SANREM CRSP
Annual Report 2009

October 1, 2008 – September 30, 2009

Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

Report coordinators

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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. The systems-based 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. Gender sensitivity is integral to the SANREM CRSP approach and reinforced by gender-sensitive participant training programs that include degree and non-degree plans. All activities link SA and NRM with the economic concerns of local populations and the promotion of good governance. This annual report covers SANREM CRSP Phase III findings and accomplishments from October 1, 2008 through September 30, 2009.

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 2009 (FY2009) include the following. Additional details on SANREM CRSP knowledge products are provided in B. SANREM CRSP Publications, Presentations and Other Products

- 66 long-term degree students (32 women and 34 men)
- 28,474 short-term training participants (including 14,137 women)
- 14 refereed journal articles
- 3 books
- 16 book chapters
- 10 theses
- 12 extension publications
- 8 working papers
- 4 websites
- 17 papers presented
- 52 electronic presentations
- 5 newsletters
- 16 reports
- 17 posters
- 5 abstracts

Long-term Research Award activities

The five Long-term Research Award (LTRA) activities were active during FY2009 and near completion. The U.S. and host country researchers, development agents, local officials, and community members in their respective sites have achieved their expected results. Highlights from each project are summarized below, and full reports compose the core of this report.

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

Principal investigator: Elinor Ostrom, Arthur F. Bentley Professor of Political Science, Indiana University; and 2009 Nobel Laureate in Economics

Host countries: Bolivia, Kenya, Mexico, Uganda

This research analyzes the effects of forest decentralization on forest sustainability and livelihoods from a local community perspective. Researchers investigated the ways in which property rights regimes and related local institutional arrangements may be altered by the changes in public policy at the national level. Specific objectives include:

- **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) 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.
- **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 assess the impacts of decentralization and other property rights reforms on natural resources (including biodiversity) and livelihoods.

Project highlights

- Decentralization was associated with increased forest investment (e.g., tree planting) in Mexico, Uganda, and Bolivia.
- Forest investment dropped significantly in Kenya after decentralization, a result not predicted. This may be the result of new reforms, which users perceive as institutional instability and users may require time to adapt to the new institutional environment.
- Local-level rule making was expected to increase in all countries as a result of decentralization; however, significant changes occurred only in Uganda.
- The effect of decentralization on wealth inequality varies. In Mexico, there was a strong correlation between decentralization and a more equal distribution of wealth. In Uganda, wealth inequality increased significantly following decentralization.
- The effects of decentralization on forest conditions/quality varied. The effects on forest conditions in Mexico were positive and very large. In Bolivia, Kenya, and Uganda, decentralization had little effect on forest conditions compared with similar forests in the region.

- Expectations related to natural resource decentralization should be adjusted to the context of the types of decentralization reforms being implemented and the country within which they are implemented.
- Decentralization includes a wide variety of concepts that should be explicitly defined when discussing any potential impacts.

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

Principle investigator: Alex Travis, Associate Professor of Reproductive Biology, Cornell University

Host country: Zambia

The goal of this project was to test and optimize a "third generation" biodiversity conservation model that uses 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 CRSP research evaluated specific hypotheses that stemmed from the model and defined the sets of conditions under which the model can operate so that it could potentially be replicated elsewhere. The specific research objectives were:

- **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.** Identify and integrate new technologies into the COMACO model to improve its profitability, food security, and rural incomes.
- **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 highlights

- Even in remote areas, it is possible to improve food safety and quality control and assurance practices to a level suitable for Hazard Analysis and Critical Control Points (HACCP) certification. Improvements in COMACO's facilities and staff allowed for HACCP certification, which resulted in business partnerships with the World Food Program, Catholic Relief Services, and General Mills, and helped increase sales to local hospitals and schools.
- Financial analysis of COMACO's operations identified profit and loss centers, which when addressed moved the cooperative toward fiscal self-sustainability and assisted in the planning and development of new Community Trading Centres (CTCs) in Zambia and Malawi.
- Research, promotion, and success of conservation farming techniques on COMACO participant farms increased adoption of these techniques on non-COMACO farms.
- Establishment of broadband satellite-based internet access at two locations improved communication between COMACO CTCs and enabled collaborative consultation and diagnosis of zoonoses by veterinary technicians in Zambia and veterinary scientists at Cornell University.
- SANREM CRSP research developed and improved value-added products distributed by COMACO, reducing raw material waste, improving product safety and quality, extending shelf life, and increasing profits.

- Wildlife census data showed that the COMACO model is stabilizing wildlife populations in the COMACO core area, due to decreased hunting pressure resulting from improved food security and livelihoods through the COMACO enterprises and extension activities.

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

Principal investigator: Jeffrey Alwang, Professor of Agricultural and Applied Economics, Virginia Tech

Host countries: Bolivia, Ecuador

The project successfully engaged local decision makers in an adaptive watershed management process in Guaranda, Bolivar Province, Ecuador and Tiraque, Cochabamba Province, Bolivia. This impact is manifest in locally developed and approved plans for sustainable watershed management in two of the three study watersheds. 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 in order to improve production systems and enhance income generation.
- **Objective 3**. Create a means of evaluating the impacts of alternative actions, policies, and interventions on income generation, and social and environmental conditions.
- **Objective 4**. Build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital.

Project highlights

- Stakeholder participation in research, modeling and planning activities increased community acceptance and adoption of findings, as well as increased available labor and trust in the extension technicians.
- In Ecuador, soil loss from erosion was quantified and found to be extensive in the lower regions of the watershed. Research identified cost-effective and locally acceptable soil erosion management techniques, including grass strips and deviation ditches, are currently being implemented.
- A number of crops and production practices of existing crops favorable in terms of income generation and lowering environmental impact were identified. For example, grass strips between potato fields to provide fodder for cattle and reduce soil delivery to streams, and adjusted fertilizer applications.
- Revenue loss associated with soil erosion was estimated to be approximately $346.50 and $2,851.72 (USD) per hectare, depending on the product, over a 10-year planning horizon.
- Nitrogen was the limiting soil nutrient in both Ecuador and Bolivia. Other soil nutrients were adequate.
- Low-cost biocontrol techniques were developed and found to be effective for pathogens affecting crops in Ecuador and Bolivia. Production of some of these biocontrols is feasible locally.
- Participatory watershed planning activities were established in both countries and watershed plans facilitating local land use are now being implemented.
- Reforestation with native species was successful in the Ecuador watershed.

- Access to land, water resources, markets, and higher educational attainment were all found to affect the choice of livelihood.

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

Principle investigator: Corinne Valdivia, Associate Professor of Agricultural Economics, University of Missouri

Host countries: Bolivia, Peru

The overall goal of this project is to evaluate and improve the adaptive capacity and capabilities of rural communities in Andean highland (Altiplano) ecosystems of Bolivia and Peru to climate and market change, drivers that affect agricultural production, food security and the sustainability of natural resources. Specific objectives included:

- **Objective 1.** Characterize the dynamics of Altiplano agro-ecosystems at various scales to understand the impact of climate and markets as drivers of change, and develop a shared understanding.
- **Objective 2.** Identify local knowledge and perceptions about production systems, landscape, and risks 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 in soils, climate, pests and diseases, landscapes, and livelihoods.
- **Objective 4.** Develop market access strategies and institutions that contribute to resilience.
- **Objective 5.** Develop stakeholders' capacities and capabilities—ability to act—to reduce vulnerability and increase adaptation in the face of changing market and climate conditions.

Project highlights

- Active participation of all stakeholders is required to ensure that collected information is trustworthy and valid.
- Recognition and respect of local knowledge increased the level of trust between community members and technicians.
- The participatory capacity building process, aside from generating knowledge and bringing existing knowledge to the surface, strengthens community organization and the capacity to learn.
- Understanding the long-term observations/perceptions of community members regarding soil quality is essential for evaluating alternative sustainable agricultural practices.
- Organic and inorganic soil amendments for potato and subsequent quinoa production significantly increased crop yields.
- Soil organic matter significantly increased and soil bulk density lowered with additions of organic amendments (compost, peat moss, and a commercial microbial activator).
- Soil water holding capacity was increased with organic amendments, which may be important for sustainable crop production as climate change proceeds.
- The process of knowledge sharing and collaborative engagement of stakeholders strengthened human capital with respect to knowledge of markets, sustainable agriculture production and climate change risk management.

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

Principle investigator: Manuel Reyes, Professor of Natural Resources & Environmental Design, North Carolina Agricultural and Technical State University

Host countries: Philippines, Vietnam, Indonesia

Communities in many forest and vegetable-producing watersheds in Southeast Asia are suffering from poverty and 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 research group, which derives its name from its objectives:

- **Objective 1. T**echnology: develop economically viable and ecologically sound Vegetable Agroforestry (VAF) systems.
- **Objective 2. M**arkets: develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies.
- **Objective 3. P**olicy: (1) identify policy options and institutional frameworks that promote sustainability of VAF production and reward environmental services, and (2) develop and test an incentive-based policy option and institutional framework for promoting VAF system particularly in the Philippines.
- **Objective 4. E**nvironmental and socioeconomic impacts: assess the short- and long-term environmental and socioeconomic impacts for farm families who adopt integrated VAF systems.
- **Objective 5. G**ender: 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. S**caling-Up: build host-country capacity to manage and disseminate integrated VAF.

The predominant agroecosystem at the Vietnam site is cashew-tree based. At the Indonesia site it is a multistory home garden system consisting of fruit and timber trees, annual rice and vegetable crops. In the Philippines an intensive vegetable-based system predominates.

Project highlights

- Yields for some vegetables are higher in agroforestry systems than in open field conditions.
- Cashew yield increased when vegetables were planted between the trees.
- The International Development Enterprise (IDE) low-cost drip irrigation system is redesigning its drip irrigation kits to achieve better water application uniformity on steep slopes.
- Government policies related to VAF tended to benefit rich farmers more than poor farmers and changes are needed in VAF policies to address this bias.
- Women farmers were found to undertake marketing activities and seek to improve their economic status for the sake of family, especially children's welfare more so than men.
- Market-oriented social networks enable and facilitate women farmers' marketing of agricultural products from family farms.
- In Vietnam, cacao establishment and yields were significantly higher when cacao seedlings were planted under mature cashew trees.
- Optimum fertilizer application rates and crop production guidelines were developed for marketable commercial and indigenous vegetables in Indonesia.

- Strains of tomato that are resistant to leaf curl virus were identified in the Philippines.
- Lack of access to current information, inability to control pricing, high transport cost, and poor post-harvest handling were identified as major marketing constraints for vegetables.
- Policymakers in the Philippines realized their limited response in terms of policy support to small farmers and saw the need for local policies to be appropriately tailored to the needs of local people, as well as the need to align policy initiatives with short- and long-term development outcomes.
- The viability of VAF in Vietnam is constrained by farmers' inability to invest in the system, inadequate institutional structures for facilitating information flow, and lack of market incentives. Targeted policy incentives are needed if small-scale farmers are to invest in VAF.
- The Soil Water Assessment Tool (SWAT) model was found to be useful for evaluating the impact of alternative land management changes in the Philippines, Indonesia, and Vietnam.
- Integrated pest management in cashew-based VAF production increase agricultural profitability and decreased farmers' health costs.
- A marketing and production system for *katuk*, a highly nutritious indigenous vegetable that produces year round, was developed and adopted by women's groups in Indonesia.

Cross-cutting research activities

Five cross-cutting research projects were initiated in 2008 to assess research finding across projects. The objectives and key findings and accomplishments of these projects are presented below.

Gendered Access to Markets: Gendered Networks and Livelihood Alternatives

Principle investigator: María Elisa Christie, Program Director Women in International Development, Virginia Tech

Participating countries: Zambia, Peru, Bolivia, Ecuador, Philippines, Vietnam, Indonesia

As markets emerge and change, producers group 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 that capture value for their agricultural 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 characteristic are most effective. In doing so, it brings to light opportunities to benefit women during current and future phases of the SANREM CRSP. The 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. Project objectives were:

- **Objective 1.** Increase women's awareness of markets and access to quality information.
- **Objective 2.** Identify gaps in networks and implications of findings to empower women to better access markets and increase bargaining power.
- **Objective 3.** Increase bargaining power through participatory research methodologies that affect social, human, and political capitals or assets.
- **Objective 4.** Recommend interventions to NGOs, government and researchers to empower women through training and reorientation of production and marketing initiatives.

Key findings and accomplishments included:

- In both urban and rural markets in Bolivia, most intermediaries and farmers at all levels are women.
- In Zambia, the main determinant of women's market access lies in the trade of crops for which they have control as well as the structure of the broader market; improving women's wellbeing requires investment in crops for which women have control.
- In Vietnam, Philippines, and Indonesia, the gender analysis helped women organize into formal networks (women farmer groups) to obtain the support of men to be actively involved in vegetable production and marketing.
- In Bolivia and Peru, strategic alliances were formed between women's groups and market-based institutions to address the gap in networks and build social and political capital to empower women to gain access to markets.

Metagenomics for the Analysis of Soil Microbial Communities and Soil Quality

Principal investigator: Karen Garrett, Associate Professor of Plant Pathology, Kansas State University

Host countries: Bolivia, Zambia

Soil degradation is one of the most important problems for sustainable agriculture worldwide. SANREM CRSP provides a unique social science context for studying human impacts on soil degradation. Using soil metagenomics, this project aims to identify indicators of soil degradation in tropical soils, a group of soils with limited existing data. Soil metagenomics is used to develop methods which foster disease-suppressive soils and soil communities that optimize for other microbes contributing to plant health and productivity, such as mycorrhizal fungi and rhizobia. The soil metagenomics cross-cutting project began in 2008 and will continue through 2010. Objectives are:

- **Objective 1.** Characterize soil microbial communities from soils representing a range of levels of degradation.
- **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.
- **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.

Key findings and accomplishments included:

- Samples from the Bolivian Altiplano (Valdivia project) and Zambian experiments (Travis project) sequenced and analysis is underway. The samples from the Bolivian elevation gradient (Alwang project) are being processed and will be sequenced shortly.
- In the Bolivian Altiplano, there is a trend (not significant) toward decreased microbial diversity with increased fallow period.
- Key queries for classifying pathosystems complexity were developed and will be useful in identifying climate change assessment research needs.

Watershed Modeling and Assessment

Principle Investigator: Conrad Heatwole, Associate Professor of Biological Systems Engineering, Center for Watershed Studies, Virginia Tech

Host countries: Bolivia, Ecuador, Zambia

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 land use changes in 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.
The objectives of this cross-cutting research activity are:

- **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.
- **Objective 2**. Assess impacts of land use practices and climate change on agricultural sustainability and natural resource management at a watershed scale.
- **Objective 3**. Design and implement low-cost community-based watershed monitoring programs.

Key findings and accomplishments included:

- Water quality analysis was completed in addition to collection of basic hydrology data. Stream samples were collected and analyzed for total suspended solids (TSS). In addition, the partner in Ecuador supported sample analysis for bacteria, nitrogen and phosphorus.
- Analysis of land use change in the upland Luangwa River watershed in 1989, 1994, 2002 and 2007 reveals different patterns of transition in land use. Older settled watersheds have a higher percentage of abandoned land indicating the poor sustainability of current agricultural practices – and the potential for recovery of productivity. The frontier watershed (98 percent forest in 1989) is being rapidly settled and is now approximately 30 percent cleared. The trends and implications of land use practices from this analysis are being used in outreach to public officials and community groups to document the impact of current practices on landscape and natural resources.
- In Zambia and Bolivia, models were evaluated for assessing erosion, runoff and nutrient impacts from land use changes. Additional work is required to adapt the respective models to the agro-ecosystems where they were applied.

Linking Knowledge and Action: Meeting NRM Challenges

Principal investigator: Esther Mwangi, Center for International Forestry Research (CIFOR)

Host countries: Bolivia, Ecuador, Uganda, Vietnam, Philippines, Kenya

This cross-cutting research included partnerships with four of the five SANREM CRSP LTRAs. The objectives of this research include the following:

- **Objective 1.** Collection of qualitative and quantitative data on the multiple strategies used by the four resource teams in linking knowledge to action (K2A) and the analysis and reporting of the data.
- **Objective 2.** Dissemination and outreach of findings generated by participating research teams.

Key findings and accomplishments included:

- In general, the research found that each project had unique challenges in facilitating the dissemination and acceptance of knowledge gained through SANREM CRSP research. These challenges included local and national political structures, social structures, and location. However, one major similarity did exist in all projects: when stakeholders are included in research activities from the beginning knowledge was more readily accepted and transferred into action.
- In Uganda, communities and their leaders found that the SANREM CRSP approach reduced resource conflicts, valued local knowledge, and provided new knowledge.
- In Ecuador and Bolivia, acceptance of research findings and participation in research projects was directly related to previous community interaction with project partners, homogeneous populations and farming practices, and greater awareness of environmental damage caused by farming.
- In the Philippines and Vietnam, the complexity of the national research, development and extension systems created funding and implementation issues, with very limited resources for research. SANREM CRSP helped fill the research gap and was linked to fostering participation and enhancing the partnership base to increases the potential for research uptake and scaling up of knowledge.

Assessing and Managing Soil Quality for Sustainable Agricultural Systems

Principal investigator: Peter Motavalli, Adjunct Assistant Professor of Plant Sciences, University of Missouri

Host countries: Bolivia, Indonesia, Philippines

The overall goal of this project is to utilize the wide range of climates, cropping systems, and socioeconomic conditions represented in the ongoing SANREM CRSP projects to evaluate sustainable agricultural management by examining common soil quality issues. Surveys were conducted among community members and agricultural professionals in two Andean regions of Bolivia, Philippines, and Indonesia to determine their perceptions of soil quality and to assess the appropriate characteristics of a field test for soil quality. Specific objectives include:

- **Objective 1.** Assess community perceptions and indicators of soil quality, including differences in perceptions of soil quality due to gender, environment, and socioeconomic factors. These assessments will include an evaluation of desired characteristics of low-cost methods to evaluate soil quality by local community members and agricultural professionals.
- **Objective 2.** Conduct a literature review of soil quality assessment techniques and identify practical but scientifically sound techniques that would be appropriate to evaluate soil quality across SANREM CRSP activities.
- **Objective 3.** 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 represented by the SANREM CRSP projects.

- **Objective 4.** To collaborate in the evaluation of soil metagenomic methods as an indicator of soil degradation.

Key findings and accomplishments include:

- Initial results indicate that farmers primarily use soil physical properties (i.e., soil color, texture and structure, water retention and drainage) and plant growth as criteria for assessing soil quality.
- Surveyed agricultural professionals stated that, for a soil quality test to be adopted, it would need to be convenient, low in cost, and accompanied by sufficient training for its use.
- Extensive training in and testing of the potassium permanganate ($KMnO_4$) portable soil quality test kit for labile carbon (C) was conducted over the duration of the project. Both practical and scientific considerations affected use of this kit among the test sites, including challenges in obtaining the $KMnO_4$ reagent and inconsistent results in identifying degraded and non-degraded sites.
- Use of a near infrared (NIR) procedure worked successfully for prediction of several soil C fractions, including water-soluble C, $KMnO_4$ C, and particulate organic matter (POM) C, but further research and development are needed to develop a low-cost, portable NIR instrument that would be suitable for developing countries.
- Use of a method that examines the ratio of peaks from Diffuse Reflectance Infrared Fourier Transform (DRIFT) analysis for separating degraded and non-degraded soils also showed some initial promise, but further testing and adaptation of this method to make it less time-consuming and costly are needed.
- Caution is needed in attempting to assess soil quality in a wide range of cropping systems and environments with a test that only measures differences in soil organic C, for other soil properties (e.g., soil chemical, physical and biological properties) may be primarily responsible for reduced agricultural production.

Management Entity activities

SANREM CRSP program extension

As a result of positive reviews of Phase III of the SANREM CRSP (2004-2009) by external reviews and an internal USAID review, the SANREM CRSP was extended for an additional five years (Phase IV) to September 30, 2014. Based on consultations with USAID/Washington, other USAID missions, and a large number of SANREM CRSP stakeholders around the world, a Phase IV research theme of: "increasing smallholder food security through the introduction of conservation agriculture production systems (CAPS)" was chosen. The Phase IV research and capacity building activities will develop and demonstrate locally sustainable CAPS for smallholder rain-fed crop production systems that improve food security and the productive capacity and ecosystem services of degraded agricultural lands.

During the last quarter of FY2009, the Phase IV RFA was widely circulated and 15 proposals were received and evaluated on the basis of scientific merit, research impact, capacity building, participatory partnerships, and inclusion of gender and minority issues. Seven long-term research activities will be funded during SANREM CRSP Phase IV.

Annual meeting

The 2009 annual meeting was held August 31 to September 1 in the Washington, D.C. area. Lead principal investigators from the five long-term research projects and the five cross-cutting initiatives presented their findings to colleagues and personnel at USAID headquarters in sessions that focused on key development implications of SANREM CRSP's research and outreach activities of the past five years.

Publications and publicity

A highlight of FY2009 was publication of the book, *The Sciences and Art of Adaptive Management: Innovating for Sustainable Agriculture and Natural Resource Management,* collectively written by 25 SANREM CRSP Phase III partners and collaborators. Also, SANREM CRSP researcher Elinor Ostrom, lead principle investigator for the LTRA Decentralization Reforms and Property Rights: Potentials and Puzzles for Forest Sustainability and Livelihoods, was awarded the Nobel Prize in Economics. Her SANREM CRSP research builds upon the earlier research for which she was awarded the Nobel Prize.

SANREM CRSP Knowledgebase

The web-based SANREM CRSP Knowledgebase (SKB) organizes and provides global access to knowledge resources generated by the SANREM CRSP. The SKB provides sustainable agriculture and natural resource management practitioners with information on best practices for site-specific conditions. The SKB is managed by the SANREM CRSP Management Entity (ME), and knowledge is contributed by the ME and SANREM CRSP researchers. The searchable SKB catalogs SA and NRM information resources, including books, reports, journal articles, videos, movies, and presentations. Over 1700 information resources were added to the SKB in FY2009. The SKB is accessible at: http://www.oired.vt.edu/sanremcrsp/menu_information/SKB.php.

Training and institutional development

In FY 2009, 21 U.S. and host country universities and institutions provided long-term training for 48 graduate students (24 Ph.D. and 24 M.S.) and 18 undergraduate students through SANREM CRSP support. Of these, 32 are women, 34 are men, and 52 are developing country nationals. SANREM CRSP partners held 152 short-term training events in 10 countries for more than 28,474 people, including 14,237 women.

Introduction

The Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) is sponsored by the U.S. Agency for International Development's Economic Growth, Agriculture, and Trade Bureau (USAID/EGAT) and participating U.S. and host country institutions. The goals of the SANREM CRSP are to support sustainable agriculture and natural resource management (SA and NRM) decision makers in developing countries by providing access to appropriate data, knowledge, tools, and methods of analysis; and to enhancing host country decision makers capacity to make better decisions to improve livelihoods and the sustainability of natural resources. SANREM CRSP research is organized around nested landscape systems approach beginning with field level systems, building through farm, enterprise, and watershed systems nested in broader ecological, governance and policy systems. SANREM CRSP activities result in the development, cataloging and transfer of technologies for increased income generation, stakeholder empowerment, enhanced resource management, strengthened local institutions, improved market access for smallholders and communities, and sustainable and environmentally sound development.

Integrated long-term research activities (LTRAs) are conducted by a consortium of universities, IARCs, NGOs, and host country institutions, each led by a U.S. university. A participatory approach engages stakeholders in research problem formulation within priority areas of inquiry. Gender-sensitive participant training programs that include degree and non-degree training plans are integral to the SANREM CRSP approach. All activities link sustainable natural resource management with the economic concerns of local populations and promotion of good governance. Areas of inquiry include:

- **Technology integration:** Technologies needed by stakeholders and decision makers to promote SA and NRM practices (i.e., GIS, biotechnology, decision support tools)
- **Governance** : Policies and institutional arrangements enabling civil society to better manage natural resources
- **Economic policy and enterprise development:** Supporting sustainable SA and NRM practices that develop niche markets and are eco-friendly and competitive
- **Biodiversity conservation and environmental services**: Investigating synergistic relationships between production, biodiversity, and livelihoods
- **Social and institutional capacity building:** Training and policies promoting improved SA and NRM leadership, NGO technology transfer, and increased civil society and government synergies
- **Globalization, vulnerability, and risk:** SA and NRM best practices to manage globalization and address risk and vulnerability caused by HIV/AIDS, food insecurity, etc.

The integrated SANREM CRSP systems approach demonstrates how linkages among gender, biophysical, technology, governance, economic, social, environmental, and globalization factors achieve sustainable development. This annual report covers SANREM CRSP research activities and accomplishments from October 1, 2008 to September 30, 2009.

SANREM CRSP Management Entity activities

The Virginia Tech 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 CRSP - 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 and policy briefs.

SANREM CRSP program extension

On June 3, 2009, USAID informed the ME that the SANREM CRSP would be extended until 2014. The letter cited the continued relevance of sustainable agriculture and natural resource management during the ongoing global food crisis, commended the SANREM CRSP on its technical progress and management over the past five years, and requested a new research proposal/plan for the next five years (SANREM CRSP Phase IV).

After consulting with USAID/Washington, other USAID missions, and a large number of SANREM CRSP stakeholders around the world, the following research theme was chosen for SANREM CRSP Phase IV: "***Increasing smallholder food security through the introduction of conservation agriculture production systems (CAPS)***". This unifying theme will contribute new knowledge and technological innovations for sustainable cropping and related systems that increase agricultural productivity, soil organic matter, and soil fertility in food-insecure regions of East, West, and Southern Africa; South and Southeast Asia; and Latin America and the Caribbean. SANREM CRSP Phase IV research and capacity building activities will develop and demonstrate locally sustainable CAPS for smallholder rain-fed, staple crop production systems that improve food security and the productive capacity and ecosystem services of degraded and productive agricultural lands.

To initiate this new program the SANREM CRSP led a symposium on conservation agriculture at the International Meeting of the Soil and Water Conservation Society (SWCS) in Dearborn, Michigan. The SANREM CRSP symposium explored the role of declining soil quality in agricultural productivity in developing countries; the potential of conservation agriculture to improve agricultural productivity, soil quality, and ecosystems services; and challenges that must be overcome if conservation agriculture is to improve food security.

During the fourth quarter of FY2009 a request for applications was widely circulated and 15 proposals for Long-term Research Award activities (LTRAs) were received. The LTRA applications were reviewed by a panel of SA and NRM professionals from institutions across the United States. The proposals underwent a two-stage review process and were rated on the basis of scientific merit, research impact, capacity building, participatory partnerships, and inclusion of gender and minority issues. Seven LTRA activities will be funded through 2014:

- A conservation agriculture production system program for the Central Plateau of Haiti. Lead principal investigator (PI): James R. McKenna, Virginia Tech
- Conservation agriculture as a potential pathway to better resource management, higher productivity, and improved socioeconomic conditions in the Andean Region. PI: Jeffrey Alwang, Virginia Tech

- Improving soil quality and crop productivity through conservation agricultural practices in cropping systems of West Africa. PI: P.V. Vara Prasad, Kansas State University
- Developing sustainable conservation agricultural production systems for smallholder farmers in Southern Africa. PI: Neal Eash, University of Tennessee
- CAPS for smallholder farms in eastern Uganda and western Kenya. PI: Jay Norton, University of Wyoming
- CAPS among tribal societies in India and Nepal. PI: Travis W. Idol, University of Hawaii at Manoa
- Conservation agriculture for food security in Cambodia and the Philippines. PI: Manuel R. Reyes, North Carolina Agricultural and Technical State University

Management Entity highlights

Annual meeting

The SANREM CRSP 2009 annual meeting was held August 31 and September 1 in the Washington, D.C. area. Lead principal investigators from the five long-term research activities and the five cross-cutting initiatives presented their findings to colleagues and personnel at USAID headquarters in sessions that focused on key development implications of SANREM CRSP's research and outreach activities of the past five years.

SANREM CRSP Knowledgebase

The SANREM CRSP Knowledgebase is an online and open access database of information resources (books, reports, journal articles, videos, movies, presentations) produced or identified, classified, and summarized by SANREM CRSP researchers. The SKB is also the repository for all SANREM CRSP - generated information resources. There are now over 3,200 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 CRSP Project Number if appropriate. The SKB is on the SANREM CRSP website at: http://www.oired.vt.edu/sanremcrsp/menu_information/knowledgebase.php.

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 4 (Heatwole et al., 2007), online at: http://www.oired.vt.edu/sanremcrsp/documents/SKB.UserGuide09.pdf

The ME has made additional efforts to promote and contribute to the linking and development of the SKB. In 2008, SANREM CRSP participated in a six week online conference for Agricultural Learning Repositories Task Force (AgLR-TF) sponsored by the Food and Agriculture Organization of the United Nations. On a whole, the conference had limited but diverse participation. There was involvement from every major world region, with the single greatest number of participants from India, followed by the United States. SANREM CRSP input is often cited in the summary report (ftp://ftp.fao.org/docrep/fao/meeting/014/ai263e.pdf), suggesting that SANREM CRSP made a significant contribution to this early attempt at sharing knowledge across various agricultural learning repositories. Moreover, the SKB benefitted from increased exposure and conversations about the types of resources the project makes available. As a member of the AgLR-TF, the SKB has a profile of its unique features as a learning

repository and is linked and accessible for reference by other task force members as well as in the public domain, http://aglr.aua.gr/node/19 .

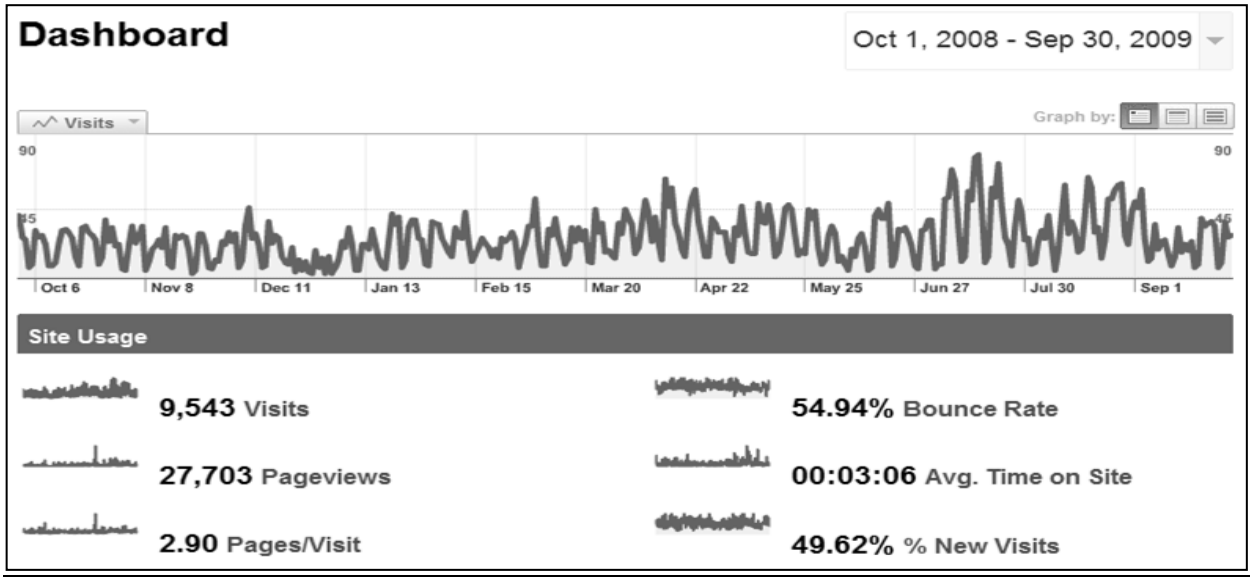
The conference gave SANREM CRSP the opportunity to participate in discussions on metadata standardization and improving resource access for researchers in developing countries, and SANREM CRSP was invited to send a representative to several conferences sponsored by the AgLR-TF in 2009. SANREM CRSP continues to communicate with other Task Force members through its continued membership in the online AgLR-TF community and looks forward to the possibility of sponsoring a representative at AgLR-TF conferences and/or training activities in Phase IV.

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, newsletters, working papers, research and policy briefs, and press releases and articles submitted to newspapers, magazines, and other websites. SANREM CRSP also has a page on Facebook, updated regularly with links to news and information about conservation agriculture, natural resource management, and ecological issues globally.

Website

SANREM CRSP partners, development practitioners, policymakers, other stakeholders, and the public are informed of SANREM CRSP activities and announcements through the SANREM CRSP website, http://www.oired.vt.edu/sanremcrsp. The ME tracks visitors to the website using Google Analytics, a free service that generates detailed statistics on website visits.



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 was inactive on that site for 30 minutes
Pageview: an instance of a web page being loaded by a browser.
Pages/Visit: average number of pages viewed during each visit
Bounce rate: the percentage of single-page visits, i.e., the person left the site from the homepage
Avg. Time on Site: Time on site: how long a visitor is connected. Time on site can be misleading because visitors often leave browser windows open when they are not actually viewing or using a site
New visit: a computer accessing the website for the first time

Figure 1. Google Analytics data for the SANREM CRSP website, FY2009

Since the ME launched the website in October 2004, there were more than 26,000 visits and more than 90,000 pageviews. Visits in FY2009 came from 147 countries and involved more than 9,000 visitors. Of those, about two-thirds were in the United States. About a third of the visits were direct traffic (visitor entered the URL directly), a fourth were from links on other sites, and the remaining visits were generated by search engines.

Table 1. Annual change in SANREM CRSP website visits

	FY 2008	FY 2009	% change
Visits	8,014	9,543	+19.08
Pageviews	34,172	27,703	-18.93
Pages/visit	4.26	2.90	-31.92
Bounce rate %	46.87	54.94	+17.22
Avg. time on site	4:10	3:06	-25.76
New visits	45.93	49.62	+8.02

Table 2. Top 5 countries visiting SANREM CRSP website, FY 2009

Country	Visits	Pages /visit	Avg. time on site	New visits (%)
1. United States	7,042	3.12	3:12	40.34
2. Philippines	376	2.16	2:46	82.71
3. India	165	2.39	2:53	76.97
4. United Kingdom	129	2.35	1:48	79.07
5. Kenya	122	2.56	4:49	72.13

Information products

The ***SANREM CRSP Newsletter*** is published as an e-mail bulletin and online at http://www.oired.vt.edu/sanremcrsp/menu_information/newsletters.php. It provides a concise update of SANREM CRSP activities, accomplishments, and future events. Issues in 2009 appeared in March, June, and October.

SANREM CRSP research briefs promote and disseminate relevant sustainable agriculture and natural resource management messages and information. These concise summaries of peer-reviewed SANREM CRSP research findings suggest how new knowledge can be applied in the field. ***Policy briefs*** present peer-reviewed findings with direct policy implications or recommendations for sustainable development. The objective is to provide policy makers with easily accessible information to increase understanding of often complicated policy issues. SANREM CRSP Phase III published eight research briefs (http://www.oired.vt.edu/sanremcrsp/menu_information/researchbriefs.php). One policy brief was published (http://www.oired.vt.edu/sanremcrsp/documents/policybriefs/108VAF.pdf).

The ***SANREM CRSP working papers*** series provides an early look at research in progress. Each paper was internally reviewed by the ME, but not yet refined for formal publication. Examples are preliminary baseline studies reports, discussions of methodological or thematic issues, and topical syntheses and literature reviews. The Phase III series, inaugurated in 2006, has posted 27 entries. All are available on the website: http://www.oired.vt.edu/sanremcrsp/menu_information/working_papers.php.

Newspaper, magazine, and online articles

Part of the SANREM CRSP's mission is to establish the program as a respected authority on sustainable agriculture and natural resource management, raise the profile of the program, and to disseminate SANREM CRSP generated knowledge around the world. The ME achieves this in part by distributing stories to newspapers, magazines, and other websites. In 2009, media placement included news of SANREM CRSP researcher Elinor Ostrom's Nobel Prize in economics on the home page of the USAID website and in USAID's *FrontLines* magazine, the *Washington Post* and other media.

Book on adaptive management for sustainable systems

The Sciences and Art of Adaptive Management: Innovating for Sustainable Agriculture and Natural Resource Management edited by Associate Program Director Keith M. Moore was published by the Soil and Water Conservation Society in 2009. The book is available for purchase or downloadable at: http://www.swcs.org/en/publications/the_sciences_and_art_of_adaptive_management/
The table of contents follows:

SANREM CRSP leveraged funding

SANREM CRSP PIs were 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 3). This year, SANREM CRSP co-PIs generated $375,207 in leveraged funding. The majority of those funds ($288,207) went directly to the support of SANREM CRSP activities.

Table 3. SANREM CRSP leveraged funding, FY 2009

Source of funding/support	Non-tracked funding or support contributing to SANREM CRSP activities	Funding or support for non-SANREM CRSP activities resulting from SANREM CRSP activities	Total ($)
U.S. organizations	$277,707	$62,000	$339,707
Host country organizations	$10,500	$25,000	$35,500
Total	**$288,207**	**$87,000**	**$375,207**

Training and institutional capacity development

Long-term degree training

The SANREM CRSP uses degree training to strengthen the technical skills of researchers, extension agents, 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 CRSP addresses specific host country SA and NRM questions, opportunities, and constraints. In FY 2009, 21 U.S. and host country universities and institutions provided long-term training for 48 graduate students (24 Ph.D. and 24 M.S.) and 18 undergraduate students associated with SANREM CRSP activities. Of these, 32 are women and 34 are men and 52 are developing country nationals studying at six U.S. and 11 host country institutions. In addition, 154 long-term training participants were supported. These included 78 men and 76 women (47 Ph.D., 50 M.S., and 57 undergraduates) and 122 were host country nationals. See A. Training Participants

Table 4. Long-term degree training participants by country, FY 2009

Country	Doctorate		Master's		Bachelor's		Total
	Men	Women	Men	Women	Men	Women	
Bolivia	2	1	6	4	10	5	28
Colombia				1			1
Ecuador			1				1
Indonesia	1	1	1				3
Kenya		1					1
Korea	1						1
Peru		1	4	1			6
Philippines		1	1	3			5
Thailand	1	1					2
USA	5	7	1			1	14
Vietnam						2	2
Zambia				1			1
Zimbabwe		1					1
Total	**10**	**14**	**14**	**10**	**10**	**8**	**66**

Short-term training

SANREM CRSP partners held 152 short-term training events serving more than 28,474 people, including 14,237 women. Training events were held in 10 countries. Training included 13 field days that introduced new and alternative conservation technologies to more than 21,799 people, including 11,240 women. Fifteen seminars addressed 581 people, including 218 women. Of 3,611 people participating in 28 short courses, 1,694 were women. Also, 96 workshops were held serving more than 2,483 people; at least 985 of them were women. (For a full accounting of these training events, see A. Training Participants)

Table 5. Short-term training participants by country, FY 2009

Country	Women	Men	Total
Bolivia	795	1,053	1,848
Ecuador	347	616	963
Indonesia	1	2	3
Kenya	16	45	61
Mexico	12	30	42
Peru	141	183	324
Philippines	112	264	376
Uganda	4	5	9
Vietnam	63	117	180
Zambia	12,646	12,022	24,668
Total	**14,137**	**14,337**	**28,474**

Long-term Research Award (LTRA) program

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

Principal investigator: Elinor Ostrom, Arthur F. Bentley Professor of Political Science, Indiana University

Host countries: Bolivia, Kenya, Mexico, Uganda

Research team:

- University of Colorado: Krister Par Andersson, political science
- International Food Policy Research Institute: Ruth Meinzen-Dick, senior research fellow, environment and production technology
- Harvard University: Esther Mwangi, Giorgio Ruffolo Post-doctoral Fellow in Sustainability Science, Center for International Development, Kennedy School of Government
- Charles Darwin University: Bruce Campbell, director, Research School of Environmental Studies
- University of Alberta: Marty Luckert, forest economics

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 improved local livelihoods. In response to this challenge, this project aims to improve forest and natural resource policy by developing and disseminating knowledge about institutional conditions that make such policies more or less effective in equitably delivering benefits equitably to local people while sustaining natural resources. This is achieved 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). The research analyzes the effects of forest decentralization from a local community perspective rather than at the macro level. We pay particular attention to the way in which property rights regimes and related local institutional arrangements may be altered by the changes in public policy at the national level. Specific research objectives include:

- **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 impacts 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 assess the impacts of decentralization and other property rights reforms on natural resources (including biodiversity) and livelihoods.

Theoretical framework

Decentralization policy reforms 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 national policies with environmental outcomes. We propose that the effects of a policy change depend on the role played by local institutional[1] arrangements. Our research focuses on the institutional arrangements and incentives of local governance actors—local community leaders in particular—to explain their decisions and actions as well as the resultant outcomes for forests.

Our approach builds on the work of the new institutionalism school of political economy (North 1990, Ostrom 1990, Knight 1992, Horn 1995, Bates 1998). New institutionalists seek to explain political behavior by examining the constraints imposed on individuals by institutions. Whereas early forms of institutionalism implied that institutional structures *determined* social or political outcomes, new institutional scholars have come to view institutional arrangements as *moderating* the effects of other variables. Our approach also emphasizes the value of considering institutions at multiple levels, drawing on earlier work that analyzes institutions as "two-level games" (Putnam 1994), "nested action arenas" (Ostrom 2005), or systems of multilevel governance (Hooghe and Marx 2003). We recognize that institutional arrangements are nearly always made up of several layers of social orders—from local micro-interactional orders to international and transnational arrangements—and that the relationships of complementarity and contradiction between these layers are crucial.

We use these insights to analyze decentralized resource governance. Through this approach, we highlight the ways in which decentralization reforms are filtered by institutional arrangements to produce outcomes visible on the landscape. The existing set of multi-tiered institutional arrangements shape 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 complex, since 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 occurring simultaneously and influencing local decisions. We have a two-pronged approach to dealing with this challenge. First, we use our framework for institutional analysis (Figure 2) to organize and clarify the conceptual linkages among public policies, property rights regimes, local institutional arrangements (administrative rules governing resource access, voting, and harvest), 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.

Institutional analysis framework

The institutional analysis employed in the project is structured by an adaptation of the Institutional Analysis and Development (IAD) framework (Figure 2). This framework helps the researcher organize the context-specific analysis of institutions and the incentives they generate (for reviews, see Ostrom 2005; Gibson et al. 2005). In this analytical approach, we emphasize a contextually grounded analysis of local institutional arrangements and incentives. In other words, the effects of decentralization reforms are affected by a filter of institutional mediation. We view the decisions of local governance actors, including

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

community members, authorities, local government officials, and NGOs, to be shaped by both national and local-level institutions, as illustrated by Figure 2. The local actors' incentive structures are composed of the perceived rewards and penalties from sociopolitical as well as financial or economic arenas. These incentives emerge from the patterns of interactions between local community leaders and a variety of other actors such as resource users, central government representatives, and private interest groups who operate under varying contextual conditions.

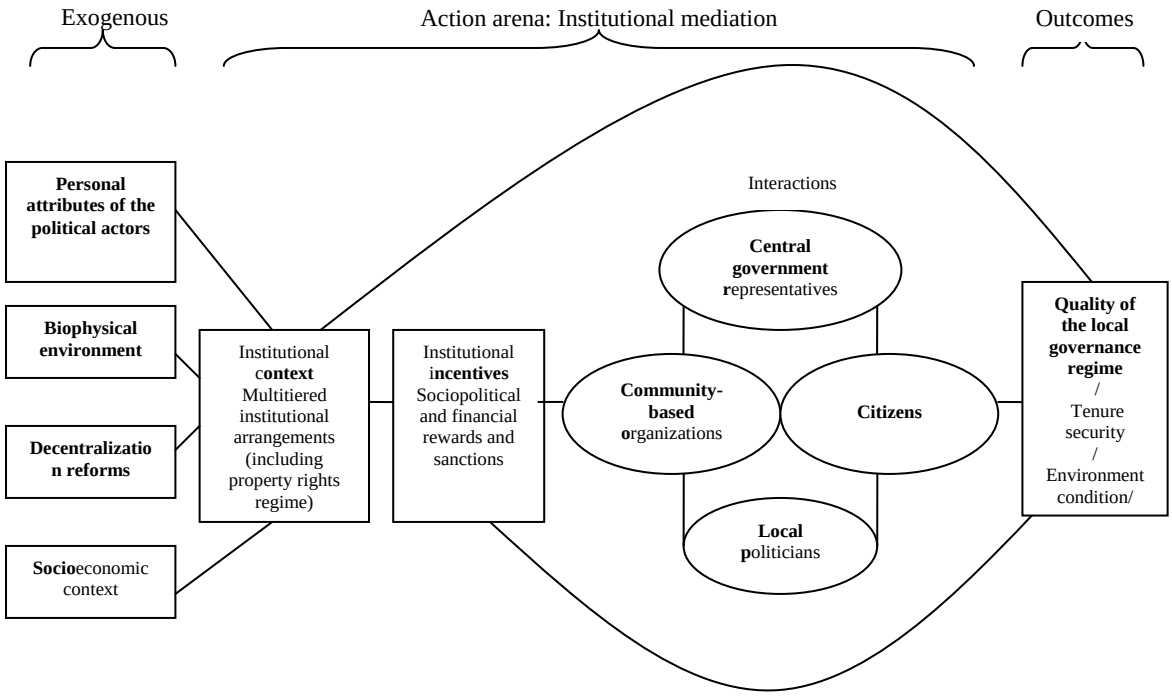


Figure 2. From Andersson, Laerhoven, and Gordillo (forthcoming), adapted from Ostrom (2005)

We propose that the characteristics of these local interactions will in part depend on local and national level institutions, such as the particular mandate given to local governments or communities and their experience in governing in a particular policy domain (i.e. forestry, irrigation or fisheries). Following this logic, local community members will invest their time and resources into governance activities when they reap some rewards. 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 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. 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 the level where resource users interact and make day-to-day decisions about things, such as what type of products to harvest on a certain day, where they will harvest, who they will ask for help, and how much they will harvest. These decisions at the *operational* level are influenced by governance processes at two superior levels of authority: the collective choice and constitutional levels. Figure 3 illustrates the multilevel dynamic of how decisions at one level are

influenced by decisions at other levels of governance. The nested governance decisions in Figure 3 can be made by any or all of the actors in the action arena of Figure 2. That is, for any given level of spatial aggregation, including all systems of the SANREM CRSP framework—household, community, local, state, national—decisions can be made at the operational, collective choice, or constitutional level.

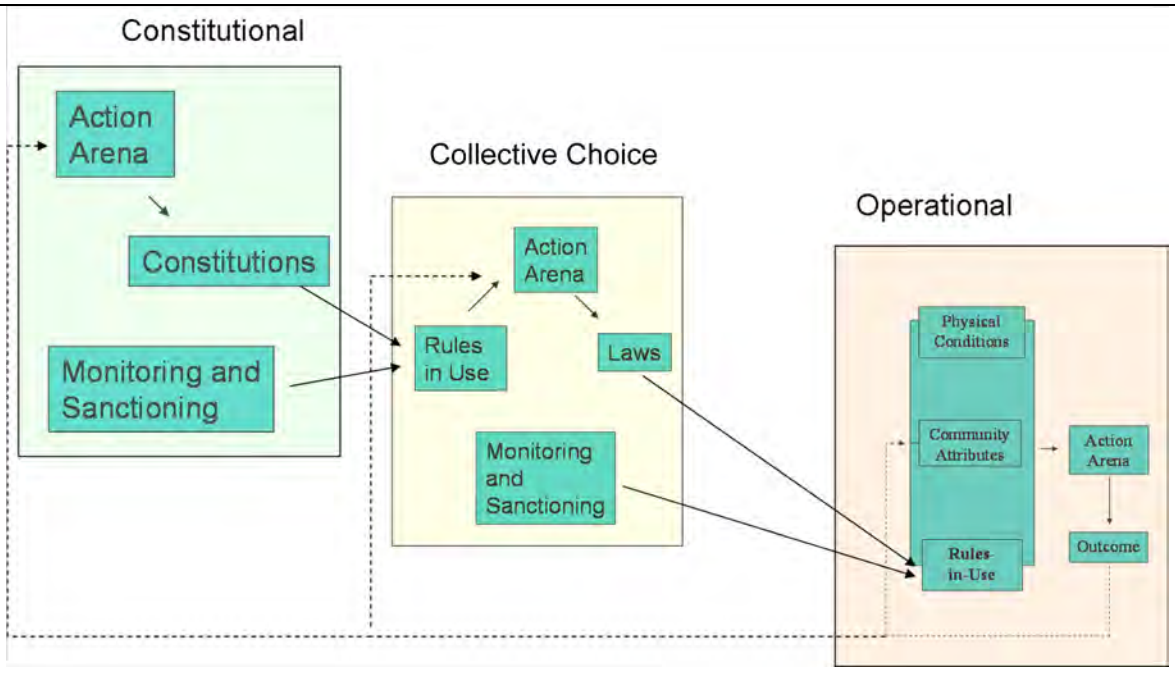


Figure 3. The nested nature of governance decisions. Adapted from McGinnis (2000)

At the *collective choice* level, policy makers make decisions about 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, and other times the participants are appointed by government officials. Whoever is making the collective choice decisions, these decisions are influenced by rules created at the *constitutional level* of governance. At this highest level of governance, decisions are made about who is authorized to make collective choice-level rules, what means may be used in enforcement of these rules, and what sanctions may be applied to those who do not comply with the rules.

We use this framework to organize and clarify the conceptual linkages between public policies, property right regimes, local institutional arrangements, and the changing nature of natural resources. One of the most important tasks at this stage of the research is to identify the ways and mechanisms decentralization could plausibly influence local decision making. For example, who are the targeted actors that one should pay particular attention to, 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 the LTRA-1

project, our research design includes two pairs of countries in two regions with varying degrees and types of decentralization, and it relies on over-time observations of the sites where we work. This design allows us to carry out a longitudinal, cross-sectional comparison of how communities respond to decentralization reforms. The combination of a carefully conducted institutional analysis, a comparative research design, and over-time observations 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 regard 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 local community and household-level decision making. This allows us to test several highly policy-relevant hypotheses, as outlined in Table 6 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 NRM. From this central proposition, we derive several testable sub-hypotheses and several more specific research questions and subquestions, outlined here and in Table 6 below.

The first research question looks at the effects of national decentralization policies on resource sustainability and the equity and efficiency of forest resource management at the local level. In particular, we look at the institutional conditions that make local actors more likely to invest in local forest governance institutions and in effective forest conservation. The second question looks at how decentralization policies change property rights to the forest, including 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 examine how community and household responses to policy changes are linked to gender and poverty levels, and how community monitoring contributes to empowerment of rural communities and accountability of public officials. The research scrutinizes the differential effects of decentralization in detail, parsing out what specifically is meant by decentralization in the various countries and determining the repercussions of specific policy components.

Implications for research, action, and policy

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

- doctoral dissertations
- journal article submissions
- site reports
- conference papers
- national advisory committee meetings
- national policy consultations
- regional policy exchanges
- on-the-ground trainings 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 conditions those outcomes produce is evolving. Our cross-country study, using socioeconomic and biophysical methodologies and comprising both cross-case and within-case analysis, 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 gets 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. **National policy consultations** were also held to 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 help determine what parts of our research are useful and how policymakers plan to use it. Additional **regional exchanges** allowed interactions between policymakers and other practitioners in each region (i.e., East Africa regional exchange and Latin America exchange). These regional exchanges facilitate shared learning around 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).

A number of outcomes were shared with policy makers, practitioners, and other researchers. First, decentralization reforms are not uniform and they have uneven impacts. Second, holding ecological and cultural settings constant, these uneven impacts are conditioned by several factors, including the level and degree to which power, authority, and resources are devolved; the range and security of rights to resources that is accorded to local communities; and the extent to which community preferences and needs are taken into account in decision making. Third, mechanisms and strategies can be designed to try and ensure that such reforms are beneficial for poor, rural men and women as well as forest resource sustainability. In short, we shared with policymakers, practitioners, and researchers the reasons why institutions matter—they are important for distributing benefits and ensuring accountability when major policy reforms occur, and can ultimately be designed to promote accountability and equitable distribution of resources.

Table 6. SANREM-CRSP LTRA-1 conceptual model

Research questions	*Sub-questions*	*Hypotheses*	*Methods*
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 were 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.
	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.
	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 made to see whether communities with high discount rates invest less in governance and suffer more forest degradation after decentralization.
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.
		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

The objectives for our project are closely intertwined; all three objectives involving building capacities among stakeholder groups. Their similarity, and complementary capacity-building activities must be considered together to assess the project's effectiveness. Therefore we will address the research accomplishments associated with all three objectives together in the section below.

Critical research accomplishments

The primary accomplishments of this project revolve around the gathering of detailed data at both the household and community levels in 24 forests across four countries, complemented by a national-level, forest-community survey in the two Latin American countries. Community-level data was collected following the International Forestry Resources and Institutions (IFRI) protocol, which captures both social and biological information. This collection of data allowed project partners to assess the institutional compatibility of stakeholder organizations, user groups, policymakers, and others involved in forest governance; and to identify gaps and capacity-building needs that would enable all involved to better achieve natural resource and livelihood goals. Data collected includes:

- Bolivia. 572 forest plots and 165 household surveys in 7 communities (2 funded by University of Michigan); national survey of 200 forest communities
- Kenya. 146 forest plots and 702 household surveys in 7 communities
- Mexico. 204 forest plots and 288 household surveys in 5 communities; national survey of 146 forest communities
- Uganda. 254 forest plots and 720 household surveys in 9 communities (2 funded by University of Michigan)

Throughout the project, we have relied on contacts at many levels to facilitate all three objectives. In addition to regular contact with user groups, our partner organizations formed NACs that met regularly throughout the project to discuss findings and needs. The NACs also helped identify study sites and provided a perspective on trends and policies at higher levels of governance. Roundtables, trainings, and cross-community workshops created education and exchange opportunities for stakeholders at all levels. . This multilevel approach culminated in international exchange meetings between the two countries in each region, held in 2008 (for Uganda and Kenya) and 2009 (for Bolivia and Mexico).

Development impact

Data gathering allowed researchers to amass information used to draw conclusions at country, regional, and international levels and identify ways to benefit the targeted communities by skill building, providing site-specific information, and improving local quality of life.

In an analysis of the overall project data, we found that:

- Decentralization was associated with increased forest investment (e.g. tree planting) in Mexico, Uganda, and Bolivia; forest investment actually dropped significantly in Kenya, a result that we had not predicted. This outcome may be because the reforms are so new that people perceive the new rules as institutional instability, and may require some time to adapt to the new institutional environment.
- Local-level rule making was expected to increase in all countries as a result of decentralization; however, the only significant changes in this variable occurred in Uganda. We speculated that the

macro-level instability was so significant that user groups were induced to make local rules to compensate.

- The effect of decentralization on wealth inequality was expected to vary. In Mexico, we found a strong correlation with years of decentralization and a more equal distribution of wealth. In Uganda, wealth inequality increased significantly following decentralization.
- The anticipated effects of decentralization on forest conditions in the four countries were more difficult to predict. The effects on forest conditions in Mexico were positive and very large, as we predicted. However, in the other countries decentralization policies had little effect on the perception of forest conditions compared to similar forests in the region.
- Because of these disparate findings, we argued that expectations related to natural resource decentralization should be adjusted to the context of the types of decentralization reforms being implemented and the country within which they are implemented. Decentralization includes a wide variety of concepts that should be explicitly defined when discussing any potential impacts.

The theory indicating how decentralization will vary by context is imprecise. The Coleman et al. analysis indicates that the stability of reforms, scarcity of forest products, size of forest units affected, and dependence of user groups on the resource will affect many decentralization goals. In addition, these effects might differ depending on details of the decentralization reform.

Previous analyses of forest decentralization have focused on the macro level. We have looked instead at the behavior of local users. The changes and adaptations of local institutions and user behaviors in response to broader policy reforms, as well as the environmental outcomes of such reforms, need to be given greater attention.

Further analysis conducted during the extension period showed the following:

- Despite recent work that suggest that rights of access and use (to enter the forest and harvest) are the most important types of property rights for forest users we find that households with rights of access are actually less likely to rank the vegetative density of the forest highly than those who have no rights of access or use. Those with more complete property rights (management, exclusion, alienation) are those who are the most likely to rank the vegetative density of the forest highly.
- Property rights are most significantly and substantively related to high ranking of vegetative conditions in government forests, rather than community and private forests. Formal property rights are necessary in government forests to ensure that there is not over-exploitation of the forest stock, while less formal rights may be sufficient in community or private forests—in communities because informal norms exert control over behavior and in private forests because of informal contracts between owners and households.
- Households with property rights in government forests as well as other forests are more likely to rank the vegetative conditions in government forests more highly than those who only have rights in government forests. However, households with property rights in community forests as well as other forests are less likely to rank the vegetative conditions of community forests highly than those with property rights only in community forests. In other words: Those who rely solely on a community forest do not over-exploit it, while those who rely on a community forest as one among other types of forests which can be accessed, tend to rank conditions more poorly--perhaps because they have more forests to compare to or perhaps because they can exploit the community forest and risk violating social norms, yet still have some access to resources in other forests. Those who use only a government forest, however, are more likely to over-exploit the government forests, but when there are alternative forests available they switch their use to them.

- Households with more assets tend to rank all types of forest vegetation poorly. Those who are distant from markets are more likely to rank the forests poorly while those who live farther from the forest are more likely to rank the forest highly. When rules are perceived as fair, forest vegetation is more likely to be ranked highly. Forest subsistence is negatively related to vegetation in private forests, not significantly correlated in government or community forests.

Uganda. In Uganda, the first SANREM CRSP site (Mabira forest) was involved in a particularly contentious struggle to determine the fate of the forest. Throughout the conflict, SANREM CRSP partners have worked closely with neighboring communities, Kirugu and Nakalanga, to strengthen forest management committees, monitor the level of illegal activities in community managed forests, and assist the communities in diversifying local sources of income through pineapple farming and rearing of goats and cattle.

Part of the learning experience also derived from exchanges between communities, exemplified by the trip arranged for leaders from Kyarukooka to Sango Bay, where there is a successful collaborative forest management system. Residents of Sango Bay's Mujanjabula and Mugamba settlements formed a "Save the Forest" Association; they carry out joint patrols with National Forest Authority officials, have planted a community woodlot, and also plant trees for timber and medicinal purposes. The level of illegal activities in the forests managed by the association is low and the forest has continued to improve. The group also visited neighboring communities who were in the process of forming forest management committees.

Community leaders from Nakalanga and Kirugu visited communities who have started collaborative forest management in nearby forest patches of Mabira Forest reserve.

During the extension period, half-day workshops were held in Wakisi, Malamaganbo, and Kakindo to discuss the roles of communities and local institutions in the management of forest resources following the implementation of the forest sector reforms. A policy brief in the local language (translated during the extension period) was used in the discussion and also distributed to the local leadership and members of the forest associations in the study sites.

Community-level learning was complemented by multiple strategies, including the formation of a NAC, whose members represented numerous scales of governance with the ability to influence necessary policy changes. NAC members in Uganda also participated in feedback workshops, meant to share research findings with forest user groups.

Using these various mechanisms, Ugandan researchers found an increasing rate of deforestation in the country but some communities and districts where management of forest resources has improved (Ecosystem and Community/watershed level). They also found participation of local communities and local councils in forest use decisions is still limited (Policy/market level) and there is an increased rate of tree planting by the private sector and individual farmers (Farm household/enterprise level). Finally, they have concluded that the National Forest Authority has made an impact on plantation establishment but has not been very successful in conservation of natural forests (Policy/market level).

Kenya. In Kenya, the research team worked in collaboration with resource people from government ministries to equip community members with the skills necessary for sustainable forest management. In Aberdares, the main focus was on forest enrichment and rehabilitation. Community members were trained in tree nursery management, seed production and storage, and related topics. A few groups in some sections of the forest had leadership wrangles; therefore the team also trained them in group dynamics, conflict resolution, and leadership. In Ramogi, the main focus was on business management skills related to participatory forest management projects that would improve the livelihoods of community members.

The members were trained in basic bookkeeping, beekeeping, proposal writing, and participatory skills for problem identification among others. As in Aberdares, they also had group problems and received conflict resolution training.

The Kenyan team noted an increase in the number of community forest organizations from one visit to the next and found greater awareness about Kenya's new Forest Act following the team's site visit. Physical improvements were also in evidence, with a new electric fence in one site helping to prevent cattle from grazing in the forest. Another community developed an ecotourism facility in collaboration with an organization, using advice of the research team.

Target communities in Kenya also showed an increase in the number of NGOs and community-based organizations working within the natural resource sector, and an increase in the number of government projects aimed at poverty alleviation (Policy/market level). In Aberdares, examples included green zones and the Plantation Establishment and Livelihood Improvement Scheme (PELIS), both Kenya Forest Service initiatives. In Ramogi, PLAN International, Action Aid, and CARE Kenya were also active. In the second case, the town council was taking a more proactive role in forest management than the team witnessed during their initial visit (Policy/market level). They also found greater acceptance among foresters of the involvement of community members in forest management (Policy/market level).

Data from the household surveys collected in Kenya showed the following:

- Most forests in the country face challenges due to population pressure and high dependence on forest products for livelihoods. In all the sites, forest adjacent communities depended fully on the forests for all their energy needs, most of their poles and posts, all their herbal medicine needs and some of their construction needs. Some forests such as Aberdares and Mau were heavily degraded due to human impacts, which included clearing of large tracts of forestland for cultivation of crops. The main reasons for the high dependence on forest products were related to population increase, high poverty levels, and unemployment.
- It also emerged that forests did not offer dependable cash income. A majority of the communities harvested products for subsistence use but did not rely on the forest products fully for cash income. There was therefore limited time dedicated to forest activities for poor farmers.
- Government linkages with communities are poor due to conflicts between the forest managers and users, high corruption among the forest managers, poor forest management strategies, and poor communication flow to communities. Linkages with other stakeholders were also limited and only a few 'elite' were beneficiaries of information from non-governmental organizations. Most women and other marginalized groups were often left out of development activities mainly due to low or no education, lack of time to attend meetings, lack of contacts within the local settings thereby limiting information flow. There was also a general lack of technical knowledge of forest management and conservation among community members thus limiting their involvement in management activities.
- Women are unlikely to inherit property (an exception is Aberdares, where unmarried women can inherit land) and are also disadvantaged by the expectations of the new forest act. For instance, due to low education, many could not be selected for leadership positions. Time constraints also affected their ability to attend meetings. Although women spent much time in the forest collecting products, they were rarely consulted about any forest management initiatives.
- The Ramogi Hills forest was selected as a good example of a sacred forest with strong cultural ties and institutions. Results from the study of this forest indicated that the rules crafted to protect the forest were respected by a majority of the; even illegal harvesters avoided harvesting from within the sacred grove. Since the people value the sacred forest for its cultural and historical significance, they also made extra efforts to assist in the conservation and management of the

forest, including use of energy-saving stoves and restrictions on the sale of wood products. The site may hold lessons for developing similar success in other forests.

The Kenya team has also been involved in piloting an educational program in schools, starting with several schools adjacent to the Ramogi Hills, Kakamega, and Mau forest sites, to raise awareness on the importance of forest conservation. Children planted indigenous trees, and established a nursery to raise thousands more. They hope to expand the program to schools across the country in the future.

Mexico. Data from the national survey of 146 forest communities showed two clear tendencies. From 1994 to 2000, forest production grew by 49 percent (from 6.3 million cubic meters of round wood to 9.4 million cubic meters). Five years later in 2005, timber production had dropped to the 1994 level. This loss of wood production during the early 2000s occurred in the middle of a considerable increase in national consumption of forest products, from 16.3 million cubic meters of round wood in 2000 to 27.5 million in 2003 and 21.3 million in 2005. As a consequence, the deficit of forest products increased in volume (+167%) and value (+222%) in spite of the relative monetary stability during this period (Ecosystem and Policy/market level).

The data on the performance of the forest sector during 2000-2005 reflects an important loss of community capacities to produce raw materials and value-added products, during a period of remarkable growth in public investment in the forest sector. The budget analysis of public funding highlights some of the reasons for policy failures: 60 percent of the resources were invested in reforestation and plantations based mostly on top-down approaches, with little attention to the development of planning, management, administrative, and productive local capacities. Given an increasing national focus on restoration and conservation and because the majority of forests in Mexico are collectively owned, a failure to provide additional training and advice to forest communities could both further marginalize these communities and undermine the likelihood that these policies will succeed.

The national survey identified some of the main challenges faced in achieving sustainable forest management arrangements:

- Rights holders in the majority of *ejidos* are aging, and the generational replacement required for forest protection and community entrepreneurship is under threat in the majority of forest communities.
- Tenure conflicts are frequent and have pervasive impacts on local peace and on forest areas.
- Poverty is widespread, and the income alternatives of forest populations are poor and often not compatible with the conservation of the forest cover. This is particularly true for those forest ecosystems with the highest biodiversity.
- There are few incentives to sustain and develop local institutions.
- Forest communities are facing a loss in productive capacity, and are becoming less able to compete in today's open markets. Most of these challenges have not been addressed by any public program; those that have tried to support local institutional and production capabilities are marginal in financial and political terms.

Social organization has not been perceived as a key resource by mainstream forest and environmental policies; on the contrary, policies have often negatively impacted community organizations because they disregard local collective property arrangements and the potential advantage of groups with communal social capital for sustainable forest governance. The results from the national survey in Mexico show that the communities with stronger organizations are also those with the more intense protection and conservation activities. Communities with developed and successful forestry experiences constitute a low

percentage of forest communities, but their presence and success express the viability of community forestry as a driver of local economy in forest regions.

Bolivia. Researchers focused their final months of work on the preparation of numerous papers. They also participated in a national workshop on indigenous territories and forest valuation, and junior researchers received certificates from the Latin American Council of Social Sciences. Findings show a low level of efficiency in municipalities involved in forest management. The municipal governments have constructed infrastructure (including roads, drinking water systems, and electricity) in some areas but are largely absent in terms of forest sector activities. The Forest Superintendence, charged with fulfilling the goals of the forest law, is largely absent as well (Policy/market level).

As part of the closing activities of the project, Bolivia hosted both a community exchange meeting and an exchange meeting with researchers from Mexico, held in series at the end of September. The community meeting was attended by 13 representatives from six of the Bolivian communities studied during the course of the SANREM CRSP grant, each having the opportunity to build additional capacities as well as share experiences with other communities.

Representatives presented the details and challenges of forest management in their community and compared their experiences with those of other communities. All attendees learned about the design principles articulated by Elinor Ostrom and were asked to apply these concepts to their own communities, followed by a general discussion. All communities received folders describing the physical, human, social, and institutional conditions of each community and the team's findings in their communities.

This community meeting was followed immediately by the exchange meeting with the Mexican research team and Bolivian community representatives. Both teams presented on the conditions and findings in their communities. Twenty additional participants joined in this meeting.

Degree and non-degree training activities

In total, over the course of the project, partners have trained 1,468 men and 1,251 women from numerous backgrounds and on numerous topics. All of these individuals were trained in host countries. Participants ranged from user group members and community-based organizations to local officials, national-level officials, and NGOs. In addition, the project supported 8 degree program students (4 male, 4 female).

Publications, presentations, other products

Over the course of the project, we have produced 1 dissertation, 6 reports, 10 papers, 10 presentations, 5 abstracts, 3 fact sheets, 2 research briefs, and 2 newsletter articles that were made available on the SKB. Other materials will be entered as soon as they become available.

Networking activities

In Kenya, an IFRI regional training was carried out, and participants from different organizations and universities in Kenya and Tanzania were trained on the IFRI methodology and IFRI data management.

In Bolivia, the research team participated in a national workshop on indigenous territories and forest valuation for sustainable forest management and certification, held in Santa Cruz. The team also hosted the exchange workshop described above, attended by representatives from NGO Jatun Sach'a, the Forest Superintendence, the Ministry of Rural Development, and others.

In Mexico, SANREM CRSP support was provided by the Instituto de Investigaciones Sociales of Universidad Nacional Autónoma de México (UNAM), enabling Co-PI Leticia Merino´s participation and giving access to office space, computers, and vehicles for field work. The National Forest Commission (CONAFOR) and the Community Forestry Project (PROCYMAF) have supported training activities with communities. Two NGOs, Grupo de Estudios Ambientales (GEA) and Grupo Autónomo para la Investigación Ambiental (GAIA) also supported one of the training activities.

In Uganda, partners produced a DVD addressing forest policy and community forest management issues.

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

Principal investigator: Alex Travis, Assistant Professor, College of Veterinary Medicine, Cornell University

Host country: Zambia

Research team:

- Cornell University: Alfonso Torres, College of Veterinary Medicine
- Wildlife Conservation Society-Zambia: Dale Lewis

Research strategy and development objectives

Our project design used 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 Luangua River Valley, Zambia, with an overarching goal of conserving native biodiversity. This section provides a brief introduction to the problems that currently exist, and then gives a schematic representation of how the COMACO model attempts to alter SA and NRM practices to improve food security and livelihoods of stakeholders and to protect wildlife.

Current practices in the absence of COMACO

Inconsistent rains and sub-optimal farming practices limit crop production, and lack of access to markets limits income. In combination with the lack of a developed non-farm economy, these factors leave the inhabitants of the Luangua Valley highly susceptible to chronic poverty and food insecurity. Cash crops such as cotton and tobacco offer better short-term returns and are actively encouraged by large-scale outgrower schemes intended to provide regional 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.

Poor livestock management, the presence of a number of serious animal and human infectious diseases, 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 adopted the strategy of illegally killing wild animals so that they could barter the game meat for produce. This limits the development of other economic opportunities including existing safari and ecotourism markets that are a major source of income for communities and the federal and regional governments. Figure 4 describes how unsustainable agricultural and natural resource management practices in the Luangua Valley create a vicious cycle that ultimately results in widespread poverty and hunger.

COMACO seeks to improve biodiversity conservation through improvements in food security and livelihoods. This community-owned enterprise implements sustainable agricultural practices at the level of individual farms using extension support, marketing, and pricing strategies organized around COMACO's regional trading centers to increase small stakeholder profits. Figure 5 shows how this model attempts to make improved agricultural and natural resource management strategies sustainable by

directly linking them to improvements in food security and rural livelihoods. Conservation of biodiversity resources leads to expanded economic opportunities such as honey production, improved fish yields, and consumptive and non-consumptive ecotourism.

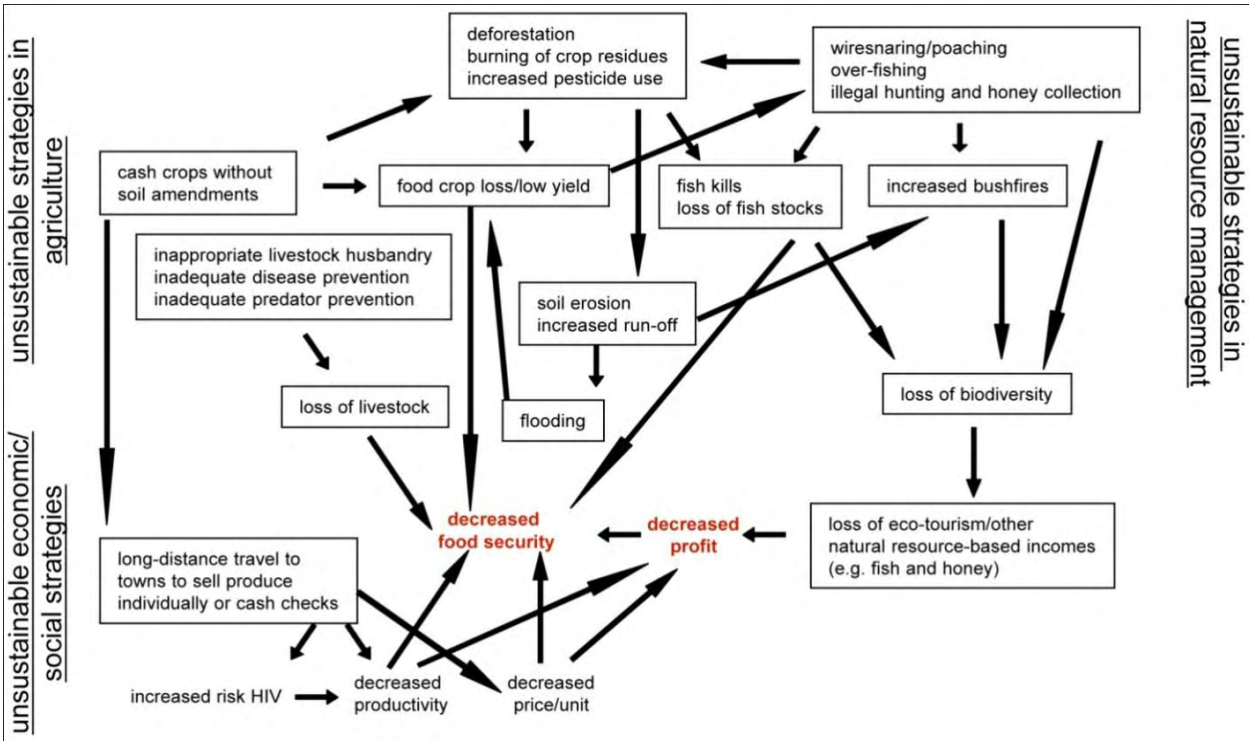


Figure 4. Unsustainable agricultural production and NRM systems in the Luangua Valley

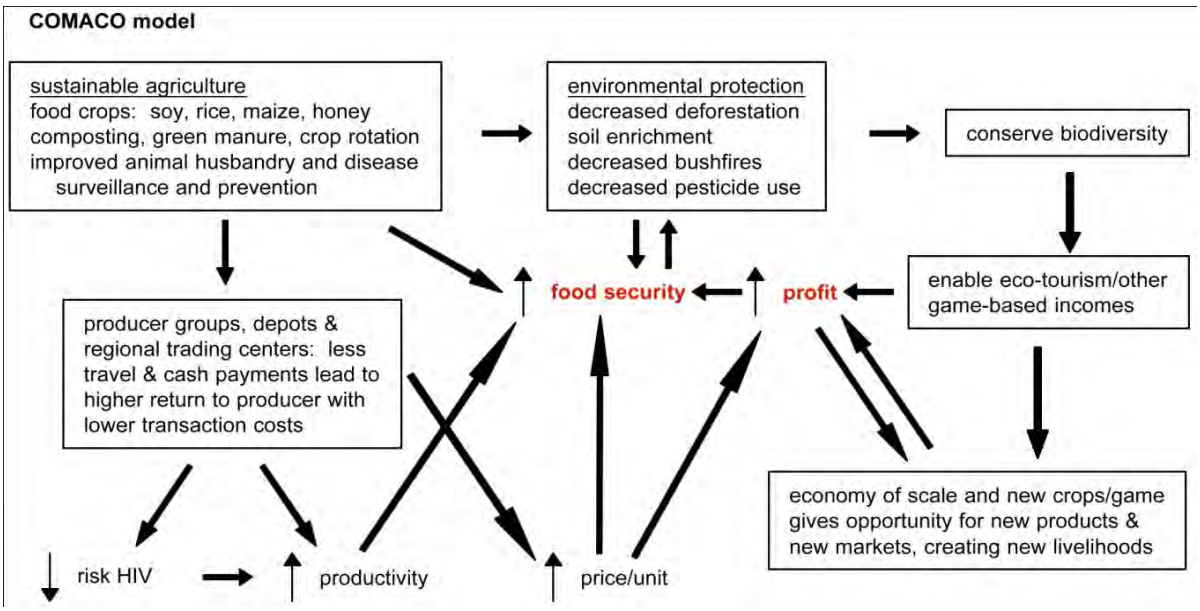


Figure 5. The COMACO model

SANREM-CRSP research. Scientists from Cornell University, in conjunction with partners at the University of Zambia (UNZA), Zambian Wildlife Authority (ZAWA), Tropical Soil Biology and Fertility (TSBF), International Rural Poultry Centre (IRPC), and the Conservation Farming Unit (CFU), performed social and biophysical research to test the COMACO model that led directly to development impacts, improving the function of the model and building host capacity.

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.

Note. Because the model is continually evolving, success or failure of the model as a whole is difficult to quantify beyond documenting its expansion, now more than 40,000 participating households, and its progress toward economic self-sufficiency. Rather, we test specific hypotheses and provide examples of how multidisciplinary research can affect poverty alleviation, food security, and biodiversity conservation.

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

As noted in the executive summary, a highlight of our work was the formulation of a spreadsheet-based model for monitoring sales and volume figures for the variety of value-added products and commodities that COMACO buys, produces, and sells. This analysis shows that COMACO continues to be far from fiscally self-sufficient, largely due to its rapid expansion. Two new CTCs were built and will become operational for the next harvest (Nyimba and Chama, May 2010), at which time they will begin to produce revenue. Additional new CTCs are being built on the western plateau in Serenje and Chinsali, though these are farther from becoming operational. Improving scale will ultimately assist COMACO in securing larger contracts for its products, but rapid expansion does impart business risks to the "ItsWild!" brand if there are notable variations in quality or uniformity between products from the CTCs. However, the increased scale of production opens new opportunities beyond value-added products, for COMACO has now entered African commodities markets (e.g., two 100-ton consignments at a price of 1,800,000 Kwacha ($374 USD) per ton).

SANREM CRSP researchers performed the first business economic analyses of COMACO. This work helped COMACO staff understand the profits and costs associated with each specific activity. This insight into the business helped staff members understand the importance of scaling up the production of value-added products, the importance of large and stable (predictable) contracts and access to larger markets, and the importance of transportation costs. This latter point was one of several important factors that resulted in the relocation of the Feira CTC to Nyimba.

Building on food science research and capacity building and, of course, cognizant of critical support from the Royal Norwegian Embassy to COMACO, our economic research has helped document and foster tremendous increases in production scale, product diversity, and revenues generated by the large contracts that COMACO was able to procure. For example, in the last six months, COMACO had a total of 2,623,753,458 Kwacha ($545,128 USD) in sales revenues. Although costs have multiplied tremendously during this time for the expansion and construction of new and existing CTCs, this increase in sales

revenues shows the tremendous growth of the business versus its inception a few years ago. This has translated directly into improvements in rural incomes and food security for the most impoverished farmers in Eastern Province, Zambia, that COMACO benefits.

In addition, our historical cost analysis helped identify the capital investments needed to launch a regional trading center, which is crucial since the model is now expanding to the north and west with new trading centers in Nyimba, Chama, Serenje, and Chinsali, and possible international expansion into Malawi.

Finally, SANREM CRSP researchers were instrumental in the identification of COMACO activities that could enable access to global carbon markets, potentially providing a new source of revenue to establish premium pricing that encourages sustainable agricultural and natural resource management practices. Specifically, the economic analyses and observations identified a potential opportunities to derive profit from soil sequestration and reforestation associated with conservation farming activities. This year alone, COMACO is estimating planting 1.1 million *Faidherbia albida* seedlings (grown in COMACO producer group leader nurseries) and 3.0 million *Gliricidia sepium* that would be eligible for such markets. Building on SANREM CRSP research with non-SANREM CRSP funding, Cornell researchers continue to work with COMACO to perform the modeling and project design and development required to access global carbon markets. Revenue from carbon markets could help cover the "conservation dividend" (premiums for complying with best practices) that could sustain the use of these practices.

Development impact

- SANREM CRSP economic research and capacity building have resulted in accelerated adoption of business methods and accounting (e.g., Lusaka headquarters now receives daily sales reports).
- Financial analyses and modeling demonstrated the impacts of transportation costs and the benefits of value-added food products (helping change the location of the third CTC from Feira to Nyimba).
- Financial models can be used as an instrument for COMACO to adapt business, marketing, and pricing strategies into the future.
- Historical analyses of CTC costs were used to help prepare budgets for the new CTCs in Serenje and Chinsali, and potential new CTCs if the model is replicated in Malawi.
- For development practitioners and agencies such as USAID, our economic research provides the information necessary to replicate the COMACO model in other areas; costs for building, equipping, and staffing a regional trading center and what components of the model could allow it to prosper under different circumstances.

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

Critical research accomplishments

This objective includes three main components: soil/crop sciences, food sciences, and veterinary sciences. Progress was outstanding on all three fronts, with all meeting and/or surpassing the goals established in the initial proposal.

Soils

SANREM CRSP research investigated the effects of climate (rainfall, temperature), soil properties (texture, carbon, pH, nutrients), and landscape position on crop yields through conservation farming. We covered the three agro-ecozones in eastern Zambia, which are widespread across southern Africa, so that our work will benefit farmers within and beyond the Luangwa Valley. We determined that individual

aspects of conservation farming do not provide the same benefits as biochar and mineral fertilizers, and that conservation farming is practiced differently by many farmers. We also found that conservation farming is suitable for improving productivity in higher rainfall areas. This information will be important for extension officers who focus their efforts on maximizing crop yields through improved farming techniques. In the long run, this information is also essential for predicting the effects of climate change on farm production, and developing policy to mitigate these changes. For example, our data imply that with decreasing rainfall, a consequence of climate change, yields would be significantly affected in this region, impacting food security and rural livelihoods.

On-going soils and crop research includes the following:

- Multivariate analyses were performed to discern the benefits of various soil amendments and farming practices in light of different rainfall, slope, and soil types.
- Soil samples are being analyzed for mineral and nutrient composition resulting from different farming practices.
- False chronosequence data continue to be collected in the current harvest season.
- Soil samples were collected and submitted for analysis as part of the cross-cutting metagenomics activity led by SANREM CRSP collaborator Karen Garrett.

Food sciences

SANREM CRSP research had a dramatic impact on COMACO's production of value-added food products, directly building capacity, and directly improving food security and rural incomes. SANREM CRSP food scientists made key recommendations to improve the processing facilities and food handling methods. These suggested changes were immediately adopted, significantly improving product safety. SANREM CRSP researchers then held a workshop that included both theoretical and hands-on training in safe and hygienic food production, which allowed COMACO's facilities to pass their certification and quality assurance testing, leading directly to a large contract for High Energy Protein Supplements (HEPS) with the WFP and Catholic Relief Services (270 ton at $350 USD/ton). HEPS is a key product in the treatment of malnutrition and for those afflicted with HIV/AIDS. Previously, HEPS had to be imported at great cost. Now, COMACO's farmers can meet this critical need locally and simultaneously increase their own food security and family incomes.

SANREM CRSP research on peanut butter processing and formulations led to an improved product with reduced oil separation and improved packaging to increase shelf life. Rice breakage was reduced, and new products are being researched to utilize rice that does break. Both of these improvements increased profitability and food security. The impacts of SANREM's food scientists led COMACO to appreciate the need to build capacity in food sciences and they hired a Zambian food technologist, Jimmy Chikahya, who now provides oversight of food production training and new product development. The project also established communication between COMACO and the University of Zambia for product testing and quality assurance.

Cornell food scientists established contact between COMACO and international food-processing company General Mills. During their site visit, specialists from General Mills were impressed with the quality of COMACO's food processing facilities, which is in part a result of the activities of this project. As a result of the visit, General Mills donated an extruder to COMACO and trained, at its own cost, COMACO's food processing specialist and a Cornell master's student at one of the company's facilities.

The General Mills partnership is a significant boost for COMACO's value-added processing capacity and is expected to boost COMACO revenues significantly. For example, COMACO has expanded its sales to regional hospitals and is beginning to sell to local schools. About 60 percent of COMACOs value-added products are now used within Eastern Province itself, providing local benefits and unknown cost savings

over importation of these products. In addition, these activities reduce the carbon footprint versus importing and enhance the long-term livelihood of COMACO participants.

Overall, these activities and achievements will enable COMACO to increase export markets and develop new value-added products with longer shelf lives under the difficult local environmental conditions. Specific accomplishments include:

- providing theoretical and hands-on training on basic food hygiene and good manufacturing practices for the COMACO production staff,
- testing the efficacy of hand washing training with fluorescent "Germ Glo" reagent,
- introducing swipe kit testing for microbial pathogens, including *Salmonella spp* and *Eschericia coli*, and using those kits to test the efficacy of training on the hygienic maintenance of preparative surfaces and instruments,
- providing COMACO with electronic and printed materials for future in-house training on food safety and personal hygiene identifying and correcting some of the problems encountered in their food processing facility,
- assistance in developing new products, including soy milk and tofu, and providing COMACO personnel with suggestions for the utilization and commercialization of new products,
- creating and testing a honey roasted peanut product and energy bar prototypes, experimenting with extrusion using a modified dye and alternate feed formulas to produce a puffed rice product, and producing chicken and ruminant feed using production waste such as rice hulls,
- establishing a COMACO product development laboratory consisting of a workplace for cooking, as well as lab space for basic procedures such as moisture analysis, pH, solids content, and water activity,
- providing the CTCs with necessary instrumentation and training for quality control monitoring of products,
- identifying improvements in systems to better control the processing of raw material to value-added products including inventory control forms for raw materials and products, development of incident report log data sheets, development of spoilage and loss reports to better track performance, creation of specification sheet templates for each product, and improved COMACO extruder systems by adding water pumps, feed rate meters, and a new water holding tank, which should improve the quality of extruded products by allowing more control over the process,
- improving marketing of value-added products,
- attracting leveraged resources for COMACO through the General Mills Foundation who made significant contributions to the projects by (1) donating a second extruder for the CTC to enhance processing capacity, and (2) enhancing the local knowledge and skill base in food processing and product development by providing training in the company's U.S. facilities for COMACO food-processing specialist Chikahya and Cornell master's student, Colin Seeley.

Veterinary sciences

SANREM CRSP researchers identified that more than 80 percent of poultry were dying before sale or consumption, leading to extremely low returns from an activity practiced by the majority of rural households. Research identified the causes of mortality, which led to recommended improvements in roost design and husbandry. These changes were taught to thousands of villagers by SANREM CRSP veterinary researchers, and this training is being continued by COMACO's extension officers. Husbandry changes alone were able to improve production by about 50 percent.

However, even with improved husbandry, Newcastle disease virus was still endemic and devastating the flocks of entire villages (a major reason why improved practices had not evolved previously). Partnership with the IRPC led to a vaccination program mounted by community vaccination teams. Tens of thousands

of chickens were vaccinated, and off-take and census data are being collected and analyzed to determine whether this vaccination program can be economically self-sufficient. If so, it would provide increased food production and nutrition, an additional income source, and livelihoods for the vaccinators.

Specific accomplishments included:

- Participatory and observational research to define husbandry practices for household poultry and goat production.
- Determined that goat and poultry mortality were 67 and 80 percent prior to sale or consumption.
- Identified improvements in household husbandry practices to increase returns.
- Trained thousands of rural farmers in improved animal husbandry practices.
- Trained COMACO's extension officers in basic poultry and ruminant examination and management.
- Produced husbandry manuals for improved poultry and goat production.
- Produced a training manual on "training the trainers" for implementing successful field days on animal husbandry.
- Confirmed that Newcastle disease virus as a major, endemic cause of poultry mortality.
- Instituted with IRPC and WCS AHEAD a community vaccination program involving the formation and training of community vaccination teams (one man and one woman per team).
- Established data collection on flock size, mortality, sale, consumption from vaccinated and control villages in conjunction with the three vaccination cycles a year.

Supporting technology
Broadband internet access was established at two locations by satellite linkage using SANREM CRSP funding. This technology leap facilitates research communications between COMACO staff in the field and staff at the Lusaka headquarters, and COMACO staff and Cornell researchers in the field with partners at Cornell as well as around the world. This access saves innumerable hours of travel and thousands of dollars in fuel costs alone because staff previously had to drive for 30 minutes to the Mfuwe airport to send e-mails and for web-based phone calls.

Development impact

- Established benchmark maximum maize yields for different agro-ecozones that will provide a barometer of success of conservation farming methods, impacting the evolution of conservation farming practices and training.
- Improved COMACO's physical and human capital host capacity in terms of safe and hygienic food production.
- Reduced COMACO's wastage of rice and peanuts during food storage and processing.
- Improved the variety, quality, and shelf life of COMACO's value-added products, which contributed directly to new products, new markets, increased profitability, and premium pricing provided to farmers to maintain compliance with SA and NRM practices.
- Developed a manual of standard operating procedures and best practices, which provides a framework for continued success for safe, hygienic and profitable food production.
- Improved household poultry production throughout the target population (goats to a lesser extent because of more regionally specific goat production areas).

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

Progress on aspects of this objective was delayed due to unanticipated personnel issues. However, additional funding was leveraged to perform a new social survey to address issues of food security, effects on household income, technology adoption, and gender. In addition, new efforts are being made to evaluate health benefits attributable to the model.

For COMACO's activities to be sustained, they must provide tangible advantages to the participants. Social data continue to be collected to evaluate the impacts on income, nutrition, health, gender equality, and natural resource management practices. If COMACO is not having its intended social benefits, then policy changes can be made to improve the COMACO model.

One very positive finding is that COMACO is gender neutral in terms of the prices it provides male versus female farmers for the same products. This is especially important given the high percentage of families run by a single female head of household. SANREM CRSP social research has brought gender to the fore, resulting in new appreciation that has impacted COMACO staffing practices. For example, before the start of the SANREM CRSP project, there were no female extension officers. Now, gender is strictly balanced in vaccination teams. Social science research must continue to assess if COMACO is having its desired impacts.

Critical research accomplishments

- A social science survey was designed and implemented. Data are being analyzed to determine if household incomes and/or food security are improving (part of a "value of statistical life" analysis).
- Data were collected from community health centers to quantify potential health and livelihood benefits of COMACO activities. Data is being analyzed to determine if health of COMACO participants is improving.

Development impact

We do not yet know the full development impacts of the social research. However, preliminary analyses show that sustainable agriculture technologies introduced into the valley by COMACO are being utilized by many non-COMACO households. Although the potential extent and impact of this technology adoption are an unexpected benefit of the model, the scope of the impact confounds attempts to quantify COMACO's effects on food security by comparing COMACO versus non-COMACO households.

Additional social benefits that were revealed on a preliminary basis include the scope of extension/outreach education and the gender neutrality of the payments at the local depots. The gender sensitivity of crop selection and training and equivalent access to markets could represent noteworthy social successes of the model since the percentage of households headed by single women is growing due to male exodus to more urban areas for employment and because of changing demographics due to HIV/AIDS and related infectious disease.

Objective 4. Determine the extent to which the COMACO model improves biodiversity and watershed conservation.

Several areas of SANREM CRSP research are having direct impacts on multiple stakeholders. The results of a "willingness to pay" survey of foreign tourists will help the Zambian Wildlife Authority (ZAWA) understand the value tourists place on varied species of wildlife and particular conservation efforts. The survey results can also help ZAWA adjust park entrance fees, publicize the presence of different non-game species, and promote specific activities.

Wildlife data have documented the large impact COMACO has had on stabilizing numbers of hoof stock in the COMACO core area relative to controls. These data in turn will allow scientists and wildlife managers to assess whether or not animals will move back into areas they inhabited prior to extermination by poaching. This information will be valuable to the Zambian government as they set new wildlife use policies. The results of COMACO's indirect approach to biodiversity conservation will also be useful to the Wildlife Conservation Society (COMACO's parent organization) and other wildlife preservation organizations in designing future conservation programs. Additionally, aerial counts of Africa's largest hippo population show species numbers and map their distributions. These data will provide a critical picture of this population as it faces increasing pressures from siltation and changes in river morphology, and increasing conflict with local fishermen and farmers due to net destruction, attacks, and crop predation.

Watershed analysis has shown that clearing of forests on the slopes (escarpment of the Luangwa Valley) has the greatest potential to increase runoff and siltation. This is valuable information because the clearing of forests for cotton and tobacco farming and charcoal production is intensifying. This information provides federal and regional government officials, as well as traditional rulers, with key insights into how they should develop land use strategies to avoid deleterious downstream effects.

Critical research accomplishments

- Completed a willingness-to-pay survey of tourists visiting Luangwa Valley's national parks.
- Instituted controls for collection and validation of data from wildlife aerial surveys to assess impact of COMACO on wildlife populations.
- Expanded yearly aerial surveys to a valley-wide scope.
- Performed aerial survey to quantify hippo population in the Luangwa River.
- Collected data on guns and snares collected from participating COMACO households and the number of poachers who have completed COMACO's Poacher Transformation Program.
- Collected proxy data to evaluate the impact of COMACO's attempts to alter consumptive wildlife practices, including surveys of safari hunters and data from ZAWA anti-poaching patrols, e.g. number of snares encountered, number of poachers encountered/arrested, number of poached elephant carcasses found.
- Collected data from satellite images and evaluated canopy loss and bushfire incidence.

Development impact

- Willingness-to-pay survey data can assist ZAWA officers with structuring national park entrance fees that include the cost of species management plans.
- Wildlife surveys document success/failure of model at stabilizing wildlife populations in the Valley Game Management Areas. Wildlife populations impact the marketing and success of COMACO's ecotourism business arm, the community Bush Camps.

Degree and non-degree training activities

Two African women will be completing PhDs and 10,768 men and 10,996 women participated in short-term training events. The vast majority of the short-term trainees were involved in field days promoting either the prices and marketing opportunities that COMACO provided or improved conservation farming practices.

Publications, presentations, other products

One book chapter, two extension publications, a fact sheet, a professional report, four magazine and newspaper articles, 15 electronic publications, four posters and eight papers were published or presented in FY2009.

Networking activities

Networking activities are too numerous to list in full. Key relationships that arose as a result of SANREM CRSP research and key meetings that improved communication flow with government officials are highlighted.

- Long-term relationship between COMACO and Nyambe Lisulo-Mkandawire of the University of Zambia regarding food quality and safety testing.
- Long-term relationship with General Mills, by means of Carmen Moraru with Sheri Schelhaas and John Mendesh.
- Relations between COMACO and ZAWA that has translated into a data sharing partnership with SANREM CRSP researchers.
- PI Travis discussed COMACO and SANREM CRSP research with the Zambian ambassador to the United States, Inonge Mbitkusita-Lewanika.
- SANREM CRSP researchers met with WFP Logistics Officer Felix Edwards to facilitate the steps involved in COMACO's production of HEPS for WFP purchase.
- SANREM CRSP research on goat production was facilitated by information from Harrison Chitambo, Francis Mulenga, chief veterinary officer of the Ministry of Agriculture and Barnabas Chitalu of Heifer International.
- PI Travis met with USAID Mission Director, Melissa Williams and the Economic Growth Team in Lusaka. Updates were given on the scope and impacts of SANREM CRSP research and the current status of COMACO's business, social, and environmental activities. New possibilities for future synergies were identified.
- A major workshop/conference was held in Chipata June 24-26, 2009. Attendees included Eularia Siamujaye, permanent secretary of Eastern Province, Kennedy Kanenga, a scientist at Msekera Research Station, Sitali, district veterinary officer, Chindauka, district forestry officer, Lusizi Mwale, ZAWA area manager, and Ballard Zulu, acting USAID Zambia team leader for economic growth.

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

Principal investigator: Jeffrey Alwang, Professor of Agricultural and Applied Economics, Virginia Tech

Host countries: Bolivia, Ecuador

Research team:

- Virginia Tech: George W. Norton and Darrell Bosch, agricultural and applied economics; Mary Leigh Wolfe, Brian Benham, and Conrad Heatwole, biological systems engineering
- Penn State: Paul Backman, plant pathology; Jonathan Lynch, horticulture and plant nutrition
- Florida A&M: W ills Flowers, entomology and biocontrol
- University of Denver: Sarah Hamilton, international development and gender analysis
- INIAP/Ecuador: Victor Barrera, Carlos Monar, Elena Cruz, Luis Escudero
- ECOCIENCIA/Ecuador: Adriana Cardenas, Juan Calles
- Sigagro/Ecuador: Carlos Montufar
- PROINPA/Bolivia: Ruben Botello, Nadezda Amaya, Illich Figueroa
- PROMIC/Bolivia: Omar Vargas, Ana Karina Saavedra

Research strategy and development objectives

Introduction

LTRA-3, "Watershed-based Natural Resource Management in Small-scale Agriculture: Sloped Areas of the Andean Region," addressed an important problem: households and communities in environmentally fragile Andean Region areas need alternatives to strengthen economic vitality through more productive livelihoods while ensuring environmental sustainability and social development. Our overall goal was 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. The project had 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 in order to improve production systems and enhance income generation.
- **Objective 3**. Create a means of evaluating the impacts of alternative actions, policies, and interventions on income generation, and social and environmental conditions.
- **Objective 4**. Build local capacity to evaluate policy alternatives, make and enforce decisions, and strengthen social capital.

These research objectives helped us attain our development objectives: (i) more effective management of natural resources and sustainable use of natural resources in Chimbo, Ecuador, and Tiraque, Bolivia; (ii) diversify economic activities through alternative natural resource-based livelihood strategies; and (iii) 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 involved several components but was built on a livelihoods approach to understanding human decisions. In this framework, household decisions are determined by the household's asset[2] (or capital) base; available alternatives; the institutional, policy, and social environments; exposure to risks and access to information; and the natural environment (Figure 6). Households allocate assets among activities in order to meet an objective (utility maximization, profit maximization, risk minimization given levels of incomes, long-term well-being). These activities are bundled into a livelihood strategy. In our research program, household decisions about livelihoods, use of natural resources, and investments in natural resources were investigated. Particular attention was devoted to identifying the determinants of household decisions and how local actions, such as policy changes, local land use plans and restrictions, and changes in incentives such as market prices affect these decisions. This information was produced as a part of a participatory research approach whereby stakeholders and users of the information were engaged from the start. In our case, some of this participation was found to be a critical determinant of uptake of research results. The research themes and, in some cases, the research designs were informed by and altered as a result of stakeholder input.

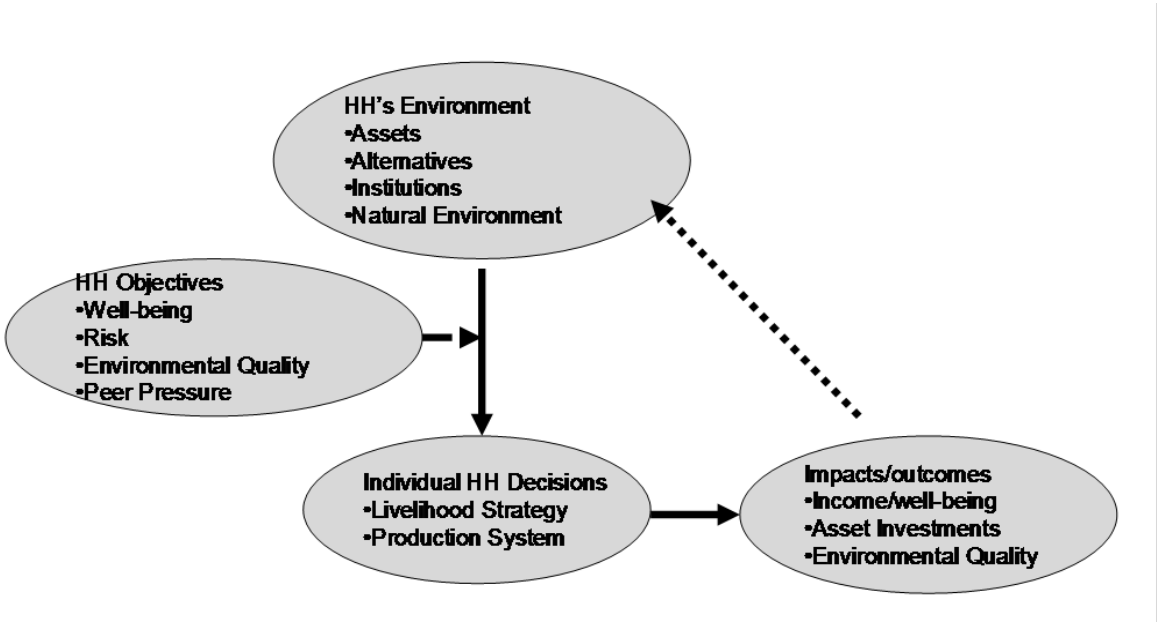


Figure 6. Household decisions and impact

Household decisions have impacts on outcomes including household wellbeing, the ability to save and invest (impacting the future asset position), and the natural environment. We experienced two broad types of impacts resulting from policy or institutional innovations in the watersheds: changes in household wellbeing and asset position, and impacts on soil quality and quantity, biodiversity, runoff, and water quality. The latter impacts continue to be felt at the field and farm level, but due to geographic inter-linkages implied by the watershed, they are aggregated to the watershed level. Some local actions have impacts on a larger scale (run-off into the river, carbon sequestration).

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

Acceptance of the validity of model findings requires the buy-in of stakeholders; this buy-in was obtained by involving stakeholders in field research, model, and scenario development. We compared and contrasted the predictions from our mathematical models with more simple approaches used by local non-governmental organizations (NGOs) and the perceptions of local stakeholders. We found fairly solid correspondence, building confidence in our approach to adaptive watershed management.

The watershed management approach (Figure 7) 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 the 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 utilizes activities such as monitoring, data analysis/assessment, planning, and implementation according to a set 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). This cycle continues using adaptive management to achieve existing and new goals as they arise. Common elements of the approach include:

- Definition of management units: large, small, or multiple watersheds.
- Definition of management cycles: time required to complete monitoring, assessment, planning, and implementation cycle (typically four to five years).
- Stakeholder involvement: agencies, organizations, and individuals interested in water quality, ecosystem health, economic objectives, and management strategies are included in watershed management activities.
- Strategic monitoring: water quality, ecological health, and economic indicators are monitored to measure the extent of problems and the stressors involved.
- Assessment: data analysis and professional judgment are 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 plans document the assessment results, goals, and chosen management strategies for the watershed; the plan helps educate the public on watershed-specific issues.
- Implementation: selected management strategies are implemented and tested.

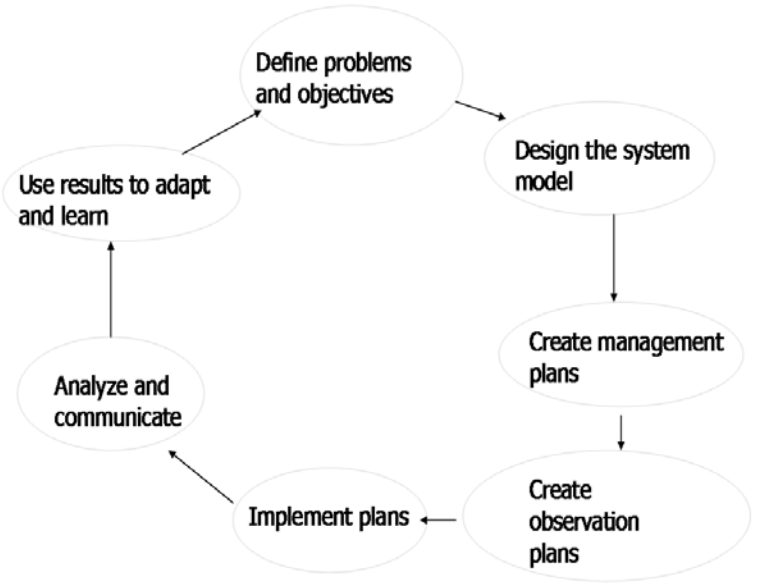


Figure 7. Adaptive watershed management

Methods and research components

Research activities were divided into five categories roughly corresponding to research objectives 1-4. Activities involve a number of scientific disciplines—soil science, agricultural engineering, geography, plant pathology and agronomy, socioeconomics, ecology and biology—and in most cases the work is transdisciplinary 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 8.

Data generation

We invested significant resources into describing economic, social, and physical characteristics of the watersheds. This information was incorporated into a geo-referenced database. Some of this description was used to create an information baseline from which comparisons of changes can be made over time (e.g., socioeconomic baseline, assessment of biodiversity, aggregate information on soil loss and soil productivity). Some was used to better inform watershed decisions (particularly the socioeconomic and geographic information). It was also used to build our three basic models: (a) models of physical production (soil and environmental attributes, productivity); (b) models of household decisions (using data from socioeconomic baseline surveys plus geo-referenced data on agro-climatic conditions and distances to markets); and (c) 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).

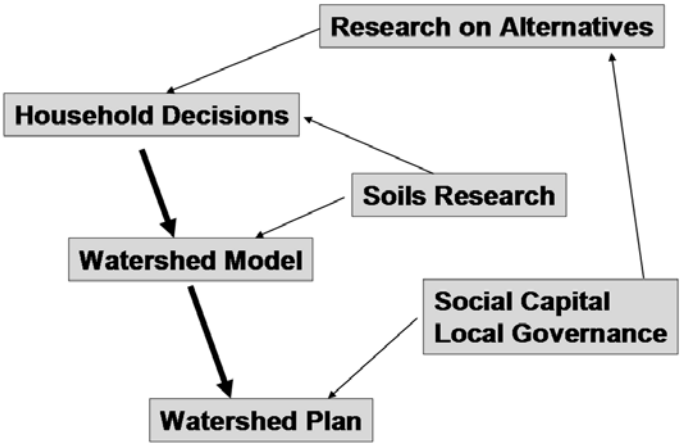


Figure 8. Linkages among research activities

Determinants of household decisions

This research component used information including livelihoods and outcomes, agro-climatic data, access to infrastructure, and the risk environment. We employed two broad means of modeling household decisions: a positive analysis using econometric techniques in a two-stage process and a normative analysis using partial budgeting techniques to evaluate the economic attractiveness of alternatives. To analyze livelihood adoption decisions, we used a two-stage technique. In the first stage we estimated the determinants of livelihood adoption using a multinomial logit econometric model; in the second stage we estimated the wellbeing impacts of this adoption, conditioned on the adoption decision. This positive analysis was used to determine how households respond to changes in the physical, institutional, and social environment, and how these responses affect household wellbeing. It was also 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); these predictions were aggregated and incorporated into the watershed model.

Identification of alternatives

This research generated 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. We also analyzed the functioning of agricultural product markets and barriers to participation in different, often higher-valued markets. By identifying these barriers we could, together with local decision makers, seek means of overcoming them, thus broadening participation and improving incomes. We also conducted case studies of small-scale value-added processing activities, particularly dairy and cheese processing in Ecuador.

Impacts on watershed scale

The inputs into the watershed models included some of the information described above. The models are used to link field- and farm-level activities and aggregate outcomes such as water quantity and quality, soil loss, sedimentation, and carbon flows. The models take information on the spatial distribution of natural conditions, rainfall, and human decisions, and relate this information to aggregate outcomes. They are used to simulate the aggregate impacts of alternative policies on outcomes of interest.

Adaptive watershed management and stakeholder engagement
In order to build local capacity to use the information created through the economic and watershed models, stakeholders were engaged in a participatory watershed planning process. This process began with a community visioning exercise whereby problems and concerns along with objectives are identified, moved on to training in watershed management techniques, used local stakeholders to help generate information, and compared scientific findings with the stakeholders' own perceptions about the relationship between policies and outcomes.

Research activities were conducted in laboratories in Ecuador, Bolivia, in U.S. participating universities, on-station, on farmer fields, and in participating communities. Physical science experiments were all conducted under standard scientific norms with replication and randomization. Social science activities included quantitative data analysis using data from random surveys, budget and cost analysis, and qualitative and participatory analysis.

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 included collection and analysis of data on watershed characteristics including agro-climatic and geo-physical 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 were fed into a GIS and used to model the watersheds.

Critical research accomplishments

- Completed GIS for each watershed. The GIS model includes information on soil characteristics, slope and elevation, rainfall, land use, water resources, the transportation network, and other infrastructure. Other variables 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, distances to markets, and other variables. Our baseline household survey data are included in the GIS for both sites.
- Documented the extent and severity of soil erosion in the region, with particular attention to impacts on soil carbon retention, 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 used test plots to measure erosion under different management practices. Several practices such as grass strips and deviation ditches were found to be cost-effective and widely accepted. As a result, the project extended them to farmers in the Guaranda, Ecuador site.
- Evaluated the extent of adoption of conservation practices and found several controllable factors to be associated with higher rates of adoption. For example, participation in research activities was associated with more adoption, as was more available labor and more trust in the extension technicians. We also find that adoption is much more frequent when the erosion control techniques are packaged with other technologies that improve incomes (such as new varieties of potatoes or more effective pest-control measures).
- Soil erosion rates were estimated using modeling and runoff plots.
- In Bolivia, we documented that several species of nematodes cause damage to several of the most important cash crops. Research plots evaluating biofumigant rotation crops were established to

evaluate their impacts. We identified a number of promising controls that can also be used as green manures and so enhance soil health. Biological control systems were evaluated with very positive effects to control foliage pathogens in several key crops in both Bolivia and Ecuador.

- Identified causes of water level and quality deterioration. In the Ecuadorian Andes, pressures related to water are reflected by an increase in conflicts over water 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 depend mainly on the remaining forest. In both cases, human activities such as agriculture and livestock production have led to pollution of the páramo and high deforestation.
- Created and applied a protocol for measuring and monitoring biological diversity. Despite appearances, we found biodiversity in both Ecuador sites and in Bolivia to be high. We engaged schoolchildren in efforts to collect information on biodiversity indicators as a part of their education. This recognition of biodiversity indexes was incorporated into local curricula.
- Established a monitoring system for aquatic biodiversity in Ecuador as a means of measuring water quality. Identified indicator species and established a school-based monitoring system. Water quality in the rivers in our Ecuador site is relatively good, but several threats to that quality were identified. The use of macroinvertebrates as indicator species appears to be justified.
- Monitoring and water-quality analysis results from BMWP/Col and ABI indexes, physical-chemical parameters, and other indicators showed that water quality is relatively good in the study watersheds. The microbiological analysis found fecal contamination from human and animal sources to surpass acceptable limits in most of the rivers tested. The presence of native fish (*Astroblepus sp.*) and diverse macroinvertebrate communities, however, suggested that water quality for non-potable us is acceptable in the area. However, deforestation is evident and could affect water quality over time.
- Collected cost of production data and monitored 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.
- Completed and analyzed baseline surveys of socioeconomic data. We now have a solid understanding of livelihood strategies, farming practices, income and wellbeing outcomes, and gender relations for households in Ecuador and Bolivia.
- Characterized the extent and causes of erosion in both watersheds. 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. This result is related to well-established rotations in the upper watershed. 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.
- Developed and evaluated a number of practices and technologies to address soil degradation. These include use of cover crops, enhanced rotations, and soil erosion-control practices.

Development impact

- The GIS is being used for several purposes: establishment of a baseline and regular updating to facilitate monitoring of change; data storage and management; visual presentation of research results; ability to present data and research findings in visual fashion is expected to increase research uptake. In addition, 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. We found that visual evidence is a particularly useful tool in presenting research findings to stakeholders, and the ability to visualize information has led to increased uptake of research results (knowledge to action).
- Biodiversity monitoring enhances the information about how actions in the watershed affect environmental outcomes. Participatory monitoring was used, and participation is increasing local awareness of biodiversity and its value. Even though the project has ended this phase, these monitoring activities are continuing in both countries. Biodiversity indicators are now included as a part of curriculum in schools.
- Ability to monitor prices in local markets enhances decision making at local levels. Individual producers are now better aware of costs and potential profits. It is estimated (from our econometric results presented more completely below) that increased information leads to welfare gains of 10 percent to 20 percent for households in the watersheds. We have enabled more informed actions on the part of individual decision makers.
- Baseline surveys provide information about general socioeconomic conditions in the area, how people earn their livings, and can be used to monitor program impacts. This information will increase efficiency in planning, and the use of hard information will enhance decision making.
- Information on erosion sources and factors affecting water-quality degradation has already been transmitted to policymakers. Local land use plans now encourage appropriate land uses, especially in fragile areas. Local governments are engaged in extending soil erosion control techniques, and the national government in Ecuador is considering adopting measures to pay land users in the Chimbo region to reduce siltation and flooding farther downstream.
- Authorities in Ecuador are aware that the most serious water quality problem is the disposal of human waste from Guaranda and Chillanes into the river without treatment. The local governments in both cities are currently considering options to lessen the impacts of human wastes on water quality.
- At sub-watershed levels, measures to protect the remaining forest are being undertaken. These include the establishment of stream bank protection and fencing of strategic areas for water provision.
- Data gathered about aquatic microinvertebrates in the area are the first ever done and will be references for future studies in the area and others in the Ecuadorian Andes.
- Stakeholders participate in monitoring of climatic and water flow conditions in both countries. This participatory monitoring is an initial step toward quantification of water resources and an engagement of stakeholders in water resources management. 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 water resources and challenges to them.

Objective 2. Generate and validate environmentally sustainable alternatives in order to improve production systems and enhance income generation.

Research to meet this objective included laboratory work to identify solutions to agricultural pest problems, on-farm participatory evaluations of alternative varieties and farming techniques, analysis of

market chains and the performance of and access to agricultural markets, and measurement of economic gains/losses from existing and new technologies. Some alternatives might be new crops and new on- and off-farm income-generation strategies; others would include technical improvements to existing practices.

Critical research accomplishments

- We generated information on the relationship between on-farm management practices (tillage, rotations, conservation structures) and soil loss for Ecuador and Bolivia (Figure 9). We have multiple years of data, and the analysis was used to design appropriate extension messages. Evidence shows widespread adoption of soil erosion management practices in the upper watershed in Ecuador. Adoption is less pronounced in the lower watershed, but even there extension efforts are beginning to bear fruit. Extension messages have not yet been completed for the Tiraque site in Bolivia, but PROINPA has indicated that it is preparing extension materials. Grass strips and deviation ditches are the two most cost-effective anti-erosion practices in potato-growing areas, while contour plowing is recommended in all locations.

Figure 9. Soil erosion trials in Tiraque, Bolivia, 2009

- Evaluated the relationship between management practices and soil nutrient balances for common practices in Ecuador and Bolivia and incorporated this information into our land use planning exercises. We verified evidence from other areas that soil coverage and tillage practices were largely responsible for macronutrient losses. For example, in Ecuador we found that the majority of lost macronutrients in maize were related to practices of leaving bare ground before the first seasonal rains and hoeing for weed control. Both of these practices can be avoided through more judicious use of cover crops and modified tillage techniques. Maize cultivation represents the biggest source of macronutrient losses in the Ecuador watershed.
- Estimated the economic cost 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 (USD) per hectare, depending on the product (Table 7).

Table 7. Present value of the losses in productivity as a result of the soil erosion, Alumbre sub-watershed, Bolivar, Ecuador

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	6600.00
Costs (USD/ha/year)	$338.00	$364.00	$85.00
Income (USD/ha)	$345.60	$289.60	$70.00
Present value of economic losses by soil erosion in a period of 10 years (USD/ha)	$2581.72	$346.50	$50.10

- Information on land use and soil erosion was also used to create watershed plans and as input into our physical modeling exercises. We generated information on erosion hotspots to guide reforestation measures. Reforestation with native species is now occurring in the Ecuador watershed with funding from government and USAID.
- Several strategies were 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). See Table 8.

Table 8. Alternative practices identified during SANREM CRSP Phase III

Illangama Sub-watershed	***Alumbre Sub-watershed***
• Deviation ditches and grass (*Phalaris tuberosa*) • Rotations: natural pasture - potatoes (Fripapa and Natividad) - barley (Shyri 89, Grit 8, Jazmin/Cardo) – fava bean (INIAP-440 Quitumbe andINIAP - 441 Serrana) - quinoa (INIAP pata de venado and Tuncahuán) • Live barriers with native plants (yagual, tilo, romerillo, piquil, chachacoma, aliso, higuerón, tilo) • Chocho in association with pasture pasto (INIAP - 450 Andino) • Better timing of planting (dry and wet season) • Crops in association with maize—fava bean with improved varieties • Improved pastures with various mixtures such as rye grass (Magnum and Geyser), blue grass (Amba and Cara), white clover (Haifa), red clover (Amagua), biannual rye grass (Tetralite), perennial rye grass (Amazon and Kinstong)	• Strip cultivation (wheat, maize, and climbing bean) • Live barriers with native plants (nogal, alisos, siete cueros, and guarango) • Bench terraces with horticultural crops (increased incomes) • Fruit trees planted on contours to create live barriers in degraded areas (chirimoya, citrus, avocado, and blackberry) • Reduced tillage options for beans and peas • Improved pastures with various mixtures such as rye grass (Magnum and Geyser), blue grass (Amba and Cara), white clover (Haifa), red clover (Amagua), biannual rye grass (Tetralite), perennial rye grass (Amazon and Kinstong) • Rotations: hard maize (INIAP 176) – climbing beans (INIAP- 412 Toa, INIAP- 421 Bolívar, INIAP - 426 Canario siete colinas); fréjol arbustivo (INIAP - 427 Libertador rojo moteado, INIAP - 428 Canario guarandeño). • Gerplasm developed for climbing beans and maize INIAP- 111 (maíz choclero). • Contour plowing and cover with alfalfa (*Pennisetum sp.*)

- 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. For example, we have introduced grass strips between potato fields to provide fodder for cattle and reduce soil delivery to streams. Our research in Ecuador adjusted fertilizer recommendations to be specific to the needs in the lower watershed. This research allows maize and bean farmers to be more efficient in their use of inputs and increases their profitability. 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). Producers evaluated the treatments and decided that the best treatment was the one with 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 sowing density of 60,606 (25 cm x 66 cm).
- Found that in Ecuador nitrogen is a key limiting nutrient; phosphorus, potassium, sulphur, 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, sulphur, and magnesium. The application of phosphorus, potassium, sulphur, 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 the following: N—50 percent in the grain, 3 percent in the maize-cob, and 47 percent in the residues; P—59 percent in the grain, 2 percent in maize-cob, and 39 percent in the residues; K—12percent in the grain, 3 percent in maize-cob, and 85 percent in the residues; Mg—32 percent in the grain, 2 percent in maize-cob, and 66 percent in the residues.
- Our investigations of nutrient balances in Bolivia also show that nitrogen is the primary limiting factor. Other soil nutrients are adequate.
- In Bolivia we identified the most suitable fava bean variety (habilla de altura). This variety was determined to be an excellent addition to income-earning strategies for households. We evaluated a number of maca production systems, varying planting density and elevation, and find 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 were established to promote production and coordinate marketing of this important crop. Kañawa test plots show highly variable yields, and additional work is needed before we can recommend this product as a food security supplement. This crop can be added to conventional rotations to improve soil health, diversify income sources, and provide additional foods for the families in the area.
- Assessed milk marketing and dairy chains in Ecuador (Table 9) and the potato chain in Bolivia. Identified a number of important obstacles to participation in higher-valued chains. Improved access to information and formation of producer groups and networks are steps that are being taken to improve access in both cases. A producer group in the upper Illangama (Ecuador) watershed was formed and is currently seeking financing for a small-scale cheese processing facility.
- The characterization of milk production by each group is shown in Figure 10. 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.

Table 9. Characterization of groups of milk producers, Illangama sub-watershed, Bolivar, Ecuador

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

- Management of yield variability caused by nematodes and diseases was investigated. We found that bio-intensive pest management is a promising option, but soil health in Tiraque, Bolivia, is so low that additional fertility is required to produce sufficient biomass for green manuring. We investigated the potential of arugula and mustard seed as green manures and found soil quality to be limiting the effectiveness of each (more below).
- In both producer typologies, 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.
- We developed several new biocontrol techniques for a variety of pathogens in both Ecuador and Bolivia. These techniques can lead to local cottage industries for the production of biocontrols and thus increase incomes in two ways. First, they lower the cost of pathogen control and improve the quality of the product. Second, value added can be retained locally from production of the control products. For example, we found nine endospore-forming bacteria (seven collected from unmanaged apple orchards and two from vegetables) in Bolivia. They were evaluated for ability to suppress bitter rot pathogen (*Colletotrichum acutatum*) on apple fruit. Effectiveness of the bacteria in combination with or without AgSil (potassium silicate) was also tested. All bacterial treatments (except isolate BacJ alone) significantly reduced lesion area compared with unsprayed controls (Table 10). AgSil alone was not effective, for it was not significantly different from the unsprayed control. Field experiments indicate that several of the isolates were able to suppress apple scab disease severity throughout the growing season (Figure 11). PROINPA has developed protocols for the reproduction of these bacteria.
- We have also developed several green manures for use in fields in Bolivia. Like the bio-controls, these techniques can increase incomes, but mainly through increased soil health, soil fertility, and productivity. We have evaluated the use of green manure crops for suppression of nematodes.

Figure 10. Characterization of milk production technologies, sub-watershed of the Illangama River,

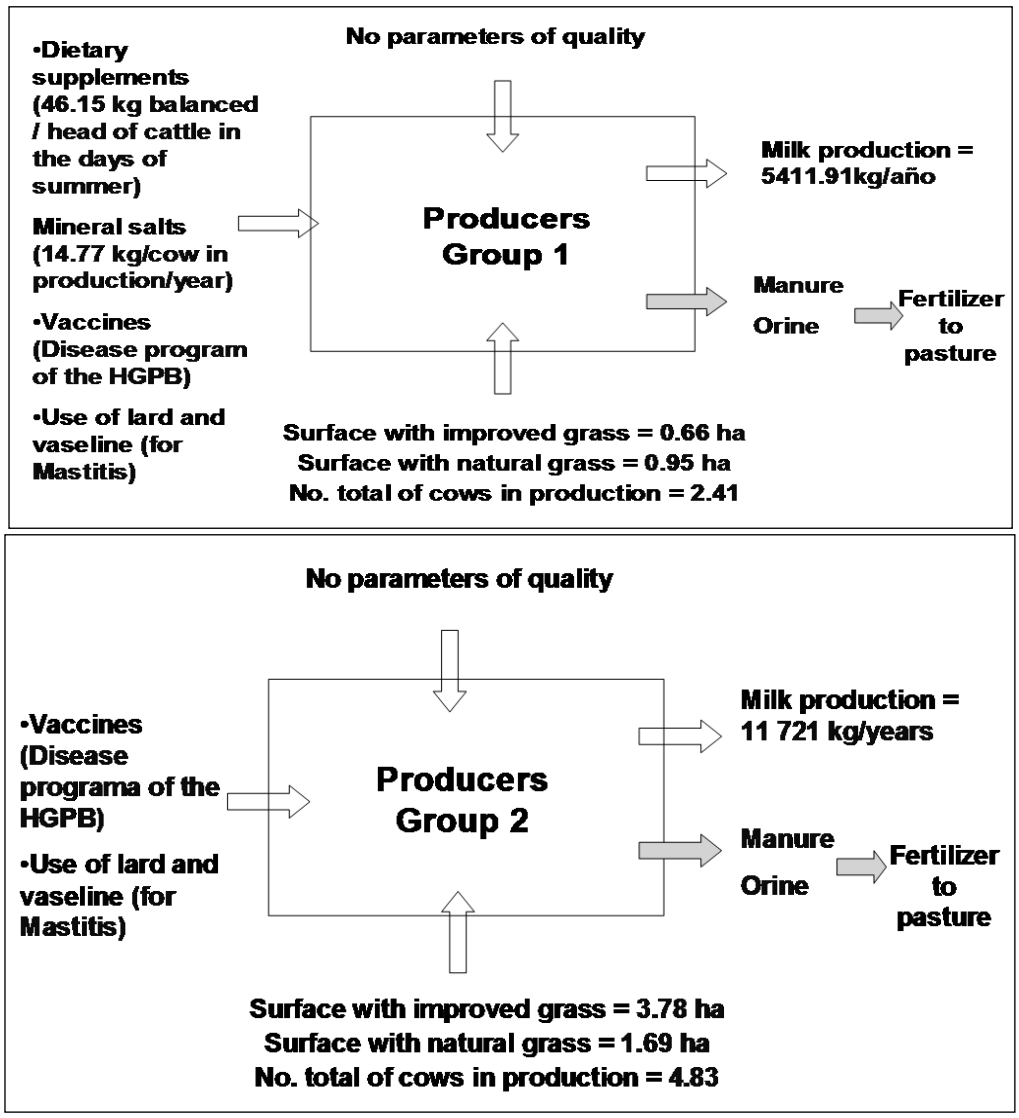


Table 10. Suppression of bitter rot lesion area by endospore-forming bacteria isolated from apple and vegetables

Treatment/ Bacterial isolate	Mean lesion area (mm2)z	
	Bacteria alone	**Bacteria + 2% AgSil**
Untreated control	268 ax	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 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.

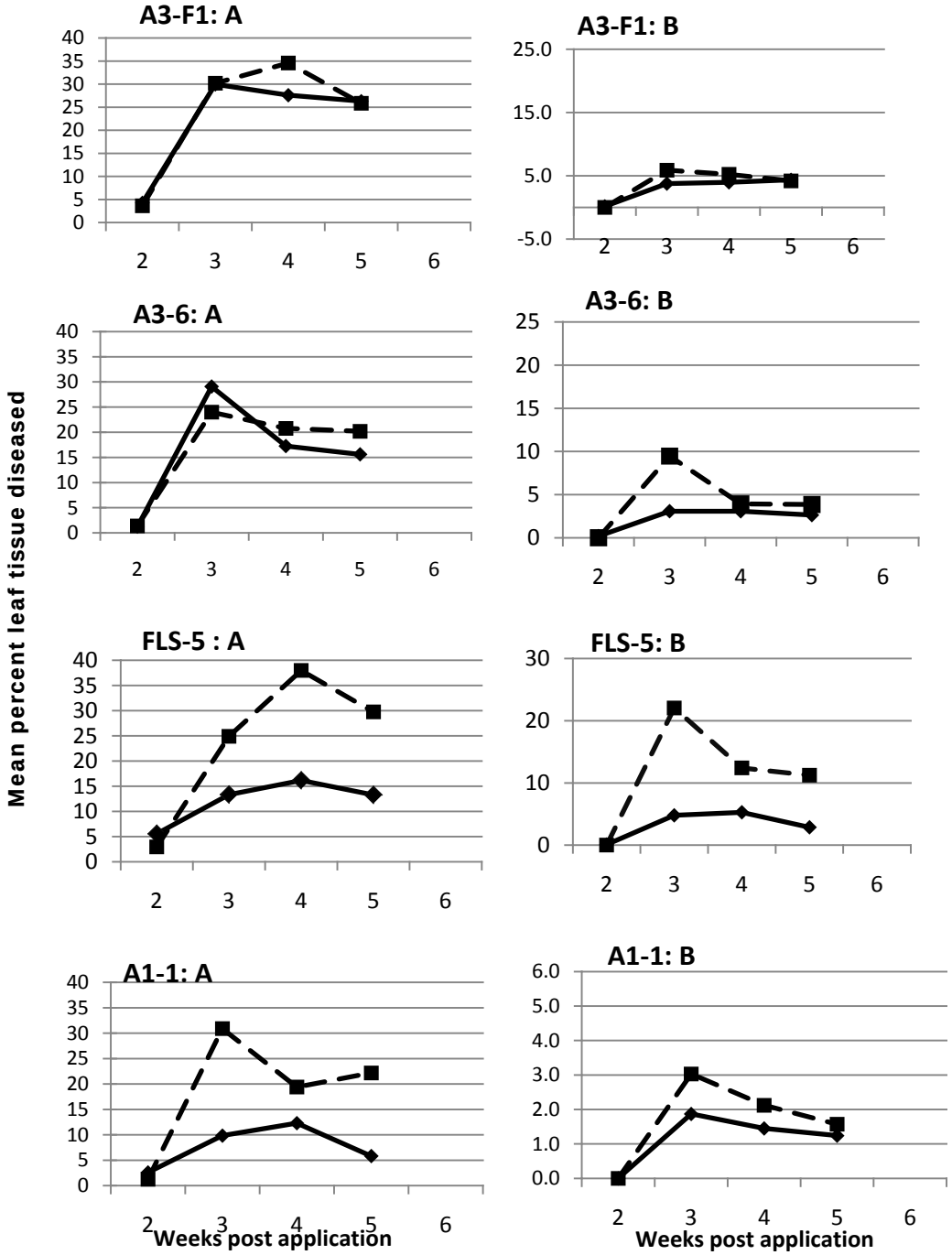


Figure 11. Effect of bacterial isolates on apple scab disease severity on branch inoculated Rome Beauty and Golden Delicious trees*. Disease assays in two research plots; (A) and university drive (B). Solid lines represent branches treated with bacterial isolate, and dashed lines represent non-treated control.

[z] Disease severities were measured using the following scale: 0 – no disease present; 1 - infection of one lateral or axillary shoot; 2 - infection of 2 lateral or axillary shoots or infection of on terminal shoot; 3 - infection of both the lateral and terminal shoots, infection of 3 terminal shoots, or infection of terminal shoot with resulting stem swelling; 4 - infection of 2 lateral shoots with infection of terminal shoot or infection of 4 terminal shoots; 5 – presence of dry dead brooms on the plant; 6 – plant killed due to witches' broom

[y] Bacterial treatment and cacao variety means followed by the same lowercase letter within each group are not significantly different according to Tukey's HSD ($P \leq 0.05$).

- Before our work there were 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.
- We found that cacao variety had no significant effect on disease severity throughout the rainy season. Treatment had a significant effect on disease severity; with application of *Bacillus pumilus* isolate ET reducing disease throughout the rainy season when compared with control plants and all other treatments. There were no significant differences due to variety or treatments during the dry season except that tolerant national variety A2634 had less disease than the susceptible EET-19 in September but not December. However, although not significantly different, disease severity of resistant clone CCN51 averaged less than half that of susceptible variety EET19 at the final disease assessment date of the rainy season. Also, *B. pumilus* isolate ET was the only bacterial treatment in which disease severity did not increase from September to December of the dry season, indicating that the bacteria prevented further disease development after initial infection. There was no significant variety X treatment interaction during the rainy or the dry seasons, therefore the AUDPCs presented are averages across all plants of a variety or treatment. Thus, although no bacterial treatment was entirely effective, *B. pumilus* isolate ET provided the best disease suppression, reducing AUDPC by 58 percent in the rainy season and preventing substantial increase of disease severity during the dry season (Table 11).

Table 11. Results on cacao treatments with biocontrols, Ecuador

	Rainy Season (Jan 08 - May 08)	Dry Season (Jun 08 - Dec 08)	
Variety	**AUDPC of disease severity[z] from 7 Feb – 21 May**	**Disease severity in Sep**	**Disease severity in Dec**
A2126	65.7 a[y]	0.94 ab	2.33 a
A2634	61.1 a	0.42 a	1.40 a
CCN51	110.9 a	0.45 ab	0.70 a
EET19	92.3 a	1.50 b	1.65 a
IMC67	122.7 a	0.42 ab	1.65 a
Treatments			
Control	77.4 a	1.10 a	1.65 a
A20	104.2 a	0.50 a	1.70 a
CT	74.8 a	0.55 a	2.05 a
CUR	103.8 a	0.55 a	1.25 a
ET	32.8 b	0.94 a	0.94 a

- We identified 99 isolates of endophyte bacteria, 53 from cereals, 32 from fava bean, 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. We also evaluated isolates against chocolate spot in fava bean (*Botritys fabae*). We have isolated 23 isolates from the following: penicillium, aspergillus and cladosporium. These isolates can be of use in Ecuador where some of the same diseases are present in Andean fruits.
- 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 vol/vol) 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 for more detail on this series of trials.

Development impact

- Each of these research themes promotes enhanced decision making at the farm and community level. At the farm level, we raised incomes by 20 percent to 30 percent through adoption of improved management techniques. More than 40 percent of farmers in the upper Illangama watershed in Ecuador adopted some form of reduced erosion practices. At the community level, land use planning was enhanced by knowledge of the relationship between practices and soil loss.
- In Bolivia, individual farmers have created land use management plans, and the municipal government used project-produced information to create a land use plan for Tiraque. This latter effort was required by the government of Bolivia and will lead to more sustainable land use practices.
- Reforestation in Ecuador is leading to increased biodiversity and to less soil and nutrients delivered to streams. An analysis of the market potential of wood and medicinal herbs indicates that over time, harvest of forest products will raise incomes.
- Access to higher-valued agricultural product marketing chains raises incomes in the area and creates economic space needed to implement conservation practices. Public actions to increase access to markets will build local capacity to take similar decisions in the future.
- Before our work there were virtually no organo-chemicals 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. Biocontrols represent a major avenue toward sustainable crop production; they are environmentally safe, lower cost, and can lead to local industries. For example, our partner in Bolivia is currently licensing small-scale production of several biocontrol technologies that were identified and evaluated under our project.

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 aggregates individual responses (changes in practices at the field, farm, and market scales) to the watershed level and creates a mapping between policy (and other interventions) and outcomes at the aggregate level.

Critical research accomplishments

- Calibrated watershed models for both Ecuador and Bolivia sites. These models were used to estimate watershed-level runoff and impacts on water quality of alternative land uses. Simulations were used to evaluate alternatives and to inform community decision making. In Ecuador, we held a number of workshops with local government authorities to examine how projected changes in land use will effect erosion, runoff, and water quality. Results were incorporated into community land use plans.

- The field-scale model Groundwater Loading Effects of Agricultural Management Systems (GLEAMS) was applied to selected individual management systems to provide more detailed input to the Soil and Water Assessment Tool (SWAT). This information was used to evaluate water quantity and quality impacts of different livelihood scenarios.
- Household data were used to produce a comprehensive analysis of the determinants of livelihood strategies. The Ecuador analysis was completed by Robert Andrade as a part of his master's thesis in agricultural and applied economics at Virginia Tech. We measured 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 were used to simulate changes in strategies as policies are adopted by local governments and, when used in conjunction with the watershed models, show how policy affects land use, which in turn affects erosion and water quality in the area (Table 12 and Table 13).

Table 12. Livelihood clusters and their attributes

Variables	Diversified households (Livelihood 1)	Engaged in agricultural markets (Livelihood 2)	Rural non-farm economy (Livelihood 3)	Agricultural subsistence and wage work (Livelihood 4)
% 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 CSOs, %	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

- 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; increased education and access to credit and irrigation all will affect livelihood choice. Andrade used these estimates to simulate three policy interventions: increased access to education, increased access to credit, and more irrigation. He 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.

Table 13. Variables in multinomial logit estimation of the determinants of livelihood choice

Variable	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 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	Household head age
Household size	Number of members that are part of the household
Dependency ratio	Percentage of members < 18 years old and > 71 years old
Watershed	Household 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 and school (GIS)
Distance to cities	Distance to the closest main city and markets (GIS)

- Data on farmer risk perception and its impact on potato variety selection was collected and analyzed for Bolivia 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.
- Analysis of data from the baseline survey in Bolivia shows how farmers use variability in geography to manage risk and how this risk management affects overall farmer efficiency. In response to climatic risks, farmers plant potatoes in geographically separated fields. Frequently this separation may imply more than two hours of travel time to remote fields. Depending on weather outcomes (drought, frost, hail), some fields may be farmed more intensively or more efficiently. At the field level we find clustering of high-productivity (high-efficiency) fields and low-productivity (low-efficiency) fields.

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 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 an impact it has on actions. The importance of having working watershed models cannot be overstated: Stakeholders now possess the knowledge upon which to can make informed decisions about the watershed.
- We have determined the best pathways by which knowledge can contribute to action. We found: (i) trust in the research team is essential, and this trust cannot be built overnight; (ii) continual engagement of the stakeholders is important; (iii) provision of practical benefits of research to stakeholders improves uptake of later results; (iv) technologies that are "income neutral" or that do not produce many monetary benefits should be packaged with income-increasing technologies where possible; (v) community organization and presence of strong social network increases uptake in some cases but not in others.
- The household data analysis creates opportunities for better-informed decision making. The results are being used in our communities to understand how policy can change household decisions.

- The information on farmer risk perceptions and their determinants is being used to guide potato-breeding programs at PROINPA. It also informs extension efforts.
- Information about risk management strategies will enable design of instruments to reduce inefficient risk management.

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

This objective, a critical component of the overall project, used science-based models to assist in adaptive watershed management. It was important to integrate local stakeholders into the research planning process, for they helped validate model results and provided insights into the weaknesses (and strengths) of the modeling process.

Critical research accomplishments

- Professionals and community members in Ecuador were trained in the adaptive watershed management process. Researcher Brian Benham 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: (i) Building Stakeholder Partnerships; (ii) Watershed Characterization—Approach and Data Needs; (iii) Developing Water Quality Goals and Identifying Possible Solutions; (iv) Designing a Watershed Management Implementation Program; (v) Implementing a Watershed Management Plan; and (vi) Measuring Progress and Making Adjustments. The community workshop on January 23was led by Juan Calles and Adriana Cárdenas of ECOCIENCIA and Wills Flowers of Florida A&M. Community stakeholders were engaged throughout.
- Professionals from Bolivia and Ecuador were trained in watershed modeling. Training occurred in two phases. During February 2008, two Ecuadoreans (Adriana Cardenas of ECOCIENCIA and Juan Montufar of SIGAGRO) and one 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. All brought with them 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 biological systems engineering.
- Participatory watershed planning activities were established in both countries. In Ecuador, the project team in conjunction with local governments and stakeholders adjusted the adaptive watershed model to meet their own realities. The team and stakeholders used project information on livelihood classes, together with the profile of household and community assets, to create a comprehensive development plan for the watersheds. They used SWAT model results, together with GIS techniques, to create a variety of watershed assessment and planning tools, such as environmental vulnerability maps (Figure 12). This map was validated with local stakeholders and was used by local stakeholders in developing their watershed plan.
- We evaluated the degree of correspondence between local perceptions of soil erosion, an intermediate technology developed by our partner PROMIC in Bolivia, and SWAT model predictions about the relationship between land uses and soil loss.

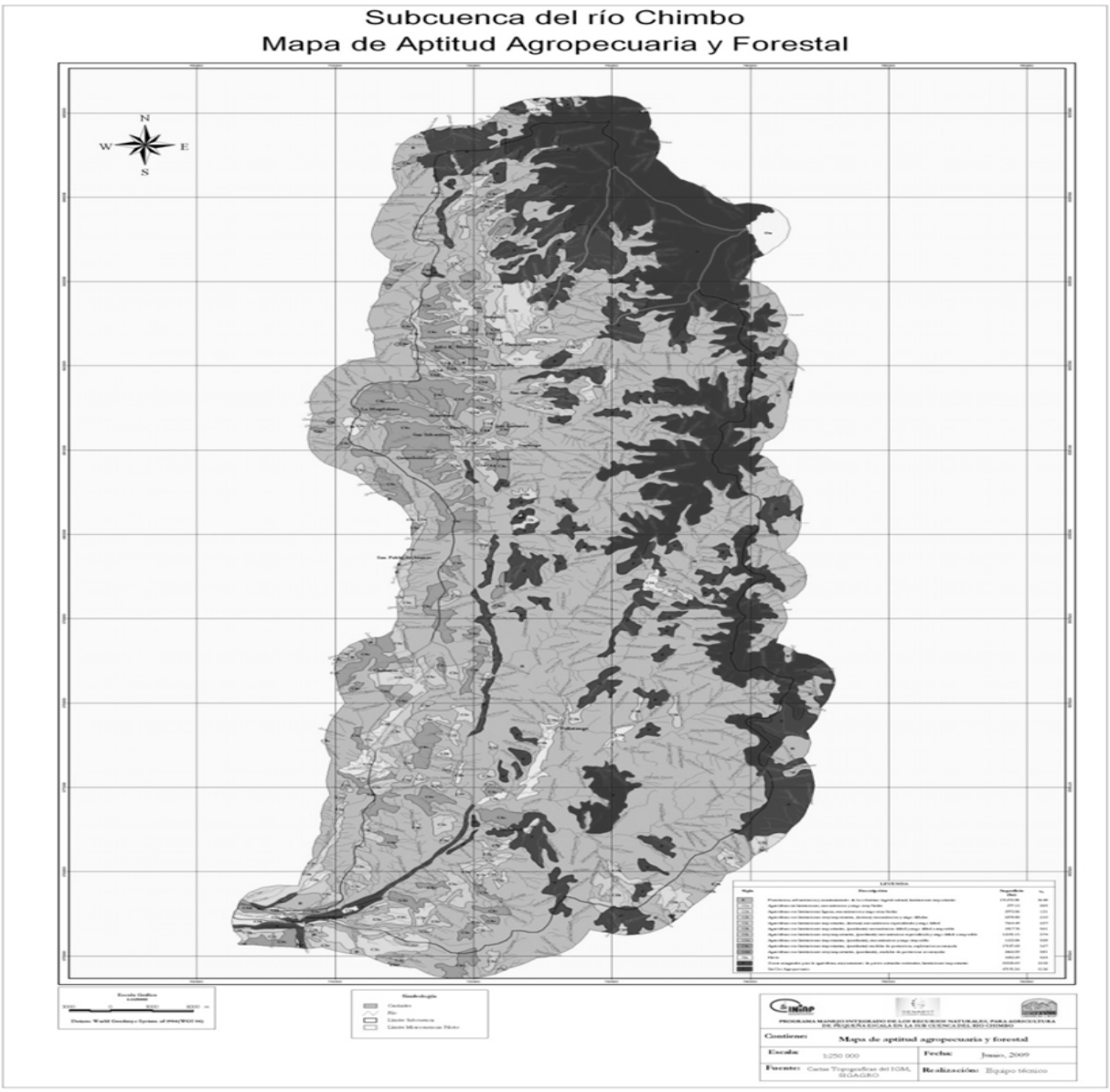


Figure 12. Vulnerability analysis based on SWAT results, GIS analysis, and participatory risk mapping, Ecuador, 2009

Development impact

- Wolfe, Heatwole, and Benham conducted a four-day water-quality modeling workshop for university professionals and officials of government agencies and NGOs in Cochabamba, Bolivia. The workshop provided participants with hands-on training in the background and application of the following models: GWLF, GLEAMS, and SWAT. Thirteen people participated in the workshop. Extensive workshop resource materials were provided to all participants. Those presentations made in English (some were in Spanish) were translated by PROINPA and PROMIC staff. Extensive interaction/discussion occurred during the workshops.
- An analysis of changes in land use and impacts of the project in Ecuador indicate major changes in land use, increased yields, increased diversity, better use of rotational crops, enhanced food

security, and other important impacts (Table 14**Error! Reference source not found.**). The model we adopted for working with stakeholders, engaging them in research, and using stakeholder perceptions as an input into validation of technologies worked quite well in this watershed. Lessons learned include the need to engage stakeholders early, build confidence of stakeholders in research team, and provide productivity-enhancing technologies as a part of conservation efforts.

Table 14. Impacts of best management practices in Illanagama watershed, Ecuador, 2009

Name	2006	2009
Land in cultivation (ha)	0.90	0.90
Land in potato (ha)	0.25	0.31
Land in pasture (ha)	3.04	2.28
Land in improved pasture (ha)	0.59	1.35
Milk production (l/día)	33	51
Potato yield (t/ha)	10.80	16.20
Pesticide value ($/ha)	396	296
Net benefits ($/año)	1021	1378
Food security:		
Quinua	N/A	INIAP Tunkahuan y Pata de Venado
Barley	N/A	Shyri y Jazmin
Chocho	N/A	450 Andino
Faba beans	Genetic deterioration	Guagrahaba e INIAP 440 y 441
Conservation practices:		
Improved rotations	N/A	Crops-pastures
Strip cultivation	N/A	Crops-pastures
Diversion ditches	N/A	1372 m linear
Contour plowing	N/A	Crops
Diversion ditches with grass lining	N/A	With milín grass and native plants like Quishuar, Yagual, Chachacoma, Romerillo, Aliso, Pumamaqui, Lupinus, Piquil
Minimum tillage	N/A	In crops
Improved irrigation management	N/A	Broadcast irrigation
Protection of water supplies	N/A	Native species like Quishuar, Yagual, Chachacoma, Romerillo, Aliso, Pumamaqui, Lupinus, Piquil

Degree and non-degree training activities

The LTRA-3 group has made major headway in its training activities by aggressively identifying suitable candidates, promoting flexibility in program design, and leveraging funding from different sources. We have completed six graduate students (four men, two women) at U.S. or European universities; six undergraduate honors theses at host-country universities (four men, two women); and are currently supporting four graduate students (one man, three 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 focused on environmentally beneficial agricultural management practices with other activities related to biodiversity, adaptive watershed management, and watershed planning. While the balance was toward participation of men, special efforts were undertaken to promote participation by women.

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 in 2008.
- Raul Jaramillo Velasquez (Ecuador) completed his Ph.D. in horticulture at Penn State in 2008.
- Rachel Melnick (Ecuador) completed her Ph.D. in plant pathology at Penn State with partial funding from SANREM CRSP in 2008.
- 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 CRSP 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 final year of master's training in agricultural and applied economics at Virginia Tech (expected completion December 2009). She is examining how information affects potato marketing decisions in Bolivia and the role of gender in these decisions.

Publications, presentations, other products

In 2009, LTRA-3 produced a wide variety of publications and presentations; including one book chapter, two working papers, two conference papers, four analytical research reports and numerous electronic presentations. A further highlight was the completion of four theses by SANREM CRSP funded students.

Networking activities

Our project created strong linkages among the project team, local governments, regional governments, stakeholder groups, NGOs, and other donors. As described in this report, the local linkages were a component from the start. In particular, the governments of Guaranda and Tiraque are actively using SANREM CRSP inputs as a part of their planning processes. The new mayor of Guaranda has asked the project team to build linkages with several NGOs in the area to multiply the project's impacts.

In Ecuador, our team developed a proposal that was funded by the Ministry of Environment of the Government of Ecuador. This project focuses 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. Project also established linkages with Proforestal, El Instituto Nacional de Meteorología e Hidrología (INAMHI), and La Fundación Mujer y Familia Andina (FUNDAMYT) of Ecuador.

During 2008 the Ecuadorean 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 members and representatives of regional and national governments. Our project site was inspected by national policymakers concerned about water quality, the environment, and measures to improve household wellbeing. Partially as a result of our activities, the National Constitution was modified. Articles 12 and 14 of the New Ecuadorian Constitution establishes: "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 water resources, hydrographic watersheds and ecological streams," respectively. This constitution promotes application of our approaches to other watersheds in Ecuador.

In Bolivia, the research team continually interacted with local authorities to build confidence in the process and facilitate uptake of subsequent findings. We 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 linkages to local universities are strong in both countries. Undergraduate thesis students were involved in research through the duration, and many of our research activities were led by university faculty.

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

Principal investigator: Corinne Valdivia, Associate Professor of Agricultural Economics, Division of Applied Social Sciences, University of Missouri

Host countries: Bolivia, Ecuador

Research team:

- University of Missouri: Peter Motavalli, soil science; Jere Gilles, rural sociology
- Kansas State University: Karen Garrett, plant pathology
- University of Connecticut: Anji Seth, climatology
- Iowa State University: Cornelia Flora, sociology, agriculture and life sciences; Jan Flora, sociology
- International Potato Center: Greg Forbes, plant pathology; Roberto Quiroz, natural resource management
- Universidad Mayor de San Andrés, Bolivia: Jorge Cusicanqui, plant production systems; Magalí García, agro-climatology
- Universidad de La Cordillera, Bolivia: Elizabeth Jiménez, economics
- Fundación PROINPA, Bolivia: Miguel Angel Gonzales, Javier Aguilera, agronomy
- Universidad Nacional Agraria La Molina, Peru: Edith Fernández-Baca, sustainable production; Celia Turín, animal sciences

Research strategy and development objectives

The project's goal was to develop knowledge and practices to build resilient livelihoods in rural communities of Andean agro-ecosystems vulnerable to changes in climate and markets. To accomplish this, we studied the dynamics of current agro-ecosystems to identify knowledge, practices and strategies that reduce vulnerability, value biodiversity, and build natural and human capital. This research has two dimensions: structural and transformative. The structural entailed understanding the effects of markets and climate as drivers of change at various scales in the social and ecological systems and the feedback effects. The transformative sought to understand human agency, the links between knowledge and action, and the role of collaborative research institutions and processes with stakeholders at the individual, household, and group levels.

The conceptual model (Figure 13) captures these two dimensions, the structural and transformative elements of the research; and the various scales at which the project tackled disciplinary and interdisciplinary research to reveal the effect of the two drivers on ecosystem vulnerability. Critical to developing adaptive capacity was understanding the driver's impacts at multiple scales on Altiplano ecosystems including: market effects on decision making; effects of climate trends; effects of projected climate changes on biodiversity; and interaction effects, such as the outcomes of livelihood strategies resulting from these changes, i.e., land use patterns and their effect on biodiversity. This understanding informed development of information and adaptive practices and strategies pursued in the agronomic and market-research programs and the climate policy arena. We sought in the three years of field work to identify interventions and actions that would improve wellbeing and value biodiversity. The final year concentrated on returning findings to the communities through processes that sought not only to link knowledge systems but to identify the actions to be taken.

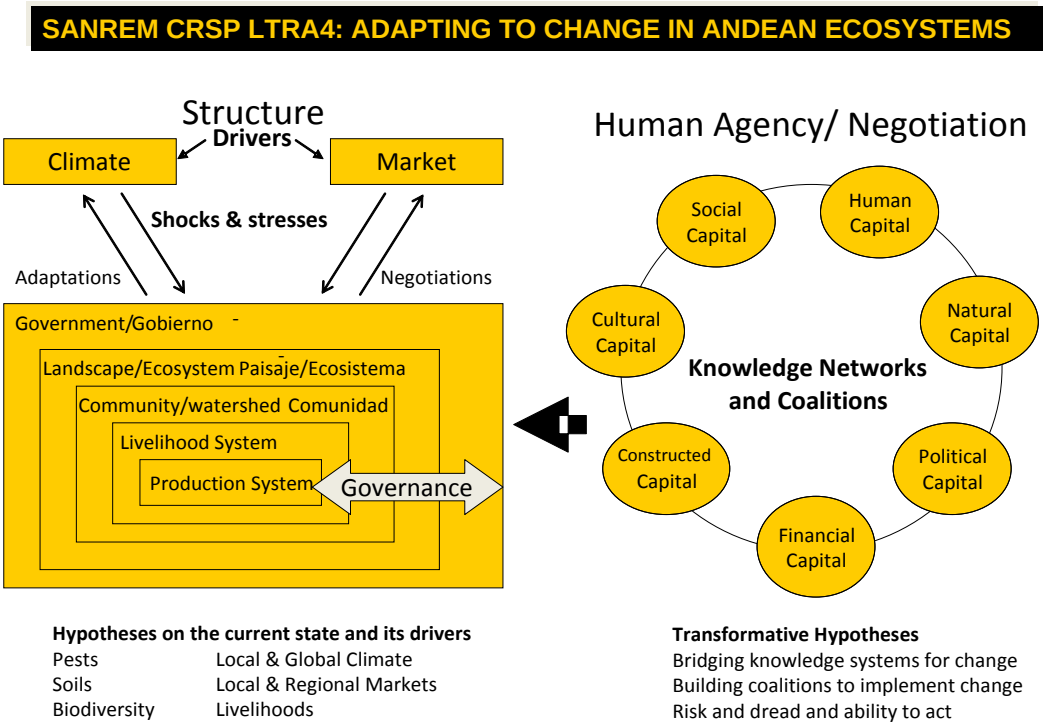


Figure 13. Research conceptual model

This LTRA had five specific objectives.

- **Objective 1.** Characterize the dynamics of Altiplano agro-ecosystems at various scales to understand the impact of climate and markets as drivers of change, and develop a shared understanding.
- **Objective 2.** Identify local knowledge and perceptions about production systems, landscape, and risks 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 in soils, climate, pests and diseases, landscapes, and livelihoods.
- **Objective 4.** Develop market access strategies and institutions that contribute to resilience.
- **Objective 5.** Develop stakeholders' capacities and capabilities—ability to act—to reduce vulnerability and increase adaptation in the face of changing market and climate conditions.

Objective 1 studied the dynamics of the ecosystem, focusing on soils, climate, pests and diseases, biodiversity, livelihoods, and markets to determine how changing climates and markets have impacted agro-ecosystems and how these have affected livelihood strategies. Objective 2 studied people's knowledge, perceptions of change, and experienced hazards. Scientific and local knowledge gained under Objectives 1 and 2 informed research in Objectives 3 and 4, which focused on identifying adaptive practices and strategies necessary to build resilient livelihoods and ecosystems. Climate forecasts, soil management, crop alternatives, pest management practices, and market information were developed to inform decision making. Objective 5 focused on strengthening capacities, studied forms of participation and institutions (forms of organization) and the effect on stakeholders' ability to act.

Multiple disciplinary teams through this integrating framework tackled five research themes: climate, soils, pests and diseases, biodiversity-production systems and landscapes, and livelihoods and institutions. A knowledge-to-action theme studied processes and ability to act.

Climate

Altiplano climate conditions and trends over the past 30 years and decision makers' knowledge and perceptions of these climate trends at the household and community-watershed scales were studied, and then compared through participatory processes. Perceptions were captured through community participatory assessments and household surveys. Climate trends and current conditions were compared with climate change projections for the Altiplano. The study of current trends and projections to middle (30 to 50 years) and late 21st century informed social and agricultural alternatives for adaptation. Research on local knowledge forecast indicators and their link to trends and projections was developed through a participatory research process that builds local knowledge systems (cultural and human capital) and fosters a common understanding and trust. Participatory assessments and mapping of climate hazards were carried out with community participants to evaluate climate forecast products in terms of effect on current production systems and identify adaptation strategies (ability to act).

A coalition building approach—advocacy coalitions—informed the process of building the social and political capitals necessary to identify adaptation strategies and partners. The projections were evaluated with stakeholders in the climate change community, where we aim to develop a climate change working group. Results were shared with stakeholders at the local, regional, and national levels, seeking also to inform government and international policies for adaptation. Landscape research at the watershed level, especially imagery analysis and participatory mapping of change at the watershed/community scale, were and continue to be inputs in a dialog about vulnerabilities and planning for adaptation.

Pests and diseases

Field research on pests and diseases aimed to understand changes in their dynamics, which depend on micro-regional variability in altitude, temperature, location, and social and economic conditions. At a regional (ecosystems) scale, climate change scenarios were incorporated into models of diseases, and data on pests was gathered for three years to contribute to models that predict changes in movement from low to high elevations as temperature and humidity change. This research aims to build new knowledge (human capital) by sharing findings on dynamics of Andean potato weevil and potato tuber moth, and through participatory approaches identify management practices compatible with the economic (economic capital) and labor (human capital) realities of farmers. The purpose was to produce information that is relevant, appropriate to the decision makers' context, and consistent with their decision-making process. Understanding of this changing dynamic led to a co-learning strategy where farmers were trained on the findings from the research as well as how to monitor conditions.

Soils

Research was undertaken to characterize soils and evaluate quality under different fallow systems and changing management practices, identified as responses to climate and markets. Soil quality indicators developed are a proxy for the state of the natural capital (biodiversity) and were included in the analysis of farmers' land use practices, adaptive livelihood strategies, and effect on environment. This research linked with a biotechnology project on soil metagenomics that studied microbial indicators for soil degradation/health quality. While characterization was undertaken at the community/watershed scale, soil amendment experiments to enhance soil quality to buffer climate variability and change shocks took place at the field level, with selection criteria determined by the management systems. Disciplinary research findings contributed to local knowledge through participatory assessments of soil amendment practices

researched and knowledge building through sharing soil quality indicators developed at each site. The latter focused on community participants and extension agents.

Biodiversity

To understand changes at the watershed/landscape scale, we studied changes in land use patterns, shifts in crop varieties, and land cover. At the field level, farmers and researchers evaluated performance of current native varieties. At the community level, we evaluated existing varieties and changes in their use through time. At the municipality level, we assessed diversity of native potato and other crop varieties. We also identified and assessed varietal performance by planting gardens in communities and directly on farms in the first two years of the project. At the landscape level, analysis of changes through imagery analysis, when available, was undertaken to support community planning to identify varieties more resilient to projected medium-term climate-change scenarios and current climate trends. Imagery analysis as well as ground truthing and participatory mapping of changes in landscape provided a picture of the changes in vegetation in one region, as well as the tools for discerning, with communities, the role of drivers in these changes and what to do. Imagery was secured for only one site, a May 2007 SPOT satellite image of the northern Altiplano watershed in Bolivia; therefore the landscape change analysis was conducted there as a proof of concept.

Livelihoods and markets

The focus of the social and economic research was on decision makers at the household and community levels. It identified livelihood strategies and how climate, markets and environmental change have shaped them. It evaluated if and how differences in access and control of capitals explain livelihood strategies as well as the impact of economic, social and political factors. The purpose was to compare strategies and practices across communities and ecosystems to discern the effect of geography and markets. This enabled understanding of how the capitals, resources, and the capabilities of individuals, households, and community engender agency and adaptation. With the household economics approach, the strategies were evaluated to determine their differential impact on men and women. Assessments of practices under Objective 3 were conducted in the context of input and output markets in Objective 4. Community participatory assessments with a gender perspective (Objectives 2 and 5) led to identifying differences in the perceived benefits and constraints of the practices and strategies. Economic portfolio research informed on market integration (or lack thereof) and the effect on income generation, food security, and vulnerability (Objectives 1, 2, and 4). Indicators of livelihood diversification, as well as of accumulation of assets, are measures of economic and social wellbeing. These were analyzed along with indicators of environmental wellbeing (natural capital) —soils and crop diversity, and fallow length—to assess how the natural capital contributes to wellbeing and how decision makers invest in the natural capital. Risk perceptions (Objective 2) were studied in the context of livelihoods and capitals. Household surveys gathered the data to link livelihoods with perceptions of risk, types of capital, and ability to cope with risk events (Objective 5)—agency. This research, as well as the research on perceptions of change elicited through community participatory evaluations and mapping, are key to develop new knowledge about adaptation options to climate and market changes, and to learn how this information is shared through networks.

Ability to act – knowledge to action

The research design incorporated the concept of agency—the right side of the conceptual model (Figure 13). In the sustainable livelihoods framework, agency—defined as the ability to act—is the hinge articulating livelihoods with structures. At higher scales than community, it connects people with markets and government institutions through individual and collective action, and stakeholder platforms. We collected data throughout the project about who participated and who did not in the collaborating

communities' research groups. A panel survey completed at the end of 2009 will allow us to compare changes between 2006 and 2009 among participants and non-participants, as well as analyze changes in the sources of information. Objective 3 identified practices and information through participatory approaches and disciplinary research. The research on soils, pests, climate, and native crops built on local knowledge and perceptions.

Objective 4 identified strategies that may improve bargaining power in commodity markets or reduce the perceived risks of decision makers to access resources through group action. The identification of high-end income markets—niche markets for traditional cultivars—was one example. Strategies and institutions targeting improvement of bargaining or negotiation in markets that enhance Andean biodiversity and income were studied (the Andean Platform) to determine how it would facilitate articulation to high-income markets like exports. An approach implemented was Advocacy Coalition, a mechanism to link actors at different levels in markets with aligned incentives. Participatory market-chain approaches that develop stakeholder platforms were studied to access export markets of chuño and tunta. These mechanisms of linking farmers with markets were evaluated in terms of participation and impact on ability to act. The sites permit comparisons under different market-access conditions of various types of commodities and mixes of traditional and commercial products.

Objective 5 is a critical research and development objective. It is accomplished by examining different approaches to capacity development: participatory research, research interest groups, advocacy coalition, and stakeholder platforms. The development dimension consists of strengthening or developing the adaptive capacities of stakeholders. Processes such as sharing knowledge about markets through protocols that require participants to identify what needs to be done to address barriers, in themselves lead to a change in attitudes. The capacity building dimension involves degree and non-degree training as well as a co-learning environment. Information was shared with decision makers at the household and community levels, and stakeholders at regional and national levels. These activities allowed us to gather the first data to test a transformative hypothesis and identify the pathways through which knowledge becomes information for action. Our activities included 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 required an understanding of the system and grew in focus during Years 3 and 4. Objective 5 was accomplished throughout the life of the project; its final intended output is to assess change. In Year 4, the aim was to build on local knowledge by sharing the findings of research conducted during the past 3 years in the context of climate and market information, which is reflected in the large number of events and products shared with community research groups in Year 4.

Research hypotheses

The overall working hypothesis of LTRA-4 is that bridging knowledge systems through participatory approaches designed to foster agency will lead to decisions that contribute 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 disciplinary and trans-disciplinary questions are posed and addressed.

The research strategy aimed to address the following questions.

- Is climate changing in the Altiplano ecosystem?

- Do people perceive this change, and do they have the knowledge, capital resources, and capabilities to adapt?
- Are markets and their signals affecting the decisions of producers, and in turn are these decisions changing the landscape of the Altiplano? If so, are changes affecting the resilience of the environment?
- Are the changes in climate trends and variability, and their impact on livelihoods combined with the market signals and responses, increasing adaptation or increasing vulnerability?
- Does an increase in livelihood 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 affect the livelihood strategies pursued, the various types of capital they access, and their ability to use information?
- Can scientists in collaboration with producers identify and/or develop technologies and interventions that address climate-change effects on soil degradation, pests and diseases, plant biodiversity loss, and vulnerability due to lack of information about climate?
- How does knowledge shape decisions, and how and when are people capable of using new information for decisions (collective action, groups, entrepreneurship)?
- Because the nature of the information is inherently probabilistic and/or is used in an uncertain decision-making environment, do the new information and participatory processes used in designing it reduce uncertainty?
- Does collaborative research with decision makers, where knowledge systems are shared through groups and participatory approaches, engender knowledge that is relevant to the users (in their language and context) and guarantees necessary conditions for ability to act?

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

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

Comparisons included access to and participation in markets, effects of climate trends in short-term strategies, and approaches to collaborative research between communities and organizations with differing principles of collaboration. Collaboration revolved around volunteer farmer groups in Umala and community organizations in Ancoraimes and Puno. While groups in Bolivia contributed to new research activities in soils, pests, biodiversity, and climate, in Peru the focus was on approaches that increase social and political capitals. Peru introduced knowledge already developed through co-learning and coalition building approaches. Research on soils and pests was initiated in the last year of the project research according to plan in Peru. Finally, comparison of landscape changes across sites to evaluate how market and climate drivers have an effect on land use and vegetation cover, and its changes, is research on integration that is ongoing.

Objective 1: System dynamics and drivers

Hypotheses: Changes in climate have a negative impact on ongoing cropping systems.

Methods: Conduct 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. Also, use satellite and aerial imagery to validate perceptions, and weather information and stream gauging to develop a watershed model with climate scenarios. GIS mapping of pest and disease responses to climate will be generated.

Hypothesis: Traditional cropping systems are changing in the face of increased climate risks. Changes in cropping systems and soil management practices from traditional agricultural management systems due to climate and markets will cause soil degradation, as evidenced by lower soil organic carbon, nitrogen, and other soil properties.

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

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

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

Hypothesis: 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).

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

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

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

Methods: Focus groups and local expert panels will describe and evaluate local practices and recommended integrated pest management (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.

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

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

Hypothesis: 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).

Objective 2: Perceptions and risks

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

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

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

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

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

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

Objective 3: Practices and information

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

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

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

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

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

Hypothesis: 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.

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

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

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

Methods: Models from the IPCC are evaluated by scientists and local experts at workshops. Mitigation and adaptation strategies are identified.

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

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

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

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

Objective 4: Strategies and institutions in market integration

Hypothesis: 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.

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

Methods: Focus groups will examine the uses and desirable traits of native cultivars. Marketers and urban consumers will be surveyed to identify potential demand. Data from USAID's Market

Access and Poverty Alleviation Project (MAPA) will be analyzed for the regions of study to identify existing links.

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

Methods: Community members will be trained to conduct surveys of stakeholders related to potato marketing and supported as they carry out these investigations. This information will be returned to community members so that they can identify marketing and production strategies.

Objective 5: Capacities, capabilities, and ability to act

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

Hypotheses:

- Social capital of producers will be increased during the life of the project, leading to out-scaling of site research findings between countries.
- Group formation and vulnerability affect member participation and dissemination of information throughout the community. Gender and life cycle differences exist in ability to participate in groups.
- Interaction between university researchers and stakeholders (NGOs, USAID, international organizations, government institutions focused on climate change) will increase as a result of this project and lead to upscaling research findings in the area of climate change and adaptation.
- Networks of rural producers in Altiplano ecosystems will lead to out-scaling of research products.

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

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

Research progress by objective

Objective 1: Characterize the dynamics of Altiplano agro-ecosystems at various scales to understand the impact of climate and markets as drivers of change, and develop a shared understanding.

Critical research accomplishments

This year we completed a second household survey to assess impact of the project's three years of research in Bolivia and Peru. It was also the third year of research on dynamics of pests at the Bolivian sites and the first in the Peruvian site. Under soils, a third year of organic amendments research was conducted in Bolivia, while in Peru research was conducted comparing soils conditions in private and communal management of croplands. Landscapes research concentrated on analysis of change in the vegetation cover in the northern Altiplano, changes in the vegetation diversity in the central Altiplano, analysis of *bofedales* (peat bogs) in Peru and Bolivia, and mapping of resources and land use with Peruvian farmers in two ecological zones. Biodiversity mapping was conducted in Umala and Ancoraimes using maps with different degrees of resolution, for no additional images were obtained for our research project. Finally, climate research focused on extremes and impacts on agriculture, especially soil humidity projections, and eliciting findings of regional climate change projections conducted by Peruvian scientists for the Puno region and Bolivian scientists in other regions of the Andes. A significant amount of time was dedicated to returning all the research results and the local knowledge through information products (more than 60) that targeted community groups in Bolivia and Peru. In the next sections we present the findings of Year 3 field activities of each theme.

Climate
The focus this year was to develop more detailed evaluations of climate tendencies using monthly and daily data to avoid annual mean distortions. Understanding Altiplano climate change will certainly require high resolution scenarios in this region of complex topography. Additional analyses of monthly station observations show recent increases in summer precipitation and decreases in spring precipitation at Patacamaya, Viacha, and Belen; however, the trends are not yet significant (Seth et al. 2009b). Analysis of extreme indexes was performed for temperature at El Alto and for precipitation at Patacamaya, where daily observations of sufficient quality and length are currently available. Results show significant increasing trends in warm nights and warm spells, while frost days have also been increasing (not significant). Precipitation extremes show increasing trends in consecutive dry days and heavy precipitation events as well as precipitation intensity, though the trends are not significant at this time. (Thibeault et al. 2009a). Manuscripts were completed, submitted, and revised about the projections (Seth et al.), extremes (Thibeault et al. b), trends (Garcia et al.), and linking knowledge systems in climate (Valdivia et al.).

Pests and diseases
The three-year field research plan for Bolivia was completed, where monitoring of the dynamics of pests took place in the Central and Northern Altiplano. Climate trends and change were found to be different in these regions, affecting the production system and the behavior of pests and diseases. The approach used to monitor pests was similar in the two regions of Bolivia, but the crop focus was different. In the north the focus was potatoes and in the Central Altiplano, potatoes and quinoa (Jarandilla el al., 2009; Gonzales et al. 2009). The major pest threats identified by farmers – the Andean weevil and the potato tuber moth were studied. Third-year research results are still being analyzed, but preliminary findings were presented at the SANREM CRSP annual meeting.

Changing climate and other factors are affecting the dynamics of pests differently in the central and northern Altiplano. As a consequence, local knowledge has not been perceived as effective, and farmer perceptions of control of this threat are low, while the risks are high. The analysis of the household interviews conducted in 2006-07 showed that pests were perceived as a large threat. Losses to pests were also high and prevalent. The Andean weevil is one of the most prevalent concerns of farmers in all crop-producing communities. The studies on dynamics of Andean weevil find that it is a complex of species, (in the Altiplano sites the genus *Premnotrypes spp* and *Rhigopsidius piercei*). In the central Altiplano the "new" genus *Phigopsidius piercei* is increasing. It has adapted to the changing production patterns and is causing high degree of losses in the high elevations of this ecosystem. In the northern Altiplano, *Premnotrypes spp* prevails, and incidence increases with temperature, affecting more potato crops in the middle of the watershed at this point.

The lesson learned is that dynamics are indeed changing. Farmers at the beginning of the research were not able to distinguish between these two genera, which behave very differently in their reproduction. The project's strategy was to share the findings and develop integrated pest management training (co-learning) to identify and manage crops. Three years of data and two of trainings were completed. Field research is captured in articles prepared for the Spanish book of the project in Bolivia (Mamani et al. on Andean weevil in the northern Altiplano; Jarandilla in the central Altiplano; Mamani et al. on potato tuber moth in northern Altiplano; Paredes and Vera in the central Altiplano). Migration and competing demands for labor are reducing the use of organic amendments and soil management practices that can reduce the incidence of weevil.

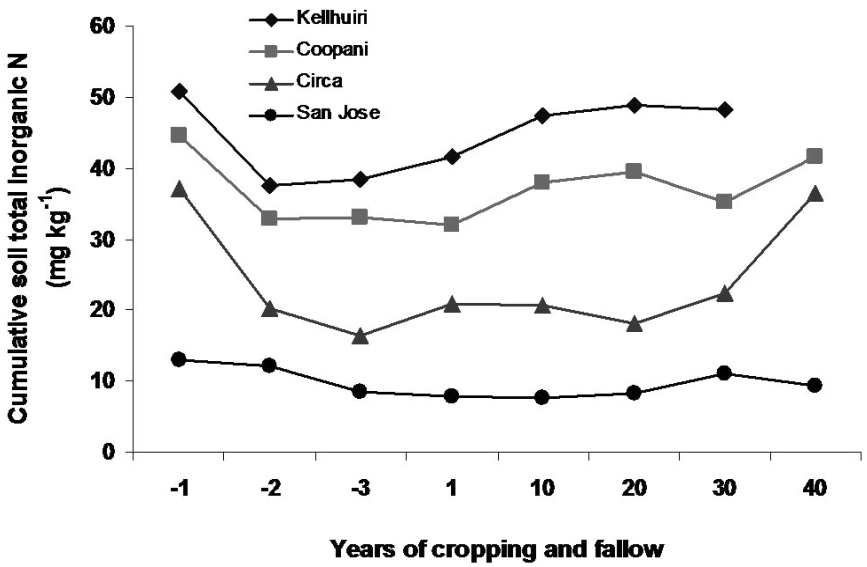
Soils

Using community surveys and participatory workshops current and perceived changes in soil and crop management practices due to climate and socioeconomic changes in Ancoraimes and Umala over the last 10 years were evaluated. . The information collected led to conclusions regarding perceived changes in cropping systems and soil management practices.

The consequences of climate and socioeconomic changes identified by community members were examined in further detail in a study that examined the effects of reduced fallow periods, which was identified as a major source of soil degradation. Soil samples were obtained from a chronosequence of fields that represented different years of cropping and fallowing on a similar soil type across a range of landscape positions. These soils were extensively analyzed for differences in soil organic carbon (C) and other soil properties and were further analyzed under the soil quality cross-cutting project for changes in soil organic C fractions and soil quality. During the last year, soil samples collected on the basis of crop and fallow years from the different Umala communities in the central Altiplano of Bolivia were incubated under controlled temperature and their soil water content and potential C and nitrogen (N) mineralization evaluated.

The cropping system traditionally consists of three years of planting in a rotation of potatoes first, followed by grains or cereals in the next two years. Figure 14 shows that initial cropping caused a large decline in potential soil N mineralization, which varied depending on the community. Soils in communities positioned in lower-lying areas (i.e., San Juan Circa and San Jose) had relatively lower total soil N initially and therefore were generally lower in native soil fertility compared with soils from the upper communities. With the exception of soils from San Jose, most of the other soils had increased potential soil N mineralization with the higher the number of years of fallow. These results suggest that different soil fertility strategies may be needed in the lower communities to manage the inherent lower native soil fertility. Moreover, as fallowing length decreases, future research efforts to increase soil fertility during fallowing should possibly focus on improved fallow systems in which multipurpose leguminous cover crops are used and the role of native species (e.g., thola—*Parastrephia lepidophylla*) in soil fertility is evaluated further. Previously reported findings in this project indicated that soil under thola

had significantly higher soil total organic C, total N, pH, soil test K, exchangeable Ca and Mg, and CEC compared with cropped soil.



The first three negative numbers indicate the number of years with crops and positive numbers refer to the number of years of fallow.

Figure 14. Cumulative potential soil N mineralization after 84 days of incubation of soils with different cropping and fallow lengths from different communities in Umala.

Extensive information was also gathered on the use of organic and inorganic soil amendments among the different communities in Ancoraimes and Umala, which to date was documented in theses of Blas, Herrera and Plata, and in forthcoming articles in the Bolivian book (Cusicanqui, Valdivia, Jimenez and Gonzales). This information provides an understanding of how use of these amendments is changing in response to socioeconomic factors, including increased urban migration for employment. Manure (cow, sheep, camelid) and compost samples were collected from the communities to evaluate differences in composition of the organic materials commonly used for amending potato crops. As expected, increased time of composting reduced the carbon-to-nitrogen ratio of the material, but nutrient content was relatively similar across communities. Based on survey information, farmers differentially evaluated the effectiveness of each manure type, with some preference for sheep manure as a soil amendment for potato. Access to sheep manure is more limited, and the prices are high, according to participatory assessments, which question its cost-effectiveness among farmers with few sheep and/or labor availability.

A study of the management in Aynoka and private lands in Peru was also undertaken to compare the effects of individual and communal management on soil fertility and soil total organic C in Peru. A graduate student at Universidad Nacional Agraria la Molina (UNALM) in Peru undertook this research as part of his master's thesis; the results of his analysis have not yet been completed. The study compares the effect of two management systems on land degradation. Altiplano soils are relatively young and very susceptible to degradation and loss of fertility. Soils are gradually less productive, requiring that farmers increase fertilizer applications each year to maintain production. The soils were sampled in the two management systems to determine the quantity of labile carbon and develop recommendations to maintain fertility. Information about the Aynoka (private lands) management system was collected with farmers using participatory methodologies. Practices and types of soils were discussed with farmers. Soils samples were collected and taken to Lima to analyze at the UNALM soils laboratory. Analysis of the

differences in soil management practices measured by soil composition is still underway. Results will be shared with the community. The central hypothesis is that the Aynoca management systems will show better soil quality, demonstrating that some traditional practices are good for soil conservation (Baylón and Condor, 2008). This research is significant because of the existence of different management systems in the Altiplano region of Bolivia and Peru and their potential effects on soil fertility and soil organic management. Institutions such as Aynoca may be used as avenues to share new knowledge to increase organic amendments that may buffer future losses of soil humidity due to climate change.

Landscape biodiversity and water

Research on biodiversity was conducted at the ecosystem, watershed, and farmer field levels. In the case of the northern Altiplano, data was collected and is currently being integrated into a database management system using GIS. This site was selected as a baseline site for climate change research due to the observed changes in trends and the production systems. It is for this site that images were secured (May 2007) to analyze the diversity of vegetation and land use patterns. Several articles were prepared for a book to be published at the end of 2009. Navia (forthcoming) documented the methodology applied to the mapping of resources in the northern Altiplano through image analysis. Navia and Yucra (forthcoming) concluded a preliminary analysis of the micro-watershed Chinchaya Chojñapata in Ancoraimes using temporal analysis with Landsat Thematic Mapper, finding an increase in the vegetation cover of 47 percent (believed to be increased cropping areas) when comparing 1996 and 2006.

Peat bogs (*bofedales*) research is being conducted by P. Zorogastua as part of his doctoral work. This resource is critical in terms of water holding and carbon sequestration capacities. These are being lost to farming through drying due to climate change. Field work was conducted in February 2009 in Ancoraimes. The natural grasslands in the middle and higher elevations are overgrazed due to the high number of animals per hectare. This is also happening in the *bofedales*. Cover and land use ground truthing of the watershed was completed using the satellite image (SPOT of May 15, 2007), the panchromatic mode with special resolution of 2.5 m x 2.5 m, and multispectral mode of 5 m x 5 m. The SPOT image was digitally processed with Environment for Visualizing (ENVI). Analysis of images and field work has identified an area of 875.8 ha of *bofedales*, which is 2.84 percent of the watershed. This study will contribute to our understanding of the trends affecting the natural resource base critical to resilient social and ecological systems in the highlands. Farmers and researchers also developed digitized maps of land resources at a second site, Apopata in Peru, where peat bogs are a critical resource for the alpaca production system. Water flow was studied in the Ancoraimes watershed. The purpose is to determine the relationship between climate and water flow and availability in the watershed of the Hunauisco River in Ancoraimes. This is the master's thesis research of M. Peñaranda. Preliminary findings are included a book to be published this year (Peñaranda et al. forthcoming).

Analysis of the interaction between climate trends and production systems in Ancoraimes was conducted with participatory research and landscapes analysis. It shows that the changing climate conditions resulted in the introduction of new crops such as onion and turnip. The study also found an increase in evapotranspiration. This is a region with access to irrigation. The study describes differences in rainfall and temperatures using data from the project and nearby weather stations. Analysis of the vegetation of the last decade found that crops are moving to higher elevations in the watershed.

Diversity of potatoes and oca (*Oxalis tuberosa*) was studied in the middle and high elevation landscapes of Ancoraimes Municipality. Field studies were completed with 28 farmers involving 51 plots of potatoes and 19 of oca. Other completed studies through farmer interviews were conducted for these two crops and others such as Izaño (*Tropaeolum tuberosum*) and papalisa (*Ullucus tuberosus*). Calahuancane first, Chojñapata second, and Cohani third are the communities with more diversity of Andean crops and varieties, while Chinchaya, more linked to markets through the sale of onions, has less. In Umala,

mapping of diversity at various altitudes was completed. The study focused on land use distribution and vegetative cover (Fabiani and Alejo 2009). About 50 native and 35 introduced species were identified.

Livelihoods

Perceptions and effects of climate change on agricultural production in Peru. The knowledge, attitude, skills, aspirations, and practices short-term impact measure was used in evaluating perceptions and effects. Quantitative (household survey of 2006-07) and qualitative techniques (participatory workshops, informal conversations) were implemented. The survey contains data on knowledge, skills, and practices of the family production unit, livestock, soils, climate, markets, social organization, and food security. This study analyzed information related to climate in the survey of Santa María (49 households) and Apopata (70 households). Through participatory workshops, information about attitudes and aspirations was collected. Key informant interviews with 10 producers in each community were completed (Rivera et al. 2009). Results highlighted negative perceptions of the future regarding climate, the lack of use of outside sources of information, and the role of changing religions on attitudes about the future.

Migration patterns. In the Peruvian SANREM CRSP data, it was found that households from both communities use off-farm employment as a livelihood strategy: 42 percent in Santa María (the mixed farm-oriented community from the lake side agro-ecological zone) and 34 percent in Apopata (the livestock-oriented community from the dry puna agro-ecological zone). In both cases, those who work off the farm are the male members of the wealthier households. Males from the poorest households and females in general remain in the community working in farming. Employment off the farm takes place throughout the year; however those from Santa María return during the potato harvest season (May), while Apopata community members avoid leaving during the alpaca mating and birthing seasons (January-March), peak labor demand periods. Off-farm employment in Santa María is related to agriculture in the surrounding towns of the region, while in the case of Apopata jobs are found in distant coastal regions. The existing rural development policy fosters employment on the coast, a pull factor that wealthier households can respond to. Uncertainty and few job opportunities in the Puno region act as a push factor. Policies should foster employment opportunities in the local area, which would benefit the most vulnerable, who are unable to migrate (Turin, 2009). The findings highlight the different nature of migration, one dependant on the wealth of the migrants and seasonality of production systems that agroecological conditions permit.

Panel research on livelihood strategies. A survey of 318 households was conducted in August and September in Bolivia and of 120 households in Peru from July through November. The purpose of the survey is twofold: to measure changes related to practices, knowledge, perceptions, and attitudes as well as to assess the networks of information and to study changes in livelihood strategies, market integration, coping mechanisms, and assets. About 9 percent of the households interviewed in 2006 have permanently migrated, 1 percent of the heads of household (male or female) passed away, and 5 percent decided not to participate. This new sample contains 85 percent of the households interviewed in 2006. Preliminary results based on field observations show an increase between 2006 and 2009 in permanent migration and a decrease in temporary migration, probably related to economic and social events of the last three years. The number of varieties of potatoes farmed appears to have decreased between 2006 and 2009. It appears that risk perceptions about frost and drought continue to increase, and farmers are more aware of climate change, identifying it as a very high threat.

Interactions

Analysis of interactions among climate trends and change, market linkages, and livelihood strategies in the Bolivian Altiplano. Garcia and Yucra (2007) report that communities in Ancoraimes and Umala notice climate changes in reference to increases in temperature as well as evapotranspiration, which

translate to loss of soil moisture. These trends affect crop yields and production volumes (Jiménez et al. 2009). Market integration and the role of markets vary within and across landscapes. Table 15 gives an example in production of potato, one of the major crops in this region. It shows potato production for consumption and sales by agroecological zones in the Altiplano. In the central Altiplano Umala Municipality, there are families who are fully integrated into the market, others who sell only their surplus potatoes, and yet others who grow only for self-consumption. In Ancoraimes in the northern Altiplano, production for home consumption is dominant across ecological zones (Romero 2009) with families marketing only surplus production. While yields per hectare are greater in the Ancoraimes zones, the amount of land available for potato production is much smaller, with land fragmentation as a main constraint to food security. This also highlights the role of markets as a driver promoting crop diversification for cash income where onion and pea are examples of cash commodities, and potato becomes the product for household consumption.

Table 15 presents a summary profile of the communities we collaborated with in research in Bolivia. Garcia and Yucra (2007) reported that the municipalities of Umala and Ancoraimes registered increases in temperature and increased evapotranspiration that negatively affect crop production and productivity. In this context, farmers are developing adaptation strategies leading to changes in production choices (Jiménez et al. 2009). Table 15 includes data from the household surveys by landscape position (low to high) in Bolivia's northern (Ancoraimes) and central (Umala) Altiplano. Farmers integrate and depend on markets in varying degrees, either by producing for sales, a combination of production for consumption with sale of surplus, or production mainly for consumption. The type of crop and the portfolio is determined by market opportunities and livelihood strategies (Romero, 2009).

Table 15. Distribution of production for consumption and sales based on the purpose of production by Zone in 5 Altiplano landscapes of Bolivia (2006)

Landscapes		Groups	% of families	Purpose of Potato Production	Consumption %	Sales %
Umala (181 households)	Low Zone (127 households)	1	34	Market	27.7	67.2
		2	66	Market & Consumption	64.1	33.3
					**	**
	High Zone (54 households)	1	79	Market & Consumption	95.1	4.3
		2	21	Consumption	65.1	30.8
					**	**
Ancoraimes (149 households)	Low Zone (57 households)	1	68	Consumption	93.6	5.8
		2	32	Market & Consumption	67.6	30.1
					**	**
	Mid Zone (42 households)	1	65	Consumption	97.6	2.4
		2	35	Market & Consumption	72.0	25.0
					**	**
	High Zone (50 households)	1	76	Consumption	85.6	13.5
		2	24	Market & Consumption	53.7	45.3
					**	**

** Significant differences at 1%

Vinto Coopani (highlands of the central Altiplano). This community has experienced more frequent adverse climate shocks as well as longer periods without rainfall; threatening its major source of livelihood—crop production. As a result of increased uncertainty, community efforts have focused on recovering and valuing native potato varieties to enhance food security. Markets also influence decisions, and in recent years production has favored those who sell in the markets. The *waycha* variety commands good market prices, while other varieties (*chunchu, lucki, sacampaya, sutamari*) have to be processed (freeze dried) into *chuño* to obtain good prices. A variety preferred for consumption unpeeled (*khati*) also has a strong demand in local markets but can be produced by only few families because it requires access to good soils.

Kellhuiri (highlands of the central Altiplano). Farmers in this community have a large diversity of potatoes, but prefer or prioritize production of *waycha, imilla,* and *sacampaya* due to market demand. The first two are preferred because of size and color, while the third, *sacampaya,* commands a lower price because it is sold processed (*chuño*). Despite a lower price, *chuño* is a key buffer to food security and can be stored and sold throughout the year. Trends and projections showing increased minimum temperatures threaten the capacity to process *chuño,* however, because freezing nights are key to processing. Another concern is that rising temperatures are related to increases in presence and spread of pests, affecting the capacity to store potatoes.

San Juan Circa (low elevation, central Altiplano). Farmers in this community are aware of climate changes, especially increased frost events and changes in the timing of rains. Even though they know this to be true and they have native potato varieties, they still focus on *waycha* because of its strong market demand. Native varieties are mostly used for direct consumption or processing because their prices are low. The trend is to decrease diversity. A benefit of native varieties is that they improve soils and humidity factors that are declining under current trends in climate and production practices.

Chojñapata (high elevation, northern Altiplano). Warming trends are significant in this region, and farmers in group discussion attributed this warming with their ability to grow *waycha* and *imilla negra* potato varieties, which have good yields and strong market demand. In the past, they could produce only *luck`I,* a bitter variety that has to be processed before consumption.

Calahuancani Baja (mid-elevation, northern Altiplano). Farmers in this community also acknowledge climate changes that were beneficial. While in the past they planted bitter potato varieties and quinoa, in the past decade they introduced preferred market varieties like *waycha* and *imilla negra*. These are perceived to be more resistant to pests and frosts and to have a shorter production cycle. Warming has also made possible the production of onions for market.

Cohani (mid-elevation, northern Altiplano). Knowledge-sharing activities showing that 75 percent of all potato production is *waycha* due to its high yields, short production cycle, lower losses to pests, and high demand. This is a local concern because it means high dependency on one variety in this community. Diversification was a traditional approach to addressing risks.

Chinchaya (low elevation near the lake, northern Altiplano). As in the other communities, w*aycha* dominates, with 66 percent of total production. Markets are the driving force, and climate has made it possible to produce. This community also has as a main commodity, onions, introduced more than two decades ago and also possible due to water access. Since 2006, livestock production (cattle) has become an important source of income in this community, the wealthiest of those we collaborate with in the region.

Loss of potato diversity is mainly driven by markets, but the opportunities for dominant market varieties, especially in the case of the northern Altiplano, was created by climate change. Native varieties are now being farmed in the historically colder higher elevations.

Climate and livelihoods

A poster and presentation at the Copenhagen meetings by Valdivia et al. (2009) highlighted the following: observational data collected to study climate trends of the past 30 years showed warming in the central Altiplano and drying in the northern Altiplano. Projections of climate change for the Altiplano suggest increasing temperatures and later onset of rains. Analysis of extreme events shows increases in variability. The overall scenario for decision making is one of increased uncertainty. Weather-related hazards are the greatest threat to the livelihoods of Andean farmers, so they have developed a large number of strategies

to reduce and cope with them. These strategies revolve around the use of climate indicators to help farmers decide when, where, and what to plant so as to minimize losses to droughts, floods, frosts, and hail. Stars, clouds, winds, plants, and animals are observed to help make production decisions. In the Altiplano of Bolivia, changes in climate particularly associated with later onset of the rainy season and the presentation of more extreme rainfall, drought, and frost events, has undermined production strategies tied to the use of these indicators. The later onset of rains is also reducing the options that farmers have for planting dates and is threatening the production of two of the most important sources of plant protein in their diets: quinoa and fava beans. Also, the behavior of certain indicator species was changing due to climate and environmental shifts. So while climate is changing, the ability to respond to climate-related risks is declining.

Climate change and livelihoods

An article submitted to the Annals of Geography articulates the findings of livelihoods, climates, landscapes, and knowledge systems (Valdivia et al. 2009). Building adaptive capacity is necessary to enhance resilience through social learning and the use of early warning systems. We find that rural communities in the Andes are particularly vulnerable to changing climate trends, the imperfect nature of markets, and outmigration. Changing climate trends in the past 40 years and climate projections that point to increasing temperatures and later onset of rains during the planting season challenge current local knowledge systems about agriculture in this region. Of the 360 household surveyed in nine rural communities, those in the northern Altiplano access and control fewer capital, income, and food buffers, and have higher outmigration than the central Altiplano. Losses from climate shocks are high, but the types of hazards vary by location. Loss of employment or sickness of an adult are ranked as a high threat to livelihoods in the northern region. The use of local knowledge indicators of climate is declining, while downscaling of climate forecasts is unlikely to occur due to the lack of data points and the large number of micro-climates. Participatory mapping and research are processes that enhance adaptive capacity and are critical to building resilience. This article advocates empirical and indigenous methods in developing early warning systems that can inform coping strategies. This approach combines science and indigenous knowledge to enhance adaptive capacity.

Climate change, soils, and productivity

A book chapter written by Motavalli et al. (2009) highlighted the findings of soils research and their implications under climate change. Based on the meteorological studies of Seth et al. and Thibeault et al. indicating increasing temperatures and higher incidence of extreme weather events, the chapter discusses the potential consequences of climate change on soil properties and processes in the Altiplano and possible adaptations that farmers may make to mitigate those effects. Among the principal effects of climate change in this region are lower soil water content, especially later in the growing season, loss of soil organic matter, increased soil erosion, changes in cropping practices, and increased landslides and mudslides. Suggested adaptations to climate change for this region include soil and water conservation measures to capture and reduce soil moisture loss; soil conservation practices to reduce soil erosion; improved irrigation methods; the planting of shorter-season crop species and varieties that are drought- and frost-resistant; increased use of soil fertility inputs, including alternative organic amendments; improved crop residue management; and maintenance of genetic diversity. Several areas of research are needed to more effectively assess the possible effects of climate change on soils in the Altiplano region, including development of a more detailed inventory of soil resources in the region and assessment of the potential long-term impacts of climate change using soil simulation models.

Soils: Impact of climate and market change on cropping systems and soil quality

Mechanization trends, especially the use of the tractor, differ among regions. Mechanization has an impact on soils due to both the technology itself and the abandonment of traditional practices such as the use of manure and crop rotation. There is an increased dependency (where there is access to cash) on chemical fertilizers and pesticides, especially in the central Altiplano. The families that are focusing on

selling crops are choosing the best quality soils and using mostly chemical fertilizers. On the one hand organic fertilizers are more costly. The number of sheep have decreased (source of organic manure) and competing labor demands make it easy to purchase and apply chemical fertilizer. The development of dairy has a second effect; it reduces the land available for food crops, and as a consequence reduces the time the plots can be left in fallow (Valdivia et al. 2009; Romero 2009). Due to the decrease in the length of the rainy season (Seth et al. 2009a) and the need to increase yields, new varieties are being introduced (short production cycle reduces risks). If biodiversity is to be retained or recovered, research on performance of native varieties at higher elevations or in poor soils needs to be tackled on the supply side, while on the demand side there is a need to develop approaches that offer these varieties to markets that value biodiversity or mitigation of climate change (social responsibility).

Development impact

The purpose of Objective 1 was to understand the dynamics of change and the interaction effects among livelihoods, climate, markets, and environmental dynamics. Understanding of trends was shared both within the team and with the communities. Our goal is to assess how the process of knowledge sharing affects knowledge. Several workshops took place integrating climate and market information with the knowledge generated on soils, dynamics of pests, and changes in the landscape. Following are some examples from the Peru site, where collaborative research on soils pests and landscapes took place this year.

- A soils characterization (taxonomy) according to type of crop and management (*aynokas* – private lands) was developed with farmers. Researchers and farmers validated traditional soil management practices. Farmers will be able to contrast their local knowledge with scientific findings through the comparison of soil analysis results and their own local indicators of fertility, following similar procedures in Bolivia. This information has fed into discussions to understand loss of soil fertility related to type of land management systems. It also was useful to compare local and scientific taxonomical knowledge.
- There is perceived, widespread knowledge of climate change in both communities of Peru. Important indicators are that the fall frost is very strong, while it is very hot during the day and with little rain. Santa María has a greater percentage of people who perceive that the weather is colder and the rains do not last as long as before, or that it does not rain when it is supposed to (95.9 percent in Santa María and only 2.9 percent in Apopata).
- The perceptions in Peruvian communities of the effects of climate change on agricultural production are negative. While in the past the climate was more favourable, indicators now point to extreme temperatures, decreased rain, increased hail and frost, and the virtual disappearance of the snow, increasing the vulnerability of agricultural production.
- The expectation of producers in both communities is that climate change will be unfavorable for production, according to what they have heard and experienced.
- The practices used to counter the effects of some weather events have not changed substantially and include building fires to combat frost and improving barnyard areas for livestock. In the Santa María community, at least three-fourths of producers say they plant resistant seeds.
- Methods of predicting weather change in both communities include looking at the stars and seeking advice from elders, strategies used with confidence to predict rain, frost, and hailstorms. Confidence in these methods is greater in Santa María to predict frost and hail, and greater in Apopata to forecast rain.

- In both communities, the Bristol[3] calendar is used by some residents and other resources by a smaller number.

Objective 2: Identify local knowledge and perceptions about production systems, landscape, and risks to assess the effect of climate and market change on livelihoods.

Critical Research Accomplishments

The research on perceptions and local knowledge is key to linking knowledge systems. In the process we first sought to understand the perceptions and local knowledge systems on climate, soils, pests, and vulnerabilities to their livelihoods. By linking this knowledge and understanding with the research findings in Objective 1, in a process that is participatory and seeks to identify strategies to address key concerns and opportunities, we expect to change from perceptions and attitudes of coping with events to anticipating and planning for events.

Climate perceptions and risk
The impacts of climate change are greater in high altitude areas of the Andes than in the adjoining lowlands. Temperatures were rising and extreme events are more frequent (Seth et al. 2009a; Valdivia et al. 2009). Evapotranspiration rates were increasing so that soils are drier, particularly at the beginning of the growing season. There has also been a dramatic increase in insect pest damage to staple crops and the incidence of new species of insect pests. Farmers in the Altiplano feel that climate and insect risks are the greatest threat to their livelihoods (Rees 2009). Changes in the region are significant enough that conventional strategies for dealing with risk are being abandoned (Gilles 2008). Farmers in the region are aware of changing conditions and are much more open than in the past to considering new technologies. Future research designed for this region must take into account climate risk and changing climatic conditions in the selection of experimental practices and techniques.

Soils in Bolivia
Work on identifying local classification systems for soil quality was completed during the first two years of the project, and maps were completed and revised identifying the location of these soils in the community. This information is being supplemented with survey information that was gathered for the cross-cutting soil quality project to determine the specific perceptions of soil quality among community members. Farmers generally have specific criteria for soil quality, primarily based on soil physical characteristics (e.g., color, texture, drainage) and relative crop growth.

Soils classification according to local perceptions in Santa María
Through participatory mapping, different types of soils were identified by community members in Santa María, Peru. Three types of soils were identified: *chiara la'ka, challa,* and *wila la'ka* (Figure 15). The *chiara la'ka* soil, the most productive, is a dark soil that retains water well, needs few fertilizers, is easy to work, and has medicinal use. Likewise, it better protects crops against frost and is very sought after by producers. *Challa* on the other hand is a sandier soil, not as productive as *chiara la'ka*. It does not need much water, is easy to work, and shields plants against frost. This soil is used to protect house walls. Both soils are used for tuber, legume, and cereal production. *Wila la'ka* soil is also not as productive as the first type, needs more fertilizer, and quickly becomes compacted. It is hard to work and can easily be lost by wind and water erosion. It does not filter water and is the least sought after type of soil. Though the same

[3] This calendar, created by New York physician Cyrenius C. Bristol, was used since 1832 across South America as a guide for calculating optimal dates for planting and harvesting crops as well as for practices such as baptizing children.

crops are produced in this soil as in the first two types, productivity is lower (Puno research team presentation, annual meeting, La Paz 2009).

Figure 15. Participatory soil mapping by community members in Santa María, Peru

Development impact

Crop pests, livestock disease, and frost are the most prevalent causes of loss. Northern Altiplano families in Bolivia have fewer resources and less income, especially those who live in the middle and high levels of the Ancoraimes Watershed. Our research found that those who have fewer assets have higher perceptions of risks. High perceptions of risks also mean lower willingness to take on new risks such as those inherent in new technologies. In this context of risk and uncertainty, participatory approaches are recommended by the literature and were tested in the development of practices and information (Objective 3) and strategies (Objective 4).

Lessons learned:

- Importance of active participation of stakeholders to ensure that collected information is trustworthy and valid. Likewise, the participatory process and recognition and respect of local knowledge increase the level of trust between community members and technicians.
- Participatory capacity building processes strengthen community organization and the capacity to learn (Baylon and Condor 2008).
- Many farmers base their judgments on long-term observations; therefore understanding community member perception of soil quality is important for evaluating alternative sustainable agricultural practices.
- The information gathered shows the spatial distribution of soil resources based on community and farmers' perceptions of soil type suitability for different crops. Funding for a more detailed soil survey is necessary so soil resources can be evaluated and mapped in a scientifically rigorous manner. Such information would facilitate improved agricultural management and land use planning.

Objective 3: Develop practices and information strategies (networks to access new information) to address changing conditions and perceived risks in soils, climate, pests and diseases, landscapes, and livelihoods.

Critical Research Accomplishments

Climate

Validate performance of models for precipitation intensity and dry spells related to the Bolivian highlands – extreme events. At present there is a tradeoff between having a sufficient range of model results and model resolution. In this research phase we opted for a sufficient range of models to characterize future climate. The global climate models employed in the IPCC Fourth Assessment Report (AR4) (Solomon et al. 2007) were analyzed using the Coupled Model Intercomparison Project (CMIP3) dataset (Meehl et al. 2007). The models comprise global atmosphere and ocean components with land vegetation and sea ice processes, and they employ horizontal grid resolutions that vary from near 100 km to more than 400 km. The medium and higher resolutions of these models do represent an elevated plateau in this central Andean region and provide a rough starting point for this evaluation.

Analysis of the simulated current annual cycle of temperature and precipitation shows that the models capture the timing of the rainy season onset and demise and the dry season. They also capture the weaker annual cycle observed in monthly temperatures. However, compared with observations, the models have a small warm bias and a wet bias, with too much moisture transport from the Amazon (Seth et al. 2009a). Analysis of 21st century projections shows agreement among the models that mean temperature increases of 1.5° C are likely by 2030 and greater than 4° C (5-6 standard deviations) through the annual cycle by the end of the century. Expected precipitation changes are generally smaller and negligible when averaged over all seasons. Our analysis suggests, however, that the early rainy season (September-November) is likely to be drier and the peak rainy season (January-March) is likely to be wetter, implying a shift toward a later, stronger rainy season (Seth et al. 2009a). This shift is consistent with a larger-scale analysis performed for the South American Monsoon System, which also shows a drying during the early season and increased precipitation in January through March (Seth et al. 2009b).

Because changes in mean climate can be reflected in the distribution of extremes, we also examined indexes of temperature and precipitation extremes. Temperature-related extremes show strong trends in increasing warm nights and heat wave duration, fewer frost days and larger extreme temperature variability (Thibeault et al. 2009a). Observed frost days were increasing recently, perhaps due to higher temperatures and reduced moisture (Garcia et al.) However, frost days are expected to eventually decrease, with the expected increasing temperatures in the future. Precipitation extremes are projected to increase in both heavy rainfall events and dry spells. Both of these signals are seen in the observed records at Patacamaya, though the dry spell signal is not statistically significant (Thibeault et al. 2009a). Much of the rural agriculture is rain-fed and thus vulnerable to variation in rainfall and the vagaries of soil moisture. Climate model projections suggest that, despite increases in precipitation during the peak rainy season, soil moisture is likely to be substantially reduced throughout the year due to the higher temperatures and related evapotranspiration rates (Thibeault et al. 2009b). These results should be considered interim because higher resolution models scenarios are in development.

We were able to document the following through the research on climate based on temperatures at La Paz/El Alto:

- Mean temperatures—increasing but no significant trend
- Frost days—increasing but no significant trend (Thibeault et al. 2009b)

- Warm nights—increasing with significant trend
- Warm spells—increasing with significant trend

Based on precipitation at Patacamaya (no trends show significance at this time):

- Dry days—increasing but no significant trend
- Precipitation—increasing but no significant trend
- Precipitation intensity—more variable but no significant trend
- Mean precipitation—decreasing in September, October, and November and increasing in January, February, and March, but no significant trends

Monitoring of local knowledge climate indicators. We do not yet have sufficient data points to evaluate local climate indicators, but this research will be continued under a McKnight Foundation grant.

Soils

The final year of this field study, which evaluated use of different conventional and alternative soil amendments, was completed in Umala, and a second year of response to these amendments was evaluated in Ancoraimes. Also, a Ph.D. student completed a controlled microcosm study in which he examined rates of decomposition and nitrogen mineralization with additions of organic amendments to the soil. He also evaluated the addition of these amendments at different rates on soil water-holding capacity and heat capacity.

Figure 16 shows the average potato tuber yield response among Umala communities in 2007 and 2008. In Umala, 2008 yields were uniformly higher than in 2007, and the highest yields were recorded with use of inorganic fertilizer combined with either sheep or cow manure. Farmers rated each treatment both at first flower and on harvest. Residual effects of the fertility treatments were also evaluated in 2008 and 2009, for farmers commonly rely on soil amendments applied to the potato crop for subsequent grain crops such as quinoa (Figure 17).

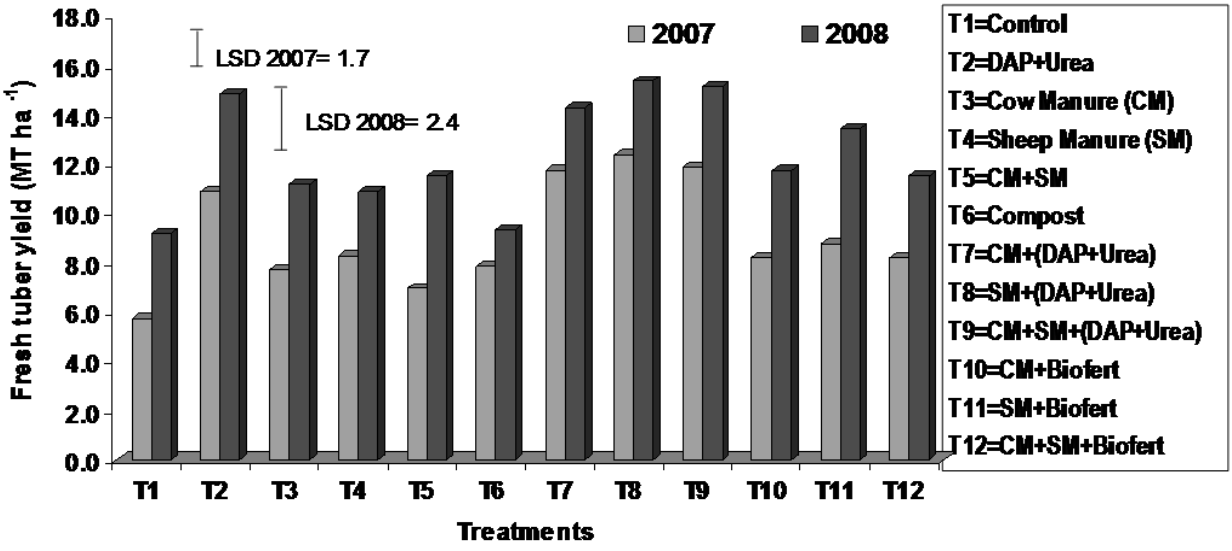


Figure 16. Average potato tuber yield response among Umala communities in 2007 and 2008 in response to inorganic and organic soil amendments. Vertical bars indicate the least significant difference (LSD) at $p < 0.05$.

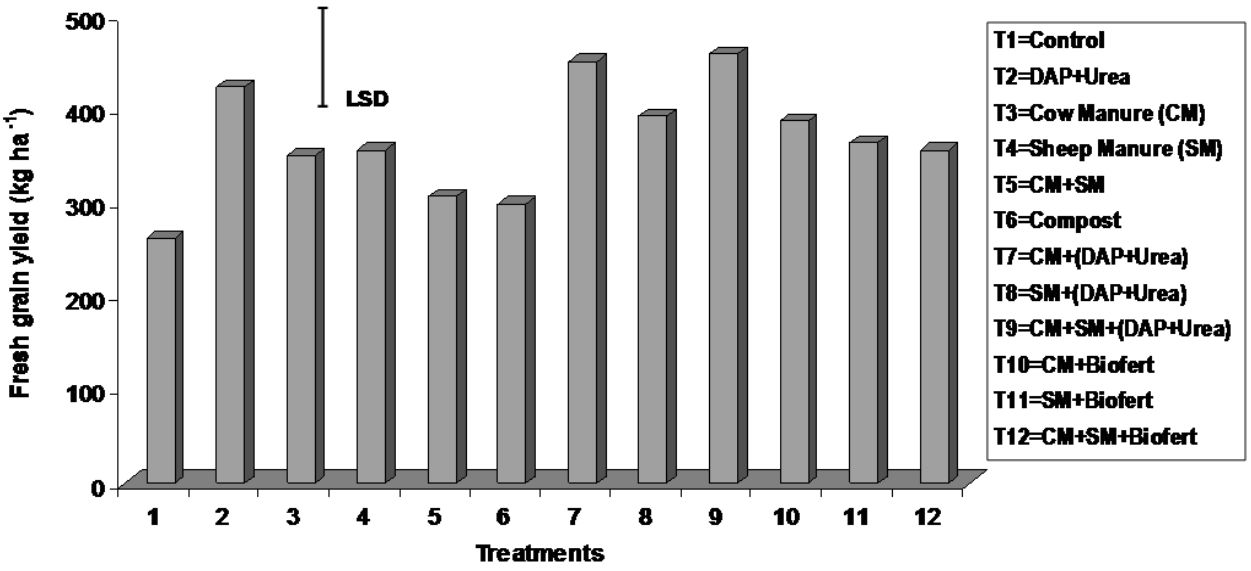


Figure 17. Average quinoa grain yield response among Umala communities in 2008 in response to inorganic and organic soil amendments applied to preceding potato. Vertical bars indicate the least significant difference (LSD) at $p < 0.05$.

In general, quinoa yields were higher in plots that received fertilizer compared to organic amendments applied alone (Figure 18). A primary reason for this difference was the higher residual inorganic N from the potato crop available at planting time for the quinoa when the fertilizer was applied. Similar results were observed in Ancoraimes (data not shown) with higher potato yields when manure and fertilizer were combined, but in those communities response to manure, especially sheep manure, was higher, possibly because of the higher rate of manure application (i.e., 15 t ha^{-1}) compared with what was applied in Umala (10 t ha^{-1}).

The change in gravimetric water content was determined on soils receiving different types and rates of organic amendments to better understand the possible effects of adding organic soil amendments on buffering climate change (Figure 19). In general, all the organic amendments significantly increased water retention capacity of the soil at -10 kilopascals (kPa) as rates of application increased. Adding the microbial conditioning agent sold under the trade name Biofert in Bolivia did not significantly affect soil water retention capacity. Increasing soil water retention capacity would provide additional moisture to crops in this semiarid region, and also would help in moderating soil temperature increases caused by global warming.

The use of a rapid, portable, and relatively inexpensive tool to evaluate the N status of the potato plant was also assessed in the field. This tool would allow for improved soil N management in a region where soil testing laboratories are not readily available or are expensive for local farmers. The portable Cardy nitrate meter was used to measure the nitrate content of sap extracted from potato petioles and the results compared to total N of the petioles measured in a soil and plant testing laboratory (Figure 20).

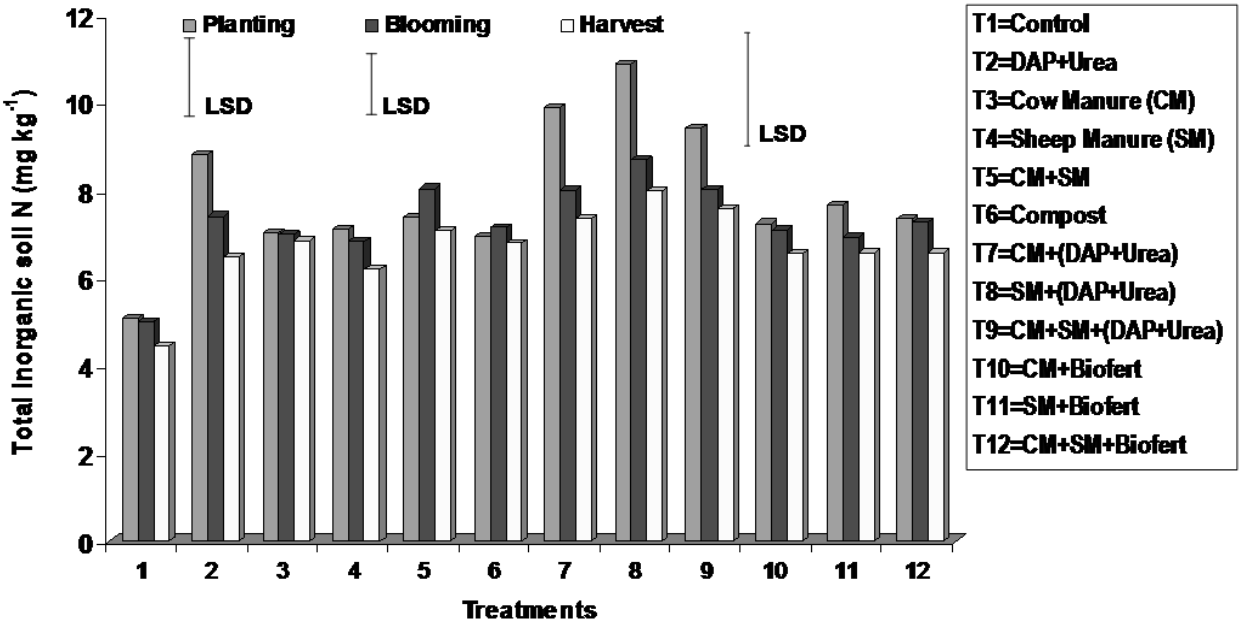


Figure 18. Average soil inorganic N (ammonium + nitrate) among Umala communities in 2008 in response to inorganic and organic soil amendments applied to preceding potato. Vertical bars indicate the least significant difference (LSD) at $p < 0.05$.

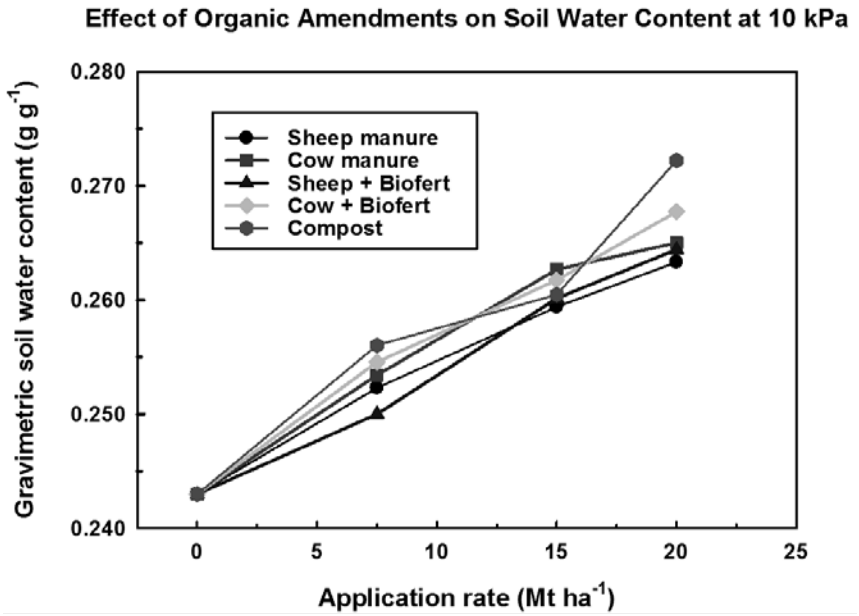


Figure 19. Effects of the type and application rate of different soil organic amendments on gravimetric soil water content at -10 kPa suction.

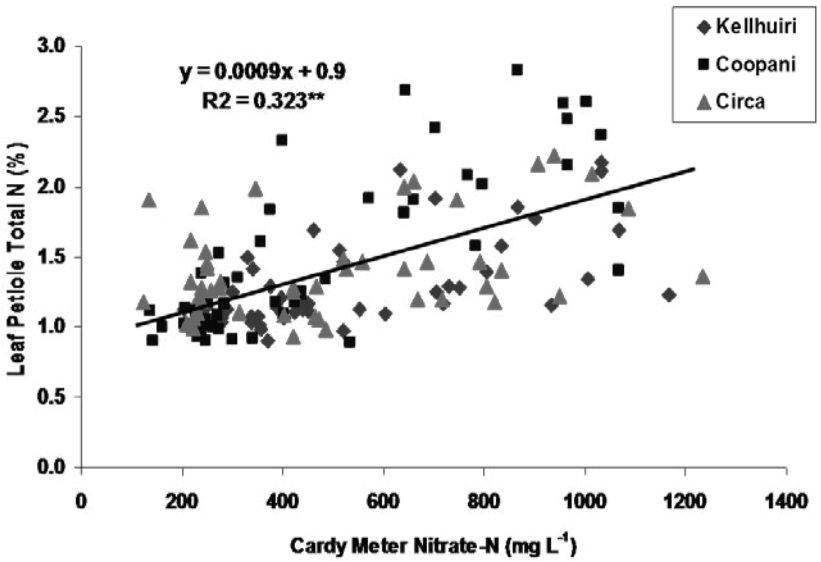


Figure 20. Relationship between Cardy nitrate meter measurements of potato petioles measured in the field to total N measured of petioles in a soil and plant testing laboratory.

The results show a significant relationship between the two measurements but with variation among the field trials conducted in Umala. The reason for the variation is not clear but may be due to the greater incidence of frosts and hail in the lower communities. Further research is needed before recommending use of the Cardy meter for routine evaluation of the N status of potato crops in this region. It is recommended that a chlorophyll meter, which is a portable and more dependable hand-held unit, be tested along with the Cardy meter to see if it correlates well with petiole N content under the regional field conditions.

The soil quality cross-cutting project determined that indigenous communities across a range of countries, including Bolivia, Indonesia, and the Philippines, primarily rely on physical indicators such as color, texture, water retention/drainage, and plant growth to measure soil quality. Responses among surveyed agricultural professionals working in the communities indicated that a soil quality test would need to be convenient, low in cost, and accompanied by training in its use. Spectroscopic methods for determining soil quality, including a rapid, low-cost field method using potassium permanganate, were tested on both degraded and non-degraded soils from the SANREM CRSP projects. The results indicate that these tests allow producers to assess the effectiveness of their management practices in improving soil quality.

Pests and diseases

Pest management. A conceptual paper was presented at the Copenhagen Meetings on Climate Change (Garrett et al. 2009). SANREM CRSP students developed baseline estimates for Andean potato weevil and potato tuber moth populations in Altiplano communities and their responses to weather conditions over multiple years (described in a manuscript in preparation). These will be important for understanding the effects of soil management strategies on pests where the inter-annual variability of weather conditions can be high. We developed a model of current and projected late blight risk in the Altiplano using climate change scenarios developed by the IPCC in a geographic information system (Sparks et al., in preparation). The models and methodologies are adaptable to other disease and pest systems and can be used to evaluate risk for the relevant range of systems under land management and climate change scenarios. With linked support from the U.S. National Center for Ecological Analysis and

Synthesis, we prepared a synthesis of the place of plant disease in ecosystem services (Cheatham et al.,2009). This conceptual framework will be useful for evaluating the effects of changes in tillage on plant disease, including scenarios where there may be a tradeoff between disease risk and soil loss. We also developed a set of open-access training modules for quantitative analysis of plant disease epidemics. These have now been accessed by more than 40,000 unique visitors in more than 100 countries and will be an important resource for training new scientists in integrated pest management. See: http://www.apsnet.org/education/AdvancedPlantPath/Topics/RModules/default.html.

Integrated Pest Management (IPM) in Peru.Training in IPM for the Andean potato weevil was carried out using the farmer field school (FFS) methodology, which promotes participatory training under the philosophy of learning by doing. Training is carried out in farmers' fields, and training sessions are scheduled according to the phenological development of the potato, a total of 12 workshops throughout the process. The topics were: Andean potato weevil, IPM and the Andean potato weevil, soil tillage, installation of live barriers with *tarwi*, two sessions on manual collection of weevils, two sessions on hilling potato, two sessions on monitoring and evaluation of the potato crop, good practices and harvest, and selection and storage of potatoes (Candela and Condor 2009). We applied a pre- and post-test to quantitatively measure the knowledge of farmers. We also evaluated farmers through focus group discussions at the end of the training process. Both evaluations assessed the knowledge acquired by farmers during an entire crop season. In the initial test of knowledge on the topics, the score was 32 percent out of 100 percent, while the final test result was 84 percent (Condor and Quispe 2009).

Landscape analysis as an informational tool

A quantitative assessment of vegetative cover of the Ancoraimes subwatershed is ongoing through the thesis research of Fredy Navia. The purpose is to analyze changes in the Chinchaya-Chojñapata watershed through temporal analysis of Landsat TM imagery. The study assesses quantitatively the change in vegetation cover between 1996 and 2006 (Figure 21).

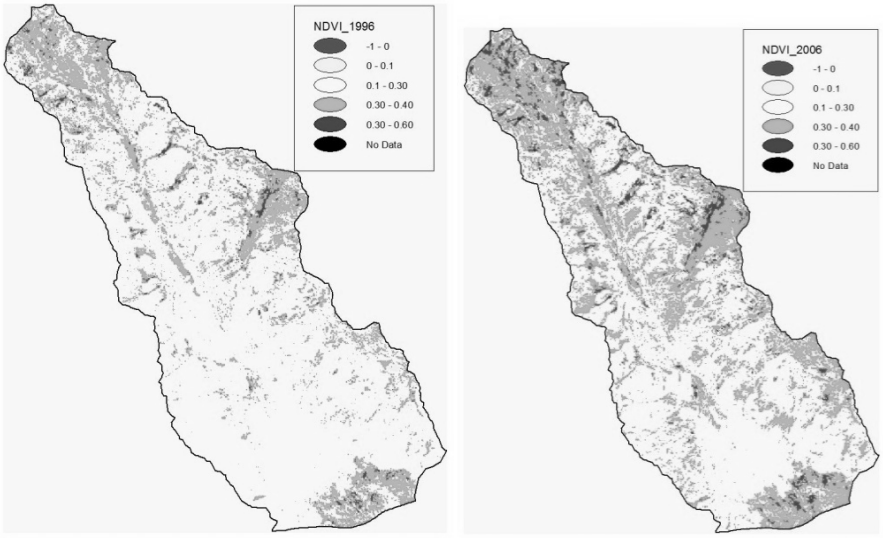


Figure 21. Vegetation indexes in Ancoraimes, 1996 and 2006, Navia and Yucra (2009)

Data show an increase in vegetative cover, specifically crops, of 47 percent in the last ten years. This study is intended to provide a baseline and monitoring tool for changes that take place in this region (vegetation, land use), seeking to integrate data on climate/weather data, soils, vegetation, and socioeconomic characteristics with this tool and participatory approaches. Preliminary results of the

spatial modeling of crops show that potatoes and barley are present in all three levels of the watershed (3800-4300 meters above sea level). (Vasquez and Navia 2009; Navia and Yucra 2009).

Livelihood strategies and networks: Bridging local and scientific knowledge systems
At the beginning of the fourth year, a protocol for sharing knowledge with communities was developed and tested. The approach consisted of linking local knowledge with that learned through the project's research activities (*protocolo de socialización*). Knowledge was shared in the context of climate and market conditions through leaflets, posters, reports, and a process that included focus group discussions. The goal was to determine how the information can aid future decisions. These events (Table 16 and Table 17) were conducted in Spanish and Aymara so that women and the elderly could understand and contribute to the discussion. Of special concern among farmers was the information shared about climate trends and the impacts of markets on agricultural production and the preservation of varieties. A majority of community members in Ancoraimes participated in knowledge sharing except in Chojñapata and Cohani, where mostly women participated due to the migration of male heads of household. In Umala, knowledge sharing took place only during the communities' general assemblies, resulting in very brief presentations. One of the communities refused to participate in PROINPA's activities. The project had to develop alternative strategies to fulfill agreements with the communities.

Universidad de la Cordillera and UMSA themes of the knowledge-sharing activities included climate and market impacts on livelihood strategies. Knowledge sharing of market channels and gender is also being taken to community groups to identify what can be done. A comment by a participant in Umala was that, when they gather for the general assembly, they rarely if ever touch on these issues. This project helped facilitate the discussions on issues related to climate and market impacts. A participant in Chinchaya (Ancoraimes) indicated that there is a need to keep updating the information as situations change, such as the fact that three years ago they had small numbers of cattle, but those numbers have significantly increased since the first survey.

Evaluating changes in information networks, producer practices, and capitals
A survey was developed for Bolivian and Peruvian communities at the beginning of the year and conducted at the end of the year to ensure that knowledge-sharing activities would be completed and effects analyzed. Databases were developed in Bolivia, and the analysis is being finalized. In Peru, data processing for one community was finalized (November 2009), and the second will be completed by the end of 2009. Analysis will be conducted in 2010.

Interaction effects
Climate change and socioeconomic factors in the Altiplano have led to changes in soil management practices, such as reduced periods of fallow that have generally decreased soil organic matter and increased soil degradation. This project focused on increasing soil organic matter to reduce degradation and improve long-term sustainability by use of conventional and alternative soil amendments. However, other strategies may need to be explored to increase soil organic matter, such as a greater use of cover crops, fallow systems that include multi-purpose leguminous cover crops, and implementation of additional soil conservation practices such as vegetative barriers.

Constraints to adoption of organic amendments
One strategy to reduce climate risk in the face of declining land availability was for household members to migrate temporarily to seek off-farm employment. Labor availability is a serious constraint to the adoption of many agricultural practices. Lack of available labor has led to a decline in on-farm diversification and in some areas (Central Altiplano) the substitution of chemical fertilizers for manure (Gilles et al. 2009).

Development impact

The use of both organic and inorganic soil amendments for potato and subsequent quinoa production significantly improved both crops. Data presented in previous annual reports showed that additions of organic amendments, including alternative organic amendments such as compost, peat moss, and a commercial microbial activator, significantly increased soil organic matter and lowered soil bulk density. The amount of improvement in soil water retention was shown to be a function of application rate, and this improvement in soil water retention may be important for sustainable crop production as climate change proceeds.

This research explored the use of soil amendments to increase soil organic matter. Other management practices such as improved crop residue management, conservation tillage, and introduction of cover crops may also be viable options. The highest responses for both initial and residual crop production were for treatments that combined inorganic fertilizers with organic amendments. The residual effects of the fertilizer treatment may be a result of the recommended rate of fertilizer application being too high to meet the N requirements of the potato crop or due to the poor performance of the crop due to weather or pest limitations. Farmer preferences were for organic soil fertility additions over inorganic fertilizer, but combined treatments were rated as doing well by farmers.

The results of this research indicate that increased use of organic and inorganic fertilizers would be important to increase crop production. Increasing soil organic matter would also have benefits in improving soil properties that may reduce the effects of climate change and slow down the rate of soil degradation.

Summary of impacts:

- Farmers increased their knowledge of IPM. A 52 percent increase in knowledge regarding Andean potato weevil and IPM was observed in Santa María. In the initial test of knowledge on the topics, the score was 32 percent out of 100 percent, while the final test result was 84 percent.
- The presence of women throughout the training process was an important outcome, with 56 percent being women.
- Continual participation through the year was monitored, with 29 people in the first workshop and an average of 24 participants throughout the participatory process.
- In the qualitative assessment among farmers, the elements of highest interest were the manual techniques for collecting of adult weevils, harvesting using blankets, and planting live barriers. Participants also felt they had increased their knowledge of the Andean weevil life cycle.
- The tools used to disseminate knowledge were shared regionally through informal conversations and/or small meetings.
- The use of new knowledge and techniques is beginning this farming season, and there is a desire to implement them during the next farming season.
- The facilitator in charge learned to value the knowledge of farmers and the need to treat farmers as equals. This served to generate empathy with the farmers and to improve the working relationship with them. In other words, the change in attitudes, knowledge, and practices was a two-way process that affected all those who participated, both farmers and facilitators.

Objective 4: Develop market access strategies and institutions that contribute to resilience.

Critical research accomplishments

Institutions to access technology and markets
Reducing transaction costs for market integration is key to increasing farmers' returns. We studied the Bolivian Andean Platform (BAP), an institution that links farmers with high-income markets (Figueroa, 2009). Strengths included promotion of collaboration between market chain actors and formal organizations of support and reduction of search, information, and contracting costs for all stakeholders. The increase in monitoring and enforcement costs for all producer associations' members was offset by the reduction of information and search costs. Those who participated benefited through long-term access to improvements in native varieties, and reduced search and information costs. However, lack of clear contract rules were a constraint. Collective action through farmer groups to access new potato technologies also was evaluated (Figueroa and Valdivia, 2008). Labor constraints reduced participation in the Native Potato Varieties Group.

Livelihood strategies and networks advocacy coalitions for markets
The first step in the process of building coalitions was completed this year. This consisted of sharing the results of the baseline survey with farmer groups in the communities of Umala and Ancoraimes. In research conducted by thesis students on markets and marketing strategies for potato (Umala) and onion (Ancoraimes), one of the weaknesses identified was the lack of a farmer organization. Farmers acknowledge this as a problem. Farmers in Umala in the past had formed an association to market potatoes as a group, Asociación de Productores de Papa del Municipio de Umala (APROPA–Umala) in the lowlands of San José Llanga and San Juan Circa. Problems of collective action (lack of member coordination) were not overcome. Participants in a focus group on gender and transaction costs discussed formation of a new organization and hoped to be able to link with organizations that could provide technical and logistical support. Identifying what is needed and who to link with are the first steps in strengthening human capital and bridging social capital.

Chinchaya, in the northern Altiplano, is the only one of our collaborating communities that has an association of onion producers: APROCCHI (Asociación de Productores de Cebolla de Chinchaya), which in turn belongs to a larger association of 20 rural communities in the province Omasuyos. The main benefit of this association is access to space in the market of El Alto, where they can sell and store their products. Members also are able to access production inputs through the municipality. The other communities in Ancoraimes (Cohani, Calahuancani Baja, Chojñapata) do not have farmer associations to market their products (peas, onions, potatoes) but acknowledge the advantages of being organized to obtain better prices. At present, small producers participate in markets on their own, which means they take on marketing risks such as low prices due to the small amount traded and the high variability in quality. Farmers face a buyers' market where increasing income is a function of higher levels of production and productivity.

The study of women's participation in the marketing of agricultural products found that potato varieties with the largest demand are *waycha, imilla negra, dessiré* or *alfa, sani cron, canchán*, and *phiño*. Those that command the greatest prices are *waycha, imilla negra,* and *phiño. Waycha, imillla negra, desire,* and *phiño* are produced in Umala communities because of their strong market demand. Native varieties like *pituwayaca* also have a good demand, but production is low because it requires fields that were in fallow for many years, which means farming in areas that are far away from the homestead. Alternative marketing strategies include advocacy coalitions and market chain approaches for native crops and camelid products. A study developed this year focused on understanding marketing strategies. Umala farmers market their crops on the farm or at the local market (Patacamaya) where wholesalers purchase

and transport to Chijini (market in La Paz). Ancoraimes farmers have two main local fairs: Morocollo and Chejepampa. Several farmers also take their products to the La Paz markets and regional fairs (Río Seco, Alto Lima), where they sell directly to consumers (Jiménez et al. 2009).

Findings from the interviews conducted for the study of women's participation in the marketing of crops point to differences in the bargaining power of women between Umala and Ancoraimes. A key difference is the number of buyers and sellers in the nearby markets where they sell. While Ancoraimes producers participate in more than one market to sell potatoes, onions, and peas, producers in Umala participate in only one, the Feria de Patacamaya, where they sell potatoes and chuño. While Ancoraimes' farmers use several markets, they offer small amounts of product of varying quality, resulting in low prices. Umala producers, on the other hand, have a strong market with good prices, a result of the amount and quality of the potato sales. Differences in marketing processes are highlighted in Table 16 and Table 17.

Table 16. Marketing and gender in Umala: The producers

Questions	Communities of the Municipality of Umala			
	San José Llanga	San Juan Circa	Vinto Coopani	Kellhuiri
Where do you market and why?	Patacamaya	Patacamaya	Patacamaya	Patacamaya
	Because it is the closest and more accessible fair in terms of transportation costs for the farmers.			
Who market?	Women and men	Women and Men	Women and Men	Women and Men
What is your ability to bargain on the prices? Who sets the price?	Prices are established by the middlemen, both the wholesalers and/or retailers			
What type of market is it?	Regional Fair	Regional Fair	Regional Fair	Regional Fair
Are you organized to sell?	There are no communities that today organize themselves to market their product			

Table 17. Marketing and gender in Ancoraimes: The producers

Questions	Communities of the Municipality of Ancoraimes			
	Chinchaya (onion)	Cohani (pea)	Calahuancani Baja (potato and onion)	Chojñapata (potato)
Where do you market?	Sector Faro Murillo (c/6 Ceja) La Paz	Chijini, Chejepampa	- Morocollo - Chejepampa - Achacachi	Morocollo Chejepampa Achacachi Chijini
			- 16 de Julio - Rio Seco - Garita de Lima	
Who markets your product?	Women and Men	Women and Men	Women and Men	Women and Men
What is your ability to negotiate prices?	Producers set the price	Wholesalers set the prices		
What type of market do you sell at?	Urban market	Urban market and rural fairs	Urban markets and rural fairs	Urban market and rural fair
Are you organized?	Yes, they are organized to market onions	Market on their own, individually		

According to the perception of the buyers in the market chain study, the most common problems relate to amount and quality of the product. Prices increase during the months of February and March due to the

lack of supply (Jiménez et al. 2009). Women are the dominant actors in the rural wholesale and retail fairs and are described as the best negotiators. On the other hand, in urban markets wholesale and retail agents play a larger role. Prices and price changes are a function of supply and demand in these markets, and the nature of the market, be it rural fair or urban market (Jiménez et al. 2009).

Women who are in charge of marketing crops (47 percent of households interviewed) in Ancoraimes sell mostly in local markets (45 percent) (Romero et al. 2009). When men are in charge of marketing, sales take place in the urban markets (84.5 percent sell in El Alto and La Paz). When both are in charge of marketing, sales take place mostly in urban markets (75 percent). Women are in charge of marketing most of the potatoes, peas, and sheep. Men are in charge of marketing most of the onions. When marketing is done jointly by men and women (19 percent of the households interviewed) the social networks are wider and more diverse, and so are the sources of information used in negotiations, which go beyond the community. On the other hand, women who are responsible for marketing on their own participate in markets (mostly local) less often and have less land; therefore they have less produce to sell. This is a group that expresses more fear at the possibility that prices will be low in a given year (household survey, 2006). Men who are in charge of selling (34 percent of the households interviewed) belong to households that rely mostly on agriculture for their incomes, especially onion production and livestock sales. They participate in urban markets, have good networks and access to water, and do not migrate for work.

Sharing of markets and climate information

Several activities of sharing knowledge on climate and markets were undertaken to evaluate findings on IPM and soil amendments in the context of these changes. Materials on climate change developed by the Bolivian Program on Climate Change were shared during the workshops. These were conducted in depth in Ancoraimes and through regular community meetings in Umala. A panel survey conducted at the end of the program will capture the data to evaluate knowledge, attitudes, and perceptions of this process. The protocol for Ancoraimes also includes what action the community can develop that includes this information. This process is informed by the advocacy coalitions approach in the Peruvian communities as planned.

Markets for alpaca fiber

Commercialization of raw Alpaca fiber by producers in Apopata takes place between October and March. However, producers point out that they used to shear some alpacas in August, a practice they can no longer continue because weather changes in recent years have made August colder. Shearing and sale of *tuis* (young alpaca) fiber is done in December or March. Farmers can shear animals any time during the year, depending on their immediate cash need.

Apopata producers go to the Saturday fair in Mazocruz to sell fiber or buy needed products. Just a very small number of farmers go to Santa Rosa or to the Conduriri or Ilave fairs. One of the main reasons is that Mazocruz is only 15 km away. Apopata has little access to transportation and communication. So not surprisingly, they receive information about the market (prices, market changes, demands) through neighbors and/or family.

The commercialization chain of alpaca fiber is composed of intermediaries who buy at fairs or *q'atos* that the communities, districts, or provincial capitals organize. They take this fiber to the big enterprises in Arequipa, where it is classified and transformed for national and international markets. A second commercialization route is through municipal collection centers in Mazocruz. This route is for smaller quantities because, although the amount received for the fiber might be higher, the payments take longer than through the intermediaries, who pay immediately. It would seem that Apopata producers are not making many changes to their market strategies to ensure the sale of their product, despite the fact that 80 percent of farmers interviewed for the household survey said that they were improving the presentation of their products for the market. What is evident is that farmers want to change strategies, but most of their

plans have remained as aspirations rather than actions. They wish to improve the quality of their products, increase their sales, and establish strategic alliances for better markets (Rivera et al., 2009). Linking these aspirations to coalition building is an opportunity that this project has put into the hands of Apopata producers.

A women's interest group is looking at ways of building capacity to go from selling raw products to added-value products, linking with producers from other localities who have managed to capture better markets for their alpaca fiber products, and building social capital with state and civil society institutions that can strengthen their links to markets.

Interaction between climate change and market opportunities
The approach to working with communities has differed across sites to address the culture of each organization. UMSA in Ancoraimes developed a process that, as at other sites, included identifying farmers' needs. In assessing participation in the third year of the project, UMSA decided to implement new research activities in line with perceived climate changes. Farmers had identified that, with increased warming, there were possibilities to incorporate new crops or new varieties.

In the last year, research was undertaken on community fields with new varieties of onions at higher elevations, new varieties of quinoa (which experienced a large increase in prices in the last two years), turnips at very high elevations, and peas. This was a means to discuss opportunities in the short term due to warming, and the value of diversification. While the research was only for a year, UMSA has established trust with the rural communities. This will be evaluated through the household survey data and in-depth case study.

Development impact

Notions have increased within the community that coalitions are needed to have access to better markets in Santa María as well as Umala and Ancoraimes. For many the idea of working together to market products and obtain better prices was an individual strategy, not a collective one (with the exception of onions). The process of knowledge sharing on climate and markets provided opportunities to discuss possibilities for increasing market income and identifying barriers. This was the first stage in a strategy development process that requires multiple iterations to bridge social and human capital. The impact at this point is on knowledge and awareness leading to a change in attitude.

Objective 5: Develop stakeholders' capacities and capabilities—ability to act—to reduce vulnerability and increase adaptation in the face of changing market and climate conditions.

Critical research accomplishments

This objective included the impact on capacity building of degree and non-degree training, as well as understanding the institutions and participatory processes that can contribute to agency, the ability to act. Research this year concentrated on knowledge-sharing processes along with participatory research. Monitoring of these activities included evaluations with farmers as well as tracing participants in order to analyze the effects of participation. While ample data was collected, data analyze and synthesis is still being completed. We aim to deliver two products: analysis of the data to respond to our hypothesis and a methodology—lessons learned, best practices—to implement participatory research, an assessment that leads to impact on knowledge, perceptions, skills, and practices.

Impacts of participation on livelihood strategies

Participation in the project was monitored every year. The objective is to evaluate who participates and whether participants are able to use the knowledge to change their practices. A monitoring protocol was developed to link to the 2006 database of sampled households. The livelihood and capitals characteristics of the households are evaluated. Analysis of the characteristics of participating households yielded interesting results. In the case of Ancoraimes communities, those who participated in 2006 were families in the lower income groups. In Umala, families belonged to the middle income groups (second and fourth income quintiles).

The behavior changes in 2008 showed that both the lowest- and the highest-income quintiles participated in Ancoraimes; participating households in Umala belonged to all income quintiles in even proportions. If this is analyzed in relation to migration, participating Ancoraimes households have lower rates of migration throughout the year compared with those who do not participate. Umala experienced the opposite relationship in 2007. In regard to gender, participants were mostly men, about 60 percent, in both regions.[4] A second survey was conducted at the end of 2009. This survey measured differences in knowledge, attitudes, perceptions, and practices between participants and non-participants in activities undertaken with the communities. A key constraint to participation is time availability. The short periods of time available to participate limit the ability to assimilate and understand several of the technical findings. Repetition is a critical element in the learning process. Themes are brought up in many ways and contexts to facilitate learning. This approach was implemented in Ancoraimes. It is also important to promote this learning in the local schools and enhance opportunities for discussion and information sharing. The survey completed at the end of Year 4 is the key source of data for analysis on the changes experienced by participants and non-participants in the processes.

Community participatory research and gender

Methodologies were developed to build a shared understanding of the drivers affecting livelihoods, resource management, and crop and livestock production in Altiplano communities. Gender and wealth interactions explained which households were most vulnerable (Yana 2008). Labor migration in regions with smaller farm sizes (Ancoraimes) resulted in work overloads for women in the household and their inability to access regional markets. This did not preclude their active participation in formal research groups. The group of women in Cohani had higher rates of participation than in other communities. Explicitly inviting women to participate in groups and training allowed them inclusion (Talleres 2007; Yucra 2008). Community requirements of a household representative in the participatory research groups in Ancoraimes also ensured participation of women.

The relevance of participatory approaches (cross-cutting activities)

The degree of knowledge acquired by the participants was measured with knowledge tests administered before and after training. Qualitative tests were also applied in the case of IPM training through focus groups. Findings are currently being synthesized. A summary example of the process developed in one Peruvian community follows.

Training activities in Peru were conducted with a methodology especially oriented toward development of a participatory approach. In this context, the development of themes was based on the philosophy of "learning by doing" following the cycle phases of adult learning[5]. More training activities were planned and implemented in Santa María than Apopata because the first was selected at the beginning of the project and because it engages in crops and livestock production. In contrast, Apopata producers focus on

[4] *Analisis de Evaluaciones Participativas*, 2007-2008.

[5] The adult learning cycle is based on the following steps: (i) extraction of previous experiences of the participants in the issues scheduled, (ii) analysis and discussion of the issues, (iii) new information and (iv) implementation of new knowledge.

camelid production. There were 32 training activities in Santa María on the following themes: diagnosis of natural resource problems, mapping and geo-referencing, characterization of Aynocas, integrated management of Andean potato weevil, animal health, and advocacy coalitions. Apopata participated in nine training activities on the following themes: diagnosis of natural resource problems, mapping and geo-referencing, management of *bofedales*, animal health, and advocacy coalitions (Candela and Condor 2009).

Advocacy coalitions. Analysis of responses after a two-year advocacy coalitions (AC) process in the Peruvian Altiplano showed that it worked better in Apopata than in Santa María—the community with higher bonding social capital. We observed that Santa María presents a community power structure formed by interest groups as diverse as its livelihoods strategies and allowed by its location at the lakeside agro-ecological zone. This power structure made it difficult to arrive at consensus and to take political action. We also observed that Santa María's bonding social capital (internal associations) was a response to the demands of external organizations, and its bridging social capital was based on relationships of dependency on those organizations.

On the other hand, Apopata presents a community power structure with groups that share interests because of its homogeneous livelihood strategy (alpaca herding) defined by its location at the dry puna agro-ecological zone. This condition would facilitate the definition of the communal goals, such as improving access to the alpaca wool market, and would explain the existence of few internal organizations. Furthermore, Apopata had less clientelistic relationships with external organizations. We argue that the type of social and political capital in Santa María does not promote activities that require collective action such as AC. By contrast, Apopata provided a conducive environment to building coalitions. We also conclude that, when building participatory processes such as AC in regions like the Altiplano, it is important to consider heterogeneity of livelihoods, the type of community power structure, and the historical institutional environment (Turin et al. 2009).

Analysis of the impact of participation and the institutional approaches to participation
Data was collected through a panel survey implemented at the end of the year, documentation of participation by region, and by activities implemented by our collaborating institutions in Bolivia and Peru. This research will be completed during the no-cost project extension and seeks to understand the institutional approach to collaboration with farmers and its impact in engaging farmers in long-term research and the effect of activities on information flows and changes in knowledge, attitudes, perceptions, and practices. The analysis will include the participatory research evaluations, monitoring and evaluation with groups of farmers, and the evaluation of participating and non-participating farmers' changes in knowledge attitudes and practices to determine which institutions and processes lead to linking knowledge systems that benefit the most vulnerable groups, such as women and families, with lower levels of capital.

Development impact

The evaluation of knowledge in the case of training about dynamics of pests with farmers in Ancoraimes found the following: before the workshop their knowledge of the subject was between 40 percent and 50 percent, and after the training the acquired knowledge increased to more than 72 percent. Their perceptions of acquired knowledge coincide with technical evaluation throughout the training workshops, conducted with the actual tests, where knowledge testing before the training was 46 percent to 52 percent and after the training was 82 percent.

Participation

- In terms of participation at training workshops in Santa María, it was found that there was a slight preponderance of women—54 percent versus 46 percent of men. In Apopata, on the other hand, male participation is higher than women's, 58 percent versus 42 percent.
- Migration in Santa María is greater in July, August, September, and part of October. Forty-seven percent of the workshops were implemented during the largest migration of male villagers, and 53 percent were implemented when they were home. Migration in Apopata did not influence attendance at training workshops because it takes place at any time of year and is mostly due to commercial activities.
- Participants in both communities are mostly adults averaging 59 years in Santa María and 56 years in Apopata.
- In both communities the majority of members who attend training activities were poor people with incomes of less than $66 a month and, to a lesser extent, those with monthly incomes of $66 to $133.
- The workshops generated an inter-learning process that has benefited the local team, who learned how to work with villagers, changing attitudes about collaboration, and the value of local knowledge.

Advocacy coalitions

- Human capital at the community level was strengthened through the formation and functioning of the local research team.
- Strengthening of social capital has happened at two levels: with local, municipal, and regional actors during strategic coordination visits to institutions in Ilave and Puno which facilitated the signing of letters of agreement with *Comision Nacional de Camelidos* (CONACS) and the realization of the activities agreed upon in these letters; and at community level (bonding social capital) through interaction among members to reach agreements on proposals, their formulation and presentation to the communal assembly, and decision making on their relevance in terms of community priorities.
- An important achievement of the coalition building process was the weaving of the social network established between the community and actors from civil society.
- A lesson learned in terms of when an advocacy coalition process does not work came from the experience we had in Santa María. The process there was abandoned because the president of the community no longer wanted to work on this process. One possible reason is that the president had personal interests that were more directed toward being visible in what he was doing as president. For this he needed material results such as infrastructure that could be seen and quantified. Capacity building does not involve material goods or infrastructure, therefore was not useful for his purposes. If the community, as we later learned, was interested in continuing the advocacy coalition process, why did they not protest or demand that the process continue? The reason might have a cultural vein to it. Cultural capital is very important to Aymara communities as to most indigenous communities. Respect for the authority, even if the people do not agree at all with his or her actions, is so strong that the idea of opposing or disputing his or her decisions (even when this authority is supposed to represent the will of the majority) is not even considered (Fernandez-Baca and Condor 2009).

Degree and non-degree training activities

Long-term training included 7 Ph.D.s, 24 master's degrees, and 33 undergraduate theses, a total of 64—29 women and 35 men. By nationality, 9 were from the United States, 7 from Peru, 43 from Bolivia, and 5 from other developing countries.

Year 4 non-degree training activities included: 44 workshops with farmers; 4 pest biology training visits with farmers to Patacamaya; 11 audiovisual training sessions with farmers; 3 farmer training courses; 3 short courses with farmers; 3 farmer training sessions on livestock practices; 6 workshops with students, officials, academics, and stakeholders; 1 international seminar; 4 seminars in Bolivia, Peru, and the United States with government and academia, and others. In all, 1,081 men and 779 women participated through the year, a total of 1,860.

Publications, presentations, other products

Products published this year in the SANREM CRSP SKB totaled 174. This included 10 refereed articles—7 published and accepted, 3 resubmitted; 4 book chapters; 6 theses; 25 working papers; 11 abstracts; 18 presentations at professional meetings; 33 presentations about to various stakeholders; 16 research posters at professional meetings and conferences; and 51 posters, leaflets, and training manuals for the collaborating rural communities. Also uploaded to the SKB but not yet published, either because products are under review or not all the information is available at the time, are an additional 4 journal articles, 20 articles from thesis research to be published in a book in Bolivia, 2 book chapters, 16 theses, 29 technical reports, 17 electronic presentations, 17 posters, and 35 printed extension materials for the collaborating rural communities. A program about our local knowledge indicators research in Ancoraimes in the northern Altiplano was aired on Channel 4, La Paz, and shared for a BBC program. A CD of presentations of the final international seminar in La Paz was produced.

Networking activities

From Copenhagen to La Paz and Lima, as well as at scientific meetings in the United States, we conducted workshops and seminars to present the findings of our research. The purpose was to share the sciences and the implications for development programs, as well as inform policymakers as a process of out-scaling the methods and findings to larger programs. Examples from 2009 are the methods and findings incorporated into the training of scientists and public officers in Bolivia in collaboration with the National Program on Climate Change (September), the seminar at USAID-Washington in May about the findings on climate change and development of adaptive capacities; the seminar in January at the Ministry of the Environment in Lima on global climate change model projections for the Altiplano; an international seminar in La Paz for the academic and public service communities; and finally, sharing our findings at the Copenhagen meetings in March and through USAID in December. Every institution collaborating in the project was very active. UNALM participated in the second Congreso Internacional de Páramos “Paramundi,” where the advocacy coalition’s framework methodology was presented and at the Camara de Comercio de Lima (Chamber of Commerce) informing midsize entrepreneurs on climate change. Cecilia Turín presented at the Farmer First Revisited Conference, and Elizabeth Jiménez presented in Argentina on climate change and social sciences. In October a project by University of Missouri and Universidad Mayor San Andrés to monitor local indicators for the next four years in Bolivia was funded by the McKnight Foundation.

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

Principal investigator: Manuel Reyes, Professor, Natural Resources and Environmental Design, North Carolina Agricultural and Technical State University (NCA&T)

Host countries: Philippines, Vietnam, Indonesia

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Research strategy and development objectives

Communities in many forest and vegetable-producing watersheds in Southeast Asia are suffering from poverty and degradation of forest, soil, and water resources. The overall hypothesis of this research is: "Integrating vegetable production in tree systems and trees in vegetable production systems will alleviate poverty and will enhance environmental protection, ecosystem diversity, and sustainability on small farms in Southeast Asia." The project goes by the acronym TMPEGS based on its six main objectives. The objectives are described below and their interdependence is depicted in Figure 22.

- **Objective 1. Technology**: develop economically viable and ecologically sound Vegetable Agroforestry (VAF) systems.
- **Objective 2. Markets**: develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies.
- **Objective 3. Policy**: (1) identify policy options and institutional frameworks that promote sustainability of vegetable VAF production and reward environmental services, and (2) develop and test an incentive-based policy option and institutional framework for promoting VAF system particularly in the Philippines.
- **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.

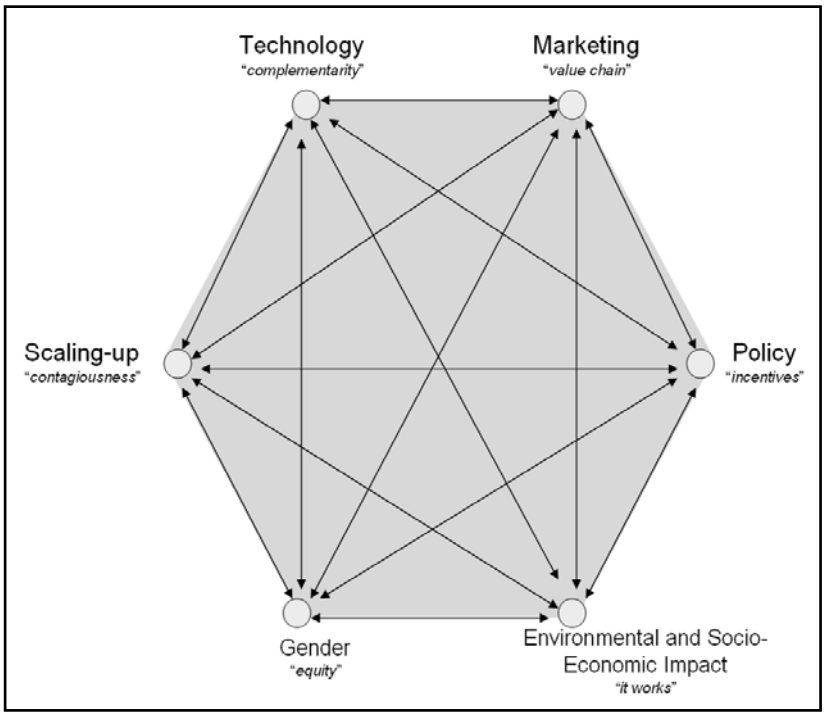


Figure 22. TMPEGS objectives and their interdependence.

Overview of individual research objectives

Research is conducted in Indonesia, Philippines, and Vietnam. Each country has particular research protocols to test the overall hypothesis. However, there also are common research objectives, including the following:

- The technology objective 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 objective aims to identify opportunities for greater profit along the value chain extending from production inputs to handling and sale of vegetables and tree products. It seeks to answer the questions: "What can be done to enhance income from timber, vegetables, or tree fruits? What opportunities exist to improve post-harvest handling to enhance vegetable or tree-fruit quality?" Transportation cost issues and the demand for indigenous vegetables are common to all three countries.
- The policy objective aims to identify incentives that promote investments in VAF systems. Issues of concern include market inefficiencies, soil erosion and degradation impacts, and policymaking

processes. This element seeks to answer the question: “What policy incentives promote wider adoption of VAF systems by small-scale male and female farmers?” These incentives can be incorporated into local, regional, or national government policies.

- The environmental and socioeconomic impact objective aims to measure whether the overall hypothesis works. The socioeconomic approach is a participatory development model with a monitoring feedback loop between small-scale farmers (both women and men smallholders), scientists, and other stakeholders. With respect to environmental impact, a water-quality model is being used to simulate and quantify hydrologic effects of current practices and compare them with hydrologic impacts of proposed VAF practices. It seeks to answer the questions: “Can VAF improve the quality of life of small-scale farmers? Will small-scale farmer incomes increase with VAF? Can VAF reduce the non-sustainable destructive hydrologic impacts of current practices?”
- The gender objective addresses equity. Alleviating poverty means that quality of life is improved for both women and men. This research aim ensures that women benefit from this project. It seeks to answer the question: “What alternative mechanisms can improve women’s involvement, socioeconomic status, and decision making in 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 smallholders. This research element seeks to answer the question: “How can innovations be efficiently spread geographically and to different levels of society?” Research is focused on training need assessments and the effectiveness of TMPEGS outreach activities such as workshops, seminars, and farm visits.

Objective interdependency

This section describes the interdependence of each objective on the others in the TMPEGS conceptual model (Figure 23), which shows a dynamic iterative process. The iterative flow is illustrated by solid and broken arrows. The solid arrows illustrate the predominant flow in the model. The initial baseline study helps to set technology development priorities. Various technologies and combinations are then tested. Potentially innovative technology needs to be considered from environmental and socioeconomic perspectives. Environmental and socioeconomic impact studies are conducted in conjunction with marketing, gender, and policy studies to identify institutional innovations. Successful technological and institutional innovations are then scaled up to other stakeholders, especially smallholders.

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

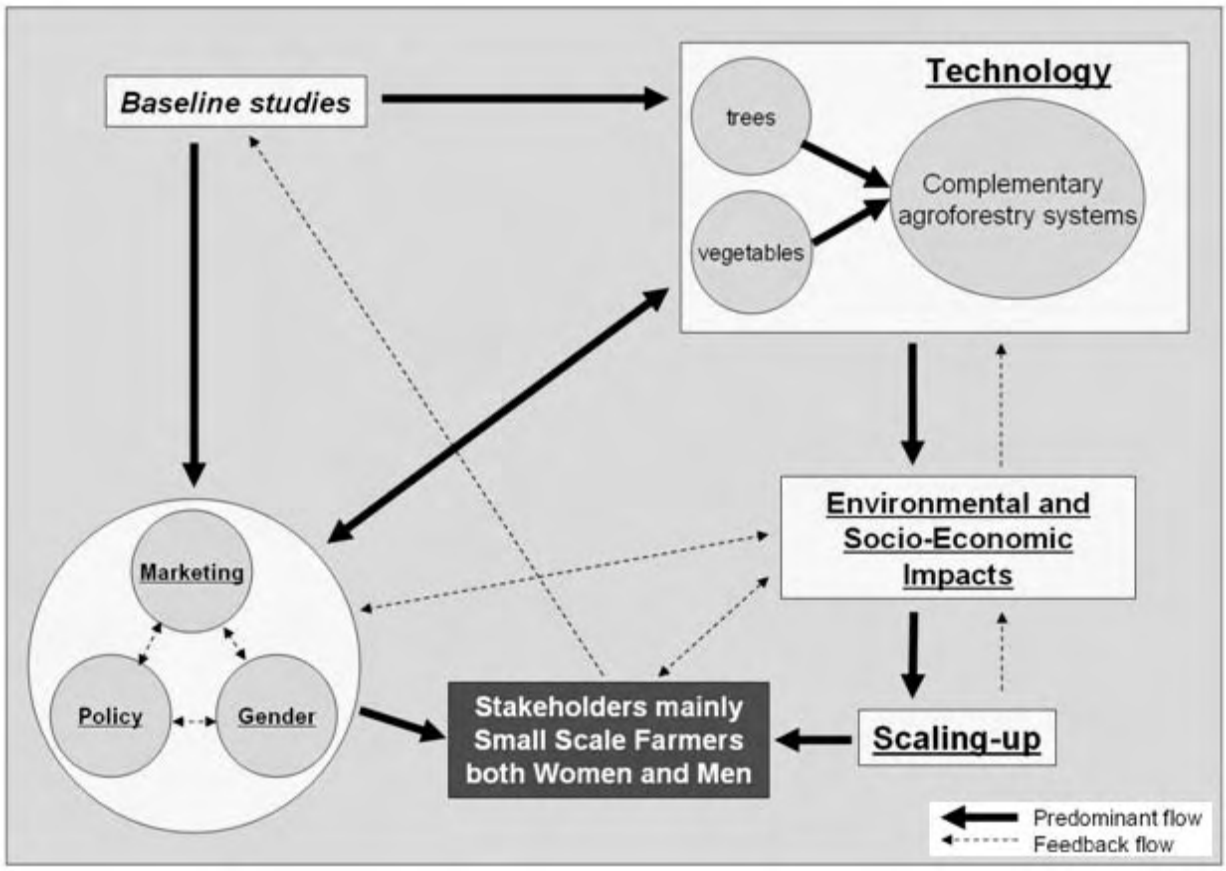


Figure 23. Conceptual Model of TMPEGS

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

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

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

Policy baseline studies revealed government priorities. The Vietnam Cacao Development Program aims to have 100,000 hectares of cacao by 2010. Hence, cacao was chosen for Vietnam's technology study. Planting of cacao between cashew rows is a major research focus. It was also found in Vietnam that some indigenous vegetables are marketable, excellent sources of micronutrients, and home production could improve family income by reducing off-farm purchases. Hence, performance of these indigenous vegetables under cashew understory is being studied.

In the Philippines the design life of a hydroelectric plant and irrigation reservoir is being shortened by soil loss from vegetable fields in its contributing watershed. Therefore, local government is encouraging soil conservation within its watershed. The potential of growing trees with vegetables for soil conservation is being encouraged.

Technology and other objectives

Technology influences other objectives. 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 teams. The environment impact team will need data on agroforestry management of distance between trees, vegetable density and cover, fertilization rates, tillage practice, kind of trees, rooting depth, growth period, yield, and many other parameters for environmental impact analysis using computer simulations. Simulation results will be used to quantify soil conservation and water quality benefits of the indigenous vegetable-tree systems. Yield and other data will be provided to the socioeconomic team for a benefit-cost analysis to see if such indigenous vegetable-tree systems improve smallholders income.

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 incentives those policies will provide. Gender may be affected by technology, for example, a successful technology may impact men and women differently. Marketing research can also concentrate on technological breakthrough. For example, new markets may be researched on indigenous vegetables that thrive in VAF systems.

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

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

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

Research progress by objective

Objective 1. Technology develop economically viable and ecologically sound VAF 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 mainly used as a source of starch.
- A researcher-managed experiment in a Binh Phuoc extension center farm on vegetables under different cashew shading conditions 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 located next to a vegetable row had a higher average yield of 6.6 kg/tree. Average yield of cashew trees located 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, was 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.
- An experiment with *Arachis pintoi* as a cover crop was set up at an NLU experimental field. The experiment includes vegetables, okra, and kangkong with and without pintoi as a soil cover crop with three replications. Vegetable growth characteristics, yields, and pest attacks 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 of 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. Farmers' group discussions were conducted for identifying issues and constraints in relation to small garden VAF technology and adoption. Data on yield performance, input use, and prices were collected for crop budget analysis.

Drip irrigation.

- A drip irrigation study on young cacao plantings showed that an NLU-designed (NLU) drip irrigation system 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 farmers' irrigation practices. 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 significant adoption constraint among poor farmers.

Cacao-cashew complementarity.

- In the cacao-cashew experiment, a higher growth rate of cacao trees was found where cacao have sufficient shading under old cashew plantations compared with those planted in young cashew plantations.
- 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. Termite control now 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 of 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 were monitored. Data on input uses and cashew yield were collected. Two students were trained to conduct soil quality tests using test kits. Data on soil quality of cashew plantation with and without clear weeding were measured using soil quality test kits. Initial results from field assessment show that organic matter in both cashew plantations that maintain a weed cover to protect soil from erosion and in cashew plantations integrated with cacao plantations is significantly higher than in cashew plantations 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 rapid 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

Indigenous vegetable identification.

- Identification and characterization of indigenous vegetable from several land races was completed. The indigenous vegetables were kemangi (*Ocimum americanum*), katuk (*Sauropus androgynus*), honje (*Etlingera giseke*), kucai (*Allium tuberosum*), beluntas (*Pluchea indica*), kenikir (*Cosmos caudatus*), pegagan (*Centella asiatica*), and sambung nyawa (*Gynura procumbens).*
- All of the indigenous vegetables were collected from eight sub-districts: Nanggung, Parung, Tamansari, and Cibinong in Bogor County, West Java Province; and Pandegelang, Cadasari, Mandalawangi, and Cimanuk in Pandegelang County, Banten Province.

Crop production guidelines.

- Phosphorus rates for vegetables grown in the ultisol–Nanggung were determined. Some vegetables used in the experiment were amaranth (*Amaranthus* sp), kangkung (*Ipomoea*

aquatica), eggplant (*Solanum melongena*), chili (*Capsicum annuum* L), tomato (*Lycopersicon esculentum*), green bean (*Pahaseolus vulgaris*), and yardlong bean (*Vigna unguilata*). This experiment was established as a preliminary database to build soil phosphorus status and as a quick reference to obtain phosphorus optimum rate in the acid soil, Ultisol-Nanggung, of seven vegetable crops. This experiment was followed by a correlation and calibration study to build phosphorus fertilization recommendations based on soil analyses. Proper fertilization enhances vegetable-tree complementarity.

- At a soil phosphorus concentration of 10.8 ppm (Bray-1) of Ultisol, application of phosphorus fertilizer of up to 180 kg P_2O_5 ha^{-1} linearly increased plant height of kangkung, eggplant, chili, tomato, yardlong bean, and green bean, and increased linearly the yield of amaranth, kangkung, eggplant, chili, tomato, and green bean. To build a wider soil phosphorus range, application of phosphorus more than 180 kg P_2O_5 ha^{-1} is needed.
- 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*), and 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. Results indicated 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.
- Twenty-two farmers grew katuk, chili, and eggplant under the tree and open systems. Yields for chili and eggplant were 14 percent and 60 percent less, respectively, in the tree system compared with the open systems. Hence, many farmers did not want to continue growing those vegetables, though the high price of fertilizer and farmer preference for growing rice were the main reasons for discontinuing vegetable farming. For katuk, yield increased 2.5 times, leading some farmers to respond positively to the VAF concept.
- It was found that optimum population of katuk is 160,000 plants/ha, while for kemangi the optimum population could not be determined. Kemangi could be increased to more than 200,000 plants/ha. There was no significant effect of plant spacing in kenikir.
- 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.
- Research was completed on fertilizer impact on kangkong and yardlong bean. Furthermore, optimum phosphorus rate experiments were completed on amaranth, kangkong, eggplant, tomato chili, green bean, and yardlong bean.

Philippines

<u>Tree-vegetable interactions.</u>

- Data collection and analyses of the degree of tree-vegetable interaction of VAF systems on above-ground parameters such as spatial light transmission, spatial productivity of associated crop and tree biomass, canopy width, canopy height, and tree spacing were conducted in Songco, Lantapan, Bukidnon, covering 21 farms, two agroforestry systems, six tree species, eight vegetables, and four aspects. Based on the data collected, researchers identified three zones of tree-vegetable interactions, namely, competition, complementarity, and neutral zones. On the basis of these three zones identified, researchers developed a net complementarity index (NCI) as a simple tool to assess appropriate tree-vegetable integration.

- It was concluded that the optimum tree spacing or tree line (hedge spacing) in VAF systems can be achieved when two complementary zones at the optimum meet, which is about 20 to 25 meters apart. Using NCI we found that *Eucalyptus robusta*, *Eucalyptus torillana,* and *Acacia mangium* are suitable tree species for VAF systems; and cabbage, Chinese cabbage, cauliflower, and bell pepper are suitable vegetables crops.
- Researchers found support for the importance of complementarity as indicated by the positive relationship between the height of the canopy and NCI, which allows more light to reach the vegetables, particularly those immediately under the trees.
- It was found that tree pruning greater than 40 percent is detrimental to NCI. The amount of canopy left after pruning should be between 60 percent and 80 percent.
- Trees with broad canopy have a negative relationship with net complementarity, which indicates that broad-leaved trees like *Gmelina arborea* and mango are not appropriate in VAF systems. If broad canopy trees cannot be avoided, regular pruning should be done.
- *Eucalyptus torillana*, *Eucalyptus robusta,* and *Acacia mangium* were found to be more appropriate tree species than *Gmelina arborea* and *Maesopsis eminii*. The eucalyptus has a light, narrow, and erect canopy, allowing more light to penetrate to the associated vegetables. *Acacia mangium* may not be appropriate in term of canopy type, but due to its N_2-fixing, fast growth, and deeper rooting pattern, it may not cause competitive interaction with associated vegetables. *Gmelina arborea* is not an appropriate timber tree species for VAF. Apart from having a broad and thick canopy, it also competes with vegetables for water and nutrients.
- There was a direct relationship between tree height and vegetables' positive response; the taller the trees, the better for vegetables because more light is available to the vegetables.
- Planting the vegetables on the south side of the trees yielded best results, allowing more sunlight to reach the vegetables. Vegetables planted on the east side of the tree lines, thus getting the morning sun, yielded higher than those planted on the west side of the tree lines because the study site typically receives rain every afternoon.
- All vegetables responded positively to the presence of tree hedges and complementary indexes (measuring the contributions in the complementarity zone of the vegetable-tree relationship). The tree vegetables had the highest complementarity indexes (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 in complementarity zone, followed by alikway. Among the leafy vegetables, the jutes were the best performers, followed by amaranthus. Among the fruit vegetables, eggplants performed well. Yardlong beans were also responsive to a tree-based system in the complementarity zone. Among the commercial vegetables Chinese cabbage had the highest CI, followed by bell pepper and carrot. The lowest CI was tomato.
- 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 adaptability index, followed by yardlong bean and carrot. At 40 percent light transmission, almost all the vegetables tested grew well. 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. Carrot and Chinese cabbage performed similarly. Overall, adaptability indexes are lower at 20 percent light transmission compared with 40 percent, 60 percent, and 80 percent. This finding supports tree pruning recommendations for VAF systems discussed in the previous section.
- Commercial vegetables responded well to tree integration during the wet season planting (June-October 2007). Increases in yield averaged 29 percent and ranged from 13 percent to 40 percent, which means that integration of trees to intensive vegetable systems increased farmers' yield by

29 percent. Tomato had the highest percent yield increase, 40 percent, followed by carrots, 37 percent. Chinese cabbage was more responsive to a 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. Carrot and Chinese cabbage had the highest increase in yield at 30 percent. Tomato did not do well during the dry season planting. This was due to high incidence of pests caused by planting of tomato on the same land without the customary rotation of non-solanaceous plants. Despite 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, amaranthus from Bangladesh, amaranthus from Vietnam, and Jute 3504 had the highest marketable yields. Among the fruit vegetables, eggplant 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, yield was lower than in the wet season planting. Eight indigenous vegetable decreased yields because of presence of tree hedges.
- 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 the 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 in the presence of tree hedges. Malunggay and Chinese malunggay still had positive yield increases of 10 percent and 20 percent, respectively.
- 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 make up the tomato bowl 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 as well as 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 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 farmer evaluations based on fruit marketability, fruit size, fruit form, fruit color, plant appearance, and plant height and canopy.

<u>Drip irrigation.</u>

- IDE-drip optimum operating conditions were determined and research published in the journal *Applied Engineering in Agriculture*. 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 percent and 50 percent. These findings are important design guides for efficient installation of IDE-drip kits.

- Drip irrigation did not have a statistically significant affect on the fruit yield, total above-ground biomass, stem diameter, and plant height of bell pepper. The control treatment with 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 demonstrated a statistically significant improvement in fruit yield, total above-ground 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 the 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 was not so dramatic as to create statistically significant differences. Cabbage, Chinese cabbage, tomato, and bell pepper tests with and without drip irrigation throughout the growing season were carried out. Results of the field experiments showed greater quantity and better quality of crop yield under drip-irrigated plots than in rain-fed areas. Yields of cabbage, Chinese cabbage, tomato, and bell pepper were higher in drip-irrigated than in rain-fed systems despite the frequent rainfall occurrences while the experiment was being conducted.

Reduced tillage and cover crop.

- 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 plain coulter and that the inverted-T opener design performed satisfactorily in breaking the soil. A 12-tooth coulter performed better than coulters with lesser or greater numbers of teeth. Curved-tooth coulters required less horizontal draft force than straight-tooth coulters. An opener shoe with a larger rake angle required less horizontal draft force. Use of the plastic siding on the opener reduced the horizontal draft force and can help control the width of soil opening. The use of spikes on the sides of the opener shoe was helpful in breaking the soil. Motorcycle parts can be retrofitted in the design of the no-till equipment. The last prototype is still being constructed and tested.
- Low-statured vegetables such as carrot, Chinese cabbage, and common cabbage were significantly outcompeted by the cover crop, *Arachis pintoi*. However, positive response was observed in taller fruit vegetables like bell pepper and tomato.

Taiwan

AVRDC 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. When trees were planted closely, tree-crop interaction became apparent as tree hedgerows or components grew and started to develop heavy canopy in later years. In Year 1 researchers found that young trees did not influence vegetable production; in Year 2 vegetable yields with trees were higher than in open systems; and in Year 3 most vegetables tested had significant decreases in yield except for cucumber and eggplant. As trees matured, yield loss in vegetable crops was compensated by fruit production in intercropped trees.

Development impact

TMPEGS studies in Vietnam, Indonesia, Philippines, and Taiwan showed mounting evidence that a new horizon in agroforestry research was discovered, that is, yields for several vegetables are higher in agroforestry systems than in open field conditions. There is also evidence that because of SANREM CRSP, smallholders are practicing VAF. Furthermore, smallholders saw the prospects of increased income from indigenous vegetables, and with extension assistance from TMPEGS are producing them. Moreover, TMPEGS trained smallholders 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; in the Philippines a local government unit already initiated drip kit purchases.

Vietnamese scientists are completing a study to identify cacao varieties that are suitable to integrate with cashew trees. From several TMPEGS studies, smallholders Vietnam are seeing exceptional cacao growth when cacao seedlings are planted under mature cashew. 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 applying vetiver mulch on the seedlings was an effective natural method that can control termite attacks. Lastly, 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 tree litter can significantly improve soil quality and provide protection for soil erosion. Hence, with all these findings, Vietnam is ready to scale up for a sustainable system of integrating cacao in existing cashew.

From several TMPEGS studies, smallholders in Indonesia 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.

From several TMPEGS studies and trainings, smallholders in the Philippines are seeing benefits of increased yields and improved fruit quality from several elite strains of tomato that are 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.

International Development Enterprise, the designer and manufacturer of 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 in sloping lands. IDE-drip kits are used worldwide by millions of smallholders, further stressing impact to the developing world of this TMPEGS study.

Objective 2. Marketing: develop a market value chain at the local, regional, and national levels that builds on existing marketing strategies.

Critical research accomplishments

- Marketable commercial vegetables identified. Marketable commercial vegetables preferred by smallholders were identified in Indonesia and the Philippines. The Vietnam team found that perennial commercial crops were preferred by smallholders over commercial vegetable crops, and they cannot compete with commercial vegetable-growing provinces in Vietnam. Therefore, the Indonesian and Philippines technology teams experimented with vegetables for commercial sale, while the Vietnam technology team experimented on vegetables for home consumption only and with soil conservation.
- Indigenous vegetables with market potential identified. Indigenous vegetables preferred by smallholders and with good marketable potential were identified in Vietnam, Indonesia, and the Philippines. Technology teams in the three countries conducted experiments on these indigenous vegetables.
- Smallholder vegetable market constraints identified. Marketing constraints faced by farmers are: (i) lack of access to marketing information, (ii) inability to control market pricing, (iii) high transport cost, and (iv) poor post-harvest handling.

Vietnam

- It was found from rapid market assessment surveys that perennial crops were more valuable to farmers than annual crops. Cashew, rubber, durian with coffee, and pepper are the most preferred by farmers, with cacao vague to informants because this crop is new. On the other hand, the five most profitable and marketable diversified crops were durian, bamboo shoots, cassava, rambutan, and vegetables.
- The findings of the baseline study and market value chain research indicate that it would not be wise for the project to pursue an income-enhancing strategy based on intensive vegetable-tree crop production for smallholders in Nghia Trung. Low use of technology, weak extension activities, inadequate supply of production inputs, poor marketing infrastructure, and weak market linkage and post-harvest performance are the detriments to the development of agricultural markets in Nghia Trung. There is a need to facilitate on-farm research in diversified vegetable production at the home garden scale.
- The study area has a well-developed marketing system for major cash crops such as rubber, cashew, coffee, and black pepper. However, for a new crop such as cacao many farmers have only limited information of the marketing system. Because cacao is a new crop that has potential for improving farmers' incomes, better access to markets and market information and reduction in marketing costs will encourage farmers to adopt this crop.
- Cacao is a new crop with unknown prospects for its production and marketing. On-farm trials and associated agronomic and marketing analyses are needed before extension of cacao to non-experimental households.
- Markets need significant intervention to empower smallholders. Support on techniques and market price information, more efficient supply of input factors, extension activities, irrigation, and marketing infrastructure are all needed.

Indonesia

- Based on the baseline study, the potential vegetable species or products for Nanggung farmers were identified. Most commercial vegetables that were grown in the area of study are yardlong bean, tomato, chili, green bean, mustard green, and cucumber.
- There were four market channels for selling vegetables.
- Problems faced by farmers that affect vegetable marketability are: (i) farmers have inadequate knowledge of on-farm management such as soil, pest, and disease management; and (ii) farmers have limited knowledge of proper harvesting and handling of produce, grading of harvested vegetables, as well as the non-practice of collective marketing.
- Market traders face irregular supply of products, low to medium quality of produce, and limited knowledge of storage and capital.
- Through support from SANREM, a farmer group already sells bananas based on market specifications and collectively to a big fresh-fruit wholesaler in Tangerang. This has resulted in a better pricing scheme for their produce.
- Studies showed that lack of market information, remote location, and poor accessibility to production resources are detrimental for Nanggung smallholders in adopting VAF. However, Indonesian scientists identified market advantages for selected indigenous vegetables katuk and kucai. It was found that katuk and kucai are on 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 an opportunity for the women's group to earn $2 per woman per day in sorting, grading, and packing the katuk.
- In Indonesia, viable VAF systems and practices were tried by several farmers, both women and men, particularly for katuk species. Farmers were empowered by enhancing market awareness, marketing training, and developing market linkages. As a result farmer groups have expanded their market roles. The new practices incorporate conventional practices to alleviate soil erosion and thus are sustainable. Farmers' socioeconomic conditions (agriculture-based incomes) have improved.
- Women in Indonesia are developing their own katuk marketing system and slowly leaving the middle person marketer.

Philippines

- The top five vegetables preferred by farmers for growing and marketing are cabbage, umbok (Chinese cabbage), potato, carrot, and tomato, while those for trees are eucalyptus, gmelina, falcata, jackfruit, and lanzones.
- While many farmers prefer to bring their vegetable produce directly to storage facilities in the city markets, most sell their supplies to the small-scale traders who take these to the marketplace.
- In general, the VAF supply chains are for: (i) vegetables – farmer to producer to trader to storage facility to runner to classifier to shipper and lastly to institutional buyer-consumer; (ii) forestry commodities; (iii) seeds – farmer to producer to consumer; and (iv) timber and fruits – farmer to producer to market intermediary to institutional buyer-consumer.
- The top three marketing constraints faced by vegetable farmers are lack of access to market information, inability to control market pricing, and high cost of hauling and trucking. For the usually small-scale traders, these are lack of capital, inability to control the quality of goods, and inability to control market pricing. Meanwhile, the top three marketing constraints for agroforestry products are undeveloped market for timber and fruits, difficulty in selling timber posed by legal and permit requirements, and poor timber quality that affects pricing.

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

Development impact

- In Indonesia, because katuk and kucai grow well under trees and have high market demand, TMPEGS provided training to Nanggung smallholders 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 show small-scale farmers how to properly prepare katuk for market. This involved training for women in sorting, grading, and packing katuk. To ensure that katuk and kucai produce is sold, TMPEGS linked small-scale farmers to traders. TMPEGS also selected farmer groups at three villages and collaborated with the local government to establish production trial plots and distributed 50,000 stems of katuk and 5 kg of kucai seedling to three farmer groups. TMPEGS found out that other farmers from both these villages and outside the project area are planting katuk as well. All these activities showed potential for increasing income to Nanggung farmers by establishing a niche in katuk and kucai production.
- In the Philippines, TMPEGS believes that empowering smallholders 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 smallholders to organize and market vegetables as a village.

Objective 3. Policy: Identify policy options and institutional frameworks that promote sustainability of VAF production and reward environmental services.

This objective sought to identify policy and institutional reforms for smallholder adoption of VAF and related sustainable practices; to provide policy recommendations for reversing negative trends of policy disincentives, creating enabling conditions for wider adoption of sustainable farming systems (SFS); and to understand the policy and institutional context of VAF systems at the national and local level. We hypothesized that policy incentives are needed to stimulate smallholder investments in VAF. The first step was addressing the question of whether policy incentives for VAF exist in the Philippines and in Vietnam by conducting an intensive review of national and local policies, focusing on incentives, disincentives, constraints, and gaps for smallholder investments in VAF systems. Our findings suggest that policy incentives do exist, but smallholders are hardly benefiting from these policies due to myriad factors including (i) inherent flaws of many policies; (ii) poor implementation; and (iii) lack of resources to leverage implementation, among others. These informed our sub-hypothesis that localized incentive mechanisms can offset the gap between national policies and local implementation. The next step was facilitating identification and developing policy and institutional options that provide incentives for smallholder adoption of/investment in VAF, which resulted in the enactment of a municipal ordinance on incentives for smallholder investments in SFS in Lantapan, Bukidnon, Philippines. This is a promising

response to the weaknesses of national-level policies in affecting the lives of small farmers. The third step was building capacity for effective implementation of the ordinance, leveraging for co-financing, and mainstreaming the incentive mechanism in local development efforts. The issue/question being pursued is the effectiveness of a localized incentive mechanism for sustainable livelihoods and provision of environmental services.

Critical research accomplishments

Our activities in this objective were divided into two parts: (i) analysis of the policy environment in the Philippines; and (ii) synthesis of policy reviews in the Philippines and Vietnam.

- Conducted an intensive review of key national policies related to tree growing and vegetable production to determine the extent to which incentives exist for smallholders to invest in VAF. Local policies and perspectives of farmers and policymakers were taken into account. It was found that the policy environment in the Philippines is supportive of VAF but is insufficient in stimulating smallholder investments. Large farmers rather than smallholders are benefiting more from national policies because they have more access to policy information and can leverage the associated costs of policy implementation.
- Some issues are better resolved through national policies, while a number of issues are better addressed by local policies. For the vegetable sector, issues of price regulation and control, commodity protection, reducing costs across the market value chain, non-tariff barriers, and global trade require national policy interventions. For the tree sector, issues of restrictive policies, transaction costs, land tenure and resource rights, and domestic and international market incentives are also to be addressed through national policies. At the local level, promoting smallholder investments in VAF 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. Finally, policy linkages between national and local levels need to be established, and policymakers need to mobilize adequate responses at both levels. Thus, the viability of a VAF system depends on a whole set of policy environments provided by governments. These findings were feedback in several meetings with the local government of Lantapan, and the research report was summarized in a policy brief for wider dissemination as well as published as a journal article.
- Policy reviews of VAF environments in the Philippines and Vietnam were synthesized and reported. The policy context in the Philippines and Vietnam is generally supportive of VAF, with generic incentive packages to boost the forestry and vegetable sectors, but it is insufficient in stimulating smallholder investments. In the Philippines, large farmers benefit more from national policies, while in Vietnam only commercial producers are actively involved in the growth of the sector because national incentives are more directed toward commercial producers in urban areas than smallholders in remote areas. In both cases, the policy reforms reflect government efforts to build farmers' capacities to actively participate and link them to greater markets. However, the challenge that remains is the weakness in the bridging work among policymakers at various levels, researchers and educators, local entrepreneurs, industry and local producers.
- A 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. 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. 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 response to smallholders. 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 the province or commune level.

Development impact

Local officials, policymakers, and other stakeholders value the results of our policy study, particularly the concept of incentives. Policymakers in Lantapan have realized their limited response in terms of policy support to small farmers and see the need for local policies to be appropriately tailored to the needs of local people, as well as the need to align policy initiatives with short- and long-term development outcomes.

Objective 3. Policy: develop and test an incentive-based policy option and institutional framework for promoting VAF system particularly in the Philippines.

Critical research accomplishments

Our interventions to achieve this objective were divided into policy and institutional.

- For policy intervention, we facilitated several feedback sessions and planning with local government unit (LGU) officials and policymakers, which resulted in the formulation of incentive-based policy to support farmer adoption and investment in sustainable practices, build social capital with local communities, and build institutional capacity of LGU. In May 2009, the LGU passed Municipal Ordinance No. 114, which outlines an incentive mechanism that encourages investment in SFS by smallholders. Under the ordinance, support for agricultural development will be provided as incentive to farmers and farmer organizations that meet sustainable farming criteria, resulting in increased productivity, profitability, and sustained environmental services (ES). The series of planning workshops resulted in the five-year SFS Investment Plan, which specified seven types of incentives: (i) input subsidies for crop production and NRM-based livelihood projects; (ii) improved extension services; (iii) subsidized crop insurance; (iv) micro-financing support; (v) infrastructure support; (vi) awards and recognition; and (vii) marketing support. The LGU has allocated funds to build institutional capacity and establish linkages with potential partners. The incentive mechanism is mainstreamed within programs that are both locally and externally funded, such as the Mindanao Rural Development Project (MRDP) and the Mindanao North Coast Integrated Area Development Project (MNCIADP). Hence, despite differences in project designs, the most important criteria on improving farm productivity and ES provisioning are met.
- For institutional intervention we facilitated organizational analysis to assess the strengths and weaknesses of the Municipal Agricultural Extension and organized a seminar series for technicians involving TMPEGS scientists. The technical capacity of agricultural technicians is a crucial determinant of successful implementation of the SFS program.
- At the system level, the Municipal Agricultural Extension system maintains that agricultural development is largely a function of effective extension; by making it more accessible and up-to-date for all farmers, good extension can be a major bearer of economic growth and rural development. As a result of good extension driven by policy change, e.g., incentive-based policy, significant impacts on livelihood and the environment are highly foreseeable.

Development impact

The interests among policymakers, LGU staff, and other stakeholders in the incentive approach to agricultural development were observed through their willing participation and time invested in planning meetings, as well as their financial contribution – such investments in time and money would have not been possible without perceived value to this type of policy change. The use of incentive mechanism as a rural development strategy is a significant departure from implementing conventional development projects at the local level, where many are delivered as aid, relief, dole-outs, or political exchange of favors. Through this, the LGU was able to allocate and leverage its meager resources for joint undertakings and co-financing the SFS incentive system. Recently the Asian Development Bank (ADB), which is funding the Integrated Natural Resources Management Program in the Philippines, has chosen Lantapan as one among four pilot watersheds in the country, building on existing initiatives including the SFS incentive system.

Vietnam policy study

Policy review of the forestry sector focusing on benefit-sharing policy and on the vegetable sector was conducted. More than 10 documents on government policies and regulation relating to the forestry sector were reviewed. Interviews with key stakeholders, local authorities in Nghia Trung village and Binh Phuoc Province on VAF systems, environmental benefits and reward system were conducted. Meeting with Department of Agriculture and Rural Development (DARD), extension center, and local stakeholders in Binh Phuoc province had been done to identify programs and policy for supporting vegetable production and VAF systems. A report on policy relating to forestry and vegetable sectors was prepared. A policy paper on VAF policy in the Philippines and Vietnam was completed jointly by a NLU researcher and Delia Catacutan from the Philippines. The joint policy paper was submitted to an international journal for publication.

In Vietnam, the study 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 the intensive forestry with agroforestry methods, integrated management, and multipurpose forest utilization with special 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.

With a very small proportion in both planted areas and export volumes, vegetables have steady annual growth rates. The vegetable development has called for the core solution of scattered and small-scale production, lack of qualified variety and certification, and weak post-harvest activities. The study has reviewed the national policies and programs applying to the vegetable industry. These policies and programs have actually demonstrated the Government of Vietnam's interest in trading enterprises shifting to farmers and other facilities during the process of WTO integration and the government's response to public requirements of food safety. The analysis of policy performance shows that linkages among policymakers, researchers, and educators have not been strong and prompt enough to translate such a highly valuable model into policy incentives for the time being concerning sustainable farming system, particularly the VAF model.

The local authority's understanding of GoV's policy has apparently not been thorough, flexible, and sharply focused enough to incorporate the incentives into local circumstances. Though being shifted to agricultural sector, the GoV's incentives have initially favored relatively highly developed areas for commercial purposes. The promotion of safe vegetable production has not been strategic for selling but

for consumption. As the DARD has prioritized its incentives for commercial vegetable production, Nghia Binh commune has generated little interest because of its poor market and high transportation costs due to remote location. Though home vegetable gardens have received the local authority's encouragement, especially for poor households and those in remote areas, incentives have not yet been demonstrated or translated into any local proposals. Thus, such models are apparently still in research papers and experiments.

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 is also a reflection of export opportunities related to regional income growth, trade liberalization, and incentive policies regarding land use, credit, and investment. However, incentives in Vietnam are more favorable for commercial vegetable and fruit producers.

Policy study found that the viability of VAF is constrained by various factors, including farmers' inability to invest in the system, inadequate institutional structures for facilitating information flow, and lack of market incentives. Targeted policy incentives are needed if smallholders are to invest in VAF.

Objective 4. Environmental and social impacts. Assess the short- and long-term environmental and socioeconomic impacts for farm families of adopting integrated VAF systems.

Critical research accomplishments

Environmental impact

Philippines

- The quantitative prediction of environmental impacts of land use changes in watersheds could serve as a basis for developing sound watershed management schemes, especially for Philippines watersheds with agroforestry systems. The SWAT model was parameterized and calibrated using data from two Manupali River sub-watersheds with an aggregate area of 200 ha to simulate the effect of land use change on runoff volumes, sediment yield, and stream flows.
- Model simulation results demonstrated that SWAT can predict runoff volumes and sediment yield with Nash-Sutcliffe Efficiency (NSE) ranging from 0.77 to 0.83 and 0.55 to 0.80, respectively. Simulation of land use change scenarios using the SWAT model indicated that runoff volume and sediment yield increase by 3 percent to 14 percent and 200 percent to 273 percent, respectively, when 50 percent of the pasture area and grasslands is converted to cultivated agricultural lands. Consequently, this results in a decrease of baseflow of 2.8 percent to 3.3 percent, with the higher value indicating a condition of the watershed without soil conservation intervention. Moreover, an increase of 15 to 32 percent in runoff volume occurs when the whole sub-watershed is converted to agricultural land. This accounts for 39 to 45 percent of the annual rainfall being lost as surface runoff. While simulation results are subject to further validation, this study has demonstrated that the SWAT model can be useful for evaluating the impact of land use changes in Philippine watersheds.

Vietnam

- The SWAT modeling is mainly focused on the upper watershed area of the Be River where the VAF on-farm trials were conducted. Initial assessment revealed that the SWAT model is a very useful tool for assessing/evaluating the environment and economic impacts of adopting VAF production systems for the study site and to generate policy recommendations. For example,

SWAT was used to determine how the changes in land use, land management, and farming practices affect losses in soil fertility/quality at the watershed level. The SWAT model was applied to evaluate the effect of land use on soil loss and water quality in Nghia Trung sub-watershed. SWAT showed that, if no weeding practice is applied on cashew, the average sedimentation load per hectare of cashew will be reduced by about 10 percent. Familiarizing local decision makers in SWAT modeling is expected to improve the research-action linkage and may assist decision makers.

Indonesia

- SWAT was applied in Nanggung watershed, West Java, Indonesia. MapWindow-SWAT, which runs on MapWindow, a free GIS software, was used. Very little input data was available for Nanggung. Hence, the global data provided in MW-SWAT was used as a first attempt to complete SWAT in Nanggung, Indonesia. As an initial attempt the results looked very promising for using SWAT as an environmental simulation tool in Indonesia. A major limitation, however, is that SWAT predictions in Nanggung cannot be validated because no measured hydrology data was available; thus, simulated SWAT cannot be compared with observed values.

Socioeconomic/adoption impact

- The cultivation of cashew in Nghia Trung village, Vietnam has intensified over time with increasing use of inorganic fertilizer and pesticides. Pesticide use, however, poses threats to the environment, including adverse health effects on farmers and others, and pollution of the watershed. Therefore, it is vital to know how current pesticide use endangers farmers' health and whether the marginal gain from reduced pesticide use could surpass the marginal loss in cashew productivity and farmers' benefits. This study was therefore conducted to determine the impact of pesticides on cashew yield and estimate the health costs to farmers from pesticide use. A Cobb-Douglas function was employed to examine pesticide productivity on cashew production. A health cost model was applied to quantify the health impairment of farmers with respect to personal characteristics of the farmers and their use of pesticides. Data for estimating pesticide productivity were generated from a survey of 80 randomly selected cashew farmers for the years 2005, 2006, and 2007. The surveyed farmers' health costs related to pesticide use were recorded for 2006.
- The study found that preventive spraying is the main pest management method among cashew farmers. However insecticide use was found to have no significant impact on cashew yield at the margin. Other variables such as herbicide use, amount of NPK fertilizer, and tree density are significant factors affecting cashew yield. Herbicide use has a significant effect on cashew yield, but it is still not clear whether yield increase is mainly due to reducing weed competition or from preventing harvesting losses. It was found that 67 percent of farmers who have used pesticides reported problems with headache and/or fatigue. The percentage of farmers reported to have dizziness and shortage of breath is 26 percent; with skin irritation, 10 percent; and about 14 percent have other health symptoms. Results from the health cost function estimation show that the total pesticide dose and number of times the farmers had contact with pesticides significantly influenced their health costs. The average per capita health cost was estimated at 149,000 VND/yr ($7.80/yr).
- These findings indicate that promoting sustainable pest management practices in a cashew-based VAF production system through reducing pesticide use and applying integrated crop-pest management will reduce production and farmers' health costs as well as other negative environmental impacts in the watershed. Findings from pesticide study were used for training and case teaching materials for local extension workers, agriculture and rural development agents, and as material for extension programs in Binh Phuoc province.

Adoption of VAF systems and practices

Vietnam

- Vegetable home garden. Information on vegetable trials and nutrition benefits from vegetable consumption was transferred to local farmers through meetings, training, group discussions, and local workshops. Through the women's association at Nghia Trung village, NLU team has provided some seed money to support 17 women farmers to develop vegetable home gardens. It was reported that 15 women farmers have expanded or improved their gardens to increase vegetable cultivation for home consumption. Surveys on daily food consumption conducted in 2005 and at the end of 2008 to early 2009 revealed that the share of home-produced vegetables in total vegetable consumption of local farmers increased by 16 percent. Benefits of no-weeding practices on cashew production were transferred to local farmers through various field visits and local meetings and workshops during the project implementation period. It was revealed from group discussions conducted with local farmers and village leaders in July 2009 that the number of farmers applying either no-weeding or reduced weeding practices in cashew cultivation was estimated to increase by about 18 percent. A very low adoption rate on drip irrigation was reported by local farmers. Main reasons for no adoption of drip irrigation on vegetable cultivation include: small area of vegetable home garden; only small benefit in term of increased income from using drip irrigation on vegetables; and drip kit not available in local markets. Low adoption rate on drip irrigation on perennial crop such as cacao was due to high initial investment. It was revealed from farmer group discussions that about 8 percent of the farmers have reduced the amount or/and number of insecticides used on cashew. The practice of using *Arachis pintoi* as a soil cover crop was adopted for a cacao demonstration site of the organic cacao program of NLU.
- Cacao-cashew system. With support from the cacao program of Binh Phuoc province, the cacao-cashew system continues to expand in the province. High adoption rate of cacao was reported in the nearby Duc Lieu village and in Bu Dang district. Binh Phuoc now becomes the province having second-largest cacao area in the country. The cacao-cashew system is being considered to have high potential for reducing poverty in the province.

Indonesia

- Vegetables planted in medium light have good prospects of increasing incomes of smallholders. In Indonesia it was also found that VAF systems in Nanggung sub-district represented by katuk cultivation have entered the stage of early adoption, especially by women farmers. Farmers saw the practice of VAF cultivation and participated in VAF training and discussions. This interaction contributed to farmers' good perception of VAF technology. With the support of their farmer's groups, some farmers participated on VAF cultivation in their own lands. The progress of VAF adoption in Nanggung was possibly affected by enabling factors such as (i) socioeconomic characteristics, (ii) biophysical characteristics, (iii) institutional factors such as good farmer organization, and (iv) presentations of VAF knowledge and practice. This early adoption is in its critical stage and needs to be maintained. Proposed maintenance efforts cover at least two factors: pest management and fertilizer application. These factors are significant to assure vegetable yield under trees. If this early adoption fails, farmers will see and consider not adopting. In contrast, profitable VAF production will be an incentive for more farmers to adopt the technology.

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 smallholders

have planted vegetables with trees in Year 4 and their inputs and yields were monitored by TMPEGS researchers. The data are still being analyzed.

Development impact

- Dissemination of research findings in Vietnam could improve health of small-scale farmers both women and men by minimizing pesticide exposure and by improving diet. Furthermore, they could provide 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 income through VAF production in medium light. In Year 4, TMPEGS scientists in all countries monitored adoption of VAF practices and calculated benefit/cost ratios of TMPEGS' recommended sustainable practices.
- Environmental impacts of sustainable practices were 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 benefit smallholders.

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.

Critical research accomplishments

- In Indonesia, women's involvement in agriculture involves certain activities like nursery care, maintenance and fertilization, and harvesting. Involvement of women is often dependent on whether the household can afford to hire labor. Furthermore, women's roles are restricted by socio-cultural factors in some of our villages with expenditures for agricultural inputs mostly the domain of men. In the Philippines it was reported that in a majority of cases women alone handled crop or seed selection, setting aside of planting materials for the next cropping cycle, growing of subsistence crops in separate plots, preparing lunch, and fetching water. Women have a big role in weeding and crop care, purchase of farm inputs, drying and cleaning of produce, contacting buyers, hiring transportation, and selling produce. It was concluded that women and men see themselves as partners in accomplishing farm life.
- Men are the dominant labor force in commercial crop production, while women predominate in raising subsistence crops, particularly in home gardens. In Indonesia and Philippine sites, most if not all niches in the agricultural production cycle that normally require arduous work are mainly handled by male spouses. These include land preparation, planting, crop management and maintenance, fertilizer application and/or pest control, and harvesting. In Vietnam husbands dominate only in planting, fertilizer application, and pest control; gender equality is observed in land preparation, crop management, and harvesting. More men than women control the following agricultural domains: farm-level decision making, including purchase of farm inputs and timing of harvest or marketing; involvement in farmers' organizations, associations, or cooperatives; and participation in agricultural training and extension services. Far fewer Indonesian wives are involved in farming organizations compared with Vietnamese or Filipino wives. Female participation in training, though generally low, is higher in the Philippines compared with Vietnam and Indonesia. Women's limited organizational and training involvement is due to such factors as their preoccupation with household duties, the holding of meeting or training during hours or times that disregard women's work and needs, and the perceived male orientation of many extension services.

- If the men lead in productive work, it is the women who reign in reproductive roles. The latter consist mainly of unremunerated domestic chores, particularly washing clothes and dishes, cooking meals at home and on the farm, cleaning the house, and attending to childcare activities. Dominance in the agricultural marketing sphere varies by country. In Vietnam male and female spouses generally share equally in the tasks of marketing their farm produce. In contrast, marketing activities in Indonesia are predominantly handled by men but varies by village, while in the Philippines these are usually conducted by women. Although Filipino wives exercise control over the actual sale of produce both on the farm or at the marketplace, their husbands still dominate in such post-harvest tasks as sorting, grading, and transporting. Moreover, women's greater participation in marketing does not seem to translate easily to a greater say in farm expenditures. Limited data also indicate some gender differentials in the choice of agricultural crops to grow for the market and access to/control of land resource for production purposes. Furthermore, while women may help in planting and caring for trees, men dispose of timber and other tree products in the market.
- After the surveys, the collection of subsequent data to explore alternatives to improve women's status was designed and initiated using qualitative methods, namely on-site observation, key informant or in-depth interviews, focus group discussions, case studies, and/or an interpretive approach.
- In Vietnam, qualitative research was started to gather information on the structure and performance of the Nghia Trung women's association, the preparation of case studies on the role of women in the VAF system, and the identification of measures for monitoring and assessing the impacts of VAF technologies and training on women. The role of women's associations is believed to be strategic in ensuring women's participation through members who will collaborate in sustainable agriculture and natural resource management and VAF extension training; and increasing the number of women participants in technology training, adoption, and scaling up. The case studies will reveal the constraints women face in VAF technology adoption as well as the impact of adoption on their lives.
- In Indonesia the gender analysis showed the importance of meeting women's practical needs (i.e., solving financial difficulties or low productivity, and access to health care) over strategic needs (i.e., low competency and limited organizational participation). Because the women also felt strongly about their food provider role, the plan turned to addressing nutritional issues. Focus group discussion was conducted among 30 women belonging to two village groups to discuss local ways of utilizing indigenous vegetables, learn the nutritional and medicinal values of such vegetables, demonstrate new ways to cook nutritious foods using these vegetables, and distribute a small recipe book on indigenous vegetables written by the gender team. Another focus group discussion was held to examine the role and dynamics of power in a women's organization before initiating a small income-generating project with selected women's groups, as well as to understand how to strengthen the organization.
- In the Philippines quantitative surveys were augmented with qualitative research. Because findings connected women and small-scale vegetable marketing, TMPEGS employed the methods of key informant interview and on-site observation to produce a case study of women *biyahidors* (small vegetable traders). This case study provided insights on the formation and interconnectedness of an informal alliance of six *biyahidors*, their motivations for engaging in the trade, the features of their microenterprise, their business problems and strategies, the social benefits they derive from the network, and their needs and aspirations. Other pertinent survey data were fed back to the technology team, facilitating the inclusion of selected women farmers among the trainees for specific technologies like drip irrigation.

Women and marketing

- 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, but those few who are active seem to have the support of male household/family members. The women's case in Vietnam falls somewhere in between with husbands sharing in decisions about their market role and selection of market trader.
- 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 in 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-valued vegetable crops like cabbage, tomato, bean, potato, and Chinese cabbage in family farms and single-handedly market their produce, some with additional purchases from nearby farms. However, those in Indonesia help grow household subsistence crops like rice, vegetables and root crops. While they had experience growing and selling guavas and jasmine flowers in commercial quantities in the past, now they have started to produce katuk, a green leafy vegetable eaten by lactating mothers to increase breast milk. Introduced by SANREM, this 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 Philippines and Indonesia are not solely composed 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 *langgana* in Indonesia, *suki* in the Philippines, and *mối* in Vietnam. Initial data showed that the use of such terms confers some expected obligations and privileges on the market partners: 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 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 older than 18 can apply for membership in the women's union. Several benefits are available to members: technical training on crop and animal production, handicrafts, and being part of a rotating savings and credit group.
- Participatory group discussion 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 of 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 by 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 were distributed and six women agreed to be the first recipients. After each harvest these six women will sell the katuk and return cuttings to the group, who will give them to other members. 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 Bakti Wanita Tani had their first harvest of latuk in September 2008. Training on how to conduct savings and loan activities was conducted for the women of Bakti Wanita Tani. The members agreed to form a savings and loan group within Bakti Wanita Tani. Additional training was provided on management and recordkeeping for the elected officials. The activity developed with the women farmers in Hambaro will be used as a model for other villages in Nanggung.

- In the Philippines, conversations with men and women in the study site constituted 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 result seems to negate the assumption that women's voices are muted in discourses that concern them, such as ensuring the family wellbeing. They mobilized actors to accomplish their everyday farm lives. The technologies that are being introduced by TMPEGS, particularly indigenous vegetables and drip kits, are seen as allies that would make a difference in their farm lives.
- In Vietnam, women's roles and division of labor within their households leave women little time to attend formal or scheduled training courses and social activities. Women can learn, however, through informal networks such as neighborhood or relatives. Considering and taking advantage of informal gender networks to develop programs by the government and other agencies in the future are recommended.
- In the Philippines, a study was conducted on gender organization. It was found that women actively participated in ensuring family wellbeing by mobilizing human and non-human allies constituting the network. Human allies include the family, middlemen, employers, and government and development agencies such as the Department of Agriculture and the World Agroforestry Center. Non-human allies include land, water, capital, crops, knowledge and technologies from past and current SANREM CRSP activities (particularly indigenous vegetables and drip kits for the latter), cell phones, and others.
- Before the entry of TMPEGS in the site, there were already VAF farms, particularly the Binahon farm. From this research it was learned that the view of the relationship among people, livelihood, environment, and scientific achievement (SANREM CRSP Phases I and II, and ICRAF Landcare) and how these are mobilized as allies make the difference between farmers who do or do not practice VAF. Women play significant roles in plant nursery establishment as well as in the marketing of products. However, there is a need to define the role of husband and wife in an agroforestry farm to optimize the socioeconomic, cultural, and environmental benefits of the system. For example, it was found that the establishment of the nursery, the tree farm operation, and the integration of trees with vegetables are equally as important as linking and networking, for it is through the networking process that markets are identified and established. In the case of the Binahon farm, the wife is in charge of the farm operation. The husband, while involved in the farm operation, is more focused on attending meetings and conferences where he is able to establish a network and a reputation as a credible source for seedlings, other planting materials, products, and other services such as catering and accommodation for farmer training activities.

Development impacts

- Women's consciousness of the gendered nature of their roles and expectations were awakened or heightened during the course of the project. The women were pleased to share and reflect on their individual accomplishments as a result of market engagement.
- Through a combination of informal and formal networks, SANREM CRSP women partners developed their own katuk marketing system. Women were keen on planting katuk because this vegetable produces year round, contributing to the food security of the household, a main concern for women. Women were also provided vermicomposting technology out of their concern for cheaper farm inputs and their desire to try out an alternative win-win solution that benefits the environment.

Objective 6. Scaling up: Build host country capacity to manage and disseminate integrated VAF systems

Critical research, training, and service accomplishments

- Scientists from Vietnam, Indonesia and the Philippines attended Soil and Water Assessment Tool, no-tillage vegetable, and soil quality workshops.
- Vietnam, Indonesia, and the Philippines identified farmers who are examples and proponents of SANREM CRSP technologies.
- With a partner from Thailand, scientists from Vietnam, Indonesia, and Philippines organized the first Southeast Asian Soil and Water Assessment Tool conference January 5-9, 2009, in Chiang Mai, Thailand. More than 80 scientists from 16 countries participated in the conference. The conference website has had more than 12,100 visits.
- The website for the Second International SWAT Conference in Southeast Asia, set for January 4-7, 2011, (http://ssc.hcmuaf.edu.vn/) has had 2,201 visits.
- A SWAT book with nearly 60 sponsors was published, and copies were distributed mostly in Southeast Asia.
- Top administrators from Nong Lam University, Vietnam; Bogor Agricultural University, Indonesia; University of the Philippines at Los Baños, Philippines; and Chiang Mai University, Thailand; visited with staff of several U.S. federal agencies in Washington (USAID, USDA, and NSF), NASULGC, American Council on Education, Mars Inc. scientists, and with embassy staffs from Indonesia, Philippines, and Thailand. Top administrators also visited counterparts from NCA&T and Virginia Tech. NCA&T, Virginia Tech, and Mars Inc. funded these visits.
- 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.
- The TMPEGS gender coordinator undertook informal orientation training with the country gender teams on the cross-cutting research framework, especially the participatory network mapping method during her field visit to Vietnam and Indonesia.
- Organized visits by Theo Dillaha, María Elisa Christie, Keith Moore, and Ronald Cantrell were made to TMPEGS 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. Because of the SANREM CRSP influence, vegetable on-farm research with an underserved small farmer in North Carolina was started, funded by the USDA.
- Established and maintained TMPEGS website.

Vietnam

- Kickoff and planning workshop.
- Short training on household survey, nutrition survey, and data coding.
- Short training on rapid market assessment.
- Seminar to introduce the environmental leadership program at the University of California-Berkeley.
- Seminar to introduce RUPES/ PES concept and approach.
- Field training on drip irrigation for perennial crop (cacao).
- Short training on household survey of pesticides and health cost.
- Soil quality training workshop.
- Field day and discussion with local farmers on the design of field experiments on termite control in cacao, vegetable/natural vegetative strips for soil erosion control.
- Farmer training on soil quality and vegetable drip irrigation.
- Orientation meeting and training on PRA survey on integrated crop and pest management.
- Seminar on policy relating to VAF and workshop to develop policy analytical framework.
- SWAT modeling training at NLU.
- Team meeting and training on gender research method.
- Findings from the study on pesticide use and health cost used as case teaching materials for students and for training of local staff in extension and rural development in Binh Phuoc province.
- Workshop to disseminate research results to farmers and local authorities; project's working papers, posters, research briefs disseminated to extension centers in Binh Phuoc province as materials for extension program in the province.
- Technical workshop to report results from project research activities in 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.
- 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 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 CRSP meeting in the Philippines.
- Six abstracts were prepared by the team, from which four posters were developed and presented during the SANREM CRSP annual meeting in the Philippines.
- Theo Dillaha, María 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 methods, and to visit the study site to conduct initial market network assessment.
- Pham Hong Duc Phuoc participated in the workshop organized by Binh Phuoc Province on cacao program.
- Nguyen Kim Loi presented a paper in the SWAT conference in Thailand and in the 5th International SWAT Conference in Colorado.
- Results of the study on pesticide use and farmers' health cost conducted in Nghia Trung were used by Dang Thanh Ha as case teaching material in the course on environmental and natural resource economics. The case teaching material was used for two on-job bachelor's degree programs in Binh Phuoc Province (60 students in rural development and 78 students in

agricultural economics). A majority of these students currently staff various government agencies and local leaders from village to provincial levels in Binh Phuoc province.

Indonesia

- A SANREM CRSP base camp was established. Small-scale farmers both women and men visit the base. A SANREM CRSP field assistant was at the base to assist and answer farmers' questions about VAF.
- Hosted the no-tillage vegetable workshop conducted by Ronald Morse and David Midmore.
- Conducted a drip irrigation workshop.
- At least 13 brochures on vegetable fertilization and management were produced in Bahasa Indonesia (national language) for scaling up thrust in Year 4. This is the first time this was done in the Bogor region.
- Several papers were presented in international and Indonesian society meetings, including papers presented in the SANREM CRSP annual meeting in the Philippines.
- A paper for SWAT Chiang Mai conference was presented on results of simulation in Nanggung site.
- Funded by Department of Education, Indonesian embassy in Washington, NCA&T hosted Juang Kartika, Bogor Agricultural University researcher on personalized training on soil quality and writing of an extensive review of literature on *Arachis pintoi*.
- Hosted visits of Theo Dillaha, María Elisa Christie, Keith Moore, Manuel Reyes, and Ronald Cantrell in TMPEGS project sites in Indonesia.
- Hosted visit of External Evaluation Panel (EEP) member Edwin Price in SANREM CRSP project in Indonesia.
- Training on post-harvest handling was conducted with several women participants to improve katuk (an indigenous vegetable) quality and satisfy market requirements.
- The BAU gender team developed a book on nutritional and medicinal values and cooking instructions for 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 child education, and productive activities.

Philippines

- Farmers field day about VAF successfully conducted with several small-scale farmers both women and men in attendance.
- Completed the documentation of the Binahon Agroforestry Farm owned and operated by Mr. and Mrs. Henry Binahon. A video, brochure, and story were developed about the farm. The farm illustrates a working model of VAF, the requirements for a successful development of a farm, and the establishment of a small farm nursery by farmers as a major consideration if we are to push for VAF systems.
- Conducted a drip irrigation workshop.
- Hosted the Soil and Water Assessment Tool modeling workshop.
- Hosted the annual SANREM CRSP meeting in the Philippines, May 2008, with close to 30 participants coming from TMPEGS.
- Hosted the visit of several annual meeting participants in the research site at Barangay Songco, Lantapan, Bukidnon, Philippines.

- About five posters and two oral presentations were given at the annual SANREM CRSP meeting in the Philippines.
- Designed a resource booklet on the Binahon Agroforestry Farm and extension materials for promotion of sustainable VAF production systems.
- 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. Presentation to local government units and other research institutions, and within local and international scientific community.
- Abstract for SWAT Chiang Mai conference was submitted for simulation in Alanib site.
- Several presentations were done all over the Philippines and international conferences on TMPEGS research findings in the Philippines.
- Published some articles on the SANREM CRSP website.
- Facilitated development of a municipal ordinance, "Providing an incentive-support system to encourage adoption and investment in sustainable farming systems in Lantapan, Bukidnon".
- The local government unit was arranging purchase of several drip kits for use by small farmers both women and men.
- Hosted visits of Theo Dillaha, María Elisa Christie, Keith Moore, Manuel Reyes, and Ronald Cantrell in TMPEGS project sites in the Philippines.
- Hosted a farmers' field day at SANREM CRSP 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, as well as the use of a low-cost drip irrigation system in bell pepper production.
- Similar farmers' field day conducted at Claveria, Misamis Oriental, showcasing the different tomato lines under a tree-based system. Several vegetable farmers, extension workers, and personnel from Academe (MOSCAT) participated in the event. A participatory form was distributed and filled out by the evaluators.
- Vegetable grafting technology training was conducted for vegetable farmers, Academe, LGU officials, and agricultural technicians.
- Presentation of the integrated approach technology of SANREM CRSP on drip irrigation and VAF systems stimulated the participants' interests on the technology. It likewise enhanced the awareness and knowledge of the participants, particularly on the recent developments in the various aspects of the VAF technology that could contribute to promotion of VAF practices.
- The presentation is considered a strategic move to expand areas of collaboration from researchers and development workers to policymakers. Upgrading the discussion to policy level will ensure that other aspects of supports to technology promotion could be addressed systematically. Support may include finance and credit facilities and marketing support including infrastructure development.

Development impact

Knowledge of VAF was disseminated through experiments, workshops, and farm activities. Many smallholders 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 post-harvest 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 their farm lives. Furthermore, cacao-cashew experiments are showing to many stakeholders the agronomic, environmental, and economic advantages of integrating cacao with cashew.

Degree and non-degree training activities

LTRA-5 had 28 students involved in long-term degree training. Of those, 16 were women, 12 were men, and 27 were from host countries. Three completed and two are completing Ph.D. programs, eight completed master's degrees, one completed a diploma, and 14 completed bachelor's degrees.

Publications, presentations, other products

LTRA-5 researchers have produced two papers accepted for publication in an international journal, one book, one book chapter, one paper published in a national journal, ten working papers, six presented papers, 44 presentations, 23 reports, 26 posters, 26 fact sheets, three newsletter articles, and one prototypes of an animal-powered no-till seeder.

Networking activities

- Soil and Water Assessment Tool conference 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.
- Reyes visited USAID Missions in Jakarta with SANREM CRSP Management Entity members and EEP Chair Cantrell.
- Reyes visited U.S. State Department in Vietnam together with ME members and Cantrell.
- Reyes visited underserved limited-resource or small-scale farmers in North Carolina and presented them with results from the vegetable-tree interaction study, which led to a project on specialty vegetable crops for small farmers in North Carolina.
- TMPEGS networked with several SANREM CRSP scientists from all over the world when it hosted the annual SANREM CRSP meeting at Los Baños, Philippines, in May 2008.
- The ME team of Dillaha, Moore, and Christie, and EEP Chair Cantrell visited TMPEGS sites in Vietnam, Indonesia, and the Philippines; and visited with several TMPEGS scientists and staff.
- NCA&T Provost Alton Thompson, chair of SANREM's board of directors, attended SANREM CRSP 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 UPOU and NCA&T.
- Rector Trinh Truong Giang and two other top administrators from Nong Lam University were hosted by NCA&T for a 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 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 CRSP drip paper at the 2008 ASABE International Meeting in Rhode Island and networked with committee members of the first international Soil and Water Assessment Tool Conference in Southeast Asia, held in Chiang Mai, Thailand, January 5-8, 2009.
- Strong partnership with International Development Enterprise. Robert Yoder 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.
- During the SANREM CRSP annual meeting in the Philippines, Reyes met with Emil Javier, former minister in the Department of Science and Technology, president of the University of the Philippines system, chancellor of UPLB, and director of AVRDC.
- The SANREM CRSP management review panel (APARIQ) appointed by USAID visited NCA&T. The visit connected Reyes to a panel member, Hans Gregerson, who provided him with sound project management advice by e-mail.

Vietnam

- The 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.
- Delia Catacutan introduced the policy review in the Philippines and knowledge-to-action concepts and research method to NLU researchers and students at NLU.
- Dillaha, Christie, Moore, Cantrell, and 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 the workshop organized by Binh Phuoc Province on the cacao program and networked with the local government of Binh Phuoc Province.

Indonesia

- Linkages were developed between farmer partners and a local trader who is willing to buy and market all of farmers' production, especially katuk, kucai, and cassava.
- ICRAF has developed collaboration with Badan Pengkajian dan Penerapan Teknologi – Agency for Assessment and Replication Technology (BPPT) to use their land in a production plot trial at Kebun Agro Medika Hambaro, Nanggung Sub-district, Bogor.
- SANREM CRSPEEP 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.
- Networking with JAXA as Earth Observation (EO) agency was done to get medium resolution image of ALOS/PALSAR satellite. Three images were acquired free from the 2007 archive image.
- Networking with National Mapping Coordination Agency (Bakosurtanal) gave the opportunity to visit Banda Aceh, NAD Province, for application of SWAT in this province with Teuku Ferijal, who is recently graduated from Texas A&M University and participated in the 2009 SWAT-SEA Conference.
- Networked with the Competitive Grant Directorate General for Higher Education, Department of National Education for 2008-2010, Indonesia, which resulted in additional funding to strengthen women's organizations involved in health services, early child education, and productive activities other than farmer groups.

Philippines

- In Malaybalay City February 11-15, 2008, Catacutan participated in the national training-workshop 'Trees in Multi-use Landscapes in Southeast Asia (TULSEA): A Negotiated Toolbox for Integrated Natural Resource Management." The Bukidnon participants were mostly members of the Working Group – RUPES-Manupali Watershed.
- Saludadez visited Virginia Tech and networked with Moore and the SANREM CRSP team. She also met top administrators when she visited NCA&T.

- SANREM CRSP scientists networked with farmers, traders, technicians, and consumers from Lantapan, particularly Sungco and Kibangay, and attended the farmers' field day at the SANREM CRSP experimental site in Kimanga, Kibangay, Lantapan.
- SANREM CRSP scientists networked with several farmers at Claveria, Misamis Oriental, during a farmers' field day

Cross-cutting research activities

Gendered Access to Markets: Gendered Networks and Livelihood Alternatives

Principal investigator: María Elisa Christie, Gender Equity Coordinator, SANREM CRSP; and Program Director, Women in International Development, Virginia Tech

Host countries: Zambia, Peru, Bolivia, Ecuador, Philippines, Vietnam, Indonesia

Research Team:

- Bogor Agricultural University: Herien Puspitawati, Trikoesoemaningtyas, Tin Herawati
- Cornell University: Vongai Kandiwa Majaha
- De la Salle University, Ma. Elena Chiong-Javier
- Instituto de la Pequeña Producción Sustentable, Universidad Nacional Agraria la Molina: Edith Fernández-Baca
- Instituto Nacional Autónomo de Investigaciones Agropecuarias INIAP: Elena Cruz
- Nong Lam University: Nguyen Duc Thanh, Dang Thanh Ha, Le Thanh Loan, Tran Duc Luan
- Universidad Mayor San Andrés: Elizabeth Jimenez
- University of Missouri: Corinne Valdivia
- Virginia Tech: Jeff, Alwang, Nadezda Amana

Research strategy and development objectives

This research set out to determine how 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.).

- **Objective 1.** Increase women's awareness of markets and access to quality information.
- **Objective 2.** Identify gaps in networks and implications of findings to empower women to better access markets and increase bargaining power.
- **Objective 3.** Increase bargaining power through participatory research methodologies that affect social, human, and political capitals or assets.
- **Objective 4.** Recommend interventions to NGOs, government and researchers to empower women through training and reorientation of production and marketing initiatives.

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

The greater the number of nodes (participants, individuals) in women's networks and the number of ties or relationships (i.e. the denser the networks), the more "options" (pathways) women producers have available to them for getting their product to market, and the higher the market prices or guaranteed sales they are able to secure.

Hypotheses

1. Information. When women producers have multiple ties in networks that link them to more information, they can access more quality information about markets.
2. Income. Women producers who have more ties to trusted nodes providing information in the marketing network will have a better positioning in the bargaining process if the barrier is information.

Research progress by objective

Profiles of case studies, including abstract, brief literature review, key references and, in some cases, full case studies, from eight out of nine cases from three out of four LTRAs were compiled and posted on the SANREM CRSP website. Research was completed in all participating LTRAs and is in the process of being written up, summarized or translated.

While many of the findings in specific research areas vary due to the differing nature of the case studies, there were some overarching themes to the research. To begin, women's informal networking is a weak but important source of power and requires attention from local leaders to improve its strength. However, building and strengthening women's agency is a long process which cannot be approached unilaterally due to the variances in life cycle and gender norms pertaining to different cultures and regions that affect a woman's ability to participate in groups. Furthermore, market women have great negotiating capacity that is enhanced by the access to information through mechanisms such as radio programs and cell phones. Ultimately, though, women generally are working more hours than men and receiving less pay for the same work. Access to markets and information, networks and the bargaining power of the woman in the household, production chain and marketing decisions are all important determinants of women's roles in each of the LTRAs.

As mentioned earlier, generalizations should be avoided, for gender differences exist even between different regions and groups in a given country. The different structure of each LTRA and the late start in Year 4 makes it difficult to coordinate a cross-cutting project, but each case study made strides in analyzing the role of women according to their particular line of research. Due to the inherent overlap of the four project objectives, each aiming to describe and improve the role of women in society, the project accomplishments and findings are discussed in the context of each LTRA, not the specific objectives.

Critical Research Accomplishments

LTRA 2: Socioeconomic change and gender equity in Luangwa Valley, Zambia.

- Women control rice and groundnuts, men control cotton, tobacco and rice.
- The main determinant of women's market access lies in the trade of crops for which they have control as well as the structure of the broader market.
- Social networks are less important in facilitating access to market information than other means (i.e. notice boards or fliers) regardless of gender or group membership.
- Women are in charge of managing the household.
- Men decide how household money should be spent.
- Women face profound structural disadvantages because of cultural norms and practices that limit their mobility.

LTRA 3: Are potato markets gendered? An analysis of the potato marketing chain in the Jatun Mayu watershed of Tiraque, Bolivia.

- Women largely control the Tiraque-area potato markets, meaning they have great negotiation capacity, bargaining power and relationship with the wholesalers (80 percent women).
- Most farmers have access to information about prices, volumes and possible markets through radio, social networks and especially the growing use of cell phones.
- Women are extremely important in the potato marketing chain which provides farmers better access to information.
- Informal social networks are very important to support each other in production and marketing activity.
- Women's organizations are important because the Union (Syndicate) is only led by men; women have no right to vote.
- Whole family participates in production and marketing of agriculture, but responsibilities are clearly differentiated by gender: men have leading role in production; women lead in marketing.
- Women are in charge of generating and managing farm income, but decisions about total income and household management are largely made by men and women together (60 percent of reporting households).

LTRA 3: How gender relations affect potato and dairy marketing in highland Ecuador in the Illangama River watershed, Ecuador.

- Gender differences in household and community clearly exist within the watershed: women have a clear disadvantage in terms of participation and decision making.
- Gendered access to the dairy markets depends on the volume of the transactions; men dominate the larger-scale transactions.
- Women who market their cheese directly to the market are making a greater benefit than those who go through intermediaries.
- Family subsistence based on potato-milk system: men responsible for agricultural production, marketing of products, and investments and production decision making; women responsible for livestock production and cheese processing, and accompanying transport of products to market.
- Potato production involves all family members at various levels; men and women participate together in production and marketing activities but gender differences in households, productive activities and the community clearly exist in which women are the disadvantaged.
- Men are in charge of investment and of decision making at community organization level; women attend meetings but do not participate in decision making.
- Natural capital is controlled by men (86 percent of reporting households).
- Women tend to work an average of two hours more per day than men.

LTRA 4: Women's participation in commercialization and market strategies—A case study of Ancoraimes and Umala in La Paz, Bolivia.

Identified rural and urban markets to include in research and traced basic marketing circuit for key agricultural products: potato, chuño, peas and onion in rural markets of Patacamaya, Chejepampa, Morocollo y Achacachi and urban markets in La Paz and El Alto; also identified and interviewed key players (producers and intermediaries) in circuit and interviewed 50 percent of the 27 families selected. Participant observation in markets (collection centers and retail) with 27 families.

- In both urban and rural markets most intermediaries and farmers at all levels are women.
- Key findings per rural market:
    - Patacamaya (Umala) is primarily a wholesale market selling mostly potato and chuño from Umala, Luribay, Muruta, etc.

    - Chejepampa (Ancoraimes) sells mostly peas from Cohani, Karcapata and Canta. It has several collection points, not dominated by one family, allowing for producers to sell product directly.
    - Morocollo (Ancoraimes) is collection point for peas and fava beans (dried and fresh) from distant communities. Unlike the previous market, two of its three collection centers are controlled by one family, preventing farmers from selling products to highest bidder.
    - Achacachi (Achacachi) sells potato, chuño and onion from communities in bordering municipalities including Challuyo, Chinchaya, and Humacha. There are few potato or chuño wholesalers, as these are sold in more strategic points in the street near the plaza. Onion and peas are sold directly to consumers by producers or intermediaries.
    - Women—producers and buyers—are the main negotiators in the rural markets, with men serving primarily as drivers or helpers.
- Findings at wholesale markets in the urban centers of La Paz and El Alto are as follows:
    - Faro Murillo (El Alto) sells large quantities of onion from the Departments of Oruro, Tarija, Cochabamba, Sucre and communities from the shores of Lake Titicaca such as Pocoata, Humacha and Chinchaya.
    - Feria 16 de Julio (El Alto) primarily sells potato in large quantities—from Altiplano communities. It receives chuño in smaller quantities. Peas and onion are sold to small vendors or directly to consumers.
    - Río Seco (El Alto) sells in small quantity and directly to consumers. Products include potato, quinoa, chuño, fava bean and onion originating in Lake Titicaca communities (Compi, Achacachi, etc.).
    - Villa Dolores (El Alto) sells potato, fava bean and dried peas in the street. Several agencies sell potato from Araca, Palca and Sorata. Relations are between wholesaler and retail intermediaries and the final consumer.
    - Chijini (La Paz) principally sells potato from Cochabamba, Araca, Challuyo and Umala; onion from Oruro and Cochabamba; and peas primarily from Palca. Intermediaries ranged from rural wholesalers to small intermediaries.
    - As with rural markets, most intermediaries at all levels are women, as are the producers selling their products.
- Key findings regarding intermediaries. A total of 50 intermediaries were interviewed, of which 50 percent purchased from farmers in weekly rural markets, 30 percent were wholesalers primarily in urban markets, and 20 small vendors. In all cases, women were the primary negotiators and actors.
    - The first own their means of transportation. Men, in some cases the husbands, drive the trucks and serve as assistants. The women obtain products from farmers at low prices, arguing the high costs of transportation and booths, etc. Relations with producers are generally strictly commercial.
    - The second are primarily in urban markets where they own agencies that are generally run by a woman, with one to three assistants who help carrying heavy loads. These increase the prices significantly and are the least communicative of all informants.
    - The last are always women, who purchase from intermediaries and sell directly to consumers. They have strictly commercial relations with the first but sometimes friendship with consumers.

LTRA 4: The role of building social and political capital through advocacy coalition formation on women's ability to face market changes in the Peruvian Altiplano.

- Data gives us an idea of the existing livelihood strategies and among these current market strategies as well as some initial, though not very detailed, information of types of networks.

- Seems more plausible that women are joining the group on their own rather than as a result of learning from women who are already members and share knowledge through farmer to farmer exchange/sharing.
- Most of the information comes from bonding social capital (social network) rather than from external sources.
- Information is differentiated by gender.
- Interest group generated list of institutions (government and NGOs) with which to form strategic alliances and advocacy coalitions.
- In process of signing a cooperation agreement with RED SOCIAL (NGO) for future activities in benefit of the women's group.
- There is still a culture of men assuming the representation in front of external presences/intervention (such as this Project) even when the topic being dealt with is more related to the role of women.

LTRA 4: Networks, market chain collaboration, and transaction costs in the Bolivian Highlands: A case study on the Bolivian Andean Platform for chuño and tunta.

- Rural households in the Bolivian Highlands lack reliable information about market prices, consumers' quality expectations, and contacts for trading.
- Extreme climate events, such as droughts, make agriculture activity risky and limit produce quality and amount.
- The Bolivian Andean Platform (BAP), developed according to the Participatory Market Chain Approach (PMCA) guidelines, reduces information, search, and contracting costs in the market chain, while promoting agency capacity and market involvement for small-scale producers.
- BAP price setting policy is a disincentive to farmer's participation because it does not reward higher quality of chuño and tunta.

LTRA 5: Gendered networks linking upland women farmers to urban markets in the Philippines.

- Networking is an integral facet of social life as it links individuals and groups in a complex web of ties that delineate the individuals' social capital.
- The Philippine agricultural sector's women's active market involvement is culturally sanctioned, so farm women have cultivated networks along the path to marketing agricultural crops.
- To better understand market-oriented networks, a qualitative study was undertaken among selected group of women farmers in a watershed community noted for vegetable production in the Southern Philippines.
- Initial findings showed women's market networks as being female-dominated and having fewer nodes than male-dominated networks. However, after reanalyzing raw data and redoing network diagrams, a very slight increase in the average number of nodes for female-dominated networks was found. Thus, a re-entry into the field is proposed to check two female-dominated networks that reported few nodes and determine why, if the data is correct, there are so few.
- Networks serve to bridge women's information gaps, particularly about existing market supply and demand for particular products, prevailing or fluctuating market prices, buyers' preference and market demand for new crops.
- Regularity of transactions between women and people in their respective networks confers expected obligations and privileges on the partnership including exclusive patronage, preferential treatment, lenient or reduced pricing, and quality assurance for products or services exchanged.
- Networks empower farm women's productive status but have not been found to directly influence their household bargaining status.

LTRA 5: Women's access to markets: A case study on gendered networks at Nghia Trung Community, Bu Dang district, Binh Phuoc province, Vietnam.

- Women's roles and division of labor within households as well as design of laws, institutions, market structures, and technologies to assist women actually leave them with little time for agricultural extension, training courses, social activities, or access to markets: in response women have formed informal networks.
- Obstacles to women's access to markets include, but are not limited to, the overload of housework, lack of skill, low level of education, no transportation and no means of communication.
- Information sources come from the mass media (every household has a television and radio with a lot of agricultural extension programs or market information), through telephone communication and social networks.
- Husband and wife discuss and agree together on price, location, time and to whom to sell their production goods. Women may decide on these issues themselves when dealing with low value products.
- Women rarely participate in agricultural training and extension activities which limit their market access and other resources.
- Gendered networks are complex (comprised of several actors: local government, organizations, households, buying stations, middle men, traders, and women themselves) which are divided further into formal and informal networks.
- Informal and formal gendered networks exist: male participation in formal networks is at 70 percent.
- The formal networks established are a means by which to approach the local government.
- Informal networks provide women access to markets, trading, micro-credit, information, education, and health care.
- There are at least four recognized social networks affected by gender differences: the Farmer's Union (male dominated), Women's Union, network of traders (both male and female join), and traditional networks of local people.
- Results show improving women's abilities in marketing, information analysis, accounting, and risk reducing behavior (especially on seasonal price of agricultural products) widens chances to gain access to formal networks.
- Males and females have equal roles in income generation and cultivation activities of major crops (cashew, rubber tree, cacao).
- Farmers decide based on what they do best: thus men take care of crops (production, transport and storage) and women sell small products to the market and are in charge of keeping the money.
- Wholesale is the job of both males and females.
- Females are the dominant labor force in home gardens and small-scale commercial cultivation, in cooperative marketing of surplus farm products; however, they receive lower wages than men.
- Husbands and wives have equal roles in decision-making related to income generating and other activities.

LTRA 5: Gender analysis in access to markets for vegetables in Nanggung, Indonesia.

- Men produce and sell main agricultural products such as rice, corn, or cassava; women produce and sell minor vegetables.
- Involvement in marketing vegetables gives the women more opportunity to be part of the family decisions regarding farming (type of crop to plant, inputs and marketing).
- Most agricultural products used for consumption, surplus sold around village or to middlemen.

- Access to markets is open to everyone but dominated by men (via domination of niches), thus few women use it.
- All nodes in marketing network dominated by men.
- Middlemen provide information on demand and price of products.
- Men and women obtain same price when they use the same network—men only get higher price when they go directly to big market.
- Women have low mobility which limits their access to markets and information
- Most women do not negotiate for price, only terms of payment; generally middlemen decide the price.
- The ability to penetrate the market is determined by: customarily, social class, bargaining power, and economic factors (land and capital).
- Although still dominated by men, a fair number of women have access (12.6 percent) and control (12.6 percent) over marketing of agricultural products and 12.2 percent of women have access to information on the price of agricultural products.
- Even though men dominate the market in which women sell vegetables and fruit, allocation of expenditures is similar between men and women.
- A source of power for men is a long-established network between men and middlemen, institutionalized farmer groups, and access to capital.
- A source of power for women is mainly from family networking and support.
- Women who actively participate in marketing gain support from the husband in production and marketing of vegetables and are more confident in negotiating obstacles by selling directly to consumers/retail and obtaining higher prices than from middlemen.

LTRA-2: Zambia

- To improve women's wellbeing requires investment in crops for which women have control.
- There is a need to intensify efforts to develop seed systems and improve farmer knowledge on crops and agronomy.
- Understanding the mechanism through which men and women access market information opens new possibilities for female participation.
- SANREM CRSP social research brought gender to the forefront and social data continues to be collected to evaluate the impacts on gender equality.

LTRA-3: Bolivia and Ecuador

- In order to create a means of evaluating the impacts of alternative actions, polices and interventions gender considerations were taken into account.
- One paper on gender and resource ecology was produced in Ecuador.
- The development of production and marketing organizations is essential to broaden the options for both men and women to market crops.
- The social capital of the communities is sufficient to develop activities that aid in the development of women.
- These studies contributed to the strategies of life and sustainable development in the communities presented.
- Using cell phones in marketing activities and social networks provides a new opportunity for strengthening women's networks and growth in the market.
- Analysis of gender roles within the farmers' economy provides a reference framework for current and future research activities, most notably pertaining to innovation and technology transfer, of the watershed area.

LTRA-4: Bolivia and Peru

- It was made clear that to increase women's capacity around a specific economic activity they should learn more about the respective market and its actors.
- Methodologies were developed to assess change and sources of risks by gender and life-cycle stages.
- Strategic alliances were formed between women's groups and an institution that can address the gap in networks and build social and political capital to empower women to gain access to markets.
- The formation of an advocacy coalition will serve as an example that can be used to make recommendations to NGOs, government and researchers to empower women.

LTRA-5: Indonesia, Vietnam and the Philippines

- One paper was produced on gender in agro-forestry and sustainable vegetable production in the Southeast Asia.
- Training, networking and capacity building exercises achieved the following:
    - Enhanced feelings of personal empowerment and pride owing to improved earning and risk taking capacity, ability to access markets and social acknowledgement of their prominence in marketing.
    - Increased household bargaining and decision-making power in the productive spheres (farming and marketing); husbands' recognition of wives' financial contributions.
    - Organizational development among women bound by similar interests and concerns, i.e. planting and selling katuk, adoption of vermicomposting to reduce dependence on chemical inputs. Participating women's farmer groups had produced and redistributed over 75,000 katuk cutting to other farmer groups enabling the number of farmer participants to grow to 100 individuals.
- A small trader group formed voluntarily by women traders helped members to open a small trading business, exchange knowledge and information about products, trading practices and cultivation.
- Women traders expressed the need for acquiring more skills in managing their traders' group and larger capital.
- The gender analysis helped women to organize into formal networks (women farmer group) to obtain the support of the men in the family to be actively involved in vegetable production and marketing.

Development Impact

In the course of data gathering, women's consciousness of the gendered nature of their role and expectations was either awakened or heightened. The hypotheses from the cross cutting initiative were confirmed. Women producers who have multiple ties in networks linking them to more information can have access to more quality information about markets and have a better position in the bargaining process if the barrier is information. Each of the LTRAs observed specific impacts and opportunities that contribute to the gender initiative.

Degree and Non-Degree Training Activities

Students involved in the gender cross-cutting research include a PhD candidate in the Zambia project; one MSc graduate from Bolivia trained at Virginia Tech; four undergraduates in the Bolivia study; two MSc students in the Peruvian study; one MSc and two undergraduate students in Indonesia, and three undergraduate students participating in the Vietnam study.

Researchers from Ecuador, Peru and Bolivia were brought together in a training workshop focused on gender and participation facilitated by Dr. Susan Poats. The workshop had 31 participants, 13 of which were men and 18 were women. One of the key goals was to make training, including materials, available in Spanish to aid the students in SANREM CRSP host country institutions whose English communication skills are minimal. After the workshop a meeting of cross-cutting gender researchers in Bolivia and Ecuador was held at the Universidad de Cordillera, with 10 participants including 2 men. The majority of the participants were student researchers. Discussion sessions addressed on the difference between control and access of natural resources, the difference between focus groups and group interviews, and specifics on techniques for how to carry out interviews that are culturally sensitive. Additionally, the meeting brought Jere Gilles' expert advice on networks and methodologies to the group.

Publications, Presentations and Other Products

The ME made gender literature and information available in English and Spanish through electronic correspondence, the SANREM CRSP website, the Knowledge Base (SKB), and via a CD and resource notebook provided at the annual meeting in Los Baños in May of 2008. In an effort to continue providing guidance and support for individual LTRAs, including host country students, three documents containing strategies and frameworks for gender integration developed by international development organizations and projects were posted on the SANREM CRSP website. A book on field research methodologies was also distributed to gender researchers at the annual meeting. Another important outcome that year was the increased gender integration in SANREM CRSP and visibility of gender issues at the annual meeting—including presentations, posters, an evening session and a half-day workshop. Continued posting of literature on gender integration and research methodologies through the SKB also provided guidance and support for the cross-cutting research.

Each of the LTRAs is actively engaged in disseminating the knowledge gained from their research on regional and international levels. Despite delays, a full set of 12 papers will be the result of this Cross-cutting research. After initial communication with Nebraska Press, it appears that this has the greatest potential for publication as a set. The book will include two new cases were incorporated into the cross-cutting research and will be included in the collective publication: one examining gender relations and decision making in the Illangama River watershed in Ecuador with a focus on dairy and potato marketing; the other looking at chuño and tunta networks, market chain collaboration, and transaction costs in the Bolivian Highlands. A theoretical chapter will be written by Cornelia Flora and one on quantitative methodology by Sally Hamilton.

An initial draft of a literature review of scholarship pertaining to gender and social networks was produced and will provide the foundation for a more lengthy review of gendered networks, access to markets, and bargaining power once all case studies are complete. This will serve as the introductory chapter for the Nebraska Press publication. A collective bibliography has also been compiled from the lists of key references submitted by the researchers. Both the literature review and collective bibliography were posted on the SANREM CRSP website.

One paper on Social *Networks and Gender Equity in Access to Markets* in Zambia is to be submitted to the World Development or Rural Sociology journals from LTRA-2. Presentation of preliminary results from the LTRA-3 case study "Analysis of gender roles within the farmers' economy in the Jatun Mayu watershed communities of Tiraque, Bolivia" was conducted by Nadezda Amaya in the WID Discussion Series in Fall 2008 at the Office of International Research, Education and Development of Virginia Tech and also at The 25th Annual Research Symposium and Exposition held at Virginia Tech. A seminar dealing with gender and markets was planned by the SANREM CRSP team of LTRA-4. Finally, a book is being written integrating gender literature findings with gender survey results and a gender awareness workshop is being planned by the participants of LTRA-5.

Two modules on issues of gender and development (specifically gendered knowledge and NGOs and participation) were drafted for posting on the SANREM CRSP website. Each module is designed as a lesson comprised of key readings, questions to guide reading, and an outline of significant points. A third module regarding post-colonial impacts on women has also been prepared. Final findings from the case studies will be added to these modules. Fourteen other topics were outlined and will be completed and added to the website for dissemination by the end of the fiscal year.

Networking Activities

Networking activities were held in 2007 and 2008 integrating researchers from each LTRA with a focus on gender. First, in Bolivia in 2007, a gender breakfast at the 2nd Annual meeting was held to lay the groundwork for integrating gender as a cross-cutting research theme and to explore opportunities for gender research and cooperation. Several events were held during 2008, including a gender workshop and dinner at the 3rd Annual meeting in the Philippines and a "Gender and Participation" workshop in Bolivia with trainer Susan Poates. The latter incorporated 3 countries in the region, 13 men and 18 women. Additionally, there was a follow up meeting held with cross-cutting gender researches from Bolivia and Ecuador after the workshop.

Significant training, capacity building and networking activities were accomplished over this past SANREM CRSP phase. Under the direction of Elizabeth Jimenez, a group of 4 students in the Universidad de la Cordillera formed a study group called "Markets and Gender" that met weekly for four months before beginning fieldwork. The students used a collection of gender readings provided by the ME at the last annual meeting as well as other sources to prepare a reaction paper and discussion each week. This, together with the field work undertaken in markets for this project, is an important capacity-building contribution to a HC institution.

Metagenomics for the Analysis of Soil Microbial Communities and Soil Quality

Principal investigators: Karen Garrett, Associate Professor of Plant Pathology, Kansas State University

Host countries: Bolivia, Zambia

Research Team:

- Kansas State University: Karen Garrett, Ari Jumpponen, and Mike Herman
- PROINPA, Bolivia: Miguel Angel Gonzales and Jose Castillo
- Universidad Mayor de San Andrés, Bolivia: Jorge Cusicanqui
- University of Missouri: Corinne Valdivia and Peter Motavalli
- Virginia Tech: Jeffrey Alwang
- Cornell University: Alex Travis and Johannes Lehmann

Research strategy and development objectives

The soil metagenomics cross-cutting project began in 2008, and we have asked for an extension through at least the end of 2009. The following were original project objectives:

- **Objective 1.** Characterize soil microbial communities from soils representing a range of levels of degradation.
- **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.
- **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.

Soil metagenomics

One of the most exciting outcomes of the biotechnology revolution in genomics is the 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 were studied less than temperate soils, understanding and developing methods for stopping tropical soil degradation is an important topic for the SANREM CRSP. SANREM CRSP 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.

Links within SANREM

This soil metagenomics project will establish a productive link between general SANREM CRSP 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 CRSP teams will allow us to link these biological indicators with human

activities. We will also link this SANREM CRSP 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.

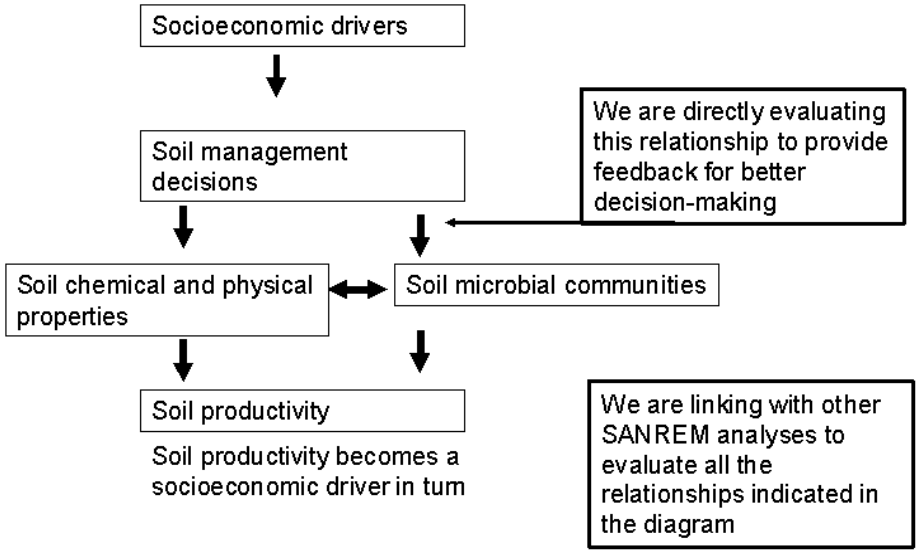


Figure 24. Socioeconomic drivers

Critical research accomplishments

Most of the project data are not yet available in final form. In preliminary analysis of the data describing the relationship between fallow period and microbial diversity in the Bolivian Altiplano, we were surprised to see that there was a trend (not significant) toward decreased microbial diversity with increased fallow period. We are evaluating whether this trend is still observed as the larger data sets are developed. Our final analyses also will emphasize microbial functional groups over simple diversity.

In synthesis projects addressing microbial communities, pathogens, and climate change, we have evaluated the following system components:

- Plant pathogens as indicators of climate change (Garrett, Nita, et al. 2009). Currently the many factors that interact to cause disease make it difficult to conclude definitively that observed changes in disease risk are evidence of climate change effects.
- Emerging plant diseases and strategies for their management (Garrett, Jumpponen, and Gomez, in press). Two of the most important risk factors –ones for which management is most controversial –are the great homogeneity of many agricultural landscapes and the intensive trade networks that move potentially contaminated plant materials around the world.
- Plant disease and ecosystem services (Cheatham et al. 2009). Plant disease influences ecosystem services through both direct effects and the effects of disease management. We summarize these relationships as well as the relationships between system biodiversity and policy. The need for more complete information about microbial communities and how they interact with other levels is one conclusion.
- Biological complexity in response to climate change published from Copenhagen Climate Conference (Garrett, Forbes, et al. 2009). We have developed key queries that can be used to

classify pathosystems in terms of how high the level of complexity is likely to be and thus where research is particularly needed to prepare for climate change effects.

- The interaction between use of crop mixtures and seasonality for plant disease risk (Garrett, Zúñiga, et al. 2009). When season lengths increase, the regional inoculum load may increase, thus the utility of plant disease management techniques that depend on lowering local inoculum loads may decrease.

System level: Our sampling schemes were designed so that we can draw inference about the regions in which we have sampled. The results will apply within fields and within watersheds.

Development impact

After we have our complete data sets describing microbial communities, we will integrate these results with soil physical and chemical characteristics, and with socioeconomic drivers to evaluate soil management decision making and its impacts on soil resources. We will work with our Bolivian- and Zambian-system collaborators to distribute the results to stakeholders in these projects.

Degree and non-degree training activities

This project has funded Lorena Gomez's master's thesis at Kansas State University as well as the short-term participation of graduate students Adam Sparks, Sweta Sutrave, and James Harris (at KSU) assisting in modeling aspects of the project. In Bolivia the project has funded the participation of students Romulo Torres and Neshmi Salaues. Neshmi Salaues, a student working with PROINPA in Bolivia, is preparing her samples for sequencing, and we will also complete analysis of her sequence data for publication. We have similar work and objectives in place for her project. Lydiah Gatere, a Cornell graduate student, has collected samples from her project in Zambia, and her samples were submitted for sequencing. Lorena Gomez is working with the metagenomic analysis for her project. Associated training projects have included a workshop in La Paz on soil metagenomics, a linked seminar course on design and analysis of experiments that use pyrosequencing to characterize soil communities, and a workshop in La Paz on statistics in agriculture. These projects have reached more than 50 participating students and faculty in Bolivian institutions.

Publications, presentations, other products

Publications from this project, most linked with the Valdivia project, include four articles published in refereed journals, four book chapters, one conference proceeding publication, and seven poster presentations by Lorena Gomez. Copies of publications can also be obtained online: http://www.k-state.edu/pdecology/int.html.

Several other publications are in preparation, including two as part of Lorena Gomez's thesis, one as part of Neshmi Salaues' thesis, one from our seminar, and a training publication from the soil metagenomics workshop.

Networking activities

We have worked collaboratively with three LTRA projects and have presented workshops and seminars in La Paz to develop capacity for incorporating soil metagenomics analyses in the work of Bolivian agricultural institutions. This work and the equipment supplied through this project will help our Bolivian collaborators utilize one of the most promising new techniques for understanding how soil management decisions influence soil resources and the productivity of soil.

We have linked SANREM CRSP researchers with other U.S. institutions through a distributed graduate seminar with sponsorship by the U.S. National Center for Ecological Analysis and Synthesis, resulting in the new publication on plant disease and ecosystem services (Cheatham et al. 2009). We have also linked with scientists at CIP, IRRI, and ICRISAT to evaluate complexity in the effects of climate change on plant disease (Garrett, Forbes, et al. 2009) as part of an ongoing analysis for future publication the journal Plant Pathology.

Our seminar course on design and analysis of experiments that use pyrosequencing to characterize soil communities linked multiple institutions remotely.

Watershed Modeling and Assessment

Principle Investigator: Conrad Heatwole, Associate Professor of Biological Systems Engineering, Center for Watershed Studies, Virginia Tech

Host countries: Bolivia, Ecuador, Zambia

Research Team:

- Cornell University: Alex Travis
- Wildlife Conservation Society: Dale Lewis
- Virginia Tech: Jeffrey Alwang
- PROINPA, Bolivia: Rubin Botello
- INIAP/Ecuador: Victor Barrera

Watershed and field studies have continued as the basis for providing a direct assessment of biophysical response in the project watersheds in Bolivia, Ecuador, and Zambia. Field data collection primarily coincides with the November-April rainy season in Bolivia, Ecuador and Zambia. Site visits in December 2008 (Zambia) and January 2009 (Bolivia and Ecuador) were used to check and calibrate field instruments and expand the sample collection with both automated and manual measurements. An important expansion to the watershed assessment program for the 2008-2009 season was the addition of water quality analysis to the basic hydrology data. Stream samples were collected and analyzed for total suspended solids (TSS). In addition, the partner in Ecuador also supported sample analysis for bacteria, nitrogen and phosphorus concentrations.

Field (plot) studies in Jatun Mayu (Bolivia) watershed supported two specific study objectives: 1) evaluating the impact of cropping on runoff, erosion, and nutrient losses in the high altitude 'upper zone' of the watershed, and 2) characterizing nutrient dynamics in fields to be able to develop and evaluate models that can then be used to analyze cropping systems and nutrient management practices and their impact on productivity and nutrient loss. A master's thesis was completed in August 2009 based on this work.

Watershed-scale analysis and integration studies through imagery analysis and modeling studies were facilitated with project partners in each site location. A second master's thesis was completed at Virginia Tech in August 2009, focusing on impacts of land use change in Zambia. Local partners in Bolivia and Ecuador are completing theses in collaboration with this work. A PhD student at Virginia Tech has contributed extensively to watershed assessment and planning in collaboration with the Zambia project

partner (WCS) through imagery analysis and modeling and is projected to complete and defend his dissertation in August 2010.

An extension of the project end date is enabling the collection of watershed data from the Zambia and Ecuador watersheds for another season with follow-up analysis. It will also enable completion of collaborator master's degrees in Bolivia and Ecuador, completion of PhD student at Virginia Tech, and will facilitate subsequent preparation and submission of manuscripts for journal publication.

Research strategy and development objectives

Basic hydrologic data characterizing watershed response provides important information for quantifying the water resources of a community. Identifying, defining, and quantifying community resources are important steps in being able to manage those resources. Hydrologic data 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.

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 by objective

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.

Specific activities and accomplishments:

- A land use/land cover map of the four Zambia study watersheds developed on a parcel (field) unit basis, using visual classification from a 1m resolution Ikonos image (May 2007) with field verification. This map (GIS data layer) supports the land use change analysis and the watershed modeling analysis of runoff and erosion.
- Analysis of land use change in the upland Luangwa River watershed through analysis of Landsat satellite imagery from 1989, 1994, and 2002 in conjunction with the 2007 Ikonos imagery. The comparison of watersheds reveals different patterns of transition in land use. Older settled watersheds have a higher percentage of abandoned land indicating the poor sustainability of current agricultural practices – and the potential for recovery of productivity. The frontier watershed (98 percent forest in 1989) is being rapidly settled and is now approximately 30 percent cleared. The trends and implications of land use practices from this analysis are being used in outreach to public officials and community groups to document the impact of current practices on landscape and natural resources.

- A new delineation of the entire Luangwa River basin was developed using improved 30m interpolation of the SRTM elevation data (over 500 million data points) and estimation of the contributing areas and flow from major tributary systems. This watershed delineation is then being used by WCS/COMACO in identifying priority area for intervention and to print maps using recent satellite imagery as a background to support community awareness of natural resources and community land use planning.

Objective 2. Assess the impacts of climate variation and land use practices on agricultural sustainability and natural resource management at a watershed scale.

The primary focus for this project period was field data collection during the rainy/cropping season December-April. Site visits in December (Zambia) and January (Bolivia and Ecuador) were used to check and calibrate field instruments. Additional rain gauges, both automatic and manual observation, were added in several watersheds to improve areal coverage. The responsibilities of field observers were expanded in Ecuador and Zambia to include estimation of flow rates during high flow events.

A key expansion of the watershed monitoring program for the 2008-09 season was to add selected water quality measurements along with the basic hydrology. The following analyses were implemented:

- Ecuador (Illangama and DelAlumbre watersheds): TSS, bacteria, total N, total P
- Bolivia (Ancoraimes): TSS
- Bolivia (Tiraque): TSS
- Zambia: TSS

The primary focus was measurement of total suspended solids (TSS) as a way to estimate sediment loss from the watersheds. Appropriate procedures, equipment and training were selected and provided for the different project partners. In Ecuador, an external laboratory is providing TSS and nutrient analysis of water samples. Locally, the field observer was trained to sample and analyze for bacteria. For Zambia, TSS filter papers are pre-weighed at Virginia Tech. Samples are filtered in the field at Emusa, air dried, and then returned to Virginia Tech for oven drying and accurate weighing.

Initial analysis of the watershed data was summarized in papers and posters that will be presented at the Feb 2009 conference – “21st Century Watershed Technology: Improving Water Quality and the Environment.” Presentations were developed with primary leadership by host country partners in Bolivia (M. Penaranda) and Ecuador (C. Montufar), and by graduate students supported by the project (Walker and Nyirongo).

The data from Zambia showed distinctly lower sediment loads from the watersheds in the plateau region of the landscape. These watersheds have a large dambo (wetland drainage-way) influence, and the significance of these landscape features in moderating the hydrology and water quality response of the watershed is evident, clearly supporting the case for the careful protection of dambos in the push for expanding the limits of cultivation into ‘new’ land. Of the two watersheds in the hilly region, the watershed with a history of cultivation (Luelo), in contrast to the primarily forested watershed (Kamwamphula), has much higher sediment load during storms, and sustained turbidity throughout the rainy season. This data will be used in outreach efforts to community and regional government officials to illustrate the impacts of land use practices.

In the Jatun Mayu watershed in Bolivia, field studies were conducted in addition to the watershed-scale monitoring. A replicated plot study was designed to examine the effect of tillage on runoff and erosion in

the high-altitude zone in the watershed, and a second study sought to quantify nitrogen dynamics as related to different cropping systems and nutrient management practices. Key findings were that runoff from native vegetation was higher than from cultivated plots. Thus, interestingly, limiting the expansion of cropping in this more fragile zone can be argued on the basis that native condition increases the water yield to the reservoirs that is in great demand as water supply and irrigation in the lower areas of the watershed.

The second major area of effort is in the development and evaluation of appropriate watershed models to assist in the analysis and extrapolation of the field data. Modeling studies included the work of two Masters theses, one with application in Zambia and one focused on nutrient dynamics in potato production in the Bolivian Andes.

- Changes in land use patterns in upland watersheds of Eastern Luangwa Valley, Zambia, and the potential impact on runoff and erosion (Nyirongo, MS thesis).
- Evaluation of GLEAMS nutrient model and evaluation of cropping systems in Jatun Mayu (Walker, MS thesis).

The broad conclusion from both studies was that additional work is required to adapt the respective models to the agro-ecosystems where they were applied. The models were developed in the United States, and assumptions about system dynamics and about parameter values do not always translate to the different physical and climatic regimes. The process for modeling mineralization and availability of nitrogen particularly needs revision in relationships as well as developing parameters appropriate to the high-altitude (lower temperatures) in potato fields in the Bolivian Andes.

GIS and watershed hydrology models were used to evaluate the impact of a proposed 40,000 ha cotton farm enterprise in the Zumwanda district – Lundazi River watershed. Results of this analysis were then used in meetings with government and community leaders to indicate the negative long-term resource and ecosystem impacts of this proposed farming enterprise. Alternatives for sustainable management and farming practices on the hilly forested land are suggested, including the importance of appropriate road design, selection of only low-sloped areas for cropping, and use of conservation farming practices to conserve soil and maintain long-term productivity (Heatwole, C.D. and Y. Her. 2009).

Objective 3. Evaluate the accuracy and value of low-cost community-based monitoring of watershed hydrology.

The network of field observers was expanded at sites in Zambia and Ecuador. A full-time assistant in Zambia was hired to provide better continuity of field monitoring programs and to do the water sampling and filtering for TSS analysis. Local observers were arranged at each stream monitoring point, and additional rainfall records kept at other locations in the watersheds. Preliminary review of the observer data shows a range in quality as might be expected. However, the data in general is very valuable to the overall monitoring effort for confirmation, filling in data gaps, and expanding the data network. Final analysis of the data has not been completed to date.

An interesting outcome is in Ecuador and Zambia where community involvement was sought and incorporated in the monitoring program; there is strong community support and interest and now institutional interest in Zambia. To date, there has not been any vandalism of equipment at watershed sites in Ecuador and Zambia (to the surprise of local partners), but there was at the sites in Bolivia where we do not have local observers as part of the study implementation.

Degree and non-degree training activities

Two Master's students at Virginia Tech have completed their degree in Biological Systems Engineering, one a U.S. female (Walker), and one a male from Malawi (Nyirongo). A PhD candidate at Virginia Tech (Korean native) is providing support for all projects but is primarily assisting with analysis and modeling for Zambia. My primary partners with LTR-3 in Bolivia (Peñaranda) and in Ecuador (Montufar) are working on MS degrees at local universities, using the goals and data of the watershed assessment program for their research. These candidates are projected to complete their analyses and degree requirements in Spring 2010.

Publications, presentations, and other products

This research has resulted in 1 refereed publication, 2 theses, 2 reports, 3 conference papers, and 3 conference posters.

Networking activities

In Lundazi, Zambia, March 2009, I met with Charles Phiri the head of the Lundazi District of the Zambian Meteorology Department (ZMD). The Lundazi station is located at the government office building complex. Air and soil temperature, rainfall, cloud cover, wind run data are recorded hourly during the day. The director learned about our weather stations operated in the Emusa area and initiated the contact to discuss the possibility of collaboration and sharing of data. The ZMD is interested in expanding their network of gauges throughout the district to provide a better representation of rainfall patterns and amounts. There is significant local variation in rainfall because the majority of rainfall is from convective storms. I shared data from the past season (2008-09) and assured him of our interest in making all data available. Mr. Phiri included the Emusa and Chazovu stations in his weekly radio and TV weather reporting, increasing interest in community records. Maintaining and sharing data is a positive outcome for increased community awareness of environment and implications for crop production. In November 2009, I met with the Provincial director of the ZMD who indicated further interest in collaboration and having regular access to our data which I assured would be provided.

Linking Knowledge and Action: Meeting NRM Challenges

Principal investigator: Esther Mwangi, Center for International Forestry Research (CIFOR)

Host countries: Bolivia, Ecuador, Uganda, Vietnam, Philippines, Kenya

Research Team:

- ICRAF/Philippines: Delia Catacutan
- University of Missouri: Corinne Valdivia
- Virginia Tech: Jeff, Alwang, Nadezda Amana
- Nong Lam University: Dang Thanh Ha
- Universidad Mayor San Andrés: Elizabeth Jimenez
- Universidad Nacional Agraria la Molina: Edith Fernández-Baca

Research strategy and development objectives

This cross-cutting research was completed with four of the five LTRAs. The objectives of this research include the following:

- **Objective 1.** Collection of qualitative and quantitative data on the multiple strategies used by the four resource teams in linking knowledge to action (K2A) and the analysis and reporting of the data.
- **Objective 2.** Dissemination and outreach of findings generated by participating research teams.

The purpose of this research is to determine the best approaches for facilitating K2A at all levels of government and within different community organizations (i.e. stakeholder groups, households, etc.). Data for this research was collected for each of the participating LTRAs through key informant interviews, round-table discussions, ongoing discussions with project participants, analysis of political structures, and review of policy changes resulting from K2A activities. This information was analyzed to assess similarities across projects, determine challenges faced at all levels of government and within different community structures, and identify areas for future research.

In general, the research found that each project had unique challenges in facilitating the dissemination and acceptance of knowledge gained through SANREM CRSP research. These challenges included local and national political structures, social structures, and location. However, one major similarity did exist in all projects, when stakeholders are included in research activities from the beginning knowledge was more readily accepted and transferred into action.

Research progress by objective

Objective 1. Collection of qualitative and quantitative data on the multiple strategies used by the four resource teams in linking knowledge to action and the analysis and reporting of the data.

Task 1

Key informant interviews with policymakers, practitioners, and community representatives to identify which K2A strategies and processes they consider effective and ways to strengthen these processes and improve those they find useful but relatively ineffective.

All teams have completed gathering data and information from primary and secondary sources, including interviews with all parties. In the Philippines and Vietnam, 80 interviews (40 in each country) were conducted with key informants such as researchers, local government officials, policymakers, extension agents, farmer-cooperators, and farmers. In Uganda, 40 key informant interviews were completed with similar stakeholders. Here, additional interviews with members of the National Advisory Committee and two participatory rural appraisals were conducted in the sites selected for study. For all sites, secondary data were obtained from project reports and other documents.

LTRA-4

In Ecuador and Bolivia (LTRA-4), round-table discussions were held with key policymakers, i.e., community-level elected officials, to understand their perceptions of the research and the extent to which they found it useful and relevant to them. This team engaged in an ongoing dialogue with farmer and community groups during project research activities, training efforts, and research team participation in community meetings. All stakeholders in Ecuador and Bolivia research sites were exposed to the team's

model results, and they now use these and research findings to create individual and watershed-level land use plans. LTRA-4 is conducting an extensive literature review to connect advocacy coalition and participatory approaches linking the construction of social human and political capital to the participatory nature of the institutions in our sites. A research assistant supported by LTRA-4 is contributing to this literature review.

LTRA-1

In Uganda (LTRA-1) policymakers, forestry officials, and community members and leaders found the SANREM CRSP research valuable. For forestry practitioners, the SANREM CRSP approach to research involved all stakeholders as part of the team, which stimulated dialogue between community members and forest officers. This dialogue helped to clarify the roles of key actors in forestry at national and district levels, strengthening the process of devolution. Communities and their leaders found that the SANREM CRSP approach reduced resource conflicts, valued local knowledge, and provided new knowledge. Although the majority of respondents considered the SANREM CRSP research as beneficial, a few felt it was a hindrance to their daily activities. Most hindrances were met by people who were directly deriving their income from activities in the forests and whose activities had to be stopped as result of the research findings, e.g., timber harvesters, commercial firewood harvesters, and charcoal burners.

Policymakers identified several challenges in transforming research findings and recommendations into viable policies and actions. First, research reports targeted at policymakers are often bulky and technical, limiting accessibility by busy people. Second, the transformation of research into policy usually takes a lot of time because practices are not easily revised. However, information generated by SANREM CRSP led to changes in practices within the National Forest Authority. After the SANREM CRSP research recommended fair distribution of both intangible and tangible resources from the forest, ownership of trees planted as boundary markers between community and government land is now vested in communities, unlike previously when communities' labor was used for plantings that belonged to government. Communities now own the trees that they plant as boundary markers. Communities are now allowed to plant annual crops such as beans, peas, and maize (which do not lead to destruction of the root system of the trees) in return for tending the tree seedlings. Thus communities in research sites now manage and own boundary plantings, and the crops they plant contribute to their livelihoods.

Practitioners in local and central governments indicated that a five year cycle for forestry organization strategic planning makes frequent introduction of new research findings difficult and that policy responses can rarely be immediate. However, annual budgeting processes can allow for some implementation of new findings in cases where recommendations fit well with activities already planned.

At the community level, different dissemination strategies have had different outcomes. For example, community meetings, especially those concerning environmental issues, are not well attended because communities do not see direct or quick benefits and women and youth often complained that they were not involved in research activities. Community leaders suggested that the most effective dissemination strategy is to piggyback on broader poverty reduction programs that are well attended.

LTRA-3

In Ecuador (LTRA-3), the acceptability of research was differentiated according to spatial location in the watershed. In Illangama (upper watershed), for example, community members were actively engaged in the research process and, as noted above, participants have adopted recommended practices at relatively high rates. In Alumbre (lower watershed), uptake of information and adoption of recommended practices was far more limited. Two factors contributed to this differentiation. First, the indigenous population in

the upper watershed had a relatively long history of working with partners such as scientists and agriculturalists at Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP), while the meztizo population in the lower watershed had previously had only weak contacts with INIAP. And the experimental method—mainly the use of demonstration farms—is much better accepted in the upper watershed.

K2A strategies are effective in the upper watershed. Participatory research, dialogue with decision makers, field schools, field days and other extension-like activities, and ongoing engagement in adaptive watershed management have all been successful. The main factors driving this acceptance were a homogenous population group and a tradition of community decision making in this indigenous community, greater awareness of the environmental damage caused by farming (evident during several participatory assessments and the results of the baseline and follow-up survey), trust between the research group and the target population, less heterogeneity in farming practices (the potato-pasture rotation is almost universal in Illangama), and strong evidence of economic returns from some of our project activities.

The strong democratic tradition among the indigenous households in the Illangama watershed made the local government responsive to farmer inputs. Farmers became familiar with practices to reduce soil erosion through interactions with the research team, and this exposure prompted them to lobby their local governments for more information. The local government, in turn, became receptive to the research activity and began seeking information from the research team following comments from farmers and exposure during training and other meetings.

Adoption of the adaptive watershed management approach was stimulated by both local government experience with the research team and activities and the national requirement for localities to have land use plans in place. This requirement led the local government to seek inputs from the team relative to current land use, land use consistent with environmental and economic criteria, and projections about land use changes following policy change. Thus, conditions in Illangama made it an ideal place for the SANREM CRSP approach to K2A.

In Alumbre, less immediate acceptance of the research program was evident, and a need to sequence research and outreach activities was needed. The SANREM CRSP team found very little acceptance during early stages of the project. This was due to less history of working with INIAP, a heterogeneous population with limited social networks and diverging political goals, and an urgent sense that economic progress would be hampered by efforts to improve environmental quality. This latter problem was severe: Populations in Alumbre lack “economic space” and view short-term survival as a risk—actions were focused on short-term income.

Over time, however, project activities created more confidence and acceptance. The biodiversity assessment and preliminary efforts by the SANREM CRSP team to highlight environmental concerns began to create an atmosphere that was more conducive to SANREM-type messages. Exposure to agricultural experiments and establishment of a model farm in Alumbre helped build the legitimacy of the research team among local stakeholders. Efforts to engage decision makers at the political level before establishing this legitimacy did not work. At the start of the project, community involvement was minimal, but by the end of the project, the team noticed increased interest on the part of the local government. That interest was created through our engagement of local producers.

In Bolivia, the experience was similar to that of the Alumbre watershed in Ecuador: slow acceptance and uptake from community and farmer stakeholders, and lagging local political leadership. The key challenges in Bolivia from a K2A standpoint were political divisions between our partners in Cochabamba and the local political leadership who viewed the project with suspicion (especially due to

the USAID connection); lack of demand on the part of local leadership for project outputs (water quality was not viewed by the political leadership as a primary concern, even though stakeholders expressed the need for more and better-quality aquatic resources); and the project did not have tangible outputs to benefit producers until several years in.

In Bolivia, the Andean research institute PROINPA had a long history of working in the Tiraque watershed. The institute has an agricultural research station (Toralapa) in the middle of the watershed. However, local political leadership is extremely skeptical, partly because of macro-political conditions (the highlands where the Tiraque watershed is situated are affiliated with Bolivian President Evo Morales' party while Cochabamba is firmly part of the opposition) and partly because of historical enmity between meztizo and indigenous groups. PROINPA personnel are largely meztizo and find they have to build their legitimacy in indigenous areas by working closely with producers; the politicians follow. The K2A strategy in Tiraque was modified to recognize this reality, and our research team focused on engaging producer groups in the watershed management plan. Research results (land use maps, land use vulnerability maps, SWAT model results) were used to create individual plot-level and sindicato-level (smaller producer groups) land use management plans. Producers became quite excited about these plans, and demand for them far exceeded supply. The local government, even though it has a central-government mandate to create watershed-level land use plans, was reluctant to use our research findings. However, following success with individual farmers the government began to integrate our SANREM CRSP adaptive watershed plan into its own land use planning process.

In Ecuador and Bolivia round-table discussions were held with key policymakers to understand their perceptions of the research and the extent to which they found it useful and relevant to them. Ongoing dialogue with farmer and community groups was sustained throughout the project. This participation was, according to informants and observations, the most effective means of stimulating actions. Hands-on participation, for example, in construction and monitoring of soil conservation structures in Ecuador led to adoption of similar practices in more than 60 percent of the cases. Fewer than 30 percent of casual observers and others who attended conservation training adopted these new practices. In the lower Ecuador watershed (Alumbre), fewer participants adopted the practices including one non-participant. In Bolivia, farmers and farmer groups who participated in farm-level planning activities were far more likely to adopt recommended practices than were non-participants. Policymakers and community representatives were involved in adaptive management processes. This exposed them to research model results, which they subsequently used to create individual and watershed-level land use plans.

LTRA-5

LTRA-5's review of the national agricultural research, development, and extension system in the Philippines and Vietnam found that there were many agencies spread across different regions with little coordination. Consequently, efforts are fragmented or overlapping, resulting in duplication and inefficiency. The national research, development, and extension (RD&E) system in each country is huge and complex, generally top-down and underfunded. RD&E priorities are identified at the national and regional levels, and the technologies generated are handed down to local extension agencies for application at the local level. Only in rare circumstances where funding becomes available will provincial research units undertake on-station and/or on-farm research and extension. Three or more national departments/ministries and state colleges and universities have RD&E mandates; hence, competition for funding is fierce. In both countries the private sector plays an important role, with RD&E activities centered on profits; businesses' activities are beyond the control of the national RD&E system, albeit public-private partnerships are encouraged. International agricultural research centers (IARCs) form part of the private-sector RD&E category. Within each national research institution lies the problems of inadequate technical capacity due to limited training and poor incentive structure, weak performance due

to lack of operational funds, and poor coordination and communication among research and extension agencies or bureaus within institutions.

In the Philippines, the Department of Science and Technology has set up a national research and development council that coordinates RD&E activities through its 14 regional consortia. Coordination of RD&E efforts within institutions was already problematic and is compounded by the national council's communicating and bridging efforts. Notwithstanding, the council instituted a farmer-level technology dissemination strategy through deployment of trained farmer scientists and establishment of Farmer Information and Technology Services (FITS) to enable local governments to take leadership in technology dissemination. However, only a limited number of FITS were established, for they need continued support from local government units. The potential benefits of FITS are therefore marred by lack of local support. It also remains doubtful whether the existence of FITS will resolve the need for grounded research by scientists due to their limited capacity to work with farmers through the FITS program.

At a more localized site level, the Manupali Watershed in the Philippines was the locus of RD&E interventions since the early 1980s, while work in Binh Phuc Province, Vietnam, began only in late 1990s. In Manupali, the most prominent intervention is the SANREM CRSP project commencing in 1993, while most interventions in Binh Phuc were undertaken by the provincial branch of the department of agriculture and Nong Lam University with some funding support from international partners. The participatory approach of the SANREM CRSP project brought fresh insights on the utility of research in local development planning; the timing of SANREM CRSP was propitious with government devolution in the Philippines and major policy reforms in Vietnam, where local politicians and the newly devolved extension system were tripling in their ability to perform their devolved functions. The SANREM CRSP project was therefore expected to provide scientific knowledge for development planning and policy action.

Since Phase 1 various linking strategies were used by SANREM CRSP in the Philippines, starting with the comprehensive Participatory Landscape-Lifescape Appraisal (PLLA) collaboratively implemented by a multidisciplinary team of foreign and local researchers. In the early phases, participatory on-farm research, training and group formation, cross visits, participatory planning and mapping, consultations and workshops, and engaging different community sectoral groups had already been used by SANREM CRSP researchers. The underlying objective of applying various strategies was to systematically link research-generated knowledge with policy and practice to achieve wider impacts. However, there was no assessment of impacts relative to specific linking strategies used. This could were valuable in improving K2A practices in subsequent project phases. Nonetheless, sporadic assessments were conducted to establish empirical evidence on specific impacts of the SANREM CRSP project to the Manupali community. For example, positive results were easily accounted at the institutional level through numerous farmer groups formed through research and training activities and the development of a natural resource management plan by the local government.

Adherence to SANREM CRSP cornerstones through different strategies was linked to fostering participation and enhancing the partnership base to increases the potential for research uptake and scaling up, rather than explicitly addressing collaborative knowledge production and creating room for negotiating multiple actions by multiple actors. For example, it can be deduced that community participation in problem framing (legitimacy criteria) would have increased researchers' knowledge of local context. Therefore, new knowledge produced would were relevant to the public (saliency criteria). However, participatory approaches were sometimes used only to justify public-funded research, whereas production of new knowledge remained in the hands of the researcher. The linking part then, is toward the 'action," often through organizing trainings, cross visits, workshops, and joint planning where research results are communicated as recommendations for farmers and policymakers to consider. This can be

viewed as a localized top-down RD&E approach or partial participatory RD&E, rather than directly linking knowledge with action.

The link between research and extension is weak, and many research projects rarely produce the kinds of knowledge the end users need most. In addition, projects are influenced by implementing agencies or funding agencies, which do not necessarily serve the knowledge needs of end users. RD&E management is top down instead of a two-way interactive process. At the local level, little attention is given to developing extension agents with the technical competence and social skills needed to disseminate knowledge and skills to farmers. A rich body of knowledge available for use by policymakers, extension agents, and farmers was generated and can be translated into usable tools and technologies. Additionally, only a few research and development projects implemented in the Philippines sites have resulted in policy uptake, and the gap between research investment and local benefits is wide. More efforts are needed to reconcile the supply and demand of knowledge.

Interviews with key informants (policymakers, extension agents, farmer-cooperators, farmers) on current SANREM CRSPVAF activities in the LTRA-5 sites showed that the VAF research is appropriate for the majority of farmers are engaged in vegetable production. Farmers appreciate the additional knowledge gained through participating in research activities, which they can apply to improve their practices. Three strategies of K2Athat farmers prefer are training, on-farm trials, and field visits. Research-proven technologies have a particularly high influence on farmers' decisions and actions. Farmers recommend that researchers provide feedback, interact with farmers more informally, and treat them as equals.

Task 2

Analysis of results from key informant interviews to evaluate the effectiveness of multiple strategies and processes (e.g., advocacy coalitions, national advisory committees, policy round tables) influencing the adoption of new actions, including practices and policies at multiple levels.

LTRAs 1, 3, and 5 have conducted qualitative analysis of their results, outlined above. The findings in Uganda suggest that different linking strategies are effective at different levels of governance due to the nature of decisions being made. For example, the national advisory committees, which included representation from national-level policymakers, non-governmental and research organizations, were more effective in facilitating a change in practice (e.g., tree ownership and non-resident cultivation/taungya) even before policy changes were implemented. The inclusion of local-level actors in data gathering served to increase local knowledge contributions, while the policy round tables provided a platform that brought together forest officials, communities, and researchers, allowing officials to hear firsthand about local-level resource use and access problems; this in turn contributed to their endorsement of changes in practices.

In the Philippines, farmers found training, on-farm trials, and field visits to be the most influential in their decisions to adopt certain actions. Overall, research-proven technologies have a particularly high influence on farmers' decisions and actions. The combination and sequencing of linking strategies and processes are critical to success. Feedback sessions are useful for stimulating discussions between researchers and practitioners on how knowledge generated from research can be more effective on the ground. Hence, the sessions resulted in better understanding and appreciation of the important link between researchers and practitioners. As a result, the researchers planned to organize a knowledge-based decision-making symposium in the first quarter of 2010 to introduce the concept of K2A and how this can benefit not just researchers but also practitioners, particularly policymakers, extension agents, and farmers. Bukidnon State University will host the event.

On-farm research, trainings, and seminars remained a popular linking strategy among farmers. In on-farm research, farmers are able to interact with researchers on a more regular basis, giving rise to co-production of new knowledge. Farmers remain keen on acquiring new knowledge that benefits them; for some, this is a source of wealth and pride. At the incipient stage of the research project, clarity of research objectives and potential benefits motivate farmer participation. In other words, community engagement has a temporal dimension—the earlier people are engaged, the better, although this implies continuing investments to maintain, if not enhance, the degree of participation at every stage of project implementation. In relation to the above, research designs should include nurturing participation and building synergy with its associated costs.

According to farmers, researchers should be strategic and should demonstrate a positive attitude toward them. Participating in research activities could be tiring and time-consuming, but with empathy, open communication, and regular feedback of research results, the incentive is there for farmers to participate. Research communication should be plain and simple, preferably in the local dialect. Knowledge from voluminous reports is hard to extract, and busy politicians do not have time to assimilate them. However, when they were part of the whole research process, there is no need to advocate for policy change in an after-the-fact mode; policy change will come earlier and will be an added innovation in the research project.

Extension agents can play important boundary roles in linking research with policy and practice. However, they are often limited by lack of resources to improve mobility; they have limited technical capacity and are less motivated to improve their work due to lack of incentives and in some cases a safe space when sensitive political or scientific issues emerge.

Based on grassroots experience in Ecuador, higher levels of government are now interested in the watershed approach to land use planning. At the regional level, the provincial government of Bolivar has adopted a recommendation that localities adopt the adaptive watershed management approach. The project found the tool to be successful at a local level, and this success filtered up through the political planning process. At the national level, the constitution of Ecuador was recently revised to include the watershed basis of land use planning.

Findings indicate that the strategy is somewhat less important than the research results. When the project produced information demanded by farmers, localities, and higher levels of government, adoption followed. However, adoption was contingent on trust in the researchers and the process. This trust was built patiently over time by addressing the needs of farmer groups, by responding to local government needs, and by integrating the community into the process.

External considerations also play a role in technology adoption. In both Ecuador and Bolivia, localities were mandated by central government to produce land use plans. The fact that the project focused on tools that were useful in the process was serendipitous. In Ecuador, flooding downstream in the lower Chimbo River focused national attention on the need to improve soil retention efforts upstream; this project was well placed to address the need. However, trust was key; the SANREM CRSP team in both sites had gained the trust of local stakeholders, and this facilitated K2A.

Objective 2. Dissemination and outreach of findings generated by participating research teams.

Task 1

Continued training of communities through the formation and maintenance of advocacy coalitions**.**

LTRA-4 focused on ensuring that researchers are trained in advocacy coalitions (AC), a concept that includes an evaluation of institutions to understand who benefits from the research and who has the ability to incorporate information into decision making. The markets theme focuses on the use of AC in the process of knowledge sharing in the area of markets (Umala, Ancoraimes, and Puno); the second theme focuses on knowledge sharing on climate (Ancoraimes). Bolivian researchers attended training led by Edith Fernández-Baca in Peru. Four researchers were trained and developed a proposal on incorporating AC in the socialization of market information in Bolivia. AC is an essential element in the Peru program, a capacity skill shared by researchers with their Bolivian colleagues.

Two male and two female research assistants who are master's degree students in various fields participated in the graduate module in Puno, Peru in November 2007. At that time, funding for the knowledge-to-action cross-cutting research was not yet in place, so LTRA-4 funded this activity, which benefits both the LTRA-4 research and the case studies on climate adaptation (Edwin Yucra and Justina Condori) and markets (Olga Yana and Griselda Gonzales). Two of the student researchers (Yana and Yucra) are involved in the case studies in Bolivia on markets and climate.

Task 2

Information exchange among community representatives, practitioners, and policymakers intended to provide feedback and stimulate discussion on the attributes of knowledge they are most likely to use and to sensitize each of these categories of actors on the knowledge needs of the others.

LTRA-4 researchers met with the National Program on Climate Change in Bolivia, presented their climate information-sharing plan, and invited the program to include their information products in this plan. The team is now in the initial stage of determining how to collaborate and how to evaluate the information shared with resource managers. In Peru, LTRA-4 presented its case study to the USAID Mission in October. This presentation focused on pathways for linking knowledge systems and for identifying agency.

Task 3

Cross-case analysis that synthesizes findings, presents the lessons learned for policy, practice, and methods, and recommends future research areas.

The cross-case analysis of results and lessons is underway. Uganda, Kenya, the Philippines, and Vietnam have completed their case studies. A comprehensive literature review that maps out strategies, problem domains, knowledge systems, and effectiveness of strategies was completed. The case studies and literature review will be used to draw lessons and insights on linking knowledge to action.

Publications, presentations, other products

LTRA-4 compiled guidelines to generate products that integrate AC in a protocol of sharing information with the communities for markets and climate. The Uganda team (LTRA-1) completed and circulated a video that explains its strategies for linking knowledge with action and their effectiveness. LTRA-5 (Philippines and Vietnam) conducted two presentations at international forums where feedback was received, and a video production to present the K2A system on agriculture, forestry, and natural resources in the Philippines is being finalized. The video presents a story line of LTRA-5 VAF research in the Manupali watershed in the context of K2A. Uganda conducted an exchange workshop that brought together Kenya and Uganda teams and where knowledge and experiences were shared.

A Center for International Development-Harvard University working paper that provides a historical analysis of K2A strategies, their effectiveness, and research gaps is in process.

Assessing and Managing Soil Quality for Sustainable Agricultural Systems

Principal investigators: Peter Motavalli, College of Agriculture, Food and Natural Resources, University of Missouri

Host countries: Bolivia, Indonesia, Philippines, Zambia

Research team:

- University of Missouri: Peter Motavalli, Keith Goyne, and Jere Gilles
- Cornell University: Johannes Lehmann
- U.S. Department of Agriculture-Agricultural Research Service: Robert Kremer

Research strategy and development objectives

The intent of this proposal was to enhance and strengthen ongoing soil science-related project activities across the SANREM CRSP and initiate new cross-cutting research that examined common soil quality issues across a wide range of climates, cropping systems, and socioeconomic conditions. Surveys were conducted among community members and agricultural professionals in two Andean regions of Bolivia, Philippines, and Indonesia to determine their perceptions of soil quality and to assess the appropriate characteristics of a field test for soil quality.

Identifying and developing appropriate methods to quantify and assess changes in soil quality are essential for evaluating the extent of soil degradation and the effectiveness of improved management practices. Therefore, an important development objective for this project was to examine different methods for assessing soil quality, including a low-cost, rapid field test and other methods that may have promise with additional research and development. A principal hypothesis of this research was that methods that assessed soil organic C fractions or ratios of labile to stable soil organic C would be sufficient for determining soil quality in a wide range of cropping systems and environments. It should be noted that caution is needed in attempting to assess soil quality in a wide range of cropping systems and environments with a test that only measures differences in soil organic C, for other soil properties (e.g., soil chemical, physical and biological properties) may be primarily responsible for reduced agricultural production.

Following are the specific objectives of the soil quality cross-cutting initiative:

- **Objective 1.** Assess community perceptions and indicators of soil quality, including differences in perceptions of soil quality due to gender, environment, and socioeconomic factors. These assessments will include an evaluation of desired characteristics of low-cost methods to evaluate soil quality by local community members and agricultural professionals.
- **Objective 2.** Conduct a literature review of soil quality assessment techniques and identify practical but scientifically sound techniques that would be appropriate to evaluate soil quality across SANREM CRSP activities.
- **Objective 3.** 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 represented by the SANREM CRSP projects.
- **Objective 4.** To collaborate in the evaluation of soil metagenomic methods as an indicator of soil degradation.

Among the hypotheses tested in this project were:

- Soil physical properties (e.g., soil color, texture, and drainage) and crop growth would be the primary indicators of soil quality for farmers across the SANREM CRSP projects, and these perceptions would not differ significantly by site or by gender.
- Agricultural professionals working in the communities would have specific characteristics that they would be able to define for an appropriate soil quality test.
- Analytical methods that assessed soil organic C fractions or ratios of labile to stable soil organic C would be sufficient for determining soil quality in a wide range of cropping systems and environments.
- Spectroscopic-based methods may be the most appropriate for assessing soil quality because they have the potential for being low in cost, easy to use, and rapid. They also may have some application for remote sensing.

Research progress by objective

Objective 1. Assess community perceptions and indicators of soil quality, including differences in perceptions of soil quality due to gender, environmental, and socioeconomic factors. These assessments will include an evaluation of desired characteristics of low-cost methods to evaluate soil quality by local community members and agricultural professionals.

Critical research accomplishments

Surveys were conducted among community members and agricultural professionals in the Andean region of Bolivia (Umala and Cochabamba), Indonesia (District of Nanggung on the island of Java) and the Philippines (Lantapan on the island of Mindanao). The selected sites were communities in which the SANREM CRSP long-term research projects were already working. In Cochabamba, the communities of Toralapa Baja (relatively low land area), Waylla Pujru (relatively intermediate land area) and Sancayani Alto (relatively high land area) were selected and 88 men and women community members surveyed. In Umala, 32 community members (28 men and four women) from four communities (Kelihuiri, San Juan Circa, San Jose Llanga, and Vinto Coopani) and eight agricultural professionals were surveyed. These surveys examined community and agricultural professionals' perceptions of soil quality and appropriate characteristics of a soil quality testing procedure. The influence of gender on these perceptions is also being examined. Difficulty was encountered in identifying a collaborator in Zambia to conduct the survey, so this activity was not completed.

Based on a preliminary analysis of the surveys, the major findings are as follows:
- Farmers primarily use soil physical properties (i.e., soil color, texture and structure, water retention and drainage) and plant growth as criteria for assessing soil quality.
- Agricultural professionals indicate that the soil quality test needs to be convenient, low in cost, and accompanied by sufficient training for its use.
- Farmers and agricultural professionals had some differing perceptions of management practices that reduced soil quality.

- Few communities have access to soil testing, and the primary limitations for more soil testing are cost and lack of knowledge of the value of soil testing. However, a majority of both farmers and agricultural professionals expressed interest in assessing a soil quality test in the field if it was available.

Further analysis of the survey results is ongoing and is part of the dissertation research of the Ph.D. and master's students involved in this project.

Development impact

These findings will assist in understanding the perceptions of soil quality among community members and agricultural professionals, and help in the development of appropriate soil quality testing procedures.

Objective 2. Conduct a literature review of soil quality assessment techniques and identify practical but scientifically sound techniques that would be appropriate to evaluate soil quality across SANREM CRSP activities.

Critical research accomplishments

Based on a survey of the literature, several soil quality tests were selected for comparison. The $KMnO_4$ test was widely assessed for use as a rapid and relatively inexpensive procedure for soil quality. Currently, this test is being examined by the Natural Resources Conservation Service (NRCS) under a wide range of agricultural conditions across the United States. A field kit version of the $KMnO_4$ test, developed at Ohio State University, substitutes an interpretation chart for a more expensive portable spectrophotometer and makes the test more practical for field use. Spectroscopic methods such as NIR analysis DRIFT or mid-infrared analysis are being tested in developing countries by researchers from the International Agroforestry Center (ICRAF) and other institutions. These methods could be rapid, overcome the difficulties of lack of access to affordable soil testing facilities, and potentially be used through remote sensing. Although portable field NIR units were developed, the current high costs of NIR analysis and DRIFT make them less likely to be utilized where resources are scarce. The Ph.D. student, based at the University of Missouri, is including this literature review as part of her dissertation project.

Development impact

The information provided by the literature review allowed for the selection of analytical methods that may have some success under the different cropping systems and environmental conditions of the different SANREM CRSP projects. Because several of these tests are being studied by different institutions, there are some opportunities for further assessment and development of the tests and accompanying information for interpretation and recommendations.

Objective 3. 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 represented by the SANREM CRSP projects.

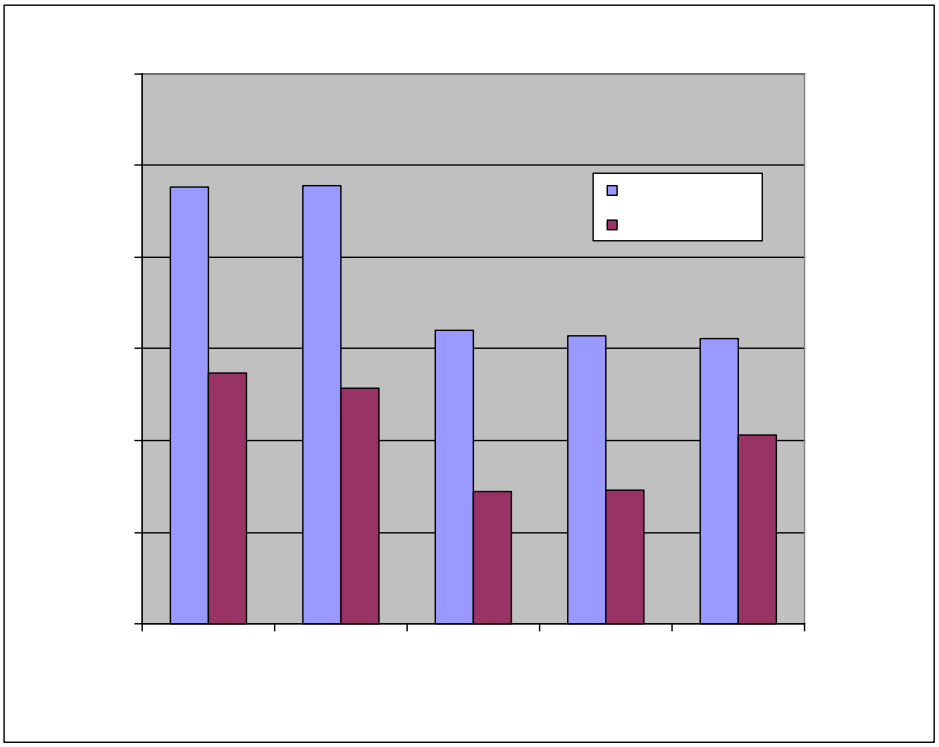
Critical research accomplishments

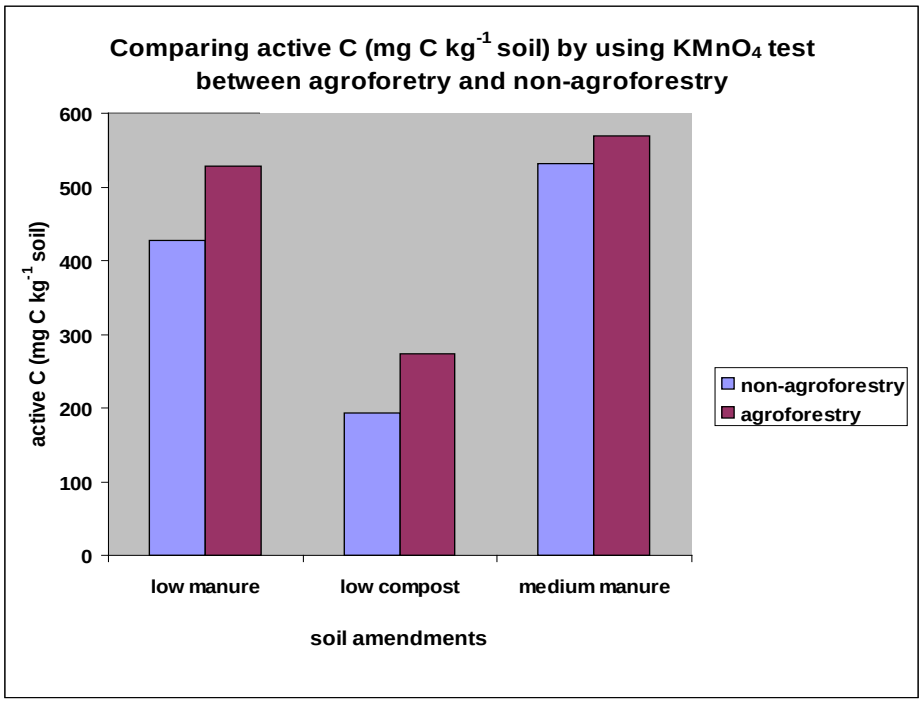
Significant progress was made under this objective, but analyses are ongoing with samples collected from the Philippines and Indonesia. The soil samples collected from the Umala site in Bolivia compared soils from different communities with different lengths of cropping and fallow length. Soils collected at the Cochabamba sites in Bolivia were from degraded and non-degraded fields identified by farmers in each community of that SANREM CRSP project. On Mindanao in the Philippines, soil samples were collected from different landscape positions from cultivated and non-cultivated sites. In Indonesia, the soils were collected under agroforestry or non-agroforestry management and with different soil fertility practices with either no fertilization or fertilizer with organic and inorganic amendments. The soil samples were tested for water-soluble, $KMnO_4$-extractable and particulate organic matter (POM) labile C. These results were then correlated with results from the NIR analysis and DRIFT. For the DRIFT analysis, humic acid is extracted from the samples and any remaining mineral material destroyed with use of HF digestion, for the soil mineral fraction often needs to be removed to reduce interference with C peaks.

The field kits for the $KMnO_4$ test were distributed among the collaborators, they were given training, and they tested two versions of the kit: one with a portable spectrometer and the other with a visual color chart for interpretation of the test results. One problem encountered with the kit was with restrictions and high costs associated with obtaining $KMnO_4$ reagent in several countries. The method also required too many steps in preparing standards in the field, and the strong solar radiation encountered in tropical countries, especially at high altitudes, may cause degradation of the reagent in the field. Therefore, we modified the procedure to reduce the number of steps required in standard preparation and suggested that the field test be conducted early in the morning or late in the afternoon.

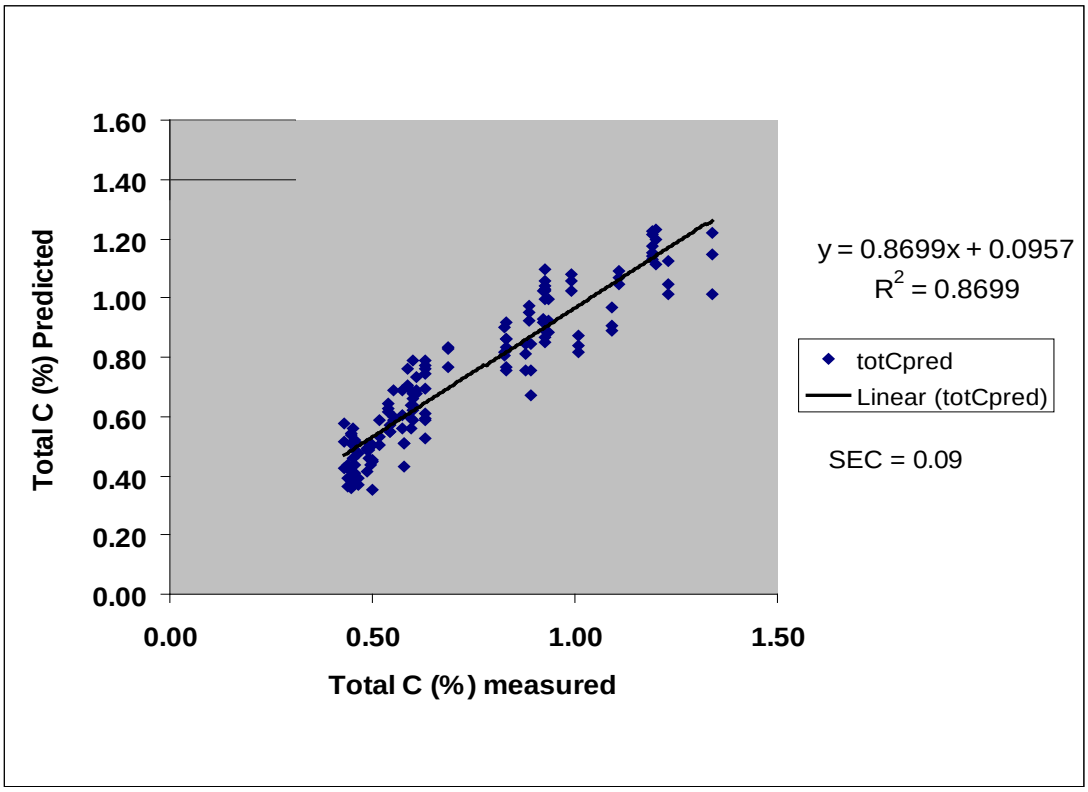
Figure 25 and Figure 26**Error! Reference source not found.** show results for use of the $KMnO_4$ test with samples from the Philippines and Indonesia. These results show that the $KMnO_4$ test can distinguish the effects of different management practices and landscape position on labile soil organic C. However, results for the Bolivian sites using the $KMnO_4$ test were less consistent. For example, measurement of labile organic C determined by the $KMnO_4$ test in communities in Umala showed a decline in labile organic C with increasing length of fallow period, which was not expected. Similarly, soils from areas in Cochabamba that were selected by farmers to be degraded and non-degraded did not show a consistent trend in labile organic C as measured by the $KMnO_4$ test. These results may indicate that the $KMnO_4$ test has limitations for use in assessing soil quality because farmer identification of degraded and non-degraded sites may be on the basis of crop production or other limiting factors, such as soil physical restrictions, that are not detected by this test.

Both the NIR and DRIFT tests showed promise for use in distinguishing soil management effects. Figure 27 shows the relationship between predicted versus actual total organic C in soil samples collected in Umala with different fallow length using NIR. Significant relationships between predicted models based on the NIR scans and the actual measured amount were also observed for water-soluble total organic C, $KMnO_4$ C and POM C. The NIR method has the advantage of being rapid and requires little sample preparation compared with DRIFT. However, portable NIR field instruments currently available may be too costly for use in developing countries. In addition, calibration information must be developed with soil samples of known characteristics before use of the NIR instrument with samples of unknown quantities, and insufficient information is available in these regions to determine whether this calibration varies from site to site for assessing soil quality based on differences in labile organic C fractions.




Comparing active C (mg C kg-1 soil) by using KMnO4 test between agroforetry and non-agroforestry
active C (mg C kg-1 soil)
600
500
400
300
200
100
0
low manure
low compost
medium manure
soil amendments
non-agroforestry
agroforestry

Results of DRIFT analysis of humic acid separated from the Umala soils are illustrated in Figure 27. The analysis used the ratio of reactive (O-containing) and recalcitrant (R) carbon functional groups (O/R ratios) as an index of soil quality to determine the effects of management practices. The higher O/R ratio found in the soils after 40 years of fallow is one indicator of the higher labile organic C pool that developed with increased fallowing. Use of fallow is an important practice for farmers in this region to restore soil fertility in degraded land after cropping. The procedure for DRIFT analysis as followed in this research may be too costly and time-consuming for routine analysis, but this procedure may be valuable as a laboratory procedure for use in soil testing and research to assess changes in soil organic C fractions, especially if whole soil samples can be used without the need for separating the humic acid fraction.



Development impact

Identification and development of simple and rapid field methods for assessing soil quality or other soil characteristics that are important for sustainable crop production are essential for evaluating soil management practices. Based on our surveys, few farmers in these regions use soil testing; therefore they have limited information to help them make management decisions. Based on the results of this project the following findings were made:

- Laboratory and field-based tests (e.g., $KMnO_4$ test) that measure more biologically available forms of soil organic matter can be indicators of changes in management practices and are relatively rapid and inexpensive tests for evaluating some forms of soil degradation.
- Near infrared spectroscopy is a rapid and nondestructive field method for evaluating changes in soil organic C fractions, but its current cost may make it less favorable for developing countries.

- Similarly, DRIFT analysis using the mid-infrared range was also effective, but its cost and the sample preparation required may make it impractical for routine analysis unless whole soil samples can be used.
- Development and testing of an inexpensive NIR field instrument that uses only limited wave lengths may have some promise for use in soil quality assessment.

Degree and non-degree training activities

This project was responsible for training one Ph.D. student from Thailand and one master's student in Indonesia. Non-degree training was conducted in Bolivia, the Philippines, and Indonesia for use of the portable field kit.

Publications, presentations, other products

Seven presentations, posters, and abstracts were produced under this project.

Networking activities

Extensive networking was undertaken with this project, including discussions with Keith Shepherd at ICRAF, Ray Weil at the University of Maryland, Roberto Quiroz of the International Potato Center (CIP), and Ken Sudduth with USDA-ARS regarding assessment of soil quality and soil organic C fractions. University researchers in Indonesia participating in this project have developed a proposal to the Indonesian government on analysis of soil quality. I would like to pursue further development of an inexpensive NIR unit either through government or private funding. I have also been asked to be a coauthor on a chapter on soil quality assessment with our collaborator in the Philippines, Nonilona Daquiado at Central Mindanao University.

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Appendixes
A. Training Participants

Table 18. Cumulative Long-Term Degree Trainees: 2004-2009

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Ghenti Constadini	M	Albanian	Agricultural Economics	Ecuador	N	Sep 06	Jun 07	PhD	Y	Y	J. Alwang	Virginia Tech
Samuel Bell	M	Australian	Applied Economics	Zambia	N	Sep 05	May 10	PhD	Y	Y	Schulze	Cornell
Diego Pacheco	M	Bolivia	Political Science	Bolivia	N	Sep 02	Apr 07	PhD	Y	Y	E. Ostrom	Indiana University
Patricia Uberhuaga	F	Bolivian	Economics	Bolivia	N	Aug 05	Dec 08	PhD	Y	Y	P. Pacheco	Royal Vet and Ag Univ, Denmark
Nadezda Amaya	F	Bolivian	Economics	Bolivia	Y	Aug 07	Dec 09	MS	Y	N	J. Alwang	Virginia Tech
Ana Sinañi	F	Bolivian	Economics	Bolivia	N	Nov 08	Aug 09	BS	Y	Y	J. Cusicanqui	UMSA
Angélica Quenta Callisaya	F	Bolivian	Agronomy	Bolivia	N	Sep 08	Sept 09	Lic	Y	N	E. Jiménez	UMSA
Betty Cruz	F	Bolivian	Agronomy	Bolivia	N	Nov 07	Jan 08	Lic			J. Cusicanqui	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Carolla Chambilla	F	Bolivian	Agroecology	Bolivia	Y	Jun 08	Jun 10	MS	Y	N	P. Motavalli	UMSS
Claudia Jarandilla	F	Bolivian	Plant Pathology	Bolivia	N	Sep 06	Mar 08	ING	Y	N	M. A. Gonzales	UMSA
Dora Aguilar Endara	F	Bolivian	Agronomy	Bolivia	N	Sep 07	Mar 08	ING	Y	N	J. Cusicanqui/ J. Pascuali	UMSA
Justina Condori	F	Bolivian	Agronomy	Bolivia	N	Oct 08	Jun 10	MS	Y	N	Jorge Cusicanqui	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	M. Peñaranda / T. Ruíz	UMSA
Olga Yana (UC)	F	Bolivian	Sociology	Bolivia	N	Sep 06	Sep 08	MS	Y	Y	E. Jiménez	Universidad de la Cordillera
Porfidia Ajata (UC)	F	Bolivian	Economics	Bolivia	N	Sep 06	Oct 08	MS	Y	N	E. Jiménez	Univ. Andina Simón Bolivar
Rina Beatriz Paredes Torrez	F	Bolivian	Biology	Bolivia	N	Oct 08	Sep 09	Lic			K. Garret	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Sonia Tola	F	Bolivian	Plant Pathology	Bolivia	N	Nov 07	Sep 08	Lic	Y	N	J. Cusicanqui	UMSA
Teresa Canaviri	F	Bolivian	Agronomy	Bolivia	N	Nov 07	Sep 08	Lic	Y	N	Karen Garrett / Jorge Cusicanqui	UMSA
Virginia Mamani	F	Bolivian	Agronomy	Bolivia	N	Oct 08	Sep 09	Lic			M. A.Gonzales	UMSA
Virginia Quispe Herrera	F	Bolivian	Agronomy	Bolivia		Sep 08	Sep 09	Lic	Y	N	M. A. Gonzales/E.Jiménez	UMSA
Viviana Vera	F	Bolivian	Plant Pathology	Bolivia	N	Oct 07	Sep 08	ING	Y	N	Miguel A. Gonzales	UMSA
Jose Carlos Claros	M	Bolivian	Agronomy	Bolivia	N	Sep 06	Sep 07	BS	Y	N	Botello	UMSS
Richard Sánchez	M	Bolivian	Economics	Bolivia	N	Aug 07	Mar 08	BS	Y	N	Amaya, Botello	UNITEPC
Alan Callisaya	M	Bolivian	Geography	Bolivia	N	Nov 08	Sept 09	Lic	Y	N	K.Garrett / J. Cusicanqui	UMSA
Antonio Paz Arcani	M	Bolivian	Agronomy	Bolivia	N	Nov 06	Aug 07	ING	Y	N	M. Peñaranda / T. Ruíz	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
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	M.A. Gonzales	UMSA
Carlos Cladera	M	Bolivian	Soil Science	Bolivia	N	Oct 07	Sep 08	ING	Y	N	M.N. Gonzales	UMSA
Dieter Fabiani Hurtado	M	Bolivian	Ecology	Bolivia	n	Oct 08	Sep 09	Lic	Y	Y	K. Garret	UMSA
Edwin Yucra	M	Bolivian	GIS Climate	USA	N	Sep 07	Dec 09	MS	Y	N	J. Gilles	UMSA
Eliceo Tangara	M	Bolivian	Soil Science	Bolivia	N	Sep 06	Sep 07	ING	Y	N	J. Aguilera	UMSA
Elvio Herrera Aruquipa	M	Bolivian	Soil Science	Bolivia	N	Oct 06	Sep 07	ING	Y	N	R. Miranda	UMSA
Freddy Navia	M	Bolivian	GIS Landscape	USA	N	Sep 07	Dec 09	MSc	Y	N	J.Gilles	UMSA
Gerardo Mamani	M	Bolivian	Agronomy	Bolivia	N	Nov 08	Aug 09	BS	Y	Y	Cusicanqui	UMSA
Gerson Alejo Aruni	M	Bolivian	Agronomy	Bolivia	n	Oct 08	Sep 09	Lic	Y	N	P. Motavalli	UMSA
Javier Aguilera Alcón	M	Bolivian	Soil Science	Bolivia	N	Aug 06	Sep 10	PhD	Y	Y	P. Motavalli	Univ. Missouri-Columbia
Jhonny Plata	M	Bolivian	Agronomy	Bolivia	N	Feb 09	Sep 09	BS	Y	Y	Cusicanqui	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Jhony Machaca	M	Bolivian	Agronomy	Bolivia	N	Nov 08	Aug 09	BS	Y	Y	Cusicanqui	UMSA
Juan Sipe	M	Bolivian	Soil Science	Bolivia	N	Oct 07	Sep 08	ING	Y	N	M. A. Gonzales	UMSA
Julio Sarmiento Vargas	M	Bolivian	Agronomy	Bolivia	N	Nov 06	Aug 07	ING	Y	N	J. Cusicanqui/ D. Cruz	UMSA
Marco A. Vasquez	M	Bolivian	Agronomy	Bolivia	N	Feb 09	Sep 09	BS	Y	Y	Cusicanqui	UMSA
Marcos Willy Quispe	M	Bolivian	Soil Science	Bolivia	N	Oct 07	Sep 08	ING	Y	N	R. Miranda	UMSA
Miguel Angel Gonzales Aldana	M	Bolivian	Plant Pathology	Bolivia	N	May 07	May 09	MS	Y	N	K. Garrett	UNALM
Milan Mamani	M	Bolivian	Biodiversity	Bolivia	N	Sep 06	Sep 07	ING	Y	N	M. A. Gonzales	UMSA
Mirco Peñaranda	M	Bolivian	Water Resources	Bolivia	N	Jul 08	Jun 10	MS	Y	N	J. Cusicanqui	UMSA
Rene Luque	M	Bolivian	Agronomy	Bolivia	N	Nov 08	Aug 09	BS	Y	Y	J. Cusicanqui	UMSA
Reynaldo Mamani	M	Bolivian	Agronomy	Bolivia	N	Nov 08	Aug 09	BS	Y	Y	J. Cusicanqui	UMSA

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Romulo Torrez	M	Bolivian	Soil metagenomics	Bolivia	N	Aug 08	Sep 09	MS	Y	N	K.Garrett/R. Miranda	UMSA
Javier Osorio	M	Bolivian	BSE	Ecuador/ Bolivia	N	Jan 07	Dec 09	PhD	N	Y	Wolfe	Virginia Tech
Juan Carlos Huarachi	M	Bolivian	Agronomy	Bolivia	N	Dec 08	Oct 09	BS	Y	N	Saavedra, Vargas	UMSS
Juan Pablo Peñaloza	M	Bolivian	Agronomy	Bolivia	N	Jul 08	Oct 08	BS	Y	N	Saavedra	UMSS
Griselda Gonzales	F	Bolivian	Ag innovation	Bolivia	N	Apr 07	Apr 09	MS	Y	N	Elizabeth Jiménez	CIDES - UMSA
Alejandro Romero	M	Bolivian	Rural Devel.	Bolivia	N	Apr 08	Apr 09	MS	Y	N	E. Jiménez	CIDES - Universidad Mayor de San Andres
Gustavo Medeiros	M	Bolivian	Rural Devel.	Bolivia	N	Sep 08	Sept 09	MS	Y	N	E. Jiménez	UMSA
Pam Jagger	F	Canadian	Political Science	Uganda	N	Sep 03	Sep 08	PhD	Y	Y	E. Ostrom	Indiana Univ
Catherine LaRochelle	F	Canadian	Economics	Ecuador/ Bolivia	N	Aug 06	Aug 09	PhD	Y	Y	Alwang	Virginia Tech
Juana Chamacho	F	Colombian	Anthropology	Ecuador/Peru	N	Jan 05	Jun 06	PhD	Y	N	Nazarea	University of Georgia
Lorena Gomez	F	Colombian	Soil metagenomics	USA	N	Jan 08	Sep 09	MS	Y	N	Karen Garrett	Kansas State

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Rasmus Lybaek	M	Danish	Information and Media Studies	Vietnam	N	Oct 06	Dec 06	MS	Y	Y	DT Ha	Aarhus University
Eugenia Núñez	F	Ecuadorian	Social Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Barrera	Universidad de Bolivar
Marcia Salazar	F	Ecuadorian	Agricultural Economics	Vietnam, Latin America	N	Aug 05	Aug 06	MS	Y	N	Gerald Shively	Purdue
Martha Gonzalez	F	Ecuadorian	Social Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	V. Barrera	Universidad de Bolivar
María Figueroa	F	Ecuadorian	Agricultural Economics	Ecuador	N	Sep 06	Aug 08	MS	Y	Y	C. Valdivia	University of Missouri Columbia
Luis Escudero	M	Ecuadorian	Agronomy	Ecuador	N	Aug 08	Jul 10	MS	Y	N	Barrera	Universidad Cotopaxi
Victor Barrera	M	Ecuadorian	Social Science	Ecuador	Y	Aug 06	Nov 08	PhD	Y	Y	Alwang	Universidad de Madrid
Carlos Montúfar	M	Ecuadorian	Environmental sciences	Ecuador	N		Mar 10	MS	Y	Y	Barrera	Universidad SEK
Dely Chavez	M	Ecuadorian	Soils and water	Ecuador	N	Aug 06	Sep 07	BS	Y	N	F. Valverde	Universidad Estatal de Bolivar
Edwin Chela	M	Ecuadorian	Soil Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Valverde	Universidad de Bolivar
Moazir Celleri	M	Ecuadorian	Social Science	Ecuador	N	Jan 07	Jan 08	BS	Y	N	Barrera	Universidad de Bolivar

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Raul Jaramillo	M	Ecuadorian	Soils-Horticulture	Ecuador	N	Jun 06	Jun 08	PhD	Y	Y	Lynch	Penn State
Robert Andrade	M	Ecuadorian	Economics	Ecuador	N	Aug 06	Aug 08	MS	Y	Y	Alwang	Virginia Tech
Charmaigne Pailagao	F	Filipino	Environmental Science	Philippines	N	Jun 08	Mar 09	MS	Y		Ma. Victoria Espaldon	UPLB
Isidra Bagares	F	Filipino	Public Policy	Philippines	N	Jun 08	May 09	MPA	Y	Y	Agnes C. Rola	UPLB
Janice B. Sevilla	F	Filipino	Envi. Science	Philippines	N	Nov 06	Mar 09	MS	Y	N	Victoria Espaldon	UPLB
Laarni Lacundula	F	Filipino	Envi. Science	Philippines	N	Oct 06	Mar 07	PhD	Y	N	V. Espaldon	Univeristy of the Philippines-Los Baños
Nelsa J. Olila	F	Filipino	Agricultural Economics	Philipines	N	Jan 08	Mar 09	PhD	Y	Y	Victor B. Ella	Central Mindanao University
Andre Quiray	M	Filipino	Envi Science	Philippines	N	Jun 08	Mar 09	MS	Y	N	Ma. V. Espaldon	UPLB
Jerico Tolentino	M	Filipino	Computer Science	Philippines	N	Jan 06	Sep 07	Diploma	N	Y	J. Saludadez	UP-open
Nathaniel R. Albuyog	M	Filipino	Ag Engineer	Philippines	N	mm m 07	mm m 08	PhD	Y	Y	V. B. Ella	UPLB
Noel Gordolan	M	Filipino	Ag Engineer	Philippines	N	Oct 06	Aug 07	BS/MS	Y	Y	V. B. Ella	UPLB

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Jacelie E.Alvarez	F	Filipino	Development Communication	Philippines	N	Sept 08	Oct 08	BS	N	Y	J. Saludadez	UPLB
Priya Bhagowalia	F	India	Ag Economics	Philippines, Vietnam	N	Sep 04	Jun 05	PhD	Y	N	Shively	Purdue
Dileep Birur	M	India	Ag Economics	Philippines, Vietnam	N	Jan 05	Jun 05	PhD	Y	Y	G. Shively	Purdue
Anurag Mishra	M	Indian	BSE	global	N	Aug 05	Sep 08	PhD	Y	Y	Benham/ Mostaghimi	Virginia Tech
Juang G. Kartika	F	Indonesian	Horticulture	Indonesia	N	mm m 06	mm m 08	MS			Anas D. Susila	Bogor Agricultural University
Mega Ayu Lestari	F	Indonesian	Horticulture	Indonesia	N	Aug 07	Dec 07	BS	Y	Y	Purworko	Bogor Agricultural University
Nia Kurniatusholiha t	F	Indonesian	Horticulture	Indonesia	N	Aug 07	Dec 07	BS	Y	Y	Purworko	Bogor Agricultural University
Novita Novaliana	F	Indonesian	Horticulture	Indonesia	N	Aug 07	Dec 07	BS	Y	Y	Purworko	Bogor Agricultural University
Prima Rahanita	F	Indonesian	Horticulture	Indonesia	N	Aug 07	Dec 07	BS	Y	Y	Anas D. Susila	Bogor Agricultural University
Ratna Pambayun	F	Indonesian	Horticulture	Indonesia	N	Aug 07	Dec 07	BS	Y	Y	Purworko	Bogor Agricultural University

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Tin Herawati	F	Indonesian	Family and Consumer Science	Indonesia	N	Aug 08	May 11	PhD	Y	Y	Trikoesoemaningtyas	Bogor Agricultural University
Didik Hermanto	M	Indonesian	Horticulture	Indonesia	N	Aug 07	Dec 07	BS	Y	Y	Purwoko	Bogor Agricultural University
Edy Setywan	M	Indonesian	Plant Protection	SE Asia	N	Aug 05	Dec 09	PhD	Y	Y	Rauf/ A.D. Susila	Bogor Agricultural University
Tisna Prasetyo	M	Indonesian	Horticulture	Indonesia	N	mm m 08	mm m 10	MS	Y	N	A. D. Susila	Bogor Agricultural University
Maki Hasegawa Pajaro	F	Japanese	Computer Science	Philippines	N	July 07	Sept 08	MS	N	Y	J. Saludadez	UPLB
Lydiah Gatere	F	Kenyan	Soil & Crop Science	Zambia	N	May 06	May 10	PhD	Y	Y	Lehmann	Cornell
Younggu Her	M	Korea	BSE	Zambia, Bolivia, Ecuador	N	mm m 07	mm m 10	PhD	Y	N	Heatwole	Virginia Tech
Moussa Keita	M	Mali	Local Devel	Mali	N	Jan 04	Jun 06	DEA	Y	Y	K. M. Moore/Cisse	Delta-C
Cecilia Turin Canchaya	F	Peruvian	Rural Sociology	USA	N	Aug 07	Dec 10	PhD	Y	Y	J. Gilles	UNALM
Doris Bartolo	F	Peruvian	Ag innovation	Peru	N	Mar 07	Dec 08	MS	Y	N	Silvana Vargas	UNALM

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Helen Villanueva	F	Peruvian	Biology	Peru	N	Nov 06	Nov 08	MSc	Y	N	Karen Garrett	Universidad Nacional Mayor de San Marcos
Jenny Choque Flores	F	Peruvian	Ag. Innovation	Peru	N	Mar 07	Dec 08	MS	Y	N	Jan Flora	UNALM
Olga Rita Quispe	F	Peruvian	Agricultural innovation	Peru	N	Mar 08	Sep 09	MS	Y	N	E. F. Baca	UNALM
Rubi Raymundo	F	Peruvian	Plant Pathology	Peru	N	Aug 06	Aug 07	MS	Y	Y	Forbes/Garrett	UNALM
Guido Yactayo	M	Peruvian	BSE	Bolivia/ Ecuador	N	Aug 07	May 09	MS	N	Y	Mary Wolfe	Virginia Tech
Alex Fernandez	M	Peruvian	Ag innovation	Peru	N	Mar 08	Sep 09	MS	Y	N	E. F. Baca	UNALM
Christian Candela	M	Peruvian	Ag innovation	Peru	N	Mar 07	Sep 09	MS	Y	N	E.F.Baca	UNALM
Clovis Bailon Flores	M	Peruvian	Ag innovation	Peru	N	Mar 07	Dec 08	MS	Y	N	S. Vargas	UNALM
Jorge Pretel	M	Peruvian	Statistics	Peru	N	Mar 06	Sep 07	ING	Y	N	K. Garrett	UNALM
Pedro Camacho	M	Peruvian	Ag innovation	Peru	N	Mar 08	Sep 09	MS	Y	N	E. F. Baca	UNALM
Oleg Stakhanov	M	Russian	Political Science/Sociology	Uganda	N	Aug 05	Aug 06	MS	Y	N	A. Manu	Iowa State University

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Bunjirtluk Jintaridth	F	Thai	Soil Quality	Bolivia	N	Aug 07	Sep 09	PhD	Y	N	P. Motavalli	Univ of Missouri-Columbia
Aksarapak Wongcharoen	F	Thai	Economics	Vietnam	N	2004	2008	PhD	Y	Y	Coxhead	University of Wisconsin
Bunjirtluk Jintaridth	M	Thai	Soil Science	Bolivia	N	Aug 07	Sep 09	PhD	Y	N	P. Motavalli	UMSA
Evelyn Lwanga	F	Ugandan	Political Science	Uganda	N	Aug 01	Dec 08	PhD	Y	N	E. Ostrom	Indiana Univ
Amy Duchelle	F	USA	Forestry	Bolivia	N	Aug 03	Jun 08	PhD	Y	Y	P. Pacheco	Univ of Florida
Alexandra Silva	F	USA	Natural Resources	Zambia	N	Oct 08	May 09	BS	Y	Y	Travis	Cornell
Danielle Buttke	F	USA	Biomedical Sciences	Zambia	N	Aug 04	May 10	DVM	N	Y	A. Travis	Cornell
Emily Steubing	F	USA	Veteranary Medicine	Zambia	N	May 08	Sep 09	DVM	Y	Y	A. Travis	Cornell
Erin McDonald	F	USA	Veterinary Medicine	Zambia	N	Jun 05	May 08	DVM	Y	Y	B. Lucio/A. Torres	Cornell
Sarah Katt	F	USA	Business	Zambia	N	Aug 04	May 06	MBA	Y	Y	N/A	Cornell University
Tamika Lewis	F	USA	Verterinary Medicine	Zambia	N	Sep 05	Jun 09	DVM	N	Y	Travis/Pell	Cornell
Amelia Henry	F	USA	Soils-Horticulture	Ecuador	N	Jun 06	Jun 08	PhD	Y	Y	Lynch	Penn State

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Anissa Polatewich	F	USA	Plant Pathology	Bolivia	N	Sep 07	Dec 09	PhD	Y	Y	Backman	Penn State
Julia Pryde	F	USA	Engineering	Ecuador	N	April 06	Sep 06	MS	Y	Y	M. Wolfe	Virginia Tech
Rachel Melnick	F	USA	Plant Pathology	Ecuador/ Bolivia	N	Jun 06	Jun 10	PhD	Y	Y	Backman	Penn State
Erin Frank	F	USA	Plant Pathology	USA	N	Aug 07	Sep 07	MS	Y	Y	Karen Garrett	Kansas State
Jeanne Thibeault	F	USA	Climate/Geography	USA	N	Aug 06	Aug 09	PhD	Y	Y	A. Seth	University of Connecticut
Lisa Rees	F	USA	Agricultural Economics	USA	N	Jun 06	Aug 09	PhD	Y	Y	C. Valdivia / L. Marks	University of Missouri Columbia
Shauna P. Dendy	F	USA	Plant Pathology	USA	N	Jun 06	May 07	MS	Y	Y	K. Garrett	Kansas State
Jessica Perdew	F	USA	Agricultural Economics	Indonesia	N	Aug 05	Jun 06	MS	Y	Y	Gerald Shively	Purdue
Sally Walker	F	USA	BSE	Bolivia	N	mm m 08	mm m 09	MS		Y	Heatwole	Virginia Tech
Eric Coleman	M	USA	Political Science	global	N	Sep 03	May 09	PhD	Y	Y	E. Ostrom	Indiana University
Forrest Fleischmann	M	USA	Public Policy	All	N	Sep 07	May 12	PhD	Y	Y	E. Ostrom	Indiana University
Colin Seeley	M	USA	Food Science	Zambia	N	Sep 08	Sep 09	MPS	Y	Y	Moraru	Cornell University

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Colin Deschamp	M	USA	Civil/Env Eng	global	N	Jan 05	Dec 06	MS	Y	Y	Mostafhimi	Virginia Tech
Johannes Postma	M	USA	Horticulture	Bolivia/ Ecuador	N	Jun 06	Jun 07	PhD	Y	Y	Lynch	Penn State
Mike Castelhano	M	USA	Economics	Ecuador	N	Aug 06	Aug 08	MS	Y	Y	Alwang	Virginia Tech
Adam Sparks	M	USA	Plant Pathology	Bolivia, Peru, Ecuador	N	Jan 07	Apr 09	PhD	N	Y	K. Garrett	Kansas State
Justin Thomas M.	M	USA	Rural Sociology	USA	N	Sep 07	Sep 09	PhD	Y	Y	J. Gilles	Univ. Missouri-Columbia
Dulani Woods	M	USA	Ag Economics	USA	N	Aug 07	mm m 09	MS	Y		G. Shively	Purdue
Patrick Ward	M	USA	Ag Economics	global	N	Jan 09	mm m 11	PhD	Y	Y	G. Shively	Purdue
Gustavo Garcia Lopez	M	USA	Political Science	Mexico	N	Aug 05	May 10	PhD	Y	Y	E. Ostrom	Indiana University
Diep Phan	F	Vietnam	Economics	Vietnam	N	2002	2007	PhD	Y	Y	Coxhead	University of Wisconsin
Duong Tran Lan Anh	F	Vietnamese	Agronomy	Vietnam	N	Sep 05	Sep 09	BS	Y	Y	LV Du	Nong Lam University

STUDENT NAME	Sex (M/F)	Nationality	Discipline	Country(s) Supported	Sandwich Program(Y/N)	Start Date	End Date	Degree	SANREM CRSP (Y/N)	Non-SANREM CRSP (Y/N)	SANREM CRSP Advisor/PI	University or Degree Granting Institution
Luong Thi Bich Van	F	Vietnamese	Agricultural Economics	Vietnam	N	Sep 04	Dec 07	BS	Y	Y	LV Du, DT Ha	Nong Lam University
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	Vietnamese	Agricultural Economics	Vietnam	N	Sep 04	Dec 07	BS	Y	Y	ND Thanh, DT Ha	Nong Lam University
Hoang Van Anh	M	Vietnamese	Agricultural Economics	Vietnam	N	Aug 06	Jan 07	BS	Y	Y	DT Kim Lan	Nong Lam University
Huynh Van Lao	M	Vietnamese	Agricultural Economics	Vietnam	N	Oct 05	Nov 07	MS	Y	Y	DT Ha	Nong Lam University
Le Van Nhu	M	Vietnamese	Agronomy	Vietnam	N	Jan 08	Dec 08	BS	Y	Y	Le Van Du	Nong Lam University
Vuong Hoang Cuong	M	Vietnamese	Agricultural Economics	Vietnam	N	Aug 06	Jan 07	BS	Y	Y	DT Kim Lan	Nong Lam University
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 07	Sep 09	MS	Y	N	Eloundou-Enyegue	University of Zambia
Vongai Kandiwa	F	Zimbabwean	Devel Sociology	Zambia	N	Sep 04	Jul 09	PhD	Y	Y	Eloundou-Enyegue	Cornell

Table 19. Non-degree Training Activities: FY2009

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Bolivia						
Field Day	June 2009	Vinto Coopani farmers, Umala	18	8	PROINPA	Observe the reproduction process at Patacamaya Lab.
Field Day	June 2009	San Juan Circa, Umala	10	7	PROINPA	Review the life cycle of the potato weevil.
Field Day	June 2009	Kellhuiri/Llujturi, Umala	8	5	PROINPA	Inform about the different stages of pest development.
Seminar	October 17 2008	Participants from the Peruvian National Association of Animal Sciences	95	100	Corinne Valdivia, University of Missouri	The role of livestock in Andean Livelihoods in the Context of Climate Change
Seminar	October 17 2008	Masters students in UMSA's Natural Resource Management Class	9	6	Jere Gilles, University of Missouri	Bridging local and scientific knowledge
Seminar	October 18 2008	Students in the Universidad de la Cordillera's bilingual education program	14	8	Jere Gilles, University of Missouri	Impacts of climate change
Seminar	October 21 2008	USAID officers Peru Mission	8	7	Corinne Valdivia and Edith Fernandez Baca, Universidad Nacional Agraria La Molina and University of Missouri	Climate change projections for the Altiplano; social capital and advocacy coalitions in adaptation strategies.
Seminar	January 9 2009	USAID Bolivia officers and stakeholders	13	8	University of Connecticut University of Missouri	Findings form research on Climate Projections for Altiplano mid and end of century; implication for soils
Seminar	February 2009	Students and faculty at KSU, PROINPA, WSU, and OSU	9	6	Kansas State University	Gaining a shared knowledge of soil metagenomics experiments, including joint preparation of a manuscript for publication
Seminar	Apr-Jun 2009	2 junior researchers on the CERES team	2	0	CERES	Certification by Latin American Council of Social Sciences
Seminar	June 24 2009	Researchers in Climate Change Community from Bolivia Peru and the US	7	10	Universidad Mayor San Andrés; U Conn; MU	Share findings and discuss development of working group on modeling climate & adaptation
Seminar	June 29-30 2009	Researchers, practitioners and students La Paz Bolivia and Lima Peru	32	26	Universidad Mayor de San Andrés; Universidad de la Cordillera; MU	Share the knowledge, research findings of SANREM in the Andes.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Short course	07/10/2008	Farmers	29	18	PROINPA	Pest control in potatoes and water quality
Short course	30/10/2008	Farmers	15	4	PROINPA	Soil health, compost and water quality
Short course	10/12/2008	Farmers	12	13	PROINPA	Soil health, compost and water quality
Short course	January 2009	Farmers from Chojñapata community, Ancoraimes.	6	7	Universidad Mayor de San Andrés	Strengthen knowledge about the life cycle of the Andean weevil and potato moth.
Short course	January 2009	Farmers from Cohani community, Ancoraimes.	4	8	Universidad Mayor de San Andrés	Strengthen the knowledge of the life cycle of Andean weevil and potato moth.
Short course	January 2009	Farmers from Cohani community, Ancoraimes.	3	8	Universidad Mayor de San Andrés	Strengthen basic knowledge of the handling and applying of agrochemicals.
Short course	January 2009	Farmers from Calahuancane Baja community, Ancoraimes.	6	9	Universidad Mayor de San Andrés	Strengthen the knowledge of Andean weevil and potato moth life cycle.
Short course	March 26 2009	Farmers from the community of Chojñapata, Ancoraimes	5	5	Universidad Mayor de San Andrés	Integrated management of Andean potato weevil. Understanding the different control methods that can be applied in the community.
Short course	April 8 2009	Farmers from the community of Calahuancane Baja, Ancoraimes	7	5	Universidad Mayor de San Andrés	Integrated management of Andean potato weevil. Understanding the different control methods that can be applied in the community.
Short Course	April 23 2009	Farmers from the community of Calahuancane Baja, Ancoraimes	16	4	Universidad Mayor de San Andrés	External parasite dips, (cattle, sheep, camelids, hogs).
Short Course	April 24 2009	Farmers from the community of Cohani.Ancoraimes	25	7	Universidad Mayor de San Andrés	External parasite dips, (cattle, sheep, camelids, hogs).
Short Course	May 15 2009	Farmers from the community of Chojñapata, Ancoraimes	14	4	Universidad Mayor de San Andrés	External parasite dips, (cattle, sheep, camelids, hogs).
Short course	07/10/2008	Farmers	29	18	PROINPA	Pest control in potatoes and water quality
Short course	30/10/2008	Farmers	15	4	PROINPA	Soil health, compost and water quality

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Short course	10/12/2008	Farmers	12	13	PROINPA	Soil health, compost and water quality
Workshop	Aug dates in 2008	Students and faculty in La Paz, Bolivia, from UMSA, PROINPA, and other institutions			Kansas State University with UMSA	Provide a general understanding of soil metagenomics and its application for analysis of soil management decisions
Workshop	October 2008	Cross-Cutting Gender Researchers from Ecuador, Peru and Bolivia	13	18	HC consultant (Susan Poats)	To bring together researchers from the region to participate in a full-day gender workshop.
Workshop	October 2008	Students participating in LTRA 3 and 4	2	8	US Universities (Maria Elisa Christie; Jere Gilles)	Mastery of concepts: the difference between control and access of natural resources; the difference between focus groups and group interviews; techniques for how to carry out interviews that are culturally sensitive; and advise on networks and methodologies to the group
Workshop	October 2008	Vinto Coopani farmers, Umala	16	8	PROINPA	Research products and quinoa varieties information
Workshop	October 2008	San Juan Circa farmers, Umala	20	5	PROINPA	Sharing research products and quinoa varieties
Workshop	October 2008	Llujturi/Kellhuiri farmers, Umala	6	4	PROINPA	Returning research results about quinoa varieties
Workshop	October 21-23, 2008	Bolivian graduate students supported by SANREM	2	4	Jere Gilles, University of Missouri	Recording and analysis of qualitative data
Workshop	October 23 2008	Team of researchers and students in Bolivia	6	7	Corinne Valdivia, University of Missouri	S*ocializacion*, methods and process of knowledge integration and sharing with community research groups
Workshop	03/11/2008	Local stakeholders	3	8	PROINPA	Watershed management and agricultural production
Workshop	24/11/2008	Local stakeholders	11	6	PROINPA	Watershed management and agricultural production
Workshop	December 2008	Farmers from the community of Calahuancani, Ancoraimes.	12	9	Universidad de la Cordillera	Share research results on climate and market changes
Workshop	December 2008	Farmers from the community of Cohani, Ancoraimes.	7	14	Universidad de la Cordillera	Share research results on climate and market changes

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	December 2008	Farmers from the community of Chinchaya, Ancoraimes.	21	17	Universidad de la Cordillera	Share research results on climate and market changes
Workshop	December 2008	Community farmers, Chojñapata, Ancoraimes.	5	8	Universidad de la Cordillera	Climate and market changes knowledge sharing
Workshop	December 2008	Farmers from Chinchaya community, Ancoraimes.	22	16	Universidad Mayor de San Andrés	Present 2 years of research results on management of pests, soils, and climate.
Workshop	December 2008	Farmers from Cohani community, Ancoraimes.	7	14	Universidad Mayor de San Andrés	Present research results of 2 years of research on pest management, soils & climate.
Workshop	December 2008	Farmers from Calahuancane Baja community, Ancoraimes.	11	10	Universidad Mayor de San Andrés	Present research results of 2 years of findings on pest management, soils & climate.
Workshop	December 2008	Farmers from Chojñapata community, Ancoraimes.	11	12	Universidad Mayor de San Andrés	Present research results of 2 years of findings on pest management, soils & climate.
Workshop	January 14 2009	SENAMHI Peru and the Ministry of the Environment	0	16	University of Connecticut and University of Missouri	Findings from research on adaptation and climate change projections for the northern Altiplano, and research experiences of SENAMHI
Workshop	2/2009	PROINPA & University	13	9	Penn State (Melnick)	Bio-control and biofumigants
Workshop	2/2009	PROINPA & University	7	5	Penn State (Poleatewich)	Bio-control and use of endophyte bacteria
Workshop	February 2009	Farmers from the community of Vinto Coopani, Umala.	15	13	Universidad de la Cordillera	Share research results on climate and market changes
Workshop	3/26/09	Professionals from PROINPA and UMSA	7	1	University of Missouri	To train professionals in PROINPA and UMSA to use soil quality kit.
Workshop	28/02/2009	Farmers	18	23	PROINPA	Soil health, compost and water quality
Workshop	3/2009	PROINPA & University	18	16	Virginia Tech (LaRochelle)	Risk and inefficiency: a GIS approach
Workshop	22/03/2009	Farmers	25	22	PROINPA	Soil health, compost and water quality
Workshop	February 2009	Farmers from Cohani community, Ancoraimes.	1	8	Universidad Mayor de San Andrés	Integrated management of the Andean weevil (first part). Awareness of different control methods useful to community.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	Februray 11, 2009	Farmers from the community of Chojñapata, Ancoraimes.	5	7	Universidad Mayor de San Andrés	Practical use and application of pesticides. Reinforce basic knowledge of agrochemicals management.
Workshop	Februrary 18, 2009	Farmers from the community of Chinchaya, Ancoraimes.	12	5	Universidad Mayor de San Andrés	Practical use and application of pesticides. Reinforce refresh basic knowledge of agrochemicals management.
Workshop	March 18, 2009	Farmers from the community of Chinchaya, Ancoraimes.	11	0	Universidad Mayor de San Andrés	Integrated management of Andean potato weevil; different control methods useful to the community.
Workshop	April 2009	Farmers from the community of Kelluiri, Umala.	18	8	Universidad de la Cordillera	To present research results on climate and market changes
Workshop	May 06 2009	Farmers from the community of Calahuancane Baja, Ancoraimes	9	5	Universidad Mayor de San Andrés	Strengthen knowledge of the Andean potato weevil and integrated pest controls.
Workshop	May 13 2009	Farmers from the community of Cohani, Ancoraimes	13	11	Universidad Mayor de San Andrés	Strengthen knowledge of the Andean potato weevil and integrated pest controls.
Workshop	May 20 2009	Farmers from the community of Calahuancane Baja, Ancoraimes	8	9	Universidad Mayor de San Andrés	Strengthen and deepen understanding of climate change, through the projection of videos.
Workshop	May 2009	Farmers from the community of San Juan Circa, Umala.	36	4	Universidad de la Cordillera	To present the research results on Climate and market changes
Workshop	May 2009	Vinto Coopani / Kellhuiri farmers, Umala	22	8	PROINPA	Review the life cycle of the potato weevil.
Workshop	May 2009	San Juan Circa farmers, Umala	7	3	PROINPA	Training on quinoa moth and *Ticona.*
Workshop	May 20 2009	Farmers from the community of Chinchaya, Ancoraimes	23	6	Universidad Mayor de San Andrés	Strengthen knowledge of the Andean potato weevil and integrated pest management.
Workshop	May 21 2009	Farmers from the community of Chojñapata, Ancoraimes	4	8	Universidad Mayor de San Andrés	Strengthen knowledge of the Andean potato weevil and integrated pest management.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	May 26 2009	Farmers from the community of Cohani, Ancoraimes	8	10	Universidad Mayor de San Andrés	Strengthen and deepen understanding of climate change, through the projection of videos.
Workshop	May 29 2009	Farmers from the community of Calahuancane Baja, Ancoraimes	5	9	Universidad Mayor de San Andrés	Strengthen and deepen the knowledge and aspirations in product development, based on experiences from other regions (irrigation and soil conservation).
Workshop	June 9 2009	Farmers from the community of Cohani, Ancoraimes	9	8	Universidad Mayor de San Andrés	Strengthen and deepen the knowledge and aspirations in product development, based on experiences from other regions (irrigation and soil conservation).
Workshop	June 17 2009	Farmers from the community of Chinchaya, Ancoraimes	28	7	Universidad Mayor de San Andrés	Strengthen and deepen understanding of climate change, through the projection of government videos.
Workshop	June 25 2009	Farmers from the community of Chojñapata, Ancoraimes	5	10	Universidad Mayor de San Andrés	Strengthen and deepen the knowledge, and aspirations about the development of product experiences from other regions (irrigation and soil conservation).
Workshop	June 26 2009	Farmers from the community of Chinchaya, Ancoraimes	22	7	Universidad Mayor de San Andrés	Strengthen and deepen the knowledge and aspirations in product development, based on experiences from other regions (irrigation and soil conservation).
Workshop	June 28 2009	Farmers from the communities of Chinchaya, Cohani, Calahuancane, and Chojñapata. Leaders from Peru.	17	14	Universidad Mayor de San Andrés; UNLAM; MU	Project researchers visit with producers of Peru. Exchange experiences on pests, climate and soils, between producers in the region.
Workshop	July 6-8 2009	Students and faculty in La Paz, Bolivia, from UMSA, PROINPA, and other institutions	14	11	Karen Garrett and Lorena Gomez, KSU, in collaboration with UMSA	Provide experience in using the R programming environment for data analysis in agricultural experiments, using published peer-reviewed training publications as background

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	July18 2009	Farmers from the community of Chojñapata, Ancoraimes	6	7	Universidad Mayor de San Andrés	Strengthen and deepen understanding of climate change, through videos.
Workshop	July 27 2009	Farmers from the communities of Chinchaya, Cohani, Calahuancane, and Chojñapata, in Ancoraimes	8	7	Universidad Mayor de San Andrés	Improve farmers marketing skills. Where to sell their agricultural products.
Workshop	September 2009	Community representatives, CERES team	17	4	CERES	To present research results, lead communities in exchange and visioning process, present technical folders with data and other information
Workshop	September 2009	Community and agency representatives; CERES team	31	10	CERES	Present research results from both countries, share findings and experiences
Workshop	October 2009	Students from PROINPA, UMSA, U-CORDILLERA, UNALM, INIAP-Ecuador, CERES SANREM, PIEB, Intercoopoeration La Paz	13	18	Universidad de la Cordillera-Virginia Tech	"Gender and participation in natural resource management for sustainable development: concepts, methods and examples"
Ecuador						
Field day	24/06/2009	Farmers, professionals and partners	131	81	INIAP, Virginia Tech	Natural resource management. Illangama river
Field day	19/11/2008	Farmers, professionals and partners	105	35	INIAP, MAGAP	Implementation of activities in IPM in cultivation of Blackberry. Alumbre river
Short course	13/10/2009	Farmers	16	9	INIAP	Soil conservation practices. Alumbre river.
Short course	14/10/2009	Farmers	20	10	INIAP	Soil conservation practices. Illangama river.
Workshop	02/10/2008	Professionals INIAP and partners	16	10	INIAP	Livelihoods: methodologies and their implications for the analysis of economics.
Workshop	23/10/2008	Farmers	25	15	INIAP	Training on natural resource management. Illangama river
Workshop	09/12/2008	Farmers	25	10	INIAP	Training in Integrated Management of tomato in Alumbre river

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	10/12/2008	Farmers	13	12	INIAP	Training in Integrated Pest Management in cultivation of potatoes. Illangama river
Workshop	11/12/2008	Farmers	23	14	INIAP	Training in Integrated Pest Management in the cultivation of grass. Illangama river
Workshop	12/03/2009	Farmers	69	49	SENAGUA	Social networking and water management institutions. Illangama river
Workshop	19/03/2009	Farmers	23	14	SENAGUA	Social networking and water management institutions. Guaranda river
Workshop	24/03/2009	Farmers	51	11	SENAGUA	Social networking and water management institutions. Illangama river
Workshop	14/04/2009	Farmers	17	19	INIAP	Training in human nutrition. Alumbre river
Workshop	15/04/2009	Farmers	13	18	INIAP	Training in human nutrition. Illangama river
Workshop	27/05/2009	INIAP Staff	12	13	Alwang & Barrera	Socioeconomics in watershed management (at INIAP in Quito)
Workshop	15/09/2009	Farmers	15	7	INIAP	Training in water resource management. Illangama river
Workshop	16/09/2009	Farmers	15	7	INIAP	Training in water resource management. Alumbre river
Workshop	23/09/2009	Professionals	10	5	Universidad San Francisco (Quito); Dr. Wills Flowers (Fl A&M)	Principles of biomonitoring
Workshop	06/10/2009	Farmers	17	8	Universidad Estatal de Bolívar	Training in pasture management. Illangama river.
Indonesia						
Short course	12/1/08	Professionals and students from Bogor Agricultural University	2	1	University of Missouri	Train professionals and students in Bogor Agricultural University to use the soil quality kit.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Kenya						
Workshop	Apr-Jun 2009	Government ministries, forest user groups, community members	45	16	KEFRI	Community members in Aberdares and Ramogi were trained in forest rehabilitation, nursery management, seed production and storage, etc; groups were also trained in group dynamics, conflict resolution, and leadership; proposal writing, problem identification, and participatory skills were also addressed
Mexico						
Workshop	Jan-Mar 2009	Community reps from 42 communities in Oaxaca, Mexico	30	12	UNAM	Discuss the nationals survey conducted by Mexico, develop community strategies
Peru						
Workshop (1st)	November 2008	Farmer from Santa María Community	7	8	UNALM	Identify and differentiate types of soils in private plots and aynocas. Soil sampling.
Workshop	December 2008	Farmer from Apopata Community	25	19	UNALM	Share survey information with community.
Workshop	January 2009	Farmer from Santa María Community	20	05	UNALM	Share survey information with community.
Workshop	January 2009	Farmer from Santa María Community	10	0	UNALM	Soil sampling of the community.
Workshop (2nd)	February 25 2009	Farmers, members of Santa María Community	11	07	UNALM	Mounding or hilling to reduce pest load in potato production.
Worshop (2nd)	February 23 2009	Farmers, members of Santa María Community	8	12	UNALM	IPM for the Andean potato weevil. Collect adult weevils to minimize attack of pest.
Workshop	March 21 2009	Farmer from Santa María Community	9	11	UNALM	Diagnosing and monitoring fields for degree of pests & diseases in potato (Aynocas).
Workshop	April 25 2009	Farmer from Santa María Community	14	10	UNALM	Assess the condition of potato production.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	May 2009	Farmer from Santa María Community	6	4	UNALM	Soil sampling in two land management systems (Aynokas and private).
Workshop	May 2009	Farmer from Santa María Community	6	4	UNALM	Soil sampling in two land management systems (Aynokas and private).
Workshop	May 22 2009	Farmer from Santa María Community	18	23	UNALM	Use of a new technology for potato harvest (Aynocas).
Workshop	June 20 2009	Farmer from Santa María Community	12	10	UNALM	Strengthening knowledge regarding potato storage and seed selection.
Workshop	July 22-24 2009	Farmers from Apopata	6	0	UNALM	GPS training for community resources mapping, including water and household locations.
Workshop	July 28 2009	Farmers from Santa María	6	2	UNALM	GPS training and mapping of community resources and household locations.
Workshop	July 31 2009	Farmers from Santa María	4	6	UNALM	Leadership training of community authorities.
Workshop	August 22 – 23, 2009	Farmers from Santa María and Apopata Community	13	3	UNALM	Basic guidelines to develop project proposals.
Workshop	August 31 2009	Farmer from Santa María Community	8	17	UNALM	Qualitative assessment with farmers' learning of IPM practices.
Philippines						
Seminar	May 2008	PIs and gender researchers from all LTRAs	10	19	Maria Elisa Christie	To understand networks and nodes.
Seminar	Jan. 7-8, 2009	Scientists and government leaders from 16 countries with most from Southeast Asia	58	16	Organizers: Dr. Philip Gassman Iowa State University, USA Dr. Hiroaki Somura Shimane University, Japan Dr. Attachai Jintrawet Chiang Mai University, Thailand Dr. Manuel Reyes North Carolina A&T State University, USA	Several papers about global application of the SWAT model were presented

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Seminar	February 26, 2009	DLSU academic community and NGO representatives	40-50	0	DLSU-SDRC	Public dissemination of findings
Seminar	March 5, 2009	Horticulture major students (HORT 115 class)	10	12	Department of Horticulture, Crop Science Cluster, College of Agriculture, University of the Philippines Los Banos	To familiarize the students with the installation, operation and maintenance of the low-cost irrigation system of IDE for small farms and to give the students some insights of the SANREM research activities on drip irrigation
Seminar	March 17, 2009	Songco community leaders and household representatives	50	0	Joint Songco LGU and DLSU-SDRC	Public validation and dissemination of findings
Short course	11/26/08	Professionals from Central Mindanao University	0	2	University of Missouri	To train professionals in Central Mindanao University to use the soil quality kit.
Workshop	May 2008	PIs and gender researchers from all LTRAs	7	16	Maria Elisa Christie	To exchange methodologies and develop a framework for gender research.
Workshop	Nov. 28, 2008	Women key informants	0	10	DLSU and ICRAF	Impart knowledge on vermicomposting
Workshop,	Jan. 5-6, 2009	Scientists and government leaders from 13 countries with most from Southeast Asia	32	8	Dr. Raghavan Srinivasan Texas A&M Univ., USA Mr. Chris George United Nations University	Introduction to SWAT Hands on training on SWAT model.
Workshop	January 22, 2009	Women key informants	0	10	DLSU and ICRAF	Validate findings of the gendered networks study and formulate guidelines for women's participation in vermicomposting project
Workshop	22 January 2009	Municipal Planning and Development Officer, Municipal Agriculturist, Agricultural Technicians, Farmer, Facilitator, Researcher	23	0	ICRAF (facilitators)	To appreciate the concepts and principles of incentive-based policies; finalize the 5-year SFS Investment Plan of Lantapan; and develop action plan from Jan-June 2009.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	February 2009	Farmers group; non-government organization; People's Organization; LGU officials, Dept of Agriculture, Dept of Environment and Natural Resources; Academic Institution	28	19	University of the Philippines Los Banos	To promote SANREM sustainable vegetable agroforestry farm (VAF) among the local policy makers, decision makers in the province of Bukidnon.
Workshop	August 3-7, 2009	Loi Nguyen Kim and Manuel Reyes	1	0	USDA-ARS, Temple, Texas and Texas A&M University	Participated in SWAT conference and workshop
Uganda						
Workshop	**Jan-Mar 2009**	**Community based organizations involved in the Mabira forest (Uganda Site #1)**	**5**	**4**	**UFRIC**	**Create awareness and train local communities and schools about conservation, including managing trees planted to demarcate forest boundaries, patrolling of the forest boundaries to reduce illegal forest resource use, and establishing alternative income generation activities such as bee keeping**
Vietnam						
Short Course	Nov. 2008	On-job students in rural development in Binh Phuoc province	34	26	Binh Phuoc continuous education center, Nong Lam University	Assessing health cost, impact of pesticide use on cashew yield and related rural development issue
Workshop	Jan 2009	Staff/representatives from NLU, Can Tho University, HCM Technical University, DONRE HCMC and Ninh Thuan province, College for resource and environment management, VN Agricultural research institute, Tay Nguyen University.	35	7	Dr. Raghavan Srinivasan Texas A&M Univ., USA	Introduction to SWAT Hand on training on SWAT model.

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	March 2009	On-job students in agricultural economics in Binh Phuoc province	48	30	Binh Phuoc continuous education center, Nong Lam University	Introduction to human capital method, assessing health cost from pesticides use
Zambia						
Field Days	September-October 2007 and 2008	Farmers	665	882	COMACO/WCS	Training in compost making and conservation farming
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 Day	March and April 2009	Farmers	172	39	COMACO (Zambia)	To teach farmers on how to raise early maturing seed for maize
Field Day	May 2009	Farmers	3500	4000	WCS COMACO	Market information, commodity preparation, premium price compliance scorings
Field Day	June 2009	Bee-keepers	450	200	WCS COMACO	General skills in apiary management and harvesting
Field Day	June 2009	Vegetable farmers	250	300	WCS COMACO	Organic farming practices
Field days	July-August 2009	Farmers	175	415	Sarah Dumas, Cornell, Petronella Simwinga, COMACO	Training in improved poultry nutrition, husbandry, and disease prevention and diagnosis.
Field Day	Sept – Oct 2009	Farmers	4500	4500	WCS COMACO, Conservation Farming Union	Near zero tillage practices with cover crops, intercropping with legume, etc.
Seminars	9th Feb 2009 And 25th March 2009	Bee Keeping Officer	1	0	Ministry of Tourism and Natural Resources (Zambia)	To form an Eastern Province Bee Keeping Association
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	October 2008	Extension Officers	5	0	Kasisi Agriculture Training Centre (Zambia)	Sustainable Agriculture and Biological Pest Control

Program type (workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Short courses	2day courses, between Feb 2-18, 2009	Farmers raising bees	61	9	COMACO	Train farmers in bee raising and honey collection
Short Course	10th Feb to 10th April 2009	Food Processing Technologist Jimmy Chikahya, Cornell MPS student Colin Seeley	2	0	General Mills (USA)	To learn about extrusion technology and product formulation
Short course	June 2009	Bee-keeping staff	1500	1500	WCS COMACO	Hive management, harvesting procedures, processing techniques
Short course	June-July 2009	Transformed poachers	38	0	WCS COMACO	Alternative livelihood skills
Short course	June-August 2009	Food processing	2	00	Training by Cornell and General Mills	Advanced food processing techniques for new products
Short course	July 2009	Food processing staff	25	10	WCS COMACO	Food quality assurance techniques and guidelines
Workshop	November 2009	Producer Group Cooperative leaders	37	8	WCS COMACO, Local Distric Ag. Officer	Governance, marketing, organization, information dissemination
Workshop	November 2009	Extension staff and lead rice farmers	50	15	WCS COMACO, Cornell	Rice intensification growing methods

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C. SANREM CRSP leveraged funding, FY 2009

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	
Social sciences survey on food security	A. Travis, L. Buck, D. Lee	Cornell	Oct-Dec 2009	Cornell	$5000 (approx)	
Assessing carbon in complex landscapes	J. Lassoie, D. Wolfe (Cornell) Lewis (COMACO)	Cornell, COMACO	June 2009-May 2010	Cornell		$12,000
USDA Linkage fund for research on Climate Change through CIP	Garrett	KSU	April 2007-April 2009	USDA		$ 50,000
Workshop on Statistics in Agriculture – La Paz, Bolivia	Garrett	KSU	Jan 2009 – Sept 2009	American Phytopathological Society	$5000	
Assessment of glaciers retreat and other global change impacts on the dynamics of peet bogs (Humedales de Altura) in Ancoraimes.	Castañón and Cusicanqui	UMSA	Dec 2007 – Jan 2009	National Bolivian Climate Change National Program PNCC		$ 25,000
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	FY 2009	6 weeks faculty salaries, benefits, and foregone indirect	$ 155,660 70,047	

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] ($)	Funding or support for non-SANREM activities resulting from SANREM activities[5] ($)
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	

[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.

D. USAID Common Indicators for SANREM CRSP

Indicator	Documentation (list each relevant item by indicator category)
New technologies/ management practices under research	• Soil quality indicator methods • Soil amendments • Climate trends for Altiplano regions • Participatory management approaches to link local and new knowledge • Approaches to increase agency (ability to act) on new information • Information kits to predict dynamics of change in pests/diseases due to climate change • Management of native potato varieties, oca and quinoa • Coalition building for adaptation and for market integration • Community Trading Centres (CTC) now operating with tracking of profit and cost centers • Food production now performed in hygienic fashion • Food products testing for safety and quality • Food processing methodologies being tested for improvements in phase separation and extending safe shelf life • Conservation farming technologies being tested (soil amendments, time frame for maximum benefits) • New husbandry practices for poultry and goat production • Evaluating leaf curl virus resistance in tomatoes in Mindanao • Optimized vegetable fertilization in Nanggung • Testing best spacing and planting densities of indigenous vegetables in Nanggung • Fabrication and testing of animal drawn no-tillage vegetable seeders • Introduction of cacao trees in established cashew plantations • Perennial peanut as a permanent cover crop for vegetable production • Simulation of agroforestry systems using the SWAT model • Gendered market networking approaches • Pyrosequencing technologies for characterizing soil microbial communities • Management for mycorrhizae in Bolivia • Improved fallow in Bolivia • 9 technologies including soil conservation, biocontrol of pests, and improved varieties in Bolivia and Ecuador
Technologies or management	• Soil amendment practices

Indicator	Documentation (list each relevant item by indicator category)
practices being field tested	• Varieties of native potatoes • Information formats for climate, markets, pests and disease dynamics • Landscape maps for planning • Participatory approaches to link to markets • Conservation farming methods • Effects of COMACO's market linkages on biodiversity conservation • Global models of climate change • 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 • College of Agriculture, Universidad Mayor San Andres (UMSA)-Bolivia

Indicator	Documentation (list each relevant item by indicator category)
	• Universidad de la Cordillera-Bolivia • Universidad Nacional Agraria La Molina-Peru • Universidad Nacional del Altiplano-Peru • CIDES – Post gradute Program for Development, UMSA • PROINPA Foundation (NGO)-Bolivia • Centro de Investigatión y Promotión del Campesinado (CIPCA) - 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) • 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)
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) • 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, BoliviaAlpaca producer group in Apopata Peru • Community Markets for Conservation (COMACO)
Technologies made available	• Soil amendments tested with communities in Bolivia

Indicator	Documentation (list each relevant item by indicator category)
for transfer as a result of SANREM assistance	• Integrated Pest Management Knowledge for Andian Weevil and Potato Moth in Bolivia and Peru • Information packets and processes for pests and diseases, climate indicators, trends and forecasts, tested new Varieties in quinoa in Umala and Ancoraimes • new varieties of onions tested at higher elevations in the Altiplano • Market information; • Approaches to link to markets • Approaches to building linkages with strategic partners in climate adaptation and market integration initiated with farmer groups • 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	• Established linkages with Bolivian National Climate Change Program and with UNDP to share research findings on adaptation in rural communities • educational policies in Zambia, differences between provinces (provides a policy background for analysis of SANREM impacts on childhood education) • Mabira Forest degazetting • Land Use and Irrigation Management Policy in Ecuador • Land Use and Irrigation Management Policy in Bolivia
Analytical studies of policies or institutions disseminated	• Developed a study of the Platform for Andean Crops with lessons learned. • Dissemination through seminars and workshops about climate change and adaptation in the Andes at USAID in the US Bolivia and Peru, to the climate change community, to the institutions working on adaptation in the region.