, focusing on improving the conditions of the populations in the sub-watershed of the Shacundo River in the watershed of the Chimbo River. The financed amount is $120,000, which will be used to support the SANREM research. During 2008, the Ecuadorian government adopted as a national priority the livelihood and adaptive management framework for integrated management of watersheds. This action followed extensive interactions among our host-country team and representatives of regional and national governments. Our project site was inspected by national policy makers who are concerned about water quality, the environment, and measures to improve household wellbeing. As a result of this action, the National Constitution has been modified. Articles 12 and 14 of the New Ecuadorian Constitution establish: "The human right to the water is fundamental and cannot be waived. Water constitutes strategic national patrimony of public, inalienable, imprescriptible, unattachable and essential use for the life"; and "The State will guarantee the conservation, recovery and integral management of the hydric resources, hydrographic watersheds and ecological streams," respectively. This constitution promotes application of our approaches to other watersheds in Ecuador.

In Bolivia, the research team is continually interacting with local authorities to build confidence in the process and facilitate uptake of subsequent findings. We have successfully engaged farmer groups (*sindicatos*) that are interested in the research into farming alternatives and also express strong support for creating of farm-level land-use plans. We have created these plans on a pilot basis.

Project highlights

- We have a functioning GIS for each site that includes, among other things, information on soil characteristics, slope and elevation, rainfall, land use and soil cover, water sources such as streams and rivers, the transportation network, and other infrastructure. These GIS are being used for several purposes: establishment of a baseline and regular updating to facilitate monitoring of change; data storage and management; and visual presentation of research results. Our ability to present data and research findings in visual fashion is especially helpful when we interact with local decision makers. The use of GIS data to inform local decisions will help establish a process of evidence-based decision making in areas where most public decisions are made without good evidence of impacts. While GIS are available in most countries, we are demonstrating the utility of spatial data presentation and analysis to a wide variety of potential users of information.
- We have and are using calibrated watershed models for both our Ecuador and Bolivia sites. These models are being used to estimate watershed-level runoff and impacts on water quality of alternative land-use patterns. Results are being used to evaluate alternatives and as input into community decision making. The ability to simulate land-use changes represents a huge step forward in evidence-based decision making at local levels in both of our countries. Our collaborative research process has built confidence in the research process and leads to greater acceptance of our findings. It fosters both knowledge and capabilities to make decisions – we have yet to see how much an impact it has on actions. The importance of having working watershed models cannot be overstated: We now possess the bedrock upon which we can make informed decisions about the watershed.
- We have taken major steps in implementing a watershed approach to land-use management in areas where watershed had been just a concept. Research institutions and national and local governments now better recognize the utility of planning and decision making in the context of a watershed. For example, local governments in both our Ecuadorian watersheds are interacting with the regional government to coordinate actions and build plans. Decision makers recognize that actions in one part of the watershed have implications in others.
- We have completed baseline assessments in both our sites. The information is being used to inform current decisions and forms the basis of evaluating project impacts over time.
- Several strategies have been identified for managing plant pests and diseases using lower-impact techniques such as biological control and other integrated management practices. We have new, more environmentally benign and economically effective means of controlling cacao diseases, diseases of other Andean fruits, and diseases in conventional crops (potatoes, maize, beans).
- During 2008, the Ecuadorian government adopted as a national priority the livelihood and adaptive management framework for integrated management of watersheds. After our project site was inspected by national policymakers, the National Constitution was been modified. Articles 12 and 14 of the New Ecuadorian Constitution establish: “The human right to the water is fundamental and cannot be waived. Water constitutes strategic national patrimony of public, inalienable, imprescriptible, unattachable and essential use for the life”; and “The State will guarantee the conservation, recovery and

integral management of the hydric resources, hydrographic watersheds and ecological streams," respectively. This national policy change is a result of the extremely favorable view on the part of national and regional governments of our work. It means that our model of adaptive management will be adopted for important watersheds across the country.

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

PIs

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Celia Turín and Silvana Vargas, Nacional Agrarian University-La Molina, Peru
Carlos Laruta, Centro de Investigación y Promoción del Campesinado, Peru

Host countries

Bolivia, Peru

Research objectives

- **OBJECTIVE 1**: characterize the dynamics of Altiplano agro-ecosystems at various scales in order to understand the impact of climate and markets as drivers of change
- **OBJECTIVE 2**: 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**: develop practices and information strategies (networks to access new information) to address changing conditions and perceived risks
- **OBJECTIVE 4**: develop market access strategies and institutions that contribute to resilience
- **OBJECTIVE 5**: develop stakeholders' capacities and abilities to act to reduce vulnerability and increase adaptation in the face of changing market and climate conditions

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-ecological systems 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 and action to achieve adaptation at the individual, household, and group levels. The research conceptual model (Figure 3-21) captures these two dimensions.

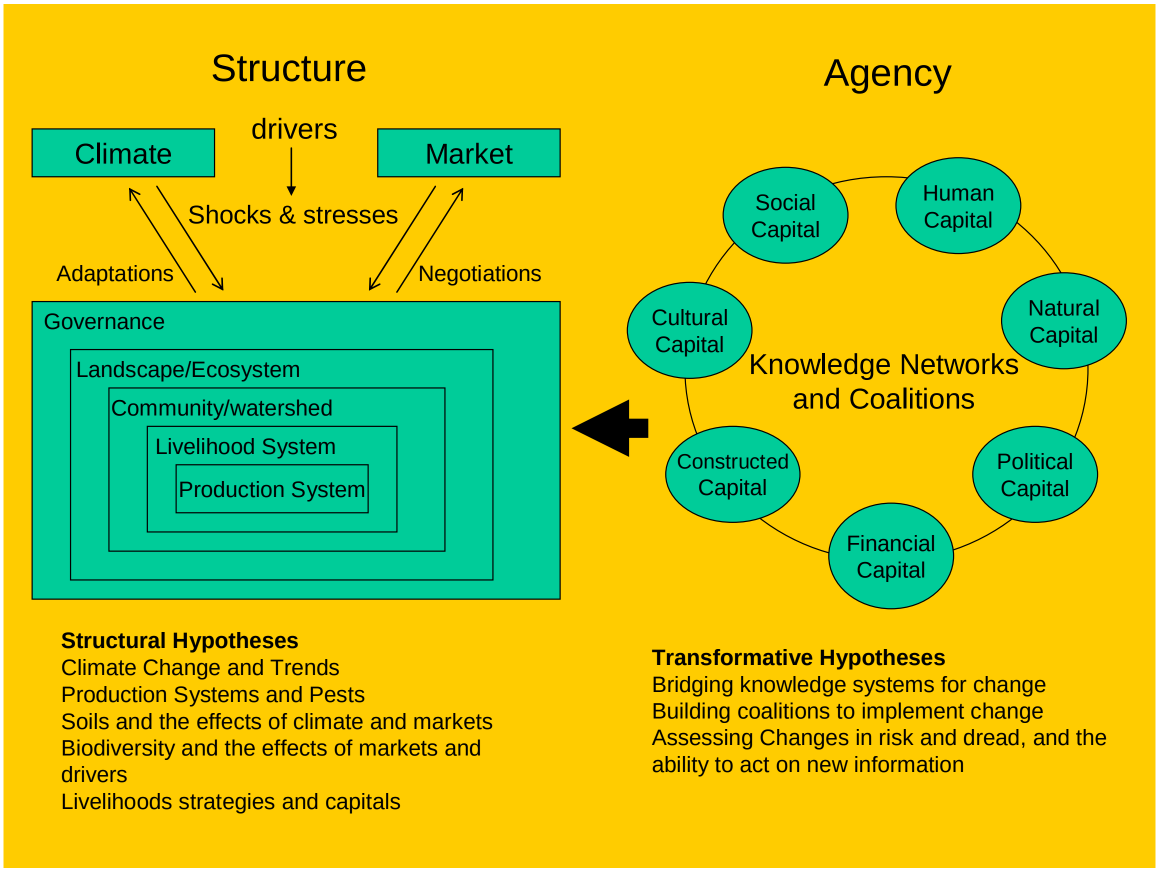


Figure 3-21. Research conceptual model

Critical to adaptation is 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 wellbeing and value biodiversity.

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 affected agro-ecosystems and how these impacts have influenced livelihood strategies. Objective 2 studies people's knowledge, perceptions of change, and experienced hazards. Both objectives provide information relevant to the Targeting Outcomes of Programs (TOPS) 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 developing knowledge in two dimensions, using theme teams for a multidisciplinary, integrated approach. 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 cite examples.

Climate

Research describing climate conditions and trends over the past 30 years in the Altiplano allows us to compare these trends 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 region, which will be used to predict medium (30-50 years) and 21st century climate-change scenarios. Interdisciplinary research on local forecast indicators, assessing the links between climatology and farmer observations, are part of participatory research to build a common understanding of how climate variability is addressed and how climate information is used and flows. In tandem, participatory assessments and mapping of climate hazards are carried out by the social sciences and community participants, which are assessed with communities along with climate forecast products in terms of effects on current production systems.

Local and new knowledge about climate predictions and 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 in the region; on the other hand, they must be shared with stakeholders at the local, regional, and national levels 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 in the highlands as temperature and humidity vary. 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 and quality. While characterization is done at the community/watershed scale, soil amendment experiments take place at the field level to enhance soil quality 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 various levels: 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. In addition, 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 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 in 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 communities 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 of) 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 wellbeing. These are combined with indicators of environmental wellbeing (natural capital), for example soils and crop diversity, to assess how the natural capital contributes to wellbeing 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 3-21. 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. Research addresses who has the ability to act throughout the research project, 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 identified 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. AC 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 credit – micro-credit programs –by different community strata. Various forms 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 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, AC, 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, and its final intended output is to assess the process of change.

Figure 3-21 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 LTRA-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, and implementers) are capable of negotiating and benefiting from climate and market changes. To test this overall working hypothesis, several discrete (disciplinary and trans-disciplinary) questions (see 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 these changes, 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 as well as their impact on livelihoods, combined with the market signals and responses, increasing adaptation or increasing vulnerability?
- Does an increase in livelihood wellbeing 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 impact 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, individual 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 who benefits, why, and how by the project's practices and/or strategies.

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, Aymara.

Comparisons include access to and participation in markets, effects of climate trends in short-term strategies, and approaches to collaborative research among communities and organizations with differing principles of collaboration. Collaboration revolves around voluntary farmer groups in Umala and community organizations in Ancoraimes and Puno. While in Bolivia groups 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: initial community participatory assessments of hazards and risks using focus groups, group interviews, and interaction with panels of local experts, followed by evaluation of observed climate trends over the past 35 years using daily data from existing stations and evaluation of Intergovernmental Panel on Climate Change (IPCC) models to see if the models reflect trends. In addition, satellite and aerial imagery will be used to validate perceptions and weather information, and stream gauging will be used 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, evidenced by lower soil organic C and N and other soil properties.

  Methods: changes in cropping systems 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 systems 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: 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 and 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 surveys will provide details on cropping systems. This 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 (potentially due to climate change).

  Methods: Focus groups and local expert panels will describe and evaluate local practices as well as 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 wellbeing than less diverse ones.

  Methods: assess 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 high Altiplano region.

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

- Perceptions of risks will differ among 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 members of the communities.

- 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 samples 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 within 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 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 by producers. 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 located at higher altitudes will place a higher value on use of soil organic amendments versus inorganic fertilizers.

  Methods: participatory workshops with community members; 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: IPCC climate models are evaluated by scientists and local experts in local workshops, and 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 and will be evaluated by community members. The most promising will be included in the market development efforts under Objective 4.

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

  Methods: Farmer research 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 traditional (native) varieties and cultivars of tubers and grains that are currently 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 USAID's Market Access and Poverty Alleviation Project will be analyzed for the regions of study to identify existing links.

- Participation of a community in the AC 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 is relevant, in the language of the user, and fits within the decision-making process of the potential user. Second, the decision maker has 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 among 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 areas 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 capitals 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 capitals that contribute 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 to demonstrate the effects of increased soil organic matter on increased temperature and decreased rainfall

Research progress by objective

OBJECTIVE 1: characterize the dynamics of Altiplano agro-ecosystems at various scales in order to understand the impact of climate and markets as drivers of change

Critical research accomplishments

Climate

Climate change analysis for the 21st century continues, showing coherent deficits in early-season rainfall and a more intense and shorter rainy season for the South American monsoon region. A resulting manuscript, in collaboration with M. Rojas (University of Chile) and S. Rauscher (International Center for Theoretical Physics) is in review for the journal *Climatic Change*. A manuscript on the analysis of projected changes in mean climate for the Altiplano, in collaboration with M. Garcia, is ready for submission to *Geophysical Research Letters*. Coordination with colleagues at Servicio Nacional de Meteorología e Hidrología del Perú (SENAMHI) has been initiated to collaborate on the calculation of extreme indices using observed datasets. Analysis will be part of a collaborative peer-reviewed publication. The lower elevation represented in the models permits too much moisture. Further research is in progress to examine this. Therefore, results for projected frost days and heat waves should be taken with caution. A manuscript with these results is in preparation with student Jeanne Thibeault as lead author. An article was published in a Bolivian journal highlighting vulnerability to climatic hazards consistent with observational data of climate trends over the past 30 years.

Standardized measures of extreme precipitation and temperature have been analyzed and demonstrate trends by mid-century in decreasing frost days, increasing heat-wave duration, intensity of precipitation, as well as numbers of consecutive dry days. The evolution of temperature and precipitation during the 21st century suggests that moderate changes will be experienced by mid-century, with potentially much larger responses in mean and extreme climate by late century. Although these projections are consistent with the large-scale circulation changes projected for the tropics and for the South American Monsoon, the projected trends in frost days and heat-wave duration disagree with the recent observed trends in the region, which suggest increases in frost frequency. The observed increase in frost frequency may be explained by increased daytime evapo-transpiration yielding drier soils and colder nighttime temperatures, which may dominate the warming signal in the Altiplano. These results are an input to analysis on short-term, medium-term, and 21st century adaptation.

Vulnerable populations in the region (Ancoraimes) facing desertification trends and heavy reliance on crops for income and production for consumption have been depleting assets for coping with events. Households in this region have a higher level of concern with changes in climate, while in Umala concerns are with specific hazards, frost and drought, consistent with the pattern of warming in this region.

Yucra and Garcia are evaluating the influence of local airflows on the microclimate behavior or Andean catchments at our baseline site for climate change in Ancoraimes, Bolivia

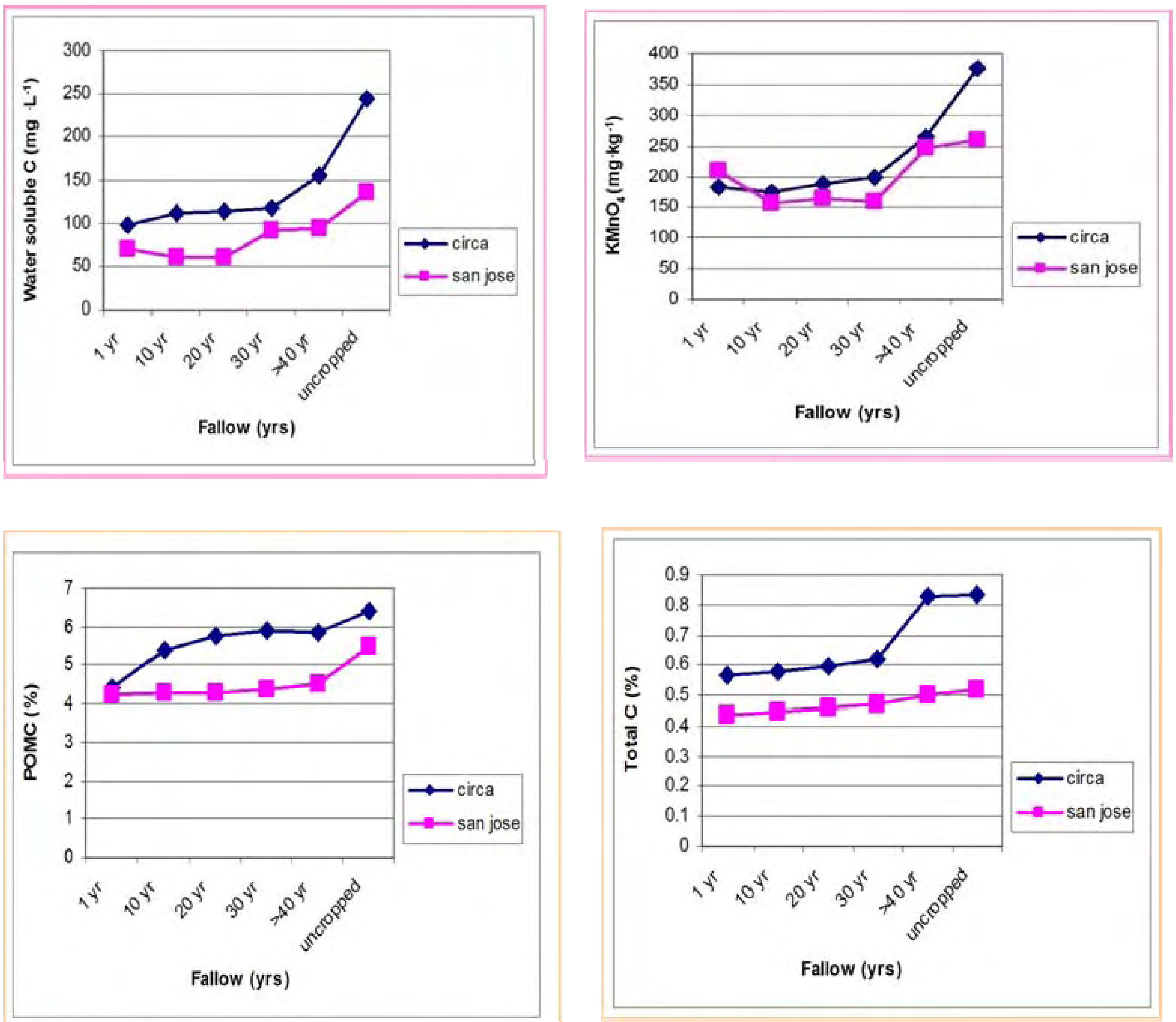


Figure 3-22. Effects of fallow on soil organic carbon fractions in two communities in Umala
A water soluble C (mg.L-1), **B** KMnO4 (mg.kg-1) **C** POM-C (%), and **D** total C (%)

Soils

In Santa María, Peru, plans were developed to set up soil experiments in potato crop fields testing the effect of privately versus community-managed soils. The study compares current soil management practices in the *aynokas* (community-managed, privately used plots of land) versus private landholdings. Peter Motavalli met with scientists in Lima in March to set up the study.

Effects of changes in fallow management. This research was undertaken due to initial surveys and participatory workshop results in Umala and Ancoraimes that indicated a decrease in the period of fallow that was traditionally followed to assist in restoration of soil fertility. The reduction in fallow length is attributed to several reasons. These include greater intensity of land use, smaller land holdings, increased land area in forages, and reduction in animal stocks. The Ancoraimes communities have had the greatest reduction in fallow length compared with those of Umala. Initial results reported last year indicated that several soil properties, including soil organic C, pH, and neutralizable acidity, are affected by fallow length, but these changes were not consistent across all communities. Also, soil under th'ola vegetation, predominantly present in long-term fallow fields in Umala, was observed to have significantly higher soil total organic C, total N, pH, soil test K, exchangeable Ca and Mg, and CEC compared with cultivated soil of the same type.

For this year, additional sandy (cha'lla) soil samples were taken from fallow and cultivated fields in Umala to provide a more representative sampling of the effects of changes in fallow length. Samples are also currently being taken from two communities in Ancoraimes for comparison, although the practice of fallowing cultivated fields is much less practiced in Ancoraimes compared with Umala. As part of the cross-cutting soil quality projects, the fallow and cultivated soil samples collected from Umala were analyzed for soil C fractions, which provide measures of labile and resistant soil C and soil quality (Figure 3-22, A-D). The potassium permanganate ($KMnO_4$) test is a measure of labile C and showed a large increase in uncropped and long-term fallow fields compared with fallow fields, especially in the community of San Juan Circa (Figure 3-22, B). Similar changes were observed in water-soluble organic C (Figure 3-22, A), another measure of labile C; and particulate organic matter C (POM-C), a measure of more intermediate C (Figure 3-22, C). Further testing of these samples for different soil C fractions is currently being conducted using near infrared reflectance and Diffuse Reflectance Fourier Transform Infrared Analysis (DRIFT) mid-infrared analysis.

In coordination with the soil metagenomics project, soil samples for analysis of microbial species have been collected in Ancoraimes and Umala, and analysis is underway. These samples were collected in fields across the community and will allow evaluation of the effect of fallow period and the presence of th'ola.

Pests and diseases

We are completing our multiyear multisite analysis of potato tuber moth and Andean potato weevil populations and their relationship to climatic conditions; a data set that consists of three years of observations in four sites across the project's Altiplano transect. Data for the analysis of pest dynamics in relation to climatic conditions includes pests and climatic measurements from farmer's fields. Comparisons across sites will be completed in Year 4. In the central Altiplano this year, white moth species observed were *P. operculella*, both in the lower and higher elevations. *S. tagolias* was present only in the lower region. Crop damage, though, was 20 percent in the lower elevation while 8.5 percent in the higher. Andean weevil, on the other hand, had an effect only in the higher elevation sites.

Both climate (frost) and pests in potatoes resulted in early harvest and lower production levels. Quinoa also experienced lower productivity. Species affecting quinoa are also being monitored. Farmers' comments centered on the need for early maturing varieties to respond to frost conditions. Along with monitoring Andean weevil and white moth, training on management of pests has been provided at sites in Bolivia by PROINPA and UMSA.

In Peru this year, a study of pest management was initiated in Santa María. Notions regarding pest life cycles were discussed with community members, as well as discussions regarding current pest management practices and the value of introducing IPM practices.

Production systems, biodiversity, and landscapes

We are conducting a participatory GIS project to evaluate land use at intermediate scales. On production systems, biodiversity, and landscape analysis, students were selected for research on vegetation diversity in Umala and Ancoraimes. Images for Ancoraimes from 2007 have been provided by Conrad Heatwole, while other three sites remain. Costs are a constraint that we need to address to secure images for this research. We secured International Potato Center (CIP) collaboration.

Baseline data on climate, soils, vegetative diversity, and water flow for Ancoraimes is being systematized by F. Navia using geographic information systems. In collaboration with CIP, master's degree students in Peru were trained to develop geo-referenced community maps of their landscape. In Bolivia, agreements are in place, and P. Zorogastua will be training master's students working in Ancoraimes on vegetative diversity of the landscape and land-use pattern changes. Zorogastua will also conduct research on high-altitude inundated grasses, a resource that is critical in feeding camelids in Chojñapata Bolivia and Apopata Peru. While UMSA was able to develop new maps with the Ancoraimes communities using satellite imagery, we have not been able to develop similar activities at other sites because we have not been able to obtain the images. In the meantime, Ancoraimes is a pilot site for the landscape research and a baseline for climate-change impact assessment.

In Santa María Peru, soil maps were prepared based on local perceptions identifying the *aynokas* areas and the type of crops in each one for the current agricultural season. Training on a global positioning system (GPS) was completed to obtain coordinates to decide on satellite images needed. Participatory workshops are being conducted with community members to characterize soils according to type of crop and management (*aynokas* – private lands).

Livelihoods, networks, and markets

A description of the income diversification, land-use patterns, and fallow practices (Turin and Thomas, 2008) provides information on the livelihood characteristics and capitals of households in 11 communities, along with a diagram of the distribution of communities by altitude and distance to Lake Titicaca. Apopata in one extreme (highest altitude in the Peruvian Altiplano) has livestock as the main source of income, with complete reliance on markets. Cluster analysis of 360 households in the central and northern Bolivian Altiplano (Valdivia, Jiménez, and Romero, 2007) with human, economic, and life-cycle characteristics identified three income groups per region, with significant differences in average income among regions. Central Altiplano households had higher income, market participation selling crops and livestock, and higher diversification of potato crop varieties. Response to climate shocks did not rely on sales of animals, contrary to the Northern Altiplano, where migration was also a more significant strategy and where parcel or field size is significantly smaller than in the central Altiplano.

Research findings for ongoing managed crops and varieties of potatoes (Jiménez, Valdivia, and Romero) presented at the international conference organized for the Year of the Potato highlight the greater potato diversity managed in Umala and the different roles that varieties play in each region's livelihood strategies. Markets are an incentive to the selection of varieties like *waycha*, but household preferences are the main force in maintaining a diversity of varieties for household consumption and non-market exchange.

Perceptions of climate and climate risks differ among regions. The research finds that there is consistency among the climate trends research, the nature of shocks experienced in each region, and the role of assets and other strategies in coping with shocks (Valdivia et al., 2008). Recent analysis of the Peruvian household survey (Turin, 2008), highlights the contrasts between a crop livestock community in the region near the lake and a pastoral community. Reliance on markets, parcel size, portfolio diversification, and human capital differs, especially among women. Labor opportunities off the farm are available in areas near the lake, while migration is necessary for members of the pastoral community. This has implications regarding access to labor, for it is mostly men who migrate and may be away at any time of the year in Apopata. Bridging social capital linking to external institutions is greater in Santa María. Both communities perceive changes in the climate with similar experiences in terms of stronger frosts, hotter and colder days, and less rainfall. However, the timing of the rains, of concern in crop production, is different.

Formal credit institutions are currently not an option for the majority of households in all regions. Family networks are a main source of credit, especially those outside the communities, consistent with seeking strategies that are not covariant with risks in the region, as well as temporary migration.

System levels

Research takes place at multiple scales. In the case of climate, it includes community and watershed records through weather stations, regional research focused on trends of the past 30 years, and projections at the Altiplano (northern) ecosystem level. Pest research takes place in specific fields, but the design (time and place) covers three years and sites representing a transect of northern and central Altiplano ecosystems. Soils research takes place at the field level, though sites are selected to represent household/private and community management systems. The experiments take place at various altitudes and climatic conditions of lowland and highland semiarid conditions, three systems near the lake, and sub-humid conditions. Production systems research has a farm-household level, and landscape research focuses on watershed level to assess changes in land-use patterns at the community and watershed levels. Livelihoods research focuses on the household decision level. Interaction effects are studied in the following relationships: the effect of climate on the household level, the effect of climate on the field level (interactions between climate and pests, and climate and soils), interactions between household decision making and the market, and interactions among all these changing land-use patterns at the appropriate landscape level. This objective links field, household, watershed/community, and ecosystems. Inter-scale relations are analyzed at the household and community landscape levels. The research design facilitates comparisons in three Altiplano ecosystems.

Development impact

This research provides information on existing natural capital conditions, practices, attitudes, and sources of vulnerability of households. The information from Objective 1 contributes baseline information that is currently being included in the information products being designed and returned to community members in all research sites. Research on soils, pests, climate, and biodiversity provide an understanding of the role of climate and markets as drivers. It also provides information on ecosystem dynamics. Information from the surveys in Bolivia and Peru are currently incorporated into posters and leaflets for community members and shared in workshops during November and December of Year 4. This directly informs knowledge, attitude, skills, aspiration, and practice (KASAP), for a second survey will be conducted in Year 4 to assess change. Findings in Objective 1 inform Objectives 3 and 4 in terms of skills and practice.

In Peru, soils characterization (taxonomy) according to type of crop and management (*aynokas* versus private lands) has contributed to discussions about loss of soil fertility related to type of land-management system. It also was useful to compare local and scientific taxonomical knowledge.

Challenges and responses

Several communities have been affected by frost. Actions have been taken to address the impact on second-year experiments, especially soils amendment research.

Financing was a constraint at the beginning of Year 3. Insufficient personnel was an issue with the new activities implemented in Ancoraimes on watershed research. A person was hired to replace Mirco Peñaranda, who is working on his thesis research full time.

Coordination of the landscape research started in November of Year 3. Progress at sites other than Ancoraimes has been slow, for imagery has not been obtained. Costs are the main constraint, and PIs are determining alternatives. This has delayed training on ground truthing that is required to conduct the study of vegetation diversity in Ancoraimes.

Relationships have improved in Peru between the team and the Santa María community president. Local veterinary technicians are being trained, a request from the community president. Unfortunately, the community continues to favor programs or projects that provide infrastructure or material aid. As a result, project activities have had to be postponed at times because the community has been called to participate in a government aid program activity. This has forced the team to be more flexible in its time allocation and in some cases postpone or change activities and even face loss of travel funds. This is because activities planned are suddenly cancelled by the community, and the team is not informed until its members are in the community on the day the activity was to take place, a potential lack of ownership of the project by the community.

Development of products that link local and new knowledge has taken more time than anticipated, especially efforts to coordinate and develop consistent products across all research sites. As a consequence, the household survey planned for the end of Year 3 will take place in March and April of Year 4. The co-PIs in Peru and Bolivia and met with PI Corinne Valdivia in Puno to coordinate this, as well as to review the survey instrument that will be applied in all 11 communities.

OBJECTIVE 2: identify local knowledge and perceptions about production systems, landscape and risks, in order to assess the effect of climate and market change on livelihoods

Critical research accomplishments

Climate

Survey results were analyzed to understand why there has been a decline in the use of traditional weather indicators and the risk reduction strategies associated with climate hazards. In 1999, 98 percent of producers in the community of San Jose Llanga, a community in the central Altiplano of Bolivia, used biotic indicators (plants and wild animals), and 100 percent used abiotic ones (stars, winds, clouds) to inform their production systems. Seven years later, 38 percent used biotic indicators, and 60 percent used abiotic. Statistical analyses did not reveal any significant differences. To better understand this, we have undertaken in-depth interviews to determine why the change in the use of indicators has taken place. Preliminary findings suggest that:

- lack of access to labor and tractors at planting time has reduced the ability to adjust planting times in response to abiotic indicators
- there has been a decline of wild species that are customarily observed
- climate change is affecting some indicator plants, and
- most of the people who do not use indicators rely on the advice of neighbors who still do use the indicators.

Similar results are reported from the survey conducted in Peru. Jere Gilles is coordinating with the Peru site to ensure that comparable methods are used.

A journal article published in *Umbrales*, a series of El Centro de Investigación para el Desarrollo (CIDES) at UMSA in La Paz, presents findings on relationships among livelihood strategies, assets, and risk perceptions of climate (Valdivia et al., 2007). Posters and presentations on climate livelihoods and risks (Valdivia et al., 2008; Gilles et al., 2008) were presented at the SANREM CRSP annual meetings in the Philippines. Gilles traveled to La Paz in January to complete research on networks and climate indicators for a publication accepted to the Bulletin of the American Meteorological Society. Participatory evaluations continue in the field projects to capture farmers' perceptions of the soils, dynamic of pests, and crop varieties research. This local knowledge on soils, pests, and landscape changes is being incorporated into the information products returned to community research groups in Bolivia and Peru. This will be completed through March 2009.

Along with eliciting local knowledge as a basis for construction of new knowledge, a central hypothesis of Objective 2 relates to the effect of capitals and information on risk and dread attitudes among decision makers in the Altiplano. Rees and Valdivia (2008) analyze how capitals (natural, human, and social), portfolio activities, diversification, and lifecycle characteristics are related to levels of dread to climate hazard risks. We hypothesized that networks and capitals have a positive effect in reducing dread. Rees prepared a poster for the Philippines meeting (Rees, 2008) and is completing her master's thesis, which will be defended in November 2009. Preliminary findings regarding activities indicate that perceptions of risk increase as additional hectares of crops (rain-fed) increase in the portfolio of activities. On the other hand, diversification of the portfolio to other sources of income has a negative effect on perceptions of risk. Being in Chinchaya, the community in Bolivia closest to the lake and with greater access to water, has a negative and significant effect on perceptions of risk. Also significant was access to credit, which reduced the perceptions of risk. Findings in Objective 1 indicate that access to credit, a buffer against assets loss after a shock, are not prevalent, underscoring the likelihood that perceptions of risk will continue to be high if other insurance mechanisms are not developed.

Using the imagery obtained for Ancoraimes with support from the cross-cutting watershed project, the UMSA team was able to contrast in community workshops the initial landscape change maps developed and construct new maps. This is part of the process of returning knowledge to the communities. The Umala team also developed participatory maps but with low resolution due to the lack of high-resolution imagery, and the process was not successful. We are seeking lower-cost alternatives for maps that still have good resolution. This is important because we need to capture vegetation changes in the landscape, such as development of dairy production, to reassess perceptions of the drivers of change.

System levels

Farm/household
Community/watershed levels

Development impact

Local knowledge is an essential element of the development of information products for decision making that are consistent with the context in which decisions are made, the language of the decision maker, and the way in which information is useful.

Understanding what drives and what reduces perceptions of risks regarding climate is critical to explore what types of information, practices, and strategies can address them.

Perceptions of hazards are high in the four regions, consistent with the high percentage of the population that has experienced climate shock events, though differences also exist in the nature of the hazards that concern them. Feelings of dread about climate hazards and climate change are high, with frost and droughts as major concerns in Umala (central Altiplano of Bolivia) and

Santa María (near the lake in Peru), climate change concerns in Ancoraimes (northern Altiplano of Bolivia), and concerns about extremes in the pastoral community of Apopata, Peru. Pests are consistently perceived as a threat in all cropping systems and regions.

To address perceptions and concerns with risks related to pests, training is taking place in all communities along with the research on dynamics of pests.

Participatory assessments and landscape mappings have been the initial conduit to elicit knowledge and express concerns about climate risk perceptions. These maps are an element in the process of sharing research findings with communities. Assessments with farmer groups aim at understanding the benefits and constraints of new practices, as well as perceived barriers. Products developed this year incorporate climate and market dimensions to understand how each tackles the vulnerability issues arising from these two drivers.

Challenges and responses

Assessment of participation in groups has shown that women face more barriers to participate. Strategies were developed to address this constraint. Training in Umala focused on the multiple forms in which quinoa can be prepared for consumption. This was especially targeted to women because they expressed interest in this crop for its commercial potential and for nutrition.

There are concerns about the demands on time of participants, and the team is assessing a likely decrease in participation by farmers due to the perceptions that experiments are repetitive from year to year. The plans to share findings, incorporating advocacy coalitions as part of the approach, take into account this attitude.

Time is a constraint for farmers, so the process of sharing knowledge with the communities is being coordinated among all the scientists in Bolivia. Integrated plans have been developed to assess practices as well as return information. Methodologies for participatory evaluations were standardized across sites and projects, and organized to reduce demands on farmer time.

OBJECTIVE 3: develop practices and information strategies (networks to access new information) to address changing conditions and perceived risks

Critical research accomplishments

Climate

In addition to publishing the 21st century climate projections relating to changes in the annual cycle and temperature and precipitation extremes, new research is exploring how climate warming may affect drought using a precipitation-based index and also soil moisture from the models. The models indicate a greater prevalence of drought conditions into the middle and later 21st century.

These findings apply at the scale of the Altiplano, for the climate models resolution is insufficient to provide local detail. The primary obstacle to this work is the resolution of the climate models. However, downscaling from the models is not necessarily beneficial if the quality of the large-scale climate is inadequate. Our purpose is to address the quality of the large scale models to establish a baseline of quality for downscaling to be appropriate.

Soils

The focus of this effort to identify and develop alternatives for adapting to change is to develop practices to increase soil organic matter levels as a means to improve agricultural sustainability and buffer against impacts of climate change. The initial focus of this research has been to examine the use of organic and inorganic soil amendments, including use of alternative organic sources such as household compost, peat, and commercially available organic amendments on initial and successive crop response, changes in soil properties, and community perceptions of the relative agronomic effectiveness of the organic and inorganic soil amendments. Further research was undertaken to determine how effective the organic amendments are in improving soil properties, such as increased water-holding capacity and volumetric heat capacity, which would buffer against possible effects of climate change. Also, a rapid diagnostic tool for plant N status, the Cardy nitrate meter, was tested to determine whether it could be used in the field for rapid determination of N sufficiency in plant tissue. If effective, the Cardy nitrate meter may provide farmers in communities lacking access to soil or plant testing laboratories an opportunity to improve their fertilization decisions.

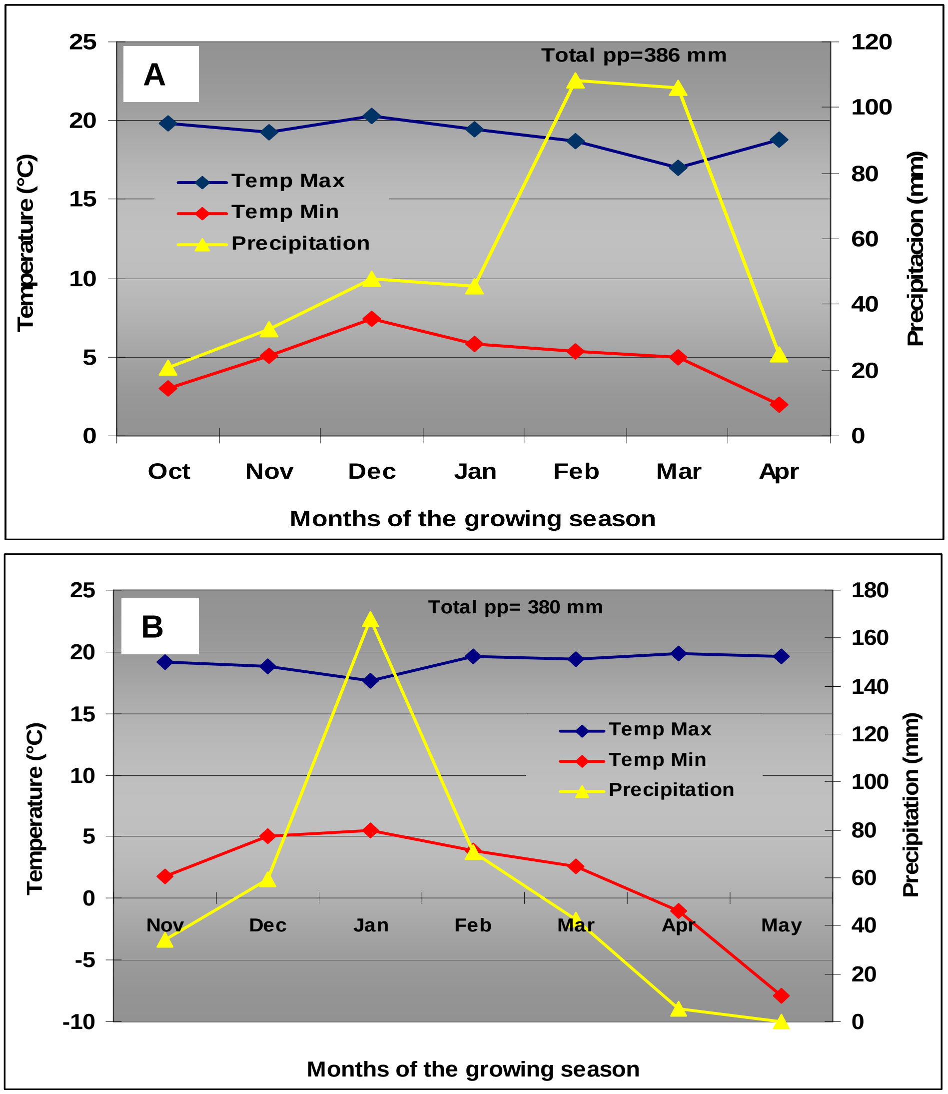


Figure 3-23. Average monthly rainfall and maximum and minimum temperature during the growing seasons in Umala

A 2006-07. **B** 2007-08.

Field experiments grown to potato were established in 2006 and repeated in 2007 in Umala and Ancoraimes. Additional trials were included to determine the residual effects of the first-year treatment applications on growth of successive grain crops such as quinoa and barley. However, due to early frost and late planting in 2007, the field trials in Ancoraimes were not successful. Therefore, this report presents results only from the field trials in Umala. Treatments in the potato trials 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 those from the Cardy nitrate meter was 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 soil nutrient content, soil water content, and soil porosity due to the treatments. Bulk density samples were taken before harvest to assess the effects of the treatments on soil physical properties.

T1=Control
T2=DAP+Urea
T3=Cow Manure (CM)
T4=Sheep Manure (SM)
T5=CM+SM
T6=Compost
T7=CM+(DAP+Urea)
T8=SM+(DAP+Urea)
T9=CM+SM+(DAP+Urea)
T10=CM+Biofert (B)
T11=SM+B
T12=CM+SM+B

Differences in monthly average rainfall and maximum and minimum temperatures in Umala in 2006-07 and 2007-08 are shown in Figure 3-23, A and B. Total rainfall over the growing season was generally similar between the two years, but early frost in 2006-07 reduced yields compared with 2007-08, when frost occurred after flowering. Potato tuber yields averaged over all the field trials in Umala in 2007-08 were generally higher than in 2006-07 but were consistent in showing the yield advantages of mixtures of the animal manures and chemical fertilizers (Figure 3-24).

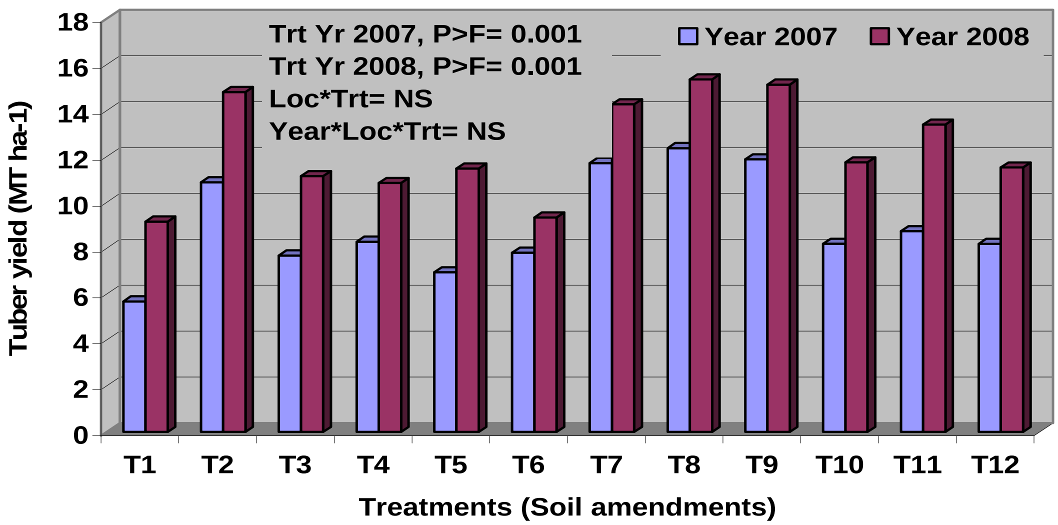
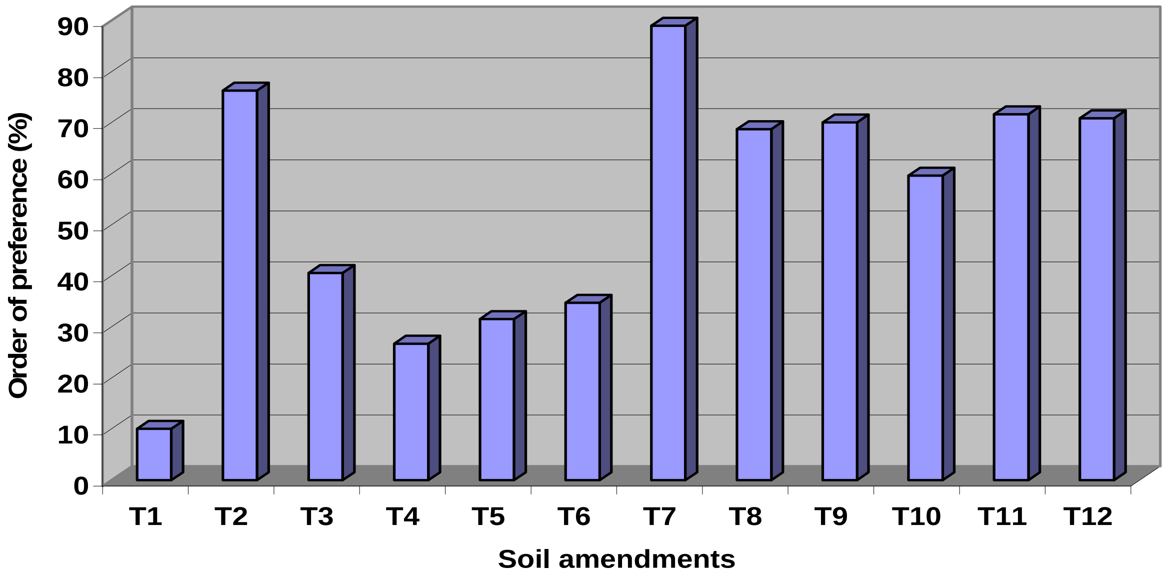


Figure 3-24. Potato tuber yields averaged over all Umala communities in 2007 and 2008 due to application of organic and inorganic soil amendments

DAP: diammonium phosphate fertilizer
DMRT is Duncan's Multiple Range Test

Application of DAP plus urea also had higher yields compared with when cow or sheep manures were added alone. Compost, an alternative organic soil amendment, did not generally result in significantly higher yields compared with other conventional organic amendments (i.e., sheep and cow manure), but some small yield increase was observed when Biofert was added to manure in 2007-08. Based on observed plant growth at first flower and differences in tuber yields, community farmers selected the mixed fertilizer plus manure and fertilizer soil amendments as their preferred treatments. The compost alternative was not highly rated by community members, but mixtures of manure plus Biofert did have a high rating, indicating that this soil amendment may have some potential if yield increases are consistent under different climatic conditions (Figure 3-25).



T1= Control	**T5= CM+SM**	**T9= CM+SM+DAP+Urea**
T2= DAP+Urea	**T6= Compost**	**T10= CM+Biofert**
T3= Cow Manure	**T7= CM+DAP+Urea**	**T11= SM+Biofert**
T4= Sheep Manure	**T8= SM+DAP+Urea**	**T12= CM+SM+Biofert**

Figure 3-25. Farmers' preference for the soil amendments based on their effects on potato plant growth and tuber yield in Umala, 2007

The portable Cardy nitrate meter measures the nitrate content of plant sap extracted from the potato petiole at first flower and allows for rapid in-field testing, which may be useful in countries such as Bolivia where soil and plant testing facilities are limited and relatively expensive. General comments about use of this meter indicate that it has often been difficult to calibrate the meter and time-consuming to extract the sap from the petioles. A comparison of the Cardy meter results with total N analysis of the leaf petioles indicates generally good agreement at lower total N and nitrate levels but poorer agreement at higher values (Figure 3-26). Also, the correlation between the Cardy meter results and total N appears to vary among the communities (Figure 3-26). Further analysis of any differences among the communities or in the way the analysis was done must be undertaken to better understand these results.

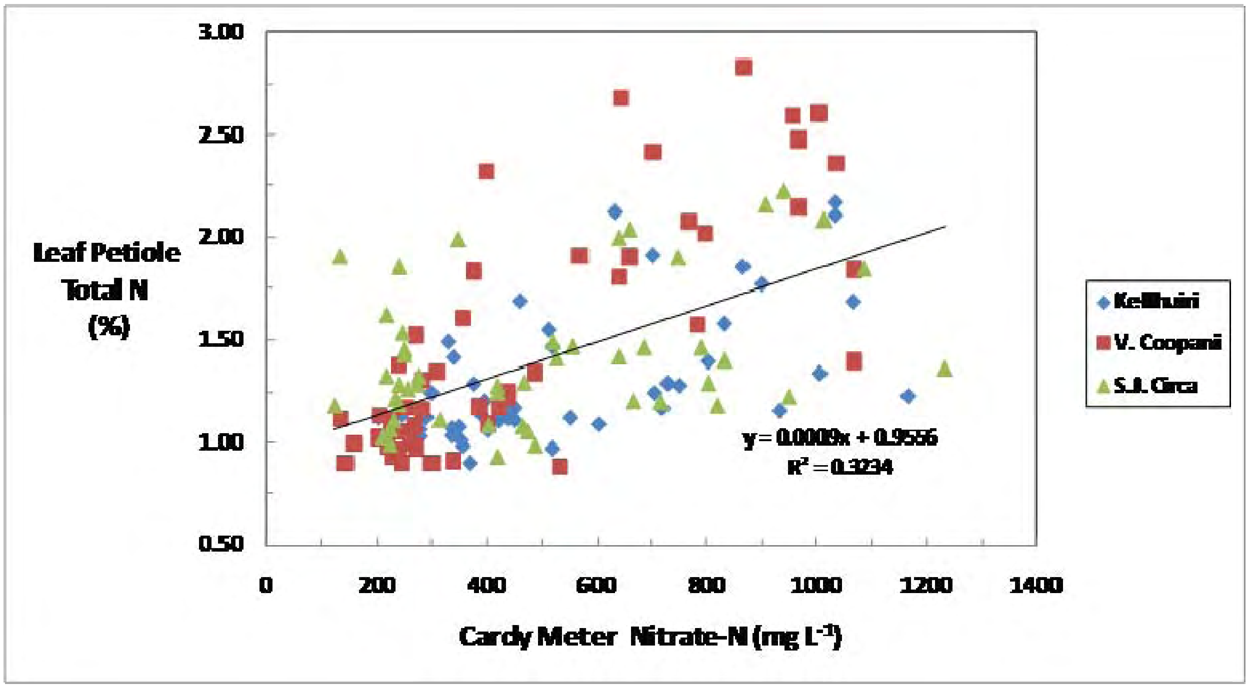


Figure 3-26. The relationship between potato leaf petiole N and Cardy meter nitrate results in three communities in Umala

Some changes in soil properties due to the application of the inorganic and organic soil amendments were observed at harvest in the Umala field trials (Table 3-18). Soil bulk density was significantly reduced by about 0.10 g cm^{-3} compared with the control with the application of compost and cow manure mixed with Biofert or fertilizer. In contrast, sheep manure and sheep manure plus Biofert or fertilizer significantly increased the amount of gravimetric water content held in the soil at harvest compared with the control treatment. This result may indicate improved water-holding capacity with these treatments or the increased removal of water by the potato crop in other treatments. Soil organic matter was also significantly higher with application of cow manure and the manures plus Biofert. Long-term increases in soil organic matter may be a major indicator of sustainability and may be important to reduce soil degradation in this environment.

Further investigation of the potential buffering effects of adding organic amendments on climate change impacts, such as increased temperature and lower rainfall, was conducted in 2007. Estimated changes in volumetric heat capacity due to the organic and inorganic treatments added in the field trials were calculated and are shown in Table 3-19. In general, some differences in heat capacity were observed among the field sites in Umala, but no significant treatment effects were detected. Changes in water-holding capacity of the sandy loam (cha'lla) soil due to application of different rates of cow manure used in the field trials was determined by measuring gravimetric water content at 10 kPa or field capacity for this sandy loam soil, and 1,500 kPa or the permanent wilting point (Table 3-18). The difference in gravimetric water content between these two levels is the water-holding capacity. The gravimetric water content at 1,500 kPa was not significantly affected by increasing application rates of cow manure, but the 10 kPa gravimetric content and the water-holding capacity were increased when cow manure was

applied at rates greater than 15 Mt ha^{-1}. Such high rates of manure addition are generally not achieved in this region of Bolivia, possibly due to inadequate supplies of manure for land application. However, farmers do practice
banding of manure in furrows near the potato hills, which may increase the effective rate of application. These results indicate that a priority to assist in improving the soil's capacity to buffer against possible effects of increased temperature and lower rainfall is increasing rates of organic amendments.

The field research in Umala and Ancoraimes is part of the undergraduate research of three Bolivian soil science students at UMSA.

Table 3-18. Changes in selected soil properties due to application of organic and inorganic soil amendments in 2007 averaged over all field trials in Umala

Soil amendment	Bulk density	Gravimetric* water content	Soil organic** matter
	- g cm^{-3} -	---------------- %	----------------
Control	1.30	7.75	1.15
DAP + urea	1.22	8.29	1.19
Cow manure (CM)	1.22	9.32	1.36
Sheep manure (SM)	1.26	11.62	1.22
CM + SM	1.22	10.39	1.28
Compost	1.20	10.19	1.28
CM + (DAP + urea)	1.18	10.09	1.34
SM + (DAP + urea)	1.26	11.27	1.25
CM + SM + (DAP + urea)	1.22	9.29	1.23
CM + Biofert	1.19	10.00	1.42
SM + Biofert	1.22	11.29	1.35
CM + SM + Biofert	1.18	10.02	1.38
$DMRT_{(0.01)}$	0.09	3.50	0.14

* Results from a soil sampling at harvest
**Soil organic matter level before treatment application was 1.11%.
DAP: diammonium phosphate fertilizer
DMRT is Duncan's Multiple Range Test.

Table 3-19. Estimated changes in volumetric heat capacity due to application of organic and inorganic soil amendments in 2007 in the field trials in Umala

Soil amendment	Field trials			
	Kellhuiri	V. Coopani	S.J. Circa	San Jose
	cal cm^{-3} $^oC^{-1}$			
Control	0.252	0.277	0.239	0.263
DAP + urea	0.252	0.278	0.239	0.264
Cow manure (CM)	0.252	0.278	0.239	0.263
Sheep manure (SM)	0.253	0.277	0.239	0.263
CM + SM	0.252	0.278	0.240	0.263
Compost	0.252	0.277	0.240	0.263
CM + (DAP + urea)	0.253	0.277	0.239	0.263
SM + (DAP + urea)	0.252	0.278	0.240	0.263
CM + SM + (DAP + urea)	0.253	0.277	0.239	0.262
CM + Biofert	0.252	0.277	0.239	0.263
SM + Biofert	0.252	0.278	0.239	0.262
CM + SM + Biofert	0.253	0.278	0.239	0.262
$DMRT_{(0.01)}$	NS	NS	NS	NS

*Volumetric heat capacity was calculated based on the soil's solid organic and mineral phase, bulk density, and soil wetness.
DAP: diammonium phosphate fertilizer
DMRT is Duncan's Multiple Range Test.

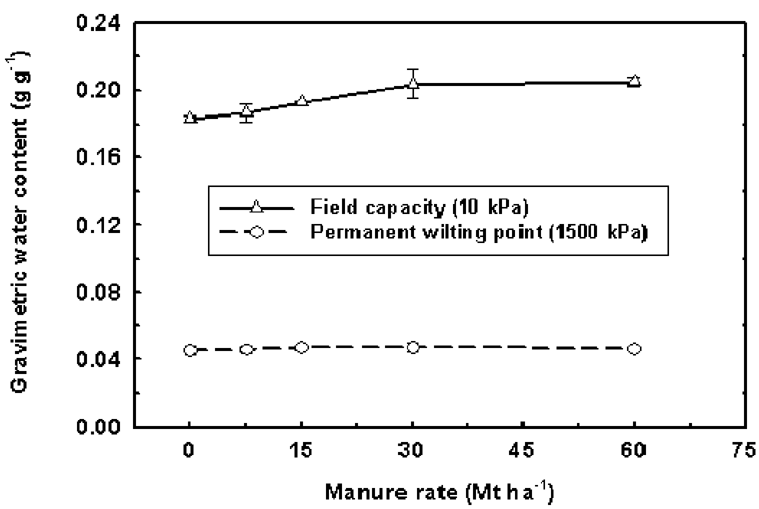


Figure 3-27. Effects of different rates of cow manure application on changes in soil water-holding capacity in a sandy loam soil from San Juan Circa in Umala

Bars at each marker indicate ± one standard deviation.

Pests and diseases

Pest management training focused on assessing IPM packages, as well as conventional control methods. These took place in Umala, Ancoraimes, and Santa María. Training also focused on safety issues in communities where chemical control is used.

The Kansas State University team evaluated the effects of climatic zone on the utility of sustainable disease management practices such as the use of cultivar mixtures of differing resistance. In regions where the season of potato production is longer, such methods have less impact, probably because there is a tendency for inoculum saturation. The effects of climate change may be greatest when there are thresholds, interactions, or positive feedbacks that affect risk (Garrett, 2008). In addition to temperature and precipitation effects, rising CO_2 may also influence disease risk (Chakraborty et al.) Sustainable management of emerging diseases will require system thinking to manage the portfolio of crops produced (Garrett and Cox, 2008).

A synthesis with sponsorship by the U.S. National Center for Ecological Analysis and Synthesis evaluated plant disease in the context of ecosystem services (Cheatham et al., 2008). Plant disease can decrease ecosystem services both directly, through damage to plants providing services; or indirectly, through the effects of steps taken for disease management. Host biodiversity can mediate the effects of disease.

In the study of disease, pest risks, and climate change, new national-scale models of disease and pest risk under climate-change scenarios were developed for the Andes and other regions of the world that adapt models based on hourly weather data to the more commonly available monthly weather data sets. Karen Garrett and her team were invited to submit a synthesis paper on disease risk mapping to the high-impact journal *Ecology Letters* by Nov. 15, 2008. Three summary chapters about climate change and plant disease risk were prepared for a new book on climate change indicators and for a report of the U.S. National Academy of Science.

Production systems, biodiversity, and landscapes

Analyses of varieties and the potential for varietal improvement and conservation are proceeding. These analyses are done in experimental fields with applicability across the community.

A major focus of Objective 3 this year and during Year 4 is preparing the elements of knowledge that are integrated as information products that return to the communities. As a result, most of the research activities revolved around developing approaches, plans, and coordination to produce this output. UMSA took the lead in Ancoraimes, PROINPA in Umala in the case of Bolivia, and UNALM in the two Peruvian sites.

This process incorporates the local knowledge elicited through participatory assessments, household surveys, and focus groups, with the research results from the soils, dynamics of pests, and the community landscape maps capturing perceived changes and vulnerabilities. Several meetings took place to develop this plan. Training on the AC method also was implemented, for this approach provides a framework for returning knowledge to build human, social, and political capitals for human agency of participating communities.

Livelihoods and information dissemination networks

In Peru, a study of the levels of adoption of IPM has been initiated in the community of Santa María. A first activity with the group in Santa María consisted of a capacity-building workshop on seed selection and monitoring of seed storage with the group of community members who will participate in the IPM trials. This included capacity building on land preparation strategies.

A concern of the people of Apopata is drying of the peat bogs (*bofedales)*. As part of this research, geo-referenced coordinates were collected this year. Coordination took place to develop landscape maps of the community as an instrument for discussion with community groups about their concerns and potential alternatives.

System levels

Practices and information developed under this objective target the household and community decision-making levels. Some of the climate change information aims at the larger unit of the Altiplano as the models focus on 150 Km^2 areas.

Development impact

We focused on the development of information products that incorporate local knowledge, perceptions of risks, trends and measurements of climate, market relevant dimensions to the product that is shared (for example, in the case of dynamics of pests, current practices, and costs of undertaking them from the survey data and the participatory assessments), field research results, and the training and assessments decision makers were provided throughout the two years of activities. The products are currently being developed and tested, with *socialización* (information-sharing processes) beginning in November 2008.

Challenges and responses

A significant early frost and planting problems in November in Ancoraimes damaged all the field plots for soils amendment research. Only one in the community of Chinchaya survived. Second-year field experiments were lost at these three sites. Motavalli and the team at UMSA developed a different strategy focusing on analysis of soils.

In Santa María, problems with the president have resulted in suspension of AC activities. Other activities such as soils research and training continue. The focus on ACs has now been placed in Apopata, especially relating to the alpaca fiber markets.

Coordination among all institutions in the development and implementation of procedures to return information to the communities has been a challenge due to the different cultures and missions of the organizations. To address this, we have conducted several workshops to ensure a common understanding of the purpose and expected outputs of the information sharing. We are also using a similar approach in advocacy coalitions, which has required training of the teams on at least two occasions, with UNALM leading this initiative. Their experience has been instrumental in guiding the team, and coordination among researchers is fluid.

OBJECTIVE 4: develop market access strategies and institutions that contribute to resilience

Critical research accomplishments

Advocacy coalition as an approach is being implemented in Bolivia and Peru to address market strategies that increase farmer negotiation capacity. Previous findings and survey data point to lack of bridging social capital, a need to strengthen human capital for negotiation, and lack of knowledge of government institutions. This approach allows us to visualize the future of the community, the assets the community has, and the links it needs to establish, based on the two main goals it seeks to achieve. It is therefore in working with rural groups to identify the next steps and actions needed either to address a barrier or implement a finding. The first training for researchers took place in Puno, Peru, where six Bolivian collaborators participated. The Apopata Peru research team has been engaged in AC building in Santa María (Year 2) and now in Apopata. Members of the team were identified and trained, and they interviewed different stakeholders from state and civil society in Ilave and Puno on themes of alpaca production and fiber processing for added value. It is too early to determine which contacts will result in emerging coalitions. Common goals and mental causal models need to be identified. Evidence of agency has not yet appeared.

The Bolivian team developed a plan to share survey results on markets and crops using the AC model. Figueroa presented at the Agricultural and Applied Economics Association meeting a selected paper on the participatory market chain approach (PMCA) on chuño and tunta platform (Figueroa and Valdivia, 2008). Coordination of gender and markets research activities has continued. Turin and Thomas (2008) evaluated the livelihoods surveys of Peru and Bolivia, and presented a paper at the Rural Sociology Society in August 2008. A poster presented at the annual LTRA-4 meeting in Puno informed the process of survey development for impact assessment to be implemented in all sites. Market analysis for Ancoraimes and Umala (Jiménez et al., 2008) was presented at the SANREM CRSP meeting in the Philippines.

Niche market assessment for native crops

Research to evaluate a recently developed strategy to increase participation in niche markets was studied in the Altiplano of Bolivia. The case study revolved around marketing of chuño and tunta, two forms of processed potatoes, to high-end income markets through a platform of stakeholders that link producers to consumers using a participatory market-chain approach. In studying the platform, research focused on the transaction costs to participation by communities and on developing a case study of farmers seeking to improve the quality of their potatoes to link to niche markets. Highlights of the findings, which were defended in a thesis in November 2008, are that the Bolivian Andean Platform's main strength rests on its promotion of collaborative interaction among market-chain actors and formal organizations of support. The platform promotes collaboration and enhances the agency of Andean producers. Even though this is the case, the platform also has weaknesses, mainly related to motivation. Some reasons for this are the lack of formal commitment (contracts). Second, the platform's organizational strategies for negotiation processes, entry and exit rules are not formally established. Third, the platform lacks a financial-services organization as stakeholder, which limits the capacity of the platform to provide financial support to ensure a permanent supply of good-quality produce. Fourth, the price offered by the platform is not consistent with the higher quality (hygiene and size) of the product, so there are no economic incentives to improve quality. Price is set once a year based on the previous year's average market price. This rigid pricing approach leads farmers to sell in the informal market.

Assessment of collective action for improvement of native potato varieties

Farmers in three rural communities of Umala were studied to determine motives for participation in groups. The case study focused on Native Potato Varieties Program (NPVP) farmers who see an increase in their possibilities to access initiatives like the Bolivian Andean Platform or other niche markets that requires organization and differentiated products. Farmers who participated in NPVP share common characteristics:

- They believe that participating in NPVP will increase their technical knowledge about agricultural practices, harvesting, and post-harvesting care.
- They believe that native potatoes are a valuable alternative to face climate events, for these are more resistant to climate variability.
- They believe that NPVP will improve their likelihood of higher income and enhance livelihoods.
- They believe that participating in NPVP is a time investment that will benefit their families.

Seventy percent of participants interviewed are younger than 70 and have a spouse and/or children who help with household and additional activities. On the other hand, farmers who do not participate in NPVP share the following common characteristics:

- They express lack of time to participate in meetings and activities because they are old and cannot handle additional activities.
- They lack labor.
- They do not receive immediate results from participation.

Non participants were older than 50. Lack of labor is overall the most common barrier, and migration is the most common cause. Transaction costs decrease in searching information and bargaining when compared with individuals' costs. On the other hand, for the same farmers there is an increase in participation, contracting, monitoring, and enforcement costs.

Access to credit

The nature of credit access and use in participating rural communities was assessed with the household survey, which measured frequency of climate shocks, coping mechanisms used, and access to formal and informal credit to understand the relationship between climate hazards and credit use. We found that 84.5 percent of the population in Umala has suffered the impacts of climate shocks in the past 25 years. In Ancoraimes almost 100 percent have done so. The most remembered events in Ancoraimes are frosts, hail, and floods, which have become stronger since 1997 and especially since 2002. The strongest climate effect in the region was drought, especially during the 1980s. This has shifted to floods in the past eight years, consistent with expected present-day trends in climate change. In this context, mechanisms to deal with shocks are necessary, but at this time farmers mostly have access to informal credit. Coping in Umala depends on savings and temporary migration. Only 19 percent of the population has access to public institutions for assistance. On the other hand, coping in Ancoraimes is linked to sale of livestock assets, which further affects future income generation. Lack of access to formal credit results in selling livestock, which means loss of productive resources. The assessment with farmers in Year 4 will focus on insurance mechanisms that could be introduced to address this situation.

Marketing strategies

Research conducted at all sites highlights the differences in market integration across the Bolivian and Peruvian Altiplano. While Santa María depends on markets for access to off-farm employment and sales of livestock, crops are produced for household consumption – food security. In the same region, Apopata relies completely on markets for food and for sale of fiber from alpacas and sheep. Labor markets are also significant in income generation but require migration (Turin, 2008). On the other hand, the study of market integration in the Bolivian Altiplano differs by region and also among communities according to the production portfolios, which are determined by a combination of the natural capital (land, soils, climate, biodiversity) and market incentives. In Umala, the major source of income is agriculture. Potatoes are the most important crop, sold at least once a week by 50 percent of producers, but some communities have diversified non-covariant income sources such as sales of milk and sheep. Middlemen are the main source of information about prices for the sale of all products. While price risks are perceived to be high, this ranks lower than other risks. While a high number of varieties are produced in Umala, only a few are marketed (Jiménez et al., 2008), primarily *waycha* comprising 44 percent of the production. Near the lake in Ancoraimes, in the same watershed, four communities display differences in the role of markets, with two relying for 60 percent of the income on labor sales and two (Chojñapata and Chinchaya) with more than 70 percent of their income from agricultural sales. Three crops are the major cash income sources: onions, peas, and potatoes. Reliance on markets is not diversified within communities. Markets in La Paz, the rural Altiplano, and on farm are outlets for onions and peas. The main sources of information are also the wholesalers (Jiménez et al., 2008). This information is being returned to communities through a process of knowledge sharing that incorporates AC in Year 4 to identify who they know in the market, what and who they need to connect, and how to interview these institutions to obtain information useful to the group (building human and social capital). These are elements in identifying new markets.

Two new undergraduate students are developing thesis projects in Bolivia on local, regional, and national market opportunities for local varieties of potatoes; and characteristics and implications of women's participation in the commercialization of crops with emphasis on marketing local (native) and introduced (commercial) varieties of potatoes in Ancoraimes and Umala. These studies are designed to improve understanding of the nature and characteristics of marketing and the role of coalitions to improve market strategies.

In Peru, progress on AC building and sharing information on markets with communities continued (Apopata). The leaders research team, elected by the community group to be trained on interview techniques, interviewed potential organizations perceived to have common goals and forms of operation consistent with the communities. They returned information from their institutional interviews to the community, and future activities were planned. A number of immediate activities have resulted from the institutional interviews. First, Asociación para el Desarrollo Sostenible y Fomento Agroecológico shared a video with the community regarding opportunities and strategies that can be implemented to improve community and household wellbeing. Capacity building on soils, pasture management, and conservation is pursued through contacts with El Collao Agrarian Agency. Finally, with respect to fiber marketing, capacity building to learn to develop breeding plans in alpacas with conducted with Comisión Nacional de Camelidos Sudamericanos. A study on fiber market in Mazocruz, the main local market, has been initiated. A small survey was completed with producers and middlemen. Likewise, a visit to the Mazocruz market took place to observe buying and selling of fiber. By the end of Year 3, a number of agreements have been signed with institutional actors such as Agencia Agraria, Sierra Sur, and PRONAMACHCS, a possible emergence of coalitions where the organization and the community agree to work together. The expectation is that interest groups within the community will form around the different agreements.

In the case of the Bolivian Andean Platform (BAP) incentives to participate are diverse, including access to market information in the case of one producer organization and access to markets in another organization. In the first case, marketing and access to information decrease transaction costs. In the second, costs of finding buyers for the native potatoes decrease. On the producer side, constraints included lack of on-time supply and quality of produce (cleanliness and size). Transaction costs reduced by BAP are search, information, bargaining, and contracting costs for all stakeholders, while increasing their costs of participation, monitoring and enforcement costs.

System levels

Farm/household/enterprise
Community/watershed
Market

Development impact

Assessment of the PMCA shows high transaction costs to participation in three communities of Umala where farmers are working to improve their native varieties with PROINPA for markets. The study assesses which groups of families can actually benefit from existing initiatives to improve market negotiation.

Participating communities in the Altiplano face financial markets that practically don’t exist, as well as a high degree of production risks. In this context, analysis of current access to credit and degree of impact from shocks provide a scenario of high risk that may deem credit programs not viable. Other insurance mechanisms are needed.

Assessment of collective action for technology improvement to participate in markets provides information on the types of organizations that can reduce the transaction costs to access technology and to access markets as groups by selling good-quality products. At this point, smaller groups and younger households in the productive life stage define those who benefit.

Challenges and responses

The Spanish term for advocacy coalitions has been changed to *alianzas* in Peru. The former is a more complicated term and difficult for people to understand. In Apopata, one problem that must be addressed as soon as possible is to look for an alternative institution to CONACS, a program that will soon end.

OBJECTIVE 5: develop stakeholders' capacities and ability to act to reduce vulnerability and increase adaptation in the face of changing market and climate conditions.

Critical research accomplishments

Farmer participation in agronomic research

Farmer participation has been an integral part of the LTRA-4 program since its inception, as captured in the research design. Farmers participated in the identification of demands, in the monitoring of research, and in the evaluation analysis of research results. The project's participatory activities, factors affecting participation, and some results of participatory research (Gilles et al., 2008) follow.

Participatory research in Umala and Ancoraimes consisted of three distinct methods, the first and third of which involved broad segments of the communities. Initially, community-wide meetings were held to assess knowledge, vulnerability, and demands. During these workshops, community members analyzed the sources of risk to their wellbeing through the communal creation of timelines and maps in addition to participation in group interviews. Maps and timelines helped create an understanding of risks over time and space. Researchers from U.S. and Bolivian universities pooled their skills and resources to decide where to focus efforts given their expertise, stocks of scientific knowledge, and the availability of resources. The selected research questions thus address a subset of the problems raised through the preliminary identification of community needs.

The second participatory methodology involved smaller groups of farmers who participated in the agronomic trials. In Umala these groups were based on smaller groups of people involved in potato producer organizations, while in Ancoraimes the community was invited to participate. These groups evaluated the use of organic amendments, quinoa varieties, and potato biodiversity. Third, the researchers (this in Year 3) brought the results of Year 1 research (Year 2 of the project), including agronomic trials, to the community in the form of workshops. Researchers collected feedback from a wider group of community members than participated in individual research activities. The initial assessment of needs produced maps that helped us identify which community members were most vulnerable to different types of climate hazards. In addition, we discovered that climate-related risks and pests were the largest sources of vulnerability in our research communities. These findings led us to devote more resources to research on insect pests and fewer resources on plant disease in the fields than was anticipated in our original project design. Participants created maps illustrating local vulnerability 35 years ago and today. The map of Ancoraimes municipality illustrates the threats farmers identify, from most to least pervasive (Gilles et al., 2008).

Agronomic trials are the second type of participatory activity. The experimental results are reported by Jiménez et al., 2008, in a poster at the annual SANREM CRSP meeting. Participatory processes are examined to determine particular biases and problems. Umala results allow examination of these issues.

Gender

One of the first things we noted is that, in spite of all attempts to have equal numbers of men and women participate in agronomic research, males participated more than females. About 65 percent of those who took part in agronomic trials were male. The fact that the evaluations took place in Spanish and at times that sometimes conflicted with household activities may have contributed to lower female participation rates. The motivations of men and women and the characteristics of the households were examined to understand how gender has affected participation in project activities. The primary motivation of both men and women was to learn new things, but women also were interested in receiving potatoes at harvest time. Women who participated came from families who had more livestock, less off-farm income sources, and more egalitarian decision-making structures. (See the appendix.)

Institutional approach

Participatory evaluations of agronomic trials were organized at the community level in Ancoraimes and through producer associations in Umala. The characteristics of those participating in each community were analyzed to determine how the structure of participation influences participation. The community approach led to a higher level of participation of people with less education and income. In Ancoraimes (community approach) 19 percent of those evaluating the potato harvest lacked a primary school education, while in Umala 4 percent had less than a primary education. The community approach led to an overrepresentation of the poorest 40 percent of households (71 percent of participants), while the producer organization approach overrepresented the richest 40 percent of households (54 percent of participants).

The design of the study allowed us to compare who participated in agronomic research by examining the household characteristics of families where women participated in agronomic experiments compared with households where women did not. Households with higher participation were on average more economically secure with more productive capital, namely, more livestock and larger land holdings as measured by land in pasture and fallow. Also, participating families tended to have livelihood strategies focused on agriculture. They had less income from off-farm sources and lived mostly from income-generating crop and livestock production. In contrast, the non-participating families depended more on remittances and off-farm employment. Participating families also were more egalitarian in their decision-making structures. In every area of decision making, participating families were more likely to share in the process.

Participants by income, municipality, migration, and trial.

SANREM research across income quintiles during in-field evaluations at two times, flowering during February and harvest during April, revealed great divergence between Ancoraimes and Umala. The most notable difference was the propensity toward exclusion of higher-income (*rico*) participants in the former and low-income (*pobre*) participants in the latter. Migration did not seem to account directly for differential agronomic-trial participation.

The third part of our research involves bringing the results of the year's research back to the communities themselves in the form of workshops. This process involves a broader cross-section of the communities than were involved individual research trials. To date, this process has been completed only in Ancoraimes. Results from the evaluations and research were returned to the community through presentations to various groups. Discussions revolved around costs and potential profits, which provide information on barriers to action, and opportunities to identify next steps with the participants. The approach is guided by a coalitions framework as it aims to build human, social, and political capitals, which are the basis for the ongoing process of adaptation.

System levels

Farm/household
Community
Policy

Development impact

Assessing the different approaches to participatory research contributes to understanding of who benefits and how effective the shared information flows to others (Year 4 research through the second household survey on impacts).

Training and degree training aim to strengthen human capital in the area of adaptation. Stakeholder meetings and training, and participation in workshops that share LTRA-4 knowledge aim to develop concerted actions for the future.

Challenges and responses

Collaboration with SENAMHI has been very good. Constraints are faced regarding the quality and length of data to analyze extreme events. This is something that we are currently addressing.

The potato harvest delayed the fourth Ancoraimes workshop to April. Workshops in Umala scheduled for March had to be postponed because of the unavailability of good-quality maps of the area. The maps for *socialización* (knowledge sharing and building) were developed for Ancoraimes but have not been developed for all the other sites due to lack of images. This is something we are still trying to resolve.

Research plans were revised by the Bolivian team, and a new structure of monitoring was set up with O. Yana and E. Yucra working under the supervision of Jorge Cusicanqui and Elizabeth Jiménez. A database by individuals participating in assessments and a database by household have been developed to monitor participation and to link with the livelihood strategies, capitals and assets, networks of information and activities in the baseline survey. We had difficulties entering the data on participation for Year 2 (Year 3 of the project). This was not solved until October 2008.

In Peru, the president in the community of Santa María has continued to show a negative position toward the idea of advocacy coalitions. We have stopped the AC research, though we are following what is happening with the soils studies and the formation of a local "barefoot" veterinary. Through these activities, alliances are happening anyhow as a result of the connections the project has established between the community and external actors. In the second half of the year, activities have ratified our perception that AC processes will not work well in Santa María unless the community owns the process. There is an obvious weakness in the community's organizational structure that does not promote activities requiring collective action such as AC. The community is not happy with its local authorities; some members have made clear that they do not feel represented. Under these conditions, building agency at the community level can be challenging. On the other hand, Apopata shows more possibilities. Just recently, community representatives said that before the project, the community was going through a process of "loosing itself" ("*Nos estabamos perdiendo como comunidad*"). With the project, they are now learning again to work together. This comment was given during a session where students of the innovation for agricultural development master's program returned the information collected during a visit to the community of Apopata and shared their analysis of their findings.

Degree and non-degree training activities

LTRA-4 had 56 students involved in long-term degree training, 29 women and 27 men. Of those, 48 were from host countries, six from the United States, and two from other countries in Latin America. Disciplinary training included social sciences, agronomy, ecology, rural sociology and development, climate, soil metagenomics, natural resources, and biology.

Three women and three men were working on their Ph.D.s. There are 25 master's degree students and 25 *licenciatura* and engineer degrees. Gilles, Valdivia, and Jiménez also taught a doctoral course in rural development at UMSA.

Short-term training in Year 3 involved 1,747 participants, 1,068 men and 679 women. In all, 62 training activities were completed. See Appendix A.

The master's student from the innovation program at La Molina-Peru assigned to document participation and learning to action has prepared his research proposal regarding how he plans to analyze the data that he has been gathering. The Puno research-technical team has been trained in project and grant proposal writing. Capacity building and training of "barefoot" veterinarians in Santa María as well as GPS as training took place in Peru.

Four students, also part of the research team, have completed the research methodologies compulsory master's course. As a result, they now have a first draft of their thesis proposal. Two students have completed the leadership and social organization course and have participated in the field practice in Apopata. They have had the chance to receive feed back from their cohorts on how the project seems to be perceived in the community.

Students in the leadership and social organization master's course visited Apopata to perform a fast evaluation of community capitals, synergies among capitals, and existing alliances between community and external actors. See Appendix A.

Publications, presentations, other products

Activities this year produced nine refereed journal articles, six book chapters, one master's thesis, seven presentations of students and investigators at professional meetings in the United States, three at international conferences, nine presentations at our LTRA 4 annual meeting, four presentations at the SANREM CRSP annual meeting, three presentations at National Academy of Science and National Science Foundation workshops, a Latin American workshop with four presentations from LTRA-4 with the McKnight Foundation in Lima, nine working papers and reports, seven seminars, and 12 posters. See Appendix B.

Networking activities

This has been a critical year in developing a network of collaborators in the climate change community. We are currently collaborating with the National Program on Climate Change in Bolivia, SENAMHI-Bolivia, and we have met with SENAMHI-Peru. All these organizations work on modeling and adaptation. We also collaborated with the McKnight Foundation to organize a workshop on climate change and agriculture in the Andes, which took place in Lima right after our annual meeting. These relations are instrumental in developing a discussion group on models, as well as linking their information products to decision makers in our Altiplano communities.

We have developed a strong relationship with CIDES-UMSA, the graduate social sciences program that trains master's and Ph.D. students in rural development, and have taught in their program. We have made presentations to the USAID mission in Bolivia on our research on climate change adaptation, the first seminar in a series of climate change brown-bag seminars. We continue to communicate with USAID Peru and were invited to give a seminar on our work in October 2008.

One of our research sites, Ancoraimes, is benefiting from the networks of our collaborators with the United Nations Development Program in Bolivia, which has supported work on adaptation, allowing us to out-scale research to four communities. The Programa Nacional de Cambios Climáticos (PNCC) study of peat bogs is taking place in the high elevation of Ancoraimes. Our project is supporting this, and PNCC is supporting other sites in the region for comparison. CIP is also supporting participation of one researcher who will focus on a comparative study of peat bogs in Apopata and Chojñapata.

Three PIs traveled to the region during the first semester to continue to foster coordination across research sites. Valdivia's travel focused on developing plans for sharing new knowledge with community groups and on developed databases that integrated baseline and monitoring. She also coordinated communication with other country stakeholders, SENAMHI, and PNCC in Bolivia; and coordinated landscape research among UMSA, CIP, Kansas State, and Virginia Tech. Gilles coordinated climate networks research.

The annual meeting of LTRA-4 took place in Puno, Peru, this year, with Peruvian stakeholders participating in the meetings. These included farmer leaders from the participating communities, as well as members of organizations that have mandates similar to the project's goals.

Participants from Bolivia, including two SENAMHI researchers, attended. Five members from LTRA-4 participated in the SANREM CRSP meeting in the Philippines and presented research results in soils, climate-change projections for the Altiplano, diseases, and livelihoods. Several posters were presented on soils, markets, participatory research, advocacy coalitions, market strategies, and perceptions of risks and capitals.

At SANREM's May 2008 gender meeting in the Philippines, LTRA-4 researchers gave two presentations: "Measuring impact on social interaction and natural resources – the use of the KASAP methodology in the Peruvian Altiplano"; and "Developing a Methodology to Enable Community Governance for Market Integration and Adaptation to Climate Changes: Agency and the Advocacy Coalition Approach in the Peruvian Altiplano."

Colleagues from Bolivia traveled to Peru in September for a planning meeting on the *socialización* and household survey activities planned for all communities in the Altiplano. Valdivia, Motavalli, Garrett, Gilles, and Anji Seth traveled on multiple occasions to coordinate field research, participate in teaching modules, give presentations to USAID and the PNCC in Bolivia, and at international meetings such as the International Conference on Potato in Cuzco, Peru, (Jiménez) and at meetings in the United States (Figueroa, Aguilera, Turin, Thomas, Gilles, Motavalli, Valdivia, Seth, Thiebault).

Results from lessons learned from the Andes were presented at the Asian Development Bank. Finally, Valdivia and the SANREM LTRA-4 research team were invited to a workshop on climate change and Andean agriculture, organized by the McKnight Foundation, to share our research and findings as the foundation plans its research program, "Climate Change Adaptation and Agriculture in the Andes." We have collaborated with SENAMHI-Bolivia on analysis of extreme events. We are also communicating with SENAMHI-Peru.

Project highlights

- A large-scale analysis of 21st century changes in the South American Monsoon has been performed and suggests weakened early-season rains and stronger precipitation in January through March. A manuscript is in review at the journal *Climatic Change*.
- 21st century climate changes in the Altiplano region are shown to be consistent with large-scale changes, also indicating a shift toward a later, more intense rainy season. A manuscript is being revised for *Geophysical Research Letters*.
- Projected changes in precipitation extremes suggest the rainy season will be characterized by longer dry spells punctuated by more intense precipitation events. While the annual precipitation totals do not change dramatically, there are likely to be significant differences in its temporal distribution. A manuscript is in preparation for *Journal of Geophysical Research*.
- Analysis of drought measures based on precipitation and soil moisture in the 21st century indicates significant reduction in soil moisture despite increases in precipitation during January through March, due to increased evapo-transpiration resulting from increased temperatures. A manuscript is in preparation for publication in *Journal of Hydrometeorology*.
- We have determined that assets and diversification have positive effects, reducing perceptions of risk. These are elements that will be shared with farmers in discussions of market effects in the context of climate variability and extremes in Year 4. We have also determined high co-variance in climatic and pest shocks, and lack of mechanisms to control these, therefore high feelings of dread.
- The type of organization of participatory research influences who participates. Participation organized through community leaders results in more inclusion of poorer members of the community and less participation by more prosperous farmers. Participation organized through farmer organizations results in heavier participation by farmers with middle-size holdings.
- Transaction costs in large stakeholder platforms to build market chains may not be an alternative for small groups, based on Figueroa’s findings in the central Altiplano.
- The use of organic amendments with fertilizer or other commercial soil amendments can improve soil properties, increase production, and meet community acceptance. Use of alternative organic amendments and commercial fertilizer to supplement conventional organic amendments, such as animal manure, may be important to reduce soil degradation in this environment.
- While high rates of manure addition are not common in this region of Bolivia, farmers do practice banding of manure in furrows near the potato hills. A possible management practice to improve the soil's buffer capacity against increased temperature and lower rainfall on crop production is increasing the effective rates of organic amendments.
- A rapid field diagnostic tool for plant N status, the Cardy nitrate meter, was tested in the Altiplano over two years to determine its use for rapid determination of nitrogen sufficiency in potato, a potential tool for farmers without access to testing laboratories to improve their fertilization decisions. The meter had good agreement at lower total N and nitrate levels but poorer agreement at higher values, varying among communities. Further

research is required to determine the observed variation before the tool could be recommended for this environment.

- Consistent relationships are found between trends in climate and local knowledge, which appeared contradictory at first. Warming in the central Altiplano is shown in the trends, while farmers perceive lower rainfall, which appears to be increased evapo-transpiration. These are critical elements of the information products linking climate and soils amendment for water retention with processes that increase human, social, and political capital.
- We have predicted the global risk of potato late blight under climate-change scenarios, with emphasis on the Andes and eastern Africa, and application of our methods to potato tuber moth is underway (manuscripts in preparation).
- The utility of potatoes for late-blight management varies across a climatic gradient from Peru to Ecuador to North America. We have modeled the utility as a function of climatic characteristics (manuscript in revision for *Ecological Applications*).
- In a synthesis project sponsored by the National Center for Ecological Analysis and Synthesis (NCEAS) with joint participation by CIP, KSU, and University of California-Davis, we developed a new evaluation procedure for plant disease in the context of ecosystem services (accepted pending revision by *Phytopathology*; revised version now under review).
- NCEAS, with joint participation by CIP, KSU, and UC-Davis, we developed a new evaluation procedure plant disease in the context of ecosystem services (accepted pending revision by *Phytopathology*; revised version now under review).
- Environmental change is affecting traditional strategies for dealing with climate change. The behavior of plants and animals that previously was used to determine planting dates and locations has changed, and some species have disappeared.
- Farmers who preserve agricultural biodiversity are involved in both market and non-market exchanges of crops. Farmers who heavily rely only on markets or only on non-market exchanges conserve less biodiversity.
- Farm households where decision making is shared equitably between men and women have higher incomes.
- Study of buffering effects of organic amendments on climate-change impacts such as increased temperature and lower rainfall indicate that estimated changes in volumetric heat capacity were not affected by applications, but some differences in water-holding capacity were observed with cow manure applied at rates greater than 15 Mt/ha. This information becomes an element in the information products developed and shared with communities to identify strategies with farmers, a Year 4 activity.

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

PIs

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Ronald Morse and Conrad Heatwole, Virginia Tech
David Midmore, Central Queensland University
Howard-Yana Shapiro, Mars Inc. and University of California-Davis
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Joshi Laxman and Meine van Noordwijk, ICRAF, Indonesia
James Roshetko, ICRAF and Winrock International, Indonesia
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Jean Saludadez, University of the Philippines-Open University
Anas Susila, Bogor Agricultural University, Indonesia

Host countries

Indonesia, Philippines, Vietnam

Research objectives

The project goes by the acronym TMPEGS based on its six main objectives.

- **TECHNOLOGY**: develop economically viable and ecologically sound vegetable agroforestry (VAF) systems
- **MARKETS**: develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies
- **POLICY**: identify options and institutional frameworks that promote sustainability of vegetable agroforestry production and reward environmental services
- **ENVIRONMENTAL** and socioeconomic impacts: assess the short- and long-term environmental and socioeconomic impacts for farm families who adopt integrated vegetable agroforestry systems
- **GENDER**: provide mechanisms to ensure women’s involvement in decision making, and sustainable production and marketing practices to improve their socioeconomic wellbeing within the vegetable agroforestry system
- **SCALING UP**: build host-country capacity to manage and disseminate integrated vegetable agroforestry

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."

Figure 3-28 shows the TMPEGS interdependence model. The hexagon is a tent with pegs from six corners. The tent is dependent on all the pegs 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, the Philippines, and Vietnam. Each country has unique 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.
- 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 these 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 VAF systems. Issues of concern include market inefficiencies, soil erosion and degradation impacts, and policy-making processes. This element seeks to answer the question: What policy incentives promote wider adoption of VAF systems by small-scale male and female farmers? These incentives can be incorporated into local, regional, or national government policies.

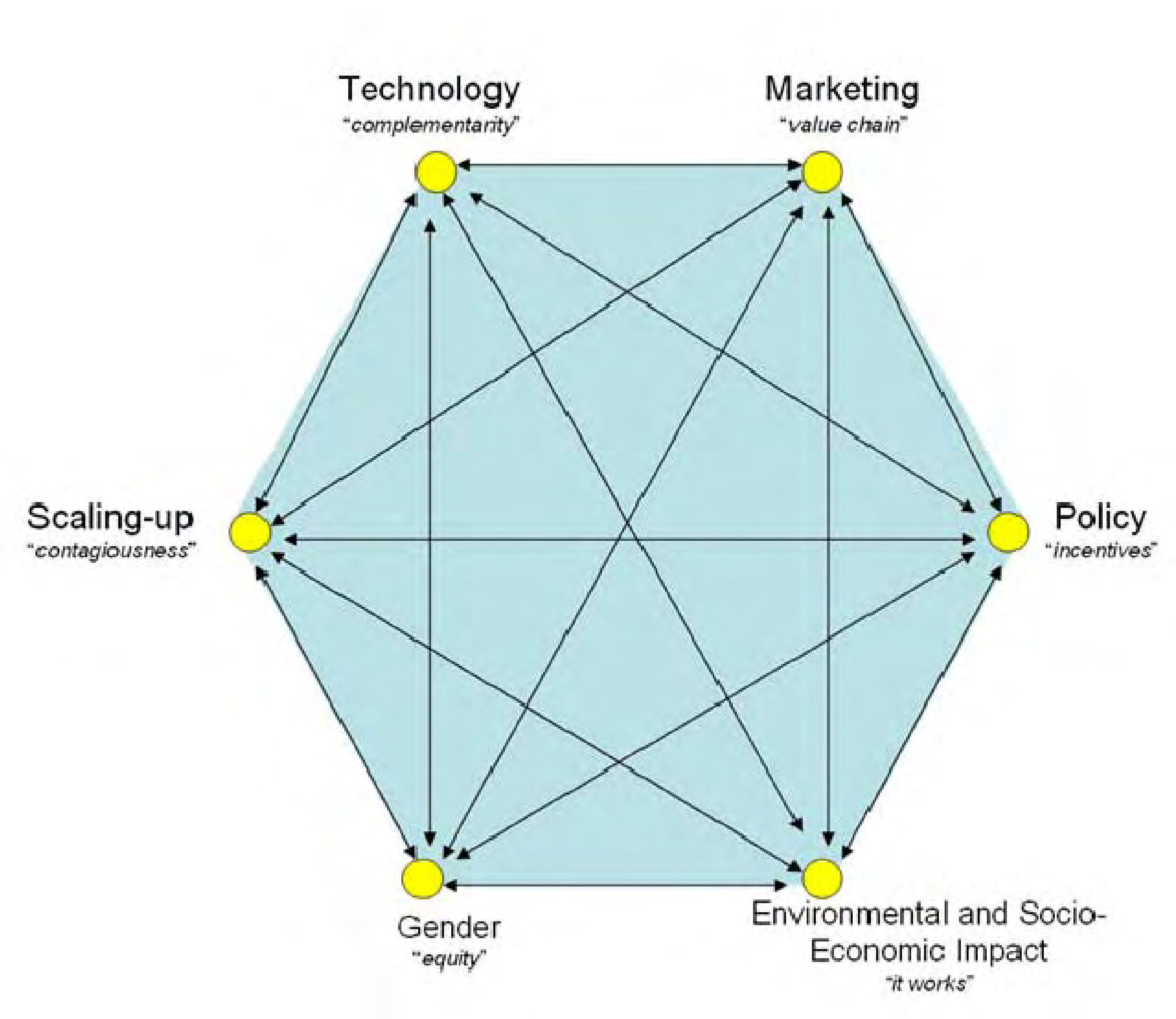

Figure 3-28. TMPEGS Interdependence Model

- 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 male and female farmers, scientists, and other stakeholders. With respect to environmental impact, a water-quality model is being used to simulate and quantify hydrologic impacts of current practices and compare them with hydrologic impacts of proposed VAF practices. It seeks to answer the questions: Can VAF improve the quality of life of small-scale farmers? Will small-scale farmers' 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 the 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 VAF 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 small-scale farmers. 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 needs assessments and the effectiveness of TMPEGS outreach activities such as workshops, seminars, and farm visits.

Peg interdependency

This section describes the interdependence of one TMPEGS peg on the others in the conceptual model (Figure 3-29). The model 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 set technology development priorities. Various technologies and combinations are then tested. Potentially innovative new 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 male and female small-scale farmers.

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 towards men. The technology and scaling-up teams would then need to modify their approaches to ensure that gender equity is attained. Another example of feedback is an economic study. If it is found that vegetable yields and 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 be stopped. Additional 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 socioeconomic, gender, and scaling-up research.

The baseline studies gathered data on site characteristics (climate, predominant crops grown, soils, diseases, and management practices), marketable products, current policies on vegetables 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 studies showed that the predominant agro-ecosystem in the Vietnam study area 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.

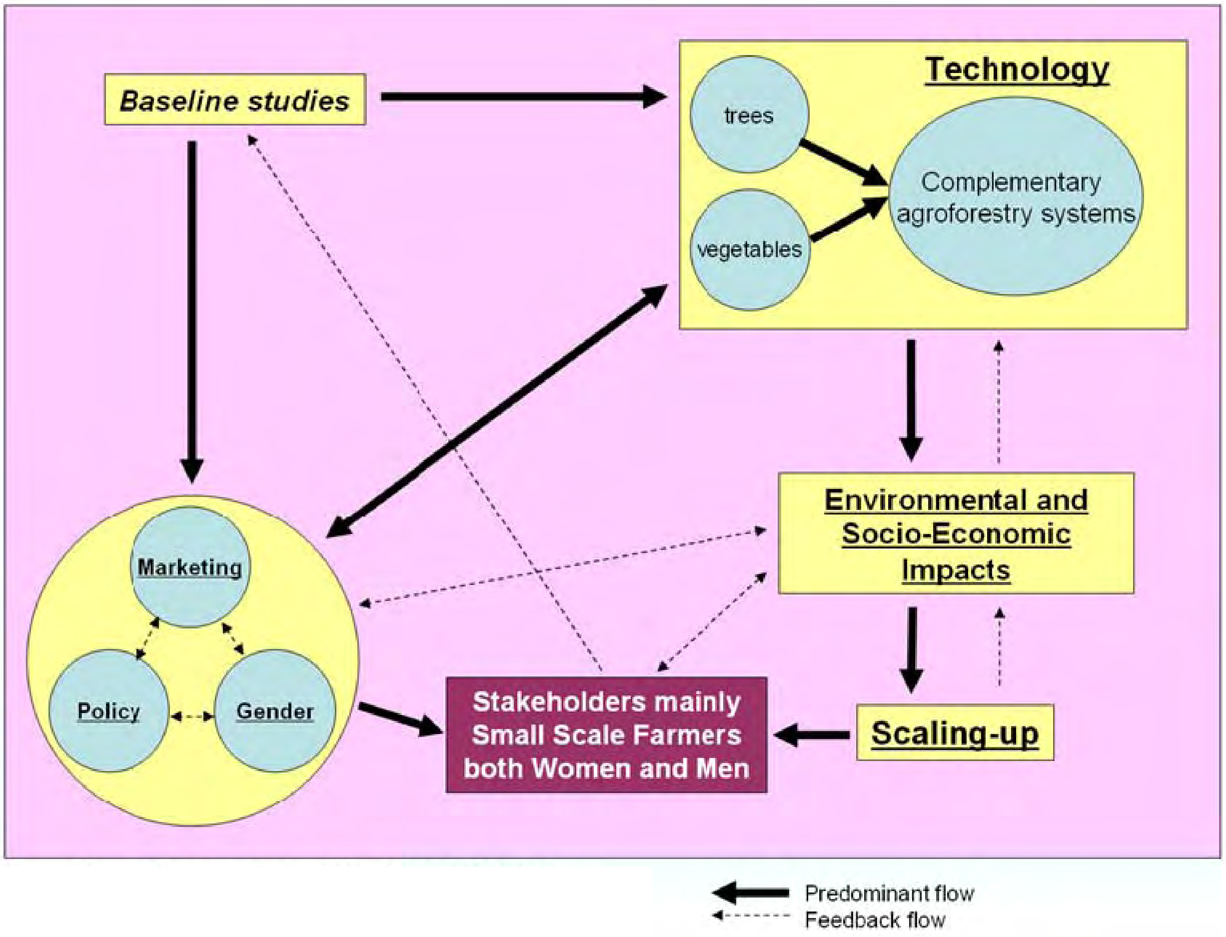

Figure 3-29. Conceptual model of TMPEGS

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 with 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 develop 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, government is encouraging soil conservation practices in 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 agroforestry practice will be fed to the environmental and socioeconomic team. The environment impact team will need data on agroforestry management of distance between trees, vegetable density, vegetable cover, fertilization rates, tillage practice, kinds 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 farm incomes.

Technology also feeds information to the marketing, gender, and policy teams. For example, technological successes may influence the types of policies to be recommended and the kinds 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 well in VAF systems.

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

Marketing, policy, and gender pegs frequently exchange information and findings among themselves. For example, in the Philippines, the marketing team informed the policy team that there are certain local government policies that favor the rich vegetable growers, which is detrimental to small-scale farmers, both women and men. Consequently, the policy team is seeking to determine the proper incentives to favor small farmers. 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 formulate policies to promote gender equity.

The marketing, policy, and gender teams mainly feed the socioeconomic peg. The socioeconomic team synthesizes the research information to enhance equitable adoption of VAF system technology. The socioeconomic impact team combines findings from the marketing, policy, and gender teams with findings 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, fast distribution to many stakeholders including national, regional, and local governments, non-governmental organizations, and the private sector, with major emphasis on “contagious” packaging for small-scale farmers.

Table 3-20. LTRA-5 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 agroforestry 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	T-1-1	Indigenous and Commercial Vegetables and Vegetable-Tree Complementarity	5. Several indigenous vegetables will yield well under trees 6. Yield of vegetables can be optimized by distance between planting 7. Reintroduction of indigenous vegetables will increase income and improve nutrition of small scale farmers both women and men 8. Some commercial vegetables yield better with trees
T-1-3-1	Soil Moisture and Vegetable-Tree Complementarity	Drip irrigation will minimize water competition between tree and vegetable thus increases agroforestry 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 and if it is being adopted.

Sub-objective	Research Activity	Hypotheses	Methods
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 agroforestry 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 vegetable farms?	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 These 6 treatments will be laid out in 2 x 2 x 2 factorial experiment in

Sub-objective	Research Activity	Hypotheses	Methods
			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.
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 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,

Sub-objective	Research Activity	Hypotheses	Methods
			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). <u>Fertilizer application:</u> <u>1. N fertilizer optimization.</u> 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% <u>2. P fertilizer optimization</u>. 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% <u>3. K fertilizer optimization.</u> 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% <u>4. Soil analysis:</u> 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, Vietnam; Nanggung, Indonesia; and	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 country. Randomized complete block design with or without perennial peanut ground cover and with three replications. These experiments are

Sub-objective	Research Activity	Hypotheses	Methods
		Songco, Philippines 2. Vegetables strip planted with perennial peanut will yield as well as with vegetables grown using traditional systems	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 increase income of small scale farmers both women	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 sources shall be compared together with their ease of use, safety, and ease of fabrication.

Sub-objective	Research Activity	Hypotheses	Methods
		and men in Songco, Philippines	
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	Vetiver 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	• Perceptions of risks will differ between local experts and other producers. 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 for common ailments	Chinese malunggay (*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 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

Sub-objective	Research Activity	Hypotheses	Methods
			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
T-2-3-2	Vegetable Strips under Cashew	1. Established of vegetative strips under	Two farmer cooperators volunteered for this experiment. Vegetated strips of lemon grass, pineapple, rau ngot, and vetiver grass will be

Sub-objective	Research Activity	Hypotheses	Methods
	Trees for Soil Erosion Control	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	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 Agroforestry 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.
M-2-1	Farmers'	No hypothesis: Service	1. The participants will be farmers from Sukaluyu, Hambaro and

Sub-objective	Research Activity	Hypotheses	Methods
	Workshops on: Disseminating Vegetable Agroforestry Baseline Survey Result and Technology and Recommendation to Improve the Quality and Quantity of Products from Vegetable Agroforestry Systems	Objectives: 1. To disseminate vegetable agroforestry 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 agroforestry marketing development and create a marketing action plan	Parakan Muncang villages. Each village can send 20 representatives to attend the workshop. Vegetable agroforestry 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 agroforestry development 4. Vegetable agroforestry development action plan will be created using PRA and led by a facilitator
M-2-2	Farmers Comparison Study Trip to Good Practice of Vegetable Agroforestry Management Site	No hypothesis: Service Objectives: 1. To improve farmers' knowledge and skill in good management of vegetable agroforestry systems	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 conducted at least in two locations. 4. Visit finding will be documented in the report and socialized to

Sub-objective	Research Activity	Hypotheses	Methods
		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 agroforestry farmers 4. To capture potential market, to collect marketing information and to see possibility in making collaboration	other farmers through focus group discussions
M-2-3	Post-Harvest Training on Vegetable Agroforestry Products and Promotion of Indigenous Vegetables Species of Nanggung Sub-District	No hypothesis: Service Objectives: 1. To improve the marketable quality of vegetable agroforestry 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 post handling methods 4. To raise awareness	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
		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 agroforestry 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 agroforestry 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-Agroforestry Systems by Smallholders in Southeast Asian Watersheds	Incentive-based policies stimulate investments in vegetable agroforestry systems by smallholder farmers	*Philippines:* For the Philippines study, the research framework, process and methods are in Figure 3-28 (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-agroforestry production among small farmers. Potentials and constraints for rewarding farmers for the environmental services provided through vegetable agroforestry systems and sustainable farming practices will also be identified.
ENVIRONMENTAL AND SOCIOECONOMIC IMPACT			

Sub-objective	Research Activity	Hypotheses	Methods
E-1	Assessment of the Hydrologic Impacts of Vegetable Agroforestry Systems in Southeast Asia	1. Conversion from conventional row crop production of vegetable to vegetable agroforestry will: • Decrease downstream flooding risks (Indonesia, Philippines) • Increase dry weather baseflows (Indonesia, Philippines) • Decrease nutrient losses in surface and subsurface flows (Indonesia, Philippines) • Decrease watershed sediment yields (Indonesia, Philippines) 2. Conversion from conventional agroforestry with bare soil under trees to agroforestry in which a soil cover is maintained via non-removal of leaves or growing of cover crops and/or vegetables will:	<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 (ungaged 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 ungaged 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
		• Decrease downstream flooding risks (Vietnam) • Increase dry weather baseflows (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 by pesticide exposure.	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 asked to express their willingness to pay for avoiding health impairment brought about by pesticide exposure.

Sub-objective	Research Activity	Hypotheses	Methods
E-2-1-2	Benefit Cost Analysis of Alternative Soil Erosion Control Practices in Cashew-Based Vegetable Agroforestry 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 agroforestry 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 recommended	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
		vegetable cultivation technologies	
E-2-3	Adoption of Integrated Vegetable-Agroforestry 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 agroforestry 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, water and other natural	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 agroforestry 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
		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 agroforestry System	1. Increased gender awareness among village leaders, sub-district officers, and TMPEGS members improves women's involvement, status, and voice in the Indonesian VAF system. 2. Women's adoption and dissemination of technology improves their involvement, status, and voice in the Philippine vegetable agroforestry system. 3. Existing women organizations and networks, linked by shared meaning systems defines women's participation in the vegetable-agroforestry	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
		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 system.	
SCALING-UP			
S	Integration of Vegetables and Agroforestry 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 by objective

Technology

Complementarity

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Objective

To develop economically viable and ecologically sound vegetable agroforestry systems

Critical research accomplishments

Vietnam

Vegetable-tree complementarity

Trial with shade-tolerant cu nang, an indigenous root crop: After several trials, it was found that cu nang grows well in dry, sandy soil under high shading condition providing high biomass. The crop is used mainly as a source of starch.

A researcher-managed experiment conducted at the Binh Phuoc extension center farm on vegetables under different cashew shading condition included eight types of vegetables: amaranth, kangkong, mustard, French bean, okra, bitter gourd, eggplant, and tomato; planted in full sunlight, along a cashew row (medium shade), and between two cashew rows (high shade). Amaranth, kangkong, okra, and bitter gourd achieved highest yield under full sunlight conditions, while mustard and French bean had highest yield under medium shade conditions. High pest infestation was observed for eggplant and tomato. Data on cashew yield shows that without vegetable integration, average yield of cashew is 6 kg/tree. Cashew trees next to a vegetable row had a higher average yield of 6.6 kg/tree. Average yield of cashew trees between two vegetable rows was recorded to be highest at 7 kg/tree, an increase of about 16.7 percent compared with the average yield of cashew trees without vegetable integration. Another set of experiments, this time farmer managed, were conducted under high-, medium-, and no-shade conditions. Data from these experiments are being analyzed. A crop budget will be conducted to evaluate the financial feasibility of the vegetable-cashew system.

Arachis pintoi as cover crop

An experiment with arachis pintoi as a cover crop was set up at the Nong Lam University (NLU) experimental field. The experiment includes okra and kangkong with and without pintoi as a soil cover crop with three replications. Vegetable growth characteristics, pest attacks, and yield were monitored. It was found that pintoi helped to reduce weeds but competed with vegetables for nutrients and water. Furthermore, there is a high cost for pintoi establishment in poor soil conditions. Pintoi helped to reduce labor in weeding by about 40 percent.

Vegetables in home gardens

An on-farm trial on vegetable production in home gardens was set up in a collaborating farm. Four vegetables – morning glory, amaranth, mustard greens, and leafy onions – were planted in 200 m^2 plots, with 100 m^2 on drip irrigation and the other 100 m^2 on hand irrigation. Drip irrigation saved significant amounts of water and about 33 percent labor. All vegetables have higher yields of about 6.7 percent under drip irrigation than with hand irrigation.

Several households with vegetable gardens for home consumption are being observed. Farmer group discussions will be conducted for identifying issues and constraints in relation to small garden VAF technology and adoption. Data on yield performance, input use, and prices will be collected for crop budget analysis.

Drip irrigation

A drip irrigation study on young cacao planting showed that the drip irrigation system designed by NLU decreased labor for irrigation, gasoline for pumping, and amount of water used. With drip irrigation, there was a 24 percent saving in irrigation cost and about 60 percent of total water used for young cacao planting compared with current farmer irrigation practice. There is a potential for scaling up NLU’s drip irrigation system for high-value perennial cash crops, but the high investment cost for installing a drip system is a main adoption constraint among poor farmers.

Cacao-cashew complementarity

In the cacao-cashew experiment, a higher growth rate of cacao trees was found where cacao has sufficient shading under old cashew plantations compared with those planted in young cashew plantations.

Vetiver grass for termite control in cacao seedlings

In Binh Phuoc province, the integration of cacao into cashew planting is seen as a way to improve income. Termite attacks on cacao seedlings, however, were found to be one of the main constraints to cacao development. At present, termite control depends mainly on synthetic pesticides. A study was conducted to test the hypothesis that vetiver grass and its biomass can repel termites. The findings showed that vetiver grass and its biomass can likely be used for termite control. The potential for using vetiver grass for controlling termites on cacao is promising.

Effect of cashew weed management practices on soil quality

Different weed management practices of collaborating farmers have been monitored. Data on input uses and cashew yield were collected. Two students have been trained in conducting soil quality tests using test kits. Data on soil quality of cashew plantation with and without clear weeding have been measured using soil quality test kits. Initial results from field assessment show that organic matter in both cashew plantation that maintains a weed cover to protect soil from erosion and in cashew plantation integrated with cacao plantation is significantly higher than in cashew plantation with clear weeding. The cashew yield in plantations with clear weeding is lower than in those without clear weeding.

A plan for studying the soil quality of cashew gardens with and without cacao integration was prepared to test the hypothesis that integrating cacao into old cashew plantings will significantly improve soil fertility and cashew yields.

Pesticide use in cashew

Participatory rural appraisal field work was carried out at the study site with the participation of local farmers, NLU, and AVRDC researchers. Stem worm was identified as one of the major pests in cashew production. During the field survey it was found that some farmers have applied pesticides on cashew even when there was no sign of pest attack. This preventive method of pesticides use is ineffective and has also posed threats to the environment and farmers' health.

Indonesia

Vegetable-tree complementarity

An on-farm trial was implemented to evaluate the production of 11 commercial vegetable species under three levels of tree shading (low light, medium light, and open area) in a nested design, replicated three times. The species included in the trial were honje (*Etlingera elatior*), terubuk (*Saccharum edule*), katuk (*Sauropus androgynus* (L.) Merrill), kenikir (*Cosmos caudatus* Kunth), kangkong (*Ipomoea aquatica* Forsskal), amaranth (*Amaranthus* sp.), chili (*Capsicum annuum* L.), eggplant (*Solanum melongena* L.), long bean (*Vigna unguiculata* (L.) Walp.), green bean (*Phaseolus vulgaris* L.), and tomato (*Lycopersicon esculentum* Miller).

Twenty-five independent variables were analyzed for their effect on vegetable survival, growth, and yield. Preliminary results indicate that vegetable production under *dudukuhan* (agroforestry) shade systems are a viable option for smallholder farmers; however, more intensive species-specific and site-specific management is required.

Indigenous vegetables

Optimum population of katuk is 160,000 plants/ha, while for kemangi the optimum population could not be determined. It could be increased to more than 200,000 plants/ha. There was no significant effect of plant spacing in kenikir.

Optimum vegetable fertilization

Research was completed on impact of fertilizer and spacing on marketable indigenous vegetables. Inorganic fertilization increased yield of beluntas, kenikir, and kemangi, while fertilization did not affect katuk. Optimum population of katuk is 160,000 plant /ha. For kemangi, the optimum population could not be determined, but it could be increased to more than 200,000 plants/ha. From the kenikir population range experimented on, there was no significant effect of plant spacing in kenikir. Brochures were written in the Indonesian language for use by farmers.

Research was completed on fertilizer impact on kangkong and yard long bean. Furthermore, optimum phosphorus rate experiments were completed on amaranth, kangkong, eggplant, tomato chili, green bean, and yard long bean.

Optimum fertilization-rate recommendation brochures for the researched vegetables were written in Indonesian together with information on water requirements, harvesting, and weed control.

Drip irrigation

Research was conducted to evaluate the effect of a low-cost drip irrigation system on the growth and yield of amaranth (*Amaranthus* sp), kangkong (*Ipomoea reptans*), yard long bean (*Vigna unguilata*), green bean (*Phaseolus vulgaris*), and katuk (*Sauropus androgenous*) during wet season. The results showed no significant response of vegetable yield to the drip irrigation application during wet season. The experiment should be conducted in the dry season to evaluate the effectiveness of drip irrigation on conventional vegetable production.

Arachis pintoi as cover crop

Experimentation on arachis pintoi as a cover crop for yard long bean and as biological pest control was initiated. Visual observations showed arachis pintoi was competing with yard long bean. It was evident that arachis pintoi stunted the growth of yard long bean and reduced its yield.

Philippines

Vegetable-tree complementarity

Observations from VAF farms:

Focus group discussion was used to elicit information from 15 VAF practicing farmers on their experiences, observations, and practices relating to tree integration into intensive vegetable systems. Most of the participants were cultivating sloping lands greater than 3˚ slope and used trees to control soil erosion. VAF systems covering 21 farms, five tree species, eight vegetables, and four aspects were assessed. Data collected were tree parameters, spatial performance of vegetables, and spatial light transmission. It was found that common cabbage, Chinese cabbage, cauliflower, and bell pepper increased their yields from 14 percent to 98 percent when trees were integrated in the system.

VAF farmers interviewed indicated competition between trees and vegetable crops. The competition started during the early growth stages of vegetables up to harvesting. Severe competition was observed from the second year and up to more than five years of tree age. Farmers recognized shading was the main problem, thus pruned the trees before planting vegetables. Farmers indicated difficulty of land preparation when trees and vegetables are integrated.

Appropriate trees for VAF:

Eucalyptus torillana, Eucalyptus robusta, and *Acacia mangium* were found to be more appropriate tree species than *Gmelina arborea* and *Maesopsis eminii*. The eucalyptus were having light, narrow, and erect canopies, thus allowing more light to penetrate to the associated vegetables. *Acacia mangium* may not be appropriate in terms of canopy type but, due to its N_2-fixing, fast-growing and deeper-rooting pattern, may not cause competitive interaction with associated vegetables. *Gmelina arborea* is not an appropriate timber tree species for VAF. Apart from having broad, thick canopies, it also competes with vegetables for water and nutrients.

Pruning trees for VAF:

Farmers generally pruned 40 percent to 50 percent of the canopy as the normal silvicultural recommendation for forest trees. With this canopy removal, light transmission can be at 70 percent compared with open field. Some farmers do not prune the trees, thus light transmission can be as low as 10 percent to 20 percent at 1 to 3 m from the tree line, and light competition can be severe. Many farmers removed all the small branches, twigs and leaves, leaving the trees like huge standing candles. This practice removes the microclimate effects created by the trees, which eliminates the benefit of having trees on the farm, thus removing beneficial effects of trees on vegetables. Based on observations in VAF farms, the canopy left should be between 40 percent and 70 percent to optimize the benefits of trees to the associated vegetables.

Tree height and VAF:

There was a direct relationship between tree height and vegetables' positive response when planted beside trees. The taller the trees, the better for vegetables under it, for more light is available to the vegetables.

What is better, vegetables planted at the south or north side of trees?

Planting the vegetables on the south side of the trees produced better yields. This was due to the fact that the sun is tilted toward the south, thus the vegetables received more sunlight. Vegetables planted on the east side of the tree lines yielded higher than those planted on the opposite side. This was due to the fact that the study site's rain usually comes every afternoon, thus in the morning it is more sunny. As a result, the vegetables were getting more sunlight than those planted on the west side. The vegetables planted on the west side of the tree line tended to have lower light duration because they were shaded by the trees during the morning sun, resulting in lower yields.

Vegetable adaptability at the competition zone:

All the vegetables were adaptable under *E. torillana* tree hedges. Fruit vegetables had the highest adaptability indices among the vegetables evaluated under a tree-based system, followed by leafy vegetables. The lowest was the climbing vegetables. Among the fruit vegetables, bell pepper and tomato had the highest adaptability index (AI). Eggplant had the lowest AI. Among the leafy vegetables, amaranth was the best adapted under a tree-based system. The commercial leafy vegetables, common cabbage, and Chinese cabbage also performed well. Among the climbing vegetables, the basellas performed well. The poorest performer among climbing vegetables was the yard long bean. Among the tree vegetables, Chinese malunggay performed the best, and the worst was katuray. Carrots were well adapted under a tree-based system, and it was the most adapted among the commercial vegetables evaluated, together with bell pepper.

Vegetable yield increases at the complementarity zone:

All vegetables responded positively to the presence of the tree hedges. The tree vegetables had the highest complementarity indices (CI) among the vegetables evaluated. This was followed by leafy vegetables and climbing vegetables. The fruit vegetables had the lowest CI. Among the tree vegetables, katuray was the most responsive to the tree-based system at the complementarity zone. This was followed by alekway. Among the leafy vegetables, the jutes were the best performers, followed by the amaranth. Among the fruit vegetables, eggplants performed well. Yard long beans were also responsive to a tree-based system at the complementarity zone. Among the commercial vegetables, Chinese cabbage had the highest CI, followed by bell pepper and carrots. The lowest CI was tomato.

Overall vegetable productivity when planted with trees:

Results showed that all vegetables increased yield when planted with trees, factoring in the competition and complementarity effects. The species with the highest productivity was jute, followed by yard long beans. Among the vegetables evaluated, tree vegetables had the highest productivity, followed by climbing vegetables, leafy vegetables, and fruit vegetables. Among the commercial vegetables, Chinese cabbage had the highest productivity benefit when planted beside trees.

Vegetables response at different light transmissions:

All the vegetables evaluated were adaptable to *E. torillana* under 20 percent light transmission. Fruit and root vegetables were more adapted to tree-based systems than leafy and climbing vegetables. Of these fruit vegetables, tomato had the highest AI, followed by yard long bean and carrot. At 40 percent light transmission, almost all the vegetables tested grew well. For AI, Chinese cabbage adapted the best under tree hedges, followed by eggplant. At 60 percent, the different vegetables tested also performed well. Amaranthus was the most adapted, followed by Chinese cabbage, basella, and bell pepper, with 0.87. At 80 percent light transmission, almost all the vegetables tested grew well. Among commercial vegetables, tomato performed well, followed by bell pepper. Carrots and Chinese cabbage performed similarly. Overall, adaptability indices are lower at 20 percent light transmission compared with 40 percent, 60 percent, and 80 percent. This finding supports the tree pruning recommendations for VAF systems discussed in the previous section.

Vegetable yields when planted with trees:

Commercial vegetables responded well to tree integration during the wet season planting (June-October 2007). Increase in yield averaged 29 percent ranging from 13 percent to 40 percent, which means that integration of trees to the intensive vegetable systems increased farmers' income by 29 percent, assuming no additional inputs of labor and fertilizers. Tomato had the highest percent yield increase, 40 percent, followed by carrots, 37 percent. Chinese cabbage was more responsive to the tree-based system compared with common cabbage. During the dry season planting (February-June 2008), all commercial vegetables responded positively to the presence of trees (16 percent) except for common cabbage, which was also the lowest performer during the wet season planting. Rainfall was unusually erratic during the dry season planting. Carrots and Chinese cabbage had the highest percent increase in yield at 30 percent. Tomato did not do well during the dry season planting. This was due to a high incidence of pests caused by planting of tomato on the same land without the customary rotation of non-solanaceous plants. Despite of this condition, tomato yield increased by 10 percent.

Indigenous vegetables responded well to tree integration during the wet season. There were three types of indigenous vegetables planted: leafy, fruit, and climbing. Among the leafy vegetables, amaranth from Bangladesh, amaranth from Vietnam, and jute 3504 had the highest marketable yields. Among the fruit vegetables, eggplants yielded significantly higher than okra. Trees had a positive response to all associated climbing vegetables during the wet season planting. During the dry season, for most indigenous vegetables the yield was lower than in the wet season planting. Eight indigenous vegetable showed decreased yields because of the presence of a tree hedge.

Vegetable trees responded well to tree integration. During the wet season, malunggay responded the best, with a yield increase of 60 percent. Alikway and katuray had higher yield increases of 90 percent and 50 percent, respectively, but the marketable yields were not as high compared with malunggay. During the dry season planting, vegetable trees were pruned down to 25 cm from ground level. Malunggay and Chinese malunggay were not able to recover as fast as katuray and alikway, thus having lower marketable yields. But most tree vegetables responded well with the presence of tree hedges. Malunggay and Chinese malunggay still had positive percent yield increases of 10 percent and 20 percent, respectively.

Evaluation of tomato elite lines against tomato leaf curl virus:

Tomato leaf curl virus disease has plagued the tomato industry in northern Mindanao, including Claveria, Misamis Oriental, and Lantapan, Bukidnon, Philippines. Before the tomato leaf curl virus plague, Claveria and Lantapan used to be the tomato bowls of the Philippines, producing 50-60 MT weekly marketed in Cebu, Manila, Iloilo, and as far as Hong Kong and the Middle

East. Hence, for a solution to this plague, evaluations of 15 elite tomato lines planted beside three types of tree hedgerows were conducted. Tomato lines were provided by AVRDC and were resistant to tomato leaf curl virus and bacterial and fusarium wilt. Evaluation was based on fruit yield. To get a good mix of the potential users of the study's results, evaluations were also sought from tomato growers, traders, consumers, and local government unit (LGU) extension workers. In evaluations done in Lantapan, among the tomato lines of WVCT and CLN, the WVCT had consistent yields, with WVCT3 having the highest yield of 4.16 t ha-1 (dried weight). WVCT lines had the highest evaluation among farmers and traders based on fruit marketability, fruit form, fruit color, and plant appearance and canopy. Among the CLN lines, CLN2768A had the highest yield of 5.42 t ha-1, but the other CLN lines had yields lower than the WVCT lines. The highest yielder of the 15 lines, CLN2768A, was also accepted by the farmers as well as the market.

Yields of elite WVCT tomato lines evaluated at Claveria indicated that tomatoes under *Gmelina arborea* yielded better (25.25 t ha-1 – fresh weight marketable yield) compared with the ones planted in *Acacia mangium* (18.35) and in open field control (18.39). The different varieties of tomato did not differ significantly in yield, but among the tomato lines evaluated, WVCT7 yielded the highest, followed by WVCT4 and WVCT3. WVCT7 also was significantly higher in farmers' evaluation based on fruit marketability, fruit size, fruit form, fruit color, plant appearance, and plant height and canopy.

Drip irrigation:

Laboratory experiments on drip irrigation were conducted at the College of Engineering and Agro-industrial Technology, University of the Philippines-Los Baños to determine the effect of slope and head on the water distribution uniformity of a 100 sq. m International Development Enterprise Easy drip irrigation system. It was found that for all slopes, a head of 3.0 m with respect to the junction of the most upstream lateral may be considered optimum from both hydraulic and practical standpoints. Linear regression models relating uniformity coefficient with either head or slope may be used for predicting water distribution uniformity for heads between 1.0 m and 3.0 m and for slopes between 0 and 50 percent. These findings are important design guides for efficient installation of IDE-drip kits.

Drip irrigation did not significantly affect the fruit yield, total above-ground biomass, stem diameter, and plant height of bell pepper. The control treatment, which had no drip irrigation and no root barrier, had smaller stem diameter, shorter plant height, and lower fruit yield and total biomass than the root barrier treatment. The root barrier was also able to improve the fruit yield, total aboveground biomass, stem diameter, and plant height of bell pepper. The difference in fruit yield and total biomass was about 1 t-ha-1 but was not statistically different. This insignificant effect of drip irrigation treatment was due to the even distribution of rainfall during this phase of the experiment. Bell pepper did not experience moisture stresses. The plastic root barrier likely improved the productivity of the bell pepper closer to the trees due to reduced competition of nutrients as opposed to water, but it was not so dramatic as to create statistically significant differences. Other field experiments on drip irrigation were carried out for other vegetables. A total of six farmer-collaborators in Barangay Songco, Lantapan, were selected. The field sites with a total aggregate area of 1,600 sq m have been prepared for the "with" and "without" drip irrigation experiments. Water supply tanks and IDE drip irrigation kits were installed based on design guides from the drip experiments at UPLB. Primary data on soil physical characteristics were gathered to serve as a basis for water management and drip irrigation operation. Periodical data collection and monitoring of certain agronomic characteristics of the crops grown, namely, cabbage, Chinese cabbage, tomato, and bell pepper under the "with" and "without" drip irrigation throughout the growing season were carried out. Results of the field experiments generally showed greater quantity and better quality of crop yields under drip irrigated plots than in rain-fed areas. From farmer's responses, there is strong potential for adoption of the low-cost drip irrigation technology in the site.

Reduced tillage and cover crop

Arachis pintoi as cover crop:

The study on the effect of cover crop arachis pintoi and drip irrigation on the performance of five commercial vegetables was started in Year 3. It took almost a year to establish arachis pintoi. Results will be reported in Year 4.

Development of no-till planter:

After testing several prototypes, an animal-drawn no-till planter using a toothed coulter, inverted-T opener, front and rear press wheels, a seeder, and a fertilizer dispenser was developed. With a 20–70 kg draft force, multiple rows in one pass were found to be theoretically possible in an animal-drawn or motor-driven planter. It was found that a toothed coulter performed better than a plain coulter and that the inverted-T opener design performed satisfactorily in breaking the soil. Further testing on the geometry and size of the opener was recommended to determine soil breaking performance and contribution to the downward force. With some minor modifications, the animal-drawn prototype is ready to be tested on farm, and an economic feasibility study will be done.

AVRDC-The World Vegetable Center headquarters, Taiwan

Vegetable-tree complementarity

Organic fertilizer:

In Taiwan, field evaluation of vegetable species and varieties under and agroforestry system continued at AVRDC's organic farm. Six vegetables (cauliflower, cucumber, eggplant, lettuce, sweet corn, and yard long bean) were grown during the fall-winter (October-December 2007) and winter-spring (January-March 2008) seasons. Vegetables were grown between tree hedgerows (alleys) and in control plots (no trees). Organic fertilizer (compost) was superimposed as a sub-treatment. Varieties within vegetable species were compared in terms of growth and yield performance. Results indicated that yield response of vegetables to organic fertilizer application varied according to species and the type and combination of organic fertilizer applied. In Trial 1 (October-December 2007) significant differences in yield were observed with cucumber and eggplant but not with lettuce, sweet corn, and yard long bean. Yield of cucumber with a combination of fertilizers was higher than with single-source fertilizers. In trial 2

(January-March 2008), yield response was significant for all vegetables except radish and tomato. Yield of Chinese cabbage with combination fertilizer was higher than with single-source fertilizers, but with common cabbage single fertilizers were better than a combination. Yield of sweet pepper applied with a combination of rape seed, soybean, castor bean, and sesame (RSCS) was higher than with single-source castor seed (CS) or a combination of CS and RSCS. In the third trial, yields of lettuce, sweet corn, and yard-long bean were not affected by organic fertilizer treatments, but yields of cucumber and eggplant differed with treatments. RSCS-CS combination fertilizer produced a higher cucumber yield than the other treatments.

Vegetable yield:

In Taiwan, AVRDC headquarters, it was found that tree-crop competition was insignificant during early establishment. Under an agroforestry system with 2-year-old trees, yield of most vegetables except Chinese cabbage increased by 29 percent to 53 percent above that of monoculture. This indicates the benefits of agroforestry on vegetable crops.

System level

Field

Development impact

TMPEGS studies in Vietnam, Indonesia, Philippines, and Taiwan showed mounting evidence that a new horizon in VAF research has been discovered, that is, for several vegetables the yields are higher in agroforestry systems than in open field conditions. Publications are being prepared to disseminate this breakthrough to several stakeholders. There is also evidence that, because of SANREM, several small-scale farmers, both women and men, are practicing VAF. Furthermore, many small-scale farmers, both women and men, saw from TMPEGS studies the prospects of increased income from indigenous vegetables and, with extension assistance from TMPEGS, are producing them. Moreover, TMPEGS trained several small-scale farmers, both women and men, in low-cost drip irrigation systems and saw increases in vegetable yield and quality. Farmers are inquiring how to purchase these kits. They are convinced of the water-conserving, labor-saving, yield-increasing, and income-generating benefits of low-cost drip irrigation systems; and in the Philippines a local government unit has already initiated drip kit purchases. Findings from marketing, policy, gender, environmental, and socioeconomic studies are being merged with these technological breakthroughs, and scaling-up strategies are being prepared for each country for implementation in Year 4.

Vietnamese scientists are completing a study to identify cacao varieties suitable to integrate with cashew trees. From several TMPEGS studies in Vietnam, small-scale farmers, both women and men, are seeing exceptional cacao growth when cacao seedlings are planted under mature cashew under stories. Cacao seedling growth was further enhanced by drip irrigation. However, small-scale farmers found that termites were killing young cacao seedlings. This risk is preventing them from investing in a cacao-cashew system. Therefore, Vietnamese scientists experimented with natural termite control and discovered that planting vetiver grass around cacao seedlings together with applications of vetiver mulch on the seedlings was an effective natural method that can control termite attacks. Finally, Vietnamese scientists found that cacao integration in cashew systems can generate a 100 percent increase in income compared with current cashew-only systems, and from previous cacao research in Vietnam, cacao trees and its tree litter can significantly improve soil quality and provide protection from soil erosion. Hence, with all these findings, Vietnam is ready to scale up in Year 4 with a sustainable system of integrating cacao in existing cashew systems.

From several TMPEGS studies in Indonesia, small-scale farmers, both women and men, are seeing benefits of optimum fertilizer applications. Indonesian scientists determined optimum fertilizer rates for several marketable commercial and indigenous vegetables. Furthermore, they found out which indigenous vegetable varieties are suitable for Nanggung conditions. They developed management brochures for each vegetable for VAF scaling up in Year 4. Several small-scale farmers, both women and men, volunteered for this scaling-up experiment.

From several TMPEGS studies and trainings in the Philippines, small-scale farmers, both women and men, are seeing benefits of increase yield and improved fruit quality from several elite strains of tomato resistant to leaf curl virus. Leaf curl virus devastated the tomato production in several southern Philippine provinces. Philippine scientists are now reproducing seeds of several elite tomato strains for distribution and scaling up to participating farmers. This TMPEGS study has the potential of resurrecting the tomato production of these southern Philippine provinces, renowned for producing quality tomatoes before the leaf curl virus devastation.

TMPEGS studies are being conducted in Vietnam, Indonesia, and the Philippines on arachis pintoi as a cover crop for soil erosion control and soil quality improvement. It was shown that perennial peanut as a cover crop was competing with vegetables and stunting their growth, reducing yield. Trials are now underway to determine whether planting vegetables on tilled 10-inch strips of perennial peanut cover will prevent this competition. Furthermore, an animal-pulled reduced-tillage vegetable seeder prototype has been designed and fabricated for tilling 10-inch strips and then seeding vegetables on areas covered with arachis pintoi. Testing of these technologies will continue in Year 4. If successful, a combination of these two technologies has the potential of improving soil quality, arresting land degradation caused by soil erosion, minimizing use of fertilizers, and increasing vegetable yield.

IDE, the designer and manufacturer of the low-cost drip irrigation kits used in TMPEGS studies, accelerated redesign of the IDE-drip system's main and sub-main lines to achieve nearly uniform pressure and improve irrigation uniformity coefficients. This was in response to TMPEGS findings of low irrigation application uniformity coefficients of IDE-drip kits, especially on sloping lands. Furthermore, IDE committed to provide $2,000 plus materials to be tested so that drip kit evaluations will continue at the University of the Philippines-Los Baños' IDE-drip kit testing site. Note that IDE drip kits are used worldwide by millions of small-scale farmers, both women and men, further emphasizing the impact to the developing world of this TMPEGS study.

Challenges and responses

Vietnam

Most of the planned activities were showed significant accomplishment. A total of eight field studies on VAF technology components were conducted and completed successfully. The major obstacle encountered was the very late release of project funds. The team had to use a cash advance from Nong Lam University to carry out project activities.

Indonesia

Despite changes in personnel and delays in hiring, field trials were successfully established and completed. Most project timelines were met except the experiment on arachis pintoi. The graduate student involved in the study quit, hence data on whether arachis pintoi can minimize aphids in yard long bean was not collected.

Philippines

Obstacles encountered were threats to peace and order at the experimental site due to the sighting of bandits who were living in remote places nearby and demanding and coercing "revolutionary tax" to the banana plantation owners and workers. This was also coupled with labor relation problems between the plantation owners and workers. This situation created some fear among the project field workers, so they were afraid to go to experimental sites.

Lack of human resources for data management and statistical analyses was another impinging obstacle to the project.

Due to limited funds to conduct the experiments as well as the limited availability of needed materials, 15N labeled fertilizer studies to monitor capability of trees to act as nutrient pumps was aborted, replaced by testing of elite strains of tomato resistant to leaf curl virus.

Marketing

Value chain

Le Thanh Loan, Vietnam coordinator
Iwan Kurniawan, Indonesia coordinator
Ma. 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

Vietnam

TMPEGS studies found that, because of small land sizes and competition from Dalat, the vegetable bowl of Vietnam, commercial vegetable production is not feasible for Nghia Trung small-scale farmers. Vietnamese scientists concluded that a better approach is for small-scale farmers, both women and men, to produce vegetables in their home gardens, hence saving money used to purchase vegetables for home consumption. Vegetable surplus can be sold to local markets for additional income. Information on the savings of home-produced vegetables in food budgets and the contribution of home-produced vegetables to household nutrition could be effective in persuading farmers to integrate vegetables into their existing cash-crop production systems.

TMPEGS studies showed that the study area has a well-developed marketing system for major cash crops such as cashew, coffee, rubber, and black pepper. It was found that for a new crop such as cacao, small-scale farmers, both women and men, have limited information of the marketing system.

Because cacao is a new crop, a survey was conducted in 80 farms on inputs and yields from both cacao-cashew and pure cashew systems. In 2008, average income from a pure cashew plantation is about $865/ha/year. Initial assessment from the survey revealed that, with an average cacao yield of 1.5 tons/ha, the cacao-cashew system will increase income per hectare by 99 percent over the pure cashew system, indicating that cacao integrated into existing cashew plantation is a viable option to help local small farmers improve their incomes.

Indonesia

TMPEGS studies showed that lack of market information, remote location, and poor accessibility to production resources are detrimental for Nanggung small-scale farmers, both women and men, in adopting VAF. However, Indonesian scientists identified market advantages for selected indigenous vegetables katuk and kucai. It was found that katuk and kucai have demand in local, regional, and national markets. Based on benefit-cost analysis, farmers could generate about $2,274/ha/year from katuk and $2,287/ha/year from kucai. There is also opportunity for the women's group to earn $2 per woman per day in sorting, grading, and packing the katuk.

Philippines

TMPEGS hypothesized that favorable impacts in the lives of small-scale farmers, both women and men, are attainable by improving the vegetable and timber marketing outlets, the local farmer organizations' marketing clout, and the volume and quality of VAF products. TMPEGS found constraints to the attainment of these objectives such as:

- Only commercial marketing of vegetables, not timber, can be realistically pursued because timber is not grown by farmers for commercial use.
- Farmers regard vegetable marketing to be an individual household rather than a collective pursuit; hence, existing organizations are weak. Thus, development plans should incorporate a community organizing intervention.
- There exist entrenched marketing practices, particularly the vegetable farmers' reliance on the *bodega* (a market warehousing facility of local village entrepreneurs providing valuable farming and marketing services to the community) that must be considered in any development plan.

System levels

Policy/market
Farm household/enterprise

Development impact

In Indonesia, because katuk and kucai grow well under trees and have high market demand, TMPEGS provided training to Nanggung small-scale farmers, both women and men, by taking them to farming villages that have successfully produced and marketed katuk and kucai. Training on post-harvest handling of katuk was conducted to prepare small-scale farmers to properly prepare their katuk produce for market. This involved training for women in sorting, grading, and packing katuk for market. To ensure that katuk and kucai produce was sold, TMPEGS linked small-scale farmers with katuk and kucai traders.

TMPEGS also selected farmer groups at three villages and collaborated with local government to establish production trial plots and distributed 50,000 stems of katuk and 5 kg of kucai seedlings to three farmer groups. TMPEGS found out that other farmers both from these villages and outside the project area are planting katuk as well. All these activities show potential for increased income to Nanggung farmers by establishing a niche in katuk and kucai production.

In the Philippines, TMPEGS believes that empowering small-scale farmers, both women and men, to organize will increase their incomes. Warehouse owners have big clout in vegetable marketing, and TMPEGS found that women farmers could play a key role in overcoming this monopoly. Local governments will be encouraged to provide marketing incentives for small farmers, both women and men, to organize and market vegetables as a village.

Challenges and responses

The 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 VAF production and reward environmental services

Critical research accomplishments

Vietnam

TMPEGS has found that national-level policy in the forestry sector is encouraging the adoption of VAF systems. The forestry sector in Vietnam is shifting from resource-exploitation centered to social forestry, from the monoculture or extensive forestry to intensive forestry and agroforestry methods, integrated management, and multipurpose forest utilization with emphasis on poverty alleviation. Major policy incentives include increasing land tenure security, allocating forest and forest land to individual households for forest development, protection and practice of agroforestry models, investment and credit policy, benefit-sharing policy, extension and technology transfer, and promoting the processing and marketing of timber and non-timber forest products.

The growth of the fruit and vegetable sector in the country is responding to rising incomes and demand for greater diversity in the diet. The recent expansion in this sector also reflects export opportunities related to regional income growth, trade liberalization and incentive policies on land use, credit, and investment. But incentives in Vietnam are more favorable for commercial vegetable and fruit producers.

The local authority's comprehension of national government policy was not sufficient for it to incorporate incentives into local government practices. Though home vegetable gardens were received favorably by local authorities, incentives have not been translated into any local proposals. Thus, such a model has been confined to research papers.

Philippines

The analysis of the policy environment of VAF systems in the Philippines has been completed. Significant research findings include:

- In theory, the policy environment in the Philippines is supportive of VAF systems but is insufficient in stimulating smallholder investments. Incentives for smallholders, albeit limited, do exist; correspondingly, disincentives persist.
- Large-scale farmers tend to benefit more than smallholders from national-level policies because the former have more access to policy information and can leverage the associated costs of policy implementation.
- It is recognized that some issues are better resolved through national-level policies, while a number of issues are better addressed by locally formulated policies.
    - For the vegetable sector, issues on price regulation and control, commodity protection, reducing costs across the market-value chain, non-tariff barriers, and global trade require national-level policy interventions.
    - For the tree sector, issues regarding restrictive policies, transaction costs, land tenure and resource rights, and domestic and international market incentives are also to be addressed through national-level policies.
    - At the local level, promoting smallholder investments in VAF systems requires decisive policy action in terms of improving the effectiveness of the extension system, with emphasis on improved technology provision and support for market linkages and infrastructure.
- Policy linkages between national and local levels need to be established, and policymakers need to mobilize adequate responses at both levels.
- The viability of VAF systems depends on a whole set of policies that government can provide.

Synthesis of Vietnam and Philippine policies

In both countries, promoting VAF systems will require policy actions that address issues impeding the growth of the vegetable sector, such as price regulation and control, commodity protection, cost reduction across the market-value chain, removing tariff barriers, and global trading regimes; and issues addressing the growth of the forestry sector, such as transaction costs, land tenure and resource rights, and domestic and international market incentives.

Distinctive difference exists between the policy development process in the Philippines and Vietnam:

- In the Philippines, local governments have policymaking powers, enabling formulation of local policies that stimulate smallholder investment in VAF. Where the benefits of national-level policies do not trickle down to the local level, local governments can offset this gap and provide adequate response.
- In Vietnam, despite the participatory nature of policymaking processes, the impetus for policy change relies on the leadership of the central government through the National Assembly.

There are implications to scaling up the impacts of VAF in both countries:

- In Vietnam, efforts to promote VAF through policy incentives should emanate from the National Assembly, rather than from the province or commune level.
- In the Philippines, without undermining the importance of national-level policies, efforts at the local level, particularly with local government units, can be strengthened to enable them to effectively provide adequate responses to smallholders.

System level

Policy/market

Development impact

Philippines

Several meetings were initiated with local government officials and policymakers regarding the development of incentive-based policies for small-scale farmers, both women and men, including VAF systems. This resulted in the development of a municipal ordinance on "providing an incentive-support system to encourage adoption and investment in sustainable farming systems in Lantapan, Bukidnon." This includes VAF. The budgetary requirements to implement this ordinance have been provided by the local government unit's special projects. The sustainable farm system (SFS) investment plan is a policy instrument that aims to support and sustain adoption and investment of good practices by smallholders in the municipality.

The focus of our work in Year 4 will be on evaluation of the policy intervention using a modified version of the Institutional Analysis and Development framework of Elinor Ostrom and colleagues at Indiana University. Through this municipal ordinance, drip irrigation is being purchased by the local government for distribution to small-scale farmers, both women and men, showing the impact of SANREM to the community.

Vietnam

Technology results showed the potential of cacao-cashew systems and production of vegetables under cashew in home-garden systems. Furthermore, market opportunities for cacao will be studied. A combination of technology and market-oriented policy incentives enacted by the National Assembly for vegetable-cacao-cashew agroforestry has the potential for increasing incomes of small-scale farmers, both women and men.

Challenges and responses

None

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 VAF systems

Critical research accomplishments

Environmental impact

In all three countries, additional input data have been collected over the past year for SWAT modeling. Data elevation models, land-use maps, and soil maps have also been prepared. In the Philippines, a SWAT model has been developed for assessing the hydrologic effects of land-use changes. Other SWAT models for small upland watersheds have also been developed and are being refined. In Indonesia and Vietnam, SWAT model development work is underway.

Initial SWAT simulation results in the Philippines showed that conversion of forest to agricultural lands causes serious erosion and sediment yield in the area. Agricultural lands planted with corn, potato, and tomato, which make up 22.38 percent of the watershed, have predicted average annual soil loss of 110 t/ha, with areas planted with potato producing the largest soil loss of 205 t/ha. Predicted rates of soil loss for forest lands were 0.7 t/ha and for pasture and grassland, 2.2 t/ha. On average, simulation results showed an annual soil loss of 13 t/ha for the whole area. SWAT simulations were also done for two sub-watersheds of the Alanib River. Using measured data from previous SANREM studies, the models performed satisfactorily during model calibration with an explained variance ranging from 0.86 to 0.89. Primary hydrologic and climatological data collection have also commenced in the test watersheds to generate data for model calibration and validation.

In Indonesia and Vietnam, SWAT model simulations are yet to be performed. Significant findings of hydrologic effects on land use, particularly VAF systems based on SWAT model simulations, are expected to be generated in the ensuing year of project implementation.

Socioeconomic impact

Vietnam

Pesticide use and farmers' health costs:

The cultivation of cashew in Nghia Trung village has been intensified over time with increasing use of pesticides. This study was conducted to determine the impact of pesticides on cashew yield and to estimate the health costs caused to farmers by pesticide use. TMPEGS found that preventive spraying is the main pest management method among cashew farmers. But insecticide use was found to have no significant impact on cashew yield. TMPEGS found that 67 percent of farmers who have used pesticides reported increasing headaches and fatigue. Results from health-cost function estimations showed that pesticide dose and the number of times the farmers had contact with pesticides significantly influenced their health costs. The average health cost was estimated at $9 annually per person. These findings indicate that promoting sustainable pest management practices in a cashew-based VAF system by reducing pesticide use and applying integrated crop-pest management can reduce production costs and farmers' health costs as well as other negative environmental impacts at the watershed level.

However, as reported by small farmers, some constraints to the adoption of cacao-cashew systems are lack of information and access to the cacao market, uncertainty about the future of the cacao market, lack of cash for investment, lack of technological knowledge, and high risk of pest and disease attack on cacao, specifically termite attacks on cacao seedlings.

Household nutrition study:

Initial data analysis on an 80-household survey on the nutrient status, nutrient efficiency from fruit and vegetable consumption, and the role of home-produced fruits and vegetables in household nutrition status showed that fruits and vegetables are important nutrient sources for local households. The adoption of vegetables in home gardens is expected to save small, poor farm households money used for buying vegetables in the market and to improve family nutrition.

Indonesia

Farm input data were recorded from every experiment, and yield per ha of the respective trials were collected. The data were used for benefit/cost calculations. For the shade management trial reported in technology section, TMPEGS found that vegetables planted in medium light have good prospects of increasing incomes of small-scale farmers, both women and men.

Philippines

Researcher-managed VAF studies were conducted; hence, not much information was gathered for socioeconomic assessment. Farm input data were collected for the drip irrigation-rain-fed vegetable experiment, and these are still being processed by TMPEGS. About 15 small-scale farmers, both women and men, will plant vegetables with trees in Year 4, and their inputs and yields will be monitored by TMPEGS researchers.

System level

Farm household

Development impact

TMPEGS studies in Vietnam could improve the health of small-scale farmers, both women and men, by minimizing pesticide exposure and by improving diet. This could lead to savings in health care, pesticide, and food purchases. As discussed in the market section, Vietnamese scientists also calculated 100 percent income increases if cacao is successfully planted between cashew trees compared with existing pure cashew farms. Indonesian scientists showed prospects of increased incomes through VAF production in medium light. In year 4, TMPEGS scientists in all countries will monitor adoption of VAF practices and calculate benefit/cost ratios of TMPEGS-recommended sustainable practices.

Environmental impacts of VAF practices will be simulated using SWAT. Simulation results will be provided to local and national government leaders showing the environmental benefits of applying SANREM-recommended technologies with the goal of persuading them to legislate policies that benefits small-scale farmers, both women and men.

Challenges and responses

One challenge is that Robin Marsh has not been allotted more time, making it difficult to ensure the necessary follow-up. Marsh will be paid by SANREM close to a month in Year 4 to assist the teams in implementing monitoring plans, and interpreting and writing their findings.

Gender

Equity

Nguyen Duc Thanh, Vietnam coordinator
Trikoesoemaningtyas, Indonesian coordinator
Ma. 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 wellbeing within the VAF system.

Critical research accomplishments

Farm women's involvement in marketing their products appears most active in the Philippine study site, where it is sanctioned by both women and men as an appropriate role for women to undertake alone and even without spouse partnership. In contrast, women's market participation in the Indonesian site is unusual and not normative, but those few who are active seem to have the support of male household and family members. The women's case in Vietnam falls somewhere between, with men sharing equally on decisions about their actual market role and which market trader to use.

In all three countries, women farmers undertake marketing activities and seek to improve their economic status for the sake of family, especially children's welfare. Family-oriented goals, rather than desire for personal empowerment, motivate them to become market players and to advance in this role.

Preliminary results in the Philippines and Indonesia conform to the hypothesis that market-oriented networks do enable and facilitate women farmers' marketing of agricultural crops produced on family farms. The networks provide valuable links to suppliers of farm inputs or goods for trading, buyers of farm products, sources of capital or credit, and market-related information such as which products are currently in great or short supply, price fluctuations, buyers' preferences, and demand for new crops.

In the Philippines, women farmers (i.e., the study's subjects) grow high-value vegetable crops like cabbage, tomato, bean, potato, and Chinese cabbage on family farms and singlehandedly market their produce, some with additional purchases from nearby farms. However, those in Indonesia help grow household subsistence crops like rice, vegetables, and root vegetables. While they were experienced in growing and selling guavas and jasmine flowers in commercial quantities in the past, now they have started to produce katuk. This SANREM-introduced crop will be collectively marketed through an ICRAF-identified middleman link. In Vietnam, the women market traders interviewed were initially engaged in selling fish and clothing in the marketplace rather than in selling food crops.

The women's market networks in both the Philippines and Indonesia are not composed solely of women but comprise a combination of female and male nodes. Nonetheless, doing a gender count has revealed the predominance of women.

Regular ties established between the women farmers and market women in their networks are known as *langganan* in Indonesia, *suki* in the Philippines, and *moi* in Vietnam. Initial data showed that the use of such terms confers some expected obligations and privileges on the market partners, such as exclusive patronage, preferential treatment, lenient or reduced pricing, and quality assurance of products or services exchanged.

Vietnamese scientists observed that both husband and wife decide what kind of crops to grow, share caring and harvesting of crops, and together choose traders to sell their products. Income-generating activities are for the family as whole, not for individuals. They also found that women above 18 years old can apply for membership in the women's union. Several benefits are available to members, such as technical training on crop and animal production, handicrafts, and being part of a rotating savings and credit group.

Participatory group discussions with women farmers in Vietnam revealed that a trader group exists in the study area. The trader group provides *mối* (regular trading partners) for buying and selling local products. Regular local customers can buy from small traders without paying money immediately and can pay back when their products are sold. A more in-depth analysis of the gendered nature of the *mối* trading relationship among local traders is needed to have a better understanding of the market network and to identify options for improving market access for small-scale women farmers and traders.

Indonesian scientists found that most village officials and community leaders acknowledged the importance of women's participation in social, production, and marketing activities. However, they do not have the knowledge and skills needed to develop programs that will facilitate equal participation of men and women. Village officials in Hambaro agreed to work with TMPEGS to develop programs that will encourage participation from women. However, responses of village and women leaders in Sukaluyu were markedly negative. Hence, a program on revolving credit was developed for women's groups in Hambaro but not in Sukaluyu. A total of 30,000 katuk seedlings was distributed. Six women agreed to be the first recipients of the katuk seedlings. After each harvest, these six women will sell the katuk harvest and return cuttings to the group. These will be given to one other member of the group. All 25 members of the women farmers group, Bakti Wanita Tani, have received training in katuk post harvest and marketing from the marketing team. The women of the Bakti Wanita Tani had their first harvest of katuk on Sept. 7, 2008. Training on how to conduct savings and loan activities was conducted for the women of the Bakti Wanita Tani. The members agreed to form a savings and loan group within the Bakti Wanita Tani. Additional training was provided for the elected officials on management and record keeping. The activity developed with the women farmers in Hambaro will be used as a model for other villages in Nanggung.

In the Philippines, the book on gender findings is nearly complete, validation of major gender findings with women farmers and market agents was done, and mapping was done for nodes and ties in the market networks of 10 women vegetable farmers who are members of the one and only women's cooperative in the community.

The study continued conversing with men and women in the study site, constituting data sets that were analyzed using the Semio-Greimas Narrative Theory. The emerging frame that women and men accomplish their farm lives in partnership continues to surface in the ongoing conversations with men and women in the field site. The emerging results seem to negate the assumption that women's voice is muted in discourses that concern them, such as ensuring family wellbeing. They mobilized actors to accomplish their everyday farm lives. The technologies being introduced by TMPEGS, particularly the indigenous vegetables and drip kits, are seen as allies that would make a positive difference in farm lives.

System levels

Farm household
Policy/market

Development impact

In the course of data gathering, women's consciousness of the gendered nature of their roles and expectations was either awakened or heightened, for they could not help but reflect on these. The women also seemed pleased to share and reflect on their individual accomplishments as a result of market engagement.

Challenges and responses

The project timeline for gender is generally proceeding on schedule. The gender teams in Vietnam, Indonesia, and the Philippines have been implementing the SANREM-CRSP cross-cutting gender research led by Maria Elisa Christie, which focuses on gendered access to markets. This research is welcome, for it provides resources for delving into market access through the perspective of gendered networks; it also expands opportunities being considered for improving women's status and welfare in the VAF system.

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 VAF systems

Critical research or service accomplishments

- With partners from all over the world, TMPEGS has been organizing a SANREM co-led first international SWAT workshop and conference in Southeast Asia to be held in Chiang Mai, Thailand, Jan. 5-8, 2009, (http://www2.mcc.cmu.ac.th/swat/detail.php?data=committee). More than 60 abstracts have been submitted for the conference.
- TMPEGS has been leading an effort to produce a SANREM- co-led SWAT textbook for the developing world published by the World Association of Soil and Water Conservation to be released at the SWAT-SEA conference in Thailand
- Eleven brochures on indigenous vegetables of Southeast Asia were produced and available for public use at http://203.64.245.173/iv_sea/publications.asp
- As gender coordinator of the project, Ma. Elena Chiong-Javier undertook informal orientation training with the country gender teams on the gender cross-cutting research

framework, especially the participatory network mapping method, during her field visit to Vietnam and Indonesia Aug. 28-Sept. 10, 2008.

- TMPEGS organized visits by Theo Dillaha, Maria Elisa Christie, Keith Moore, and Ronald Cantrell to project sites in Vietnam, Indonesia, and the Philippines.
- A presentation was made to underserved small-scale farmers in North Carolina on vegetable research in Southeast Asia and prospects of VAF for production of organically grown vegetables. Note that, because of SANREM influence, PI Manuel Reyes is currently establishing vegetable on-farm research with an underserved small farmer in North Carolina, funded by the U.S. Department of Agriculture.
- We have established and maintained a TMPEGS Web site.

Vietnam

- Rector and two other top administrators of Nong Lam University visited NCA&T. They were also brought to University of North Carolina-Greensboro and North Carolina State University.
- PRA training has been conducted for six NLU researchers with support from Manuel Palada, Greg Luther, and Woo Jong-Guy from AVRDC.
- On-field training on drip irrigation for vegetables has been conducted for four collaborating farmers when the drip irrigation system has been set up in one on-farm vegetable trial.
- Delia Catacutan visited NLU and introduced the policy review in the Philippines and the knowledge-to-action concepts and research method to NLU researchers and students at NLU.
- Training was completed for two students on assessing benefit-cost analysis for cashew-cacao systems and gender analysis; and field training for two students on using soil quality test kits.
- Two researchers from Vietnam participated in the annual SANREM meeting in the Philippines.
- Six abstracts were prepared by the team, from which four posters were developed and presented during the SANREM meeting in the Philippines.
- Theo Dillaha, Maria Elisa Christie, Keith Moore, Ronald Cantrell, and Manuel Reyes visited NLU to review the research activities of the Vietnam TMPEGS team and visit the study site in Nghia Trung, Binh Phuoc province.
- Ma. Elena Chiong-Javier from De La Salle University, Philippines, visited NLU to work with the Vietnam TMPEGS team on research framework, conduct a short training to NLU researchers on gender research method, and visit the study site to conduct initial market network assessment.
- Pham Hong Duc Phuoc participated in the workshop organized by Binh Phuoc Province on the cacao program.
- Nguyen Kim Loi sent an abstract for a paper to be presented at the SWAT workshop in Thailand in early 2009.

Indonesia

- A SANREM experimental farm was maintained. Several small-scale farmers, both women and men, continued to visit the site. A SANREM field assistant is at the farm to assist and answer farmers' questions about VAF.
- At least 13 brochures on vegetable fertilization and management have been produced in the major Indonesian language for scaling-up thrust in Year 4. This is the first time this has been done in the Bogor region.
- Several papers were presented in international and Indonesian society meetings, including papers presented in the SANREM annual meeting in the Philippines.
- An abstract for the SWAT Chiang Mai conference was submitted for simulation in the Nanggung site.
- Funded by the Department of Education, Indonesian Embassy, Washington, NCA&T hosted Juang Kartika, a Bogor Agricultural University researcher on personalized training on soil quality and writing of an extensive review of literature on arachis pintoi.
- TMPEGS hosted visits by Theo Dillaha, Maria Elisa Christie, Keith Moore, Manuel Reyes, and Ronald Cantrell to project sites in Indonesia.
- TMPEGS hosted a visit by SANREM External Evaluation Panel member Edwin Price to the SANREM project in Indonesia.
- Training with several women participants on postharvest handling was conducted to improve katuk quality and satisfy market requirements.
- The Bogor Agricultural University gender team developed a book on nutritional and medicinal values and cooking instructions of indigenous vegetables, "Resep Sayuran Lokal," which was distributed to women in Nanggung to reintroduce indigenous vegetables.
- A proposal on empowerment of women in the Nanggung sub-district through agriculture activity to achieve family welfare was funded by the Indonesian Competitive Grant-Directorate General for Higher Education, Department of National Education, for 2008-2010. The additional funding will be used to strengthen women's organizations involved in health services, early childhood education, and productive activities.

Philippines

- TMPEGS hosted the annual SANREM CRSP meeting in the Philippines in May 2008, with close to 30 participants coming from TMPEGS.
- TMPEGS hosted the visit of several annual meeting participants to the research site at Barangay Songco, Lantapan, Bukidnon, Philippines.
- About five posters and two oral presentations were given at the annual SANREM meeting in the Philippines.
- A resource booklet was designed on the Binahon agroforestry farm and extension materials for promotion of sustainable VAF production systems.
- Research was conducted to determine incentives for landowners and leaseholders to practice conservation in Barangay Songco, Lantapan.
- Lessons learned from agroforestry and vegetable farming practices were documented and disseminated by video presentations to other farming communities the Philippines, including Albay, Sorsogon, and Infanta. Presentations were made to local government

units and other research institutions; and within local and international scientific communities.

- Jean Saludadez visited NCA&T to follow up on a memorandum of agreement between NCA&T and University of the Philippines-Open University.
- An abstract for the SWAT Chiang Mai conference was submitted for simulation in the Alanib site.
- Several presentations were done all over the Philippines and at international conferences on TMPEGS research findings in the Philippines. (See Table 18.)
- Articles about TMPEGS research were published on the SANREM website.
- TMPEGS facilitated development of a municipal ordinance titled "Providing an incentive-support system to encourage adoption and investment in sustainable farming systems in Lantapan, Bukidnon."
- The local government unit has been arranging purchase of several drip irrigation kits for use by small farmers, both women and men.
- TMPEGS hosted visits by Theo Dillaha, Maria Elisa Christie, Keith Moore, Manuel Reyes, and Ronald Cantrell to project sites in the Philippines.
- TMPEGS hosted a farmers' field day at the SANREM experimental site in Kimanga, Kibangay, Lantapan. Various experiments on VAF farming systems were shown to the farmers, including the integration of indigenous tree vegetables and medicinal trees into tree-based systems and the use of a low-cost drip irrigation system in bell pepper production.
- A similar farmers' field day was also conducted in June 2008 at Claveria, Misamis Oriental, showcasing different tomato lines under a tree-based system. Fifteen vegetable farmers, extension workers, and representatives of academia, including Misamis Oriental State College of Agriculture and Technology (MOSCAT) participated the event. A participatory form was distributed and completed by the evaluators.
- Vegetable grafting technology was jointly conducted by ICRAF, AVRDC, and MOSCAT in Claveria, Misamis Oriental, and Lantapan, Bukidnon, Sept. 15-16, 2008, and Sept. 17-19, 2008, respectively. More than 40 participants joined the training at the Claveria site, while 32 joined at Lantapan. Trainings participants were vegetable farmers, academics, LGU officials, and agricultural technicians.

System levels

Field
Farm household/enterprise
Policy/market

Development impact

Knowledge of VAF has been disseminated through experiments, workshops, and farm activities. Many small-scale farmers, both women and men, are beginning to have an appreciation of VAF, gaining skills in vegetable and tree production, and aspiring to have a sustainable farming system. Skills and lessons learned have also been achieved in postharvest handling of vegetables, the prospects for women farmer networks in vegetable marketing, and the adoption of VAF in their biophysical and socio-cultural context. The technologies that are being introduced by

TMPEGS, particularly the indigenous vegetables and drip kits, are seen as allies that would make a difference in farm lives. Furthermore, the cacao-cashew experiment is showing to many stakeholders the agronomic, environmental, and economic advantages of integrating cacao with cashew.

Challenges and responses

No significant obstacles were encountered.

Degree and non-degree training activities

LTRA-5 had 10 students involved in long-term degree training. Of those, six were women, four were men, and all 10 were from host countries. Two were working on Ph.D.s, five on master's degrees, and three on bachelor's degrees. Short-term training involved 271 men and 161 women in five workshops, eight seminars, nine focus groups, and one working group meeting. See Appendix A.

Publications, presentations, other products

LTRA-5 researchers have produced one paper accepted for publication in an international journal, one manuscript for peer review in an international journal, four working papers, three papers presented, 14 presentations, eight reports, 25 posters, 23 fact sheets, two newsletter articles, two literature reviews, and two prototypes of an animal-powered no-till seeder. See Appendix B.

Networking activities

- The Soil and Water Assessment Tool conference's scientific and organizing committee established a worldwide network of scientists from 25 organizations.
- Coming publication of a SWAT textbook for the developing world also established a network of scientists from the United States, Europe, Southeast Asia, and China.
- PI Reyes visited the USAID Mission in Jakarta, together with SANREM ME members and Ron Cantrell.
- Reyes visited with U.S. State Department officials in Vietnam, together with the ME and Cantrell.
- Reyes visited with underserved limited-resource or small-scale farmers in North Carolina and presented them with results from this study, which led to a project on specialty vegetable crops for small farmers in North Carolina.
- TMPEGS networked with several SANREM scientists from around the world when it hosted the annual SANREM meeting in May 2008.
- Dillaha, Moore, Christie, and Cantrell visited TMPEGS sites in Vietnam, Indonesia, and the Philippines; and met with several TMPEGS scientists and staff members.

- NCA&T Provost Alton Thompson, chair of SANREM CRSP Board of Directors, attended the SANREM annual meeting in the Philippines and visited with top administrators from the University of the Philippines-Open University to negotiate a memorandum of agreement between University of the Philippines-Open University and NCA&T.
- Rector Giang and two other top administrators from Nong Lam University were hosted by NCA&T during their visit to the campus in December 2007. They were also brought to University of North Carolina-Greensboro and North Carolina State University.
- Juang Kartika networked with several NCA&T students, faculty, and staff, especially with Charles Raczkowski and his staff, who provided her with personal training on soil quality. She did an extensive review of literature on arachis pintoi and presented a seminar with Rector Giang and his top administrators attending the seminar.
- Jean Saludadez visited NCA&T in March 2008 to explore the memorandum of agreement being developed between NCA&T and University of the Philippines-Open University. She also visited Virginia Tech.
- Victor Ella presented a SANREM drip paper at the 2008 International Meeting of the American Society of Agricultural and Biological Engineering (ASABE) in Rhode Island and networked with committee members for the international SWAT conference in Thailand Jan. 5-8, 2009.
- A strong partnership was formed with International Development Enterprise and Robert Yoder, who co-authored with Ella and Reyes a drip irrigation paper submitted for publication in the journal *Applied Engineering in Agriculture*. This led to IDE funding for Ella to continue his hydraulic IDE-drip studies at University of the Philippines-Los Baños.
- Reyes met with Emil Javier, the former minister of the Department of Science and Technology, the president of the University of the Philippines system, chancellor of UPLB, and director of AVRDC during the SANREM annual meeting in the Philippines.
- The management review panel appointed by USAID visited NCA&T to review SANREM management. The visit connected PI Reyes to panel member Hans Gregerson, who provided him with sound project management advice by e-mail.

Vietnam

- Rector Giang and two other top administrators of NLU visited NCA&T. They were also brought to University of North Carolina-Greensboro and North Carolina State University.
- Delia Catacutan introduced the policy review in the Philippines and the K2A concepts and research method to NLU researchers and students at NLU.
- Theo Dillaha, Maria Elisa Christie, Keith Moore, Ronald Cantrell, and Manuel Reyes visited NLU to review the research activities of the Vietnam TMPEGS team and visit the study site in Nghia Trung, Binh Phuoc province.
- Phuoc participated in a workshop organized by Binh Phuoc Province on the cacao program and networked with the local government of Binh Phuoc Province

Indonesia

- Linkages have been developed between farmer partners and a local trader who is willing to buy and market all of the farmers' production, especially katuk, kucai, and cassava.
- ICRAF developed collaboration with Badan Pengkajian dan Penerapan Teknologi – Agency for Assessment and Replication Technology – to use its land for a production plot trial at Kebun Agro Medika Hambaro, Nanggung sub-district, Bogor.
- SANREM External Evaluation Panel member Edwin Price visited Bogor Agricultural University and ICRAF-Indonesia in November 2007 to assess performance of TMPEGS-Indonesia, meeting with several TMPEGS scientists and staff members.
- Networking with JAXA as Earth Observation agency was made to get medium resolution images by ALOS/PALSAR satellite. Three images were acquired free from the 2007 archive image.
- Networking with the National Mapping Coordination Agency (Bakosurtanal) gave the opportunity to visit Banda Aceh, NAD Province, for application of SWAT in this province with Teuku Ferijal, a recent graduate of Texas A&M University who will be participated in the 2009 SWAT-SEA conference.
- TMPEGS networked with the Competitive Grant-Directorate General for Higher Education, Department of National Education, for 2008-2010, Indonesia. This resulted in additional funding to strengthen women's organizations involved in health services, early child education, and productive activities other than farmer groups.

Philippines

- Delia Catacutan participated Feb. 11-15, 2008, in the national training workshop titled "Trees in Multi-Use Landscape in Southeast Asia (TULSEA): A Negotiated Toolbox for Integrated Natural Resource Management" in Malaybalay City. The Bukidnon participants were mostly members of the working group RUPES-Manupali Watershed.
- Jean Saludadez visited Virginia Tech and networked with Moore and the SANREM team. She also met top NCA&T administrators when she visited that campus.
- SANREM scientists networked with farmers, traders, technicians, and consumers from Lantapan, particularly Songco and Kibangay, attending the farmers' field day at the SANREM experimental site in Kimanga, Kibangay, Lantapan.
- SANREM scientists networked with several farmers at Claveria, Misamis Oriental during a farmers' field day.

Project highlights

- TMPEGS studies showed mounting evidence that a new horizon in agroforestry research has been discovered, that is, for several vegetables the yields are higher in agroforestry systems than in open field conditions.
- TMPEGS observed that cashew yield increases when vegetables are planted beside the trees.
- TMPEGS conducted an extensive evaluation of the water application uniformity of the IDE low-cost drip irrigation system as a function of operating head and slope. This was completed, resulting in publication of IDE-drip design guidelines for steep slopes and prompting IDE to accelerate its drip kit redesign to achieve better water application uniformity.
- TMPEGS found that VAF policies tend to benefit rich farmers more than poor farmers. Hence, there is a need to alert government policymakers to revise VAF policies to address this bias.
- TMPEGS researchers are convinced that there is evidence that women farmers undertake marketing activities and seek to improve their economic status for the sake of family, especially children’s welfare. Family-oriented goals, rather than desire for personal empowerment, motivate them to become market players and to advance in this role.
- TMPEGS is optimistic that market-oriented networks could enable and facilitate women farmers’ marketing of agricultural crops produced on family farms. The networks could provide valuable links to suppliers of farm inputs or goods for trading and many other market nodes. Regular ties established between the women farmers and certain nodes in their networks are known as *langganan* in Indonesia, *suki* in the Philippines, and *moi* in Vietnam.
- The international Soil and Water Assessment Tool Modeling conference in Southeast Asia, co-organized by TMPEGS, generated more than 60 abstract submissions and drew the best SWAT modelers in the world. It included a session dedicated solely to agroforestry and the SWAT model.
- TMPEGS is collaborating with several scientists and institutions and with the World Association of Soil and Water Conservation will publish a SWAT textbook for the developing world.

Vietnam

- TMPEGS demonstrated vibrant cacao tree growth when cacao seedlings are planted under mature cashew under stories, with growth further enhanced by drip irrigation.
- TMPEGS experimented with natural termite control and discovered that planting vetiver grass around cacao seedlings together with applying vetiver mulch to the seedlings was an effective natural method that can control termite attacks in young cacao seedlings
- TMPEGS found that preventive spraying of insecticide has no significant impact on cashew yield; initial findings showed that cashew yield decreases when the ground is weeded with herbicides, and most farmers who have used pesticides are reported to have problems with headache and fatigue.

Indonesia

- TMPEGS determined optimum fertilizer rates for several marketable commercial and indigenous vegetables.
- TMPEGS found which indigenous vegetable varieties are suitable for Nanggung conditions, identified vegetables growing well under shade, and showed that vermicost is an excellent medium for chili pepper transplant production.
- TMPEGS developed 13 vegetable management brochures, which include water requirements, fertilization, harvesting, and special treatments for the seeds and seedlings.
- TMPEGS found that most village officials acknowledged the importance of women's participation in social, production, and marketing activities, developed a program on revolving credit for women groups, and organized katuk postharvest training mainly for women.

Philippines

- TMPEGS studies demonstrated increases in yield of several vegetables due to tree integration and income-generating potential of IDE-drip and indigenous vegetables.
- TMPEGS found that tree root pruning and putting a plastic barrier between the pruned roots and the vegetables grown beside them showed a 75 percent increase in chili yield.
- TMPEGS tested 15 leaf curl virus-resistant tomato strains, identified several strains that performed well, and found that yields of several strains increased when grown beside trees rather than in open fields.
- Using SWAT simulations, TMPEGS showed that cropped areas have 157 times more soil erosion loss than forested areas.
- TMPEGS found that many vegetable farmers are practicing soil conservation methods that can be traced to SANREM influence.
- TMPEGS influenced and assisted the local government to develop a municipal ordinance titled "Providing an Incentive-Support System to Encourage Adoption and Investment in Sustainable Farming Systems in Lantapan, Bukidnon," which included VAF.
- The SANREM CRSP introduced the IDE-drip system to the locality. It is soon to be purchased by the local government and used as a VAF incentive.
- SANREM research on Lantapan and Bukidnon shows a consistent decline in agricultural employment and agricultural wages, bringing them lower than non-agricultural wage rates. This will most certainly affect the forms and rates of technology adoption.

4. Cross-cutting research activities

Gendered Access to Markets: Gendered Networks and Livelihood Alternatives

PI

Maria Elisa Christie, Office of International Research, Education, and Development, Virginia Tech

Host countries

Bolivia, Ecuador, Indonesia, Peru, Philippines, Vietnam, Zambia

Introduction

Significant progress was made in the gender cross-cutting initiative this year. Several collective efforts, together with sustained support from the SANREM CRSP Management Entity and the individual hard work of gender researchers in each project, have led to important milestones and ensured that the coming year will bring the project to fruition. The fiscal year concludes with a common program for on-the-ground research in seven countries, a lead gender researcher in each, and eight students undertaking gender research. In two LTRAs, the lead gender researcher is a student: Nadezda Amaya, Virginia Tech master’s student in the Department of Agricultural and Applied Economics’ and Vongai Kandiwa, a Cornell University Ph.D. student in the Department of Development Sociology. Gender researchers from all LTRAs participated in a panel at the SANREM annual meeting and in a dinner meeting and workshop where methodological issues, key terms, and common indicators were discussed. Building on that, they worked together to develop a theoretical framework taking the points addressed in the workshop to another level and refining the original research questions, hypotheses, definitions, and indicators. At the end of the fiscal year, researchers provided progress reports and updated profiles of their case studies, an initial literature review, and list of key references for exchange with other projects.

Table 4-1. Gender research sites in seven countries

Bolivia	Jatun Mayu watershed communities in Tiraque Province, Cochabamba
	Municipalities of Umala and Ancoraimes in the Department of La Paz
Ecuador	Alumbre and Illangama watersheds, Bolívar Province
Peru	Community of Apopata in the Santa Rosa, Mazocruz District
Indonesia	Hambaru, Sukaluyu and Paraban Munchang villages in Nanggung, Sub-district of Bogor District
Philippines	Songco Barangay, Lantapan Municipality, Bukidnon Province, and Agora Market in Cagayan de Oro City, Misamis Oriental Province
Vietnam	Nghia Trung Commune, Bu Dang District, Bin Phuoc Province and the Nghia Trung Market
Zambia	Luangwa Valley, Eastern Province

Background

SANREM CRSP promotes stakeholder empowerment and improved livelihoods through knowledge-based sustainable agriculture and natural resource management systems. The SANREM CRSP landscape systems approach demonstrates how linkages among gender, biophysical, technological, governance, economic, social, environmental, and globalization factors can be used to achieve sustainable development. Underlying SANREM's approach is the assumption that access to markets will enhance livelihoods and play a significant and positive role in sustainable agriculture and natural resource management. Access to both natural resources and markets is gendered, and gender mediates the distribution of benefits among individuals and within households in given communities. Ignoring gender in the design and implementation of development activities will lead to failure to achieve development impacts such as household wellbeing and poverty reduction as well as gender equity, resulting in the further marginalization of women and other vulnerable groups. Studies show that women's control of economic resources affects their bargaining position and investments in human capital through schooling and food. At the same time, research that ignores women's priorities, contributions, and spaces results in incomplete and faulty results.

As markets emerge and change, producers are grouping together to improve their access to resources and support sustainable livelihoods. This project compares how gendered networks and coalitions affect the ability of groups to access and control natural resources and to access appropriate markets and capture value for their agricultural and forest products. It provides insight into 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. In doing so, it moves knowledge to action and brings to light opportunities to benefit women during current and future phases of the SANREM CRSP. This cross-cutting approach operates in different social and geographic contexts, providing opportunities for collaborative and comparative efforts that build on existing research in four LTRAs.

Theoretical framework

Discussions at the gender workshop during the SANREM CRSP annual meeting led to a focus on information and on women's bargaining power. The consensus overarching research question is:

> *How does the gendered nature of networks linking women to markets impact the quality of information they receive and their bargaining power (in the household, market, etc.)?*

Networks were identified as a set of nodes and links or ties representing relationships that are built between individuals, groups, or organizations and other actors along the chain, from producers (and the groups they belong to, or construct) to the end consumers of the product(s) being produced and exchanged. Bargaining power was defined as the ability to determine or influence market-related decisions and command better prices or contract agreements, household decisions over how to allocate resources, and priorities of groups or organizations. Common indicators were suggested for networks, access to markets, nature of information, and bargaining power.

Following are the major proposition and hypotheses:

> *Women producers' participation in networks consisting primarily of women increases their access to markets. By building on their human, cultural, social, and political power, women will have the necessary tools to better negotiate in markets where key nodes might be male dominated.*

Hypothesis 1: When women producers have a diversity of network ties, they can access more quality information about markets.

Hypothesis 2: Women producers who have more ties to trusted marketing network nodes providing information will have a better position in the bargaining process.

Impact objectives

- increase women's awareness of markets and access to quality information
- identify gaps in networks and implications of findings to empower women to better access markets and increase bargaining power
- increase women's bargaining power through participatory research methodologies that affect social, human, and political capitals
- recommend interventions to NGOs, government, and researchers to empower women through training and reorientation of production and marketing initiatives

Methodological approaches and challenges

A combination of qualitative and quantitative methodologies was used this fiscal year.

- analysis of existing baseline surveys
- conduct of new surveys
- review of related literature and project documents and reports
- participative rural appraisal (PRA)
- rapid market appraisal (RMA)
- social network analysis (SNA)
- focus group discussions
- semi-structured informal interviews
- in-depth interviews with key informants
- case studies of particular product marketing chains
- participatory network mapping

Among methodological challenges and observations: In some initial LTRA surveys, interviews were too long, and gender was addressed at the end, when informants were fatigued; some surveys were applied primarily to men; in another case, some surveys' data were not disaggregated by gender. Language is an issue in Latin America in particular, where women farmers often do not speak Spanish, requiring an interpreter; this adds a layer of potential misunderstanding. Another issue is that, while women undertake much of the activity under analysis, men often formally represent the community to outsiders such as researchers. In all cases, more appropriate questions would have been included in the early surveys had the gendered networks research already been on the table. In Zambia, lack of an early baseline survey before COMACO, the marketing network under scrutiny, makes it very difficult to evaluate its impact. In several projects, follow-up surveys were undertaken or are planned for this fiscal year.

Initial findings

Data gathering is ongoing and analysis preliminary. Nonetheless, some initial findings can be reported, including cultural or ethnic diversity within regions and watersheds as well as the market-specific gendering of crops, among other factors. In many markets, transactions are almost exclusively in the hands of women.

Some products are grown exclusively for market, while others are grown for home consumption but may also be sold, depending on whether there is a surplus; prescribed gender roles for marketing such products seem to be based on this distinction. In the municipality of Ancoraimes, one of the regions of study in Bolivia, where potato is primarily grown for food, close to 70 percent is sold by women, while 80 percent of the onion crop (grown for market) is sold exclusively by men. In the municipality of Umala, the other region of our study where potato is mostly produced for sale, about 50 percent of the potato crop is sold by men and women together, while 28 percent of the same lies in women's hands and only 20 percent in men's. Interestingly, when women were exclusively responsible for the sale, households were of higher income; the lowest-income households were those in which only men sold the crop. The gendering of marketing roles by crop in these communities seems to be linked to the following factors: the amount of cash income derived from sales, income allocation, and the particular markets in which the transaction takes place. In the Ecuador site, while men are twice as likely to market household agricultural production as are women, women dominate small-scale dairy-market production, and men from communities outside the study dominate the market-intermediary nodes.

In another site in Bolivia, women are mostly responsible for marketing because of their negotiation skills and bargaining power (higher prices) with wholesalers (mostly women). Men are responsible for transportation, support, and the security of their wives. The high participation of women in markets is striking. Most farmers have access to information about prices, volumes, and possible markets through radio, social networks, and the use of cell phones.

In Southeast Asia, farm women's involvement in marketing their products appears most active in the Philippines study site, where it is sanctioned by both women and men as an appropriate role for women to undertake alone and without spouse partnership. In contrast, women's market participation in the Indonesian site is unusual and not normative, but those few who are active seem to have the support of male household and family members. In Vietnam, the situation falls somewhere in between, with husbands sharing equally in decisions about women's role in markets and which traders to use. Women's market networks in both the Philippines and Indonesia comprise a combination of females and males, though there is a predominance of females. Regular ties established between the women farmers and certain nodes in their networks are known as *langganan* in Indonesia, *suki* in the Philippines, and *moi* in Vietnam. Initial data showed that the use of such terms confers on the market partners some expected obligations and privileges, such as exclusive patronage, preferential treatment, lenient or reduced pricing, and quality assurance of products or services exchanged

Degree and non-degree training activities

Eight students in degree programs are participating in this project, which in most cases covers partial research costs.

LTRA-2

Vongai Kandiwa-Majaha, Ph.D. student, Cornell University
Chisha Chungu, master's student, Department of Gender Studies, University of Zambia

LTRA-3

Nadezda Amaya, master's student, Department of Agricultural and Applied Economics, Virginia Tech

LTRA-4

Bolivia

Virginia Aguero, Universidad Mayor de San Andrés
Olga Yana, Universidad de la Cordillera

Peru

Doris Bartolo, Alex Fernandez, and Jenny Choque, Innovation for Agricultural Development master's program, Universidad Nacional Agraria La Molina (project supervised by the Sustainable Livelihoods Institute, Universidad La Molina)

In addition, a non-degree training workshop in gender and participative methodologies in La Paz was hosted by the Universidad de la Cordillera and the graduate program in development sciences at the Universidad Mayor de San Andrés. There were 31 participants – 13 men and 18 women. See Appendix A.

Watershed Modeling and Assessment

PI

Conrad Heatwole, Center for Watershed Studies and Biological Systems Engineering, Virginia Tech

Host countries

Bolivia, Ecuador, Philippines, Zambia

Introduction

The goal of this activity is to enhance the impact of the SANREM CRSP mission by supporting and strengthening the LTRAs, providing technical support and a cross-cutting focus in watershed modeling and assessment. 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; to assess impacts of land-use practices and climate change on agricultural sustainability and NRM at a watershed scale; and to design and implement low-cost community-based watershed monitoring programs.

The primary effort in this first year of project implementation has been the installation of field instrumentation for watershed hydrologic monitoring, and specification and purchase of imagery to support land-use classification in LTRA project sites in Bolivia, Ecuador, Zambia, the Philippines, Indonesia, and Vietnam.

Following is a summary of accomplishments across the eight project watersheds in Bolivia, Ecuador and Zambia:

- 21 stream gauging stations (pressure sensors and staff gauge) installed
- 7 weather stations installed and operating
- 16 recording rain gauges (tipping bucket) installed
- initial data on flow rates at each station
- training on flow monitoring using the salinity tracer method and flow meter for project teams at each location
- base imagery acquired for 8 project watersheds

Preliminary experience with community monitoring has been positive. Observers have been engaged, even enthusiastic in their participation. The quality of the data has been good, providing valuable verification of the automated stations and logged data from sensors.

Training was a key element of all site visits: reviewing basic concepts of watershed hydrology and fundamentals of monitoring for water balance assessment, and providing specific instruction related to the installation, operation, and maintenance of different types of instrumentation. This training has been accomplished primarily through hands-on experience in the field.

Basic hydrologic data characterizing watershed response provide 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 are 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. We rely on models as tools to evaluate the biophysical conditions and response of a watershed to a variety of activities and stressors. This cross-cutting activity supports the individual LTRAs in their impact assessment and will provide insight on the data, methods, and tools and their utility in that assessment.

Research strategy

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 are 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 SWAT model, to evaluate the biophysical conditions and response of a watershed to a variety of activities and stressors.

OBJECTIVE 1: 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 land cover and land use, 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 the Bolivian Altiplano
- compare land-use classifications from Landsat, ALOS, and Quickbird imagery in Ecuador

Project partner (LTRA) 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: 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: design and implement low-cost community-based watershed monitoring programs

Hypothesis H.3a: Community-based watershed monitoring programs 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 compared with data from reference instruments also installed in the watershed

Research progress

OBJECTIVE 1: 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

Specific accomplishments:

- base high-resolution imagery acquired for eight project watersheds
- land parcels digitized and 2007 basic land-use classification for Zambia's Luelo and Kamwamphula watersheds
- analysis of fire location data derived from MODIS satellite imagery to assess the impact of the COMACO project (LTRA-5) on reducing burning

System level

Watershed

Development impact

Capacity building was achieved through formal and informal training of technical personnel in each country, and training of graduate students at Virginia Tech.

Challenges and responses

A primary challenge is the acquisition of satellite imagery for preferred time periods that will enable specific classification goals (e.g., to distinguish between crops and pasture). Cost, lack of available satellite services, and difficulties with cloud cover (Andean sites in particular) have been factors beyond our control.

OBJECTIVE 2: assess impacts of land-use practices and climate change on agricultural sustainability and natural resource management at a watershed scale

Critical research accomplishments

In the Philippines, Bolivia, Ecuador, and Zambia, preliminary watershed modeling efforts are underway. Due to the limited quantity of observed data at this point (currently being collected under the next objective), all work must be considered preliminary at this stage. However, these preliminary modeling exercises are used as a basis for practical training, for establishing the needed data sets, and for gaining modeling experience with the watersheds and land uses for the areas of study.

System level

Watershed

Development impact

Capacity building through formal and informal training of technical personnel in each country, and training of graduate students at Virginia Tech. Specific training in two workshops focused on developing basic watershed modeling knowledge and skills that are the basis for assessing watershed scale impacts as outlined in the objective statement.

OBJECTIVE 3: design and implement low-cost community-based watershed monitoring programs

Critical research accomplishments

Specific accomplishments:

- 21 stream gauging stations (pressure sensors and staff gauge) installed
- 7 weather stations installed and operating
- 16 recording rain gauges (tipping bucket) installed
- initial data on flow rates at each station
- training on flow monitoring using the salinity tracer method and flow meter for project teams at each location
- preliminary data for this first year from field observers and instruments for comparison

Site locations for hydrologic monitoring have been selected in project watersheds in Bolivia, Ecuador, the Philippines, and Zambia in consultation with field/watershed coordinators. Field equipment has been prepared and installed, partners trained in flow monitoring, and field data for land-use classification collected. The basic approach being used for stream flow monitoring is to select a monitoring location in the natural stream channel that has a stable cross-section. At each location a data-logging pressure sensor records pressure every 15 minutes. A non-vented pressure sensor is being used because of flexibility in installation options and simplicity of maintenance. A reference pressure sensor is located in each watershed to record barometric pressure, which is then used to “correct” the stream pressure data to give water depth. Sensor sensitivity is better than 1 cm. A staff gauge installed at each site is used by a field observer to record water depth on a daily basis as a reference and validation for the sensor data. The stage-discharge relationship at each monitoring station is needed to convert depth (stage) to flow rate and requires measurement of flow rate for a range of low to high flow conditions. Basic equipment for flow measurement was provided for each watershed team, including a flow meter, electrical conductivity testers, balance, and stopwatch. An important focus of the time in the field was to practice the flow monitoring techniques using the flow meter and using the salt dilution (tracer) method in the mountainous locations.

In each watershed, weather stations, recording rain gauges, and manual rain gauges have been installed to give good spatial coverage of the area. At least one complete weather station (rainfall, temperature, relative humidity, solar radiation, wind speed and direction, and barometric pressure) is located in each watershed, with two to four additional recording rain gauges across the watershed. Also, we have the cooperation of local observers to take daily records of rainfall using a manual plastic rain gauge, and some of these observers also take daily readings of stream staff gauge. The connections of the partners in the watershed are very important, and the interest and commitment of local observers appear to be very strong. This collaboration with local observers is very important for the completeness and quality of the overall data collection effort in the watersheds.

The salinity dilution (salt tracer) method for estimating flow rate in the streams is very important in some of the project watersheds because it is a flow measurement technique that is suitable for use in turbulent mountain streams. Training on flow monitoring using the salinity tracer method and flow meter was an important component of site visits, both to collect background data and to provide hands-on training to clarify methods and ensure quality control.

The data from the past season is being compiled and analyzed, with some data yet to be retrieved from instruments in Zambia.

System level

Watershed

Development impact

Capacity building through formal and informal training of technical personnel in each country is a primary impact to date.

Challenges and responses

There were significant flooding events that damaged a few stream measurement stations in Ecuador and a few cases of vandals damaging or stealing equipment in Bolivia. These issues have been repaired or replaced, and in general the work plan tasks are on schedule.

Degree and non-degree training activities

Two students (female master's, male Ph.D.) are involved in long-term degree training, both from the U.S. or other developed countries. Short-term training involved nine men and five women in two training workshops organized in collaboration with LTRA-3:

- a modeling workshop at Virginia Tech for Ana Karina Saavedra (Bolivia), Carlos Montufar (Ecuador), and Adriana Cardenas (Ecuador), Feb. 11-March 8, 2008, and
- a modeling workshop at PROINPA in Cochabamba, Bolivia, for Ana Karina Saavedra (Bolivia), Carlos Montufar (Ecuador), and Adriana Cardenas (Ecuador) and 8 others, September 2008.

Informal training in hydrologic monitoring was conducted for host-country partners in Bolivia, Ecuador, and Zambia. This field experience included selection of sites, installation of equipment, and calibration and operation of equipment related to flow monitoring and weather monitoring.

Linking Knowledge and Action: Meeting NRM Challenges

PI

Esther Mwangi, Kennedy School of Governance, Harvard University

Host countries

Bolivia, Uganda, Kenya, Ecuador, Vietnam, Philippines

Introduction

This report presents ongoing findings of SANREM's knowledge-to-action cross-cutting activity. By using a range of methods for linking their work to policymakers and practitioners, researchers find that there is great appreciation by these actors of the role of research (regardless of landscape scale) in improving natural resource management. While such engagement by practitioners and policymakers may have diverse motivations, such as need for policy options for improving market access or for enhancing sustainable use of resources, direct action is constrained by lack of implementation resources and limited mandates.

Research strategy

The overall goal of the knowledge-to-action cross-cutting activity is to identify the conditions under which research knowledge can influence the practice and behavior of policymakers, practitioners, and resource users. The activity will systematize the recording and analysis of different strategies and processes used by LTRAs 1, 3, 4, and 5 to influence policy and practice to gain an understanding of what strategies worked (or did not) and how research-policy linkages can be enhanced to improve decision making at multiple levels of governance.

This cross-cutting activity draws from four of SANREM's five LTRAs, which represent diverse resource management problems, resource settings, and strategies for engaging resource users, policymakers, and practitioners. Watershed management, climate change and market risk, agroforestry and forest governance reforms are thematic areas addressed by the four research projects. The projects, situated in East Africa, Asia, and Latin America, use a variety of strategies for bridging their work with resource users, practitioners, and policymakers. All the strategies are premised on participation by stakeholders in different ways and in different parts of the research process; and include participatory data collection and evaluation, community training, advocacy coalitions, policy round tables, and cross-community exchanges.

This cross-cutting activity was not designed as a standalone project but rather built into existing programs that had already defined and substantially implemented their methodological designs. However, all teams are addressing a common set of questions, implementing them according to predefined data collection techniques that include quantitative surveys, key informant interviews, and focus groups. Data will be collected at multiple levels to include resource users, policymakers and NGO representatives. Historical evaluations of earlier projects and interventions will also be conducted for some sites. Data analysis will be both qualitative and quantitative, including social network analysis and analytic narratives. Evaluation of the efficacy of the knowledge-to-action strategies will be pegged to the elements of the TOPS framework, which provides indicators of practices, knowledge, skills, attitudes, aspirations, and capabilities that the projects aim to influence. Information dissemination will be conducted at two levels: first, country case studies that will be targeted at specific communities within each country; and second, a book manuscript that synthesizes lessons across the different knowledge-to-action strategies and the settings, targeted at a broader audience.

The research questions addressed by the cross-cutting activity include:

- What strategies have the research projects used to try and link their research to policymakers and resource users? Have those strategies been effective? Why or why not?
- Who are the participants or actors in the research-action arena? Who is included or excluded, and why? How might who participates influence outcomes?
- How do participants in the research-action arena think about research? Do they value research? For what purposes? How do they envisage that it may help or hinder them in their daily work?
- What factors influence learning by participants in the resource-action arena? What constraints do they face? What factors influence their actions and priorities?
- How have resource users and policymakers used research findings from these projects in their daily lives and strategic planning? What institutional and other constraints have they faced?
- What kinds of knowledge systems lead to more action and policy responses? Under what conditions can successful knowledge-action efforts be promoted?
- What can be done to improve the knowledge-action link? Specifically, what kinds of insights can the SANREM experience provide to researchers regarding elements of

sequencing, timing, and delivery of their knowledge to action strategies to ensure maximum impact?

Research progress

In the initial step, research teams were involved in establishing processes for tracking how field work, training efforts, and participatory research affect decision making at different governance levels. This included designing data collection protocols and developing case-study designs. These were collaborative processes that included consultations and seminars with local partners, including universities and local leaders and officials.

As a second step toward implementation, research teams are conducting literature reviews and policy analyses of existing national research and extension systems. The climate change team, for example, is reviewing literature to explore how advocacy coalitions and participatory approaches may link to the construction of social, human, and political capital, and subsequently to the nature of institutions and norms that condition participation.

The third step has involved testing the developed protocols and actual data collection, including field interviews. Colleagues in Vietnam and Uganda, for example, have pretested their data collection instrument, identified the participants and stakeholders they will interview, and have started the interviewing them.

General (and early) assessments of the efforts and interactions outlined above suggest that:

- The reception of research interventions by local people, resource users, local leaders, government officials, and policymakers has been positive. In the Philippines and Vietnam, for instance, the interest is driven by a genuine concern to access markets for agricultural produce, an important opportunity for improving the livelihoods of the rural poor. In Bolivia and Ecuador (in the watershed management project), while Ecuadorian leaders are aware of the relationships between water quality and land use, they are unsure of how to induce changes in land use and are eager for relevant policy options. On the other hand, Bolivian leaders are remotely aware of the linkages. In Uganda, the involvement of significant stakeholders in the research partnership as well as consultative interactions between policymakers and practitioners resulted in a reduction of illegal timber harvesting.
- In Uganda, the involvement of stakeholders in research activities and processes has improved communication among actors in the forest sector. Stakeholders are now more appreciative of the magnitude of the problems involved in implementing the forest decentralization policy. However, limited resources of practitioners, including a limited mandate, bureaucratic bottlenecks, and the longer-term nature of solutions, constrain their ability to effect change as well as the pace of change.

These early findings are suggestive of change occurring at different, yet related, scales. While the perceptions of Bolivian and Ecuadorian leaders may relate to the landscape level, market access issues by farmers in the Philippines and Vietnam are clearly occurring at cross-scale levels – both at the farm level and at a higher level of the local and national markets. In Uganda, behavioral change such as declining illegal extraction of forest resources occurs strictly at the forest/landscape level; improving communication among practitioners and policymakers is doubtlessly a policy-level accomplishment.

The changes and impacts outlined above fit quite well within the TOPS framework range of impacts and relate to changes in practices and perceptions.

Financial flows to most teams were completed in July 2008, a setback of close to 10 months from the anticipated project start date. This has had a significant effect on the nature and quantity of accomplishments that have been reported above and will likely impose a significant lag on the anticipated final products and outputs of this cross-cutting activity. Team leaders would appreciate guidance from Virginia Tech project management on this. Besides this management challenge, the teams are experiencing additional political, conceptual, and normal research implementation challenges as follows:

- The political challenges in Bolivia are daunting. Although the team is trying to meet regularly with the local leadership, it has had success only through the farming *syndicatios*; the elected leaders are not very willing to interact with the research team.
- A major conceptual concern is the lack of unified indicators to measure the actual impact of SANREM on policy. Because this cross-cutting effort was added to an existing research design, we see little opportunity to include indicators midstream; however we do see an opportunity for informing the choice of indicators for subsequent investigations.
- An empirical concern is that the project's time span may be inadequate to cause major policy changes in the forest sector, but we do see viable opportunities for impacting and changing local-level practices.
- In Uganda, we have had to scale down the cross-cutting activity sites due to funding constraints.

In the end, our expectation from this cross-cutting activity is not so much to provide foolproof results on the conditions under which research may more likely lead to policy outcomes, but rather to draw insights that can be used to inform efforts at linking knowledge to action and also to identify variables that can be more closely studied in future research efforts.

Degree and non-degree training activities

The Uganda project contributed to the development of a master's degree research proposal. "Transforming research knowledge to workable solutions in natural resource management: Analysis of the knowledge- action link in forest and wildlife management in Uganda" was developed and accepted by Makerere University Post-graduate School. While this research contributes to the current activity, it does not draw funding from it.

The climate change and markets group initiated the process of advocacy coalition training in which Bolivia researchers had the opportunity to attend the training led by Edith Fernández-Baca in Peru. Four researchers were trained, and the developed a proposal on incorporating AC in the socialization of market information in Bolivia. Two male and two female research assistants, who are also master's students in various fields, participated of the graduate module in Puno, Peru, in November 2007. At the time the cross-cutting funding was not in place, so LTRA-4 funded this activity, which benefits both the LTRA-4 research and the case studies on climate adaptation. Two of the student researchers, Olga Yana and Edwin Yucra, are involved in the case studies in Bolivia on markets and climate.

Publications, presentations, other products

No products are available yet. However, the climate change and markets team has begun work on guidelines for an information-sharing protocol with communities for markets and climate. The Uganda team (LTRA-1) is in the final stages of producing a video showing use of SANREM research findings by forest user groups, practitioners, and policymakers.

All teams have consented to the production of a manuscript that incorporates each of the cases, lessons learned, and implications for future research. The manuscript will also outline a framework and methodologies for linking research to action that can be used by researchers, policymakers, and practitioners.

Soil Quality

PIs

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Johannes Lehmann, Department of Crop and Soil Sciences, Cornell University
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Host countries

Bolivia, Zambia, Indonesia, Philippines

Introduction

Soil quality assessment is a process by which soil resources are evaluated on the basis of soil function. The need for an effective, low-cost method to evaluate soil quality is important in developing countries because soil degradation is a major impediment to sustainable crop growth. Significant progress was achieved during this initial year of the cross-cutting soil quality project in preparing survey instruments for community members and agricultural professionals, in conducting a literature search, and in developing and testing laboratory and field procedures for soil quality. The project also worked closely with the SANREM CRSP soil metagenomics effort to identify appropriate field sites to take soil samples to assess differences in soil quality using the metagenomics approach. Several analytical methods for determining changes in soil quality due to soil degradation were tested with soils from a long-term experiment in the United States with different tillage and fertility treatments and from soils collected in Bolivia, which had different cropping histories. Among these tests, the potassium permanganate ($KMnO_4$) test for labile carbon (C) shows some initial promise because it is rapid, relatively low in cost, and can be distributed as a field kit either with a portable spectrometer or with a color chart. One obstacle observed in Bolivia was a difficulty in obtaining $KMnO_4$ reagent. The near infrared (NIR) procedure allowed for prediction of several soil C fractions, including the $KMnO_4$ C test, but the high cost of the portable field instrument may make it cost prohibitive for resource-poor countries. Further testing of these procedures will be conducted with soils from Zambia, Indonesia, and the Philippines.

Research strategy

OBJECTIVE 1: assess community perceptions and indicators of soil quality, including differences in perceptions of soil quality due to gender, environment, and socioeconomic factors

Critical research accomplishments

Two survey instruments were developed to assess community perceptions and indicators of soil quality and the perceived ideal characteristics of a rapid test of soil quality. The survey instrument for community members was stratified based on gender, age, land holding size, and availability of irrigation. The survey for agricultural professionals asks for background information on the gender, experience, and education of the professionals and how long they have worked in the community. These instruments will be circulated to in-country collaborators for further comments, suggestions, and translation.

System level

These surveys will be conducted in multiple countries in which socioeconomic and environmental conditions vary widely. It is expected that some common indices of soil quality will emerge but that differences will exist in the appropriate characteristics of a soil quality test for each environment.

Development impact

Increased information on community perceptions of soil quality and the local indicators of soil quality will assist in developing improved management practices that are appropriate for the socioeconomic and environmental conditions.

Challenges and responses

Among the challenges encountered with developing and instituting the surveys has been in identifying appropriate groups in each collaborating project to assist in conducting the surveys. Providing appropriate training for the individuals to conduct the surveys will also be a challenge.

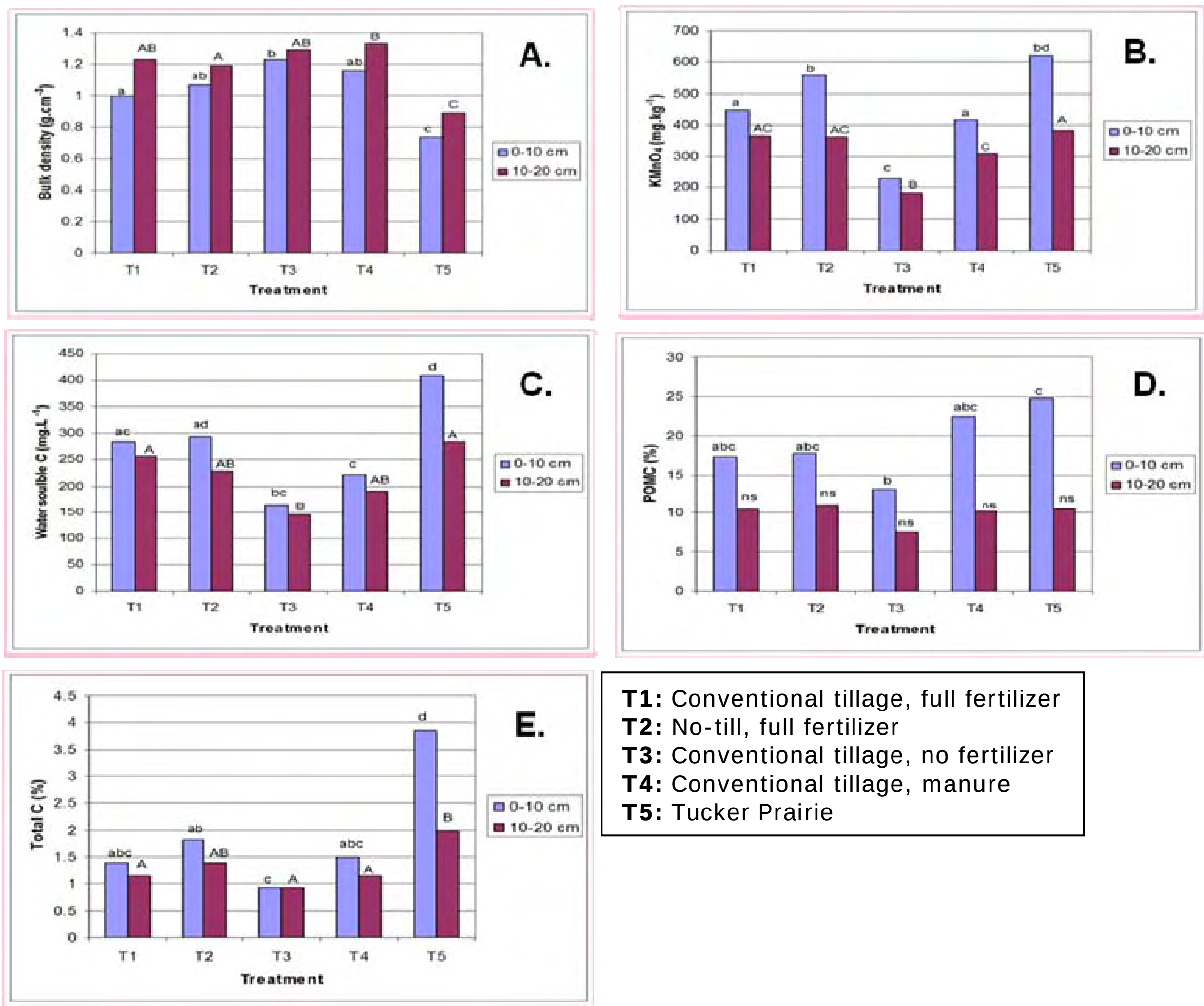
OBJECTIVE 2: determine the efficacy of spectroscopic-based (i.e., near-infrared, mid-infrared, and visible range) analytical methods to evaluate soil organic matter fractions and soil quality in degraded and non-degraded soils in a wide range of environments

Critical research accomplishments

Based on an extensive literature review, several spectroscopic-based **(**i.e., near-infrared, mid-infrared, and visible range) analytical methods were selected to evaluate soil organic C fractions as a key index of soil quality. Initial testing of these methods was done on soils collected in 2008 from depths of 0-10 cm and 10-20 cm from Sanborn Field, a long-term research site in north central Missouri that has been continually cultivated since 1888; and from Tucker Prairie, a native prairie site in Missouri that represents the undisturbed soil found in Sanborn Field before initial cultivation. This site was selected because it has established differences in soil organic matter due to the long-term nature of the treatments and provides a temperate soil contrast to the samples collected from the collaborating sites around the world. The plots that were sampled in Sanborn Field had been supporting continual corn crops (*Zea mays.* L.) and included treatments of conventional tillage, full fertilizer treatment (T1); no-till, full fertilizer treatment (T2); conventional tillage, no fertilizer treatment (T3); and conventional tillage, manure treatment (T4). Soil from the Tucker Prairie site was designated as T5.

The results of the analysis for changes in soil bulk density (Db), $KMnO_4$-oxidizable C, water-soluble C, particulate organic matter (POM) C, and total organic C are shown in Figure 4-1 A-E. They indicate the following:

- The undisturbed prairie soil had the lowest Db (0.74 g.cm-3) compared with cultivated plots at the 0-10 cm and 10-20 cm depths (Figure 4-1 A). The treatment whose soil contained the highest Db was conventional tillage and no fertilizer (1.23 g.cm-3).
- Labile C or active C pools (using the KMnO4 or water-soluble C methods) showed the highest results in Tucker Prairie compared with conventional tillage and no-till in Sanborn Field.
- The no-till treatment on Sanborn Field had more labile C (or active C) than the conventional tillage treatments including both fertilized and manured plots (Figure 4-1 B-C).
- The Tucker Prairie soil had total organic C levels (3.84 percent) three times greater than that of the conventional tillage-full fertilizer plot in Sanborn Field (1.39 percent). Similarly, POM-C in Tucker Prairie was 1.5 times greater that the POM-C value in Sanborn Field (24.73 percent and 17.23 percent, respectively, Figure 4-1 D-E).



T1: Conventional tillage, full fertilizer
T2: No-till, full fertilizer
T3: Conventional tillage, no fertilizer
T4: Conventional tillage, manure
T5: Tucker Prairie

Figure 4-1. Mean values for bulk density (g.cm3), KMnO4 (mg.kg-1), water soluble C (mg.L-1), particulate OC (%), and total C (%) as affected by tillage and fertility treatment in Sanborn Field and Tucker Prairie in north central Missouri

The same lower-case letter (0-10 cm) and the same upper-case letter (10-20 cm) do not differ significantly by LSD ($p \leq 0.05$).

These results indicate that laboratory methods, such as POM-C, $KMnO_4$ C and water-soluble C, are able to detect variation in soil C fractions due to differences in long-term soil management.

Whole soil samples from both depths of treatments in Sanborn Field and Tucker Prairie were also scanned using a portable near-infrared spectrometer and the results used to develop statistically significant predictive models of POM C, $KMnO_4$ C, and total organic C (Figure 4-2 A-C). The use of NIR could provide a rapid field-based method to determine soil C fractions and soil quality. However, a major obstacle with use of this instrument is the current cost of portable field NIR units, which may make it cost-prohibitive for resource-poor countries. Also, extensive calibration of the instrument is required before its use.

DRIFT analysis is also being conducted, and a comparison of sample preparation methods (i.e., treatment with HF, separation of humic acids, or use of whole soils) for the DRIFT analysis has been initiated.

The use of these methods is also being tested on soil samples from the SANREM LTRA projects. Soil samples collected from two communities in Umala (i.e., San Juan Circa and San Jose) for determining the effects of changes in fallow management in the Altiplano of Bolivia were tested for changes in POM-C, water-soluble C, $KMnO_4$ C, and total organic C (Figure 4-3 A-D). These results show a large increase in $KMnO_4$ C in uncropped and long-term fallow fields compared with fallow fields, especially in the community of San Juan Circa (Figure 4-3 B). Similar changes were observed in water-soluble organic C (Figure 4-3 A), another measure of labile C; and particulate organic matter C (POM-C), a measure of more intermediate C (Figure 4-3 C). Further testing of these samples for different soil C fractions is being conducted using NIR and DRIFT mid-infrared analysis.

Field kits for testing the $KMnO_4$ C procedure have been distributed to SANREM collaborators in Zambia, Bolivia (Cochabamba, Umala, Ancoraimes), and Peru. Two other kits will be given to collaborators in Indonesia and the Philippines when one of the PIs visits those projects in November. With the kits, the use of a color chart compared with the use of a portable spectrometer is being tested to estimate the amount of labile C. If the color chart is effective, this will substantially reduce the cost of the test.

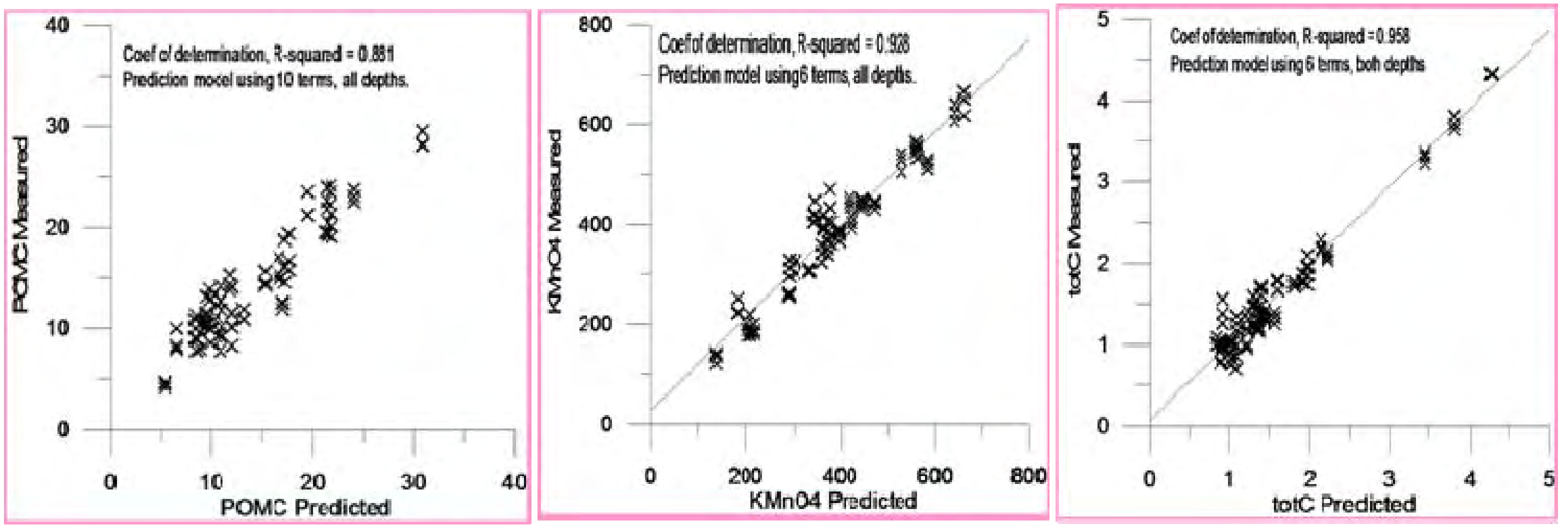


Figure 4-2. Predicted versus measured **A)** particulate organic matter (POM) C, **B)** KMnO4 C, and **C)** soil total organic C of Sanborn Field and Tucker Prairie soils using a portable NIR spectrometer

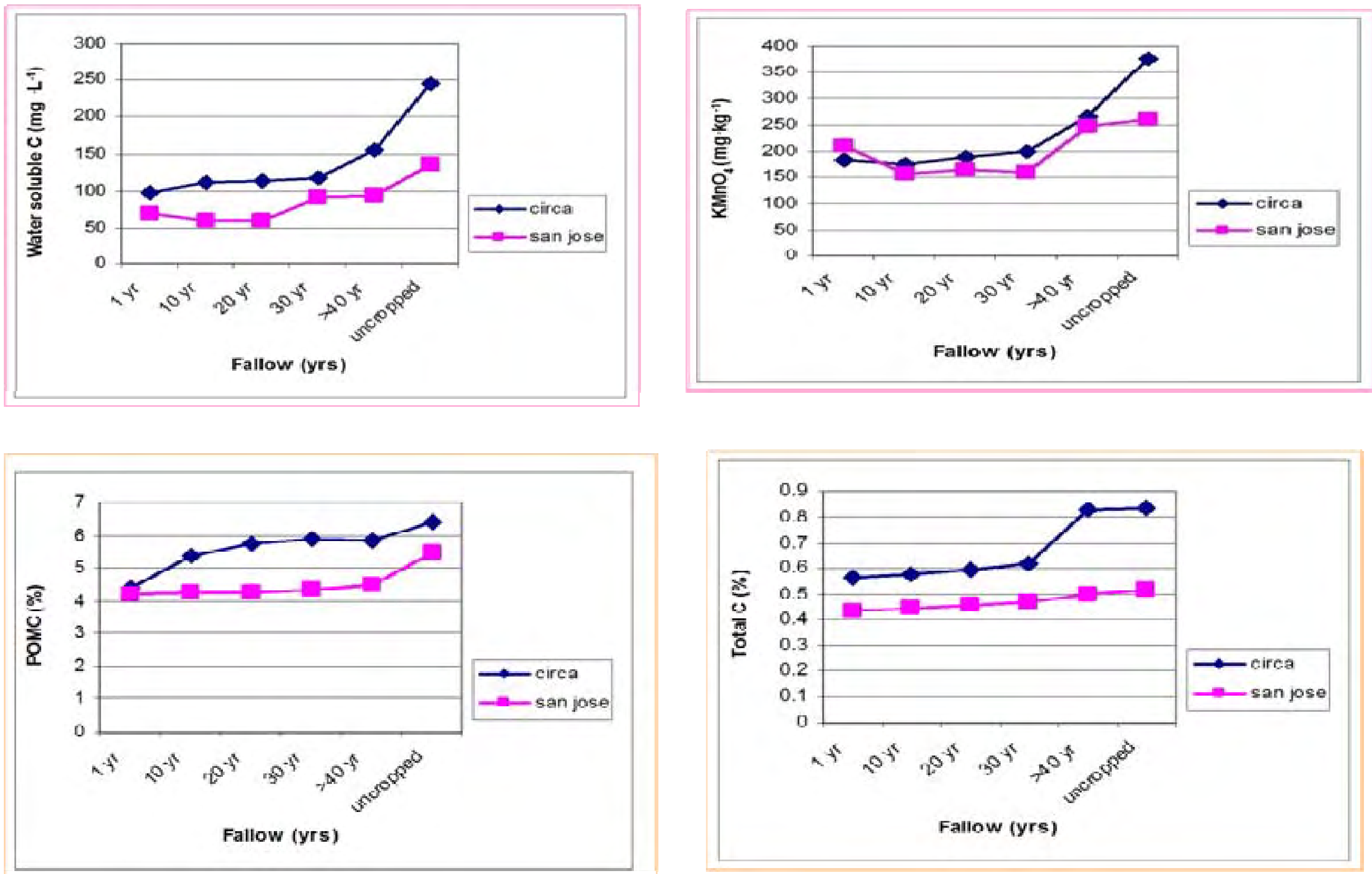


Figure 4-3. Effects of fallow on soil organic carbon fractions **A)** water soluble C (mg.L-1), **B)** KMnO4 (mg.kg-1), **C)** POM-C (%), and **D)** total C (%) in two Bolivian communities in Umala

Development impact

The use of rapid tests for soil quality that can be used in a wide variety of socioeconomic and environmental conditions would assist in assessing soil degradation and in developing improved soil management practices. Spectroscopic-based methods are appealing for use in developing countries because they do not require extensive laboratory facilities, especially the $KMnO_4$ and NIR tests. Also, they may lend themselves for use with remote sensing as the resolution of these images becomes greater and the costs become lower.

Challenges and responses

A major challenge in completing this effort is the amount of time required for analyses and interpretation of the results. One of the PIs has conducted workshops in the use of the $KMnO_4$ kits to train collaborators in how the analysis is done, and several improvements in the procedure have come out of the workshop, including streamlining the preparation of standards and a recommendation to conduct the test early or late in the day to avoid potential degradation effects of intensive light on the $KMnO_4$ reagent.

OBJECTIVE 3: collaborate in the evaluation of soil metagenomic methods as an indicator of soil degradation

The soil quality cross-cutting project has been working with the soil metagenomics project to assist in identifying the appropriate soils to collect and compare. Some sharing of soil samples and data is also envisioned for testing purposes.

Degree and non-degree training activities

LTRA-4's cross-cutting soil quality project had two students involved in long-term degree training, one of those from a host country and one from the United States or other developed country. One woman and no men were working on Ph.Ds. Short-term training involved four men and two women in one training workshop. See Appendix A.

Publications, presentations, other products

Activities this year produced no refereed journal articles or book chapters, one workshop proceeding, no website or newsletter features, two poster sessions, one published abstract, and one presentation (not including presentations made during community training workshops).

Project highlights

- Several analytical methods for determining changes in soil quality due to soil degradation were tested with soils from a long-term experiment in the United States with different tillage and fertility treatments; and from soils collected in Bolivia, which had different cropping histories.
- Among these tests, the potassium permanganate ($KMnO_4$) test for labile carbon (C) shows some initial promise because it is rapid, relatively low in cost, and can be distributed as a field kit either with a portable spectrometer or with a color chart. One obstacle observed in Bolivia was difficulty in obtaining the $KMnO_4$ reagent.
- The NIR procedure allowed for prediction of several soil C fractions including the $KMnO_4$ C test, but the high cost of the portable field instrument may make it cost prohibitive for resource-poor countries. Further testing of these procedures will be conducted with soils from Zambia, Indonesia, and the Philippines.

Metagenomics for the Analysis of Soil Microbial Communities and Soil Quality

PIs

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Jorge Cusicanqui, Universidad Mayor de San Andrés, Bolivia
Corinne Valdivia and Peter Motavalli, University of Missouri
Jeffrey Alwang, Virginia Tech
Alex Travis and Johannes Lehmann, Cornell University

Host countries

Bolivia, Zambia

Introduction

Scientific accomplishments

This project began in 2008. We have devised a sampling strategy and collected our first two sets of soil samples from Bolivia and Zambia. We plan to prepare a methods paper within the next month and to obtain our first sequencing results by the end of 2008. Our process has contributed to technological development through collaboration and training of students. The information we will obtain about soil management strategies will contribute to better agricultural management.

Research goals

- use pyrosequencing and metagenomic tools to characterize soil microbial communities from soils representing a range of levels of degradation
- identify microbial taxa that are indicators for levels of degradation, especially those that may indicate the process of degradation has begun but is still reversible
- link soil community structure to both the general soil biophysical context and the social science context to understand human impacts and drivers of human decision making for soil management

This is a new project. We should have research findings and results to report by the end of 2008. We should be able to relate these results to management decision making in 2009.

Four graduate students are receiving training in this project.

Our workshop on soil metagenomics at UMSA in La Paz, Bolivia, had 47 participants from the university and NGO communities. We are preparing our workshop materials for submission to a peer-reviewed teaching journal later in November 2008.

This project is already beginning to realize its great potential to provide new networking among international soil and microbial researchers.

Research strategy

Soil metagenomics

One of the most exciting outcomes of the biotechnology revolution in genomics is our ability to characterize soil microbial communities with much greater coverage. New high-throughput technologies such as 454 sequencing allow us to simultaneously evaluate DNA from millions of microbes in soil samples, including species that have previously been overlooked because they could not be cultured using conventional techniques. While the first studies in soil metagenomics have emphasized extensive analysis of a small number of samples, our research group at Kansas State University has developed techniques to add molecular tags and simultaneously process many tagged replicate soil samples. This allows us to compare soil microbial communities in carefully designed replicated experiments.

Need for indicators of soil degradation

Soil degradation is one of the most important problems for sustainable agriculture worldwide. Because tropical soils have been studied less than temperate soils, understanding and developing methods for stopping tropical soil degradation is an important topic for the SANREM CRSP. SANREM also provides a unique social science context for studying human impacts on soil degradation. We are applying soil metagenomic approaches to tropical soils to identify indicators of soil degradation. Ultimately more complete profiles of soil communities will also contribute to the development of methods to foster disease-suppressive soils and soil communities that optimize for other microbes contributing to plant health and productivity, such as mycorrhizal fungi and rhizobia.

General research approach

Studies of soil metagenomics have begun in concert with the soils project and social science projects so that samples are selected in the appropriate biophysical and human context. Because soil communities differ greatly among soil types, even in the absence of any human activity, comparisons of management impacts on soil communities will be made within particular soil types. Soil communities also differ greatly across very small distances, even within the same soil type and management practice, so many subsamples will be combined into each replicate sample. We are identifying fields that represent different levels of soil degradation to characterize how soil communities change. Soil DNA extraction will be performed by students and collaborators in the host countries. Tagging of DNA will be performed at Kansas State prior to 454 sequencing. We have developed a basic bioinformatics and statistical framework for working with 454 sequencing output in the context of experiments with management effects on Kansas soils. Soil community characterizations will be shared and interpreted with soil and social science collaborators.

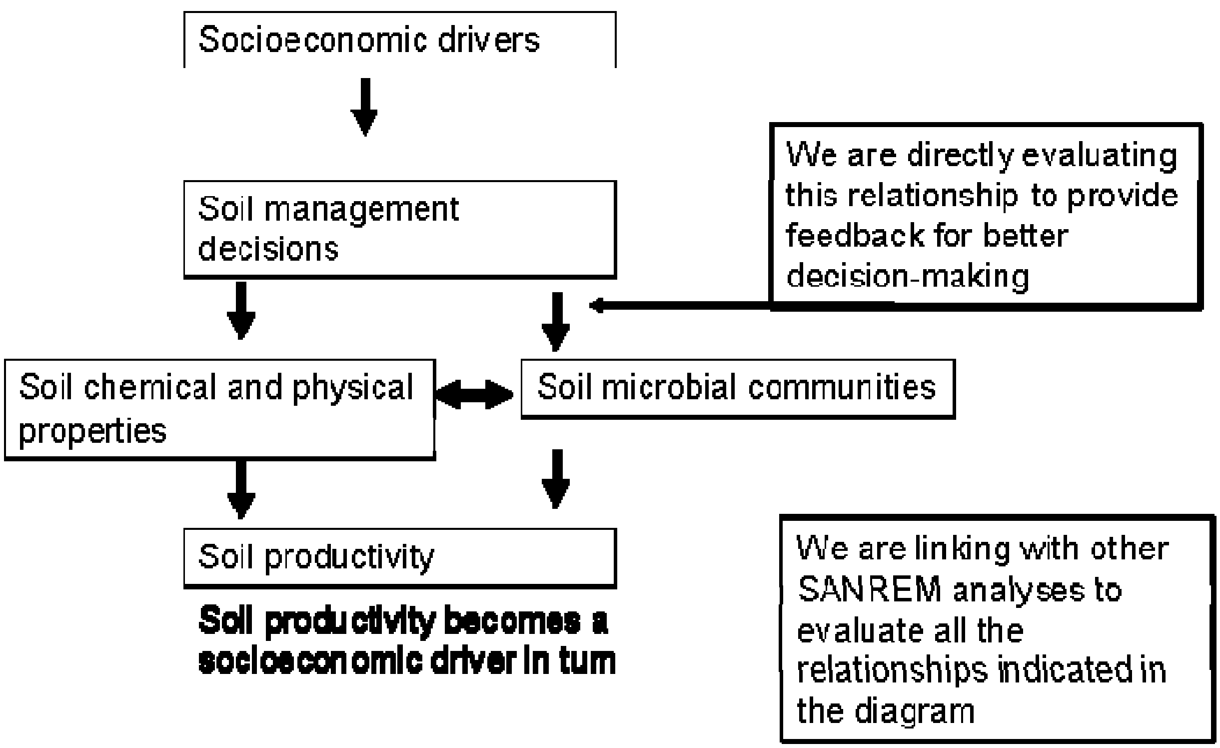

Figure 4-4. Socioeconomic drivers

Links within SANREM

This soil metagenomics project will establish a productive link between general SANREM biotechnology initiatives and a cross-cutting soils project. The soils project will provide critical biophysical context for analysis of the microbial communities. The rich economic and sociological context provided by SANREM teams will allow us to link these biological indicators with human activities. We will also link this SANREM soil metagenomics project to the many growing international metagenomics projects and databases to optimize data sharing and research synergies. Annotation of microbial DNA (constructing databases linking taxonomic and functional information with DNA sequence information) is key for successful evaluation of communities, so forming links with other metagenomics databases and projects will be essential.

Research progress

OBJECTIVE 1: use pyrosequencing and metagenomic tools to characterize soil microbial communities from soils representing a range of levels of degradation

Critical research accomplishments

We have collected our initial samples from Bolivia and Zambia and should have our first results by the end of 2008. We are also developing concepts and computer programs to support this first analysis.

System levels

This analysis is at the field, community/watershed, and ecosystem levels.

Development impact

This analysis will provide input to strategies about optimal soil management.

Challenges and responses

The equipment that we brought to UMSA was not released by Bolivian customs in time for our use in La Paz, but it is now available for training, and we were able to use other equipment in the United States for sample processing. This problem did not compromise our analysis.

OBJECTIVE 2: identify microbial taxa that are indicators for levels of degradation, especially those that may indicate the process of degradation has begun but is still reversible

Critical research accomplishments

We should have our first results to address this objective later in 2008.

System levels

This analysis is at the field, community/watershed, and ecosystem levels.

Development impact

This analysis will provide input to strategies about improved soil management and soil conservation.

Challenges and responses

We have not yet experienced any problems in this portion of the analysis.

OBJECTIVE 3: link soil community structure to both the general soil biophysical context and the social science context to understand human impacts and drivers of human decision making for soil management

Critical research accomplishments

We do not have sequencing results yet but have begun the process of preparing the integration across the system. We have further developed concepts for relating microbial communities, plant disease, and climate change impacts, resulting in several publications.

System levels

Linking with social scientists and soil scientists will allow us to link across fields, farm/households, communities/watersheds, and ecosystems.

Development impact

Linking with social sciences and soil scientists will allow us to optimize application of our new information in Bolivian, Zambian, and other systems.

Challenges and responses

We have not yet experienced any problems in this portion of the analysis.

Degree and non-degree training activities

This project had four students involved in long-term degree training, three from host countries and one from the United States or other developed countries. One woman was working on a Ph.D., one woman was working on a master's degree, one man was working on a master's, and one master's student remains to be recruited. Short-term training involved 25 men and 22 women in one training workshop. See Appendix A. We have prepared a series of peer-reviewed training modules that will include a new publication about soil metagenomics.

Publications, presentations, other products

Activities this year produced four refereed journal articles, two book chapters, one workshop proceeding in preparation, and several presentations (not including presentations made during community training workshops). See Appendix B.

Networking activities included meetings with collaborators at UMSA and PROINPA.

Project highlights

- We have assembled the first samples for our project in collaboration with our research partners in Bolivia and Zambia and should have our first results by the end of 2008.

- We have presented a workshop on soil metagenomics in Bolivia, and we are preparing a training module from the workshop for publication online in English and Spanish.

- We have produced a series of five peer-reviewed teaching publications in *The Plant Health Instructor* for the analysis of plant-microbe interactions in ecosystems; these modules have been accessed online by more 13,000 unique visitors in more than 100 countries.

- We have published three new analyses of climate change impacts on plant disease and plant-microbe interactions (Chakraborty et al., 2008, Garrett et al., in press), including one for the U.S. National Academy of Science (Garrett, 2008).

- We have evaluated plant disease and plant microbe interactions in the context of ecosystem services as a summary for policymakers (Cheatham et al., accepted pending revision).

- We have developed and applied a new graph theoretic analysis of host plant connectivity (Margosian et al., in press) that can be used to evaluate responses to new pathogens or insect pests.

5. SANREM CRSP Management Entity activities

The Virginia Tech Management Entity (ME) provides overall administrative and intellectual leadership of SANREM CRSP activities. This leadership is most clearly demonstrated in the financial management and program coordination of the LTRA and cross-cutting activities, networking with information providers and users, promoting 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 the SA and NRM inquiry areas, nurtures innovative new 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, working papers, and research briefs.

Program review and assessment activities

The SANREM CRSP underwent three major external reviews during FY 2008: a technical program review by the SANREM CRSP External Evaluation Panel (EEP); an administrative management review (AMR) by a USAID-contracted team; and a USAID review. The purpose of the EEP review was to evaluate the scientific progress of SANREM during its first three and a half years. The purpose of the AMR was to evaluate the administrative management practices of both the ME and its sub-awardees. The USAID review was to determine if SANREM would be continued for another five years and if Virginia Tech would continue as the management entity. SANREM received positive results from both the EEP review and the AMR, summarized below. Based on the continued relevance of SANREM activities to USAID applied research needs, the results of the EEP and AMR reviews, and other considerations, the USAID review recommended that SANREM be renewed for another five years beginning Oct. 1, 2009, at an annual funding level of $3 million. The EEP Year 4 Program Review and the AMR report can be viewed on request to the ME.

EEP review

The EEP review was conducted between May 2007 and January 2008. The EEP review was to be used by USAID in determining whether to renew SANREM CRSP for Phase IV. The specific objectives of the EEP review were to evaluate programmatic focus and effective scientific balance of research toward achievement of objectives; identify inadequate performances; identify activities that are irrelevant or marginal to CRSP objectives; consider the effective balance between research and training for development of institutional research capability; assess the balance of domestic versus overseas research in terms of effectiveness in removing constraints in developing countries; evaluate the cost-effectiveness of the entire CRSP operation in terms of actual cost of doing business versus costs of alternatives that may be less expensive, more efficient, and more effective; and examine ways of disseminating research results and determining the appropriateness of the research.

EEP review summary

Based on the scientific progress achieved during the first three and a half years of Phase III, the EEP recommended that the SANREM CRSP be extended for another five-year research phase. The EEP review team recognized the impressive SANREM knowledge generation and dissemination activities, the excellent graduate training, and the researchers' and ME's commitment to engage in multidisciplinary studies. SANREM was judged to be a suitable instrument to capitalize on the strong disciplinary knowledgebase and development research expertise at U.S. universities in addressing complicated issues of developing country contexts through an inter- and trans-disciplinary approach. The EEP commended SANREM's ME and researchers for their proactive responses to EEP suggestions. The EEP also recommended the establishment (funding permitting) of cross-cutting research activities related to soils, water, biodiversity and ecosystem services, governance, institutions, and gender. The ME and SANREM Technical Committee implemented a cross-cutting research activities program when funding became available.

Administrative management review

The SANREM AMR was conducted between October 2007 and May 2008. The AMR panel was asked by USAID to address two basic tasks:

- to determine if a review of the original proposal, the annual reports, the EEP reports, and the results of the AMR showed a record of good performance during the first three years of implementation and
- based on this evaluation, at what level the AMR panel would expect performance to be during the remaining two years of this award and during any five-year extension of the activity.

AMR summary

With regard to the two basic tasks assigned to the panel, the conclusions were that:

- the SANREM CRSP has had good performance during the first three and a half years of operation; and more importantly, because of its flexibility and judicious practice of adaptive management, the ME has made adjustments along the way that have steadily increased the efficiency and effectiveness of management of the SANREM CRSP; and
- given the promise of significant results, the admirable adaptive management approach of the ME, its strong partnership with and leadership of the LTRAs, and its good record during the first three and a half years, the SANREM CRSP likely will operate at an even higher level of performance during the remaining year and a half and during the five-year extension of the activity.

SANREM Knowledgebase

The SANREM Knowledgebase (SKB) is an online database of information resources (books, reports, journal articles, videos, movies, presentations) produced or identified, classified, and summarized by SANREM CRSP researchers. These experts are identifying and providing metadata for key SA and NRM information resources. This information is then accessible to potential users through the Internet. The SKB is also the repository for all SANREM CRSP-generated information resources. There are now 2,515 metadata entries, of which more than 500 are products of SANREM CRSP Phase III research. This searchable database is organized by landscape system and provides 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.

Since becoming operational in 2005, the SKB has been continually evaluated and improved as needed. 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 classifies the resource using a standard set of metadata. The Dublin Core Metadata Initiative (http://www.dublincore.net) defines the metadata elements used in the SKB. The SANREM CRSP 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 to the resource. Resources can be any type of file (PDF, Word, image, video).

The second level of permission is that of reviewer. Reviewers have all the rights of catalogers, as well as the right to review and edit metadata entered by other researchers. All resources submitted to the SKB by catalogers must be reviewed and approved by reviewers for quality control before the resources are published. Reviewers have the right to publish approved resources. Once a resource is published, it becomes available to the public through the Internet. The final, 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. Resources 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), online at: 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. http://www.oired.vt.edu/sanremcrsp/
- *SANREM CRSP Newsletter*, an e-mail bulletin updating partners and other stakeholders on SANREM CRSP activities and accomplishments
- working papers, providing early release of SANREM CRSP research findings
- research and policy briefs, which target development practitioners by highlighting technological and institutional innovations, and
- research and policy notes that identify potentially valuable emerging technologies and policy approaches.

SANREM CRSP website

SANREM partners, development practitioners, policymakers, other stakeholders, and the public are informed of SANREM CRSP activities and announcements through the ME-maintained SANREM website, http://www.oired.vt.edu/sanremcrsp. The SANREM ME tracks visitors to the website using Google Analytics, a free service that generates detailed statistics (Figure 5-1).

Since the SANREM CRSP ME began using Google Analytics in September 2006 to track website activity, the number of visits has risen by nearly 30 percent (Table 5-1). Visits in FY 2008 came from 127 countries and involved more than 8,000 visitors. Most of those visitors were in the United States (Table 5-2). About half of these visits were generated by search engines. About a fourth were direct traffic, that is, the visitor entered the URL directly; another fourth were from links on other sites.

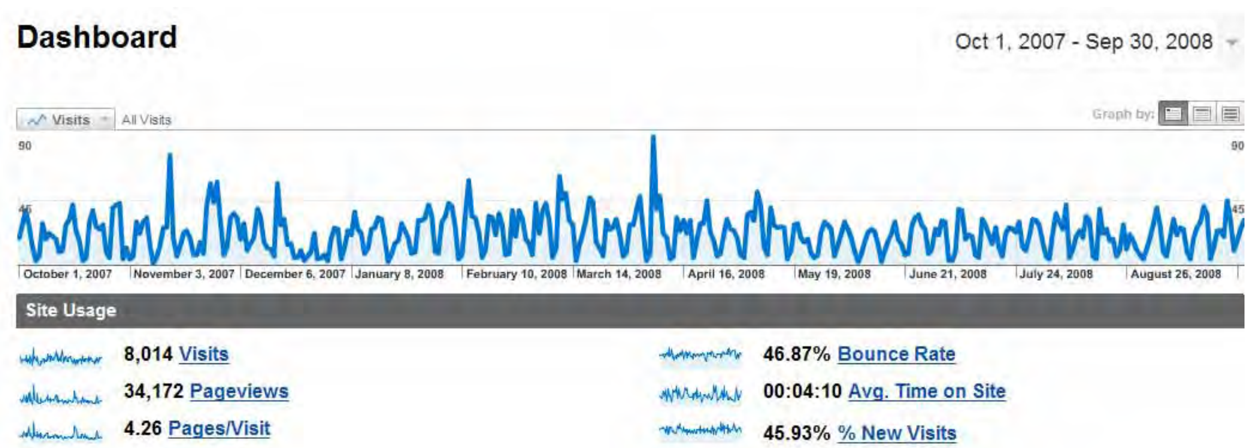

Figure 5-1. Google Analytics data for the SANREM CRSP website, FY 2008

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 in minutes, indicating 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

Table 5-1. Year-to-year increase in SANREM CRSP website visits

	FY 2007	FY 2008	% change
Visits	6,184	8,014	+29.59
Pageviews	21,590	34,172	58.28
Pages/visit	3.49	4.26	22.13
Bounce rate	48.80	46.87	-3.97
Avg. time on site	3:14	4:10	+28.87
New visits	48.87	45.93	-6.01

Table 5-2. Top 5 countries for visits to SANREM CRSP website, FY 2008

Country		Visits	Pages /visit	Avg. time on site	New visits (%)
1. United States		6,061	4.82	4:41	35.65
2. Philippines		448	2.43	2:27	73.88
3. Bolivia		114	2.91	3:41	68.42
4. Germany		87	2.29	1:27	91.95
5. India		80	1.74	0:55	93.75

SANREM CRSP information products

The ME publishes the *SANREM CRSP Newsletter* and series of research briefs to promote and disseminate relevant SA and NRM messages and information. Research briefs provide concise summaries of peer-reviewed SANREM CRSP scientific findings and how those can be applied in the field. The first SANREM CRSP policy brief was issued this year and is available on-line: Vegetable Agroforestry in the Philippines (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 authors are pursuing but that has not yet reached conclusion, for example:

preliminary baseline studies reports, discussions of methodological or thematic issues, and topical syntheses and literature reviews. The series was augmented this year with eight working papers.

SANREM CRSP Newsletter is an e-mail bulletin that provides a quick update of ME and researchers' activities, accomplishments, and future events in multimedia format: e-mail, print, and online. In FY 2008, issues were published in January, May, and August, and are online at: http://www.oired.vt.edu/sanremcrsp/menu_information/newsletters.php.

Book on adaptive management for sustainable systems

Small-scale farmer around the world are confronted by the linked problems of poverty and environmental degradation. To address these multiple and complicated factors, SANREM CRSP landscape system and technology transfer coordinators developed a guidebook for development practitioners. This book introduces an evolving adaptive management approach to SA and NRM systems. The goal of the book is to provide development practitioners with the knowledge, understanding, and tools to improve the innovative capacity of stakeholders. A sub-goal is to encourage policymaker and donor support for local innovation and adaptive management. Nearly all final chapter drafts have been submitted and reviewed. The book will be published in early 2009.

Part I of the book provides an overview of complex adaptive systems and the 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 and 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 level, 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 together 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 demonstrating the application of landscape system adaptive management principles. Material for these chapters is being researched to provide holistic, multisystem 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.

SANREM CRSP leveraged funding

SANREM CRSP PIs have become quite successful in leveraging additional funding to enhance their research and outreach activities. Funding sources included U.S. and international funding agencies, as well as host country sources (Table 5-3). This year, 18 SANREM CRSP co-PIs leveraged more than $600,000. The vast majority of those funds ($503,826) went directly to the support of SANREM activities.

Table 5-3. SANREM CRSP leveraged funding, FY 2008

Source of funding/support	Non-tracked funding or support contributing to SANREM activities ($)	Funding or support for non-SANREM activities resulting from SANREM activities ($)	Total ($)
U.S. organizations	155,480	50,000	205,480
International organizations	50,000	30,000	80,000
Host country organizations	298,346	41,900	340,246
Total	503,826	121,900	625,726

6. 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, non-governmental organizations, and relevant ministries. While developing a global knowledgebase in U.S. universities, SANREM addresses specific host country SA and NRM questions, opportunities, and constraints. In FY 2008, 25 U.S. and host country universities and institutions provided long-term training for 68 graduate students (32 Ph.D. and 36 master's) and 30 undergraduate students associated with SANREM CRSP activities. Of these, 53 are women and 45 are men. Of these students, 79 are developing country nationals studying at eight U.S. and 15 host country institutions. See Appendix A.

Table 6-1. Long-term degree training participants by country, FY 2008

Country	Doctorate		Master's		Bachelor's		Total
	Men	Women	Men	Women	Men	Women	
Australia	1						1
Bolivia	3	1	6	6	11	9	36
Canada		2					2
Colombia				1			1
Ecuador	2		3	1	2	2	10
India	1						1
Indonesia		1	1	1			3
Kenya		1					1
Korea	1						1
Peru		1	4	4	1		10
Philippines	2	1	1	2			6
Thailand		1					1
Uganda		1					1
USA	4	8	1	3			16
Vietnam					1	4	5
Zambia				2			2
Zimbabwe		1					1
Total	14	18	16	20	15	15	98

Short-term training

SANREM CRSP partners held 156 short-term training events serving more than 11,118 people, including 5,690 women. Training events were held in 11 countries.

Training included 13 field days that introduced new and alternative conservation technologies to more than 7,392 people, including 4,034 women. Nine seminars addressed 383 people, including 131 women. Of 281 people participating in 20 short courses, 92 were women. Also, 103 workshops were held serving more than 2,913 people; at least 1,118 of them were women. Ten focus groups involved 94 men and 53 women. (For a full accounting of these training events, see Appendix A.)

Table 6-2. Short-term training participants by country, FY 2008

Country	Women	Men	Total
Bolivia	756	1,265	2,021
Ecuador	256	513	769
Indonesia	136	254	443
Kenya	95	183	278
Mexico	4	7	11
Peru	165	219	384
Philippines	25	17	42
Uganda	26	68	94
USA	2	1	3
Zambia	3,963	3,263	7,226
Total	5,428	5,690	11,118

7. Appendixes

A: Training participants, FY 2008

Table 7-1. Degree training

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) supported	Sandwich program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI	University or degree-granting institution
						Start date	End date	Degree	SANREM CRSP	Non-SANREM CRSP		
Duong Tran Lan Anh	F	Vietnamese	Agronomy	Vietnam	N	Sep 05	Sep 09	BS	Y	Y	LV Du	Nong Lam University
Edwin Chela	M	Ecuador	Soil Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Valverde	Univ de Bolivar
Eugenia Núñez	F	Ecuador	Social Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Barrera	Univ de Bolivar
Juan Pablo Peñaloza	M	Bolivia	Agronomy	Bolivia	N	Jul 08	Oct 08	BS	Y	N	Saavedra	UMSS
Le Van Nhu	M	Vietnam	Agronomy	Vietnam	N	Jan 08	Dec 08	BS	Y	Y	Le Van Du	Nong Lam University
Luong Thi Bich Van	F	Vietnam	Ag Economics	Vietnam	N	Sep 04	Dec 07	BS	Y	Y	LV Du, DT Ha	Nong Lam University
Marta Gonzalez	F	Ecuador	Social Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Barrera	Univ de Bolivar
Moazir Celleri	M	Ecuador	Social Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Barrera	Univ de Bolivar
Nguyen Thi Hien	F	Vietnamese	Agronomy	Vietnam	N	Sep 05	Sep 09	BS	Y	Y	LV Du	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
Richard Sánchez	M	Bolivia	Economics	Bolivia	N	Aug 07	Mar 08	BS	Y	N	Amaya, Botello	UNITEPC
Emily Steubing	F	USA	Vet Med	Zambia	N	May 08	Sep 09	DVM	Y	Y	Travis	Cornell
Antonio Paz Arcani	M	Bolivian	Agronomy	Bolivia	N	Nov 06	Aug 07	ING	Y	N	Peñaranda/Ruíz	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) supported	Sandwich program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI	University or degree-granting institution
						Start date	End date	Degree	SANREM CRSP	Non-SANREM CRSP		
Blas Mamani Vargas	M	Bolivian	Soil Science	Bolivia	N	Oct 06	Sep 08	ING	Y	N	R. Miranda	UMSA
Carlos Cladera	M	Bolivian	Soil Science	Bolivia	N	Oct 07	Sep 08	ING	Y	N	Miguel A. Gonzales	UMSA
Claudia Jarandilla	F	Bolivian	Plant Pathology	Bolivia	N	Sep 06	Mar 08	ING	Y	N	Miguel A. Gonzales	UMSA
Dora Aguilar Endara	F	Bolivian	Agronomy	Bolivia	N	Sep 07	Mar 08	ING	Y	N	Cusicanqui/Pascuali	UMSA
Eliceo Tangara	M	Bolivian	Soil Science	Bolivia	N	Sep 06	Sep 07	ING	Y	N	Javier Aguilera	UMSA
Elvio Herrera Aruquipa	M	Bolivian	Soil Science	Bolivia	N	Oct 06	Sep 07	ING	Y	N	R. Miranda	UMSA
Jorge Pretel	M	Peruvian	Statistics	Peru	N	Mar 06	Sep 07	ING	Y	N	Karen Garrett	UNALM
Juan Sipe	M	Bolivian	Soil Science	Bolivia	N	Oct 07	Sep 08	ING	Y	N	Miguel A. Gonzales	UMSA
Julio Sarmiento Vargas	M	Bolivian	Agronomy	Bolivia	N	Nov 06	Aug 07	ING	Y	N	Cusicanqui/Cruz	UMSA
Marcos Willy Quispe	M	Bolivian	Soil Science	Bolivia	N	Oct 07	Sep 08	ING	Y	N	R. Miranda	UMSA
Milan Mamani	M	Bolivian	Biodiversity	Bolivia	N	Sep 06	Sep 07	ING	Y	N	Miguel A. Gonzales	UMSA
Miriam Gomez	F	Bolivian	Plant Pathology	Bolivia	N	Sep 06	Sep 07	ING	Y	N	Miguel A. Gonzales	UMSA
Nelly Calle Kantuta	F	Bolivian	Agronomy	Bolivia	N	Nov 06	Aug 07	ING	Y	N	Peñaranda/Ruíz	UMSA
Viviana Vera	F	Bolivian	Plant Pathology	Bolivia	N	Oct 07	Sep 08	ING	Y	N	Miguel A. Gonzales	UMSA
Angélica Quenta Callisaya	F	Bolivian	Agronomy	Bolivia	N	Sep 08	Sept 09	Lic	Y	N	Elizabeth Jiménez	UMSA
Betty Cruz	F	Bolivian	Agronomy	Bolivia	N	Nov 07	Jan 08	Lic	Y	Y	Jorge Cusicanqui	UMSA
Sonia Tola	F	Bolivian	Plant Pathology	Bolivia	N	Nov 07	Sep 08	Lic	Y	N	Jorge Cusicanqui	UMSA
Teresa Canaviri	F	Bolivian	Agronomy	Bolivia	N	Nov 07	Sep 08	Lic	Y	N	Garrett/Cusicanqui	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) supported	Sandwich program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI	University or degree-granting institution
						Start date	End date	Degree	SANREM CRSP	Non-SANREM CRSP		
Isidra Bagares	F	Filipino	PublicPolicy	Philippines	N	Jun 08	May 09	MPA	Y	Y	Agnes C. Rola	UPLB
Nadezda Amaya	F	Bolivia	Economics	Bolivia	Y	Aug 07	Dec 09	MS	Y	N	Alwang	Virginia Tech
Alejandro Romero	M	Bolivian	Rural Development	Bolivia	N	Apr 08	Apr 09	MS	Y	N	Elizabeth Jiménez	CIDES - UMSA
Carolla Chambilla	F	Bolivian	Agroecology	Bolivia	Y	Jun 08	Jun 10	MS	Y	N	Peter Motavalli	UMSS
Griselda Gonzales	F	Bolivian	Rural Development	Bolivia	N	Apr 07	Apr 09	MS	Y	N	Elizabeth Jiménez	CIDES - UMSA
Miguel A. Gonzales Aldana	M	Bolivian	Plant Pathology	Bolivia	N	May 07	May 09	MS	Y	N	Karen Garrett	UNALM
Mirco Peñaranda	M	Bolivian	Water Resources	Bolivia	N	Jul 08	Jun 10	MS	Y	N	Jorge Cusicanqui	UMSA
Olga Yana (UC)	F	Bolivian	Sociology	Bolivia	N	Sep 06	Sep 08	MS	Y	Y	Elizabeth Jiménez	Univ de la Cordillera
Porfidia Ajata (UC)	F	Bolivian	Economics	Bolivia	N	Sep 06	Oct 08	MS	Y	N	Elizabeth Jiménez	UNALB
Romulo Torrez	M	Bolivian	Soil metagenomics	Bolivia	N	Aug 08	Sep 09	MS	Y	N	Garrett/Miranda	UMSA
Edwin Yucra	M	Bolivian	GIS Climate	USA	N	Sep 07	Dec 09	MS	Y	N	Jere Gilles	UMSA
Freddy Navia	M	Bolivian	GIS Landscape	USA	N	Sep 07	Dec 09	MSc	Y	N	Jere Gilles	UMSA
Lorena Gomez	F	Colombian	Soil metagenomics	USA	N	Jan 08	Sep 09	MS	Y	N	Karen Garrett	Kansas State
Carlos Montúfar	M	Ecuador	Environmental Sci	Ecuador	N	Aug 08	Mar 10	MS	Y	Y	Barrera	Universidad SEK
Luis Escudero	M	Ecuador	Agronomy	Ecuador	N	Aug 08	Jul 10	MS	Y	N	Barrera	Univ Cotopaxi
Robert Andrade	M	Ecuador	Economics	Ecuador	N	Aug 06	Aug 08	MS	Y	Y	Alwang	Virginia Tech
María Figueroa	F	Ecuadorian	AgEconomics	Ecuador	N	Sep 06	Aug 08	MS	Y	Y	C. Valdivia	Univ of Missouri
Andre Quiray	M	Filipino	Environmental Sci	Philippine	N	Jun	Mar	MS	Y	Y	Ma. Victoria Espaldon	UPLB

				s		08	09					
Charmaigne Pailagao	F	Filipino	Environmental Sci	Philippines	N	Jun 08	Mar 09	MS	Y	Y	Ma. Victoria Espaldon	UPLB
Juang G. Kartika	F	Indonesia	Horticulture	Indonesia	N	mmm 06	mmm 08	MS	Y	N	Anas D. Susila	Bogor Ag Univ
Tisna Prasetyo	M	Indonesia	Horticulture	Indonesia	N	mmm 08	mmm 10	MS	Y	N	Anas D. Susila	Bogor Ag Univ
Alex Fernandez	M	Peruvian	Ag innovation	Peru	N	Mar 08	Sep 09	MS	Y	N	Edith Fernandez Baca	UNALM

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) supported	Sandwich program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI	University or degree-granting institution
						Start date	End date	Degree	SANREM CRSP	Non-SANREM CRSP		
Christian Candela	M	Peruvian	Ag innovation	Peru	N	Mar 07	Sep 09	MS	Y	N	Edith Fernandez Baca	UNALM
Clovis Bailon Flores	M	Peruvian	Ag innovation	Peru	N	Mar 07	Dec 08	MS	Y	N	Silvana Vargas	UNALM
Doris Bartolo	F	Peruvian	Ag innovation	Peru	N	Mar 07	Dec 08	MS	Y	N	Silvana Vargas	UNALM
Jenny Choque Flores	F	Peruvian	Ag Innovation	Peru	N	Mar 07	Dec 08	MS	Y	N	Jan Flora	UNALM
Olga Rita Quispe	F	Peruvian	Ag innovation	Peru	N	Mar 08	Sep 09	MS	Y	N	Edith Fernandez Baca	UNALM
Pedro Camacho	M	Peruvian	Ag innovation	Peru	N	Mar 08	Sep 09	MS	Y	N	Edith Fernandez Baca	UNALM
Rubi Raymundo	F	Peruvian	Plant Pathology	Peru	N	Aug 06	Aug 07	MS	N	N	Forbes/Garrett	UNALM
Helen Villanueva	F	Peruvian	Biology	Peru	N	Nov 06	Nov 08	MSc	Y	N	Karen Garrett	UNMSM
Sally Walker	F	USA	BSE	Bolivia	N	mmm 08	mmm 09	MS	Y	Y	Heatwole	Virginia Tech
Mike Castelhano	M	USA	Economics	Ecuador	N	Aug 06	Aug 08	MS	Y	Y	Alwang	Virginia Tech
Erin Frank	F	USA	Plant Pathology	USA	N	Aug 07	Sep 07	MS	Y	Y	Karen Garrett	Kansas State
Chisha Chungu	F	Zambian	Gender	Zambia	N	Jan 08	Sep 08	MS	Y	Y	Eloundou-Enyegue/Katundu-Liatto	Univ of Zambia
Nahunda Katoma	F	Zambian	Sociology	Zambia	N	Oct	Sep	MS	Y	N	Eloundou-Enyegue	Univ of Zambia

						07	09					
Samuel Bell	M	Australian	Applied Econ	Zambia	N	Sep 05	May 10	PhD	Y	Y	Schulze	Cornell
Javier Osorio	M	Bolivia	BSE	Andes	N	Jan 07	Dec 09	PhD	N	Y	Wolfe	Virginia Tech
Diego Pacheco	M	Bolivia	Political Science	Bolivia	N	Sep 02	Apr 07	PhD	Y	Y	E. Ostrom	Indiana University

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) supported	Sandwich program (Y/N)	Program			Funding ($)		SANREM CRSP Advisor/PI	University or degree-granting institution
						Start date	End date	Degree	SANREM CRSP	Non-SANREM CRSP		
Patricia Uberhuaga	F	Bolivia	Economics	Bolivia	N	Aug 05	Dec 08	PhD	Y	Y	P. Pacheco (CIFOR)	Royal Vet & Ag Univ-Den.
Javier Aguilera Alcón	M	Bolivian	Soil Science	Bolivia	N	Aug 06	Sep 10	PhD	Y	Y	Peter Motavalli	Univ of Missouri
Catherine LaRochelle	F	Canada	Economics	Andes	N	Aug 06	Aug 09	PhD	Y	Y	Alwang	Virginia Tech
Pam Jagger	F	Canada	Political Science	Uganda	N	Sep 03	Sep 08	PhD	Y	Y	E. Ostrom	Indiana University
Raul Jaramillo	M	Ecuador	Soils-Horticulture	Ecuador	N	Jun 06	Jun 08	PhD	Y	Y	Lynch	Penn State
Victor Barrera	M	Ecuador	Social Science	Ecuador	Y	Aug 06	Nov 08	PhD	Y	Y	Alwang	Univ de Madrid
Nelsa J. Olila	F	Filipino	Ag Economics	Philipines	N	Jan 08	Mar 09	PhD	Y	Y	Victor B. Ella	Central Mindanao Univ
Nathaniel R. Albuyog	M	Filipino	Ag Engineering	Philippine s	N	mmm 07	mmm 08	PhD	Y	Y	Victor B. Ella	UPLB
Anurag Mishra	M	Indian	BSE	Global	N	Aug 05	Sep 08	PhD	Y	Y	Benham/Mostaghimi	Virginia Tech
Tin Herawati	F	Indonesia	Consumer Sci	Indonesia	N	Aug 08	May 11	PhD	Y	Y	Tricoesoemaningtyas	Bogor Ag Univ
Lydiah Gatere	F	Kenyan	Soil & Crop Science	Zambia	N	May 06	May 10	PhD	Y	Y	Lehmann	Cornell
Younggu Her	M	Korea	BSE	Global	N	mmm 07	mmm 10	PhD	Y	N	Heatwole	Virginia Tech

Cecilia Turin Canchaya	F	Peruvian	Rural Sociology	USA	N	Aug 07	Dec 10	PhD	Y	Y	Jere Gilles	UNALM
Bunjirtluk Jintaridth	F	Thai	Soil Quality	Bolivia	N	Aug 07	Sep 09	PhD	Y	N	Motavalli	Univ of Missouri
Evelyn Lwanga	F	Uganda	Political Science	Uganda	N	Aug 01	Dec 08	PhD	Y	N	E. Ostrom	Indiana University
Rachel Melnick	F	USA	Plant Pathology	Andes	N	Jun 06	Jun 09	PhD	Y	Y	Backman	Penn State
Amy Duchelle	F	USA	Forestry	Bolivia	N	Aug 03	Jun 08	PhD	Y	Y	P. Pacheco (CIFOR)	Univ of Florida
Anissa Polatewich	F	USA	Plant Pathology	Bolivia	N	Sep 07	Dec 09	PhD	Y	Y	Backman	Penn State
						Program			Funding ($)			
STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) supported	Sandwich program (Y/N)	Start date	End date	Degree	SANREM CRSP	Non-SANREM CRSP	SANREM CRSP Advisor/PI	University or degree-granting institution
Amelia Henry	F	USA	Soils-Horticulture	Ecuador	N	Jun 06	Jun 08	PhD	Y	Y	Lynch	Penn State
Adam Sparks	M	USA	Plant Pathology	Global	N	Jan 07	Apr 09	PhD	N	Y	Karen Garrett	Kansas State
Forrest Fleischmann	M	USA	Public Policy	Global	N	Sep 07	May 12	PhD	Y	Y	E. Ostrom	Indiana University
Shauna P. Dendy	F	USA	Plant Pathology	USA	N	Jun 06	May 07	ND	Y	Y	Karen Garrett	Kansas State
Jeanne Thibeault	F	USA	Climate/Geography	USA	N	Aug 06	Aug 09	PhD	Y	Y	A. Seth	Univ of Connecticut
Justin Thomas M.	M	USA	Rural Sociology	USA	N	Sep 07	Sep 09	PhD	Y	Y	Jere Gilles	Univ of Missouri
Lisa Rees	F	USA	Ag Economics	USA	N	Jun 06	Aug 09	PhD	Y	Y	Valdivia/Marks	Univ of Missouri
Gustavo Garcia Lopez	M	USA	Political Science	Mexico	N	Aug 05	May 10	PhD	Y	Y	E. Ostrom	Indiana University
Vongai Kandiwa	F	Zimbabwean	Dev Sociology	Zambia	N	Sep 04	Jul 09	PhD	Y	Y	Eloundou-Enyegue	Cornell

Table 7-2. Non-degree training

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
Bolivia						
Seminar	Dec 2007	Umala municipal authorities and representatives of the participatory communities	37	8	PROINPA	Diffusion of results about potato pests and quinoa
Seminar	Jan 2008	Umala communities	36	9	PROINPA	Training farmers on Integrated Management of Crops quinoa
Seminar	Feb 2008	Umala communities	36	9	PROINPA	Agroecological analysis
Seminar	Feb 2008	Umala communities	36	9	PROINPA	Pheromones practices (plagues quinoa and potato)
Seminar	Jan 2008	4 Communities	40	35	PROINPA	Formation of the committees for commercialization.
Seminar	Feb 2008	4 Communities	40	35	PROINPA	Teach farmers about negotiation techniques to commercialize their products in the communities.
Seminar	Mar 2008	4 Communities	10	5	PROINPA	Strengthen the committees.
Seminar	October 2008	SANREM researchers	13	18	Universidad de la Cordillera and SANREM Gender Coordinator (Virginia Tech)	To introduce and explore the conceptual basis for the study of gender, sustainable development and participative management of natural resources.
Short Course	Nov 2007	Graduate students working with household survey data base	1	3	Universidad de la Cordillera	Introduction to SPSS Quantitative approaches to SSCC research
Short Course	Nov 2007	Graduate students working with household survey data base	1	3	Universidad de la Cordillera	Use of SPSS for descriptive statistics to analyze the household surveys
Short Course	Dec 2007	Graduate students working	1	3	Universidad de la	Regression analysis techniques to

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
		with household survey data base			Cordillera	analyze the household surveys
Short course	Dec 2007	Graduate students working with household survey data base	1	3	Universidad de la Cordillera	Cluster analysis techniques to analyze the household surveys
Short Course	Jan 2008	Doctoral students CIDES UMSA	4	5	J. Gilles, University of Missouri Columbia	Participatory research, networks, knowledge systems
Short course	Feb. Mar. 2008	Four communities Ancoraimes	55	35	Universidad Mayor San Andrés	Training on handling chemicals in agriculture
Short course	August 4th, 11th, 18th, and 25th September 1st, 8th, 15th, 29th and October 2th and 8th	Students that will be working on "market coalitions"	1	3	Universidad de la Cordillera	Review and assess current literature on markets, market integration and associations of small-scale rural producers for commercialization.
Workshop	Oct. and Jan. 2008	Chinchaya	6		Universidad Mayor San Andrés	Water balance in the Chojñapata Watershed: management plan formulation
Workshop	Oct 2007	Communities	36	9	PROINPA	Quantify the different weevil species
Workshop	Nov 2007	Project Students SANREM (PROINPA, UMSA, IPPS)	4	1	PROINPA	Train students to identify the potato weevil and setting of traps
Workshop	Nov 2007	La Paz Team Farmer Knowledge Sharing Plan	6	7	Valdivia and Jimenez	Identify products, methods, and assessment procedures

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
					At UMSA La Paz	
Workshop	Nov. 2007	National Advisory Committee	7	1	CERES / U. Colorado	Trained NAC members and others in community forestry and institutional analysis principles
Workshop	Nov 2007	4 Communities	40	35	PROINPA	Plague training
Workshop	Dec 2007	4 Communities	40	35	PROINPA	Soil training
Workshop	Dec 2007	Technicians of social institutions	12	8	PROINPA	Training on social committees for commercialization.
Workshop	Jan 2008	Students UMSA	12	3	PROINPA	Capacitating of students in participative evaluations
Workshop	Jan-Mar 2008	Foresters	2	0	CERES	Trained in IFRI forest data protocol
Workshops	Feb 2008	Ancoraimes, Chinchaya	8	5	Universidad Mayor San Andrés	Participatory evaluation on soils
Workshop	Feb 2008	4 Communities	40	35	PROINPA	Assess knowledge in communities.
Workshop	Mar 2008	4 Communities	40	35	PROINPA	Assess the adoption of technologies.
Workshops	Apr 2008	Ancoraimes, Chinchaya	35	15	Universidad Mayor San Andrés	Participatory evaluation on soils, pests and soil fertility
Workshops	Apr 2008	Ancoraimes, Calahuancani	20	10	Universidad Mayor San Andrés	Participatory evaluation on soils, pests and soil fertility
Workshops	Apr 2008	Ancoraimes four communities	68	42	Universidad Mayor San Andrés	Participatory Maps Assessment
Workshop	Apr 2008	Ancoraimes four Communities	68	42	Universidad Mayor San Andrés	Sharing knowledge on pests, soils, biodiversity and climatology
Workshop	Jan-Mar 2008	Foresters	2	0	CERES	Trained in IFRI forest data protocol

Program type (workshop, seminar, field day, short course)	**Date**	**Audience**	**Number of participants**		**Training provider** (U.S. university, host country institution)	**Training objective**
			Men	**Women**		
Workshop	Apr-Jun 2008	Residents and other stakeholders in Site #5 (Symae)	56	27	CERES	Trained residents in data collection techniques, outlined expectations for site visit; data gathering
Workshop	Apr-Jun 2008	Residents and other stakeholders in Site #4(San Isidro)	22	0	CERES	Trained residents in data collection techniques, outlined expectations for site visit; data gathering
Workshop	Apr-Jun 2008	Residents and other stakeholders in Site #6(provided through cost share—Tariquia)	18	15	CERES	Trained residents in data collection techniques, outlined expectations for site visit; data gathering
Workshop	May 2008	Umala Communities	40	-	PROINPA	Interest the community in promoting the resources the community has
Workshop	June 2008	Entire SANREM Bolivian team and new students who will be working on "markets and market coalitions"	15	12	Universidad de la Cordillera, and PROINPA	(1) to present and analyze regional experiences on commercialization of potatoes (2) to identify the methodological approach that will be used for developing "market coalitions" in Umala and Ancoraimes
Workshop	12 April 08	Farmers	24	16	PROMIC, Bolivia	Land use planning advantages
Workshop	27 April 08	Farmers	20	16	PROMIC Bolivia	Land use planning advantages
Workshop	10 May 08	Farmers	21	24	PROMIC Bolivia	Land use planning activities
Workshop	25 May 08	Farmers	26	**34**	PROMIC Bolivia	Land use planning activities
Workshop	7 July 08	Farmers	24	21	PROMIC Bolivia	Soil conservation advantages
Workshop	20 July 08	Farmers	19	24	PROMIC Bolivia	Soil conservation advantages
Workshop	17August 08	Farmers	25	9	PROMIC Bolivia	Soil conservation practices
Workshop	25August 08	SANREM partners (Tiraque, Ancoraimes)	8	4	PROMIC – LHUMSS	Basic concepts in watershed modeling

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
					Bolivia	
Workshop	31August 08	Farmers	19	22	PROMIC Bolivia	Soil conservation practices
Workshop	Aug 20	UMSA, PROINPA and other students and faculty	25	22	Kansas State University, Universidad Mayor de San Andrés (UMSA)	Introduce collaborators and other interested students to soil metagenomics and the SANREM project objectives
Workshop	Sep 08	Farmers	9	13	PROMIC Bolivia	Soil conservation practices
Workshop	Sep 08	Farmers	7	10	PROMIC Bolivia	Soil conservation practices
Workshop	9/2008	PROINPA staff and others	14	12	VA Tech	Watershed modeling
Workshop	9/2008	Local and regional governments, local stakeholders, Tiraque, Bolivia	8	7	VA Tech	Watershed management
Workshop	October 2008	Graduate students on charge of case studies on Bolivia and two SANREM researchers from Ecuador on charge on gender case studies in Ecuador	7	2	Universidad de la Cordillera and SANREM Gender Coordinator (Virginia Tech)	To assess the findings of the Seminar on Gender and management of natural resources on the light of gender case studies to carry out
Ecuador						
Field day	12/12/2007	Farmers	62	40	INIAP Ecuador	Implementation of activities of soil conservation and alternatives production
Field day	19/12/2007	Farmers	21	1	INIAP Ecuador	Training in natural resource management and soil conservation
Field Day	26/03/2008	Farmers	27	14	INIAP Ecuador	Training in management systems silvopastoriles
Short Course	20/12/2007	Technical team INIAP	10	2	INIAP Ecuador	Using geographic information systems

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
Short Course	21/01/2008	Professionals INIAP and partners	18	6	INIAP Ecuador	Planning participatory management of the watershed of the Chimbo river
Short Course	22/01/2008	Strategic partners	18	5	INIAP Ecuador	Planning participatory management of the watershed of the Chimbo river
Short Course	26/05/2008	Strategic partners	11	5	INIAP – UEB Ecuador	Training in GIS teachers from the UEB. First meeting
Short Course	15/07/2008	Strategic partners	11	5	INIAP – UEB Ecuador	Training in GIS teachers from the UEB. Second meeting
Short Course	23/07/2008	Farmers	20	5	INIAP Ecuador	Establishment and maintenance of pastures
Workshop	11/2007	INIAP staff and Ecuador Government	15	12	VA Tech	Watershed management
Workshop	11/2007	Local and regional governments, local stakeholders, Guaranda Ecuador	8	7	VA Tech	Watershed management
Workshop	01/02/2008	Farmers	12	2	INIAP Ecuador	Training in management and planting of fruit trees
Workshop	01/03/2008	Farmers	12	4	INIAP Ecuador	Analysis of physical vulnerability in the pilot units
Workshop	22/01/2008	Authorities	17	3	INIAP – HCPB Ecuador	Socialization of project activities to local authorities
Workshop	16/06/2008	Farmers	20	8	INIAP Ecuador	Training in Integrated Pest Management in the cultivation of beans. First meeting in the watershed of the Alumbre river.
Workshop	07/2007	Farmers	27	5	INIAP Ecuador	Management natural resources and biodiversity
Workshop	07/2007	Farmers	13	12	INIAP Ecuador	Training in Integrated Pest Management in the cultivation of beans. Third meeting in the watershed

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
						of the Alumbre river
Workshop	30/06/2008	Farmers	22	12	INIAP Ecuador	Training in Integrated Pest Management in the cultivation of beans. Second meeting in the watershed of the Alumbre river
Workshop	03/07/2008	Farmers	14	5	INIAP Ecuador	Socialization of the program activities
Workshop	09/07/2008	Farmers	16	**5**	INIAP Ecuador	Training in Integrated Management of tomato in the watershed of the Alumbre river
Workshop	22/07/2008	Farmers	19	10	INIAP Ecuador	Training on gender and natural resource management. Watershed of the Illangama river
Workshop	23/07/2008	Farmers	19	8	INIAP Ecuador	Training in management pastures in the watershed of the Illangama river
Workshop	23/07/2008	Farmers	13	26	INIAP Ecuador	Training on gender and natural resource management. Watershed of the Alumbre river
Workshop	24/07/2008	Farmers	13	17	INIAP Ecuador	Training on gender and natural resource management. Watershed of the Alumbre river
Workshop	31/07/2008	Strategic partners	11	5	INIAP Ecuador	Socialization of the baseline program to the players in the watershed of the Chimbo river
Workshop	06/08/2008	Farmers	18	6	INIAP Ecuador	Training in fruit cultivation. Watershed of the Alumbre river
Workshop	07/08/2008	Farmers	18	9	INIAP Ecuador	Training in Integrated Management of corn. Watershed of the Alumbre river
Workshop	27/08/2008	Farmers	17	11	INIAP Ecuador	Training in seed identity. Watershed of the Illangama river
Workshop	28/08/2008	Farmers	11	6	INIAP Ecuador	Training in seed identity. Watershed

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
						of the Alumbre river
Indonesia						
Focus Group	19 January 2008	Farmer sample for Participatory Research	8	-	T team of Indonesian TMPEGS-Bogor Agricultural University	Introduce participatory research program at farmer site
Focus Group	24 February 2008	Farmer group	6	2	T team of Indonesian TMPEGS-Bogor Agricultural University	Intoducing *A. Pintoi* as cover crop
Focus Group	1 March 2008	Farmer sample for Participatory Research	4	-	T team of Indonesian TMPEGS-Bogor Agricultural University	Introducing Low cost Drip irrigation system
Focus Group	7-8 April 2008	Small-scale farmers both Women and Men, agricultural extension agents of Nanggung sub district, Bogor, Indonesia, IPB Gender's Team and ICRAF's staff.	20	10	World Agroforestry Centre (ICRAF) SEA Regional Office	5. To maintain farmers, market agents and other stakeholders' interest on SANREM Project. 6. To disseminate and receive feedback from the farmer's group regarding progress of Vegetables Production Plots in three different villages in Nanggung, Indonesia.
Focus Group	6,7,8,13,14 April 2008	Research result discussion with the farmer for : Optimum Fertilizer Application rate	12	-	T team of Indonesian TMPEGS-Bogor Agricultural University	To obtain feed back of the participatory research from the farmer
Focus Group	13,14,	Research result discussion	10	-	T team of	To obtain feed back of the

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
	20,21 April 2008	with the farmer for : A. Pintoi study			Indonesian TMPEGS-Bogor Agricultural University	participatory research from the farmer
Focus Group	25 April 2008	Women farmers of the Bhakti Tani group from Hambaro	-	11	Gender Team – BAU Marketing Team- ICRAF	1. To understand and strengthen existing women organization 2. To improve women participation in VAF by providing access to production inputs through revolving loan
Focus Group	3,4 May 2008	Research result discussion with the farmer for : Low cost drip irrigation system	9	-	T team of Indonesian TMPEGS-Bogor Agricultural University	To obtain feed back of the participatory research from the farmer
Focus Group	31 July 2008	Women leaders, Members of the women farmer group	-	25	Gender Team – BAU Facilitator from Situ Gede	To understand and strengthen existing women organization
Study Tour	22 January 2008	Small-scale farmers both Women and Men, agricultural extension agents of Nanggung sub district, Bogor, Indonesia and ICRAF's staff.	25	5	World Agroforestry Centre (ICRAF) SEA Regional Office	5. To improve farmers' knowledge and skill in good management of VAF. 6. To encourage farmers, discuss and learn about success story from the success farmers. 7. To get idea and replicate the good practice management of VAF in farmer village's origin. 8. To capture potential market, to collect marketing information and

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
						to see possibility in making collaboration.
Workshop	October 2007	TMPEGS TEAM	10	15	Indonesian TMPEGS TEAM	Program consolidation
Workshop	29January 2008	Women farmer	-	6	T team of Indonesian TMPEGS-Bogor Agricultural University	To improve farmer capability in producing the best vegetable transplant
Workshop	10 February	Farmer sample for Participatory Research	8	-	T team of Indonesian TMPEGS-Bogor Agricultural University	To introduce plot lay out and soil preparation for participatory research
Workshop	11 February	Farmer sample for Participatory Research	4	-	T team of Indonesian TMPEGS-Bogor Agricultural University	To improve farmer knowledge in fertilizer application
Workshop	8 March 2008	Farmer Group	8	2	T team of Indonesian TMPEGS-Bogor Agricultural University	To increase farmer capability to install low cost drip irrigation system
Workshop	9 March 2008	Farmer Group	9	2	T team of Indonesian TMPEGS-Bogor Agricultural University	To increase farmer capability to produce *A. Pintoi* transplant
Workshop	22 April 2008	Village officials, community leaders and	19	17	Gender Team-BAU	to increase awareness among village and subdistrict officers, and

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
		women leaders from Hambaro village				community leaders on different roles and responsibilities of women and men in VAF system including their different and unequal access to and control over resources
Workshop	2 June 2008	Small-scale farmers both Women and Men, local government (village and sub district officials), agricultural extension agents, students, and the Agency for the Implementation and Application of Technology's staffs (BPPT), IPB's team and ICRAF's staffs.	80	20	World Agroforestry Centre (ICRAF) SEA Regional Office	5. To improve the quality of VAF products as required by market. 6. To enhance farmers' knowledge and skill in post-harvest handling. 7. To increase farmers' marketing role and create value add. 8. To raise awareness amongst farmers and market actors.
Workshop	10 July 2008	Village officials, Community leaders Women leaders in Sukaluyu Village	22	13	Gender Team – BAU	to increase awareness among village and subdistrict officers, on different roles and responsibilities of women and men in VAF system including their different and unequal access to and control over resources
Workshop	8 Aug 2008	Leaders of the Simpan-Pinjam (saving and loans) group	-	8	Gender Team BAU Facilitator from Situ Gede	To facilitate women's participation in VAF by providing access to production inputs through revolving loan
Kenya						
Workshop	Oct-Dec 2007	Community members in Ramogi Hills (Site #5)	4	6	KEFRI	Trained in IFRI/SANREM data collection and PRA methods
Workshop	Oct-Dec	Community members in	49	34	KEFRI	To discuss expectations and

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
	2007	Ramogi Hills (Site #5), government officials, members of civil soc orgs				responsibilities under the New Forest Act, which focuses on community participation in forest management
Workshop	Apr-Jun 2008 (3 events)	Community members in site #6 (Arabuko Sokoke)	65	26	KEFRI	Trained residents in data collection techniques, outlined expectations for site visit; data gathering
Workshop	Apr-Jun 2008	Community members in site #6	5	2	KEFRI	Trained community members in SANREM data collection methods
Workshop	Apr-Jun 2008	Community members in site #6, government officials	18	12	KEFRI	Trained stakeholders in participatory forest management, management of natural resources
Workshop	Jul-Sep 2008	Community members in site #7	12	3	KEFRI	Trained community members in SANREM data collection methods
Workshop	Jul-Sep 2008	Community members in site #7	30	12	KEFRI	Trained stakeholders in participatory forest management, management of natural resources
Mexico						
Workshop	Jan-Mar 2008	Community members in Site 4 (Comaltepec)	3	0	UNAM	Trained community members in forest mensuration techniques
Workshop	Jan-Mar 2008	Grad/undergrad students	1	4	UNAM	Trained students in IFRI and data collection techniques
Workshop	Jul-Sep 2008	Community members at Site #5 (Mexico)	3	0	UNAM	To train local residents in data collection techniques so they can assist team during fieldwork
Peru						
Field Days	April 2008	Community members of Santa Maria	12	16	Universidad Nacional Agraria La Molina	To engage in field work as part aynokas research
Seminar	July 2008	Research team	4	3	Universidad Nacional Agraria La Molina	To share information and analysis paper research gender

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
Short course	Nov 2007	Researchers at graduate Innovation module Puno	3	3	Universidad Nacional Agraria La Molina	Advocacy Coalition Methodology
Short course	Feb 2008	Puno technical team	3	2	Universidad Nacional Agraria La Molina	To learn how to use SPSS
Workshop	Nov 2007	Puno and Lima Research team	4	5	Universidad Nacional Agraria La Molina	Adjust work and Discuss work plan for year 3
Workshop	Jan 2008	Community members of Apopata	20	22	Universidad Nacional Agraria La Molina	To train farmers on animal health issues
Workshop	Feb 2008	Stakeholders in Puno	12		Universidad Nacional Agraria La Molina	To inform stakeholders on progress made
Workshop	Feb 2008	Community members of Santa Maria	12	17	Universidad Nacional Agraria La Molina	To train farmers on the biological cycle of the Andean weevil
Workshop	March 2008	Community members Apopata	5	5	Universidad Nacional Agraria La Molina	To prepare for interviews with stakeholders
Workshop	June 2008	Community members of Apopata	32	-	Universidad Nacional Agraria La Molina	To return advocacy coalitions results to the community and discuss next steps
Workshop	June 2008	Community members of Santa Maria	4	-	Universidad Nacional Agraria La Molina	To coordinate work on mapping of natural resources in the community Santa María and to train veterinaries promoters.
Workshop	June 2008	Community members of Santa Maria	12	19	Universidad Nacional Agraria La Molina	To train in IPM practices

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
Workshop	June 2008	Santa Maria	11	14	Universidad Nacional Agraria La Molina	1st workshop to map natural resources and soils according to local perceptions
Workshop	July 2008	Research team	3	3	Universidad Nacional Agraria La Molina	To evaluation of advances of year 3
Workshop	July 2008	Soils Research team	1	1	Universidad Nacional Agraria La Molina	To evaluation of advances of the Aynokas research (meeting between Puno technical/research team and Lima research team)
Workshop	July 2008	Coalitions research team	1	1	Universidad Nacional Agraria La Molina	To evaluation of advances in the work coalitions in the community (meeting between Puno technical/research team and Lima research team)
Workshop	July 2008	Research team	1	1	Universidad Nacional Agraria La Molina	To train research team of Puno on development of project proposals
Workshop	July 2008	Santa Maria	4	-	Universidad Nacional Agraria La Molina	2nd workshop to map natural resources and soils according to local perceptions
Workshop	July 2008	Apopata	27	13	CONACS	To train community members on how to develop breeding plans
Workshop	August 2008	Community members Santa María	12	14	Universidad Nacional Agraria La Molina	To characterize soils (taxonomy)
Workshop	September 2008	Community members Apopata	32	14	Universidad Nacional Agraria La Molina	To follow-up on signing of agreements as part of formation of alliances
Workshop	September 2008	Community of Santa María	4	12	Universidad Nacional Agraria	Capacity building workshop for seed selection and monitoring of seed

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
					La Molina	storage directed towards group in the community that will engage in IPM research
Philippines						
Workshop	24 January 2008	Provincial and municipal government employees, irrigators, researchers	4	6	ICRAF (facilitator)	• Review of 2007 activities and accomplishments • Presentation of LEK-PEK survey results • Planning for 2008 activities
Workshop	15 April 2008	Municipal Planning and Development Officer, Municipal Agriculturist, Agricultural Technicians, Farmer, Facilitator, Researcher	6	9	ICRAF (facilitator)	• Identify appropriate incentives to promote sustainable farming • Develop incentive-based policies and mechanisms • Develop 5-yr plan on incentive-policy
Workshop	15 September 2008	Municipal Planning and Development Officer, Municipal Agriculturist, Agricultural Technicians, Policy-makers, Researcher	7	10	ICRAF (facilitator)	• Finalize the SFS Investment Plan, particularly financial plan and institutional arrangements for implementation • Present the draft Municipal Ordinance providing incentive-support to SFS • Develop action plan from September to December 2008
Uganda						
Short Course	Jan-Mar 2008	Grad/undergrad students	3	2	UFRIC	Trained in data entry and cleaning using Access
Short Course	Oct-Dec 2007	Graduate students	3	2	IU/CIFOR	Trained in data entry and cleaning in Access
Workshop	Oct-Dec	District officials involved	30	10	UFRIC	To strengthen leadership and

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
	2007	in NRM, local council members and forest association members in Rakai District (Mugomba and Mujanjabula)				management capabilities in local communities involved in collaborative forest management
Workshop	Jan-Mar 2008	Residents, local council members, forest assn members in Site 4 (Rakai District)	24	9	UFRIC	Comparing collaborative resource management under UWA-managed national park and collaborative forest management under NFA-managed forest reserves
Workshop	Jul-Sep 2008	Community members and local officials at Site #7	8	3	UFRIC	To strengthen leadership and management capabilities in local communities involved in collaborative forest management
USA						
Workshop	2/2008	SANREM partners	1	2	VA Tech	Watershed modeling and management techniques
Zambia						
Field days	October 2007	Producer group lead farmers	50	15	COMACO/WCS	Cassava production and processing
Field days	October-December, 2007	Farmers	114	257	COMACO/WCS, Cornell	Field training and agricultural research trial instruction
Field days	October 2007	Producer group lead farmers	27	18	COMACO/WCS	Training of producer group leaders in sustainable agriculture
Field days	May-June, 2008	Farmers	114	257	COMACO/WCS, Cornell	Winter maize and vegetable production
Field days	September, 2008	Extension officers, lead farmers and farmers	118	132	COMACO/WCS	Organic crop production
Field days	September-October	Farmers	665	882	COMACO./WCS	Training in compost making and conservation farming

Program type (workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (U.S. university, host country institution)	Training objective
			Men	Women		
	2007 and 2008					
Field days	May-September, 2008	farmers	575	768	COMACO/WCS, Cornell, and the International Rural Poultry Centre	Training of poultry producers in husbandry and management, including vaccination
Field days	June-August, 2008	Farmers	910	752	COMACO/WCS	Bee-keeping and honey collection
Field days	August-September, 2008	Farmers	665	882	COMACO/WCS	Training in crop diversification and agro-forestry (included rice, soybeans, groundnuts, cow peas, organic cotton, and cassava)
Short course	July and October, 2008	Professional poachers enrolled in the poacher transformation program	14	0	COMACO/WCS	Provide poachers with advanced carpentry training/career skills that will enable them to improve their incomes with an alternative career
Short course	September, 2008	COMACO agricultural extension specialists	3	0	Kasisi Institute	Training of trainers in organic cotton production
Short course	September 2008	ZAWA Deputy Unit leaders	8	0	COMACO/WCS	Train ZAWA extension officers in wildlife monitoring

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C: SANREM CRSP leveraged funding, FY 2008

Table 7-3. Leveraged funding, FY 2008

Brief description or title of activity being funded or supported[1]	Activity leader name	Activity leader institution	Funding period (start year end date)[2]	Source of funds or support[3]	Non-tracked funding or support contributing to SANREM activities[4] ($)	Funding or support for non-SANREM activities resulting from SANREM activities[5] ($)
2 additional site visits in Bolivia (IFRI and household data)	Leon	CERES	2007-09?	U. of Michigan, U. of Colorado	$ 37,000	
Mexico national survey—supplementary funds	Merino	UNAM	2006-2008?	CONACYT/ PROCYMAF	$ 76,533	
Ecuador watershed management	Barrera	INIAP	2007-2008	Ecuador government	$ 200,000	
USDA Linkage fund for research on Climate Change through CIP	Garrett	KSU	April 2007-April 2009	USDA		$ 50,000
Student Course with UNALM students at CIP	Garrett	KSU	Sept 2006-May 2008	NCEAS National Center for Ecological Analysis and Synthesis	$ 5,000	
Agricultural adaptation measures to climate change in Original Rural Communities in Ancoraimes	Miranda and Cusicanqui	UMSA	Mar 2007 – Oct 2008	United Nations Development Program UNDP – GEF		$ 30,000
Assessment of the retreat of glaciers and other global change impacts on the dynamics of peet bogs	Castañón and Cusicanqui	UMSA	Dec 2007 – Jan 2009	National Bolivian Climate Change National Program		$ 25,000

Brief description or title of activity being funded or supported[1]	Activity leader name	Activity leader institution	Funding period (start year end date)[2]	Source of funds or support[3]	Non-tracked funding or support contributing to SANREM activities[4] ($)	Funding or support for non-SANREM activities resulting from SANREM activities[5] ($)
(Humedales de Altura) in Ancoraimes.				PNCC		
El Enfoque de Medios de Vida Sostenible para el Desarrollo Agrícola y Rural	Turin and Condor	UNALM	May 2007	Henry A Wallace ISU Workshop	$ 3,490	
O. Yana participation in the International Conference of Indigenous Women and Global Climate Change (Seminario Internacional de Mujeres Indígenas y Cambo climático Global)	Jimenez	Universidad de la Cordillera	Sep 3-5 2007	Fundación Natura y Universidad Nacional de Colombia	$ 2,400	
Climate Projections Research for the Altiplano - 1 month of salary, benefits and foregone indirect	Seth	University of Connecticut	Four months Year 1 & 2; 1 month Year 3	U. Conn.	$ 54,000 $ 15,990	
Advocacy coalitions and sustainable agriculture with Universidad Nacional Agraria La Molina Peru - 6 weeks of faculty time (salaries benefits and foregone indirect)	Flora	Iowa State University	Every Year of the project	ISU	$ 40,000	
Presentation of paper on drip irrigation at the 2008 Annual International ASABE Conference, Providence, Rhode Island, USA, June 29 – July 2, 2008(roundtrip airfare)	Ella	University of the Philippines-Los Baños	June 29-July 2, 2008	DA-BAR	$ 1,613	
Presentation of paper on drip irrigation at the 2008 Annual	Ella	University of the	June 29-July 2,	SEARCA	$ 1,200	

Brief description or title of activity being funded or supported[1]	Activity leader name	Activity leader institution	Funding period (start year end date)[2]	Source of funds or support[3]	Non-tracked funding or support contributing to SANREM activities[4] ($)	Funding or support for non-SANREM activities resulting from SANREM activities[5] ($)
International ASABE Conference, Providence, Rhode Island, USA, June 29 – July 2, 2008 (conference registration and part of accommodation)		Philippines-Los Baños	2008			
Participation in the 3rd National Agroforestry Congress to present gender roles paper	Chiong-Javier	DLSU-SDRC	November 2007	Upland NGO Assistance Committee (UNAC)		$ 200
Agricultural Productivity and Environmental Externalities	Rola	Univ. of the Philippines-Los Baños	Nov. 2007-March 2009	SEARCA		$ 16,700
Visit to NCA&T and Virginia Tech	Saludadez	University of the Philippines-Open University	March 2008	Personal funds	$ 600	
Soil and Water Assessment Tool Workshop and Conference	Reyes	NCA&T	August 2007 to Jan. 2009	Workshop Sponsors (Several sources; including in-kind)	$ 5,000	
Visit of Nong Lam University top administrtors	Loi Nguyen Kim	Nong Lam University	December 2007	Vietnam government	$ 5,000	
Soil Quality training and *Arachis pintoi* review of literature	Juang Kita	Bogor Agricultural University	September – December	Indonesian government	$ 6,000	

Brief description or title of activity being funded or supported[1]	Activity leader name	Activity leader institution	Funding period (start year end date)[2]	Source of funds or support[3]	Non-tracked funding or support contributing to SANREM activities[4] ($)	Funding or support for non-SANREM activities resulting from SANREM activities[5] ($)
			2007			
Epidemiological modeling of multi-component systems	Garrett	KSU	2007-2009	CIP	$ 50,000	

[1] Do not include non-SANREM support for students as this is reported in the Form 16 Degree Training Table
e.g.: Assessment of small reservoirs in Botswana; Support for field technicians working on LTRA-6; Non-degree training activity: Training in groundwater monitoring, Kenya; Range Rover for use by the project
[2] e.g., 2005 to 2009
[3] Organization that provided the funding or support (e.g., NSF, USDA, FAO)
[4] Value (in USD) of non-SANREM funding or support obtained that contributes to SANREM activities and results. Does not include contractual cost-share. Can include funds or value of shared or donated equipment, personnel, student support/scholarships, facilities, or other services provided.
[5] Value (in USD) of non-SANREM funding or support obtained as a direct or indirect result of SANREM activities. Funding/support does not contribute directly to SANREM activities or reportable results.

Please return to Keith Moore (keithm@vt.edu) with other annual report tables

D: USAID Common Indicators for SANREM CRSP

Table 7-4. USAID Common Indicators

Indicator	Documentation (list each relevant item by indicator category)
New technologies/management practices under research	• Community Trading Centers (CTC) now operating with tracking of profit and cost centers • Food products tested for safety and quality • Conservation farming soil amendment technologies • New vaccination practices for poultry production • Soil quality indicator methods • Soil amendments corresponding to climate change conditions • Climate trends analysis to link with local knowledge and perceptions to develop information products on climate for agriculture in Altiplano ecosystems • Participatory management approaches for vulnerable groups • Approaches to increase human agency focusing on human, social and political capital strengthening • Information kits to predict pests/diseases dynamics due to climate change • Management of native potato varieties, oca and quinoa; • Coalition building for adaptation and for market integration • Vegetable agroforestry • Low cost drip irrigation • Indigenous vegetables and agroforestry • Evaluating leaf curl virus resistant tomato strain to revive tomato production in Northern Mindanao • Optimization of vegetable fertilization in Nanggung • Testing best spacing and planting density of indigenous vegetables in Nanggung • Plastic barrier for controlling competition in agroforestry systems • Fabrication and testing of animal drawn no-tillage vegetable seeders

	• Introduction of cacao trees in established cashew plantations • Vetiver grass for controlling termite destruction of young cacao seedlings • Vegetable home gardens under cashew under stories • Perennial peanut as a permanent cover crop for vegetable production • Simulation of agroforestry systems using the Soil and Water Assessment Tool model • The Rapid Market Appraisal (RMA) has been introduced and applied to Nanggung's farmers as a method to quickly collect market information • Gendered markets – potential that women play a key role in marketing vegetables • Stopping pesticide misuse in cashew plantations • Weed management on soil quality under cashew plantations • Improved fallow periods in Bolivia • Fertilization in Zambia • Management for mycorrhizae in Bolivia • Pyrosequencing technologies for characterizing soil microbial communities in tropical agricultural systems • 9 technologies including soil conservation, biocontrol of pests, and improved varieties in Bolivia and Ecuador
Technologies or management practices being field tested	• Conservation farming methods • Effects of COMACO's market linkages on biodiversity conservation • Testing global models of climate change for the Northern Altiplano • New vaccination practices for poultry production • Soil quality indicator methods • Soil amendment practices corresponding to climate change conditions in the Altiplano • Varieties of native potatoes and quinoa • Information formats for transferring climate trends and change in regional markets, pest dynamics and diseases at each sites • Landscape maps for planning • Participatory approaches (coalition building and collective action) to link to

	markets • Vegetable agroforestry • Low cost drip irrigation • Indigenous vegetables and agroforestry • Evaluating leaf curl virus resistant tomato strain to revive tomato production in Northern Mindanao • Optimization of vegetable fertilization in Nanggung • Testing best spacing and planting density of indigenous vegetables in Nanggung • Vetiver grass for controlling termite destruction of young cacao seedlings • Vegetable home gardens under cashew under stories • Perennial peanut as a permanent cover crop for vegetable production • Improved fallow periods in Bolivia • Fertilization in Zambia • Management for mycorrhizae in Bolivia • Pyrosequencing technologies for characterizing soil microbial communities in tropical agricultural systems • 7 technologies including soil conservation and improved varieties in Bolivia and Ecuador
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 • Conservation Farming Unit • Wildlife Conservation Society-Zambia • Universidad Mayor San Andres; • Universidad de la Cordillera; • Universidad Nacional Agraria La Molina; • Universidad Nacional del Altiplano; • PROINPA Foundation • Centro de Investigación y Promoción del Campesinado (CIPCA) • Adventist Development and Relief

	Agency (ADRA) • Save the Children • Programa Nacional de Cambio Climático (PNCC) • Servicio Nacional de Meteorología e Hidrología (SENAMHI) Bolivia • International Potato Center (CIP) ALTAGRO • Kebun Agromedika Hambaro (Hambaro Medicinal Plant Garden) • Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP) • EcoCiencia – Ecuador • Sistema de Información Georgráfica Agropecuaria (SIGAGRO) – Ecuador • Programa Manejo Integral de Cuencas (PROMIC)
Producer organizations, water user associations, trade and business associations & community based organizations assisted	• Kenya Tourism Board • TIM Ivirgarzama (indigenous user group, Bolivia) • Ogiek indigenous group (Mau forest, Kenya) • Got Ramogi Community Forest Conservation Trust (Kenya) • Friends of Lake Victoria (Kenya) • Community Markets for Conservation • Producer organizations in the communities of Vinto Coopani, Kellhuiri, San Jose Llanga, San Juan Circa, Chojñapata, Calahuancane, Cohani, Chinchaya and Karkapata in Bolivia, and Santa María and Apopata in Peru • Three farmer groups and one women's farmer group in the Philippines • Two producer associations in Guaranda, Ecuador • Producer association and a water management association in Tiraque, Bolivia
Technologies made available for transfer as a result of SANREM assistance	• Increasing vegetable yield through vegetable agroforestry • Vetiver grass for controlling termite destruction in young cacao seedlings • Vegetable fertilizer rate recommendations for several vegetables in Nanggung • Integrating cacao trees in established cashew plantations • Vegetable grafting • Low cost drip irrigation for vegetable

	production • Increasing income through indigenous vegetables • Postharvest handling of Katuk • Pyrosequencing technologies are being transferred to collaborators • 12 technologies including soil conservation, biocontrol of pests, and improved varieties in Bolivia and Ecuador
Policy reforms analyzed with SANREM assistance	• Uganda: Mabira Forest degazetting proposal • "The Policy Environment of Vegetable-Agroforestry System in the Philippines: Are there incentives for smallholders?" • Land use policy and irrigation policy in Tiraque, Bolivia • Land use policy, irrigation management policy and environmental policy in Ecuador
Policy reforms presented for legislation or decree as a result of SANREM Assistance	• Municipal Ordinance entitled "Providing an Incentive-Support System to Encourage Adoption and Investment in Sustainable Farming Systems in Lantapan, Bukidnon" • Articles 12 and 14 of the New Ecuadorian Constitution on universal water rights
Analytical studies of policies or institutions disseminated	• "The Policy Environment of Vegetable-Agroforestry System in the Philippines: Are there incentives for smallholders?" Forthcoming in *International Journal of Ecology and Development*. • "A New Method for Detecting Outliers in DEA." Forthcoming in *Applied Economics Letters*. • "Competing for Coffee Space: Development Induced Displacement in the Central Highlands of Vietnam." Forthcoming in *Rural Sociology*. • Coffee Boom, Coffee Bust, and Smallholder Response in Vietnam's Central Highlands. *Review of Development Economics* **12**(2):312-326. • "Linkages between Market Participation and Productivity: Results from a Multi-Country Farm Household Sample." Selected Poster, American Agricultural Economics Association Annual Meeting, Orlando, 27-29 July. • "The Economics of Pest Management in Smallholder Cocoa: Lessons from

	Sulawesi, Indonesia." West Lafayette (IN): Purdue University Department of Agricultural Economics *Staff Paper Series* No. 08-08. • "Viabilidad socio-econoómica y ambiental del sistema papa-leche en la microcuenca del río Illangama-Ecuador." presented at the Asociación Latinoamericana de Producción Animal. • "Evaluación de la pérdida de suelo por erosión hídrica en tres sistemas de producción en la microcuenca del rio Alumbre-Ecuador." Presented at the XI Congreso Ecuatoriano de la Ciencia del Suelo.

E: Acronyms

A-B

AC, ACF	advocacy coalitions, advocacy coalitions framework
ADRA	Adventist Development and Relief Agency International, Title II USAID
ASABE	American Society of Agricultural and Biological Engineers
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASFADA	Arabuko Sokoke Forest Adjacent Dwellers Association
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AVRDC	World Vegetable Center (formerly Asian Vegetable Research and Development Center)
BAP	Bolivian Andean Platform
BMP	best management practice

C-D

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; complementarity index
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
DRIFT	Diffuse Reflectance Fourier Transform Infrared Analysis

E-H

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
FAO	Food and Agriculture Organization of the United Nations
FFH	Food for the Hungry, Title II USAID
GIS	geographic information system

GPS	global positioning system
HEPS	high energy protein supplement

I-L

IAD	institutional analysis and development framework
IASC	International Association for the Study of the Commons
ICM	integrated crop management
ICRAF	International Centre for Research in Agroforesrty
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IDE	International Development Enterprise
IFPRI	International Food Policy Research Institute
IFRI	International Forestry Resources and Institutions
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias
IPCC	Intergovernmental Panel on Climate Change
IPM	integrated pest management
IPPS	El Instituto de la Pequeña Producción Sustentable
IRPC	International Rural Poultry Centre
ISU	Iowa State University
KASAP	knowledge, attitudes, skills, aspirations, practices
KEFRI	Kenya Forestry Research Institute
KSU	Kansas State University
LGU	local government unit
LRT	local research team
LTRA	Long-term Research Award

M-O

MAPA	Market Access and Poverty Alleviation Project, USAID
MARD	Ministry of Agricultural Research and Development
ME	Management Entity
MM	Manupali Model
MOSCAT	Misamis Oriental State College of Agriculture and Technology
NAC	national advisory council, national advisory committee
NARS	national agricultural research service
NCA&T	North Carolina Agricultural and Technical State University
NCEAS	National Center for Ecological Analysis and Synthesis
NCI	Net Complementarity Index
ND	Newcastle disease
NGO	non-governmental organization
NIR	near infrared
NLU	Nong Lam University
NPCC	Native Plant Conservation Campaign
NPVP	Native Potato Varieties Program
NRM	natural resource management
OSIENALA	Friends of Lake Victoria

P-R

PA	participatory appraisal
PEN	Poverty and Environment Network (at CIFOR)
PES	payments for environmental services
PFM	participatory forest management
PI	principal investigator
PMCA	participatory market chain approach
PNCC	Programa Nacional de Cambios Climáticos
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 appraisal

S-T

SA	sustainable agriculture
SANREM	sustainable agriculture and natural resource management
SEA	Southeast Asia
SENAMHI	Servicio Nacional de Meteorología e Hidrología del Perú
SIGAGRO	Sistema de Información Geográfica Agropecuaria
SKB	SANREM Knowledgebase
SLDF	Sabaot Land Defense Force
SNA	social network analysis
SRTM	Shuttle Radar Topography Mission
SSFWM	small-scale farmers, both women and men
STC	Save the Children, Title II USAID
SWAT	Soil and Water Assessment Tool
TMPEGS	technology, marketing, policy, environmental and socioeconomic impact, gender, scaling up
TOPS	targeting outcomes of programs
TSBF	Tropical Soil Biology and Fertility Institute

U

UC	University of California; Universidad de la Cordillera
UConn	University of Connecticut
UFRIC	Uganda Forestry Resources and Institutions Center
UMSA	Universidad Mayor San Andrés
UMSS	Universidad Mayor de San Simón
UNA	Universidad Nacional del Altiplano
UNALM	Universidad Nacional Agraria la Molina
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-Los Baños
USAID	United States Agency for International Development
USGS	United States Geological Survey

V-Z

VAF	vegetable agroforestry
VIDIN	vegetable agroforestry, introduction of indigenous and improved vegetables, drip irrigation, integrated pest management, no-tillage technologies
VSAT	very small aperture terminal
WAC	World Agroforestry Center
WCS	Wildlife Conservation Society
WFP	World Food Program
WVC	World Vegetable Center
ZAWA	Zambian Wildlife Authority