SANREM CRSP

Annual Report 2011

October 1, 2010 – September 30, 2011

Sustainable Agriculture and Natural Resource Management
Collaborative Research Support Program

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Executive Summary

This annual report documents the research, education and technology dissemination activities of the SANREM CRSP for the period October 1, 2010 – September 30, 2011. The majority of SANREM CRSP research is conducted through its Long-term Research Award (LTRA) activities. This report covers the second year of SANREM CRSP Phase IV (2009-2014) LTRAs and cross-cutting research activities focusing on Conservation Agriculture Production Systems (CAPS).

Program objectives and strategy

The objectives of the SANREM CRSP program are to:

- increase scientific knowledge and technical innovations in sustainable agriculture (SA) and natural resource management (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;
- promote sustainable resource-based local enterprises in national, regional, and global markets.

Training and knowledge dissemination

SANREM CRSP training, publications, and other knowledge dissemination products in fiscal year 2011 (FY2011) included the following:

- 20 students supported for PhD training (10 women and 10 men)
- 24 students supported for master's training (13 women and 11 men)
- 12 undergraduate student supported (7 women and 5 men)
- 7,292 short-term training participants (4,319 men and 2,973 women)
- 18 refereed journal articles
- 1 working paper
- 13 papers or seminars presented
- 19 electronic presentations
- 21 posters
- 6 reports
- 1 user manual
- 2 abstracts
- 1 survey
- 1 internet site

Long-term research award (LTRA) activities

LTRA-6: A Conservation Agriculture Production System Program for the Central Plateau of Haiti

Principal investigator: Steven Hodges, professor, Department of Crop and Soil Environmental Sciences, Virginia Tech

Project partners: Virginia Tech (lead), Caritas/Hinche, Zamni Agrikol

Success in several areas was achieved this year in spite of overwhelming challenges.
Focus remains on building relationships and capacity with our partners in Haiti, on completing baseline surveys, and on successful implementation and completion of field trials. We made significant progress in each of these areas, while continuing to seek improvements, particularly in the implementation of CAPS.

New effort was concentrated in guaranteeing the success of the household surveys. Zamni Agrikol agreed to employ the survey team and provide logistical support. The survey of households, initiated in August, has included nearly 500 households. We expect to complete the sampling target of 600 in November.

For the first time, all three experimental sites have been planted according to plans provided by Virginia Tech. These sites were managed solely by our partners in Haiti, a growth in research capacity which did not exist 18 months ago. Harvest data for maize (*Zea mays*) and black bean (*Phaseolus vulgaris*) have been received for two sites, with a second-season maize crop still maturing at the third location. Introduced maize cultivars appear to be outperforming local varieties this year, and two black bean varieties have been identified as having high potential for testing and adoption by farmers in the lower plateau. Several attempts to implement adaptation and performance studies of key cover crops have yet to be successful.

Long-term training continues unchanged, with one U.S. Ph.D. student (resource economics) and one U.S. master's student (soil science) continuing their studies. Attempts to recruit Haitian students or scientists have failed to attract qualified applicants to date. Networking has resulted in improved relationships with State University of Haiti Faculty of Agriculture and Veterinary Medicine (FAMV), Caritas, and Zamni Agrikol personnel. We are seeing more interest and participation, as well as improved communications by all parties.

LTRA-7: Conservation Agriculture as a Potential Pathway to Better Resource Management, Higher Productivity, and Improved Socioeconomic Conditions in the Andean Region

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

Project partners: Virginia Tech (lead), Penn State University, University of Denver, U.S. Department of Agriculture Soil Plant Nutrient Research Unit, Instituto Nacional de Investigaciones Agropecuarias (INIAP), International Plant Nutrition Institute, Secretaría Nacional de Ciencia y Technología (SENACYT), Universidad Estatal de Bolivar (UEB), Escuela Superior Politécnica del Chimborazo (ESPOCH), Secretaría Nacional del Agua (SENAGUA), Gobierno de la Provincia de Bolivar (GBP), Alcaldía de Guaranda y Chillanes Sistema de Información Geográfica Agropecuaria (SIGAGRO-MAG), Foundation for the Promotion and Research of Andean Products (PROINPA), Universidad Mayor de San Simón, Centro Regional Avaroa, Sindicato Agrario Tiraque, Alcaldía de Tiraque

Our project tests the concept of CA for smallholder farmers in high-altitude, fragile areas of the Andean Region (Ecuador and Bolivia). It is expected that as CA is tested and successful conservation CAPS are identified, the project will diffuse the CAPS to project areas and other sites. The research is evaluating CAPS based on their impacts on soil health and productivity, farm incomes and their variability, food security, gender relations, and other social considerations. CA trials have been established in Ecuador and Bolivia. The Ecuador trials are well established, and we have finished our first planting cycle. Establishment of the trials in Bolivia has been hampered by irregular weather (both drought and flooding).

In the upper (Illangama) watershed in Ecuador, potato (*Solanum tuberosum*) is the main staple, and agricultural productivity is constrained by poor soil conditions and erratic rainfall. The lower Ecuador watershed (Alumbre) is characterized by warmer temperatures, predominance of maize and beans, very poor soil quality, low and declining productivity, low incomes, and high poverty. The site in Bolivia is a high-altitude area with low productivity, poor soils, and characterized by predominance of potatoes mixed with small grains and tubers. SANREM researchers have built strong collaboration with local stakeholders and identified a number of agricultural technologies with potential for incorporation in the CAPS. We now have: (1) established research designs for on-farm CA experiments; (2) baseline evaluations of soils and socioeconomic conditions; (3) well-established protocols for collecting cost and economic information from our experiments and preliminary information about costs; (4) functioning soils laboratories in both countries, each of which benefited greatly from interactions with SANREM scientists; (5) a nitrogen index tool calibrated for conditions in the Andes which can be used by farmers and technicians to better evaluate and manage soil fertility; (6) improved management of woodlots to enhance incomes for farmers; and (7) solid networks between researchers and other stakeholders to facilitate research and generate local buy-in.

Our field research is ongoing as research plots are established on farmer fields and we are entering the new agricultural production cycle. In both sites, the principal planting periods occur in September-November. Plots have also been established for erosion trials; during the prior SANREM phase, we examined the relationship between management practices and erosion on small-scale erosion trials. We have altered these trials to reflect our best-bet CAPS and we are using them to measure erosion under different CAPS alternatives. Along with the CA work, we have field trials and laboratory experiments to examine cost-of-production-reducing biological agents for pest and disease control, and to stimulate plant growth.

We have taken advantage of our prior SANREM research from Phase III. We have published refereed journal articles on market access and gendered decision making, on impacts of access to cellular telephones on potato market choice, and on biological control of plant diseases. The research publication Revista de Agricultura (Bolivia) accepted a SANREM proposal for a special edition of nine articles; these articles have passed through the review process and the edition is now in press. We have three additional articles under review at refereed publications (Journal of Agricultural Economics, Trimestre Económico, and Food Policy). We have also identified research with the potential for publication where additional work was needed.

Our training program has proceeded according to plan. We have four female and one male long-term graduate trainees who have started their programs at U.S. universities, and have worked with our partner institutions to identify long-term training needs. We are involving undergraduate honors students from the host countries to assist in the research. These young professionals are being trained in soil evaluation and other laboratory techniques, field experiment design, project administration, and collaboration with multiple stakeholders. This capacity-strengthening represents a major output of the project. We have completed a number of important short-term training exercises. The most prominent example of short-term training was the month-long training in Colorado of three (two Ecuadorian and one Bolivian women) scientists in methods for development and calibration of a nitrogen index tool for adjustment of fertilization levels at SANREM research sites, for eventual use by farmers. This tool, which was developed by our collaborator Jorge Delgado (ARS-Colorado State University), has been calibrated for use in Ecuador and Bolivia and will allow our project teams to quickly measure and gauge the sufficiency of soil nitrogen for plant needs. Dr. Delgado visited Ecuador to transfer the index for use in-country; his visit received substantial attention in the local press, expanding visibility of the SANREM program in the region.

A second important short-term training exercise is the SANREM research internship program, which took seven undergraduate students from Virginia Tech for a six-week research internship in Ecuador. Prior to their departure, these students spent a semester in Blacksburg receiving training on research methods and project objectives. While in Ecuador, the research interns interviewed more than 90 farmers and collected data on costs of CA practices and soil conservation measures. Their report has been entered into the SANREM Knowledge Base (SKB) and is being edited into a journal article.

We have established important networks between participating scientists and our research team and local stakeholders. All participating U.S. scientists have established primary contact points with host country researchers and are now engaged in collaborative research. An example of such collaboration is the training exchange that recently occurred between Dr. Delgado and the Ecuador and Bolivia research teams. In addition to scientific networks, each of our host country teams has taken steps to build networks with local stakeholders. In Ecuador, a partnership has emerged between the research team, the Bolivar Provincial government, the Guaranda city government, the local university (where Carlos Monar, former SANREM researcher is now an academic dean), local governments, and farmer groups. We have established seven model farms where ongoing research is conducted. Neighboring farmers visit these farms for informational purposes or to participate in research activities. In Bolivia, linkages between local farmer groups and the Tiraque municipal government have been solidified. In both countries, our teams have conducted informational meetings with USAID and other stakeholders.

LTRA 8: Improving Soil Quality and Crop Productivity through Farmers' Tested and Recommended Conservation Agricultural Practices in Cropping Systems of West Africa

Principal investigator: P.V. Vara Prasad**,** associate professor, Department of Agronomy, Kansas State University

Project partners: Kansas State University (lead), Savanna Agricultural Research Institute (SARI), Wa Polytechnic, Institut d'Economie Rurale du Mali (IER)

Surveys in Ghana documented the current farming systems, major crops cultivated, cropping systems, constraints to production, and potential adoptable CAPS (technologies). Mother (long-term multi-treatments) and baby (short-term farmer-selected treatments) trials were initiated and implemented in Ghana and Mali. Initial soil samples were collected and are being analyzed. Results from Ghana showed that soils had low fertility and soil organic carbon. Sole crops of maize or soybean (*Glycine max*) produced greater grain yields and crop residue than intercropping both after conventional or minimum tillage. Results showed that during the first year, minimum tillage produced the same grain yields of maize and soybean as that of conventional tillage in all cropping systems.

Among various fertilizer management practices, application of inorganic P fertilizer (26 kg P/ha) produced significantly higher yields of soybean compared to the no fertilizer control and application of compound (NPK, 37:16:31 kg/ha, respectively) fertilizer under all tillage practices, indicating that P is limiting in these areas. Soil and water management practices significantly influenced grain yield of maize. Planting on tied ridges produced significantly higher grain yield than planting on flat beds either with or without strips of grass or pigeon pea (*Cajanus cajan*). Overall, these preliminary results suggest opportunities for developing appropriate tillage, weed and fertilizer management practices, and soil and water conservation practices.

In Mali, initial soil samples were collected in all mother trials and are currently being analyzed. Results showed that in Cinzana, minimum tillage or direct seeding (plus one weeding/fertilizing) rendered the same yields as the conventional tillage system. Crop residues or biomass used as mulch produced an average yield increase of 26 percent over the no soil cover treatment at Cinzana. Results from Mopti showed that adding organic fertilizer to millet (*Pennisetum glaucum*) grown under conservation agriculture increased millet yields 42 percent and cowpea (*Vigna unguiculata*) yield 57 percent in the on-research station experiment, and boosted grain millet production 16 percent in the on-farm test and cowpea by 30 percent. In Motpi, it was observed that intercropped cereal and legume positively affected total grain production of the system. In all treatments, total grain yield from the millet/cowpea intercrop was higher than in the millet sole crop that is the local practice taken as the control in this experiment. The minimum tillage and cover crop project of Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA) in Sotuba indicated that *Brachiaria brizantha* could be established as cover crop. Few experiments during 2011 had included *Brachiaria.* Networking activities were initiated with EMBRAPA and CARE International in Mali.

LTRA-9: Developing Sustainable Conservation Agricultural Production Systems for Smallholder Farmers in Southern Africa

Principal investigator: Neal Eash, associate professor and soil scientist, Department of Biosystems Engineering and Soil Science, University of Tennessee (UT)

Project partners: University of Tennessee (lead), National University of Lesotho, Centro Internacional Para el Mejoramiento del Maíz y el Trigo (CIMMYT), Growing Nations

This project examines the effectiveness of different no-till and other management systems. The goal is to find an appropriate cereal, grass, and legume cover crop mix that protects the soil surface from erosion, builds soil organic matter, sequesters carbon, limits weed germination, enhances soil fertility, and increases yields and income through adaptation of CAPS to local conditions

The University of Tennessee team acquired a contract for this work in southern Africa in late April 2010. The performance against the budget and objectives was thus affected by the late flow of funds in the first year. Further, the unexpected delays in completing the sub-contract between the National University of Lesotho (NUL) and CIMMYT subsequently limited research effectiveness especially in Mozambique during the end of 2010 and early into 2011. The agreement between NUL and CIMMY has since been completed and this will be reflected in the overall expenditures for the second year. We remain confident that significant progress in understanding and enhancing CAPS in southern Africa can be made as part of the SANREM team over the next three years.

During the current reporting period, Lesotho experienced the worst growing season since 1933. Exceptional crop failures were due to early seasonal drought in September to October 2010,

followed by disastrous floods in the late part of the growing season from December 2010 to January 2011. Total economic losses and damages are estimated at USD $66 million – approximately 3.2 percent of Gross Domestic Product of the country. The heaviest losses in production were sustained by crops (US $15 million) and livestock (US $4 million). In June 2011, the research team visited Lesotho to evaluate the performance of our project under these trying conditions. Interestingly, the stability of the CAPS developed during this project stood the acid test of climate change predictions as record yields in maize were obtained in both on-station and on-farm trials and demonstrations alike; yield averages ranged from 6 to 9 tons per hectare against the backdrop of reported disastrous crop failures nationally in the same period and regions of project operations.

During this visit, PIs met with project collaborators, discussed project progression with actors in the local supply chain, and developed a list of priorities for up scaling up on-farm demonstrations. Dr. Marake from NUL has developed a plan for up-scaling farm level activities in the 2012 season that includes leveraging collaborative links with Ministry of Agriculture and Food Security and NGOs, especially World Vision International in Lesotho. Research efforts of 2011 focused on understanding the factors determining maize yield in Lesotho and continued to refine agronomic performance of the CA systems analyzed as a function of planting date, plant population, fertilizer rate, and weed management.

Two MS graduate students from the University of Tennessee participated in these research efforts, and also managed on-going carbon analysis and fertilizer calibration/management studies. The students presented their work in the ASA meetings in San Antonio, Texas and will complete academic theses. Two Basotho graduate students have also been recruited and will begin studies in 2012.

Preliminary research findings were presented at the American Society of Agronomy Meetings in Long Beach, CA, at the Conservation Agriculture Meeting in Johannesburg, South Africa in January 2011, at the regional Conservation Agriculture Meeting in Phnom Penh in July 2011, and at a carbon sequestration workshop in Guam in July 2011. We also presented our Lesotho research findings to CIMMYT and the Sustainable Intensification of Maize-Legume Cropping Systems for Food Security in eastern and southern Africa (SIMLESA) group in early September in Mozambique.

In March 2010, field days were held at Maphutseng by project cooperators to highlight the work that is being conducted on CA. The field days were attended by representatives from various UN organizations including FAO and UNDP, Ministry of Agriculture and Food Security, and NGOs. Dr. Marake also hosted a mission from ICRAF in Nairobi, Kenya. The meeting was productive and future collaboration with ICRAF may spin off of this project, looking specifically at agroforestry initiatives into CA. Dr. Marake will finalize a memorandum of understanding with ICRAF before the end of October 2011.

Baseline household surveys were completed in the Botha-Bothe district (northern Lesotho). Data entry is 83 percent complete. Drs. Lambert and Wilcox expect to begin the socioeconomic analysis of the survey results in early 2012. The development and administration of the survey was in concert with partners from Lesotho (including Dr. Marake (NUL), John Hebblethwaite (Growing Nations), and Keith Moore (SANREM ME) who provided the technology network questions. The survey was vetted by the enumerators (all NUL graduates with degrees in soil science, agricultural economics, crop science, or animal science) and Dr. Rethabile Nchee, a sociologist.

Working with August Basson and Jaap Knot (Growing Nations, Maphutseng), Malehana Mafisa (World Vision Lesotho, Mohale's Hoek District), and Dr. Marake, co-PIs are finalizing a list of households who will participate in the 2011/2012 efforts for up-scaling CA demonstrations at farm level initially in the Mohale's Hoek district, and also in other locations in Lesotho in subsequent years. The structure and design of on-farm demonstrations are being finalized by the team of social and biophysical scientists.

A research team has also recently returned from a mission in Mozambique. The focus was to solidify partnership with CIMMYT and others by directly participating in planning activities for SIMLESA and CIMMYT's ongoing activities in Mozambique. Given the inherent complementarity of our partnership and programming, it is incumbent upon members of each organization to clearly define the roles and opportunities for collaboration and grounds for the mutual exchange of information. Additionally, PIs met with representatives from the USAID mission in Mozambique to discuss current and future activities.

LTRA-10: Development and Transfer of Conservation Agriculture Production Systems (CAPS) for Smallholder Farms in Eastern Uganda and Western Kenya

Principal investigator: Jay Norton, assistant professor of soil fertility, Department of Renewable Resources, University of Wyoming

Project partners: University of Wyoming (lead), Makerere University, SACRED Africa, AT Uganda, Moi University, Manor House Agricultural Center (MHAC)

During the first half of FY 2011 we remained on schedule in implementing objectives 1, 2, and 3 of our CAPS development and implementation project in Kenya and Uganda. For Objective 1, relationships developed during the baseline survey led to development of strong, large stakeholder advisory groups at each of the four study areas. Under Objective 2, we held advisory group meetings last October in which we built consensus on the nature of the "typical" farming system, its shortcomings, and how CA components could improve upon it. With the advisory groups, we identified on-station and on-farm trial sites and participating farmers. We also discussed requirements for design of an adoptable minimum tillage implement and assessed capabilities of fabrication shops in each area. Under Objective 3, we demarcated all research plots, collected baseline soil samples, and successfully prepared and

planted each of our nine treatments at each of the 20 study areas. The six Kenyan and Ugandan graduate students involved in the project have all taken active roles in each stage and visited all the sites and participating farmers frequently this summer. The second half of the year was spent mainly collecting agronomic, soil, and trace gas samples/data. Weed and other pest control challenges identified during the first planting season were addressed by designing two pesticide-use guideline documents [Pesticide Evaluation Review and Safe Use Action Plan (PERSUAP)] that were both approved by USAID.

LTRA-11: Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS)

Principal investigator: Catherine Chan-Halbrendt, professor and chair of the Department of Natural Resource and Environmental Management, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa

Project partners: University of Hawaii at Manoa (lead), Local Initiatives for Biodiversity, Research, and Development (LI-BIRD), Orissa University of Agricultural Technology, Institute of Agriculture and Animal Science (IAAS) of Tribhuvan University

This year, we concluded the socioeconomic baseline surveys in India and conducted similar surveys for the three project villages in Nepal. The India household farm survey data were used to build a simple farm model to evaluate the impact of the various CAPS. Together with the CAPS results from the experimental plots, we presented various CAPS alternatives to the farmers and asked them which would be most preferred. The results of farmer's preference showed that CAPS that produce the highest yield, followed by increased profit, would be preferable as compared to current farmer practices. Environmental benefits were rated lower than yield and profit in the farmer-based ranking. The optimal alternative for farmers was intercropping maize with cowpea under conventional plow conditions, then the next optimal CAPS was intercropped maize and cowpea with minimum tillage.

On-farm CAPS trials were initiated both in India and Nepal. Results of these experiments are being collected and analyzed. During the year, 42 documented training and capacity building events were conducted with over 480 participants (27 percent female). These activities were related to CAPS implementation, in-country researcher, staff, and student training, of which 68 participants were U.S. University of Hawaii students and faculty.

Data gathered from the socioeconomic surveys revealed farmers in Tentuli village, India prefer growing maize followed by mustard (*Brassica* spp.). Consequently, the on-farm trials were modified to include mustard crop as a relay crop after maize planting in the monsoon season.

Twelve presentations and five posters were generated from the project during this period. Notably, a presentation entitled "Comparative economic analysis of conservation agricultural practices in tribal villages in India" was presented at the International Forum for

Agribusiness and Management Association (IFAMA) 2011 Annual World Symposium in Frankfurt, Germany, and two presentations entitled "Development of an integrated approach for introducing conservation agricultural practices to the tribal communities of Odisha, India," and "Farmers' preference for conservation agricultural practices in Kendujhar, Odisha" were presented at the Second International Conservation Agriculture Workshop and Conference in Southeast Asia, held in Phnom Penh, Cambodia.

One student from the University of Hawaii received her Master's degree with the research carried out by this project. We are currently in the application process for students from India and Nepal to enter the UH/NREM Ph.D program in 2012. In addition, three master's fellows from India have been recruited to conduct in-country analysis of the research and data collected from the field experiments. We have also initiated our collaboration with Tribuhuvan University/IAAS to provide additional research on appropriate cover crops for our project sites, as well as CAPS-related agro-forestry initiatives.

In the first year of the project, ICRISAT agreed to work with us on projects in India. In the second year, they sent a scientist to participate in our CAPS introduction workshop in Kendujhar giving a seminar and participated in discussions of potential on-farm CAPS. Also, a representative of the NGO PRADAN was invited to the workshop and participated in the discussion. PRADAN has shown great interest in the results of the maize-based CAPS experiments in Tentuli and is in close contact with OUAT. Another NGO, SAMBHAB, is interested in CAPS as a means for promoting organic agriculture among tribal people in Odisha and is also in contact with our partners in India.

One of the largest English-language newspapers in India, "The New India Express" and the Odisha newspaper "Sambad" provided coverage of the LTRA-11 project workshop held in March 2011 and a farmer training initiative in August 2011.

LTRA-12: Conservation Agriculture for Food Security in Cambodia and the Philippines

Principal investigator: Manuel R. Reyes, professor, biological engineering, North Carolina Agricultural and Technical State University (NCA&T)

Project partners: North Carolina Agricultural and Technical State University (lead), U.S. Department of Agriculture-Natural Resources Conservation Service East National Tech Support Center, Royal University of Agriculture, Centre de Cooperation International en Recherche Agronomique pour le Développement (CIRAD), University of the Philippines-Los Baños, Landcare Foundation of the Philippines

Baseline surveys were completed. Data have been gathered in the various biophysical and social science studies launched in FY 2010. For both countries, researcher-managed, farmer-managed, and "kitchen trials" were established. In Cambodia, yields of the main crop maize

were lower in conservation agriculture production systems (CAPS) compared with the plow-based system (conventional tillage). The gross profit margin was also lower in CAPS compared with the plow-based cropping system. Cassava (*Manihot esculenta*) yield in CAPS was very high at 20 tons/ha and with high farm gate price, it had an extremely attractive gross profit margin. Despite lower maize yield with CAPS, the majority of farmers who applied CAPS in 2010 continued participating in 2011. There was also evidence that neighboring farmers are starting to consider some form of CAPS. Field observations strongly suggest that CAPS yield and gross profit margin will likely be greater in 2011 compared with 2010. In 2011, maize was sown in Cambodia during the second half of June after which a one-month dry spell occurred. Only one plot under CAPS needed reseeding, while about ¾ of the farms using plow-based systems in the area were reseeded. Farmers clearly saw the resilience of CAPS to dry spells when compared with their traditional plow-based practice.

In the Philippines, maize + cowpea + upland rice (*Oryza sativa*), and maize + rice bean (*Vigna umbellata*) CAPS had lower corn yields but higher annual sales compared with monocropped plow-based maize. Prices of cowpea and rice bean were five times the price of maize, and provided a greater partial gross income for these two CAPS compared with monocropped plow-based maize. Furthermore, CAPS combining cassava with stylo (*Stylosanthes guianensis)* also had higher annual sales compared with monocropped plow-based maize.

Above ground crop biomass was monitored. Both researcher- and farmer-managed studies showed that the legume cover crop stylo was developing poorly in Battambang, Cambodia, because of alkaline soils. Therefore, testing was done to look for a replacement for stylo and early results showed very promising performances of pigeon pea and rice bean in association with maize. In the Philippines, stylo was producing abundant biomass in the acidic soils of Claveria. Stylo biomass yield was significantly higher than that of *Arachis pintoi*, a slow-starter forage legume.

Farmer organizations for conservation agriculture production systems (FOCAPS) were formed in Cambodia, while in the Philippines, CAPS was introduced to members of an already established farmer organization (Landcare Foundation). From farmer interviews and researcher observations, it is evident that unless CAPS machinery is provided, farmers will likely not adopt CAPS. No-till planters were therefore imported from Brazil and have been successfully calibrated in Cambodia and still being tested in the Philippines.

Battambang presents an unusually high proportion of household headed by single women, because many women widowed in Cambodia as a result of the war, and because men tend to migrate in search of seasonal or permanent employment to Thailand. In both countries it appears that responsibilities regarding the agricultural tasks depend on physical strength. Men perform tasks which need more physical strength, such as operating a hand tractor, whereas the women are more likely to implement lighter tasks, often with children, such as sowing or weeding. Both men and women are involved in decision making. Their decisions seem to be well accepted and recognized.

Networking continued to advance. The USDA-NRCS national leader for soil quality conducted training for scientists, field technicians, students, and government staff. The Second International Conservation Agriculture Workshop and Conference was successfully held in Phnom Penh, Cambodia July 2011 with 12 countries represented and more than 100 attendees mostly from Southeast Asia (SEA). Also the Second International Soil and Water Assessment Tool Model Workshop and Conference in SEA took place in Ho Chi Minh City, Vietnam on January 2011, with more than 100 international attendees from 13 countries. The Third International SWAT and CA workshops and conferences in Southeast Asia have been set for May 2013 in Pattaya, Thailand.

From SANREM Phase III findings, a book on vegetable agroforestry in Vietnam was published. With funding from the USDA, an experiment patterned after SANREM Phase III studies on vegetable agroforestry was established in three small farms in North Carolina. Lastly, with funding from the USDA, an experiment applying CAPS in urban home gardens commenced and SANREM/NCA&T supported Ph.D students are involved as part of their overall training about CAPS. Three master's students and a Ph.D student are conducting research in the Philippines, and two students completed master's theses in Cambodia. A website was established as well. Several CA farmer and local government trainings were conducted as well as training on the proper application of pesticides.

Phase IV cross-cutting research (CCRA) activities

CCRA-6: Economic Analysis and Impact

The economic challenges to CAPS adoption are among the most formidable obstacles that LTRAs and their collaborating host country partners need to confront. While the benefits of CAPS to participating smallholder farmers and their families are short-term time savings (e.g., in land preparation, weeding) and longer-term benefits (e.g., improved soil fertility, reduced erosion control) that result in greater yields, income, and food security, there are also substantial short-term costs of adoption (e.g., herbicides, soil amendments, specialized equipment, risk and uncertainty associated with new, intensified management systems). Additional benefits to society (e.g., ecosystem services, including carbon sequestration, reduced siltation of streams, recharged aquifers) accrue over time. However, the CAPS farmers who produce these benefits may or may not be compensated for their efforts. If not, it is important to know whether the CAPS are profitable enough be adopted by farmers.

The relative importance, magnitude, and distribution of benefits and costs may vary widely over the geographical distribution of production systems covered by the LTRAs. However, in order for wide-scale adoption and impact to occur in any region, the fundamental economic research problem remains the same: what farm-level production system(s) and sequencing of CAPS elements will minimize smallholder costs and risks while maximizing benefits and adoption? This CCRA collaborates with and assists the LTRAs in developing a common baseline and methodology for addressing this general question. Later, as relevant LTRA data become available, plans call for the analysis to be expanded to the higher level landscapes and a more comprehensive economic impact assessment of CAPS. It is expected that the resulting comparative analysis across LTRAs will provide significant insight into general strategies that promote wide-scale adoption of CAPS.

During Year 2, two primary activities occurred. First, social scientists in the LTRAs gathered production and cost data and other information that will allow for assessment of farm-level production system(s) and sequencing of CAPS elements that will minimize smallholder costs and risks while maximizing adoption and economic and environmental benefits. Second, with the assistance of a graduate student, a detailed model was developed and applied in LTRA-7 in Ecuador. The model provided results for this country, but also can serve as a template for other regions. The study was part of the master's thesis of the graduate student.

CCRA-7: Gendered Perspectives for Conservation Agriculture: Local soil knowledge and crop-livestock interaction

The Gender CCRA includes qualitative, case study-based research carried out in collaboration with individual LTRAs and CCRAs. Phase IV activities for FY 2011 comprised analysis of FY 2010 data; revisions to research design and strategy; fieldwork by graduate students; research by undergraduate students; oral and poster presentations at professional conferences; graduate student recruitment; and collaboration with SANREM's Soils CCRA. The project hosted a

visiting scholar from Southeast Asia and a guest speaker for Women's Month at Virginia Tech. Long-term training included two geography masters' students: one fully-funded graduate research assistant and an administrative assistant with partial funding. Two undergraduate researchers were involved as well (not funded). Short-term training activities included a gender workshop for students and PIs at Virginia Tech and collaboration with the PROINPA team in Bolivia. A database of 26 modules for a course on Women in Development with readings and presentations was made available online.

The CCRA developed a research strategy report, building on the analysis of gendered soils knowledge data from FY 2010. Within the context of CAPS, the research strategy integrated methods from ethnoecology/ethnopedology and the Gender Dimensions Framework (GDF), from Drs. Deborah Rubin and Deborah Caro of Cultural Practice, for collecting further data on local soil knowledge, gendered landscapes, gendered agricultural practices, and crop-livestock interaction. Geographic spatial analysis techniques (GPS, GIS) were introduced with fieldwork in Bolivia and used alongside the low-tech participatory mapping techniques tested the previous fiscal year in other regions. Multiple GIS data layers from Bolivia will be used to develop a thesis in FY 2012.

In June and July, the CCRA worked closely with LTRA-7 and the host country partner in Bolivia (PROINPA), mapping local soil knowledge, access to resources, and gendered space. Extensive discussions and fieldwork contributed greatly to the approach and data collection. Initial data analysis shows men's and women's different knowledges in correlation with gendered agricultural practices, differential use of livestock, and access to different spaces and resources in the landscape. Collaboration with the CCRA on Soil Quality/Carbon Sequestration was strengthened and applied in Bolivia. Soil samples were collected by PROINPA and await analysis at Virginia Tech. Products include a trip report with gender-based recommendations for fieldwork and CAPS. Research in Bolivia also served as a pilot project to test the methodology that will be applied in Haiti, the Philippines, and Nepal in the next fiscal year. The Gender CCRA recruited a geography student to Virginia Tech for research in the Philippines in FY 2012.

Development impacts from research strategy design and field work included raised awareness of gender-related practices and resource use for host institutions; gender-sensitive fieldwork methods, including focus group discussions (FGD) and household interviews, for collection of gender-based data; and the adaptation of geo spatial techniques, such as GPS mapping and GIS.

CCRA-8: Technology Networks Cross-Cutting Research Activity

The Technology Networks CCRA revised its research strategy by focusing on fewer countries this year, primarily in Africa. Following this strategy, collaborating LTRA PIs have incorporated technology network questionnaire items into their baseline activities at the household level in Haiti, Mali, Ghana, Kenya, Uganda, Lesotho, and the Philippines. Preliminary analysis has been conducted on attitudinal indicators from the LTRA-8 site in northwestern Ghana. This led to the

submission and presentation of a paper at the 5th World Congress on Conservation Agriculture suggesting that traditional extension agents may not be the most appropriate transmitters of conservation agricultural principles. However, there may be a significant group of risk-averse farmers (men and women) men who would be amenable to the ideas of CA.

The Technology Networks team has been involved in several data collection efforts this year. PI Moore was an observer in the household survey conducted by the LTRA-9 team in the Botha Bothe district of northern Lesotho. Later in the year, he revisited the Botha Bothe region to collect qualitative data on farmer and development agent perspectives. Master's degree student Jeni Lamb collected data for her thesis on the connection between technology networks and food security practices at the household level at LTRA-10's Kenya and Uganda sites and spent the summer analyzing data and drafting her thesis for defense this fall. This latter data collection effort provides us with the most complete data set to date (including both farmer and service sector/community levels). PI Moore was also an observer in the household baseline survey in LTRA-8's Mali sites. He arranged for a technology network survey of service sector/community actors at the Seno site to be conducted this fall.

CCRA-9: Soil Quality and Carbon Sequestration

Coordination of soil and agronomic investigations among all 13 developing countries before and after CAPS are implemented is critical to measuring soil fertility and carbon sequestration changes due to CAPS. We are coordinating all long-term research activities' data collection so that we can make meaningful and scientifically verifiable comparisons across all project sites. We have successfully obtained a USDA soil import permit, and have since received Time 0 soil samples from researcher-managed sites in Ecuador, Bolivia, Philippines, and Cambodia. These will be used to establish a common minimum dataset so that scientifically valid comparisons among project sites can be made. We have collected GIS data and produced maps of research sites in Ecuador, Lesotho and Nepal.

We are collaborating with the Gender CCRA to establish gendered knowledge of soils in Bolivia, and with the Haiti LTRA economics team to quantify the link between household economic efficiency and soil fertility. A graduate research assistant (GRA) has been employed as of May 2011 to implement data collection and conduct laboratory analyses. Ultimately, we plan to make general recommendations for the practical establishment of CAPS across global agroclimatological zones to increase soil fertility and carbon sequestration throughout the developing world based on data collected from this project.

Management Entity activities

The SANREM CRSP Management Entity (ME) provided administrative and technical support for the Phase IV program of long-term research awards (LTRAs) and cross-cutting research activities (CCRAs). This was a period of transition for the ME, as program director Theo Dillaha returned to his department of origin at Virginia Tech at the end of December. During the search for his replacement, Michael Kelly (retired dean of Virginia Tech's College of Natural Resources and the Environment) filled in until July 1 when the new program director, Adrian Ares, came on board. All the while, SA and natural resource management innovations, policies, and practices continue to be tested and the results disseminated through professional publications, extension documents, and various reports to partner organizations. The annual meeting in May 2011 of LTRA and CCRA PIs was the highlight of the year.

Phase IV annual meeting

The annual meeting was held May 17-19, 2011 in Blacksburg, VA. The three-day meeting began with a presentation on communication of research findings to multiple audiences and then focused on identifying PI priorities outcomes for the meeting. Under the leadership of interim Director Kelly, each PI lead a thematic session covering the following topics: weeding versus herbicides; erosion and carbon sequestration; crop rotations and cover crops; research team-farmer participatory experiences; contributions to the Feed the Future initiative; motorized no-till seeders versus potholes; preparing to scale-up, and adoption processes. Disciplinary discussion sessions were also held. These forums provided PIs a wide range of opportunities to share the experiences of their first year of implementation and discuss the common challenges they have faced in the establishment of conservation agriculture in multiple environments. The Technical Committee met and discussed reporting requirements and holding the next annual meeting in conjunction with the 2012 ASA/CSA/SSSA conference since many of PIs and co-PIs are already members.

Publications and publicity

SANREM CRSP Knowledgebase

The SANREM CRSP Knowledgebase is an online and open access repository of books, reports, journal articles, videos, abstracts, and presentations produced or identified, classified, and summarized by SANREM CRSP researchers. Currently, there are nearly 3,600 resources in this database. 638 of these resources are products of Phase III research while 96 entries are already derived from Phase IV projects. During FY2011, 182 items were added to the SKB. In July 2011, the SKB was added to a listing of "Related Databases" on the USDA's National Agricultural Library Alternative Farming Systems Information Center. It joins 30 other databases in this listing, among them the Agriculture Network Information Center (AgNIC) and the National Sustainable Agriculture Information Service (ATTRA). Its addition to this listing will improve access to and awareness of the SKB's extensive resources relating to Sustainable Agriculture and Natural Resource Management.

Training and institutional development

In FY2011, 10 U.S. and eight host country universities and institutions provided long-term training for 44 graduate students (20 PhD and 24 masters) and 12 undergraduate students associated with SANREM CRSP activities. Of these, 30 were women and 26 were men. SANREM CRSP researchers and partners held 186 short-term training events serving more than 7,200 people, including 2,973 women. Training events were held in 16 countries. Farmers, municipal authorities, technicians, NGO staff, students, and extension agents received training from the SANREM CRSP. Twenty-five field days were offered in several countries to 1,304 people.

Environmental Compliance

Environmental compliance procedures are required bu Title 22, Code of Federal Regulations, Part 216 for all USAID activities that may have an impact on the environment. Those LTRAs that intend to use pesticides as part of their projects are required to submit Pesticide Evaluation Review Safe Use Action Plan (PERSUAP) prior to the purchase or utilization of those pesticides. In compliance with these regulations, the ME has obtained USAID approval of PERSUAPs for the following countries during FY 2011; Kenya, Uganda, Lesotho and Mozambique.

Introduction

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. Program efforts are competitively driven and focused on the development of conservation agriculture production systems (CAPS). The 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. Gender sensitivity is integral to the SANREM approach and reinforced by gender-sensitive participant training programs that include degree and non-degree plans. All activities link sustainable NRM with the economic concerns of local populations and the promotion of good governance.

The objectives of the SANREM CRSP program 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.

This annual report documents the research and technology dissemination of the SANREM CRSP for the period October 1, 2010 – September 30, 2011. The majority of SANREM CRSP research is conducted through its LTRA activities. Progress has been made in developing CAPS during the second year of Phase IV (2009-2014). This includes progress in the four cross-cutting research activities dealing with economic impact analysis, gendered knowledge, soil quality and carbon sequestration, and technology networks.

SANREM CRSP Management Entity activities

The Virginia Tech Management Entity (ME) provides overall administrative and intellectual leadership of SANREM CRSP activities. This leadership is most clearly demonstrated in the financial management and program coordination of the LTRAs and CCRAs, networking with information providers and users, SA and NRM supporting SANREM CRSP researchers, and disseminating SANREM-generated knowledge to potential users. The ME also keeps abreast of innovations and new approaches in SA and NRM inquiry areas, nurtures innovative research and outreach activities, and circulates SA and NRM knowledge and information among partners and the public through the SANREM CRSP website, a newsletter, working papers, and research briefs.

This was a period of transition for the ME, as program director Theo Dillaha returned to his department of origin at Virginia Tech at the end of December. During the search for his replacement, Michael Kelly (retired dean of Virginia Tech's College of Natural Resources and

the Environment) filled in until July 1 when our new program director, Adrian Ares came on board. All the while, sustainable agricultural and natural resource management innovations, policies, and practices continue to be tested and the results disseminated through professional publications, extension documents, and various reports to partner organizations.

SANREM CRSP program

Seven LTRA activities were selected for funding:

- **A conservation agriculture production system (CAPS) program for the Central Plateau of Haiti**
  Lead principal investigator (PI): Steve Hodges, Virginia Tech
- **Conservation agriculture as a potential pathway to better resource management, higher productivity, and improved socioeconomic conditions in the Andean Region**
  Lead PI: Jeffrey Alwang, Virginia Tech
- **Improving soil quality and crop productivity through conservation agricultural practices in cropping systems of West Africa**
  Lead PI: P.V. Vara Prasad, Kansas State University
- **Developing sustainable conservation agricultural production systems for smallholder farmers in Southern Africa**
  Lead PI: Neal Eash, University of Tennessee
- **CAPS for smallholder farms in eastern Uganda and western Kenya**
  Lead PI: Jay Norton, University of Wyoming
- **CAPS among tribal societies in India and Nepal**
  Lead PI: Catherine Chan-Halbrendt, University of Hawaii at Manoa
- **Conservation agriculture for food security in Cambodia and the Philippines**
  Lead PI: Manuel R. Reyes, North Carolina Agricultural and Technical State University

In addition, SANREM received an associate award from USAID/Ethiopia to conduct a training of trainers program in labor-based rural road construction and related natural resources management to reduce environmental problems associated with current degrading roads.

Progress and highlights from during Year 2 (FY 2011) of Phase IV include:

- 20 students supported for PhD training (10 women and 10 men)
- 24 students supported for Master's training (13 women and 11 men)
- 12 undergraduate student supported (7 women and 5 men)
- 7,292 short-term training participants (4,319 men and 2,973 women)
- 18 refereed journal articles
- 1 working paper
- 13 papers or seminars presented
- 19 electronic presentations
- 21 posters
- 6 reports
- 1 user manual

- 2 abstracts
- 1 survey
- 1 website

Management Entity highlights

Annual meeting

The annual meeting was held May 17-19, 2011 in the International Affairs Offices in Blacksburg, VA. The agenda of this three-day meeting contained presentations covering communications and reporting, as well as extensive PI led discussions of thematic topics dealt with in the course of project implementation. These topics included: weeding versus herbicides; erosion and carbon sequestration; crop rotations and cover crops; research team-farmer participatory experiences; feed the future contributions; motorized no-till seeders versus potholes; preparing to scale-up, adoption processes. Disciplinary discussion sessions were also held. These forums provided PIs a wide range of opportunities to share the experiences of their first year of implementation and discuss the common challenges they have faced in the establishment of CA in multiple environments. Several graduate students participated in the meetings. The Technical Committee discussed reporting requirements and agreed to hold the next annual meeting in conjunction with the ASA/CSA/SSSA conference since many of PIs and Co-PIs are already members. The meeting was attended by over 40 SANREM CRSP Phase IV partners and collaborators.

SANREM CRSP Knowledgebase

The SANREM CRSP Knowledgebase is an online repository of books, reports, journal articles, videos, abstracts, and presentations produced or identified, classified, and summarized by SANREM CRSP researchers. Currently, there are nearly 3,600 resources in this database—96 of which are already from Phase IV projects. It can be searched by author, language, title, location, entry date, research activity, keywords, creation date, and resource type. This repository provides easy access of resources concerning SA and NRM to the general public and has a growing number of resources pertaining to CA. The SKB can be accessed from the SANREM CRSP website at: http://www.oired.vt.edu/sanremcrsp/professionals/knowledgebase/.

Since going online in 2005, the SKB has grown into a dynamic and reliable repository. Its dual purpose of electronic storage for SANREM CRSP-generated resources as well as a searchable database of SA and NRM information for the general public has helped guide its development. In February 2011, the entire SANREM CRSP website, including the SKB, was redesigned to improve usability and aesthetic appeal. Further development of the bibliography-generating tool for both the public and SANREM CRSP researchers has also improved functionality. Data entry and searches are facilitated by the SKB Metadata User Guide, Version 6, which was updated in April 2011. The ME now provides links to example Metadata formats within the Metadata entry page itself. The entire document can be accessed at: http://www.oired.vt.edu/sanremcrsp/documents/skb/SKB.Metadata.UserGuide2011.pdf.

Communications program

The SANREM CRSP communications program disseminates pertinent information in multiple forms for various purposes. This program consists of the SANREM CRSP website, newsletters, working papers, research and policy briefs, press releases, and other publications. The communications coordinator also keeps track of articles submitted to newspapers, magazines, and other websites that highlight SANREM CRSP activities or researchers.

Over the last year, the communications program has undergone some changes. A website redesign was completed in February, a new logo was chosen to better represent SANREM's current phase, and the newsletter was reformatted.

Social media

SANREM's Facebook page (www.facebook.com/pages/SANREM-CRSP/69503719402) had 20 new likes over the last year, an increase of 150 percent. SANREM's Twitter account (www.twitter.com/SANREMCRSP) has 34 followers and is connected to USAID and other CRSPs.

SANREM 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.

To increase usability and appeal to all audiences, the SANREM CRSP website has been reevaluated and reorganized, and debuted a fresh new look on February 15, 2011. This remodeling caters to the website visitors by being more visually pleasing and easier to navigate.

Google Analytics

The SANREM ME tracks visitors to the website using Google Analytics, a free service that generates detailed statistics on website visits. This year, visits to the SANREM website proper and the SANREM Knowledgebase have been disaggregated. When the data are combined, it indicates increases in all areas of visitation, including the number of visits, length of time on the site, and the average number pages viewed.

Since the SANREM CRSP ME launched the website in August 2006, there have been over 47,500 visits and more than 151,800 page views.

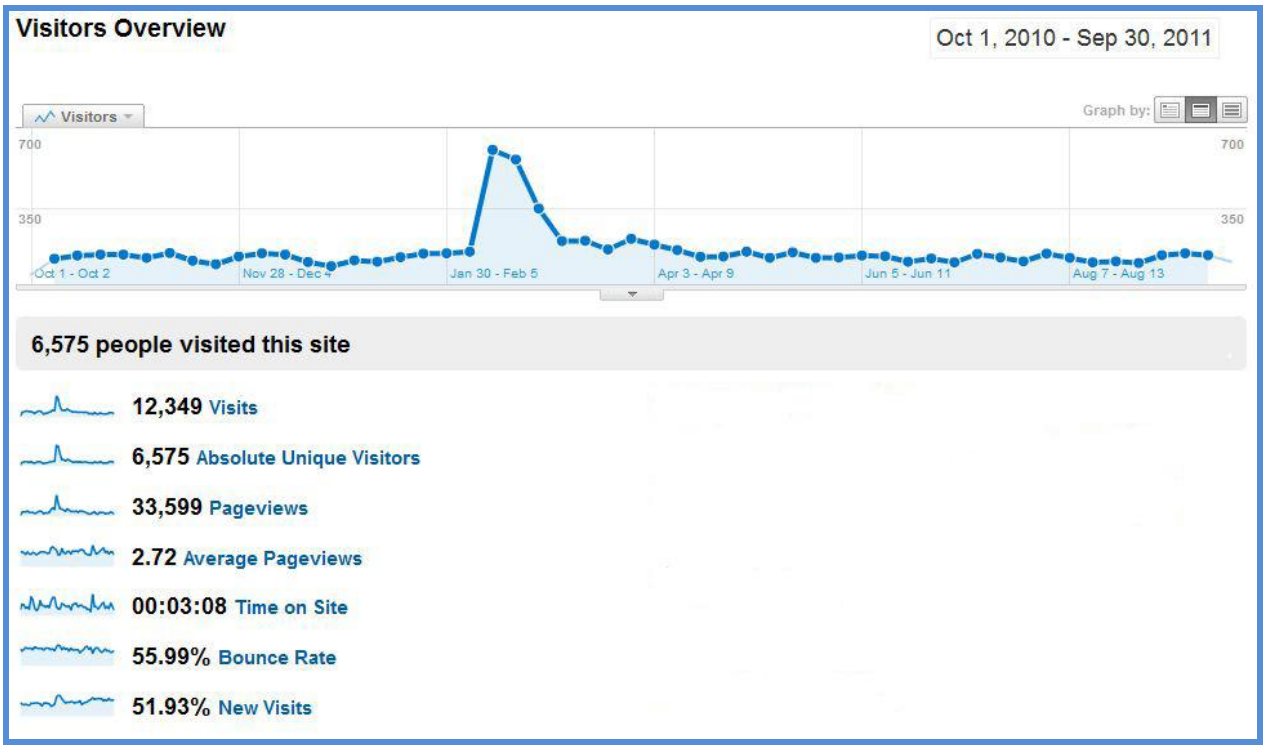

Figure 1. Visitor overview data for the SANREM CRSP website, FY 2011

Table 1. Annual Change in SANREM CRSP website data, FY2009 to FY2010

	FY2010	FY2011	Change (percent)
Visits	11,162	12,349	+10.63
Pageviews	33,715	33,599	-0.34
Pages/Visit	3.02	2.72	-9.92
Bounce Rate	51.13 percent	55.99 percent	+9.50
Avg. Time on Site	3:26 minutes	3:08 minutes	-8.84
Percent New Visits	50.30 percent	51.93 percent	+3.25

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
Page view: 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
Average 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

Global distribution of website visits

Visits in FY2011 came from 171 countries and involved more than 12,000 visitors. Of those, about two-thirds were from the United States. About a third of the visits were direct traffic (visitor entered the URL directly) and another two-fifths were generated by search engines. The rest were from other websites with links to the SANREM CRSP website, with the Virginia Tech College of Agriculture and Life Sciences, the CRSPs.org site, and USAID websites referring the highest percentage of visits. It is also worth noting that visits to the website via mobile device nearly doubled in FY2011. About one quarter of the visits using a mobile device were from countries other than the United States.

Table 2: Top 10 countries for origin of visits to SANREM CRSP website, FY2011

Country	Visits	New visits (percent)	Change in visits from FY2010 (percent)
1. United States	8,405	37.04	+1.83
2. India	321	93.77	+43.30
3. Philippines	224	75.82	+18.60
4. United Kingdom	172	83.72	+59.26
5. Ecuador	140	82.14	+75.00
6. Kenya	128	82.03	-16.63
7. Nepal	122	53.28	-29.48
8. Canada	107	87.85	+35.44
9. Germany	105	83.81	+7.14
10. Indonesia	99	89.90	+43.48

Visits to the SANREM CRSP Knowledgebase

Since beginning to monitor visits to the SKB itself in May 2011, the SKB has received over 300 hits by 180 unique visitors viewing nearly 1800 pages of content. Over 15 percent of these visits since May 2011 were referred through the SKB's partnership with AGNIC, a group of several agriculture-related online repositories. The average time spent on the site has been approximately six minutes with about 5.5 page views per visitor.

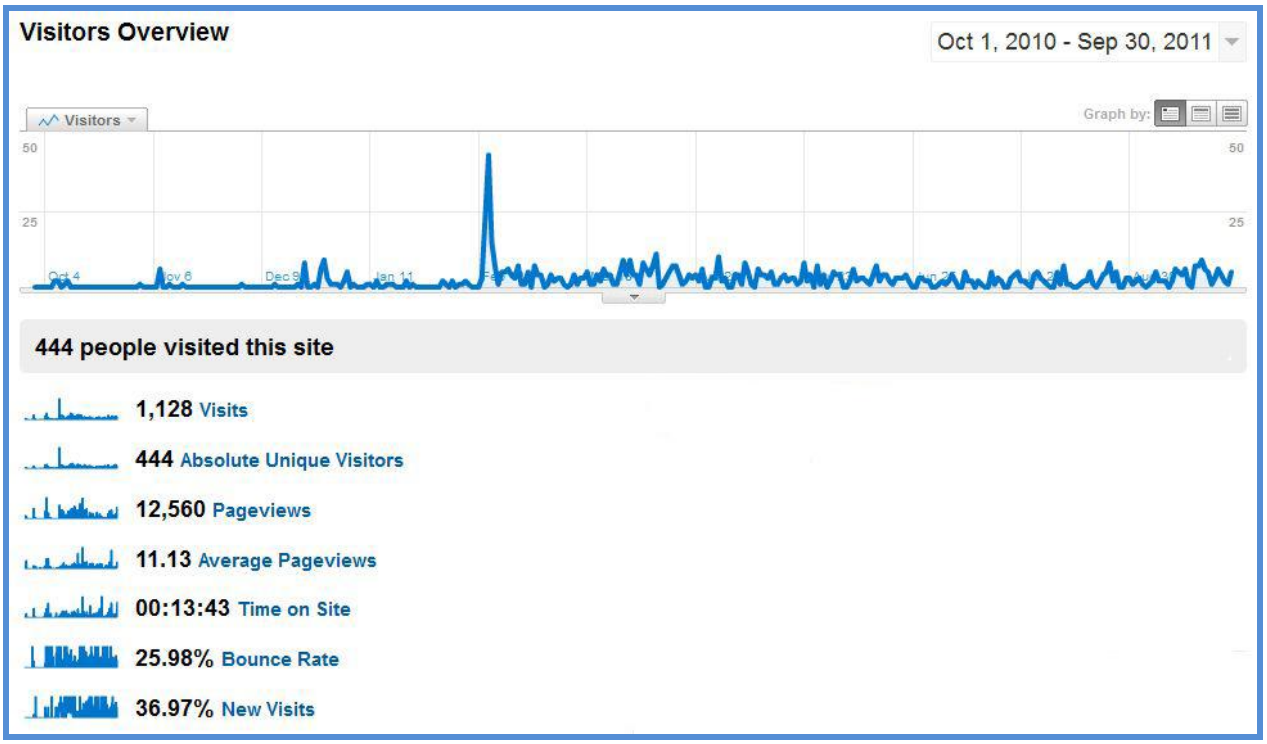

Figure 2. Visitor overview data for the SANREM CRSP Knowledgebase, FY2011

Information products

The ***SANREM CRSP Newsletter*** is published as an e-mail bulletin and online at http://www.oired.vt.edu/sanremcrsp/public/news/newsletters/. It provides a concise update of SANREM CRSP activities, accomplishments, and future events. Issues in FY2011 appeared in October 2010 and August 2011.

SANREM CRSP Research Briefs promote and disseminate relevant SA and NRM messages and information. These concise summaries of peer-reviewed SANREM CRSP research findings suggest how new knowledge can be applied in the field. Three research briefs were produced during FY2010. ***Policy Briefs*** present peer-reviewed findings with direct policy implications or recommendations for sustainable development. Two briefs were produced during FY2010. The objective is to provide policy makers with easily accessible information to increase understanding of often complicated policy issues. Research and policy briefs are available at http://www.oired.vt.edu/sanremcrsp/public/media/research-briefs/ and http://www.oired.vt.edu/sanremcrsp/public/media/policy-briefs/, respectively.

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. The Phase IV series has produced two working papers thus far, with one focusing on local network analysis in the development of CAPS, and the other providing a research

framework for technology networks and gendered analysis. All are available on the website: http://www.oired.vt.edu/sanremcrsp/professionals/research-themes/working-papers/.

SANREM CRSP publicity

Part of the SANREM CRSP's mission is to establish the program as a respected authority on SA and NRM, raise the profile of the program, and disseminate SANREM CRSP generated knowledge around the world. The ME achieves this in part by distributing stories to newspapers, magazines, and other websites.

Phase III's biodiversity conservation work in Zambia was featured in the Proceedings of the National Academy of Sciences: http://www.pnas.org/content/108/34/13957.full.pdf

LTRA-8's conservation agriculture workshop was featured on GhanaWeb.com: http://www.ghanaweb.com/GhanaHomePage/NewsArchive/artikel.php?ID=218432

Two SANREM graduate students, Jeni Lamb and Keri Agriesti, gave talks as part of Virginia Tech's Women in International Development discussion series.

Jeff Alwang, LTRA-7 PI, was featured (text, video, and photos) for his work with undergraduate students on Virginia Tech's homepage entitled "A Virginia Tech researcher uses undergrads to help improve potato farming in the Andes." http://www.vt.edu/spotlight/innovation/2011-08-01-ecuador/potato.html?utm_campaign=spt&utm_content=shaybar&utm_medium=Argyle%2BSocial&utm_source=twitter&utm_term=2011-08-01-10-00-00

SANREM's work in Haiti was also featured on Virginia Tech's homepage: http://www.vt.edu/spotlight/impact/2011-01-17-haiti/haiti.html

SANREM's associate program director, Keith Moore, spoke at the APLU's Feed the Future Research forum. Day 3 audio: http://www.aplu.org/FtFresearchforum

Phase III work in Vietnam was published in a book, which was featured on USAID/Vietnam's website: http://vietnam.usaid.gov/new-book-shows-cacao-grown-under-cashew-canopies-increases-production

Networking and partnership

SANREM CRSP was invited to participate in the Agriculture Network Information Center (AgNIC). AgNIC is a voluntary alliance and partnership of 60+ institutions and organizations working to provide quick and reliable access to quality agricultural information and sources. The SANREM CRSP continues to develop our partnership with AgNIC. As a member, the SKB linked its metadata to allow for greater searchability through AgNIC's website. The AgNIC membership helps SANREM CRSP to share the information in the SKB to reach a larger readership and increase the access to agricultural resources from other AgNIC members. Since

May 2011, fifteen percent of the traffic coming to the SANREM Knowledge Base has come through this link.

Conference participation

Mike Mulvaney attended the ASA-CSSA-SSSA International Annual Meetings on October 31-November 4, 2010 in Long Beach, CA, and represented SANREM ME at the Regional Conservation Agriculture Symposium for southern Africa on February 8-10, 2011 in Johannesburg, South Africa. SANREM Co-sponsored the Second International Conservation Agriculture Workshop and Conference in Southeast Asia on July 4-7, 2011 in Phnom Penh, Cambodia which was attended by 80 people, and funded the publication of the proceedings of the meeting. Adrian Ares participated in the CRSP Council Meeting on July 24-26, 2011 in Kampala, Uganda. Keith Moore and Mike Mulvaney presented oral and posters presentations at the 5th World Congress of Conservation Agriculture-3rd Farming Systems Design Conference on September 26-30, 2011 in Brisbane, Australia.

SANREM CRSP leveraged funding

SANREM CRSP researchers were successful in leveraging additional funding to enhance their research and outreach activities (Table 3). Funding sources included U.S. and international funding agencies, as well as host-country sources. This year, SANREM CRSP PIs and Co-PIs generated $725,000 in leveraged funding. The majority of those funds ($709,000) went directly to the support of SANREM CRSP activities. The Ecuadorian government and host country organizations provided support to SANREM CRSP research activities. (For a full accounting, see Table 21 in the appendixes).

Table 3: SANREM CRSP leveraged funding, FY2011

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	$192,000	-	$192,000
Host country organizations	$517,000	$16,000	$533,000
Total	$709,000	$16,000	$725,000

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 2011, 18 U.S. and host country universities and institutions provided long-term training for 44 graduate students (20 PhD and 24 MS) and 12 undergraduate students associated with SANREM CRSP activities. Of these, 30 are women and 26 are men. (For a full accounting of these training events, see the appendices).

Table 4: Long-term degree training participants by country, FY 2011

Country	Doctorate		Master's		Bachelor's		
	Men	Women	Men	Women	Men	Women	Total
Bolivia		1					1
Cambodia	1		2				3
Canada		1					1
Ecuador					2	1	3
France			1				1
Ghana	2						2
India		1		1			2
Indonesia		1					1
Kenya	1	1	1	1			4
Peru		1					1
Philippines	2		1	2			5
Uganda			2				2
United States	4	4	4	9	3	6	30
Total	10	10	11	13	5	7	56

Short-term training

SANREM CRSP researchers and partners held 186 short-term training events serving more than 7,200 people, including 2,973 women. Training events were held in 16 countries. In addition to farmers, municipal authorities, technicians, NGO staff, students, and extension agents received training from the SANREM CRSP. Twenty-five field days were offered in several countries to 1,304 people. For a full accounting of these training events, see the appendices.

Table 5. Short-term training participants by country, FY 2011

Country	Men	Women	Total
Bolivia	121	67	188
Cambodia	260	69	329
Ecuador	156	104	260
Ghana	169	81	250
Haiti	899	710	1609
India	204	118	322
Kenya	77	37	114
Lesotho	446	329	775
Mali	4	2	6
Mozambique	1156	953	2109
Nepal	57	41	98
Philippines	168	93	261
Tanzania	48	31	79
Uganda	341	196	537
USA	87	57	144
Vietnam	126	85	211
TOTAL	4,319	2973	7,292

Phase IV Long-Term Research Award (LTRA) program

LTRA-6: A Conservation Agriculture Production System Program for the Central Plateau of Haiti

Principal Investigator: Steven Hodges, professor, Department of Crop and Soil Environmental Sciences, Virginia Tech

Host Countries: Haiti

Research Team:

- Virginia Tech: Crop and Soil Environmental Sciences: Wade Thomason; Department of Forestry: Gregory S. Amacher
- Haiti Ministry of Agriculture and National Resources: Robert J. Badio
- Caritas/Hinche: Jacques Volcius, Augustin Guedry
- Zamni Agrikol: Gillaine Warne, Larose Deus, Stenio Louis-Jeune, Fereste Sonneus

The overall goal of the project is to test the hypothesis that adoptable CAPS for the social, economic and bio-physical conditions of Haiti's Central Plateau can be developed. The purpose is to determine if these locally adapted CAPS can improve smallholder livelihoods, significantly increase agricultural production, and restore agricultural production capacity. This goal and purpose is being examined through three research objectives:

Research progress by objective

Objective 1: Assess the adaptability of existing agricultural production and livelihood systems for transformation to CAPS.

Critical Research Accomplishments

During the past year, an economics-based household survey was initiated in the Central Plateau with help from partners Zamni Lasante, FAMV, and Zamni Agrikol. A team of seven enumerators has thus far collected information on our survey instrument for 430 farm households in a sample stratified across the plateau based on population density. The enumerator team was recruited and trained through the help of the FAMV. Pretesting of the survey instrument was conducted in July of 2011, and survey enumeration began in early August. The survey instrument covers all aspects of household/farm decision making including use of natural resources, employment of agricultural practices including CAPS, consumption and production, agricultural plots and cropping calendars, household labor and capital inputs and decision making, income and wealth, management of resources and decisions in households made by females and males, health aspects, and inter-household relationships important to decision making. In addition, the impacts of migration from the 2010 earthquake are investigated, as are aspects of climate change adaption by households made necessary by

missed planting windows and incorrect agricultural practice choices when onset of rainfall is uncertain. We also are collecting information on networks for the cross-cutting initiative of SANREM/CRSP and have coordinated with researchers in that program when both designing the survey instrument and choosing the sampling region. The survey period covers one full dry-rainy season cycle.

We anticipate survey completion in November of 2011 with data collected for 600 households. Households were sampled chiefly in the lower Central Plateau and in both plains and mountain regions. A follow-up survey carried out by CCRA-9 (Soil Quality and Carbon Sequestration) involving a subset of fields, practices, crop density and diversity, and soils from these sub-sampled households will link household and biophysical datasets. The household data will be used to inform agricultural trials managed by soil scientists on the project team in addition to an analysis of networks and information flow.

Development Impact

The survey effort is rapidly moving toward completion of the data collection phase. We have successfully engaged partners, students, and household participants in translation, field testing, and implementation. These efforts have resulted in significant increases in our knowledge and in capacity of our partners to be involved in this type of work. The data collected will be of immediate value to the agronomic component in terms of better defining our limited understanding of the cropping systems of the Central Plateau.

Challenges and Responses

In October, plans were made to initiate the baseline survey of farms in the Central Plateau in early January. A cholera epidemic initiating in the Central Plateau began to expand, threatening stability and livelihoods once again. At the same time, there was violence related to political unrest surrounding the elections. Over the next several weeks, we monitored the situation in Haiti. Realizing that these events could well distort and bias household responses, a decision was made to postpone the baseline study until after May.

It became clear over the last year that the Ministry of Agriculture and Natural Resources would be unable to commit to oversight and employment of the survey enumeration team due to time constraints and new responsibilities of the in-country coordinator. In October of 2010, we meet with administration of FAMV at the Damien campus with the intention of engaging them in the project, and potentially having them assume this responsibility. A memorandum of understanding (MOU) was completed, but subsequent gaps in communication exchanges ensued and a contract was not secured. A follow up visit with FAMV administration was made in early June, and a commitment to involve faculty as advisors to the survey and field experiments was made. Although it was clear they would be unable to assume responsibility for managing the survey team, FAMV faculty assisted in organizing student enumerator interviews, and translation of the survey into Kreyol. A budget revision to cover relevant expenses was submitted, and related expenses included in the 2012 budget. Zamni Agrikol

accepted responsibility for employment and financial management of the survey team in July and the survey began in August.

Just as initial field testing of the survey began, several kidnappings occurred in the immediate vicinity of our planned base of operations. Attempts to move to another region could not be accommodated, so a decision was made move base operations to a guarded hotel compound several miles from the affected community, to identify safe communities in which to work and to minimize exposure of partners and team members. The communities surveyed were not affected by these incidents. The field testing continued successfully and provided much needed feedback for improvement of the survey instrument and its implementation. We expect the survey to reach its target of 600 households well before the end of November.

Objective 2: Increase agricultural production through development of CAPS.

Critical Research Accomplishments

Our focus this year remained on finding cultivars of beans and maize that will respond in a CAPS environment, on building research capacity, and on introducing and testing cover crops suitable for the region and the farmers' situations. Improved black bean varieties were identified and obtained from collaborators within the Pulses CRSP in Puerto Rico, and improved maize varieties were obtained from CIMMYT in Mexico.

Trials to evaluate maize lines best adapted to CAPS and the Central Plateau were initiated this summer at three locations; Corporant, Lachateau, and Maissade. Delayed rains were followed by excessive rains at Maissade, and maize was not planted until August 9, 2011. The experimental units represent the CIMMYT "Lowland Tropical Standard" test and three local check entries.

Table 6. Maize trial activities by experimental site in the Central Plateau of Haiti, 2011

Activity	Corporant	Lachateau	Maissade
Site selection		April 28, 2011	
Staking and billionage		May 10, 2011	
Sowing	May 23, 2011	May 10,2011	August-2011
Weeding		June 1, 2011	
Chemical fertilization		June 18, 2011	
Spraying for caterpillars		May 10,2011	
Harvest			

At the Lachateau site, seedling vigor and emergence were monitored for selected lines. Germination of the local corn lines ranged from 89 to 65 percent with a mean of 80 percent. Germination of the experimental lines ranged from 100 to 60 percent with a mean of 88 percent. This was in spite of the fact that no rainfall was received for 15 days after seeding.

Table 7. Maize germination and emergence by experimental line, forty days after planting in Lachateau, Haiti 2011.

Plot	Entry	Varieties/Code	Seeds Planted	Seeds Emerged	Percent Emerged
01	08	CL02720/CLRCY 017	78	78	100
02	07	CLM161 /CLM165	78	65	83.33
03	16	Local CHECK-1	78	66	84.61
04	13	CLRCY039/CLRCY017	78	72	92.30
05	14	CLRCY045/CLRCY017	78	65	83.33
06	17	LOCAL CHECK-2	78	69	88.46
07	12	CLM451/CLRCY017	78	66	84.51
08	04	CLQRCYQ59/CLM161	78	69	88.46
09	10	Cl02720/CLRCY016	78	74	94.87
10	09	CLYN205/CLRCY017	78	74	94.87
11	18	LOCAL CHECK-3	78	50	64.10
12	02	CLQRCYQ59/CLQ2450Q49	78	76	97.43
13	06	CML451Q/CL02450Q	78	74	94.87
14	03	CLQRCYQ70/CML161	78	75	96.15
15	15	CML451/CL02450	78	71	91.02
16	11	CL02720/CL02450	78	52	94.20
17	01	CLO2450Q/CML161	78	68	87.17
18	05	CLQ-RCYQ71/CLQ-RCYQ49	78	75	96.15
19	13	CLRCY039/CLRCY017	78	66	84.61
20	08	CLO2720/CLRCY017	78	76	97.43
21	03	CLRQ-RCYQ70/CML161	78	69	88.46
22	12	CML451/CLRCY017	78	67	85.89
23	07	CML161/CML165	78	71	91.02
24	11	CLO2720/CLO2450	52	46	88.46
25	09	CLYN205/CLRCY017	78	77	98.71
26	06	CLM451Q/CL02450Q	78	62	79.48
27	10	CLO2720/CLRCY016	78	68	87.17
28	01	CLO2450Q/CML161	78	72	92.30
29	17	LOCAL CHECK-2	78	47	60.25
30	04	CLQRCYQ59/CML161	78	65	83.33
31	18	LOCAL CHECK-3	78	48	61.53
32	14	CLRCY045/CLRCY017	78	71	91.02
33	16	LOCAL CHECK-1	78	51	65.38
34	05	CLQ-RCYQ71/CLQ-RCYQ49	78	76	97.43
35	02	CLQRCYQ59/CLQ-RCYQ49	78	62	79.48
36	15	CML451/CLO2450	78	73	93.58


Figure 3. Maize in vegetative growth at Lachateau, Haiti, June 2011

Figure 4. Maize at the start of tasseling at Lachateau, Haiti, July 2011

Table 8. Average height of corn varieties 90 days after sowing and number of ears per plant

#plot	Entry #	Variety	Average height of plant (m)	Average number of ears per plant
01	08	Cl02720/CLRCy017	2.38	2
03	16	Local-Check-1	2.98	2.33
05	14	CLRCY045/CLRCY 017	2.30	2
06	17	Local Check-2	3.23	2
07	12	CLM 451/CLRCY 017	2.35	2
10	9	CLYN205/CLRCY 017	2.26	1.33
12	2	CLQRCYQ59/CLQRCYQ49	2.18	1.66
14	3	CLQRCYQ70/CLM161	2.23	1.66
15	15	CLM451/CLO2450	2.23	1.66
18	5	CLRCYQ71/CLQRCYQ-49	2.05	1.33
19	13	CLO2720/CLRCY017	2.31	1.33
29	17	Local Check-2	2.25	1

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Figure 5. Maize fields in June of 2011 at the Corporant experimental site, Haiti.

Figure 6. Maize fields at the Corporant experimental site, Haiti, showing good yield and ear size.

Plant height and average number of ears per plant were recorded from selected entries at the Lachateau site in August. The experimental lines had larger plants and more ears than the local varieties. A repeat of the test under irrigated conditions was suggested to determine if this difference would hold true under better rainfall conditions.

Harvest data have just been received for the Corporant and Lachateau sites. The Maissade site was planted at the beginning of the second rainy season in August, and is still maturing.

Black bean seed weight analysis from summer of 2010 were completed at Virginia Tech and returned to Haiti in November. From 2010 plantings, agronomists and growers selected two black bean cultivars (higher yielding and purple flowers) for seed increase and on-farm trials. Seeds were distributed to 300 farmers for local testing in December.

Black beans planted during the second rainy season in 2010 at Maissade emerged well (65 to 95 percent), but attracted leaf eating insects. After pod formation, drought resulted in no harvestable yields in November. Caritas agronomists felt that black beans were ill-suited for the

region when planted as a second season crop, and noted that they are seldom grown by local farmers.

Irrigated beans were planted in December 2010 and harvested in March 2011 at Lachateau. Four additional replicated trials were planted on farmers' fields at higher elevation sites more appropriate for black beans during the rainy season. We also have just received data from these trials, and will update our report once we analyze the data.

Development Impact
We have made progress in building the capacity of Haitian partners to carry out research trials, a skill set that was very limited when the project began in 2010. This fundamental capacity is needed before we attempt additional CAPS trials, or move to farmer fields. This capacity allows us to move to the more focused objectives of putting additional complex factors into our studies involving CAPS components and systems, as well as to consider existing barriers to CAPS adoption (i.e., lack of experience or knowledge with weed control and reduced tillage/direct seeding practices). In addition, black bean trials have been conducted on farmers' fields for two years.

Challenges and Responses
Considering the events of the last two years, and the starting point in January 2010, we have made great strides in building relationships and capacity. We continue to face resistance to planting non-food cover crops and to using reduced- or no-till methods. We have tried several times to initiate adaptation and performance trials for cover crops, but, have nothing to show for the effort. Cover crop research packages (seed, plot plans, and instructions) were provided to partners in July 2010 for a second season planting in the spring of 2011 and again in the summer of 2011. Various events have prevented successful implementation of these trials thus far. Clearly we need to improve our ability to communicate the potential importance of cover crops and to devise better methods of making sure materials are in place when VT personnel are present to assist with the plantings. We plan to meet with our partners in December or January to discuss options for establishing an early spring cover crop trial which could be used to plant into for the coming season. Where possible, we have proposed using irrigation during the dry season to establish cover crop trials to provide biomass and soil cover prior to the spring season. This will be a one-time intervention to overcome the lack of established cover crop trials in the 2011 season.

Objective 3: Increase the capacity of smallholders to adapt and improve CAPS.

Critical Research Accomplishments
With a focus on building capacity with our direct partners, we have limited efforts and opportunities to reach out to farmer organizations and communities. Four bean variety trials using varieties expected to perform well within CAPSs were conducted on farmers' fields by agronomists from Zanmi Agrikol. This has created interest in that community for improved cultivars. Zamni Agrikol reports that they distributed black bean seeds to 300 farmers in

December, and they also followed up directly with farmers concerning phytosanitary treatments, and conducted observational visits in February. In dry season meetings, 890 men and 710 women farmers were introduced to the topic of CA, the importance of controlling erosion, and improving soil quality by Zamni Agrikol agronomists. About 30 farmers have visited the maize trials, which are showing enhanced performance when compared with the native cultivars.

Development Impact
We are too early in the process to assess impacts at this time.

Challenges and Responses
We are at least one year behind where we wanted to be at this point compared to what was originally proposed. We now believe that estimate was overly optimistic even discounting the challenges of a major devastating earthquake, a cholera epidemic, election violence, and other disruptions. On the other hand, it has taken considerable time to build trust with our partners, for them to understand why we are in Haiti, and what we are asking them to do. Only as we gain that trust and see value in the project will they work with us to open doors to the community with which they work. With the knowledge base being built by the baseline household survey, the planned collaborative soil, field, and practice survey with CCRA-9, and our growing competency in research methods appropriate for Haiti, we believe we can make begin to move forward much more rapidly.

Until we make progress with Objectives 2 and 3, the main contribution will be providing training that makes smallholders more aware of erosion and its harmful effects on food security. We will continue to focus on these objectives, and on awareness training. In the upper Plateau, we will need to work with a newly assigned agronomist with regards to training.

Objective 4: Coordination and Training: Strengthen the human and institutional research and extension capacity for CAPS.

Critical Research Accomplishments
We have completed basic training required for survey enumerators, and nearly finished the surveys. The experience gained in training enumerators and conducting the baseline survey will be invaluable as we work with the CCRA-9 to conduct supporting field based in the coming year. We have clearly made great progress in conducting agronomic research. Efforts need to move forward on cover crop evaluations and multiple-component testing of CAPS.

We collaborated on an effort to bring one agronomist to the US for short training in soil science and crop production, but encountered visa problems.

We have yet to identify a graduate student or Haitian scientist for long-term training.

Development Impact
The training completed has significantly improved our ability to move forward with economic analyses and agronomic research.

Challenges and Responses
We have had great difficulty in connecting with Haitian students and scientists who are qualified and desire to pursue long-term training. We continue to seek and make contacts with those who might connect us with such individuals, but to no avail.

We are beginning from the start with a new agronomist at Caritas-Hinche for the coming year. We look forward to working with him and have been very encouraged by improved communication with this valuable partner in recent weeks.

Degree and non-degree training activities

Two graduate students, one Ph. D student in resource economics, and one master's student in crop and soil environmental sciences, have been trained this year.

Zanmi Agrikol agronomists trained 899 men and 710 women in basic agricultural conservation knowledge and soil conservation at five short courses, two seminars, and three field days.

Two extended efforts to engage Haitian students in graduate studies were initiated, and as of this time, we have yet to attract a qualified candidate.

Three Haitian undergraduate students, Manasse Mersilus, Giovanni BienAmie, and Kenel Cadet arrived at Virginia Tech in January, and worked under the guidance of Wade Thomason, Mike Mulvaney, and Greg Amacher to complete their thesis work. These students brought existing data to the US, and worked to improve their English language and writing skills. The thesis for each was completed in English. Although not formally enrolled at Virginia Tech, they attended several lectures and field visits, interacted regularly with faculty, and assisted in several grant-related activities.

Publications, presentations, and other SANREM products

We have made one presentation this year.

Networking activities

In October 2010, Hodges and Moore met with administration of FAMV. Subsequently, an MOU was signed and faculty liaison identified.

In early May, Thomason and Stewart met with Badio and traveled to field sites in Hinche, Corporant, and Lachateau to deliver seed and discuss details for the current season as well as plans for the second season and Year 3 of the project. They also collected soil samples in Bas Cange for shipment and further studies back in the U.S.

In May, Hodges, Amacher, and Kennedy traveled to South Carolina to meet with Gillaine Warne of Zanmi Agrikol to discuss the security situation in Haiti and to request assistance in hiring and oversight of the baseline survey enumerators.

In June, Hodges and Kennedy returned to FAMV and met with the vice doyen for academics, and Professors Alexandre and Duvivier, in regard to involving interested members of the faculty in the project and establishing a subcontract. We later interviewed 12 students interested in working as enumerators on the baseline survey. Interns (see "training" above) assisted in translation and in bringing interested students. We met also with Caritas Hinche to discuss progress on the project, but were unable to visit the site due to recent heavy rains and poor road conditions. An initial field test of the survey instrument was conducted with the assistance of agronomists from Zanmi Agrikol.

In July, Kennedy returned for an extended stay in the Cange area to train enumerators and to conduct the baseline survey. With several shifts in personnel, contacts were developed with Maria Flore and Michael Hebert within Zamni Lasante/Zamni Agrikol to improve communications and understand of the survey project requirements.

In July, the Richmond Diocese Sustainable Development Committee met with representatives of Caritas Hinche, the Diocese of Hinche, and Virginia Tech to discuss historical background, and to clarify roles, expectations, and future goals for the "Farm Project" at Maissade and relations between the three parties. This meeting resulted in stronger relationships between all parties, and a new understanding that the current project is focused only upon the "Experimental Farm" component and subsequent farmer field trials with CAPS, not on development of a larger farm enterprise formerly discussed with Virginia Tech personnel. Resolution of this point has created a new start for the project in Maissade. Maize trials were planted for the first time in August, and will be harvested in late November.

Project highlights

- A baseline survey of 600 farm households in the Central Plateau is nearing completion. This survey was customized for Haiti, and will provide the highest quality, most academically rigor, and most extensive econometric survey of its type for the Central Plateau, if not for all of Haiti.
- New maize cultivars appropriate for CAPS and selected from the CIMMYT lowland tropical standard test appear to be outperforming local varieties in trials in the lower part of the Central Plateau.
- Interest in newly-introduced black bean cultivars has increased grower interest in research trials and crops in the lower part of the Central Plateau.

LTRA-7: Conservation Agriculture as a Potential Pathway to Better Resource Management, Higher Productivity, and Improved Socioeconomic Conditions in the Andean Region

Principal Investigator: Jeffrey Alwang, professor, Department of Agricultural and Applied Economics, Virginia Tech

Host Countries: Ecuador, Bolivia

Research Team:

- Virginia Tech: Department of Agricultural and Applied Economics: George W. Norton, Darrell Bosch
- Penn State University: Department of Plant Pathology: Paul Backman; Department of Crop and Soil Sciences: Robert Sean Gallagher, Richard Stehouwer
- University of Denver: International Development: Sarah Hamilton
- U.S. Department of Agriculture Soil Plant Nutrient Research Unit: Jorge A. Delgado

Research progress by objective

Objective 1: Identify and evaluate production practices and farming components that can be assembled into CA production systems for Bolivar, Ecuador and Tiraque, Bolivia.

Critical Research Accomplishments

Task 1.1: Establish field research design and identify locations for crop and cover crop research. This has been completed and we now have farmer field trials being established in Ecuador and Bolivia. This design was established by using vulnerability maps produced as a part of the prior SANREM CRSP, through discussions with farmers and other stakeholders, and through consultations between the host country and U.S. research teams.

Ecuador: The experimental design has been established and treatments are in production (see below). We have experiments on farmer fields in the upper (Illangama) and lower (Alumbre) watersheds.

Bolivia: We have designated four different areas of the Tiraque watershed to establish CA plots that would be planted with the crop sequences agreed upon the previous year. These sites were near communities named San Kayani (the highest), Cebada Jincana, Wayla Puyru, and 15 de Octubre (the lowest altitude). The altitudes ranged from almost 14000 ft. to 11,000 ft. CAPS experiments include (1) vetch (*Vicia* sp.) cover crop and inclusion in a potato – quinoa (*Chenopodium quinoa*) – faba bean rotation; (2) supplemental fertility management for the potato phase of the potato – quinoa – fava bean rotation; (3) reduced-tillage potato trial; and (4) alternative forage options to precede the potato-based systems. The sites were prepared in October, and the team waited for rains in order to seed the fields. It was a La Niña year with

unusual rainfall patterns. Through mid-December, there were no rains, with the first rains in the region occurring on December 20. Rains very soon caused flooding. Frequent rains prevented planting, and washed out those that had been made. The only site with viable plants from the cropping sequence (the rest were largely weeds) was the 15 de Octubre site, and since the site was planted late, the plants were stunted and provided less than optimal ground cover. Only the cropping systems at the 15 de Octubre would continue in Year 2, while the other 3 sites would all be planted following the year- one cropping sequence.

In both countries, the research team decided to begin supplementing natural rainfall with aspersion irrigation. This added moisture will compensate for below average rainfall by bringing total water availability up to average levels. It was made necessary by the presence of drought and the damage it could do to a five-year experiment.

Task 1.2: Assess potential CA components for each farming system. We have conducted an assessment of feasible components. The research designs have been adjusted following scientist visits to the area throughout the first two years of the project.

Task 1.3: Identify the most likely full CAPS for each farming system.

Ecuador: See table 1 for the most likely CAPS in Ecuador.

Table 9. Description of CAPS in two cultivation systems, Ecuador

Illangama sub-watershed (Upper watershed)—Potato-pasture system	Alumbre sub-watershed (Lower watershed)-Maize-beans system
Soil conservation: Practices with and without deviation ditches. Note: in current year, we removed ditches as a factor in our research design following recommendations of US SANREM scientists. The presence of deviation ditches complicated unduly the experimental design.	**Soil conservation:** Practices with and without deviation ditches. Note: in current year, we removed ditches as a factor in our research design following recommendations of US SANREM scientists. The presence of deviation ditches complicated unduly the experimental design.
Tillage: Conventional and reduced.	**Tillage**: Conventional and reduced.
Rotation 1: Potato, barley (*Hordeum vulgare*), faba, and forage mix. Note: Improved forage mix has been identified with prior research.	Rotation 1: hard maize, bush beans, hard maize, peas (*Pisum sativum*) and hard maize.
Rotation 2: Potato, barley, oats (*Avena sativa*)-vetch and forage mix.	Rotation 2: Hard maize, bush beans, hard maize, oats-vetch and hard maize.
Management: Soil use (fallow, grass with residuals removed, grass with residuals	**Management**: Tillage options (conventional and reduced), cover crops

retained), fertilization with N and cover crops (faba and quinoa). Intensive pasture management (improved forages) with overseeding of white clover (*Trifolium repens*)	(peas, oats-vetch, maralfalfa (*Pennisetum purpureum)*, and native trees) Use of maralfalfa and fruit trees in contours to form live barriers.

Challenges and Responses

Our research toward this objective is proceeding exactly as planned. We had difficulties with inadequate rainfall in Bolivia (see note above). We have added supplementary irrigation on our farmer field plots for both sites in order to ensure that conditions mimic average rainfall.

Objective 2: Validate candidate CAPS in terms of impacts on: soil health, soil retention, carbon and nutrient balances; sustained productivity; profitability; risk bearing; the environment; compatibility with household livelihood strategies; and social conditions including gender considerations.

Critical Research Accomplishments

Task 2.1: Create protocol for evaluating soil and crop sustainability in experiments: physical, chemical and biological changes over time and due to differences in practices. This has been completed through consultations with scientists at Penn State, CCRA-9, Jorge Delgado (ARS), and local partners. We have gathered samples for a soils baseline in both countries and established a laboratory in Bolivia to conduct basic analysis. The work at the laboratory in Ecuador was of sufficient quality and our scientists assisted them in establishing the protocol.

Key accomplishments in both countries include the implementation of an efficient colorimetric analysis of inorganic and total N, and available P, biological nitrogen determinations, and the construction of equipment to evaluate soil hydraulic conductivity, water holding capacity, and bulk density. The emphasis here has been to promote in-country capacity building and self-efficiency. Team Bolivia has made excellent progress in establishing a small, but adequate soil and plant processing lab. With the appropriate upgrades of their microplate reader, they will be well positioned to determine labile N and available P. Arrangements to measure total C, N, and P still need to be made.

Sampling protocols have been worked out to ensure that composite soil samples taken at 0-5 cm, 5-10 cm and 0-25 cm depth will be collected and analyzed. Laboratory equipment and supplies were delivered to the team in Bolivia and it was determined that some supplies will be necessary for Ecuador as well. In Bolivia, a hydraulic conductivity apparatus was constructed and tested. Substantial effort has been invested in building capacity for soil analysis in Bolivia during one trip by Stehouwer and two trips by Gallagher.

Soil analysis capacity building

In Bolivia, the PROINPA research station located in Cochabamba is well equipped for various microbiological techniques, but had little capability to evaluate soil quality and the associated measurements in plants. As such, a major effort was undertaken by Gallagher and Stehouwer of

Penn State University to increase the capacity of this facility to conduct the key soil and plant analysis necessary to measure the progress in building sustainable CAP systems. The primary soil measurements included: (1) total carbon, N and P; (2) plant available N and P; (3) available cations; and (4) potentially mineralizable N [PMN] and particulate organic matter [POM]. Total C, N, and P are important baseline measurements for the long-term CAPS experiments, whereas available N, P, and cations are important indicators of soil fertility. PMN and POM are good indicators of increased fertility that can occur with cover crops and the application animal manures. In addition to these soil chemical indicators, we have included the measurement of soil hydraulic conductivity, soil water holding capacity, and bulk density, which are good indices of the soil erosion potential.

To conduct these analyses, some basic field and laboratory equipment, as well as reagents chemicals are required. Equipment that either has been purchased or brought from the United States include soil sampling probes, water baths, soil grinders, pipettes, and soil sieves. A microplate reader that was already in place at the station has been upgraded with the necessary filters to do rapid and inexpensive colorimetric determination of inorganic N and available P. Many of the necessary reagents were already present at the station, although a few key reagents were brought from the US. An apparatus to evaluate soil hydraulic conductivity, and another to evaluate soil water holding capacity were built on site under the guidance of Gallagher and Stehouwer. Gutierrez, Saavedra-Rivera and Botello (PROINPA staff) have been trained in the necessary extraction procedures. Training is currently in progress on the colorimetric determination of inorganic N and available P. The station does not have the readily available capability to evaluate the soils and soil extractions for total C, N, and P, and available cations.

In Ecuador, the INIAP Santa Catalina research station is well equipped for soil and plant analysis, and its personnel have considerable experience in these areas. However, when the SANREM project was initiated there was no formal institutional arrangement by which the soil and plant samples from the SANREM project could be analyzed. We are pleased to report, however, such an arrangement is now in place, and Soraya Alvarado has taken the lead in overseeing these analyses. Alvarado has considerable experience in the evaluation of soil quality and is a great asset to the project. Gallagher has been working with Alvarado and Barrera to further increase the efficiency and capacity of this laboratory.

Characterization of baseline soils in Illangama, Ecuador

SANREM test-plot (old) potato-pasture

Physical analysis of soils in test plots is presented by repetition (locality) in Table 10. In each case, we sampled soils at different depths up to one meter; the chemical analysis used extracted solution (Olsen's modified method), pH from the soil with the relationship soil: water 1:2.5 and organic material using the TOC-V SCN for total organic carbon.

Table 10. Soil physicochemical characteristics by locality in the SANREM (old) potato-pasture trial at Illangama, Ecuador in 2011

Locality (Repetition)	Depth cm	P_b g/cm^3	Θ_g percent	NH_4^+ ppm	P ppm	S ppm	pH	OM percent
	0-25	0.98	49.55	96.0	18.0	3.80	5.91	9.9
	25-50	1.07	45.45	80.0	13.0	3.50	5.95	9.0
	50-75	1.03	49.64	69.0	11.0	2.90	6.05	8.9
	75-100	0.92	64.49	79.0	12.0	3.80	6.09	9.7
II (Marcopamba, Matías	0-25	0.94	42.66	70.0	14.0	8.50	5.89	8.7
Paguay)	25-50	1.07	43.31	80.0	13.0	4.10	5.97	8.8
	50-75	0.91	51.69	79.0	11.0	2.90	5.96	8.6
	75-100	0.85	61.83	71.0	12.0	2.80	5.88	9.8
III (Mulanga, José Vayas)	0-25	0.96	49.54	78.0	13.0	3.30	6.00	10.9
	25-50	1.02	53.81	76.0	13.0	3.50	6.04	9.1
	50-75	0.93	62.52	80.0	13.0	6.10	5.96	10.7
	75-100	0.84	68.59	69.0	11.0	3.80	6.01	11.6
Interpretation				A	M	B	L Ac	M-A

B= Low; M= Medium; A= High; L. Ac= Lightly acidic.

Bulk density (P_b) did not vary between repetitions, but within repetitions there were slight differences from 0.93 to 1.05 g/cm^3 at 25- to and 50-cm depths, falling to 0.87 g/cm^3 in the 75- to 100-cm depth. Gravimetric soil moisture content (Θg) fell moderately with increased depth and differences between repetitions were minimal. These results were consistent with uniform physical and climatic characteristics across the watershed.

Available nutrient concentrations were similar without major differences up to 1 m in soil depth. The soils are moderately fertile with slightly acidic pH 5.9 – 6.0 and organic matter content medium to high up to 1 m in depth. These soils are classified as Andisoles (medium organic matter from 5 to 10 percent). According to the U.S. soil taxonomy, the soil is classified as Thaptic Haplustand.

SANREM test-plot (new) potato-pasture

Physical analysis of soils in test plots is presented by repetition (locality) in Table 11. Results are similar to those in Table 10, as both are located in Illangama.

Table 11. Soil physicochemical characteristics by locality in the SANREM (new) potato-pasture trial at Illangama, Ecuador in 2011

Locality (Repetition)	Depth cm	P_b g/cm^3	Θ_g percent	NH_4^+ ppm	P ppm	S ppm	pH	OM percent
I (Culebrillas, Manuel	0-25	0.87	49.41	69	6.3	9.30	6.10	7.8
Pasto)	25-50	1.11	42.78	62	13.0	3.60	6.32	8.7
	50-75	1.03	47.65	66	10.0	3.50	6.35	9.3
	75-100	0.92	58.24	23	12.0	4.10	6.36	10.3
II (Marcopamba,	0-25	0.95	44.12	69	5.8	10.00	6.60	8.2
Matías Paguay)	25-50	1.01	47.67	71	10.0	4.10	6.65	9.0
	50-75	0.90	57.91	68	11.0	4.60	6.55	10.9
	75-100	0.89	58.55	70	11.0	4.50	6.52	11.2
III (Marcopamba,	0-25	0.96	47.56	80	7.7	12.00	6.30	9.6
Humberto Paguay)	25-50	1.05	45.24	72	12.0	9.50	6.47	9.1
	50-75	0.92	58.81	70	11.0	6.80	6.39	9.5
	75-100	0.86	61.70	80	11.0	6.20	6.35	10.4
Interpretation				M-A	B-M	B	L Ac	M-A

B= Low; M= Medium; A= High; L. Ac= Lightly acidic.

Characterization of the soils (baseline), Alumbre watershed

SANREM trial (old) maize-bean

Physical analysis of soils in test plots for the previously established maize-bean trial in Alumbre is presented by repetition (locality) in Table 12. The results for available nutrients are presented at four depths and we observe that the concentrations of ammonium N (NH_4+), sulfur (S) and organic material (OM) fall with soil depth. Soil depth in the first repetition is greater than 1 m, while in II and III, we find rocks starting at 50 cm; these two repetitions have superficial depths which limit their productivity.

Table 12. Soil physicochemical characteristics by locality in the SANREM (old) maize-beans trial at Alumbre, Ecuador in 2011

Locality (Repetition**)**	Depth cm	P_b g/cm^3	Θ_g percent	NH_4^+ ppm	P ppm	S ppm	pH	OM percent
I (Guarumal, Margarita	0-25	0.88	44.56	66.0	12.0	1.00	5.85	6.9
Lema)	25-50	0.79	51.30	44.0	11.0	0.10	6.18	5.2
	50-75	0.59	60.65	31.0	11.0	0.10	6.21	3.9
	75-100	0.67	69.30	27.0	12.0	0.10	6.20	3.3
II (Bola de Oro, Vinicio	0-25	0.74	40.84	51.0	14.0	2.90	5.95	10.9
Paguay)	25-50	0.96	24.54	45.0	11.0	9.80	6.20	9.8
	50-75							
				Rock				
	75-100							
III (Bola de Oro, Mario	0-25	0.76	39.07	61.0	13.0	16.00	5.78	9.9
Calvache)	25-50	0.75	36.20	71.0	12.0	2.20	5.50	9.2
	50-75							
				Rock				
	75-100							
Interpretation				M-A	M	B-M	L Ac	M

B= Low; M= Medium; A= High; L. Ac= Lightly acidic.

Bulk density fell in the first repetition with depth; this result is not common in volcanic soils. Θg increased moderately with increased depth in the first repetition; while in the two more degraded soils, it falls with depth. This measure reflects the ability of the soil to retain water.

Table 13. Soil physicochemical characteristics by locality in the SANREM (new) maize-beans trial at Alumbre, Ecuador in 2011

Repetition (Localities)	Depth cm	P_b g/cm^3	Θ_g percent	$NH4^+$ ppm	P ppm	S ppm	pH	OM percent
I (Guarumal,	0-25	0.81	39.46	50.0	5.8	6.10	5.80	7.8
Margarita Lema)	25-50	0.77	44.70	47.0	9.8	5.30	6.09	4.7
	50-75	0.81	50.81	48.0	13.0	1.90	6.19	4.0
	75-100	0.56	71.28	37.0	13.0	5.30	6.26	3.5
II (Panecillo, Luis	0-25	0.71	44.51	53.0	6.0	6.50	5.80	11.1
Ilbay)	25-50	0.44	81.85	49.0	9.8	0.10	6.19	7.0
	50-75	0.39	104.14	20.0	6.5	3.50	6.45	5.9
	75-100	0.40	108.52	26.0	8.6	4.10	6.45	4.9
III (Bola de Oro,	0-25	0.69	36.94	57.0	11.0	8.20	5.70	13.1
Vinicio Paguay)	25-50	0.79	34.26	46.0	9.2	3.30	6.17	12.1
	50-75							
	75-100			Rock				
Interpretation				M	B-M	B	L Ac	B-M-A

B= Low; M= Medium; A= High; L. Ac= Lightly acidic.

SANREM trial (new) maize-bean
Virtually the same patterns as in the old trial were also observed in the new trial. Repetitions I and II had deep soils (>1 m), while III contained many rocks at <50-cm and >50-cm depths.

Bulk density fell with soil depth for repetitions I and II, and varied between 0.39 and 0.81 g/cm^3 and humidity in the second repetition was 44.5 percent at 0- to 25-cm depth and 108.5 percent at 75- to 100cm depth. This reflected a very high capacity for moisture retention throughout the profile. The results also indicated a correlation between the two measures; while bulk density fell with depth, the capacity to retain moisture increased.

Task 2.2: Establish experiments for CA components, component combinations and full CAPS. We are in our second year of field experiments in Ecuador, and have completed a year of experiments in Bolivia. In each country, we are using a complete randomized block design with a 2x2x2 factorial (see tables 14 and 15 for our treatments in Ecuador). Several revisions of the experimental design have occurred since the start of the project, but design was finalized during Mulvaney/Gallagher trips to Ecuador in March 2011. This design was approved by Alwang during visits to both countries in May and June 2011. We decided to expand investigations of cover crops to intensify potato-pasture systems in the upper Ecuador watershed, and to examine means of increasing available K in Ecuador, and increasing soil fertility in Bolivia.

Table 14. Treatments according to cycle at Illangama, Ecuador, 2011

Treatment	First cycle Jan-June 2011	2nd cycle July–Dec 2011	3rd cycle Jan-June 2012	4th cycle July-Dec 2012	5th cycle Jan-Dec 2013
1. Grass with removal, conventional tillage, potato with fertilization	Potato	Oat-vetch with removal	Barley	Faba	Pasture
2. Grass with removal, reduced tillage, potato with fertilization	Potato	Oat-vetch with removal	Barley	Faba	Pasture
3. Grass without removal, reduced tillage, potato with fertilization	Potato	Oat-vetch without removal	Barley	Faba	Pasture
4. Grass without removal, reduced tillage, potato with fertilization minus N	Potato	Oat-vetch without removal	Barley	Faba	Pasture

Removal = Cut for animal feed
Without removal = Cut and leave as ground cover

Table 15. Treatments according to cycle atAlumbre, Ecuador in 2011

Treatment	First cycle Nov 2010-Mar 2011	2nd cycle April – Aug 2011	3rd cycle Sept-Dec 2011	4th cycle Jan-Sept 2012
1. Reduced tillage with fertilization for maize and bean	Natural grass with removal	Bean with removal	Natural grass with removal	Hard maize
2. Zero tillage with fertilization for maize and bean	Natural grass without removal	Bean without removal	Natural grass without removal	Hard maize
3. Zero tillage with fertilization for oat-vetch with removal and maize	Oat-vetch with removal	Bean with removal	Oat-vetch without removal	Hard maize
4. Zero tillage with fertilization for oat-vetch without removal and maize	Oat-vetch without removal	Bean without removal	Oat-vetch without removal	Hard maize

Removal = cut for animal feed
Without removal = cut and leave as ground cover

Evaluation of the components and the CAPS will be based on the variables and indicators shown in Table 16. We are collecting all these at appropriate frequencies and conducting analyses as the data become available (see above for a brief analysis of the baseline soil data). In addition to these indicators, we are recording complete cost of production budgets for each experiment.

Table 16. Variables and indicators for field experiments, Ecuador

Variables	Indicators
Erosion reduction	Depth of soil erosion
	Total weight of soil loss (in treatments with erosion controls)
	Soil bulk density
	Gravimetric soil moisture content
	Soil compaction
Soil nutrient dynamics	Plant macro- and micro-nutrient concentration
	Nutrient uptake by crop
	Plants harvested
	Dry-weight yield
	Chemical fertilizer efficiency
	Biomass production and total content of C and N
	Available P

The Ecuador team has conducted a preliminary analysis of the experimental results from the Illangama site, where we have harvested potato on our three repetitions, and from the Alumbre site, where we harvested maize.

SANREM test-plot (new) potato-pasture
Agronomic variables
We conducted an analysis of variance to test treatment effects on root depth, total yield in t/ha, and dry matter, and found statistically significant differences across treatments (Table 17). Results indicated differences between treatments and the control. There was no significant difference in percent of plants emerging, number per hectare, or number of tubers per plant.

Table 17. Mean root depth, potato total yield and dry matter biomass percent in the study in Illangama, Ecuador, 2011

Treatments	Root depth (cm)	Total yield (t/ha)	Dry matter biomass tuber/foliage (t/ha)
T1: Grass with removal, conventional tillage, potato with fertilization	36.91 b	15.81 a	3.97/0.44 b
T2: Grass with removal, reduced tillage, potato with fertilization	34.25 b	13.97 a	3.87/0.47 b
T3: Grass without removal, reduced tillage, potato with fertilization	34.41 b	14.55 a	3.93/0.83 a
T4: Grass without removal, reduced tillage, potato with fertilization minus N.	62.33 a	5.39 b	1.47/0.48 b

Values within columns followed by the same letter are not significantly different at $P \leq 0.05$.

Mean root depth was highest in T4 compared with T1, T2 and T3. This can be attributed to soil N deficit that caused plants produced deeper roots in search for N. Nonetheless, this response did not compensate for N fertilization as demonstrated by the dramatically low yields in the treatments without fertilization compared to the others.

Statistically different yields across the treatments are also seen in Table 17.T1 and T3 had the highest yields. CA practices, at least in these initial trials, produced equal yields in the short run. This combined with fewer labor inputs (soil preparation) is likely to lead to favorable overall economic results for T3 and T2. The effect of N is important, as the yield difference between T3 and T4 is 9.16 t/ha, or a 170 percent increment due to N application. These results point to the need for decision tools (such as the N index) in order to assist in making correct fertilization decisions.

Soil chemical variables

Soil N, P and K availability, pH, and OM concentration showed no statistical differences across treatment (Table 18). This is not a surprising finding as the baseline evaluation of soils indicated they were similar and it is unlikely that the CA practices would have a major impact in such a short period. Fertilization regimes were identical (except for treatment 4).

Table 18. Mean soil chemical characteristics in Illangama, Ecuador in 2011.

Treatments	NH_4^+ ppm	P ppm	K meq/100 ml	pH	OM percent
T1: Grass with removal, conventional tillage, potato with fertilization.	100.00	16.00	0.26	6.48	10.03
T2: Grass with removal, reduced tillage, potato with fertilization.	97.33	16.33	0.22	6.54	9.76
T3: Grass without removal, reduced tillage, potato with fertilization.	97.33	15.33	0.21	6.45	9.56
T4 : Grass without removal, reduced tillage, potato with fertilization minus N.	95.00	16.33	0.19	6.45	9.56

Physical soil characteristics

We measured soil strength (as an index of compaction) using a penetrometer to a depth of 50 cm; readings were expressed in Kgf/cm^2. Before planting and before harvest, we found no difference in readings at various depths, but there was a direct relationship between depth of reading and compaction as expected (higher depth, more compaction). The lowest level of pre-planting compaction was found in treatment T1 at low depths (0 to 10 cm); at other depths there was no difference between CA and conventional practices.

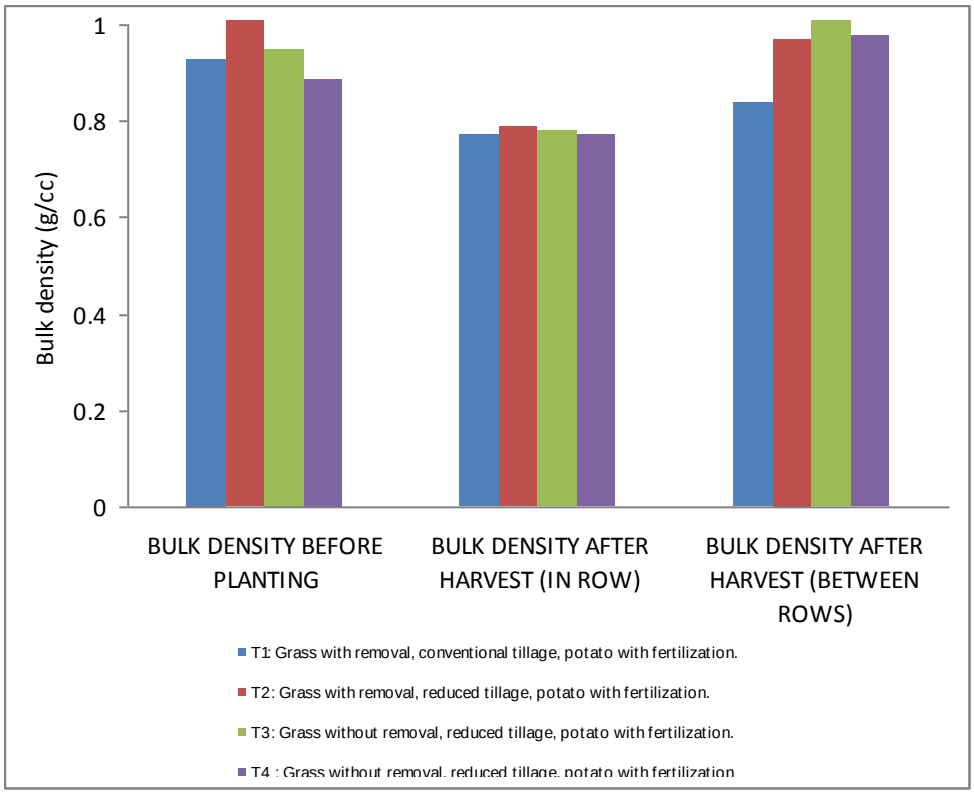


Figure 7. Bulk density before and after planting in Illangama, Ecuador in 2011.

Bulk density was measured using the oven method with samples taken between 0- and 25-cm depths. Greater bulk density was detected prior to planting and before planting between lines compared to prior to harvest between plants (Figure 7). Bulk density before planting for T2 was s slightly higher compared to T1, T3 and T4. Bulk density before planting between plants was similar for all treatments. Bulk density prior to harvest between lines was slightly higher in the CA treatments; this result needs to be closely watched in future years as high bulk density is considered to be detrimental for plant root development. However, these soils have a large buffer capacity (bulk densities of 1.3 kg/cm^3 are to be worried about). As a result, we will put more emphasis on monitoring chemical aspects of the soil and water availability.

Θ_g was measured using standard techniques with samples taken at 0- to 25-cm depth. In all cases, the measure was higher before planting than it was prior to harvest (Figure 2). The CA treatments show a higher level of Θ_g compared to the control, suggesting that CA is having a positive impact on soil moisture retention.

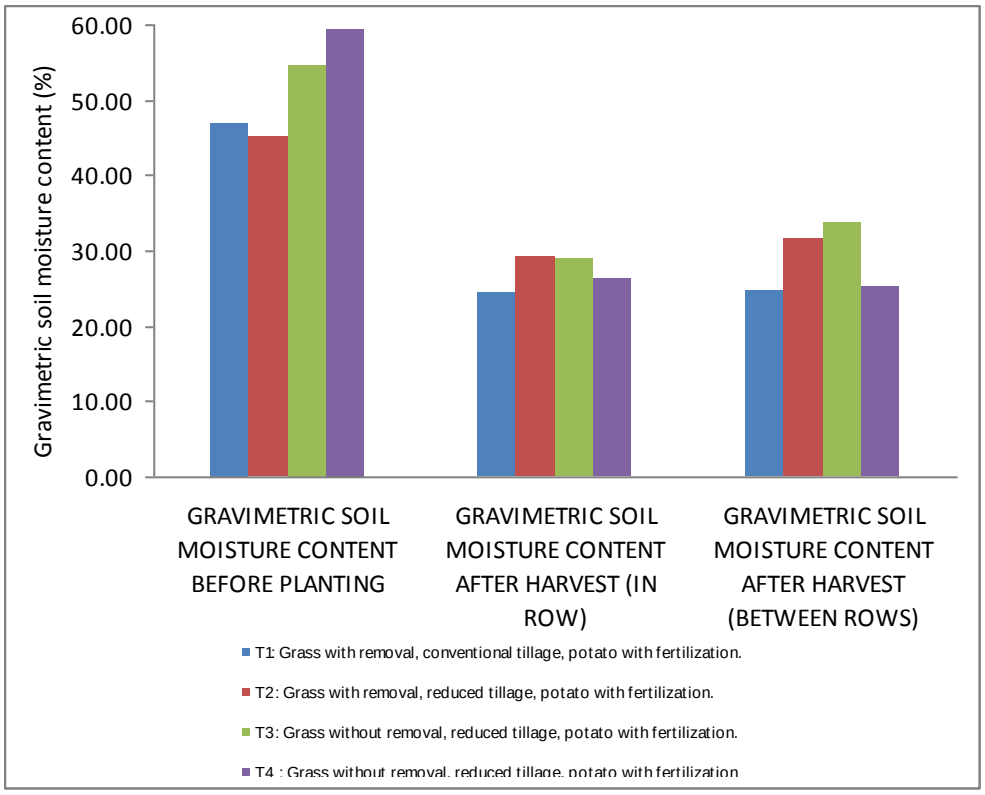


Figure 8. Gravimetric soil moisture content before and after planting in Illangama, Ecuador in 2011.

Financial analysis of treatments

Table 19 presents an overview of the cost analysis for the treatments in Illangama. Note that this is a preliminary analysis and that decisions about overall economic benefits will depend on returns and costs through the entire production cycle. In addition, we will eventually include other, more difficult-to-quantify costs and benefits (off-farm costs and benefits, carbon credits) in subsequent analyses. We also need to include the value of harvest forage (a difference between treatments is removal/non-removal of ground cover and removed ground cover has an economic value that is not included in these calculations). We use the yield and cost data presented above and a $220/mt value for potatoes in the calculations. The CA treatments greatly reduced the cost of land preparation (from $988/ha in conventional to $235/ha in reduced tillage—a 76 percent reduction). The value of added N was investigated as several scientists were skeptical of its economic value. The data from this experiment were used to verify the economic value of adding N and to help calibrate the N index.

Table 19. Economic analysis of treatments in Illangama, Ecuador in 2011

Treatments	Gross returns $/ha	Variable costs $/ha	Marginal net returns $/ha	Marginal variable cost $/ha	Marginal rate of return percent
T3: Grass without removal, reduced tillage, potato with fertilization.	3201	1 369	1 792	223	804
T4: Grass without removal, reduced tillage, potato with fertilization, minus N	1185	1 146	0	0	

Note: Margin refers to next best treatment. Results from T1 & T2 are not included in the analysis.

Table 19 presents results following dominance analysis; treatments 1 and 2 were dominated by the other two because they had lower net returns and equal or higher variable costs compared to T3 and T4 (thus their analyses do not appear in the table). The 804 percent marginal rate of return for T3 (the margin compares the difference in net returns between T3 and T4 divided by the difference in variable costs) shows this treatment to be far superior in financial terms compared to the others. This analysis does not account for the value of the removed grass, which might alter the findings somewhat; the valuation of removed grass (for feed) will be studied in subsequent project years.

SANREM trial (new) maize-bean

Agronomic variables

The dry matter biomass (natural grass and/or oats vetch) and bean yield showed no statistically significant differences among treatments. Variable means are presented in Table 20.

Table 20. Mean values for agronomic variables in bean treatments in Alumbre, Ecuador in 2011

Treatments	Dry weight biomass, natural grass and/or oats/vetch (t/ha)	Bean total yield (t/ha)
T1: Reduced tillage with fertilization for maize and bean (natural grass with removal)	5.01	1.38
T2: Zero tillage with fertilization for maize and bean (natural grass with removal)	5.04	1.32
T3: Zero tillage with fertilization for oat-vetch with removal and maize	4.27	0.99
T4: Zero tillage with fertilization for oat-vetch without removal and maize	5.26	1.07

Treatment 4 had the highest biomass yields, but treatments 1 and 2 showed the highest bean yields, with 1 being slightly higher. As noted, differences were not statistically significant.

Financial analysis of treatments

The financial analysis of the Alumbre treatments is presented in Table 21. This analysis is based on the yield and cost data already presented, and does not include the value of the removed grass/cover crop (which is fed to animals). Even without a yield benefit (see Table 21), the CA practices, because they save labor in land preparation are significantly better in a financial sense than the farmer practices. Land preparation costs fall from $568/ha with conventional tillage to $399 with zero till, a reduction of 30 percent.

Table 21. Rate of return in maize-bean systems in Alumbre, Ecuador in 2011

Treatments	Gross returns ($/ha)	Variable costs ($/ha)	Marginal net returns ($/ha)	Marginal variable cost ($/ha)	Marginal rate of return (percent)
T1: Reduced tillage with fertilization for maize and bean (natural grass with removal)	1 861	568	89	23	385
T2: Zero tillage with fertilization for maize and bean (natural grass without removal)	1 772	545	288	146	197
T4: Zero tillage with fertilization for oat-vetch without removal and maize	1484	399	0	0	

Note: Margin refers to next best treatment. Treatment T3 was dominated (see above) and thus excluded from this analysis.

T1 is financially the best treatment, with a 385 percent greater marginal return over the second-best treatment (T2). Note that this calculation does not include the feed value of the removed grass in treatment 1; inclusion of this value will increase the returns from this practice. The source of this difference is likely the supplemental fertility applied to the maize when the ground cover is removed prior to planting; yields are clearly higher for T1 and T2 where we included supplemental fertilization.

CA Experiments in Bolivia:
In Bolivia, we are also focusing on potato-based systems, but conditions in Bolivia differ from those in Ecuador, and these differences mean we had to modify our approach. In particular, soil quality is extremely low, pathogen content is high and the entire agricultural system is stressed by low levels of precipitation and soil moisture content. Growing cover crops in such conditions is a challenge, and soil health limitations require us to explore a variety of soil-health improving biological amendments.

Experiment 1: Evaluation of application of *Bacillus pumilus* and two levels of fertilization on rotation system vetch-potato-cereal to improve soil fertility

Bacillus pumilus is a P solubilizer and we are investigating its properties in combination with our CA experiments. In the second year of the rotation, we have incorporated two levels of fertilization with p plus *Bacillus pumilus*. We are conducting a physical and economic evaluation of the treatments.

The experiment is located in "15 de Octubre" in Tiraque, Department of Cochabamba. The treatments will be included in a rotation cycle of four years.

Year 1: Vetch incorporated
Year 2: Conventional potato
Year 3: Cover crop (Oats and vetch)
Year 4: Quinoa

We have first-year data available from this treatment (still to be evaluated)—soil samples, measures of dry weight and yield, relationship of C/N, and cost data. In subsequent years, the same data will continue to be collected.

In the second year of the rotation, we have established conventional potatoes and a research design (randomized block design) as follows:

Factor A (*Bacillus pumilus*):

- B1: without *Bacillus pumilus*

- B2: with *Bacillus pumilus* (1.8 l/ha)

Factor B (Levels of fertilization—sub-parcels):

- Vetch incorporated
- Vetch incorporated + 70 percent chicken litter
- Vetch incorporated + 70 percent chicken litter + P_2O_5 (40 kg/ha)
- Vetch incorporated + 70 percent chicken litter + P_2O_5 (80 kg/ha)

Experiment 2: Evaluation of alternative cover crops for CAPS in Tiraque, Cochabamba.

Identification and evaluation of suitable cover crops and their potential to improve soil health is a critical first step in identifying an entire CAPS. The objective of this experiment is to identify the most suitable cover crop varieties for the potato system that predominates in the area.

Figure 9. Vetch prior to incorporation in Tiraque, Bolivia.

Table 22. Treatments, main CA trials in Bolivia

Treatment	Year 1 Sep/2010 to Apr/2011	Year 2 A Aug/2011- Jan/2012	Year 2 B Jan/2012 - Apr/2012	Year 2C Aug/2012- Mar/2013
1	Fallow	Conventional potato + 100 percent chicken litter (12 m^3/ha)	Fallow	Faba or quinoa
2	Vetch (removed) + 30 percent chicken litter (3.6 m^3/ha)	Conventional potato + 70 percent chicken litter (8.4 m^3/ha)	Cover crop	Faba or quinoa
3	Vetch (retained) + 30 percent chicken litter (3.6 m^3/ha)	Conventional potato + 70 percent chicken litter (8.4 m^3/ha)	Cover crop	Faba or quinoa

We used a complete randomized block design with three repetitions. Fertilization was at standard levels, with chicken litter application, as common practice. We followed planting densities recommended by the Centro de Investigación en Forrajes (the Bolivian Forrage Center--CIF), and the species was *Vicia sativa.*

Our analysis variables were: Mg, Ca, K, available P, organic matter, and potentially mineralizable N content; pH; saturated hydraulic conductivity; and soil water content.

Crop analysis variables were: Biomass; C and N total amount (in biomass, species classification and yield (potato).

The economic variable was cost of production (material, inputs and labor).

The sites were prepared in October, and the team waited for rains in order to seed the fields. It was a La Niña year with unusual rainfall patterns. Through mid-December, there were no rains, with the first rains in the region occurring December 20. Rains caused flooding, and frequent rains prevented planting, and washed out established plants.

The only site with viable plants from the cropping sequence (the rest were largely weeds) was the 15 de Octubre site, and since these were late planted the plants were stunted and provided less than optimal ground cover. Only treatments at the 15 de Octubre site will continue in year 2, while the other three sites would all be planted to the year one cropping sequences next October.

We have taken soil samples from all sites and the measurements (as noted above) from the 15 de Octubre site.

In the second year, parcels were prepared by 31 August 2011, and the Waycha variety of potato was planted.

Experiment 3: Evaluation of three varieties of potato in CA system

This experiment was designed to evaluate the productivity and other attributes of three potato varieties under two tillage systems, with the end objective being to identify the most suitable variety for the CAPS.

This trial is being implemented at 15 de Octubre, under a complete randomized block design with two factors: (1) traditional versus total cover and (2) potato variety. The varieties are: Waych'a (*Solanum tuberosum andigenum*), Desiree (*Solanum tuberosum tuberosum*), and Ajiba (*Solanum tuberosum sp.*).

Factor A- Production system:
Production system with cover: use of barley remains as a mulch bed and cover
Traditional system: open furrows and cover tubers with soil

Factor B- Variety:
Waych'a
Desiree
Ajiba

Figure 10. Potatoes under direct seeding in no till in Tiraque, Bolivia.

Figure 11. Waycha potato after direct seed with cover in Tiraque, Bolivia.

Table 23. Field treatments in potato trial (varieties and tillage system) in Tiraque, Bolivia

Treatment	Description
1	Total cover+Waych'a
2	Total cover +Desiree
3	Total cover +Ajiba
4	Traditional system+Waych'a
5	Traditional system +Desiree
6	Traditional system +Ajiba

Cultivation occurred as appropriate by system. The mulch system did not require hilling to create conditions for growth of tubers. Pest control followed farmer practices and was identical for the two cultivation systems.

The main variable for evaluation was tuber yield. There were no statistical difference in yield between systems and no significant interaction between varieties and systems. Variable means are shown in Figure 12. The differences seen were not statistically significant.

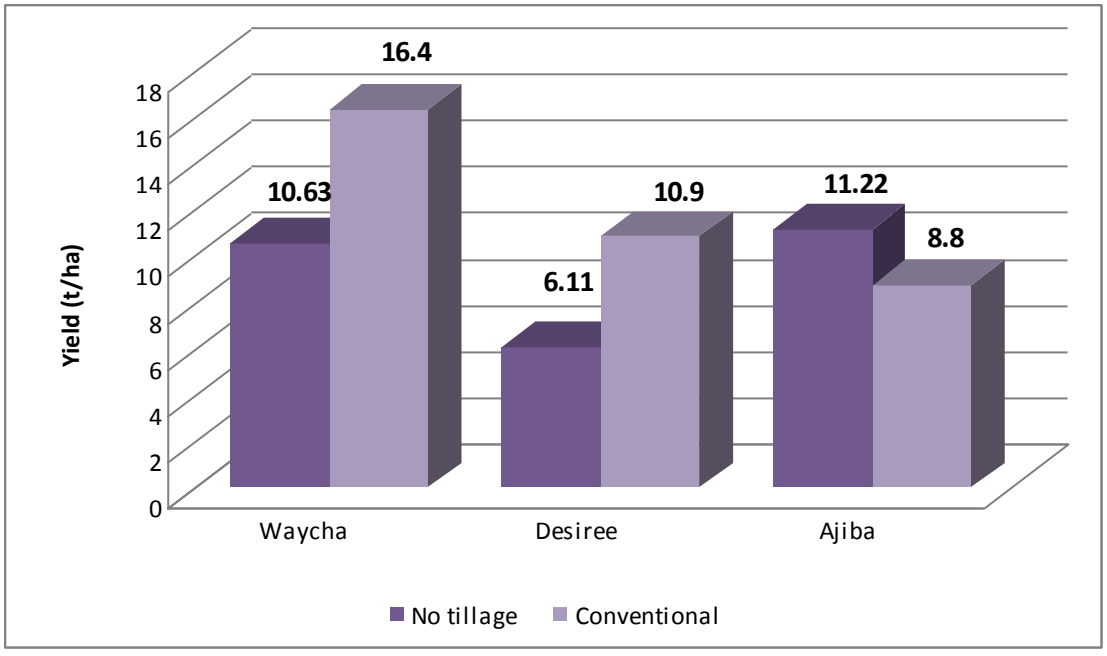


Figure 12. Mean potato yields by variety with two tillage systems in Tiraque, Bolivia.

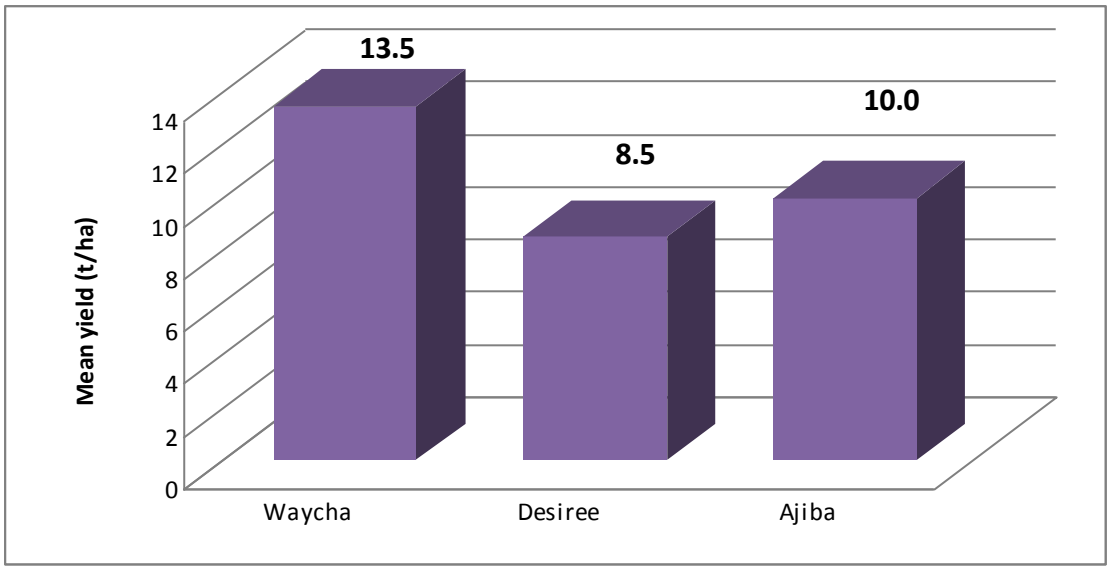


Figure 13. Mean potato yields by variety in Tiraque, Bolivia.

The experimental results showed no significant difference in mean yields, which, considering the far lower labor cost of the no-tillage system indicates that this system would be preferred to the conventional system. In a univariate analysis of yields (Figure 13), Waych'a has the highest yields and Desiree has the lowest yields; these differences were statistically significant.

Demonstration parcels

We have established in Tiraque demonstration parcels which show different cover crop alternatives and are used in participatory discussions with farmers. These plots include: alfalfa, white clover, traditional fallow, and oats/vetch mix. These parcels are growing and have been visited by a large number of local farmers over the prior year.

New trials–Bolivia

In August 2001, we have started two new trials in the 15 de Octubre experimental site:

- Evaluation of effectiveness of frequency of irrigation in potato cultivation
- Evaluation of two systems of quinoa (traditional and minimum tillage with cover crop)

The first experiment is a by-product of the need to add supplementary irrigation to ensure that our CA crop rotations received sufficient moisture. The second experiment was added following discussion with USAID/Bolivia who is interested in promoting more widespread quinoa production in rainfall-stressed areas. A CA system for quinoa is likely to have major economic impact in the country and even though quinoa is not widely planted in our research area. Due to its high market price, quinoa land area is growing substantially.

Complementary experiments include tests of soil fertility enhancements and biological control of pests in CA.

Andean agriculture certainly needs conservation agriculture and improved cropping systems to help preserve soil and produce crops in a sustainable fashion. However, the limitations of pests in the form of insects, diseases, nematodes and weeds are severe, and these are compounded when dealing with nutrient-depleted soils. CA will not be accomplished without management schemes for these other adversities. To this end, in Bolivia, PROINPA is isolating beneficial plant associated microbes (PAMs) that will be active in pest suppression, as well as support solubilization of unavailable forms of phosphorus that are common in impoverished soils. In a world that is fast exhausting its P stores, and which will soon have to rely on local sources of P, development of P solubilizing bacteria could be a critical step toward sustainability of many agricultural systems. In Ecuador, we are focusing on the development of pest-suppressing PAMs that can reduce diseases of plants, and replace pesticides that are commonly used too frequently, or at elevated rates, and sometimes even after they have been withdrawn from use in many countries. These "softer" technologies would utilize local organisms, support local industry, and address unanswered problems. Solutions could export easily to other parts of the world.

This was the first year with graduate students in place, and much of the following resulted from their efforts. The students were Anna Testen, (Master's program in Plant Pathology, and International Agriculture), and Hilary Kessler (Ph.D program in Plant Pathology, and International Agriculture), both at Penn State. Their first efforts were to obtain isolates of pathogens and beneficial micro-organisms to develop management tools for the problems outlined above. They have begun to evaluate these organisms for plant growth and disease benefits, and for nutrient sufficiency levels in the plant tissues. Below are the isolate collections, and their sources.

- 194 cultures of Bacilli from *Chenopodium album*. P solubilization tested and 16S sequenced for ID
- 335 cultures of Bacilli from *C. quinoa* from Ecuador. P solubilization tested and 16S sequenced
- 2 lines of *Peronospora variabilis*, domestic, one from Rock Springs, one from Landisville, PA
- 5 Bolivian Bacilli isolates from quinoa (from M. Claros), colonization. P solubilization tested and 16S sequenced
- 86 random fungi isolated from *C. album* roots and stems last year
- 5 probable *Ascochyta* isolates from quinoa, Rock Springs, PA
- 6 probable *Cercospora* isolates from quinoa, Rock Springs, PA 30 other fungi isolated from the leaves of quinoa and lambs quarters from Rock Springs and Landisville

These isolates will be used to develop biological controls to enhance soil fertility, promote plant growth, and combat plant diseases among target crops in Ecuador and Bolivia. One of the key efforts of the present SANREM is CA in a context of sustainable cropping systems, as noted above. Experiments are being conducted utilizing the above isolates as beneficial colonizers of roots, foliage and seed for enhanced plant productivity, by suppressing disease and improving crop nutritional status. This summer, the first field experiments were conducted in

Pennsylvania on faba bean, common bean and quinoa, and these trials were recently evaluated for plant growth, root colonization, effects on symbionts (*Rhizobium* and arbuscular mycorhizae), levels of disease, and a broad spectrum of nutrient levels in foliage. It was interesting to note that the previously unreported diseases quinoa downy mildew and quinoa *Ascochyta* leaf blight were both found in these plots, in addition to a suite of pathogens causing fava chocolate spot, bean leaf blight, and other diseases. Data are still being developed, since harvest has just begun and will continue into October. We have also imported under permit, Andean isolates of beneficial microbes and key pathogens (from both Ecuador and Bolivia) to be used in growth chamber experiments that will be carried out in the coming winter.

Isolates of *Peronospora* (downy mildew) found in quinoa purchased in the US, were compared, based on DNA sequences filed in GenBank. These short DNA sequences when compared for relatedness, indicated that the U.S. isolates were *Peronospora variabilis*, based on an almost 100 percent identical relationships. This information was confirmed based on morphological descriptors *for P. variabilis* to which it was identical to (based on the confirmation of USDA/APHIS/PPQ). Voucher samples were retained for reference in the USDA fungus collections.

We also compared the *Bacillus* isolates to DNA GenBank sequences, and could separate species to determine that the isolates we advance (at PSU and at PROINPA) are indeed safe species to work with, and are not associated with food-borne illnesses. These are then advanced to screenings for level of colonization, persistence of colonization, enhancements of nutritional levels as seen in plant tissues, disease suppression and other characteristics.

Laboratory research in Bolivia
As a complement to our field trials of CA systems and components, we are undertaking a number of laboratory-based experiments of biological pest controls and plant growth enhancers. These experiments are being conducted with consultation with the Penn State team, in particular with Dr. Backman.

Diagnosis of endophytes
Objectives: Isolate endophytes from field samples, and evaluation effectiveness in combating leaf diseases *Botrytis fabae* and *Alternaria fabae*.

We have collected 20 isolates from healthy leaves, most of which were classified as *Bacillus* sp. We are evaluating a number of parameters including disease incidence and severity, leaf loss, plant height and yield. Experiment is ongoing; results are not yet available.

Biological control of downy mildew in quinoa is tested using different isolates of *Trichoderma* sp.

Downy mildew is an especially destructive disease for quinoa in Bolivia and, because the most highly demanded Bolivian quinoa is organic, it is important to identify organic control

methods. Our objective in this experiment is to select the best isolates of *Trichoderma* sp. for control of this disease.

Progress: We have identified 30 isolates of *Trichoderma* sp. We are using two quinoa varieties (White and red quinoa). We are also investigating two types of innoculum. Evaluation variables include: disease severity (using Gaugl et al. method), plant height, and seed head length.

Results: Results showed variation between blocks (Chi-square=11.82) for disease severity (Table 24), but differences between variety are not significant. Both varieties were affected by the disease with similar intensity (Pr=0.9940).

Table 24. Analysis of variance for disease severity in quinoa

Source of variation	Degrees of freedom	X^2	$Pr > X^2$
Block	2	11.82	0.0027
Variety	1	0	0.9940
Isolate	30	1036.68	<0.0001
Variety*isolate	30	663.51	<0.0001
Innoculum	1	128.09	<0.0001
Variety*Innoculum	1	79.87	<0.0001
Isolate*Innoculum	30	425.9	<0.0001

Results also showed significant differences across the different isolates of *Trichoderma*, and differences in effectiveness cross the two varieties (Table 24). In the red quinoa variety, the majority of the isolates had a positive effect on reduction of disease severity, with the exception of Ch-17B and parc-6SC which were similar to the control (Figure 14).

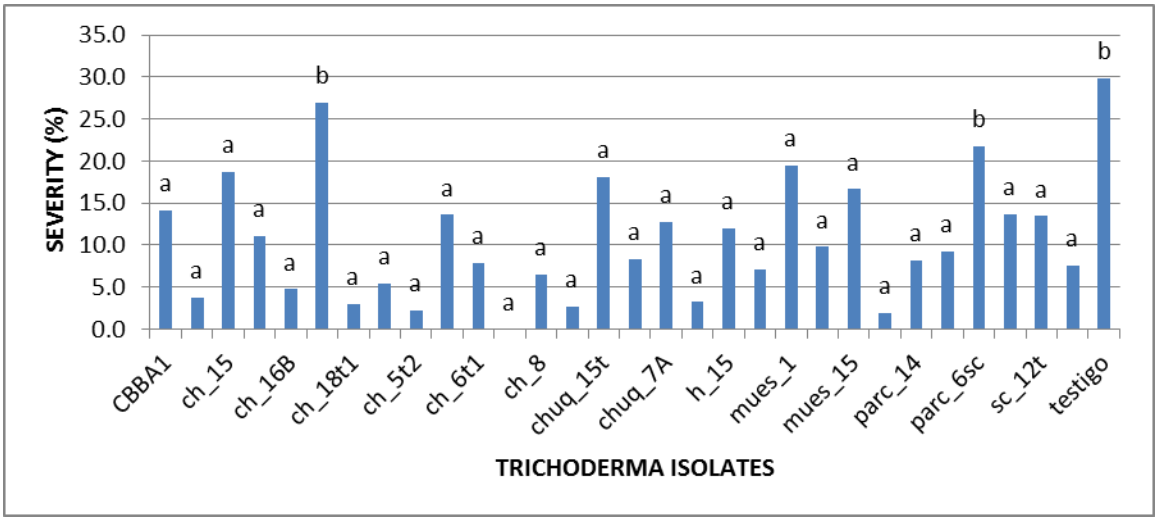


Figure 14. Effect of 30 isolates of *Trichoderma* sp. on severity of downy mildew on red quinoa.
*Different letters reflect statistically significant differences at P ≤ 0.01.

In comparison, in the white quinoa variety, we found more variability across isolates in control of the disease. Several of the isolates (CBBA2, Ch-15t, Ch-18t1, Ch-9B and ms-Ch13A) were associated with very low progress toward disease development. These experiments demonstrate the effectiveness of different isolates and motivated a finer look at the isolates (Figure 15).

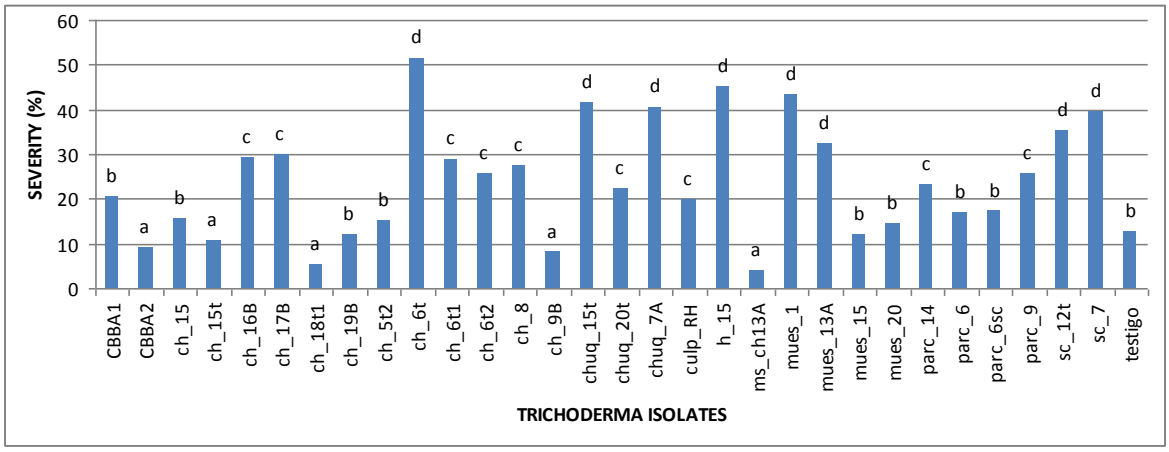


Figure 15. Effect of 30 isolates of *Trichoderma* sp. on severity of downy mildew on white quinoa.
*Different letters reflect statistically significant differences at $P \leq 0.01$.

In Figure 16, we see that the isolates CBB-2, Ch-18t1, Ch-9B and ms-Ch13A inhibited the development of the disease. These isolates will be investigated in more detail in the subsequent year.

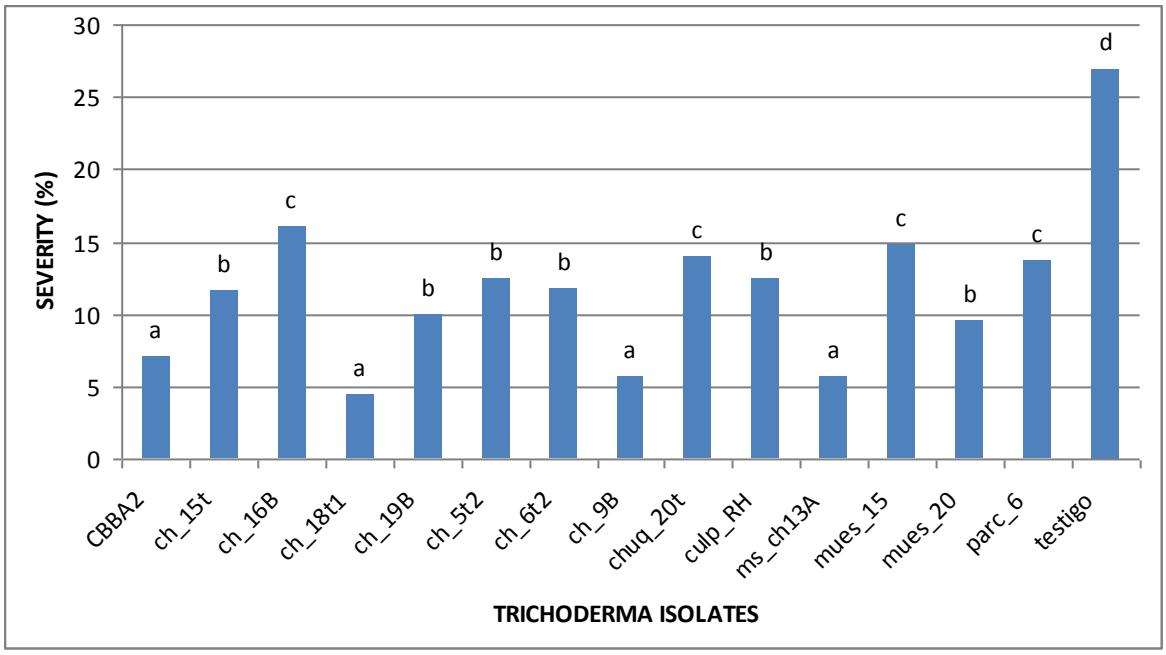


Figure 16. Effect of most effective isolates of *Trichoderma* sp. on severity of downy mildew on quinoa.
*Different letters reflect statistically significant differences at P ≤ 0.01.

We also saw statistically significant disease effects by inoculum and by variety (Figure 17). In both varieties, there was less severe disease damage with the mixed inoculum (mildew + *Trichoderma*) compared to the mildew-only treatments.

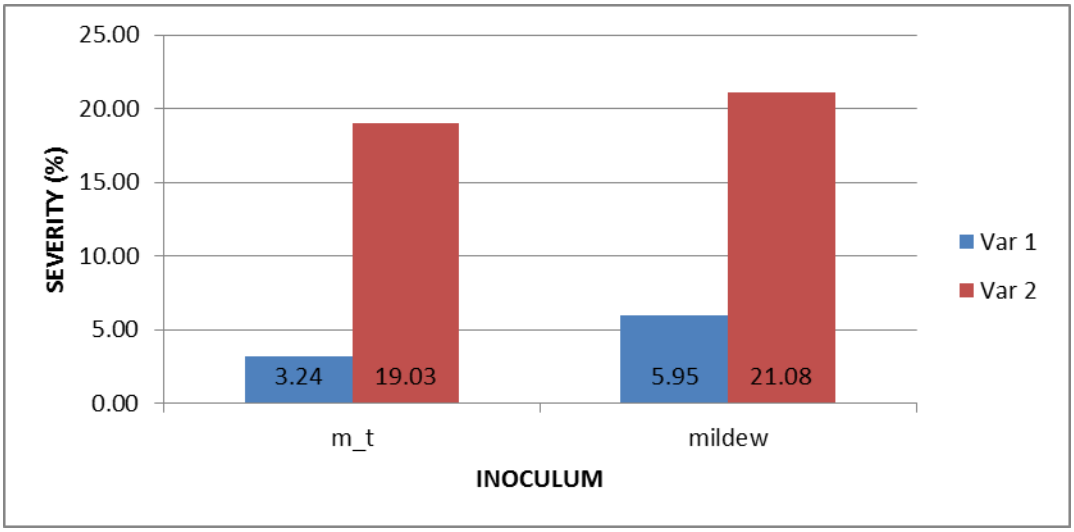


Figure 17. Percentage of disease severity in two varieties of quinoa, with two innocula.
***m_t= Mildew+*Trichoderma* sp.**

Final analysis of these data involved a cluster evaluation of the 30 isolates of *Trichoderma* sp. and their relationship to disease severity, plant height and length of seed head (not shown). Group 1 contains the majority of the isolates; this group is characterized by a lower proportion of disease

control, medium plant growth, and medium seed head length (Table 25). Group 2, comprised of CBBA2, SC-12t, H-15, parc-6SC, parc-6 and parc-14, are characterized by reduced disease severity, better plant and seed head development. Group 3 (CH-16B, CH-18t1, CH-19B, Chuq-20t and Ch-9B) have very good disease suppression characteristics, but are associated with lower plant growth and smaller seed heads.

Table 25. Characteristics of isolates of *Trichoderma* sp. by cluster.

Cluster	Severity percent	Plant height cm	Length of seed head cm
1	11.12	26.72	2.85
2	10.44	29.07	3.06
3	4.83	22.22	2.57

Conclusions: Among the 30 isolates, we have encountered some that are better at disease control and plant growth. Isolates Ch-16B, Ch-9B and m-Ch13A only inhibited the growth of the mildew (effective control). Isolates CBBA-2, SC-12t, h-15, parc-6SC, parc-6 and parc-14 inhibited the growth of mildew, but also assisted in plant growth. This experiment will be repeated, focusing only on those isolates that effectively inhibit the disease.

Task 2.3: Create and follow protocol for measuring economic dimensions of CAPS. These dimensions include fixed and variable costs of practices, productivity and profitability (including rotation effects and incorporation of new products), labor and time requirements, impacts on risk and variability, and gender roles. Each country team has been provided a template for collecting the needed data. As noted in the description of achievements in Ecuador under task 2.2, we are collecting cost data and already have some interesting results across the practices.

During May-June, the SANREM undergraduate research internship group traveled to Ecuador, and during that time they were supervised by the LTRA-7 faculty from Virginia Tech. They also interacted with the impact CCRA during this time. This group devised a questionnaire and subsequently collected and analyzed data on the costs of different CA and soil conservation practices. A preliminary report of this activity is available in SANREM SKB. This team also refined indicators for measuring the costs and benefits of different practices and established (with the impact assessment CCRA) a protocol for collecting data for the remainder of the project. These findings were shared with the Bolivia researchers who are collecting similar data.

Task 2.4: Adapt the Mexican N index tool to conditions in Ecuador and Bolivia.

Drs. Delgado and Gallagher (in 2010) visited Bolivia and Ecuador to establish protocols for collecting the data needed to calibrate the N index model. A version of this model is available in the programming language Java; farmers and extension agents in the US and Mexico use it to estimate plant uptake and losses of N in different cropping systems and thus develop N

application recommendations. Data from experimental trials conducted during the prior phase of SANREM were used to calibrate the model to represent conditions in the Bolivia and Ecuador sites. In SANREM research, we collected information on soil total N, nitrates (NO_3), ammonia (NH_4), texture, bulk density, compaction, organic matter content and the C/N. These data were used to calibrate the model during a month-long training conducted by Dr. Delgado at the ARS laboratories in Fort Collins, CO. Luis Escudero, Carlos Monar (Ecuador) and Ana Karina Saavedra (Bolivia) participated in this training. The team worked on completing two publications on the application of the N index in each country.

Dr. Delgado (USDA-ARS) visited Ecuador during August 2011 to transfer information to farmers and INIAP scientists about the soil N index and its use within a CA system. This index, which has been used as a decision-making tool for farmers in several parts of the world (see his presentation in the SKB), was adapted to conditions in Ecuador and Bolivia. This unique tool will allow farmers in both countries to adjust their fertilization according to expert recommendations. The calibration of the index involved analysis conducted in the Colorado ARS laboratory and validation in field trials.

During Delgado's visit, the Index was further adjusted using recently analyzed soils data from the field experiments. Together with Rosa Arévalo, a SANREM-trained agronomic engineer, Dr. Delgado used the data to calibrate the model to reflect conditions within the CA trials in the lower watershed (maize-beans system). Using data from the trials, model predictions were compared to measured fertility.

Dr. Delgado also recommended further linkages between SANREM/INIAP, the University of Bolívar and USDA-ARS.

Challenges and Responses
Our research toward this objective is proceeding exactly as planned. The tool is now available for use in both countries via the internet.

Objective 3: Promote adoption of the most appropriate CAPS by identifying mechanisms to increase their profitability.

The bulk of the research toward this objective will begin in years 2-3 of the project. In the current year, some steps were taken in task 3.1.

Critical Research Accomplishments
Task 3.1: Explore the potential for increased local input production.

Ecuador: In Ecuador, farmers have stricken a delicate balance between land use for farming and other alternatives. Over the years, there have been significant efforts in the project areas to introduce plans for reforestation of the more degraded areas. The analysis of vulnerability (to erosion and soil degradation) conducted in the prior phase of SANREM identified areas where

reforestation was possible and areas where small-scale agroforestry systems could assist in retaining soils and provide inputs for fuel wood and stakes for perennial crops. These efforts will raise local incomes and make CA more likely to be profitable and environmentally sustainable. In the current year, we had two woodland related outputs: (1) a visit by a commercial forestry expert to assist in planning woodland management (appropriate in the upper watershed where several reforested pine woodlands are being poorly managed) and identifying species for use in agroforestry systems; and (2) establishment of a nursery with funding from USAID in Mulanga (also the upper watershed). This nursery, funded with a small $5,000 grant from the Quito mission, is providing species for native tree and bush species to aid in reforestation in the more vulnerable areas of the upper watershed.

The assessment of alternatives for woodlot management and native species showed the following:

Illangama Watershed: Pine plantations

The pine plantations in the Illangama Watershed were initially established in 1995, with *Pinus radiata* the most prevalent species planted. *Pinus patula* (Mexican weeping pine) is also planted at these high elevations (above 3300 meters). Farmers and communities were offered credits to purchase the pine seedlings, and most of the planting was done by the individual farmers (on their own property), or by community work parties (mingas). Seedlings were purchased from the Vivero Forestal del Fundo Ecuatoriano Populorum Progressio de Guaranda (FEPP Forest Nursery) for $0.12 each, and approximately 1000 trees/hectare were planted (3x3 meter spacing). Total area planted to pine is not known.

Families and communities began selling the timber from the plantations last year (2010). The trees are sold to a middleman for between $900 and $1000 per hectare. Differences in selling price are due to access issues to remove the timber. The middleman brings in a crew to fell the trees, cut the stems into two lengths (1.10 meters and 1.25 meters), and roll the logs to a nearby road. A portable circular sawmill is set up which saws out boards and these boards are trucked to market near Guayaquil.

Communities and families expressed need for better options for selling pine. Current system of selling to middlemen limits prices received for the pine, and also limits what is harvested from the plantations. Prices paid for pine trees are by the hectare, so plantation owners are forced to sell an entire plantation, which discourages them from practicing any form of silviculture to improve tree quality and future financial returns. Current return on their investment (assuming a 15 year rotation) is approximately $58 per ha per year, without labor costs or interest on purchase of seedlings. Several sources indicated that most elders are very reluctant to change, while younger farmers are more willing to try something new. Unless there are improvements to the returns on the pine plantations, it is believed that these forests will be liquidated within the next five years. Currently the pine is an important source of firewood, which will need to be replaced with another source.

Three native hardwood species were planted as part of a "silvo-pastoral" experiment by Illangama Watershed: Native Hardwood Tree Observations. Growth and survival of this plantation was poor, and the community was not encouraged by these results. The poor performance was due in part to lack of care following planting, grazing by livestock, and possible damage from wind.

Seven native hardwood tree and shrub species have been identified as appropriate candidates for future reforestation projects. Local stakeholders expressed a strong desire to work with native species, as their experience with pine has been uniformly bad. All species have been planted at various sites, and there are mixed results on their performance. Opportunities for producing saw log-grade hardwoods from planted native species in the Illangama watershed is limited, based on observations of growth rates and stem form quality in existing trees. Opportunities for native tree establishment for firewood production, creating windbreaks, protection of fragile sites, and to improve biodiversity are numerous.

Alumbre Watershed

The watershed has several examples of native trees which have been planted during the past three-four years showing excellent performance. Several stands of trees from reforestation efforts, however, have not been well managed. The list of suitable candidate native hardwoods species appropriate for agroforestry and reforestation efforts in the Alumbre watershed is longer than in the upper watershed. In addition to all of the species found in the Illangama, there are additional species, several of which are valuable for timber production. Some of the candidate species suitable for the Alumbre are not widespread, and there are no sources of seedlings for afforestation projects.

Fuel wood sources are limited in the Alumbre, and we heard from several farmers that they are forced to extract firewood from native forests in the nearby mountains. This practice cannot go on indefinitely without serious consequences to the native flora. Potential for saw log quality native hardwoods for commercial purposed appears to be stronger in the Alumbre watershed. The lower elevations which have better growing climate, better road network, and access to markets make this watershed a better candidate for woodlots for saw timber production.

Bolivia: The main focus of work to improve agricultural productivity and profitability within our CA system in Bolivia has been to further refine biological controls and biological inputs for improved productivity within a CAPS. PROINPA (Bolivia) has a well-developed capacity (a bio-control production facility) to produce biological organisms, but work is needed to refine the particular isolates. We are examining steps to use *Bacilli* from quinoa to control quinoa diseases. At Penn State, several experiments have been performed to isolate endospore-forming *Bacilli* from *Chenopodium quinoa* seeds. This work is ongoing. Isolates that are verified to form endospores will be checked for their ability to solubilize phosphate by utilizing the National Botanical Research Institute's phosphate growth medium. Cultures will be tested for their ability to colonize *C. quinoa* in growth chamber assays and promote growth of *C. quinoa* in a

low-phosphate Andean proxy soil (actually a soil from the state of Washington with similar soil attributes to Altiplano soils).

SANREM scientists are also evaluating the economics of PROINPA's potential for producing bio-inputs. Nadezda Amaya spent summer 2011 in Bolivia and conducted research to: categorize potential bio-inputs in terms of their effectiveness in promoting plant growth, and lowering diseases; estimate market demand for bio-inputs at different levels-local and regional; and measure costs of production at different scales. The final product of this research is to inform decision makers about the appropriate scale of production for each of these inputs. She has completed a background report on this research, which shows that for some products (particularly "biol"-a fertility enhancer), local production is economically effective. PROINPA has established a local "biol" processing plant in the Tiraque area.

We have also established protocols for incorporating locally produced biological controls into our CAPS treatments.

Challenges and Responses
Our research toward this objective is proceeding exactly as planned.

Objective 4: Design and evaluate mechanisms for disseminating results to similar areas.

Work on this objective was not started during the current year. This was consistent with the initial work plan submitted during preparation of the revised project proposal and our approved years 1 & 2 work plan.

Objective 5: Evaluate overall impacts of the CRSP research program along several dimensions including soil health, productivity, economic, social and environmental.

Critical Research Accomplishments

Soil health and productivity impacts:

- Baseline soil samples have been taken in farmer fields. Some of the analysis will be conducted locally, other will be performed at Penn State, and the rest at Virginia Tech by the SANREM CCRA-9. Analyses are partially completed (see description above).
- Protocol for measuring erosion loss under different CA management practices has been established (see above and below for details).
- Training in use of N index has been undertaken. This tool will be used by research teams to evaluate N needs in our research sites and to adjust nutrient application recommendations to changing conditions.

Economic and social impacts:

- We have established protocols for collecting data on costs for all field experiments (in conjunction with the economic analysis and impact assessment SANREM CCRA-6) Fixed (equipment) and variable costs, including family labor use in cultivation and harvest were considered. Preliminary data have been collected by undergraduate research associates from Virginia Tech during the SANREM internship program (May-June 2011, in Ecuador). Abigail Nguema (MS, Virginia Tech) accompanied the interns and collected data specific to her impact assessment that used linear programming model.
- The project is collecting market data on input and product prices. Regular market surveys are being undertaken in both countries.
- Regular participatory assessments are being conducted in areas where field experiments were placed. One purpose of these assessments is to identify and evaluate unanticipated social impacts or obstacles to CA diffusion. Results from these exercises are used to refine our outreach techniques, and are not reported here.

Environmental impacts:

- The team agreed on research protocols to be used in soil erosion test plots. These plots include metal-demarcated boundaries, erosion collection points, and mechanisms for monitoring rainfall events. They had been established under the prior SANREM project to measure the relationship between weather events and soil loss, conditioned on management practices. The current SANREM team agreed that these experiments

should continue. Table 4 shows some of the indicators being collected in these experiments.

- Dr. Flowers presented and discussed efforts during the previous SANREM phase to monitor water quality using counts of macro-invertebrates. He explained that such measurement would be relatively inexpensive to continue and could be used to engage local stakeholders (particularly young people) in the project. The team agreed and Dr. Flowers worked to reinstitute the water quality monitoring program.

Challenges and Responses:
Our research toward this objective is proceeding exactly as planned.

Objective 6: Strengthen the capacity of government and non-government institutions to develop and disseminate CAPS in the Andean regions of target countries

Critical Research Accomplishments

Task 6.1: Conduct gender sensitivity training for all project staff. Collect data on participation rates by gender and by disadvantaged groups.

Gender sensitivity training was conducted during a workshop held in 2010. Recommendations from participants in this workshop were subsequently adopted by the research team. One clear problem is the imbalance between men and women in the research team (75 percent men, 25 percent women). We are continuing to address this problem in subsequent years, but are constrained by conditions in local institutions. In Ecuador, we have hired an additional (female) researcher and the team has continued to stress participation of females in meetings. The team has also entered into dialogue with the University in Bolivar to promote increased female participation in biological and agricultural sciences. The teams in both countries have already taken concrete steps to improve female participation in training events and this representation has grown in recent years. In Illangama, the women's inability to speak Spanish was identified as a problem and we have hired two bilingual assistants to address this problem.

Table 26. Indicators of female participation in SANREM CRSP, Ecuador in 2011

Indicators		Number
1	Number of female scientists in research team	3
2	Males in research team	8
3	Women participating in short-term training	55
4	Men participating in short-term training	82
5	Female extension agents working directly with farmers	2
6	Gender-focused activities, current year	2

Challenges and Responses
Our research toward this objective is proceeding exactly as planned.

Degree and non-degree training activities

We currently have five students (all female) engaged in SANREM-related long-term degree training. Two (US citizens) are seeking PhDs in Plant Pathology at Penn State, one is seeking an MS in Soil Science at Penn State and two are seeking PhDs in Agricultural and Applied Economics at Virginia Tech (one is Bolivian). All but one is receiving substantial co-funding from Departmental sources. We also have identified undergraduate honor's students in Bolivia and Ecuador (one in each country, both women) who will conduct thesis research on the project.

We have had numerous workshops, seminars, short courses and field days, with a total of 604 (412 male, 192 female) attendees. Most of these trainings were directed toward farmer-stakeholders in our areas of work. Details are presented in form 17.

Publications, presentations, and other SANREM CRSP products

Summary: appropriate publications have been submitted to the SKB.

Networking activities

Country teams have worked diligently to promote linkages with universities and other researchers, USAID-sponsored projects, and other donors. Linkages with local institutions have also been solidified.

Ecuador:

- Victor Barrera and Luis Escudero, together with the Asociación de Desarrollo Comunitario San Francisco de la Bola de Oro, have received funding from the USAID small project fund "Conservación del ambiente a través de la elaboración de fertilizantes orgánicos para la producción de cultivos en agricultura de pequeña escala". These funds will be used to supplement efforts to increase local production of organic inputs in support of CA.
- The multi-community Río Jubones, together with Consortium of Provincial Committees in Ecuador and the water supplier in Cuenca are joining together to better manage water resources, using the SANREM infrastructure as a model.
- The Ecuador SANREM team has received $500,000 ($200,000 has already been disbursed) funding from SENACYT (the Ecuador NSF-equivalent) to conduct a project based on SANREM conceptual framework in Saraguro, Ecuador. This project will last two years and will focus on means of promoting CA for food security in a dry and vulnerable region. This is the same area of the region where Victor Barrera conducted his dissertation research under prior SANREM activities.
- The SANREM team presented another proposal to SENACYT on integrated watershed management and CA. This proposal has not yet been approved, but indications are favorable.
- Several informal and formal linkages have been made with Bolivar and Saraguro Provincial Councils to develop CA for water quality improvement.

- The SANREM team met with the mayor of Chillanes. He indicated that he was interested in exploring the potential for value-added processing of blackberry in the area Chillanes currently has more than 1,200 ha of Ecuador's total land area of 6,000 hectares in blackberry (*Rubus* sp.). Such an investment would improve returns to blackberry producers and thus make CA more profitable in the region.

Bolivia:

- We are coordinating activities with the Centro de Investigación, Formación y Extensión en Mecanización Agrícola (CIFEMA) of the Universidad Mayor de San Simón (UMSS). This group of agricultural engineers is being engaged to help us generate equipment that will facilitate CAPS in potatoes, faba beans, and quinoa. We have created preliminary designs for grain removal implements for grains that are produced in the region.
- We have also coordinated with the Centro de Investigación en Forrajes (CIF) in UMSS to identify species of forages with potential as ground-cover in our CAPs. CIF is helping us establish a protocol for evaluating forage potential.
- PROINPA, following discussions between Dr. Alwang and Dr. Jorge Calvo (the USAID agricultural officer in La Paz), decided that PROINPA would become more involved in the USAID flagship food security project, particularly in evaluating technologies for quinoa production in fragile areas. Expertise to address this issue was built by the SANREM CRSP.
- The present SANREM, plus results from the previous cycle have provided the seed information for PSU and PROINPA to develop a NSF-Gates BREAD proposal. This proposal will be submitted to NSF in early November.

Project highlights

- A N index prototype has been developed. This tool will assist farmers and extension agents in evaluating nitrogen balances without resorting to costly soil chemical evaluations.
- Experimental trials have been designed and protocols for measuring key variables have been established. We have preliminary data showing positive net benefits in the short run from a variety of CA practices.
- Substantial research has been conducted on biological controls, local production of inputs, and improved woodlands management as means of increasing incomes and profitability of CA. These results have been shared with stakeholder farmers. In Bolivia, a local facility to produce organic fertilizer with locally available materials has been built and is currently under production.
- Long-term degree training has a substantial gender imbalance: we are training five female graduate students at US Universities, with substantial leveraging from the departments and colleges of the respective universities.
- Gender training for both country teams has been completed.

LTRA-8: Improving Soil Quality and Crop Productivity through Farmers' Tested and Recommended Conservation Agricultural Practices in Cropping Systems of West Africa

Principal investigator: P.V. Vara Prasad, associate professor, Department of Agronomy, Kansas State University

Host Countries: Ghana, Mali

Research team:

- Kansas State University: Department of Agronomy: Scott A. Staggenborg, Charles W. Rice, DeAnn Presley; Department of Agricultural Economics: Timothy J. Dalton, Kevin Dhuyvetter; Department of Plant Pathology: Karen Garrett; Department of Biology: Ari Jumponnen; Department of Sociology, Anthropology, and Social Work: Theresa Selfa; International Agricultural Programs: Nina Lilja
- Savanna Agricultural Research Institute (SARI): Jesse B. Naab, I. Yahaya; S.S. Seini, M.A. Askia
- Wa Polytechnic: P.H. Momori
- Institut d'Economie Rurale du Mali (IER): M. Doumbia, K. Traore, P. Sissoko, A. Berthe, O. Samake

Research progress by objective

Objective 1: Evaluate local CAPS

Critical research accomplishments

Ghana: Base line socioeconomic surveys were completed in 13 communities from three districts in Upper West region. A total of 358 farmers (157 women) were surveyed and results summarized.

Mali: Rapid rural appraisals have been conducted in test villages to evaluate local CAPS. Detailed baseline socioeconomic surveys are in progress.

Development impact

Ghana: There was strong interest in crop rotations, minimum tillage and water management practices. However, yields in the first year showed that minimum tillage has slightly lower yields than conventional tillage in some locations. In most villages the yields were not statistically different.

Mali: Farmers showed in cowpea and peanut in crop rotation and intercropping with millet and sorghum. There was interest in cover crop but main concern was livestock feeding.

Challenges and responses

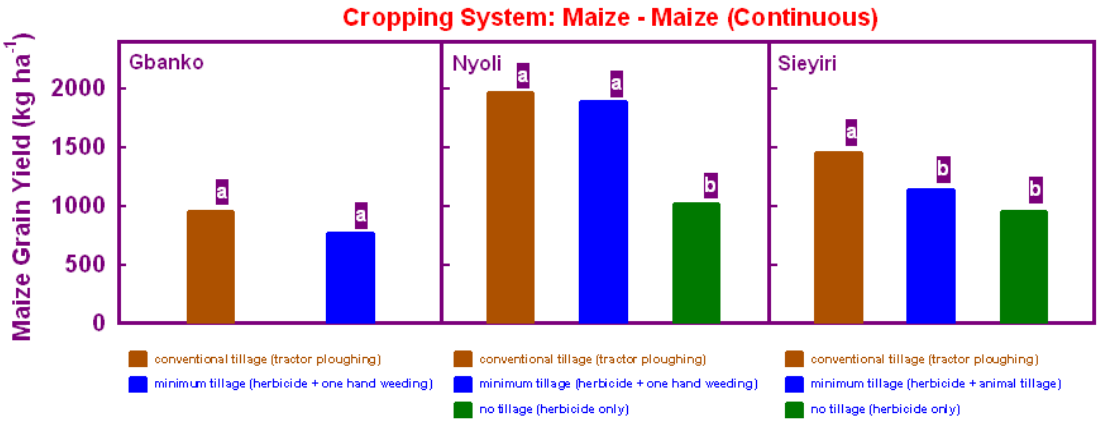
Surveys in Mali are delayed and still not fully completed and data analysis is in progress.

Objective 2: Develop cropping systems cropping systems

Critical research accomplishments

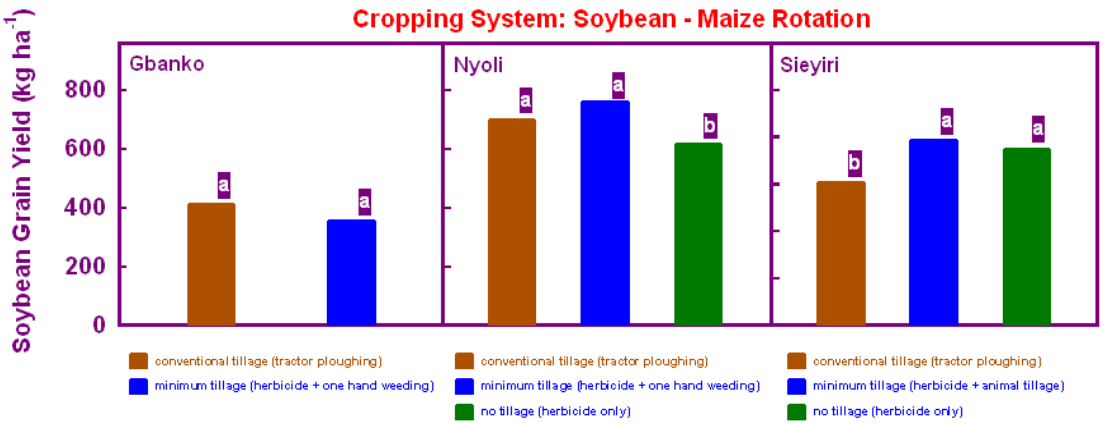
Ghana: A total of five on-farm mother tests and baby tests (66 farmers) were harvested and data were analyzed and results summarized. Four on-farm mother trials were carried out in 2011.

- Minimum tillage (pre-emergence herbicide and one hand weeding) produced the same yields of maize or soybean as conventional tillage (tractor or manual weeding).
- Sole cropping of maize and soybean produced greater yields (residue or grain) than intercropping system in all tillage practices.
- Fertilization (26 kg P/ha) significantly increased yield of soybean in all tillage systems.



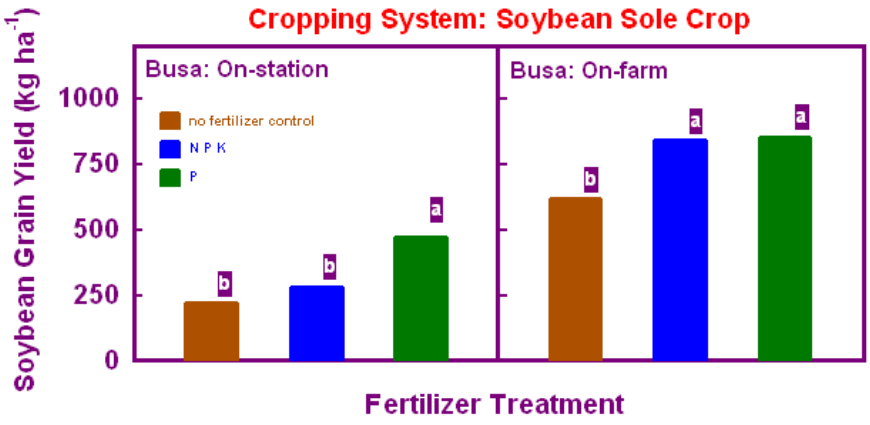
Same letters indicate no statistically significant differences at $P < 0.05$.

Figure 18. Maize yield in maize-maize cropping system in Ghana.



Same letters indicate no statistically significant differences at $P < 0.05$.

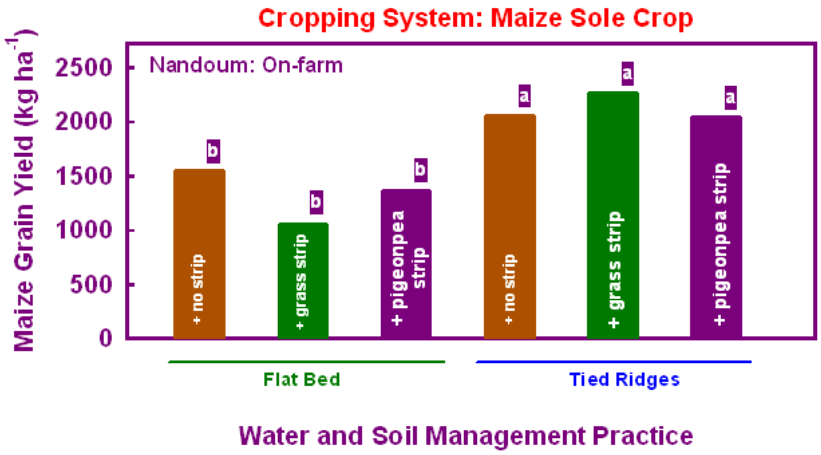
Figure 19. Soybean yield in soybean-maize cropping system in Ghana.



Same letters indicate no statistically significant differences at P < 0.05.

Figure 20. Soybean yield in soybean cropping system in Ghana

Maize planted on tied ridges with grass strips or pigeon pea strips produced higher yields than flatbed, flatbed with grass strips or flatbed with pigeon pea strips.



Same letters indicate no statistically significant differences at P < 0.05.

Figure 21. Maize yield in maize cropping system in Ghana

There was no clear evidence of effects of crop residue on maize or soybean yield.

Mali: Total of eight on-farm tests (4 agricultural systems of Mali and 52 farmers) were harvested. Soil samples collected prior to setting each experiment have been analyzed. All on-farm and on-station tests were carried forward in 2011.

- Minimum tillage or reducing tillage to two operations (planting, weeding/fertilizing) produced the same yields of sorghum as the conventional tillage (four-five operations) in Cinzana.
- Crop residues or biomass used as mulch produced an average of 21 percent yield increase in sorghum over 'no soil cover' treatment in Cinzana.
- Biomass of millet, sorghum or maize (6 to 11 t/ha) were left as crop residues. These would undergo off-season, open grazing and only about 15-20 percent of this residue is remaining at the time of planting.
- Results in Mopti region, showed that adding organic fertilizer (compost) to millet grown under CA increased millet yields to 42 percent and cowpea yield to 57 percent in the on-research station experiment, and tended to boost grain millet production to 16 percent in the on-farm test and cowpea to 30 percent.

Challenges and responses

Ghana: During 2011, only four on-farm mother trials were carried forward. The site in Sieyiri was taken over by the land owner due to water logging, and therefore, could not be continued.

Mali: Keeping the crop residue is still a challenge due to alternative use and free animal grazing. At some on-station locations in Sikasso, fencing was built as safeguard.

Objective 3: Foster and advance rapid adoption of local CAPS and integrated practices

Critical research accomplishments

Ghana: To foster and advance adoption of CAPS by farmers, sub-set of the mother trial treatments were selected by farmers and implemented in their own fields and communities. A total of 66 farmers tested components of CAPs during 2010. A total of only 42 on-farm trials were implemented in four villages during 2011.

- Minimum/reduced tillage and rotation with a legume crop, growing sole crops and following rotation, application of fertilizer and water management practice can help improve yield and would be adopted.
- The adaptation of Brachiaria as a potential solution to the challenge of permanent ground cover. Preliminary results in Mali show that Brachiaria can be established, but the more research is needed to define the time of planting (in comparison to main crop). When planted at the same time, Brachiaria overtook the main crop. Relatively better growth of both Brachiaria and main crop was observed when Brachiaria planting was delayed by two weeks after the main crop.

Mali:

- Minimum tillage or direct seeding plus one weeding/fertilizing produced the same yields as the conventional tillage (five operations that disturb the soil; i.e., planting, weeding, fertilizer application on maize in Sikasso).
- Crop residues or biomass used as mulch produced an average of 26 percent yield increase over no soil cover treatment at the Cinzana Station.

- Biomass of sorghum (13 t/ha) was left as crop residues. This would undergo off-season, open grazing, and only about 15 to 20 percent would remain by next planting.

Development impact
Ghana and Mali:
- Minimum tillage and rotation with a legume crop showed promise and new farmers also tried these practices in 2011. Application of P fertilizer and water management practice improved grain yield and is being adopted.
- Preliminary results show that Brachiaria can be established, but more research is needed to define the time of planting (in comparison to main crop).

Challenges and responses
Ghana: Fifteen on-farm trials in the village of Sieyiri in 2010 were discontinued in 2011, because the sites selected by the farmers last year were prone to water logging.

Mali: Although *Brachiaria* shows potential for cover crop, time of planting relative to main crop planting needs further investigation.

Objective 4: Assess long-term effects of CAPS

Critical research accomplishments
Total of four (Ghana) and eight (Mali) long-term experiments were implemented in 2011. Minimum data set samples were collected.

Development impact
Ghana:
- Soil samples are being analyzed. At the Sieyiri site, initial soil organic carbon was 0.6 percent. The soil is sandy and moderately acidic (pH 5.7 to 6.2).
- Results from individual experiments are given in previous section (Objective 2).

Mali:
- Initial soil OM content in all sites is below the critical level of 6 g/kg. These soils are compacted, with bulk density values around 1.8 Mg/m^3. Soils are strongly to moderately acid ($4.8 < pH < 5.9$). These soils are deficient in available P (< 7 mg/kg).

Challenges and responses
Initial soil samples are currently being analyzed. It is a time-consuming process as there is only one functioning soil laboratory in Mali and in the Wa region of Ghana. There is a lot of backlog of samples in these laboratories from other experiments. However, the samples are being processed.

Objective 5: Modeling to predict impacts of CAPS
No task was planned for this year of the project in both Ghana and Mali.

Objective 6: Assess the cost and benefits of activities

Ghana:

- Cost-benefit analysis was carried out for the 2010 cropping season baby trials to identify CAPS which can improve small holder farmer economic returns. Data were obtained from 64 farmers' trials in six communities in three districts of the Upper West region of Ghana. At Nandom in the Lawra district, maize was the main crop used by 32 farmers with three treatments – flat seedbed, tied ridges and tied ridges with grass strips, with recommended levels of fertilizer application. At Busa and Tanzu in the Wa central district, the main crop for the first year was soybean. The treatments were (1) conventional tillage with compound fertilizer NPK (CT+NPK); (2) no-till without fertilizer to soybean (NT-NPK); (3) no-till with fertilizer to soybean (NT+NPK); and (4) no-till with single super phosphate fertilizer (NT+P). At Nyoli in the Wa west district, maize and soybeans were the main crops with four treatments (1) conventional tillage (CT) maize with compound fertilizer; (2) no-till (NT) maize with compound fertilizer; (3) conventional tillage (CT) soybeans; and (4) no-till (NT) soybeans.
- Preliminary economic analysis using partial budget, showed that using minimum or no tillage system with fertilizer application (NPK) had a cost-benefit ratio of >1 for soybean yield in Nyoli, Tanzu and Busa villages suggesting positive response, when compared to conventional tillage which has cost-benefit ratio of 1. Similarly, at Nandom, benefit-cost ratios were > 1 for tied ridges with grass strips, suggesting positive impact.

Mali: No activities were reported.

Degree and non-degree training activities

Ghana:

Degree training activities: Two students were identified for PhD programs from Ghana. They both will initiate their programs in spring 2012.

Non-degree training: Annual meeting, workshop, field day and farmer exchange visits were organized in Wa from 7 - 9 September, 2011, for training, capacity building of farmers.

- Annual meeting: This meeting was attended by 42 farmers (15 women). Brief results of various experiments were presented to the farmers and discussed. Benefits of CAPs identified were lower cost of cultivation, increased income, control of soil erosion and increased soil moisture.
- Workshop: One-day workshop on farmer participatory monitoring indicators of CAPs was conducted. The main indicators identified were cost of production, yield, income, labor use, and acreage under cultivation.
- Farmer exchange and field days: Three farmer field days were organized. Total of 61 farmers (16 female and 45 male) participated to see two collaborative farmers' fields (1

male and 1 female). These two farmers had no-tillage fields of about 5 acres. Farmers interacted and learned from each other.

Mali: No training and capacity building activities were reported.

Publications, presentations, and other SANREM products

One presentation, two posters, and a working paper were prepared this year.

Networking activities

Collaboration/integration of activities was initiated with the following projects/programs:

- Integrated activities of the project funded by INTSORMIL in both Ghana and Mali
- Up-scaling the contour-ridge tillage project funded through INTSORMIL by the USAID Mission of Mali
- The minimum tillage and cover crop project funded by EMBRAPA in Mali
- Linkages were initiated with CARE International in Mali, on Conservation Agriculture/ Ecoferme activities. CARE works in Ségou and Mopti. CARE has suggested integrating their sites into the SANREM CAPS.

Project highlights

Key critical findings, results and impacts include:

- In Ghana, farmers from Busa-Tangzu (Wa Central), Nyoli (Wa West) and Nandom (Lowra-Nandom) showed interest in adopting minimum or reduced tillage, crop rotation with a legume crop (groundnut, soybean or cowpea) and improved soil fertility (application of N, or P) and water management practices (tied ridges or contour ridging). Two farmers in Nyoli village of Wa West expanded no-tillage area to 5 acres.

LTRA-9: Developing Sustainable Conservation Agricultural Production Systems for Smallholder Farmers in Southern Africa

Principal investigator: Neal Eash, associate professor and soil scientist, Department of Biosystems Engineering and Soil Science, University of Tennessee

Host Countries: Lesotho, Mozambique

Research team:

- University of Tennessee: Department of Biosystems Engineering and Soil Science: Forbes Walker; Department of Agricultural and Resource Economics: Dayton Lambert, Michael Wilcox
- National University of Lesotho: Department of Soil Science: Makoala Marake
- International Maize and Wheat Improvement Center (CIMMYT): Global Conservation Agriculture Program: Patrick Wall
- Growing Nations: August Basson

Research progress by objective

Objective 1: Integrate cover crops into CAPS to protect soil from erosion, provide weed suppression or control, include crop rotations that provide forages for livestock, improve soil quality as measured by soil carbon (C), decrease risk and vulnerability to drought.

In the light of exploratory results of the field studies and the analysis of cover crops during the winter of 2011 in Lesotho, certain grass and legume combinations have been prioritized for inclusion in the upcoming efforts to upscale on-farm demonstration in the 2011/12 growing season. Cover crop species being evaluated include rose clover (*Trifolium hirtum*), grazing vetch, wheat (*Triticum aestivum*), oat, and lentil (*Lens culinaris*). Analysis of the cover crops will continue in current year on-station trials to monitor the performance of certain indigenous species and management of already identified cover crop species.

Research and approximately fifty on-farm trials are ongoing in Sofala, Manica, and Angonia provinces in Mozambique. This research continues to evaluate cover crops, intercropping, and crop rotations. For example, maize intercropped with sunflower did not perform well and is not a good option for farmers. Sunflower (*Helianthus annuus)* planted as a sole crop on the other hand performed well. UT and CIMMYT researchers are also considering changing the bean crop in the rotation to cowpea and the sunflower intercrop to a maize/pigeon intercrop in the coming cropping season. This will be further discussed during the evaluation and planning meeting and final decisions made on these points. In Mozambique, the PIs are providing technical support to the on-station research at Sussendenga that evaluates maize population and N rates, residue cover, and 16 different varieties of maize (hybrid and open-pollinated varieties). In addition, the PIs will work with CIMMYT to initiate relay/cover crops for weed suppression and consider how to best manage a high termite population site. Lastly, the PIs

plan to assist with scaling up the CAS adoption in Mozambique using the plow/ripper/strip till conversion for ox-drawn plows, and also assist with providing ox-drawn planters.

Objective 2: Determine the agronomic and economic fertilizer rate for maize in both the basin and machine no-till methods.

Fertilizer rate studies were completed in both Roma site and Maphutseng in Mohale's Hoek. The Roma site was used to train 25 students under the supervision of Dr. Marake. Students completed undergraduate projects in CA and wrote four joint undergraduate theses in partial fulfillment of the requirements for their B.S. in soil science degree from NUL. It is anticipated that no changes to the protocol for this year will be needed, so that at least two site years of data can be evaluated. This year co-PIs plan to include more soil types in the calibration to strengthen inferential power for more accurate fertilizer recommendations. A master's academic thesis will be completed on this work at the University of Tennessee in the academic year 2011/12. In addition, a conference paper was presentated in the ASA meetings in San Antonio in October 2011. Maize yields were recorded up to nine tons per hectare.

In Mozambique, all sites were monitored by project staff and NARS partners. The sites are generally in good condition; however farmers struggled with two main problems: residue retention on CA plots and weed control (especially the second-hand weeding which was not carried out well in some communities). Pre-harvest data were taken and all sites harvested in April-May 2011. The project has emphasized the importance of collecting high-quality harvest data from the field, which was the main focus for further data collection and management skills training of extension officers collaborating with the project.

After several discussions with farmers in Bárue, Mozambique,it was agreed that cowpeas will be replaced by pigeon-pea in the coming season due to the poor performance of cowpea (no production of grain) across most of the sites. Farmers have proposed to start selling maize cobs while fresh (the price in October/November was 4-5MT/cob or USD 0.5-0.6) because it pays more than dry grain (the highest price in July was 5MT/kg). This will be further discussed during the planning and evaluation meeting.

Objective 3: Characterize the composition and contribution of N and C from legume/grass cover crops and determine the best species for maintaining soil residue cover until after maize crop harvest.

Different cover crop species have been planted and evaluated in Lesotho. Specific grass legume combinations have been prioritized for up-scaling in the upcoming growing season. Evaluation for N and C composition is underway. Carbon flux measurements were collected at the Lesotho site, starting in November 2010 under both conventional and CA management systems. One master's thesis will be completed analyzing the carbon-conservation agriculture data in the 2011/12 academic year at the University of Tennessee. Preliminary results were presented as a conference paper in the ASA meetings in San Antonio, Texas.

We are currently planning cover crop research trials for implementation in Mozambique.

Objective 4a: Determine the short- and long-term impacts of CAS on gender equity especially in terms of household income and economic impact and to involve women in decisions that impact their welfare.

The dataset of the baseline household survey conducted in Botha-Bothe (November 2010) are being analyzed at the University of Tennessee under the leadership of Drs. Lambert and Wilcox. Data entry is 83 percent completed. It is anticipated that data entry and cleaning will be completed by January/February 2012. Overall, 432 household surveys were conducted in 10 villages in Northern Lesotho with the help of project collaborators in the Department of Agriculture in Botha-Bothe District as well as Mr. Pete West, director of the Rehobothe NGO in Botha-Bothe. A separate survey of up to 50 households participating in the on-farm demonstration has been developed to follow immediately after the demonstrations have been set up in the participating households in the coming growing season.

In January 2011 in Lesotho, co-PIs conducted impromptu, semi-structured interviews with women engaged in CAPS to gain initial insight in how CAPS have been introduced, women's motivations for adopting CAPS, and what outcomes and expectations they had for CAPS versus conventional (e.g., tillage) agriculture. In November 2011, in-depth participatory research will be conducted in Lesotho. Results from this work will be used to inform and streamline participatory research efforts in Mozambique.

In Mozambique, a harvest training course was carried out before harvesting. Concomitantly, a socioeconomic survey was conducted to capture the views and ideas of the farmers about different varieties and cropping systems. Data will be analyzed as they become available.

With respect to the CA technologies promoted in Mozambique, CA addresses gender issues in the way that labor is re-distributed on-farm. Women normally carry the burden of most agricultural activities. By shifting from labor-intensive cropping systems to less labor intensive systems (i.e., some CA methods, but not all), labor hours in farming may effectively be reduced. Farmers practicing CA typically spend significantly less time planting and, if herbicides are used, less time weeding. These reductions in labor generally benefit women, especially in the case of reduced weeding. At field days and farmer discussion events, farmer appreciation of technologies – including crop cultivars – are disaggregated along gender lines to ensure that women's evaluation of technologies are represented as CA strategies are developed and disseminated.

Objective 4b: Evaluate ways and means to improve fertilizer adoption rates among smallholder farmers, the degree to which market structure influences fertilizer use, and welfare implications based on price margins.

Field research during the current growing season will provide data to assist with understanding fertilizer economics in smallholder maize production. Preliminary secondary data, in the form of spot prices for key inputs and outputs in Lesotho, were obtained from contacts whose acquaintance was developed and strengthened during the trip in January/February. In addition, biological and economically optimal input rates have been determined using fertilizer N and P and plant population yield response data collected from the Maphutseng field trials. This information will be important for modeling changes in smallholder household welfare, given prevailing input and maize prices. Research in the coming year will further investigate these interactions.

Work on fertilizer calibration and correlation is not a fundamental part of the field research in Mozambique due to the field research legacy in nearby Zimbabwe. The research team plans to evaluate this issue further (including fertilizer economics) if the need is expressed.

Degree and non-degree training

The two U.S. master's students working on this project are completing their work. Both have conducted research in Lesotho during the 2010/2011 growing season and are in advanced stages of their thesis write-up. Both presented papers in the ASA meeting in October 2011 in San Antonio, Texas.

Publications, presentations, and other SANREM products

There were none this year.

Networking activities

We have maintained close contact with the U.S. Embassy in Lesotho. Dr. Marake has had two meetings with Ambassador Bond and has provided briefs on the role of CA on climate change adaptation to members of a team developing a climate change strategy for engagement in Lesotho through U.S. embassy resources. The Ambassador and her staff were enthusiastic in their support for the ongoing work sponsored by the SANREM-CRSP project and hope to visit the research site in Maphutseng again in the upcoming season.

The Mozambique research team collaborates with the IRMA project (Maize Resistance to Stem Borer and Storage Pests for Eastern and Southern Africa), WEMA (Water Efficient Maize for Africa), DTMA (Drought Tolerant Maize for Africa), and SIMLESA.

Project highlights

We have made significant progress in Lesotho against both the agronomic objectives and are a long way into understanding the issues around plant population and fertility aspects as a basis for recommendations to farmers. The work thus far with cover crops has resulted in solid leads to explore these aspects for the legume effects as well as their weed suppression potential. The most prolific of the cover crops, grazing vetch, has the potential to respond to the livestock-crop interaction challenge in which farmers find it difficult to sacrifice crop residues given the opportunity cost of livestock feed.

The Mozambique project is more advanced than Lesotho due to the five plus year head start on this research by CIMMYT. Our involvement will build upon this in-country experience by providing economic and agronomic support and analysis of their CA work and by incorporating the early successes from Lesotho. Ongoing farmer field trials will be used to assess the riskiness of CA conventional agronomic practices. Combined with data collected from household surveys (planned March/April 2012), important insight into the reasons why farmers tend to adopt CA agriculture in some contexts more rapidly than in others will be gained.

We have developed the initial database upon which the dissemination of CA technologies will be based as opposed to the anecdotal evidence prior to our research outputs. To this effect, two theses are in the final stages of processing and based on the data therein, two papers were presented in San Antonio, Texas in the ASA meeting in October 2011. The carbon dynamics work of our project is breaking new ground in terms of methodology for real time C dynamics and will launch our efforts into climate change adaptation research.

LTRA-10: Development and transfer of conservation agriculture production systems (CAPS) for smallholder farms in eastern Uganda and western Kenya

Principal investigator: Jay Norton, assistant professor of soil fertility, Department of Renewable Resources, University of Wyoming

Host Countries: Kenya, Uganda

Research team:

- University of Wyoming: Department of Management and Marketing: Eric Arnould, Melea Press; Department of Plant Sciences: Urszula Norton; Department of Agricultural and Applied Economics: Danelle Peck
- Makere University: Department of Agricultural Economics and Agribusiness: Bernard Bashaasha
- Moi University: School of Agriculture and Biotechnology: John R. Okalebo
- SACRED Africa: Eusebius Mukhwana
- AT Uganda: Rita Laker-Ojok
- Manor House Agricultural Center: Emmanuel Omondi

Research progress by objective

Objective 1: Compile information for prototype CAPS development. Assemble stakeholder advisory groups for each area.

Critical research accomplishments

Between July and October 2010, advisory group meetings were held at each location and were well-attended by men and women opinion leaders of each community. We also identified four on-farm sites at each of the four study areas. These farmers, together with research station managers helping with the on-station sites, constitute the core of our advisory groups with which we have frequent contact to discuss, reflect upon, and plan research activities. The broader groups will convene once per year to review activities and discuss broader implications for adoption.

The baseline survey data were compiled in summer 2011 and are now being analyzed. The survey involved 200 questionnaires per study location; i.e., 200 each in Trans Nzoia, Bungoma, Tororo, and Kapchorwa. This corresponded with 50 questionnaires at each on-farm site given that there are four on-farm sites at each study location.

Development impact

Building local teams at each of the four study areas has involved important capacity building and nurtured contacts among farmers and support players that is improving understanding of

soil degradation issues and setting the stage for co-innovation and participatory evaluation of CAPS components.

Challenges and responses
Our biggest challenge has been finalizing compilation and analysis of the baseline survey. Incompatibility of the Access template created at Makerere University with computers of our Kenyan partners caused data entry problems that have been difficult to resolve. The length and scope of the survey (200 respondents per site with >15 pages) made copying very expensive and difficult so that transporting hard copies to Makerere for entry was delayed. This was accomplished during Lead PI Norton's early April visit so that AT Uganda now has all the hard copies and has completed the report.

Objective 2: Define the traditional system and develop prototype CAPS for each area that build upon local knowledge, traditional practices, and address agronomic and socioeconomic constraints.

Critical research accomplishments
We held active, participatory advisory group meetings where we forged consensus on the typical current system, the shortcomings of that system with respect to soil quality/sustainability, the concepts of CA, how specific CA practices address limitations of the current system, and which practices we should attempt to evaluate in on-station and on-farm trials.

For example, an in-depth discussion and evaluation on farmers' perception of a typical rotation system in each of the four study sites resulted in a consensus that maize/bean intercrop was cross-cutting in all sites in Uganda and Kenya. It was also established, through these meetings, that maximum soil disturbance, using animal drawn implements or hand hoes, was involved in all cropping activities undertaken by farmers in East Africa and that conservation was a whole new concept to the vast majority of the farmer participants. While farmers did not object to *Mucuna* sp. and *Dolichos lablab* as cover crops of choice, and were willing to try them out, they generally did not have much experience with either legume, mostly because neither was recognized as food crop. Farmers in the study area typically use diammonium phosphate for planting maize and nitrogen fertilizers (urea or calcium ammonium nitrate) as top dressing fertilizer.

Among the major constraints to crop yields in each study site included soil nutrient depletion, uneconomically small land sizes, weeds, inadequate or inequitable distribution of rainfall, soil erosion, pests and diseases. These meetings also identified potential CA tools for minimum soil disturbance including machetes, jab planters, chisel plows, planting sticks, herbicides, knife rollers, and others. Specific technologies and tools to be employed in the course of the study were identified through voting. Interactions during the meetings went far to develop a cohesive team and common understanding of our objectives and roles in the project.

The meetings defined the traditional/farmer practice and identified this as the conventional practice/farmer practice treatment in our study involving hand hoeing or ox-plowing to a soil depth of at least 15 cm. Minimum till was described as a system involving minimum soil disturbance using machetes, slashers, hand hoes, or some other locally available implements, to a depth of 5 cm below the soil surface, combined with herbicides. No-till was explained to the farmers as a practice that strived to eliminate soil disturbance and involved extensive use of herbicides with only pricking the surface for seed and fertilizer placement using either machetes, sticks or hand hoes.

Please refer to our research strategy for detailed descriptions of our treatments, design, and data collection activities that resulted from the meetings.

Development impact
Advisory meetings included training on erosion and soil depletion processes as caused by conventional tillage practices. This gave participants tools to discuss workable solutions for evaluating and implementing CAPS. We also explored the capability of local fabrication shops at each of our study areas. We are working with an engineer to test a prototype of the implement and then plan to have one built for each of the four study areas. It could then be duplicated by shops in each study area.

Challenges and responses
By opening the floor to many ideas for CAPS components at the meetings we ran the risk of having to reject many suggestions. We avoided hard feelings by guiding the ideas toward practices likely to improve soil quality, and then setting the stage for working together to integrate those into adoptable farming systems.

Objective 3: Evaluate agronomic, ecological and economic sustainability of CAPS compared to traditional practices.

Critical research accomplishments
During spring semester 2011, graduate student Jeremiah Okeyo, working with research associate Dominic Sikuku and the NGO partners solidified relationships for on-farm and on-station research plots. Plots were delineated at all 20 locations. Baseline bulk soil samples were taken to one meter depth from four points at four depth increments (0-10, 10-30, 30-60, and 60-100 cm). Subsamples of each of the 1152 soil samples collected were successfully shipped to the University of Wyoming. One bulk sample from the surface increment from each on-station block was sent to CCRA-9 PI Mike Mulvaney. Samples are now being analyzed by PhD student Okeyo in Wyoming, and at a Virginia Tech lab by Mulvaney's research team. We also obtained a USDA-APHIS plant materials import permit in order to import plant parts and seeds to Wyoming for analyses.

Supervised by Okeyo and Sikuku, and later, Lead PI Norton, planting was accomplished by NGO partners with local labor after the first rains in late March and early April. After a meeting

of the soil science/agronomy team at Moi University in April, each student and research associate developed one-page concept notes on their specific research questions and approaches that would be embedded in the larger research project. Agronomic data, including plant height, leaf area, yield and yield parameters, as well as trace gas samples were regularly collected in the course of crop development. Logistical challenges due to a large number of trace gas samples required and the time-consuming nature of the process limited trace gas sampling to only two blocks in Kitale and Bungoma on-station sites. Soil, plant tissues, trace gases, socioeconomic, and other data are currently being analyzed by responsible scientists and preliminary results from these analyses are expected by the end of 2011.

Please refer to our research strategy for detailed description of analyses being carried out.

Development impact
The participatory processes of plot layout, sampling, and development of built capacity and relationships provide the foundation for a successful long-term project. Each participating farmer was given a rain gauge, notepad, and pencil for recording daily rainfall, and trained in reading the Tru-Chek rain gauges. Each of the farmers took a keen interest in this and it has effectively promoted engagement in the project.

Earlier perception by farmers that good crop yields can only be realized when land is sufficiently tilled is drastically changing as farmers observe absence of discernible differences between crop performance in traditionally tilled plots compared to conventionally tilled plots that were correctly established and managed. This is especially true in on-farm plots in Kapchorwa, Uganda, whereby there was virtually no observable difference between maize growing in no-till plots and those growing in the other tillage treatment plots. This trend is expected to continue in subsequent seasons and in other sites as we learn how to better manage the agronomic aspects of our research, especially with regard to weed control. In general, however, initial observations indicate that yields, especially of maize crops, are greater in traditional/conventional tilled plots compared to CA plots. This was not surprising given that benefits of CA can be delayed. Yield data for the two seasons in the first year of the experiment are being compiled and summarized.

Challenges and responses
We have been concerned about the large size of the project, with 20 different research sites in four different districts of two countries. With different NGO partners in charge of each area, consistent implementation and monitoring of CA trials could be difficult. By having Ph.D student Jeremiah Okeyo, who has a great deal of plot research experience working for the CIAT Tropical Soil Biology and Fertility Institute, spend Spring semester of 2011 establishing the plots and educating farmers and NGO partners on their management, we have accomplished a level of consistency and engagement better than we hoped for. Also, Dominic Sikuku, an experienced consulting agronomist, is devoted to successful implementation. In partnership with other members of the Agronomy team including, co-PI Dr. Urszula Norton, UW Research Associate Dr. Emmanuel Omondi and Agronomy PhD student Judith Odhiambo, Dominic developed an

agronomic data collection protocol that brought him to each of the plots every three to four weeks. Judith spent the summer on site monitoring trace-gas emissions once per month at the MHAC and Bungoma on-station sites, as well as participating in collecting agronomic data. Emmanuel took over this role in September through December when he will swap places with Judith again. With this and other visits by NGO partners, students, and PIs, farmers and on-station sites were frequently visited to maintain a presence for discussion of the work.
While all research establishment work was timely and well-intentioned, some practices were applied unevenly among study sites, and farmer buy-in was not as clear at one study area as at the others. This was due in part to necessity to change some on-farm sites at that area after initial identification in October, so that the farmers had not attended the stakeholder meeting or met the PIs and NGO participants. This was remedied during one-week post-planting visits by Lead PI Norton, Sikuku, and Okeyo in which we enlisted the farmers to weed the plots and explained the project and their role in the research. We discussed the situation with the responsible NGO partner, and they agreed to increased contact and better management. Sikuku is following up to assist them in fulfilling this commitment.

Weed control posed one of the greatest challenges to successful establishment of our study. In all four study sites, both on-station and on-farm, chemical weed control was a new concept being tried for the first time with the introduction CAPs. Research Associate Omondi worked with SANREM associate director Mike Mulvaney to develop USAID approved protocols and guidelines for pest control for the project. The process involved a delicate balance between identifying efficacious pesticides or pesticide combinations that were both effective against their prescribed targets while at the same time met the toxicity limits imposed by USAID. The first set of herbicides approved by USAID proved inadequate in themselves or lacked appropriate combinations to achieve the desired efficacy to deal with the prevailing weeds.

Reports coming from all three East African sub-awardees were invariably that weed control had not been adequately achieved with initial herbicide recommendations. Research Associate Omondi worked on a second set of six herbicides expected to be more efficacious within the limits imposed by availability and prevailing restrictions. The second application was approved in September 2011, just in time for second season and relay planting. Sites in Uganda (Tororo and Kapchorwa) that adhered to the new herbicide prescriptions combining recommendations in the first and second sets of chemicals achieved excellent weed control in their second season and relay crops. Both sites in Kenya did not strictly adhere to those recommendations and were more adversely affected by weeds. Where herbicide application was delayed or inadequate, weeds were controlled by scraping or slashing in no-till treatments and shallow weeding in minimum-till. Closer supervision by Dominic Sikuku and greater vigilance will be undertaken in subsequent seasons to ensure that we achieve complete control of weeds and other pests in all four sites.

Another challenge observed was the preferential establishment of *Mucuna* in different geographical regions. The cover crop seems to thrive in warmer low lands and has a hard time

germinating and covering the ground in cooler regions. There will be need to identify other leguminous cover crop species that are more suited to high altitude project sites.

Other challenges faced included insect pests (e.g., maize stock borer and bean aphids) and rodent infestation especially prevalent in Bungoma and Tororo study sites, inadequate means of transportation to study sites, inadequate tools especially for planting in no-till treatment, scattered and/or low rainfall at planting time affecting germination of crops, theft of maize and beans at harvest time adversely affecting yield data especially in Uganda, and inadequate training and/or understanding of farmers and field project staff on pertinent management principles and other aspects of the research. Many of these challenges are currently being addressed with a view to ensuring even greater success in 2012.

Degree and non-degree training activities

Training involved graduate degree education for two Ph.D and one Master's students at the University of Wyoming, two master's students at Moi University, and one master's student at Makerere University. Non-degree training involved 314 men and 253 women in on-farming training, initial advisory group meetings, and a workshop.

Publications, presentations, and other SANREM CRSP products

Two posters highlighting the progress of our study were presented by Lead PI Norton and co-PI Prof. Robert Okalebo at the SANREM CRSP 2011 annual meeting held at Virginia Tech on May 17-19. The meeting was also attended by research associates Omondi and Sikuku, as well as by co-PI Urszula Norton.

A poster was presented at the CRSP Council meeting that took place at the Protea Hotel in Kampala, Uganda on July 25-26, 2011.

Networking activities

The University of Wyoming SANREM group of PIs, research associates, and graduate students meet regularly to discuss progress and related research. Lead PI Norton participated in Green Revolution 2.0 symposiums at the 2010 Agronomy Society of America meetings in Long Beach, CA, and also discussed collaboration with Southern Africa SANREM CRSP Lead PI Neal Eash. We plan to exchange soils samples for common analyses of C and N pools.

AT Uganda participated in the CRSP Council meeting and met the SANREM CRSP Director and Associate Director. AT Uganda also attended a breakfast meeting at which Cultural Practice LLC presented preliminary research findings on gender access, land ownership, and resource utilization in Uganda. Kapchorwa district was one of their research sites.

Project highlights

Advisory group project inception meetings held in October, 2010, brought together over 150 men and women, creating broad understanding of and engagement in our East African SANREM CRSP research. This sets the stage for long-term co-innovation to develop adoptable CAPS based on participatory evaluation of tillage, rotation, and cover crop components.

Twenty research sites, including one on-station trial and four on-farm trials at each of four study areas, were established with help of participating farmers and local residents at each area, including plot demarcation, baseline soil sampling, tillage treatments, and planting. Clear communication of responsibility for managing and monitoring rainfall, weeds, and input activities engaged farmers and local workers in ways we think will support a successful long-term project.

LTRA-11: Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS)

Principal Investigator: Catherine Chan-Halbrendt, professor and chair of the Department of Natural Resource and Environmental Management, University of Hawaii at Manoa

Host Countries: Nepal, India

Research Team:

- University of Hawaii at Manoa: Department of Natural Resources and Environmental Management: Travis Idol; Department of Civil and Environmental Engineering: Chittaranjan Ray
- Orissa University of Agricultural Technology (OUAT): Dr. Roul, Dr. Mishra, and Dr. Dash

Research progress by objective

Goal: Improve agricultural productivity, household income and economic opportunities, and the sustainability of smallholder agricultural livelihoods and community life through the selection, development, and implementation of locally appropriate CAPS that address the specific constraints and pressures threatening the sustainability of traditional agricultural systems.

Objective 1: Determine the set of CAPS for sustained productivity, labor, soil impact, gender equity and profitability (results collection and project maintenance)

Task 1.1: Conduct baseline surveys in three villages of Kendujhar District of Odisha State, India to gather information on demographics, land use, and agricultural systems.

In December 2010, preparations were made in Tentuli Village (India) to carry out training seminars on survey administration. Socioeconomic baseline surveys were completed in Tentuli, India and initiated in the villages of Bayakumutia and Talachampei in June 2011. Survey data encompassed assets, income, farmer practices, labor use, agricultural inputs, and market transactions. Care was taken to incorporate survey activities with the farmer's daily work routines as to minimize disruption and ensure better quality responses (survey time ranged from 90 to 120 minutes).

Task 1.2: Conduct detailed financial analysis to determine theoretical cost effectiveness of CAPS through economic analysis and enterprise budgeting.

In the summer of 2011, an economic analysis was completed for the three CAPS programs in India using baseline survey data and research station data collected from the first year of the

project. Results from structured socioeconomic surveys provided the economic information necessary to compare the costs of three integrative CAPS systems: maize with minimum tillage, maize/cowpea intercrop with plow, and maize/cowpea intercrop with minimum tillage.

Task 1.3: Conduct risk analysis of different hypothetical interventions and farmer-identified limitations of CAPS implementation.

The economic comparison of three CAPS systems was performed and primary factors to farmers for CAPS adoption were identified. Risk analysis indicated that yield risk and price (profitability) risk (impacting food security and income) were among the two primary factors influencing farmer decisions. Yield risk is of prime importance as maize is the main food source for most families. Price (profitability) risk is most important for farmers of cash crops such as cowpeas.

Task 1.4: Provide consultation for women's groups to identify preferences and risks.

In December 2010, a focus group analysis was conducted to assess the farming situation associated with farm labor, weekly activities, and participation in farming activities for women living in Tentuli village. In March, preferences from women were identified during a CAPS workshop. To facilitate gender-specific comparison of agricultural knowledge and preferences, male and female heads of household were surveyed using farmer knowledge and perceptions surveys in June 2011. Additionally, members of women self-help groups were organized for the marketing of maize green cobs, which was successfully executed during summer 2011.

Task 1.5: Exploration of agronomic and livelihood needs and relevance of CAPS for tribal farmers in Nepal.

Three villages in Nepal were selected for CAPS using the following criteria: predominance of shifting cultivation and sloped landscape, site accessibility, tribal culture, and microclimate variation. These villages are Hykrang in the district of Dhading, Thumka in the district of Gorkha, and Kholagau in the district of Tanahun.

In March 2011, farmer focus groups from the selected Nepali villages were conducted in each of the three villages to assess current farming practices and determine the most appropriate CAPS options for field trials. In each village, farming practices, cropping patterns, and livelihoods were observed by teams from UH (University of Hawaii) and LI-BIRD (Local Initiatives for Biodiversity, Research, and Development, our partner organization).

In March 2011, on-farm CAPS research trials were designed in collaboration with Thumka farmers and LI-BIRD. Farms were considered with the team input and input from the village motivator and nine fields were selected in consultation with our LI-BIRD partners. UH's agronomic team interviewed 12 Thumka farmers about current practices and surveyed soil types, fertilization, tillage, and cultural practices. During field selection, experimental plots

were numbered, marked, and recorded with GPS. Baseline data, midpoint data, and harvest data of the main crops have been collected and analyzed. Soil sample analysis is ongoing and further analysis of CAPS data will begin after collecting harvest data of relay crops.

Objective 2: Explore stakeholder preferences for CAPS to promote adoption

Task 2.1 and 2.2: Initial agronomic assessment using the AKT or FALLOW models
We were not able to employ the AKT or FALLOW models to conduct an assessment of the agronomic or agroforestry potential at our project sites because there were not enough graduate students to help. Instead, we utilized several site visits to the select farm communities to make observations, hold discussions with farmers, and then meet with our local university and NGO partners to better understand the agronomic and socioeconomic context of these farming systems and develop appropriate CAPS interventions. Factors such as soil type, slope, tillage practice and equipment available, crops, planting schedules, fertilization, residue management practices, market for crops, subsistence food needs, and labor availability were considered. This effort was supported by household surveys conducted in the villages and a workshop in India in which farmers were introduced to CAPS and completed a survey to determine their preferences of various combinations of CAPS interventions based on expected costs and benefits.

Task 2.3: Develop initial analytic hierarchy process (AHP) framework for CAPS preferences in India.

AHP surveys were conducted in India with Tentuli farmers and OUAT researchers and staff members during the March 2011 visit. Survey analysis determined farmer preferences for CAPS and the results were essential in the selection of the most appropriate CAPS systems for the 2011 planting season. In June, the results of this survey were presented to partner organizations in India and at the 2011 IFAMA conference in Frankfurt, Germany and the conference on CA in Cambodia.

Task 2.4: Discuss potential CAPS with tribal farmers in Nepal.

In March 2011, focus groups were conducted with farmers in each village to discuss local cropping patterns and LTRA-11 project objectives, methodology, and duration. With the information from the focus groups, CAPS options with the following components were identified: minimum tillage, maize, finger millet (*Eleusine coracana*), and cowpea (see Table 27, below for the plan).

Table 27. Treatment plan for on-farm trials in Nepal

Treatment	Tillage	1st Rotation	2nd Rotation
1	Full	Maize-pumpkin (*Cucurbita pepo*)-local cowpea intercrop	Millet-commercial cowpea intercrop
2	Strip (75 cm)	Maize-pumpkin-local cowpea intercrop	Millet-commercial cowpea intercrop
3	Full	Maize-pumpkin-local cowpea intercrop	Millet
4	Full	Maize-pumpkin-local cowpea intercrop	Commercial cowpea

Table 28 showed that the CAPS treatment slightly deviated from the planned Table 1 due to lack of seeds from some farms and villages.

Table 28 Nepal CAPS treatment for on-farm trials

Treatment	Tillage	Main Crop	Relay Crop
1	Full tillage	Maize	Cowpea
2	Full tillage	Maize	Cowpea + Finger millet
3	Full tillage	Maize	Finger millet
4	Strip tillage	Maize	Cowpea + Finger millet

Objective 3: Implement preferred CAPS on-farm for validation, impact on farm household welfare leading to policy recommendation

Task 3.1: Evaluate of 1st year results from CAPS field trial on OUAT research station.

An on-station field experiment was conducted from June 2010 to March 2011 and recommenced for the current year in June 2011 at RRTTS/KVK farm at OUAT in Kendujhar. The crop and soil data collected from the field experiment were documented and used to develop CAPS options and an AHP framework. The results of the experiment were presented in a two-day orientation workshop held at OUAT in March 2011.

Task 3.2: Install village field trials of selected CAPS in India.

In December 2010, experimental plot sites were established in Kendujhar District and CAPS were selected using surveys and PRA (Participatory Rural Appraisal). Sites were chosen for each of the three CAPS strategies chosen: maize/cowpea intercropping, use of horse gram (*Macrotyloma uniflorum*) as a cover crop, and minimum tillage. Crop yields for the maize and maize/cowpea intercrop treatments were collected. Soil moisture, bulk density, and nutrient content data were also collected as were crop chlorophyll content, plant height and nutrient

content. The experimental design includes three replications with two treatments a reduced tillage treatment permitting only one pass (versus two passes) of the plow to remove weeds prior to sowing, and a residue retention treatment using mustard vegetation.

Task 3.3: Monitor CAPS performance on station and village field trials.

An on-station field experiment at the OUAT RRTTS/KVK experimental station in Kendujhar, India, was conducted from June 2010 to March 2011; the trials for the second growing season began in July and are currently underway. Crop and soil data were documented from the first year experiment and used to develop CAPS options and AHP framework. The results showed that conventional tillage with intercropping with cowpeas showed the highest revenue followed by reduced tillage with intercropping (Table 29). The results were presented at a two-day OUAT workshop, the purpose of which was to introduce the concept of CAPS and receive feedback from farmers.

Table 29. Maize and cowpea mean yields (t/ha) from experimental CAPS treatments, OUAT Research Station, India

Treatment	Maize (SE)	Cowpea (SE)	Value (Rp)
Conventional till/single crop	2.25 (0.10)		56,250
Reduced till/single crop	1.50 (0.09)		37,500
Conventional till/intercrop	1.88 (0.09)	1.00 (0.09)	87,000
Reduced till/intercrop	1.70 (0.09)	0.73 (0.03)	71,700

Forty-nine farmers in Tentuli village received introductory training on CAPS on March 16, 2011. This seminar was accompanied by an AHP workshop held in Tentuli the following day. The survey revealed a farmer preference for growing maize under conventional tillage intercrop with cowpeas.

The on-farm trials have been monitored throughout the growing season by OUAT staff collecting data on initial soil bulk density, soil nutrients texture, pH, and moisture content; soil analysis was conducted at OUAT laboratory. SPAD (chlorophyll content) readings for maize and cowpea, plant height, and weather data were also taken. Harvest data are scheduled to be collected in the coming months.

Task 3.4: Install runoff and soil erosion measurement plots.
After several visits to project sites in India and Nepal and discussions with university and NGO partners, the LTRA-11 team decided to alter the soil and water conservation strategy from the original plan. In India, the maize-based cropping systems occur on areas with minimal slope. Even then, fields are normally bordered with earthen bunds. Thus, erosion is not likely to be a severe problem. The key issues are improving water infiltration and storage in the soil to improve crop growth and recharging shallow aquifers to allow for irrigation of dry-season crops. ICRISAT developed and demonstrated a number of farm- and community-scale practices to improve water capture and storage in a similar agricultural community in Khotopally, India.

We will employ a subset of those techniques in India and use a combination of soil water measurements and well monitoring to evaluate improvements to water infiltration, storage, and groundwater recharge in India. Because the farming systems in Nepal do occur on steeply sloping land, we will work with our partners to install runoff and erosion plots at select locations as described in the proposal.

Task 3.5: Conduct farmer introductory training on CAPS.

Farmer training on CAPS was conducted at the March 2011 workshop at OUAT. A PowerPoint presentation was given and an "Introduction to CAPS" poster was presented. Practical field training occurred during the implementation of the 2011 on-farm trials. At Bayakumutia and Talachampei (India), community meetings were held to introduce the project and focus groups were conducted to collect information on basic farming practices, types of crops cultivated, seasonal farming calendar, and village infrastructure.

On September 7th, a farmer training day was held in Tentuli by KVK, Kedujhar and OUAT staff members. Training curriculum focused on production and post-harvest management of maize crops. A discussion session to explore stakeholder preferences for CAPS revealed farmer preferences for the growing and harvest of maize and mustard crops.

Objective 4: To promote reflection, evaluation, and continuous improvement of implemented CAPS.

Task 4.1: Conduct training on principles of participatory planning of research and their application to host country villages.

Participatory planning of research in India was initiated in June 2010 with visits to two farm communities in which discussions about farming systems, constraints, and desired improvements were held with farmers and OUAT faculty. Based on these discussions, research was focused on maize-based cropping systems, involving legume intercrops and residue management as being most desirable and feasible for improved CAPS and farmer acceptance. Agroforesty options under consideration include the use of improved *Leucaena leucocephala* varieties or species hybrids, *Gmelina arborea* or similar N-fixing trees primarily as vegetative, soil conservation barriers along terrace bunds but that have the potential to serve multiple purposes, such as green manure, an alternative fodder during the dry season to conserve crop residues or ground covers, and as wood products for timber or fuel wood. OUAT scientists have also identified a number of hardy, drought tolerant fruit trees which will be tested and on steeply sloping lands as an alternative to more soil erosion-prone annual crops.

The knowledge from the surveys and feedback from the farmers revealed a farmer preference for the growing of maize/cowpea followed by a mustard crop. The on-farm trials were adjusted to include mustard crop as a relay crop after maize planting in the monsoon season.

In June 2011, 20 Tentuli households (India) began participating in on-farm field experiments and on August 19th, 25 maize farmers from other villages in the region travelled to Tentuli to learn about CAPS and the field experiments.

Objective 5: Build capacity of farmers, local NGOs and universities to scale up CAPS development for wider dissemination.

Task 5.1: Communities: adapt conservation agriculture handbooks to local context.

Introductory CAPS handbooks, which included results from the first year of experiments were prepared and distributed to over 40 participants during the two-day March workshop at OUAT. Our partners in Nepal are drafting a CAPS brochure for general distribution and have developed a presentation to show to national-level decision makers.

Task 5.2: Communities: engage local OUAT staff to train and support CAPS in local villages in India

In December 2010, a focus group was conducted with village farmers and OUAT staff in Tentuli to establish a seasonal farming activities calendar that incorporates farmer priorities and seasonal activities into the planning cycle. OUAT personnel were also trained in research methods and CAPS treatment implementation. This included training on use of resin-bags for soil nutrient analysis.

In June 2011, the partner project coordinator, an economics research associate, and two OUAT masters students were trained in the implementation of both the socioeconomic and farmer knowledge surveys in Tentuli. Also, field research methods and data collection training for experimental plots in Kendujhar Province was provided for the in-country PI, research coordinator, and research associates. Twenty one OUAT staff and students have been trained in field research methods and data collection, and they are currently monitoring the progress at the India field sites. Training included use of soil cores and SPAD meter to measure chlorophyll content. Finally, training for weather station maintenance, troubleshooting, and data collection was given to both the village representative and the host country project coordinator.

In Nepal, capacity building for village farmers has been regularly provided by LI-BIRD staff. All field staff members are trained in CA and CAPS. OUAT has been in close contact with the national-level NGO PRADAN and with the NGO SAMBHAB; both are interested in CAPS and discussions are ongoing. In addition, OUAT is organizing a workshop on CA to be held in December 2011. They will disseminate CAPS and provide informational materials.

Three graduate students are working on the project as fellows with OUAT and one is currently applying for the Ph.D program at the University of Hawaii. Three OUAT master's students from the agronomy, soil science, and agricultural economics departments are pursuing their thesis research through participating in LTRA-11 Project activities.

Degree and non-degree training activities

In the 10-month time period from December 2010 to September 2011, 42 documented training and capacity building events were conducted for over 480 participants (see APPENDIX B. LTRA-11 FORM 17 for a full list of training activities). CAPS education and presentation of LTRA-11 objectives were delivered to 68 participants (UH students and faculty, general public), through seminars and graduate-level classes in the U.S.

Thirty-one students and staff (mostly in-country) were given socioeconomic survey training. Data collection and monitoring training was provided for 65 people (61 of which villagers or partners in OUAT and LI-BIRD) and included setup and maintenance of weather stations, AHP analysis, soil sampling and lab equipment, and plot-specific data collection protocols. In addition, training on scientific writing was given throughout to students at UH and OUAT.

Three OUAT master's students from the agronomy, soil science, and agricultural economics departments are pursuing their thesis research in the LTRA-11 Project during this academic session. Their topics are as follows:

- Comparative analysis of CAPs in maize-based cropping systems.
- Economics of CAPS in the high elevation rain-fed farming of the North Central Plateau Zone (NCPZ), Odisha.
- Impacts of maize-based CAPS on soil properties in the NCPZ.

One student from the University of Hawaii received her master's degree with the research carried out by this project. Three master's fellows from India have been recruited to carry out their research from this project.

Publications, presentations, and other SANREM CRSP products

The project has generated public interest in host countries. Our partners in Nepal have drafted presentation materials for national-level stakeholders and will report on the outcome of the presentation later in the year. In India, 25 farmers from leading maize-based farms in the district visited the experimental plots in Tentuli and learned about the treatments and LTRA-11 program on August 19th, 2011.

Networking activities

In the first year, we visited ICRISAT's headquarters in Hyderabad and secured their agreement to work with us on our projects in India. In the second year, they sent a scientist to participate in the CAPS introduction workshop in Keonjhar. The scientist gave a presentation on some of the maize-based conservation agriculture research being conducted by ICRISAT and participated in discussions of potential CAPS with the farmers of Tentuli village. We also invited a representative of the rural development NGO Pradan to attend our workshop, and they sent a representative as well. This person did not make a formal presentation but did participate in the discussion. PRADAN does work actively with farm communities in upland districts of Odisha State, so our intention for the coming years is to partner with them to disseminate CAPS beyond

our study sites and solicit advice on improving CAPS interventions and outcomes. For example, PRADAN has developed a relationship with a local supplier of seeds of improved maize varieties, which is important to ensure a reliable and affordable source of material for farmers transitioning from their own open-pollinated varieties.

PRADAN in India has shown great interest in the results of the maize-based CAPS experiments in Tentuli and is in close contact with OUAT. SAMBHAB, is interested in CAPS as a means for promoting organic agriculture among tribal people in Odisha and is also in contact with our partners in India.

During its 2011-2012 Golden Jubilee Celebration, OUAT is organizing a workshop on conservation agriculture to be held on December 24, 2011. This workshop will provide a great opportunity for dissemination of the LTRA-11 project and CAPS.

On September 21st, 2011, our partner PI in India presented a paper entitled "The Livelihood of Small Farmers," which was based on experiences with the project thus far, in an international workshop called "Socioeconomic Empowerment," held in Bhubaneswar.

One of the largest English newspapers in India, "The New India Express" and the newspaper "Sambad" provided coverage of the LTRA-11 project workshop held in March 2011 and a farmer training initiative in August 2011.

In Nepal, our primary partner is the NGO LI-BIRD, and we worked with them to initiate CAPS treatments in three villages. We also met with and formalized partnership with Tribhuvan University. We will be working with them directly to install model CAPS at a university research station and to involve their faculty and students in our joint efforts with LI-BIRD in the farm communities.

Project highlights

- Analytical Hierarchy Process application revealed a clear Tentuli farmer preference for the option of maize-cowpea intercrop with conventional tillage. The AHP assessment also showed a preference for improved yield (33 percent out of 100 percent), followed by increased profit (27 percent), benefit to the environment (21 percent), and labor-saving (18 percent).
- A representative household maize based model for Tentuli village, India was completed. The model was contrasted with data from the experimental CAPS to determine that an intercrop of maize and cowpea with a minimum tillage system would have the greatest positive impact on labor, yields, and potential profitability.
- The University of Hawaii graduated one master's student who, for her final project, produced an article entitled 'Farmers preference of conservation agricultural practices in Kendujhar, Odisha, using the Analytical Hierarchy Process." This paper is currently awaiting publication.

- Twelve presentations and five posters were generated from the project during this time period. Notably, a presentation entitled "Comparative economic analysis of conservation agricultural practices in tribal villages in India" was presented at the IFAMA 2011 Annual World Symposium in Frankfurt, Germany, and two presentations entitled "Development of an integrated approach for introducing conservation agricultural practices to the tribal communities of Odisha, India." and "Farmers preference for conservation agricultural practices in Kendujhar, Odisha" were presented at the Second International Conservation Agriculture Workshop and Conference in Southeast Asia, held in Phnom Penh, Cambodia.

LTRA-12 Conservation Agriculture for Food Security in Cambodia and the Philippines

Principal investigator: Manuel R. Reyes, professor, biological engineering, North Carolina Agricultural and Technical State University

Host countries: Cambodia, Philippines

Research team:

- North Carolina Agricultural and Technical State University: Department of Agribusiness, Applied Economics, and Agriscience Education: Osei Yeboah
- University if the Philippines-Los Baños (UPLB): Gender Center: Maria Helen F. Dayo; College of Engineering and Agro-Industrial Technology: Victor B. Ella
- Royal University of Agriculture: German Development Service: Adrian Marc Bollinger; Department of Agronomy: Hok Lyda, Chuong Sophal
- US Department of Agriculture-Natural Resources Conservation Service East National Tech Support Center: Susan Andrews, Charles E. Kome
- Centre de Coopération International en Recherche Agronomique pour le Dévelopment (CIRAD): Stéphane Boulakia, Stéphane Chabierski, Kou Phally, San Sona
- Landcare Foundation for the Philippines: Agustin Mercado

Research progress by objective

Goal: To show that CA principles and practice of minimal soil disturbance, continuous mulching and diverse species rotations, constitute the best 'tool box' to create sustainable permanent cropping systems for annual crop production under wet tropical conditions in Cambodia and the Philippines, and that CA will reverse soil degradation, increase crop yield and profits, and reduce the labor burden on women.

Objective 1: Gender

Pinpoint gendered limitations and advantages that can promote adoption of CAPS, and determine if CAPS will decrease labor burden on women in Cambodia and the Philippines.

Critical research accomplishments

Cambodia:

- Due to the recent post-war situation and men's migrations, there was a high rate of single women's households in Battambang. The majority of smallholders manage small-medium upland farms with easy access to Thai markets.
- Most upland cropping systems commence with 'contractor' disc plowing which leads to increased production costs, weed pressure, and the mobilization of children and women in poor households for weeding.
- Farmers claim there is equity between the role of the husband and the wife. Responsibilities regarding the agricultural tasks depend on physical strength. The men are responsible of the

implementation of the tasks which need more physical strength, such as operating hand tractor for plowing, line tracing, and harrowing; the rare plowing with animal traction; and applying chemicals. The women are more likely to implement lighter tasks, such as sowing, post-harvest processing of vegetables, caring for poultry, weeding, and off-farm activities such as management of a grocery store.

- Both men and women are involved in decision making and it appears that women have a greater role than men. Their decisions seem to be well-accepted and recognized.
- Will the end of the plowing practices be considered by men as a threat to their social position in the household? Could it be an important constraint for the adoption of the CAPS? Regarding the well spread habit to pay external services for plowing, men would accept to leave plowing. Increased investment on tractors, however, suggests the contrary. Further analyses should be carried out.
- Women's participation in field visits is between 30 to 45 percent, and should be improved to include at least 50 percent of participants.
- One of two farmer organizations is led by a woman.

Philippines:

- Survey data were entered in Excel. Summary and analysis are on-going with partial results completed. Once all data analysis is completed, a socioeconomic baseline report will be prepared. It will provide the baseline for the economic impact analysis of CAPS interventions at the research site.
- The average age of respondents is 50 years old, with an average of 27 years of farming experience. Survey households are typically comprised of five members with a relatively higher average number of males working in the farm than females (2.0 and 1.2, respectively). The average farm size is 2.2 hectares.
- Maize farmers have higher production during the wet season than the dry season (3,439 kg/ha and 2,005 kg/ha, respectively). Female respondents produced higher yields than the males in both seasons. However, the activity profile and access and control by both men and women to farming resources were not recorded. Gendered data for the activity profile and resource access will be gathered during Year 3 with a restructured questionnaire.

Development impact

From baseline surveys in Cambodia and the Philippines, it appears that women are involved in labor intensive tasks of sowing and weeding. Following introduction of CAPS, women agriculture labor for weeding and sowing may decrease.

Challenges and responses

Team needs to deliberately work on facilitating attendance and active participation of more women in field visits and training in year 3.

Objective 2: Economics

Identify field- and farm-level CAPS that will minimize smallholder costs and risks while maximizing benefits and adoption in Cambodia and the Philippines

Critical research accomplishments

Cambodia:

- Diagnostic rural appraisal on the two targeted villages established three classes of farm lands with the following characteristics: (1) only lowland rice can be sown for both first and second crop cycles; (2) crops other than lowland rice can be sown during the first crop cycle and in the second cycle only lowland rice can be sown; and (3) crops other than lowland rice can be sown during both first and second crop cycles. Surveys have further highlighted that about 30 percent of the agricultural upland or "Chamcar" become wet during the second part of the rainy season which is not suited for maize cultivation, hence the project started developing systems based on upland rice cultivation.
- In 2010, the pilot area covered about 33 ha with about 26 families. Detailed yield and production input data were gathered from each participating household and the gross profit margins for 2010 were calculated for two CAPS: (1) *Stylosanthes guianensis* (stylo) followed by maize and stylo; and (2) pearl millet followed by maize and stylo; and on the control plots managed with traditional plow-based system. In 2010, CAPS yields and gross profit margins were lower compared to the plow-based systems. These results could have been partly caused by late sowing, technical inexperience, farmer's choice of the corn hybrid CP 888, and incomplete understanding of the proposed technologies by farmers. It appears also that most of the voluntary farmers wishing to cooperate with the project face problems in their fields due to weeds pressure and low fertility. To balance this low performance, the project management provided funds to farmers by alleviating part of the charge (services and input). These funds were reimbursed after harvest (internal-free-credit line with PADAC cost-shared project funds) with the following criteria: farmers who produce more than 4.5 T/ha reimbursed all production input credits (493 USD per ha). Farmers who produce less received subsidies from the project, according to their yield. The subsidy was 37.5 USD/ha for every 250 kg/ha below 4.5 T/ha (see the table below).

Table 30. Subsidies and reimbursements to farmers according to yield in the Philippines

Yield (Y)	Credit reimbursement by farmer
Y > 4.5 T/ha	493 USD per ha
4.25 T/ha < Y < 4.5 T/ha	455.50 USD per ha
4 T/ha < Y < 4.25 T/ha	418 USD per ha
3.75 T/ha < Y < 4 T/ha	380.50 USD per ha
3.5 T/ha < Y < 3.75 T/ha	343 USD per ha
……..until..... Y < 1.25	.....until ... …0 USD per ha

- The reimbursement rate for inputs collected from farmers was 98 percent.
- These subsidies are a way to provide incentives for a pronounced technical change and invest in soil capital restoration.
- It is evident from field observations that CAPS yields and gross profit margin will significantly increase in 2011 when compared with 2010.

Philippines:

- Gross sales for researcher managed plots, with treatments described in objective 4, were calculated. Plow-based maize had higher grain yield compared with four CAPS with maize as the main crop treatment. The price of maize, however, was four times lower than the price of cowpea and rice beans. Therefore, CAPS with maize + cowpea/upland rice + cowpea had the highest annual sales followed by maize relayed with rice beans. Maize with *Arachis pintoi* had the second to the lowest annual sales, and maize with stylo followed by fallow had the lowest annual sales. CAPS combining cassava with stylo had better annual sales than plow- based maize. Addition of herbaceous legumes pulled down the economic benefit of the CAPS system, particularly those associated to crops with low economic value like forages. Cowpea and rice beans can be a potential component of CAPS if varieties with greater biomass production could be identified so that they contribute to soil nutrient enrichment and particularly to P recycling in acid soils where P is the most limiting nutrient.

Development impact

Results showed typical trends for farms moving from conventional plowing to CAPS. Due to yield decrease, initial CAPS application usually has lower gross profit margin compared with plow-based systems. Many CAPS participating farmers continued in year 2 because they realized that benefits of CAPS are long-term and project provided incentives like farm input subsidies. The project is laying down ground work to convince local and national government to invest tax-derived funds in CAPS to draw farmers to CAPS. Team members have started quantifying how much investment is needed for CAPS, and what economic benefits would eventually accrue to credit entities and society in general.

Challenges and responses

It was difficult to gather accurate input costs.Number of farmer-managed treatments was reduced in the Philippines, and responsibility for the management of objective 2 was moved to an on-site scientist (UPLB to Xavier University).

Objective 3: Technology networks

To quantify the effectiveness of SANREM-supported farmer groups in training knowledge leaders, being a means of knowledge transmission, and facilitating network connections leading to widespread adoption of CAPS; and to find out whether a microcredit approach and a method to facilitate access for mechanized direct seed drilling and spraying can be successful in promoting adoption of CA in Cambodia.

Critical research accomplishments

Cambodia:

- It was found that (1) market accessibility and (2) price are major causes of cropping systems evolution. However, farming choices are also limited by (iii) ecological conditions and (iv) socioeconomic situations. Access to (v) finance is easier, but the interest rate is still high for either informal or formal micro credit service. Farmers tend to (vi) change from manual to agriculture machineries to address rapidly rising labor cost. These six factors are critical in CAPS adoption. Hence, the research team has been targeting solutions to these limitations.
- Trainings were provided to FOCAPS (farmer organizations conservation agriculture production system) members on leadership and marketing through FOCAPS; autonomy, sustainability of FOCAPS; production awareness, and bookkeeping in FOCAPS.
- The plan to introduce 'credit access' by involving traditional bank system to cover a full cropping season, from input purchase to products sales was not done for year 2. Such funding system, attached to a contract was still too risky while farmers discover radically new CAPS technologies on their most severely degraded soil. Some other constraints prevented the development of such system like the identification of the proper industrial partner, and the area in CAPS still too small to be cost effective. A subsidized method as described in objective 2 replaced the 'credit access' approach. By year 3, it is anticipated that there will be sufficient FOCAPS members and farm area to merit the 'credit access' approach.
- With respect to mechanization, the project aims to replace current plowing contractors with services oriented towards serving CAPS implementation by introducing and providing training for specific no-till planters and medium-sized sprayers imported from Brazil. The planter was better operated by SANREM/PADAC technicians in 2011 compared to 2010 and lead to a much improved stand of maize crops. It can sow from 5 ha to 12 ha/day.
- Due to increasing interest of farmers, especially some large ones wishing to start implementing CAPS on more than 5 ha, it has been proposed that they purchase their own machinery and start to provide custom services to other farmers.

Philippines:

- It was found that access of selected respondents to different support and services are from agrochemical vendors and agricultural researchers.
- CAPS training are being provided to farmers who are mostly members of the Landcare Foundation of the Philippines (LFP) and to local government officials. The provincial governor and municipal mayor were contacted about CAPS.

Development impact

FOCAPS have been organized. CAPS demonstration sites have been established with trainings being provided to FOCAP and LFP members. Team found critical factors for CAPS adoption. FOCAP and LFP connections to team, local government, market and lending institutions are being established. The groundwork is being laid for FOCAPS and LFP to be an effective CAPS transmission point.

Challenges and responses
Tractor drawn no-till planter was successfully calibrated in Cambodia. However, FOCAP membership is still low and it may not be profitable for government or lending institutions to invest in CAPS and its machinery. Recruitment of more farmers to be FOCAP members is continuing. In the Philippines, Landcare has several members who are ready to move to CAPS, however, they need CAPS machinery. The hand tractor pulled no-till planter imported from Brazil was not applicable in the sloping farms of the Philippines and the Philippine team is still building up skills in calibrating it. The machinery was designed for flat lands. Testing of tractor pulling no-till planter will continue this time on farms in flat lands. Two one-row animal drawn planters were purchased from Brazil and will be tested in sloped lands in 2012. A crimper roller to kill cover crops was also designed and fabrication and testing will commence in 2012.

Objective 4: Soil quality, crop yield and biomass

Assess soil quality and measure crop yield and biomass from CAPS and compare them with soil quality and crop yield and biomass from conventional plow-based systems in Cambodia and the Philippines

In describing treatments for researcher-managed and farmer-managed CAPS the following notations were used:

'/' is relayed cropping with planting dates varying,

'+' is planted side by side with the same planting dates

Researcher-managed trials

Cambodia:
Researcher-managed demonstration plots were established and monitored at two places in Boribo village on black soil with limestone and on land considered by farmers as degraded. These demonstration plots are not replicated and they are aimed to adjust CAPS (initially designed in Kampong Cham province on an acid Oxisol) to Battambang conditions; they are also a showcase of CAPS technologies for farmers. CAPS were implemented on 0.2- to 0.4-ha plots split in two levels of fertilizer application rates. Two new maize hybrids were sown to replace the "old" cultivars, whose yields are thought to be 25 percent less than new hybrids. Yield of maize, rice, soybean and cassava were measured and are shown in Figures 1 and 2. Biomass samples were also collected and are currently being analyzed. The treatments are as follows.

- Boribo I started in 2009 (See Figure 1)
- T1a and T1b: Maize and soybean rotation. Description below rotation started with maize (T1a). The T1b rotation started with soybean as main crop.
- Pearl millet/maize + *Brachiaria ruziziensis* in 2009; in 2010 continued with *Brachiaria ruziziensis*/soybean + sorghum + stylo at two fertilization levels of main crops maize (variety CP 888) and soybean (variety Asca); in 2011 rotation at two fertilization levels continued using a different variety of maize (CP QQQ) and soybean (98C81). There is about 60-70 days of biomass production of pearl millet, *Brachiaria ruziziensis*, and stylo.

- T2: Maize monocropping.
- Pearl Millet/maize + stylo in 2009; in 2010 at two fertilization levels of maize (variety CP 888) + stylo ; in 2011 continued at two fertilization levels using a different variety of maize (CP QQQ).
- T3a and T3b: Maize and cassava in rotation. Description below rotation started with maize (T3a). In T3b rotation started with cassava as main crop.
- Pearl Millet/maize (variety CP 888) + stylo in 2009; in 2010 at two fertilization levels of cassava + stylo; and in 2011 at two fertilization levels of using a different variety of maize (CP QQQ).
- T4: Cassava monocropping.
- Cassava + stylo in 2009; 2010 at two fertilization levels for cassava; and in 2011 at two fertilization levels of maize (variety CP QQQ) and plowed.

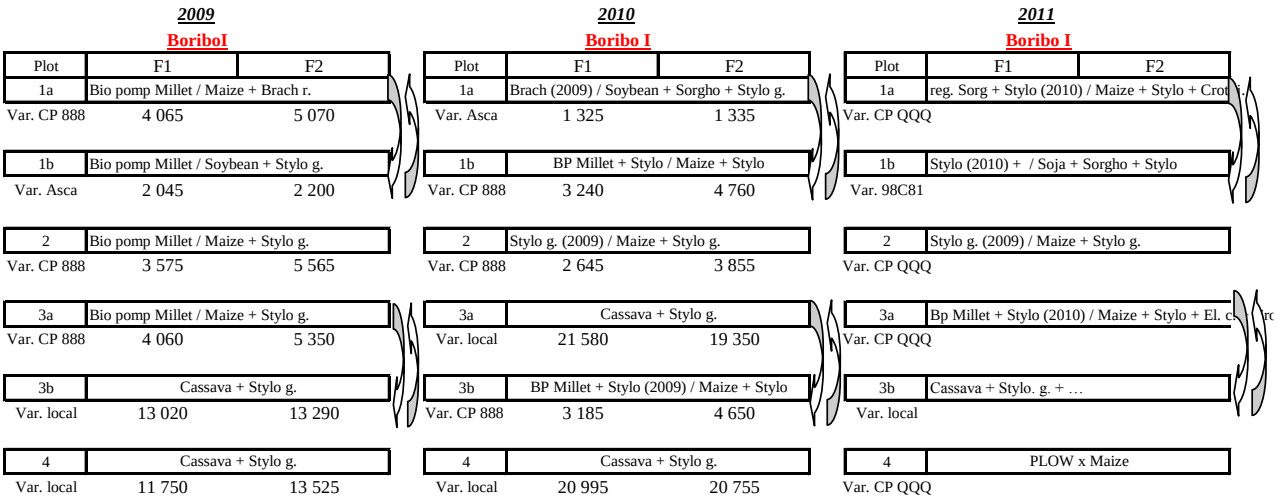


Figure 22. Crop yield is in kg/ha at two fertilization levels in Cambodia (Boribo I).

- Boribo II started in 2010 and at two fertilization levels (See Figure 2)
- T1a and T1b: Maize monocropping + rice bean
- In 2010 Pearl millet/maize (variety CP 888) + stylo + rice bean for both T1a and T1b; in 2011 T1a was with maize (variety CP QQQ) and plowed, while T1b was with maize (variety CP QQQ) + stylo+ rice bean
- T2a and T2b: Maize monocropping + pigeon pea
- In 2010 Pearl millet/maize (variety CP 888) + stylo +pigeon pea for both T2a and T2b; in 2011 T2a was with maize (variety CP QQQ) + pigeon pea)/Cassava + mungbean (*Vigna radiata)*, while T2b was with maize (variety CP QQQ) + stylo + pigeon pea
- T3a and T3b: Maize and upland rice in rotation + rice bean and cowpea. Description below rotation started with maize (T3a). In T3b rotation started with upland rice as main crop.
- In 2010 Pearl millet/maize + stylo + rice bean while in 2011 by upland rice + stylo
- T4a and T4b: Soybean monocropping and maize + sorghum + stylo

- In 2010 Pearl millet/soybean (variety Asca) + sorghum + stylo for both T4a and T4b; in 2011 T4a was in maize (variety CP QQQ) + pigeon pea while T4b was soybean (variety 98C81) + sorghum + Stylo

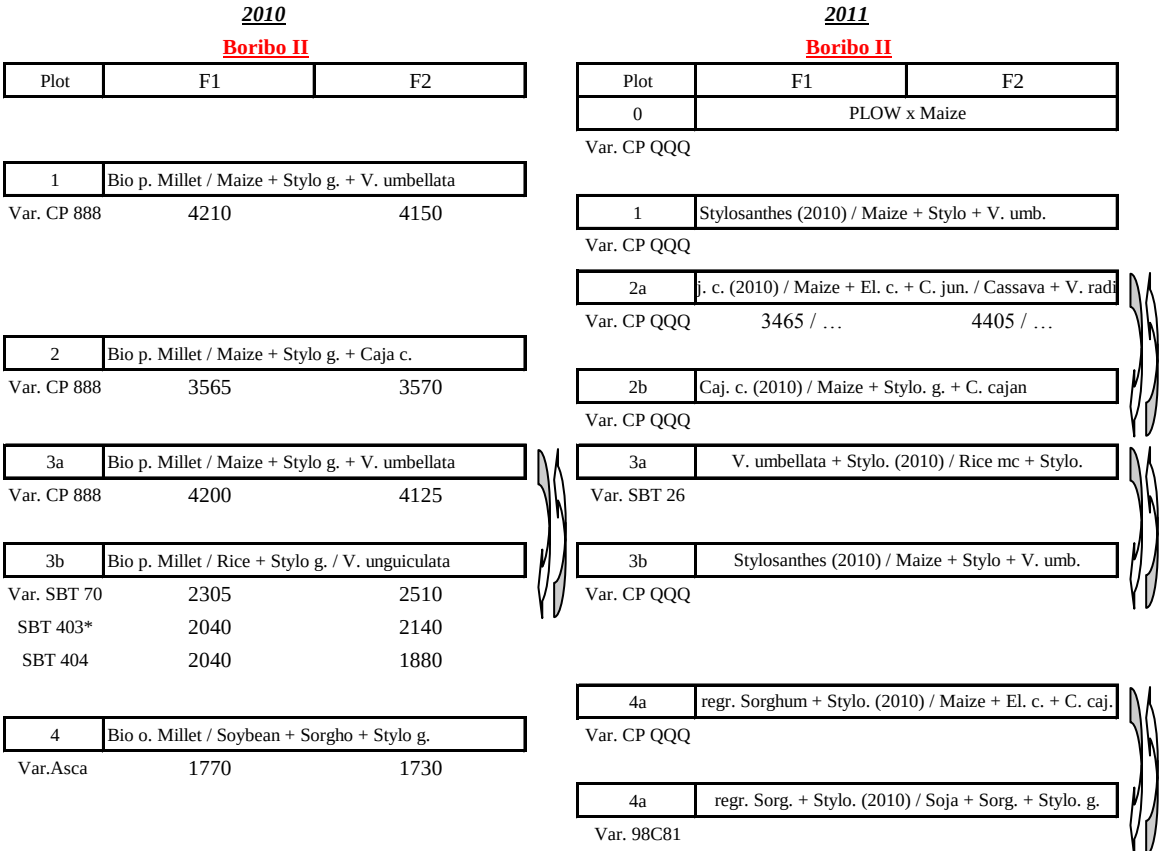


Figure 23. Crop yield is in kg/ha at two fertilization levels in Cambodia (Boribo II).

Philippines:
Researcher-managed demonstration plots, 10 m x 20 m (0.02 ha) in size, included six different cropping patterns and land management practices including the farmer's practice which serves as control in two fertility levels. The experiment has a strip-plot design with six treatments and four replications. Both undisturbed and disturbed soil samples were collected at three depths (0-5 cm, 5-10 cm and 15-30 cm) during December 2010, April 2011 and September 2011 for soil quality assessment. The soil samples were analyzed for bulk density, soil organic matter, soil N, soil P, soil pH, and infiltration characteristics. The residual soil moisture content was also measured using time domain reflectometry during the dry period. In addition, solute transport studies and crop modeling under CAPS and conventional plow-based systems commenced. The CAPS plus control treatments are:

- T1: Maize + *Arachis pintoi* followed by maize planted alongside established *Arachis pintoi*.
- Before planting, weeds are sprayed with glyphosate at the rate of 720 g active ingredient per hectare two weeks before planting. The maize was dibble planted at 70 cm x 20 cm, making around 72,000 plants per hectare. *Arachis pintoi* cuttings were planted in-between rows of maize spaced at 25 cm apart.

- T2: Maize + stylo followed by *Stylo guianensis* fallow.
- Maize was established as in T1. Stylo seeds were drilled in between rows of maize and thinned to 10-15 plants per linear meter.
- T3: Maize + cowpea/upland rice + cowpea followed by maize + cowpea/upland rice/cowpea.
- The land is prepared similar to 1. Maize is established in double rows 30 cm apart with 20 cm between plants, followed by two rows of cowpea at 30 cm apart with 10-15 plants per linear meter as shown in Figure 24.

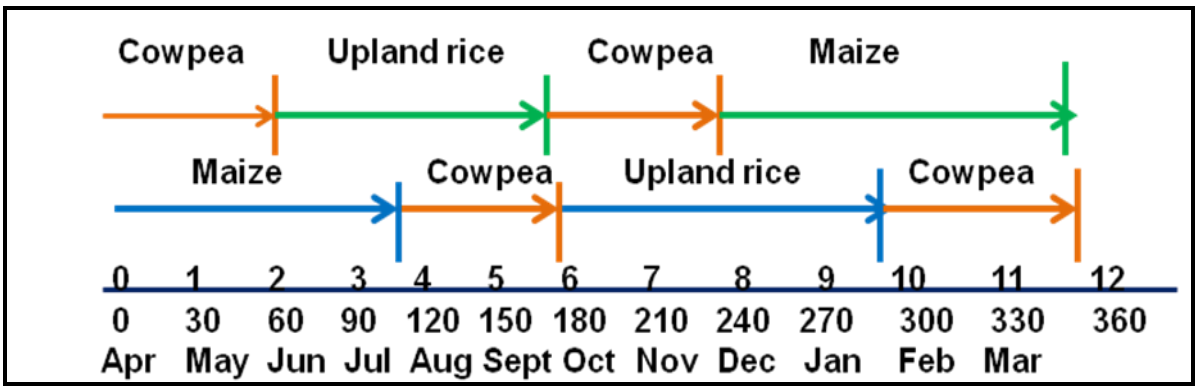


Figure 24. Cropping system sequence for Treatment 3 in Cambodia

T4: Rice beans/maize followed by rice beans/maize.
Maize is established similar to T1. Rice beans are established two weeks prior to maize harvest.
T5: Cassava + stylo. Land preparation is similar to T1. Cassava cuttings are planted in furrows 100 cm apart and 50 cm between plants, making 20,000 plants per hectare.
T6: Farmers' traditional practice. Two times plowed by animal drawn moldboard plow and two times harrowed by animal drawn spike-toothed harrow after every plowing.

Determination of corn yield, biomass, leaf area index and other plant characteristics were specifically done in two plots for evaluation of a crop model under conservation agriculture and plow-based systems.

Farmer-managed trials

Cambodia:
The farmer-managed trials in Cambodia included the following treatments:

- T1 (CAPS): Pearl millet/maize + stylo
- This treatment is based on a successful CAPS developed by PADAC from experiments conducted in Kampong Cham which commenced in 2004. After year 1, it was found that T1 may not be suited for Battambang possibly because of the highly basic soil derived from limestone which reduces growth of stylo. Adjustments will be made based on results from researcher-managed studies and farmer inputs.
- T2: Traditional plow-based.

A total of 26 farmers participated in CAPS trials covering about 33 ha. For statistical analysis of yield, biomass and soil quality, fifteen of the 26 ha were randomly chosen prior to the 2010 cropping season. In addition, 15 one-ha farms from the surrounding plow-based practicing farms from 15 households were also randomly chosen. Sampling areas of four subplots of 50 m² in size was marked for each of the 30 participating farmers. For each subplot, soil samples were collected at three depths for baseline soil quality analysis in early 2010. In 2010 and 2011, yield and biomass were collected from the subplots. The yield for CAPS and plow based treatments are in Table 1, and biomass is still being analyzed. In 2012, soil samples will be taken again for soil quality analysis.

Table 31. Yield of maize for 50 m^2 subplot under CAPS/DMC and plow based/non-DMC systems in Cambodia

Plot n°			Yield at 14% moisture (t/ha)	Plot n°			Yield at 14% moisture (t/ha)
1	DMC	Kong Nga	3 969	2	non-DMC	Kong Nga	2 727
3	DMC	Maing Kosal	3 790	4	non-DMC	Maing Kosal	2 983
5	DMC	Kuch Socheat	2 938	6	non-DMC	Kuch Socheat	1 784
8	DMC	Bun Thany	2 325	7	non-DMC	Bun Thany	
				9	non-DMC	Kuch Socheat	1 600
11	DMC	Vibol Vannak	3 446	10	non-DMC	Vibol Vannak	1 840
12	DMC	Mork Rith	2 760				
13	DMC	Chao Sambath	2 679				
14	DMC	Mork Phan	3 690	15	non-DMC	Mork Phan	3 999
17	DMC	Ven Soch	4 206	16	non-DMC	Ven Soch	4 773
				18	non-DMC	Ven Soch	
20	DMC	Tom Thy	2 080	19	non-DMC	Tom Thy	
22	DMC	Hul Sokhal	2 123	21	non-DMC	Hul Sokhal	5 393
24	DMC	Nurn Phem		23	non-DMC	Nurn Phem	
26	DMC	Hem Kai	4 180	25	non-DMC	Hem Kai	4 078
28	DMC	Kao Nab	3 399	27	non-DMC	Kao Nab	4 880
30	DMC	Heng Sokha	2 258	29	non-DMC	Heng Sokha	
Average DMC			3 132	Average DMC			3 406

Note: Greyed cells with missing data represent cases where farmers either harvested before yield samples could be collected or in one case, the farmer failed to plant a crop at all.

Kitchen studies

Kitchen studies are trials that are managed by researchers but done in small plots (i.e., some as small as 1 m by 1m) and are either non-replicated or replicated. They were established in both countries. In Cambodia, several non-replicated varieties of different crops, legume and grass cover crops were planted and being observed for future potential use in the experiment and an extensive testing of 13 maize hybrid varieties was conducted funded through PADAC and SANREM. Furthermore, they are a source of seeds or cuttings for future use. In the Philippines, the following evaluations were conducted in trials with randomized complete block designs: eight varieties of cassava, five varieties of open pollinated corn, five varieties of sorghum, six

kinds of fodder grasses, five kinds of herbaceous legumes, eight cultivars of sweet potato, seven cultivars of upland rice, and two cultivars of cowpea. Crop grain yield and above ground biomass were measured and plotted. Also, above ground biomass of grasses or leguminous cover crops was measured.

Critical research accomplishments

Researcher-managed trials in Cambodia

- Very high yields of cassava in CAPS at 20 tons/ha with the high 2010 farm gate price of 200 USD per ton. Cassava has an extremely attractive gross profit margin.
- Poor yield results of soybean in CAPS.
- The poor development of stylo on this alkaline soil was confirmed.
- Very promising performances of pigeon pea and rice bean implemented in association with maize, which has been proposed to farmers as replacement to the irregular stylo.
- Promising results of upland rice in CAPS which is attractive to certain farmers who do not have rain-fed lowland-rice fields because their rice supplies are secured.

Researcher-managed trials in the Philippines

- Conventional plow-based monoculture maize-maize system had the highest yield compared with four CAPS maize treatments. This was followed by maize + rice bean, maize + stylo, maize + *Arachis pintoi*, with the lowest being maize with cowpea.
- Maize with cowpea yielded the lowest maize yield likely because very close spacing between rows.
- The moderate fertility level (60-30-30) had higher yield across all CAPS compared to low fertility level (0-30-0).
- Stylo grown with cassava as well as with maize had significantly more biomass than the *Arachis pintoi* planted in association with maize.
- Stylo planted with cassava had more biomass compared with stylo planted with maize, but biomass production was not statistically significant at $P \leq 0.05$.
- Soil quality parameters such as bulk density, soil organic matter, N and P concentration and soil pH obtained during the soil sampling performed in December 2010 and April 2011 did not differ substantially from the July 2010 baseline levels for all CAPS treatments.
- Soil organic matter in the upper soil layer (0-15 cm) in all CAPS treatments generally exhibited consistently higher values than in the deeper layer (15-30 cm) after five and nine months of cropping regardless of fertility level.
- Both soil N and P concentrations in all CAPS treatments were generally higher in the upper soil layers (0-15 cm) than in the deeper soil layers (15- to 30 cm) under two fertility levels.
- Soil bulk density remained practically the same as the baseline conditions for all soil layers although the bulk density values obtained during the April 2011 sampling were slightly lower than those obtained during the December 2010 sampling.
- Soil organic matter at the uppermost soil layer (0-5 cm) did not exhibit a well-defined pattern of temporal variation over time, although the organic matter under conventional

plow-based system appeared to decline slightly after nine months of continuous cropping.

- Soil at the researcher-managed site remained acidic for all treatments, soil layers and fertility levels after nine months of cropping. However, compared to the baseline level, the soil pH at the uppermost soil layer (0-5 cm) slightly increased after five and nine months of cropping due to the lime application (3 t/ha).
- The Horton's infiltration model best fitted the experimental data obtained from the researcher-managed site in year 1, with a model efficiency of 95.2 percent
- Residual moisture content measured using time domain reflectometry in each of the CAPS treatments during the dry month of April 2011 was greater in the plots under conservation agriculture than the conventional plow-based system with treatment 2 (maize + stylo-stylo fallow) exhibiting the highest residual moisture content.

Farmer-managed trials in Cambodia

- In 2011, maize was sown during the 2nd half of June after which a one-month dry spell occurred. Only one plot under CAPS needed reseeding, while about ¾ of plow-based farms in the area had to be reseeded. Farmers clearly noticed the resilience of CAPS to dry spells when compared with their traditional plow-based practice.
- Despite poor yield results in 2010, only seven farmers out of the 26 decided to abandon CAPS while seven others increased the area under CAPS, whereas 12 new families joined CAPS team. It is obvious that credits and subsidies were important factors in the farmers' decision.
- Number of households and area in CAPS increased from 26 households in 2010 to 32 households in 2011, and from 33 ha in 2010 to 54.5 ha in 2011, respectively.
- Crops to be harvested in November 2011 already showed a very significantly improved performance compared with the 2010 crop.

Farmer-managed trials in the Philippines

- Data are still being collected but based on the appearance of several of the participant plots it is likely that low crop yields would result from this part of the study. Many plots were overgrown with weeds.
- It is evident to farmers that although yield was higher in plow-based maize, soil erosion was far more intense in plow-based systems compared with CAPS.

Kitchen trials in Cambodia

- From the 13 commercial hybrid varieties of maize tested, CP QQQ, 30 B 80, and CP AAA (in this order) had the best yield performance variety and the highest attainable profit margin even though their price is 2-3 percent lower than for CP 888 due to the grain quality. CP 888 is currently the most popular hybrid maize variety used in Cambodia. The research team, therefore, started using CP QQQ in researcher-managed trials.

Kitchen trials in the Philippines

- Out of the five varieties of open pollinated maize tested, IPB 13 was the most promising followed by IPB-6.
- ICSU 93034 was the most promising among the five varieties of sorghum tested.
- Out of the six fodder grasses tested, *Pennisetum purpureum* had the highest biomass yield, followed by *Setaria splendida* and *Brachiaria ruzinensis.*
- Out of the five species of herbaceous legumes tested, stylo had the greatest biomass yield followed closely by *Crotolaria juncea.*
- Out of the eight cultivars of sweet potato tested, PSB16 and Lingatos had the highest yields, whereas Miracle-check had the most biomass but approximately half the yield of PSB16.
- IR30716, IR55419-04 and NSIRC9 appeared to be promising among the seven cultivars of upland rice tested.
- In regards to the two cowpea cultivars tested, IT 82D-889 had greater yield than NOMIARC.
- Data on cassava yields are still being analyzed.

Other progress

- Two time domain reflectometry (TDR) instruments purchased in the USA and delivered to both countries were tested and soil moisture content is being already monitored in the Philippines.
- Weather station purchased from SANREM phase III was moved from Lantapan, Bukidnon to Claveria.
- John Deere tractor and six-row no-till planter were purchased for Cambodia; and a two-row planter and hand tractor were purchased for the Philippines. Also, two single-row animal drawn planters were ordered for the Philippines. The no-till planter is already well calibrated and being used in Cambodia.

Development impact

CAPS have potential for higher yield and biomass compared with plow-based systems. Farmers are providing suggestions on how they can be improved. CAPS have been introduced and imbibed by farmers in the villages SANREM is serving.

Challenges and responses

Finding the right CAPS is not easy. Yields were sometimes lower and some farmers backed out from CAPS. The research team explained to farmers that yield decrease during initial years is expected. It is crucial that in succeeding years, improved yields in CAPS are evident.

The Philippine team found that a better approach could have been to postpone farmer-managed study after the team had a handle of CAPS from experience obtained from the researcher-managed study. It would be difficult or improbable to get from farmers production inputs data without field technicians consistently visiting each farm and assisting and individually training each farmer how to gather them. The team did not have enough field technicians to visit the 24

farms and provide advice for eight different cropping systems. Farmer-managed treatments were completely changed in later part of 2011, and realigned with research-managed treatments. Instead of 24, eighteen farmers volunteered to participate and were chosen.

Treatments were changed accordingly to the promising CAPS in researcher managed studies. They are:

- T1: Maize + *Arachis pintoi* followed by maize planted alongside established *Arachis pintoi*.
- T2: Maize + stylo followed by stylo fallow.
- T3: Maize + cowpea/upland rice + cowpea followed by maize + cowpea/upland rice/cowpea.
- T4: Cassava + stylo.
- T1 are in 3 farms and T2, T3 and T4 are in five farms each. Now, there is synergism with farmer-managed and researcher-managed CAPS.

In 2010, maize crops yields on the farmer-managed CAPS farms were lower compared with farmer-managed plow-based farms. This was due to delayed sowing of maize because no-till machinery did not arrive on time delaying sowing of bio-pump millet grown on the first part of the rainy season, new technicians, and an excessive and delayed application of herbicide to control broadleaves and sedge weeds. Pearl millet is deep rooted and can retranslocate nutrients from lower parts of the soil profile to surface soil, and contribute to break the hardpan.

Degree and non-degree training

Two master's theses were completed with each student (one from Cambodia and other for France) obtaining their degree in 2011. The Cambodian student was supported by funds from SANREM, and the French student was supported by funds from the French government. Another Cambodian is completing a master's thesis through this project. Furthermore, a Cambodian is taken an English proficiency course in the University of North Carolina-Greensboro and is doing exceptionally well. He will be commencing a Ph.D program in Energy and Environmental Systems (EES) during the spring of 2012 at North Carolina A&T State University. A Filipino student started a doctoral degree in EES at NCA&T in the fall of 2011. Three Filipino and one Filipina students are pursuing graduate degrees at the University of the Philippines Los Baños. One student is in the third year of a doctoral degree and two students are completing M.Sc. degrees in Land and Water Resources Engineering. The Filipina student is completing a M.Sc. in Strategic Studies.

Publications, presentations, and other SANREM CRSP products

Form 18 shows publications, presentations, and other SANREM-CRSP products which include outputs from SANREM phase III. A book was released on Vegetable Agroforestry and Cashew-Cacao Systems in Vietnam. Two theses were completed for Cambodia, a website of this project was launched, and two other websites were completed for the two International Conferences in Southeast Asia organized through this project. Seventeen oral presentations and two posters were presented in various international, national and local scientific meetings.

Networking activities

- Meeting with members of the Claveria Landcare Association on integrating CA on their farms.
- Meetings with United Rubber Producers Association on conservation agriculture with trees using rubber trees in conservation agriculture in the Philippines.
- Meeting with Xavier University, Philippines for sustainable agriculture research collaboration particularly on socioeconomic component of CA.
- Discussion with the French Development Agency (FDA) SEA Regional Office representative and scientists regarding complementary support for research on conservation agriculture with trees in the Philippines. FDA just started in 2010 in the Philippines.
- Established a long-term relationship with Misamis Oriental State College of Agriculture and Technology (MOSCAT) and Agusan del Sur State College of Agriculture and Technology (ASSCAT), Philippines, where some faculty can be part of the research project as well as students as part of their undergraduate research and training programs.
- Michael Mulvaney (Virginia Tech), Neal Eash (University of Tennessee), and Susan Andrews, (USDA Natural Resource Conservation Service) visited the research site in Battambang, Cambodia and engaged with Stephane Boulakia in CA application in SEA.
- CIRAD through the Conservation Agriculture Network in South East Asia supported the participation of part of the Philippine team of GETS (Agustin Mercado and Victor Ella) to attend the second international CA conference in Cambodia and the Philippines.
- Stephane Boulakia participated in the kick-off meeting of the HARVEST program (USAID -Cambodia) on 24th February in Phnom Penh, and subsequently met with Dennis Lesnick, HARVEST's Chief of Party in a planning meeting on mid-April 2011 to review scope of possible collaboration in Battambang province which did not materialize. Team attempted to reach HARVEST several times, but HARVEST did not reciprocate.
- The Second International Conference on Conservation Agriculture in Southeast Asia was held in Phnom Penh, Cambodia in July 2011, and provided opportunity for interaction and connection with leading scientists and practitioners of conservation agriculture in Asia, the Pacific and South America during poster presentations, soil quality workshop, and field visits.
- Victor Ella participated in the annual IPM-CRSP Meeting in the Philippines in August 2011, to explore possible inter-CRSP collaboration.
- The National Academy of Science and Technology of the Philippines roundtable discussion in February 2011, allowed to interact with distinguished and highly respected scientists in the Philippines, and relayed to them the prospect of conservation agriculture for sustainable food production in the Philippines.
- Farmers' Field Day in Claveria, Misamis Oriental in January 2011 contributed to develop interactions with farmers and farmers groups.
- Victor Ella and Stephane Boulakia visited North Carolina A&T State University, USA, in May 2011 and met with scientists and graduate students of NCA&T.

- Victor Ella, Stephane Boulakia and Manuel Reyes visited Rodale Institute in Pennsylvania, USA in May 2011 to meet other scientists and researchers doing conservation and organic agriculture in the institute.
- Soil quality training in Claveria, Misamis Oriental in June 2011 enabled interaction with USDA scientist, local government units, technical staff of the municipal and provincial offices of the Department of Agriculture and Department of Environment and Natural Resources, and faculty and staff of Misamis Oriental State College of Agriculture and Technology.
- Meeting with the governor of Misamis Oriental, Hon. Oscar Moreno, during the visit of Manuel Reyes from NCAT, Susan Andrews from USDA and Michael Mulvaney from Virginia Tech in June 2011.
- Susan Andrews visited Phnom Penh, Kampong Cham and Battambang, Cambodia and gave a soil quality workshop at Kampong Cham. She also connected with several scientists, and faculty, government staff and students in Cambodia July 2011.
- Members of SANREM team from the Philippines, Reyes and Andrews, met with the president of Misamis Oriental State College of Agriculture and Technology in April and June 2011.
- Planning meeting of the Philippine GETS team at UPLB in October 2010.
- Reyes, Eash, Mulvaney, Andrews, and Boulakia visited with USAID Mission in Cambodia and discussed with its personnel the prospects of Conservation Agriculture. They also arranged a meeting with HARVEST Chief of Party Dennis Lesnick.
- Eash, Mulvaney and Boulakia met with HARVEST Chief Lesnick and offered SANREM services in conservation agriculture for HARVEST site in Battambang which is also SANREM's site in Cambodia.
- Reyes attempted several times to arrange a meeting with USAID mission in the Philippines but was unsuccessful, and was not able to brief them of SANREM progress since his last visit with USAID-Philippines in June 2010.
- Reyes met with Yuji Niino, land management officer, FAO regional office for Asia and the Pacific in Bangkok, Thailand and invited him to be part of the committee to organize the Third International Conservation Agriculture workshop and conference in Southeast Asia, May 2013 to be held in Pattaya, Thailand. He accepted the invitation and relayed that FAO will contribute to the conference.
- Reyes met Samran Sombatpanit and many scientists from the Land Development Department of Thailand. We agreed on the framework of the Third International Conservation Agriculture workshop and conference in Southeast Asia, and the Third International Soil and Water Assessment Tool workshop and conference in Southeast Asia both of which will be sponsored by SANREM and will be held May 2013 in Pattaya, Thailand. Land Development Department (LDD) of Thailand is hosting the conferences as part of LDD's 50th anniversary celebration and in conjunction with the second World Association of Soil and Water Conservation World Conference.
- Reyes and Sombatpanit visited the Ambassador Hotel, Pattaya, Thailand to make arrangements for the III and SWAT-SEA III conferences which will be held in that hotel.

- Maria Helen F. Dayo shared the gendered research activities of SANREM in other research institutions in Luzon region adapting the presentation materials of Maria Elisa Christie.
- Dayo participated in the Annual IPM conference held in Los Baños, Laguna where she shared aspects of the SANREM project to IPM-CRSP participants.
- Reyes visited with Bunjirtluk Jintaridth, former Ph.D student of Peter Motavalli, and discussed with her the soil quality research she did for Indonesia and the Philippines as part of the cross-cutting activity led by Dr. Motavalli during SANREM phase III. Reyes got copies of the soil quality paper and was hoping to get the gender part of the research as well. The soil quality part looks ready to be published. Included in it were studies that were done in Bolivia.
- Manuel Reyes visited with faculty from Cantho University, Vietnam and made a presentation, Introduction to Conservation Agriculture, to faculty and students of Cantho University. Susan Andrews presented a lecture on fundamentals of soil quality.
- Reyes visited with Rector Giang and Associate Dean Loi Nguyen Kim of Nong Lam University. He was able to get some funds from the CA-Conference partners and supported three faculty members of Nong Lam University to attend the second international workshop and conference in CA, Royal University of Agriculture, Phnom Penh, Cambodia.

Project highlights

In 2011, maize was sown during the 2nd half of June after which a one-month dry spell occurred in Battambang, Cambodia. Only one plot under CAPS needed reseeding, while about ¾ of plow-based farms in the area had to be reseeded. Farmers clearly saw the resilience of CAPS to dry spells when compared with their traditional plow-based practice.

Cross-cutting Research Activities (CCRA) program

Economic Analysis and Impact CCRA

Principal investigators: Michael Bertelsen, George Norton

Research progress by objective

Objective 1: Identify the costs and benefits of CAPS in cropping systems/practices and related animal and forestry sub-systems

Critical research accomplishments

Regional programs identified CAPS elements and farming programs to be assessed. For example, in LTRA-7, the three main elements consisted of reduced or minimal tillage, maintenance of organic soil cover (food crop or cover crop) and the implementation of purposeful crop rotations. The crops and rotations differ by watershed, but there are many similarities in CAPS across the various sites.

Budget data were gathered for the CAPS elements to be evaluated in regional sites. These data were collected from the on-farm trials and are in the process of being supplemented in some sites with farmer surveys. For example, in Ecuador 100 farmers were surveyed in two sub-watersheds this past year to obtain cost of production data for the crops that are include in the experiments. The costs, yields, and environmental effects differ by treatment, and data to measure these differences were obtained from the records of on-farm experiments. Very few of these data exist yet for most sites as the experiments are in their early stages, but budgets were constructed for the Ecuador site.

Development impact

These budget data will be an input into subsequent economic impact assessments, both in terms of assessing the profitability of specific CAPS elements for specific crops and cropping systems and for assessing the optimal sequencing of CAPS elements.

Challenges and responses

The biggest challenge is that the CAPS experiments in the various regional programs are not very far advanced and hence there are few data yet from the various on-farm treatments, either in terms of input costs and yields or in terms of organic matter (carbon) differences or soil loss. To get around that problem in Ecuador we combined additional farm level survey data on cost of production with data from partially completed experiments.

Objective 2: Identify optimal CAPS in each cropping system being researched and sequencing of CAPS elements

Critical research accomplishments

A linear programming model was built and applied for the LTRA-7 site in Ecuador that can also be used as a template for analysis in other regions. This model was used to assess optimal CAPS in the Ecuador site in Year 2. The model had the crop budget data for the Ecuador site imbedded in it and was used in an MS thesis paper entitled "Projected Farm-level Impact of Conservation Agriculture in the Andean Region." The model focused on farm households in the Chimbo River sub-watershed of central Ecuador. This study assesses the economic benefits of CA practices in Ecuador. The objective is to evaluate the impact of CA innovations on farm income and to identify the optimal mix of practices for farmers in the study area, where optimal is defined as profit-maximizing. Two farm-level linear programming models—one for the Illangama watershed and one for the Alumbre watershed—were developed. The models maximize profits subject to farm resource and production constraints, allowing an assessment of the likely livelihood improvements attainable through the diffusion and adoption of CA innovations. Study results indicate which experimental cropping activities designed to decrease soil degradation are likely to contribute to increased incomes for farm households and by how much.

This farm-level model was developed to maximize income subject to various levels of resource constraints, facilitating an assessment of the likely livelihood improvements attainable through the diffusion and adoption of CA techniques. The model tested in Ecuador will form a template that can help with impact assessment in the other regional programs.

Development impact

SANREM is developing and disseminating sustainable agricultural technologies, such as water-deviation ditches, cover crops, minimal tillage, and crop rotations to improve the livelihoods of rural households in Ecuador. The primary objective of the impact study is to evaluate the effects of the practices introduced with respect to farm income and carbon sequestration and to identify the optimal mix of conservation agriculture technologies for farmers in the study area. The first impact will occur when the farmers learn which practices they should adopt. If many farmers adopt the practices there will be a watershed or regional economic and environmental benefit.

Challenges and Responses

An immediate challenge will be to introduce the model in sites where the data are still collected from the CAPS experiments. However, as long as the crop rotations are set, the model structure can be adapted to each region and as the budget and other data are generated, they can be entered into the model.

Objective 3: Identify broader economic and social impacts of wide-scale CAPS adoption

No tasks planned or undertaken this past year.

Objective 4: Identify any policy changes required to bring CAPS adoption in each cropping system

No tasks planned or undertaken this past year.

Degree and non-degree training activities

Master's student Abigail Nguema completed her thesis on the project. She began on the project in June 2010 and finished in September 2011

In collaboration with LTRA-7, seven undergraduate students learned how to survey farmers in Ecuador and construct crop budgets. They surveyed 100 farmers in the process.

Publications, presentations, and other SANREM CRSP products

Nguema, Abigail, "Two Papers Evaluating the Economic Impact of Agricultural Innovation," MASTER'S thesis, Virginia Tech, Blacksburg, VA, September, 2011.

Networking activities

Participated in the annual meeting of SANREM in May 2011, discussed the impact assessment approach with SANREM Co-PIs and made a brief poster presentation at the annual meeting on impact assessment. The poster by Michael Bertelsen, George Norton, and Abigail Nguema summarized the Ecuador work described above before the data collection was completed. It was available at the meeting to be read by all project co-PIs.

Project highlights

A master's thesis paper entitled "Projected Farm-level Impact of Conservation Agriculture in the Andean Region." It focused on farm households in the Chimbo River sub-watershed of central Ecuador. A farm-level model was developed to maximize income subject to various levels of resource constraints, facilitating an assessment of the likely livelihood improvements attainable through the diffusion and adoption of CA techniques. The model tested in the Latin American site will form a template that can help with impact assessment in the other regional programs.

Gendered Knowledge

Principal Investigator: Maria Elisa Christie

Research progress by objective

Objective 1: Document differences in men and women's knowledge, beliefs, and perceptions of soil quality

Critical research accomplishments
Data were organized and analyzed on gendered soils knowledge, beliefs, and perceptions, as well as on practices and participation from Focus Groups Discussions (FGD) in FY 2010 (Mali, Philippines, Ecuador, Uganda, Kenya, and Ghana). Gender disaggregated data were gathered by dividing men and women into different groups to describe photos and soil samples. They then were prompted to describe soil quality, determine which soil was – in their opinion – better for growing crops, and explain how they arrived at these conclusions.

Significant research findings of data from FY 2010 indicated that men and women describe soils differently using the following categories: physical properties (color, texture, stickiness), soil fertility indicators (crop health, weather, organic matter), and labor-related properties (plowing, stickiness, pests, erodibility). Furthermore, the results of preliminary research aimed at creating a methodological design for the future.

The qualitative methodology to collect gendered soils knowledge, beliefs and perceptions of soil quality was adapted to include gendered space and gendered landscapes. This methodology utilized a gender dimensions analysis framework (GDF) used in USAID projects and revised it to include a spatial dimension. It was adapted to incorporate the ethnoecology concept of Kosmos, Corpus, and Praxis (beliefs, knowledge and practices) with a focus on soils (ethnopedology). This approach now includes methods to collect data on gendered space in order to document how men and women's soil knowledge relates to labor, time allocation, and access to resources, including information and technology. This revised methodology will help us further relate gendered knowledge, gender spaces, and gender roles to CAPS.
The CCRA collaborated with the Soils CCRA to create a semi-structured questionnaire, transect and soil sampling strategies for working with LTRAs. Research was planned for Bolivia, Nepal, Haiti, and the Philippines; data gathering was completed in Bolivia and analysis is underway. In future sites, soil samples will be selected by men and women along transects in correlation with unstructured interviews, participatory mapping, and soil description/identification exercises.

In addition, the CCRA prepared literature reviews on gendered knowledge and landscapes, political ecology, and conservation agriculture as a part of student research in Bolivia and the Philippines. The CCRA included a literature review on ethnopedology, the study of local soil knowledge systems, in order to better understand local analysis and practices with soil.

Identification and review of previous project work from PROINPA and other regional sources is in progress. A graduate research assistant conducted fieldwork in Bolivia during June and July 2011. The PI traveled to Bolivia in late June to conduct a workshop on program and methodology and to initiate field work with the PROINPA team. Fieldwork began in late June with the PROINPA team and included a focus group on mapping gendered soils knowledge on a satellite image; visits to four households, and mapping farmers' fields for later soil sampling by PROINPA. After the PIs return to Virginia, field work continued for four more weeks. Student field work included ten household visits (20 people), another focus group discussion (broken down into a men's group and a women's group for increased participation of women and identification of gendered differences in knowledge and perceptions), field visits for GPS mapping, and participant observation. Initial data analysis shows men and women's different knowledges in correlation with their different use of and access to various landscape features. Preliminary findings based on focus group discussions show that men's descriptions of soils tend to focus more on what goes into it—crops, water, wind, as well as, how soil quality is influenced by location—whereas women's descriptions tend to focus more on what comes out of soils—food, fodder for animals, and production rates, as well as, how production affects soil health. This is possibly correlated with gendered practices whereby men prepare the soil for planting and women plant the seed, use the plot for pasturing, and prepare food for consumption and market. Analysis is ongoing and will explore the possible relationship between gendered soil perceptions and the individual's security of access to those places.

Also, findings from household interviews showed that both women and men farmers are growing more potato varieties because of their perceptions of increasing temperature. However, data also shows that farmers would prefer to sell more crops and buy food, such as pasta, which may negatively affect nutrition.

Outputs also include an Endnote database and 24 SANREM CRSP Knowledgebase Entries on gender, gender and agriculture, women and development, political ecology, and ethnopedology from literature reviews mentioned above. In addition, twenty-six Women in Development (WID) teaching modules including on gendered knowledge and space were created and made available online.

Development impact

An initial understanding of men and women's local soil knowledge, gender space, and access to resources currently held by smallholders in the study sites establishes a baseline to facilitate CAPS development and scaling up. The research in Bolivia provided a model for using spatial imagery in research and for adding landscape/space to the Gender Dimensions analytical framework developed primarily by Deborah Rubin and Deborah Caro of Cultural Practice (2009) and used in USAID projects.

Challenges and responses

The initial focus on food production in participatory mapping and interviews ("what do you grow there?") left out some critical spaces for pasturing, which are often women's spaces; this

was addressed by adjusting the methodology to ask people how they "use" the land. Also, asking people about "your land" left out people who did not own land and also spaces to which people had access and deployed soils management knowledge; it also left out the traditional form of labor exchange in Bolivia ("ayni"). The team adjusted by asking where you work the land though it was clear that discussing land ownership or rights is a touchy issue. An unexpected methodological challenge was that poor eyesight can make the photo interpretation exercise—which was intended as an icebreaker as much as for data gathering— difficult and tedious; it is also a factor in the mapping on a satellite image. With the latter, it is clear that researchers need to mark a few key landmarks in order to orient the farmer within the map image. The participatory mapping methodology, on the other hand, was engaging and brought out much information during the accompanying interview process. One lesson learned was that it can be important to interview women (including widows) in company of others, and the focus on interviewing male and female heads of household separately should be accompanied by an invitation to have friends or family present. In general, women were less educated than men and required the assistance of their younger family members (children, daughter-in-law), or even the interpreter, to draw and label maps.

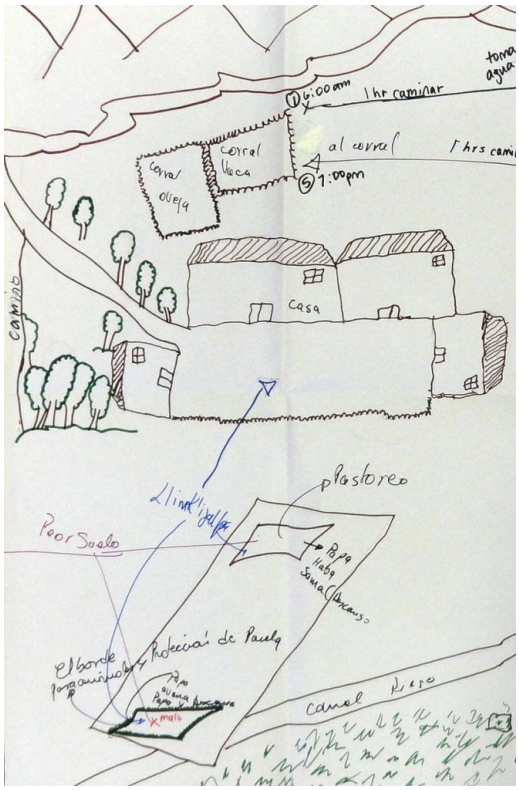


Figure 25. This is a section of a participatory map drawn by a woman farmer during a household interview in Bolivia. It shows her family's house, pens to keep animals ("corrales"), mountains, and two plots. The plots are drawn to illustrate its uses: a crop rotation for food and as places for pasturing. Grasses around one plot are for feeding animals and to provide protection. The farmer also described the type of soil ("llink'I jallp'a") for both plots, indicating that it was her family's 'worst' soil. In general, men's maps included more details about irrigation and crop rotation in context with soil management practices, while women's maps focused more on crop rotations in context with pasturing or feeding animals. (This map was presented in Keri Agriesti's WID presentation on October 19, 2011 and will be included in her upcoming Master's thesis.)

Objective 2: Document the gendered nature of crop-livestock interaction with respect to the conservation objective of maintaining the crop residue cover on the soil

Critical research accomplishments

This objective is intertwined with the one above; FY 2011 fieldwork together with FY 2010 confirmed that access to assets and livestock must be part of the approach to gendered knowledge and soil management practices. The qualitative research methodology was revised to focus on the gendered nature of crop-livestock interactions in relation to gendered soil knowledge, beliefs, perceptions, as well as practices, participation, and gendered landscapes. Initial testing of the methodology and collection of this data was done in June-August 2011 in Bolivia, as described above. Initial findings of the gendered nature of crop-livestock interaction related to crop residue cover show that livestock interaction with crops is an integral part of men and women's livelihoods. In household interviews, both women and men farmers reported expanding their crop-based production and having less access to land for pasture because it has been privatized (through government policies). Both men and women farmers have adapted and are now dependent on cultivation of crops to feed themselves and their animals, as well as to sell at the market. Generally, women use a crop cover as one way to feed and pasture sheep. Crop rotations include oats and barley that serve as fodder.

Outputs of this include maps of gendered landscapes of soils knowledge and access to and control of assets (livestock, information). Men and women also 'rent' their crop/crop cover to other farmers for income or labor. Farmers sometimes will also 'rent' this space as pasture when crops freeze, or are destroyed.

An annotated bibliography on gender and crop-livestock interaction and 23 SANREM Knowledgebase entries were created. This information was used to inform methodology and student field work. Furthermore, a semi-structured questionnaire on soils knowledge and crop-livestock interaction was designed and sent to the LTRA-9 team. Also, presentations and working papers were generated and disseminated for knowledge products.

Development impact

The Gender CCRA works to identify gendered activities, soil knowledge, and spaces that facilitate smallholder CAPS adaptation and scaling up. LTRA partners may use these findings to support CAPS development in gender-equitable and gender-inclusive ways. For example, the data on men and women's differential use, access to, and knowledge of the agricultural landscape can assist researchers and farmers in identifying crop rotation, soil management, and crop cover practices that benefit both men and women. Both men and women reported increasing privatization of land affecting area available for grazing; therefore, less land available for pasture may increase pressure on productive lands. Also, no-till or minimum tillage could increase both men's and women's labor time. These should be taken into account in policy recommendations.

Challenges and responses
Focusing on crops may leave out some spaces important to women's livelihoods, such as lands used for pasturing animals. See challenges and responses under Objective 1. Other spaces outside of crop-bearing fields must be considered for impact on CAPS initiatives, such as pastures or green houses. The importance of the latter in the Bolivia site given NGO interventions to improve household nutrition (though it was also used to grow products for market) illustrates the need to consider different actors in a farmer's networks that provide agricultural inputs and information. Research was adjusted to gather data on the role of sheep and grazing in Bolivia. CAPS need to consider how increasing production has taken pastureland so that plots have a dual purpose and intensified use: the focus on increase of crop production means the plot is both used for grazing (after harvest or during fallow) and for food consumption. Research will need to understand full pasture cycle in different seasons to complement previous findings. Less sheep means more purchase of fertilizer to replace manure and could impact women's storage of wealth through their herds.

Once again, as in the first year, it proved difficult to train field assistants to capture people's expressions as they are and not to summarize or put words in people's mouth, In Bolivia, this challenge was complicated by the need to use a translator and the three layers of language: Quechua to Spanish to English.

Degree and non-degree training activities

The current Graduate Research Assistant (GRA) completed one year of coursework and carried out fieldwork in Bolivia during June-August 2011. Her thesis focuses on gendered soils knowledge and gendered landscapes for CAPS in Sangk'ayani Alto, Bolivia.

A Graduate Assistant (GA) was recruited (partially funded by SANREM) and will be working on a master's degree in geography with her research focusing on participatory mapping and using qualitative GIS techniques to understand gendered aspects of CAPS. She is scheduled to work in the Philippines with LTRA 12 as a SANREM GRA in FY 2012.

Short-term training events included a Gender Workshop in December 2010 for students and faculty leaving for field work, including SANREM students working with LTRA 10 in East Africa and the Technology Networks CCRA (Jeni Lamb); with LTRA 6 in Haiti (Nathan Kennedy); and with LTRA 7 in Bolivia and the Gender CCRA GRA (Keri Agriesti). It also includes two focus group discussions (FGD) with farmers in Bolivia, a PROINPA gender workshop on methodology, and training two undergraduate students (Jess Martin and Sara Díaz) for gender research and analysis of fieldwork data. The CCRA also created 26 modules for a Woman in Development course complete with readings and PowerPoint presentations on gender and development for students and faculty accessible to all members of the SANREM team.

Publications, presentations, and other SANREM CRSP products

The CCRA generated and disseminated knowledge products through professional presentations and a training workshop. Several abstracts were submitted and accepted for presentations in FY 2012.It also produced a soil knowledge survey for the South Africa team; one-page for the web on the Gender CCRA research objectives for FY 2011; four abstracts submitted and accepted for professional conferences; and four papers and three posters.

Networking activities

Other special events include hosting scholar Dr. Herien Puspitawati from the previous phase of SANREM (Indonesia), cultural anthropologist and Professor Dr. Susan Paulson, and senior social development analyst Dr. Deborah Rubin from Cultural Practices. Dr. Rubin is serving on the SANREM GRA's thesis committee.

Project highlights

The Gender CCRA raised awareness of the importance of women's work and spaces in the landscape in the research community and the Bolivia research team PROINPA.

CAPS research must consider pasturing of animals—often in women's hands and their primary asset—as both a gender-based constraint and opportunity. It must address the need for producing forage crop so as not to negatively affect women or increase grazing pressure on soil. Fieldwork from household interviews in the Bolivia site found that the current crop rotation many farmers use includes oats and barley mostly for animal feed. This food security for animals must be ensured since no longer can open graze or feed crop cover.

Collaboration with the Soils CCRA in Bolivia has led to collection of soil samples for laboratory analysis to compare with descriptors and perceptions of soils identified by men and women as their "best" and "worst" soils.

Technology Networks

Principal Investigator: Keith Moore

Research progress by objective

Objective 1: Identify agricultural stakeholders' knowledge and beliefs which inform production practices.

Critical research accomplishments

Technological frames are cognitive orientations (knowledge and beliefs) of social actors that shape the way they understand the world around them and behave meaningfully in it. We measured indicators of those knowledge and beliefs through a set of Likert-scaled statements (questionnaire items) often identified with conventional, conservation, and risk-averse agriculture. Data on these items were collected at the household level by the LTRA-6 team in central Haiti, the LTRA-8 team for north western Ghana site and the Mopti site in Mali, the LTRA-9 team for northern Lesotho, the LTRA-10 team for their sites around Mt. Elgon in Kenya and Uganda, and the LTRA-12 team in the Philippines.

The Ghana data were shared with the CRRA this winter. After preliminary review, technological frame items were subjected to principal components factor analyses separately for farm men and farm women respondents. The resulting factors did not align tightly with expectations for CA, conventional agriculture, or risk-averse agriculture technological frames, but local variants of conventional and risk-averse agriculture were identified. These were analyzed with respect to the extent of contact with extension agents.

The analysis concluded that extension agent contact has little influence over the technological perspective of farm men and farm women (Tables 1-2). However, there was considerable diversity among both farm men and farm women over whether "tillage causes land degradation". Those farm men with a positive view of investment in modern capital intensive technologies were found to disagree that "tillage causes land degradation", consistent with the conventional agriculture technological frame. Farm women's perspectives echo these relationships (Tables 3-5). However, there is also a significant group of risk-averse farm men and farm women who would be amenable to the ideas of CA. These findings were submitted in a paper presented at the 5th World Congress of Conservation Agriculture.

Please note in the tables below the following nomenclature:

1. Values followed by different letters within the same row are statistically different.
2. Rows marked by * signify that mean scores within the row are significantly different at the .05 level; ** refers to the .01 level.
3. Composite scores were measured on a scale from 1 to 5, with higher scores signifying agreement with the technological frame concept.

Table 32. Mean factor scores for men's agricultural production orientations according to the following beliefs

	Contact with extension agents		
	No Contact	Contact with one agent	Contact with > one agent
Farming is a capital intensive business*	3.6[a]	3.7[a]	3.4[a]
Farming requires interdependent staple crops and livestock**	3.4[a]	3.0[b]	4.1[a]
Extensive diversification of crop production is important *	3.3[a]	3.5[a]	3.2[a]
Market participation is necessary for sustainable farming *	3.1[a]	3.1[a]	3.4[a]
N	106	81	13

Table 33. Mean factor scores for women's agricultural production orientations according to their beliefs

	Contact with extension agents	
	No Contacts	Contact with at least one agent
Farming requires growing staple crops and feeding livestock*	3.2[a]	3.5[a]
Local food security is important*	4.1[a]	4.1[a]
Technological innovation is important for agriculture*	3.9[a]	4.0[a]
Farming is a cash-cropping business*	3.5[a]	3.9[b]
N	128	29

Table 34. Comparison of mean scores for farm men and women's agreement with CA principles

	Gender	
	Farm Men	Farm Women
One should maintain a permanent crop cover*	2.7[a]	2.6[a]
Tillage causes land degradation*	3.1[a]	3.1[a]
Rotating crops is always the best practice*	4.2[a]	4.1[a]
N	200	157

Table 35. Mean factor scores for men's agricultural production orientations according to their beliefs.

	Tillage causes land degradation		
	Agree	Neutral	Disagree
Farming is a capital intensive business*	3.5[a]	3.5[a]	3.8[b]
Farming requires interdependent staple crops and livestock**	3.6[a]	3.5[a]	2.9[b]
Extensive diversification of crop production is important*	3.6[a]	3.0[b]	3.3[ab]
Market participation is necessary for sustainable farming**	3.3[a]	2.9[b]	3.0[b]
N	83	33	84

Table 36. Mean factor scores for women's agricultural production orientations according to their beliefs

	Tillage causes land degradation		
	Agree	Neutral	Disagree
Farming requires growing staple crops and feeding livestock**	3.6[a]	2.8[b]	3.1[b]
Local food security is important*	4.1[a]	4.0[a]	4.2[a]
Technological innovation is important for agriculture**	3.7[a]	3.8[ab]	4.1[b]
Farming is a cash-cropping business*	3.4[a]	3.5[ab]	3.8[b]
N	66	29	62

The CCRA-PI participated in some of the data collection interviews conducted by the LTRA-9 team in Botha Bothe Province, Lesotho. Data collected for the technology network module by the LTRA-9 team have been forwarded to the CCRA team and entered in preparation for data analysis. A follow-up visit in August allowed the opportunity to gain a more in-depth understanding of farmer and service sector perspectives through semi-structured interviews with a range of extension agents, farmers, NGO representatives and input suppliers. In collaboration with LTRA-9 co-PIs, the findings are being drafted into a working paper describing those perspectives. These results suggest that agricultural support sector agents have a wide range of perspectives on those living in the villages, possessing land, and interviewed as representatives of farm households. Not all are perceived as truly committed to farming nor have what it takes to be a successful farmer. On the other hand, some farmers are highly critical of the government and how it has or has not helped farmers.

Household level technological frame data collected by LTRA-10 in the four research sites of Kenya and Uganda was also shared with the CCRA. These data have been cleaned and are ready for analysis. Technological frame data on the service sector agents in Kenya and Uganda were collected and entered by master's student Jeni Lamb. In collaboration with the LTRA-8 team, PI Moore participated in the household baseline survey data collection in the Seno, Mopti Region in Mali. As part of this mission, he adapted the data collection instrument and identified the sample for the completion of the agricultural service sector/community agents' survey in October 2011.

Development impacts

Social networks reinforce ideals, norms, and behaviors in agricultural production processes. An understanding of "shared mind-sets", the knowledge, beliefs and perceptions currently held by

smallholders in the study sites, provides a foundation to facilitate communication of CA principles and target smallholder households for CAPS development and scaling up.

The master's research conducted in conjunction with LTRA-10 will also contribute to the overall research theme of "increasing food security of smallholders through the introduction of CAPS" through a focus on food security. In part, this responds to the priority concern of USAID/Uganda. The research aims to identify synergies between the twin objectives of technological change and enhancing food security.

Challenges and responses
Developing effective translations of the Likert scale questionnaires, which preserve the meaning of the statements, has also been a challenge. The 20-item battery of Likert statements have been translated into French for the Mali and Haiti sites. These were further revised to better capture local understandings by the data collection team during training at each site. Furthermore, these items have been and will be adapted to the local cultural understandings and back-translated to confirm appropriateness and accuracy.

An issue was noted during data collection in the Lesotho highlands: these respondents appeared to easily fall into simple yes/no response sets, rather than making more refined distinctions on the attitudinal/knowledge items. It is hoped that as the survey team moved down the mountain toward more commercial areas, response sets might become more discriminating.

Objective 2: Quantify and describe structure and resource flows of agricultural sector networks.

Critical research accomplishments
Data on the structure and quality of relationships between farmers and other members of the agricultural production network were also collected by each of the LTRA teams at the same time as the technological frames data.

Development impacts
By studying networks at the SANREM sites, the Technology Networks CCRA will identify characteristics that enable smallholder CAPS development and scaling up. LTRA partners may use these findings to determine the key network relationships for successful CAPS adaptation. For example, the combination of data on shared mindsets and network relationships will help to identify farmers who are both opinion leaders and structurally well positioned for transmitting trusted information.

In the master's research, measuring the similarities between agricultural production and food acquisition networks provides an enriched dataset for understanding the vulnerability of smallholder households to food insecurity whilst undergoing technological change. It is anticipated that this research will have broad implications for other projects seeking to

synergize connections between technological change and the overall objective of increasing food security.

Challenges and responses

Introducing the concept of social networks and the value of this information for scaling up CA continues to be difficult. While LTRA PIs in Africa and Haiti are coming to understand technology network objectives, with the possible exception of Haiti, the other teams still lack a social scientist that is familiar with the research using social networks to study technological change processes. More importantly, the LTRAs did not plan for the additional data collection modules in their baseline surveys. Consequently, easier to understand descriptions of the technology network research have been drafted and extensive discussions have been conducted with each of the LTRA Lead-PIs and their teams.

Only linkage data on extension agents were retrievable from the Ghana data base. Interviewers did not seem to understand the logic of the network/structure questions, consequently little remains to further advance the analysis at this site without an additional household level survey. Consequently, we have come to recognize the importance of having a technology networks researcher on-site when adapting the questionnaire to the local community and training the survey interviewers.

Objective 3: Determine opinion leaders and supporting relationships needed to facilitate technological change.

Work on this objective will not commence until after the first round of data collection at each of the LTRA sites has been completed and analysis of the local networks and technological frameworks have been initiated.

Degree and non-degree training activities

A female graduate research assistant has been working on a master's degree in agricultural and applied economics with her thesis focusing on the relationship between technology networks and food security. She defended her thesis proposal during the Fall Semester 2010 and spent the Spring Semester 2011 conducting primary data collection in Kenya and Uganda in collaboration with LTRA-10 in-country partners. She learned to adapt to on-the-ground conditions for data collection and survey management. These are important field research skills and understandings that one only gets through the conduct of an actual field work project. A considerable number of contacts and networking have occurred at the research sites as this is part and parcel of the technology networks research endeavor. After the fieldwork was completed two seminars were presented, one at Makerere University and the other at USAID/Kampala involving a total of 19 men and eight women. The seminars presented initial findings of the technology networks and food security research at the household and agricultural service sector actors.

Additional short-term training with household interviewers for baseline and network surveys involved 9 men and 13 women.

Publications, presentations and other SANREM CRSP products

One journal article; two papers published in conference proceedings; two posters; and one presentation.

Networking activities

Moore met with officials from USAID/Uganda and USAID/South Africa (for Lesotho). Network connections were also established with NGO and government partners at the Lesotho and Uganda sites. GRA Lamb presented a seminar to USAID/Uganda at the end of her data collection activities.

Moore also met with colleagues from FAO, ACIAR, CIRAD and CIMMYT at the Fifth World Congress on Conservation Agriculture/Third International Farming Systems Design Conference.

Project highlights

This CCRA presented a paper on the impact of extension agent contact on the technological perspectives of farm men and women in northwestern Ghana to the 5th World Congress on Conservation Agriculture incorporating the 3th International Farming Systems Design Conference. Findings suggest that there may be a significant group of risk-averse farm men and farm women who would be amenable to CA.

Fieldwork and data analysis have been completed for a Master's thesis in Agricultural and Applied Economics entitled: Social Networks and Food Security: Household Level Impacts of Access to Food and Agricultural Production Resources in Kenya and Uganda.

Soil Quality and Carbon sequestration CCRA

Principal Investigator: Michael Mulvaney

Research progress by objective

The overarching goal of this CCRA is to determine if dryland smallholders in the developing world can increase soil organic C (SOC), and hence soil fertility, by adoption of CA. We know that CA increases SOC under mechanized agriculture in the developed world, but it is unclear if such increases are feasible in the developing world for smallholders growing staple crops. There is also an interest to determine the potential for C sequestration in these systems, which may potentially lead to payments under C trading schemes.

Coordination of soil and agronomic investigations among all 13 developing countries before and after CAPS are implemented is critical to measuring soil fertility and C sequestration changes due to CAPS. We are coordinating and standardizing soils data collection from LTRA project sites so that we can make meaningful and scientifically valid comparisons across all project sites.

Our specific objectives are to:

1. Quantify SOC in host country project sites before and after CAPS implementation.
2. Identify CAPS cropping systems or biophysical elements that improve soil fertility.
3. Relate increased soil fertility to site-specific socioeconomic environments.

We also facilitate LTRAs and host country partners to build capacity regarding biophysical data collection from CA plots vs. current practice controls in order to determine effects on production and the ability to produce sufficient biomass to protect the soil and increase SOC.

The hypothesis of this CCRA is that CAPS in developing countries will increase SOC and soil fertility in <5 years after implementation, compared to conventional practices. We propose to use SOC as an indicator of soil quality and fertility. Although total SOC is expected to increase slowly after CAPS implementation, we will focus on parameters that are sensitive to short-term (<5 years) changes in agricultural practices by quantifying SOC by density fractions and structural changes at Time 0 and after several years of CAPS. Basic soil fertility parameters such as total N, available P, K, Ca, Mg, pH, cation exchange capacity (CEC)) and other soil characteristics will also be measured.

One of the main functions of this CCRA is to facilitate coordination among the crop and soil scientists throughout all the LTRA project areas in order to quantify SOC and soil quality. This includes, but is not limited to:

1. determination of a common minimum dataset to determine SOC baseline data before the implementation of CAPS,
2. building a soils library from host country project areas in order to perform further soil analyses that will quantify several indicators of soil quality under one laboratory,
3. identify elements that improve soil fertility in project areas, and

4. relate increased soil fertility to site-specific socioeconomic environments.

This work necessitates close collaboration with project PIs and socioeconomic CCRA activities. We are identifying local gendered knowledge of soil fertility as well as determining the capacity of local CAPS to improve SOC. If the latter holds true, we will also determine the potential for payments under a C trading system in coordination with LTRA and CCRA economists.

Objective 1: Quantify SOC fractions in host country project areas before CAPS implementation.

Critical research accomplishments

- The CCRA PI (Mulvaney) has obtained a USDA permit to import foreign soils. We currently have Time 0 soil samples from sites in Bolivia, Ecuador, Philippines, and Cambodia. These samples are currently undergoing laboratory analyses for SOC and fertility determination. A summary of the samples received to date, coordinates, selected climate data, elevation, and cropping systems can be found in Table 1.
- A GRA was hired on May 16, 2011. He has conducted a pre-test of soil testing protocols in Haiti and is currently working to process and analyze our Time 0 soil samples.
- Assisted in the design of on-farm plots and treatments in Thumka, Nepal. Laboratory capacity was expanded in Santa Catalina, Ecuador by reviewing and modifying laboratory procedures and assisting in the construction of a soil hydraulic conductivity apparatus.
- Soils laboratory capacity building was assisted by providing the supplies necessary to make bulk density measurements (by the clod method) and soil texture analyses in-country.

Table 37. Summary of select site characteristics from localities contained within the CCRA-9 Time 0 soil library

Country	Site	Coordinates	Mean annual ppt. mm	Mean annual temp. °C	Elevation m	# of soil samples recorded	Cropping system(s)			
Philippines	Barangay Rizal	N08°39′23.0″ E124°51′45.1″	3000	22.1-32.4	673	30	Maize + arachis pintoi - Maize + arachis pintoi	Maize + stylo - stylo fallow	Maize + cowpea - upland rice +cowpea	Maize-maize conventional plow based system
Cambodia	Battambang	S13°10′ E103°20′	1378	22.9-32.1	13	76	Pearl millet/maize + stylo (DMC) on-farm paired plots.	Traditional plow-based maize (non-DMC) on-farm paired plots		
Ecuador	Microcuenca del Alumbre	S01°55′19.4″ W79°01′16.4″	570	11.2-22.2	3371-3665	6	Hard maize-bush bean-hard maize-pea-hard maize vs.	Hard maize-bush bean-hard maize-oat/vetch-hard maize		
Ecuador	Microcuenca del Illangama	S01°61' W78°98'	690	8.1-20.0	2600	6	Potato-barley-faba bean-forage mix	Potato-barley-oat/vetch-forage mix		
Bolivia - Carbon CCRA	15 de Octubre	S17°26′01.9″ W65°43′22.9″	510	10.7	3276	18	Potato-bean-cereal-fallow	Potato-beans-cereal-vetch (incorporated)	Potato-bean-cereal-vetch (removed)	
Bolivia - Carbon CCRA	Cebada Jichana	S17°28′51.6″ W65°38′39.8″	510	9.6	3562	18	Potato-bean-cereal-fallow	Potato-bean-cereal-vetch (incorporated)	Potato-bean-cereal-vetch (removed)	

Bolivia - Carbon CCRA	Waylla Purju	S17°27′36.1″ W65°39′57.1″	510	9.9	3648	18	Potato-bean-cereal-fallow	Potato-bean-cereal-vetch (incorporated)	Potato-bean-cereal-vetch (removed)
Bolivia - Gender CCRA	Tiraque Province	S 17°23'73.5"-17°26'47.0" W 65°37'32.7"-65°39'33.7"	483	7.9-24.7	2548	30	Potatoe-bean-oat/barley		
Uganda	Tororo	00°45′N 34°05′E	1200	15.7-30.6	1097-1219	4	Maize-bean intercrop	Maize-bean intercrop w/ mucuna relay	Maize-bean-mucuna intercrop
Kenya	Bungoma	00°35′N 34°35′E	1200	15.7-30.6	1097-1219	4	Maize-bean intercrop	Maize-bean intercrop w/ mucuna relay	Maize-bean-mucuna intercrop
Uganda	Kapchorwa	01°24′N 34°27′E	<1000-1200	9.3-29.2	1093-1466	4	Maize-bean intercrop	Maize-bean intercrop w/ mucuna relay	Maize-bean-mucuna intercrop
Kenya	Kitare (Trans-Nzoia district)	01°01′N 35°00′E	<1000-1200	9.3-29.2	1093-1466	0	Maize-bean intercrop	Maize-bean intercrop w/ mucuna relay	Maize-bean-mucuna intercrop
Lesotho	Maphutseng	30°S12′45.1″E 027°29′S44.8E	712	9.4-21.6	1449-1458	12	Conventional tillage (maize-bean)	No till (maize-bean)	

- GIS data collection was conducted in Lesotho, Nepal, and Ecuador.
- A research proposal to obtain beam-time from the Near Edge X-Ray Absorption Fine Structure (NEXAFS) synchrotron in Madison, WI was submitted in coordination with Dr. Kang Xia at VT. This will enable us to quantify the structure of the SOC at time 0 and determine any changes due to CAPS. The structure of C determines, in part, its longevity in soil. The other factor influencing C longevity is SOC association with clay minerals, which may also be investigated using NEXAFS. If we are to have a discussion regarding the C sequestration potential of CAPS, we must understand the mechanisms of C sequestration and determine its ability to resist decay. We may also be able to estimate the mean residence time of SOC from Time 0 samples, if we can attract additional funding.

Development impact

A soils library from project research sites analyzed within a single laboratory will allow scientifically rigorous comparisons of soil quality at time zero before and after CAPS implementation. Time 0 samples will serve as a benchmark against which all future changes in soil fertility will be compared. This may also lay the foundation to allow those adopting CAPS in the developing world to earn C credits as part of a future C trading market.

Challenges and responses

Carbon sequestration rates.: A global data analysis from 276 paired treatments indicated that an average of 0.57 ± 0.14 t C ha^{-1} yr^{-1} was sequestered after changing from conventional tillage to no-till, except in wheat-fallow rotations where no change was found (West and Post, 2002). The study noted that an additional 0.20 ± 0.12 t C ha^{-1} yr^{-1} can be sequestered by including rotations (except changing from continuous corn to a corn-soybean rotation, which resulted in non-significant treatment differences in SOC accumulation). In our CAPS systems, which employ both minimum tillage and crop rotations, we might therefore reasonably expect to sequester approximately 0.77 t C ha^{-1} yr^{-1}, such that after three years we may accumulate approximately 2.3 t C ha^{-1} yr^{-1}. However, the authors note that C sequestration rates reach a maximum in about 5-10 years after conversion from conventional agricultural practices, so after three years of our CAPS trials, we may reach C sequestration rates that are approaching their maxima, thereby increasing our chances of finding significant differences in SOC between treatments. After careful deliberation among the biophysical scientists, we are attempting to circumvent this potential problem by sampling soils at shallow depths. This will give us every chance to identify significant differences in C sequestration among experimental treatments, although the outcome is uncertain. Another potential criticism may be that we will not have benchmarks for SOC at deeper horizons, since there is some evidence that there are no SOC differences between no-till and plough-till when averaged at depth (Blanco-Canqui and Lal, 2008; Deen and Kataki, 2003). It should be noted that these studies were conducted in temperate climates. There is limited and conflicting evidence either way from tropical locations. Sisti et al. (2004) found that after 13 years in Southern Brazil, rotations that included vetch had significantly higher SOC concentrations to a depth of 100 cm. Diekow et al. (2005), working in Brazil at 30ºS, found similar results to 107.5 cm when legume rotations were included or when N fertilizer was

applied, with an amazing C sequestration rate of 1.42 Mg C ha^{-1} yr^{-1} in the whole 0-107.5 cm profile. Granted, these studies were conducted in an area with mild climate and year-round rainfall, which are not typical for the sites in this project. However, our locations are not in temperate regions, either. Therefore, the issue of C sequestration at depth at our project sites remains unknown. Ideally, we would like to have soil samples to 30 or 60 cm or even 100 cm. However, practical and financial constraints limit us to investigations of the surface horizons. We must leave it to the individual LTRA PIs to investigate at deeper depths if they are interested in such questions.

Incomplete dataset: While we anticipate receiving Time 0 soil samples from all the project sites, it is possible that LTRAs or their project partners will not be able to send us soil samples from their project sites and/or may collect the samples in an inappropriate manner. The CCRA-9 has offered to pay for shipping costs associated with this objective. If needed, and if our budget allows, we will travel to the sites to collect these samples ourselves or assist the LTRAs in sample collection. In addition, we are dependent on the LTRA project partners to determine grain yield, above-ground biomass, and percent ground cover. It may be assumed that we will likely have an unbalanced dataset, in which case we intend to handle those data using appropriate non-parametric statistical methodology.

Identify cropping systems or biophysical elements of cropping systems that improve soil fertility and increase C sequestration.

Critical research accomplishments

This objective necessitates the implementation of "best-bet" (researcher-recommended) CAPS trials at project locations. Currently, the LTRAs are in various stages of CAPS implementation. Most projects have identified parameters that will be included in best-bet CAPS trials, or already have full CAPS treatments in place. We will collect data on the cropping systems used in project areas, such as cropping systems, soil type, slope, aspect, parent material, climate, and biomass at each project site.

Development impact

The identification of those cropping systems or elements of cropping systems that produced increases in productivity and soil fertility will allow researchers, extension agents, and producers to identify which of those elements apply to them, and correlate those elements to cultural practices that will improve fertility and productivity in their areas. This cross-site comparison will allow CA actors to select those elements that may apply to their agro-ecological zone, and thereby 'cross pollinate' successful CA technologies from one area of the world to another. This information is crucial to make practical recommendations to a wider audience. Should host countries be compelled to participate in a C trading mechanism, the sequestration of soil C via CAPS may have economic ramifications for those countries. Currently, no trading mechanism exists where soil C is incorporated into economic models, but since soil is the second greatest C sink on the planet, there is intense interest in developing such models.

Challenges and responses
Although many sites have already implemented CAPS trials, the main challenge at this point is to have all of the LTRAs implement researcher-recommended CAPS trials on researcher-managed plots. After CAPS on researcher-managed plots are tested and approved, the recommendations may be extended to farmer-managed fields. In some cases, on-farm trials have been implemented before researcher-managed trials. We will gather additional information from farmer-managed trials as they are implemented, as our budget allows, but we intend to concentrate our focus on researcher-managed trials. This objective requires the completion of Objective 1 in conjunction with a meta-analysis of the project locations, climate, and soil type.

Objective 3: Relate successful CAPS components to site-specific environmental conditions, including socioeconomic environments: What combinations of environmental conditions enable success of CAPS?

Critical research accomplishments
We currently have soil sampling teams collecting data in Bolivia to quantify gendered knowledge of soil fertility and relate that knowledge to gendered space in Bolivia, in collaboration with the Gender CCRA PI. We have assisted in building the capacity of the local partner there (Foundation for the Promotion and Research of Andean Products, PROINPA) to collect data on soil texture by providing the needed supplies and technical assistance. We also have geo-referenced data from the gendered survey. Soil samples from the survey are forthcoming.

We have initiated soil survey activities in Haiti in coordination with the household economic survey currently underway in the Central Plateau. A pre-test of our sampling strategies (household selection, field selection, and soil sampling protocols) was instrumental for ground-trothing our methodology and required significant modification to meet on-the-ground demands. The objective is to determine if soil fertility impacts household economic efficiency. We will also be able to create a high resolution (>1 km^2) soil fertility map of 100 km^2 within our area of operations. This second objective involves collaboration with scientists from University of Georgia, The League of Hope, Zamni Agrikol, the USDA, Auburn University, University of Florida, and those from Virginia Tech.

Development impact
Knowledge of how gendered perceptions, beliefs and knowledge as well as access to assets will improve understanding of soil management practices and how it may be effectively utilized for successful CAPS implementation at the field scale.

The coordination of household economic surveys with soil fertility analyses represents the first study of this kind. How soil fertility affects household economic efficiency has important ramifications for the development of agricultural technology practices that improve soil fertility: Does increased soil fertility really improve the household economic situation of the rural poor in developing countries?

A map of soil fertility within our area of operations has two important impacts. First, since we are collaborating with many eminent researchers with specialized knowledge in the area, the protocols we develop would become the standard protocols for soil sampling and testing in Haiti. There is currently much activity related to soil sample testing in Haiti, though there is no agreement on methodology for soil depths or extractants. Our effort to bring together those researchers interested in the topic represents the first wide-scale attempt to standardize the methodology used in Haiti. The second impact of the soil fertility map is to determine the nutrient deficiencies of the area, such that a coordinated effort to remediate those deficiencies can be mounted. Without the knowledge of which nutrients are limiting, fertilizer recommendations are merely guesses. Apart from water, fertilizer is the most important factor in determining crop yield.

Challenges and responses

The CCRA-9 PI will facilitate research objectives from the socioeconomic CCRAs as they pertain to soil quality, fertility, and agronomic practices. As such, the CCRA-9 PI will depend heavily on the experimental design and methodology implemented by the CCRA-6 and LTRA socioeconomic collaborators.

There are no known correlation and calibration datasets available for either Bolivia or Haiti. Therefore the development of fertilizer recommendations will have to be extrapolated using similar soil types found within the United States. Further research needs to be conducted to correlate soil nutrient extraction with plant nutrient uptake and calibrate the soil test value to yield response.

The development of a soil fertility map is logistically challenging, in terms of language, transport, difficulty of terrain, and personnel management. The lack of technically qualified scientists also represents a problem for the analyses of soil samples in-country.

Degree and non-degree training activities

The ME agronomist has been awarded adjunct status with the Department of Crop, Soils, and Environmental Sciences (CSES) at Virginia Tech. This allowed disbursement of funds to support a degree seeking student within CSES. A Ph.D candidate was hired on May 16, 2010. He will focus on the Time 0 soil sample analyses and conduct his field research in Haiti.

The CCRA-9 PI has been asked to serve on the graduate student committees of two degree-seeking students at Virginia Tech. One student, Ryan Stewart (male, US citizen), is working on his master's at the Department of Crop and Soil Environmental Sciences under the direction of one of our project LTRA agronomists, Wade Thomason. The other student, Nathan Kennedy (male, US citizen), is working on his Ph.D in the Department of Forest Resources and Environmental Conservation under the direction of Gregory Amacher. Mr. Kennedy will investigate the potential for C payments for CAPS implementation in Haiti, among other projects.

Short-term training on various field data collection techniques has involved 77 men and 28 women.

Publication, presentations, and other SANREM CRSP products

Articles Published in Refereed Publications: 1
Papers/Seminars Presented: 4
Posters: 5

Networking activities

The CCRA-9 PI was invited to serve as the Program Co-Chair at the Second International Conservation Agriculture Workshop and Conference in Southeast Asia in Phnom Penh. In addition to this role, he is currently serving as the lead Editor for the Proceedings resulting from this workshop and conference. Networking activities were also conducted at the:

- 5th World Congress of Conservation Agriculture/3rd Farming Systems Design Conference in Brisbane, Australia
- ASA-CSSA-SSSA International Annual Meetings in Long Beach, CA
- Regional Conservation Agriculture Symposium for southern Africa in Johannesburg, South Africa.

Technical assistance was provided to the laboratory staff at the Instituto Nacional de Investigaciones Agropecuarias (INIAP) in Santa Catalina, Ecuador to assist in the construction of a soil hydraulic conductivity apparatus. In Cange, Haiti, soils laboratory capacity building was assisted by providing the supplies necessary to make bulk density measurements (by the clod method) and soil texture analyses in-country. Technical assistance has been provided to various LTRA PIs and collaborators, particularly in the countries of Nepal, Haiti, Lesotho, Ecuador, and the Philippines. We have exchanged information with all the LTRA PIs as well as various host country scientists, non-governmental organization (NGO) personnel, extensionists, agricultural suppliers, farmers, and students, as noted in the CCRA travel reports, reiterated below.

Project highlights

- Building a Time 0 soil library from all LTRA project sites. These will be used to establish a common minimum dataset so that scientifically valid comparisons among project sites can be made.
- GIS data for CAPS trials collected in Ecuador, Lesotho, and Nepal.
- Pre-testing of methodology to coordinate household economic surveys with soil fertility surveys has been conducted in Haiti.
- Laboratory capacity building conducted in Ecuador and Haiti.
- Soil sampling is underway in Bolivia to determine gendered knowledge of soil fertility.

Associate Awards

Training of trainers for environmentally sound design and implementation of labor-based feeder road public works construction projects of the Productive Safety Net Program (PSNP)

At the request of USAID/ETHIOPIA, the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP) designed and implemented a training of trainers (ToT) program in labor-based road construction (LBRC) and related natural resources management to reduce environmental problems associated with the construction of Ethiopian Public Safety Net Program (PSNP) public works projects involving the construction and maintenance of rural feeder roads. The overall goal of the project was to improve the quality and sustainability of rural feeder roads constructed through the PSNP. Specific objectives of the project included: (1) develop a ToT curriculum on environmentally sound and sustainable rural feeder road construction and maintenance using a labor-based road construction (LBRC) approach; (2) implement the developed ToT curriculum on environmentally sound and sustainable rural feeder road construction and maintenance; and (3) assess and recommend improvements to the implemented ToT curriculum on environmentally sound and sustainable rural feeder road construction and maintenance.

The Training of Trainers for Environmentally Sound Design and Implementation of Labor-Based Feeder Road Public Works Construction Projects of the Productive Safety Net Program (PSNP) training program was held June 13-24, 2011 at the Ghion Ambassel Hotel in Dessie, Ethiopia. The training program consisted of 8 ½ days of classroom instruction and 2 ½ days of field demonstrations and exercises. Forty-one trainees participated in the two-week training program led by four civil engineering trainers with experience in LBRC and associated natural resource management and environmental issues. The training program was designed to train trainers who would then train woreda-level trainers in the fundamentals of environmentally sound and sustainable LBRC and maintenance, who would in turn train woreda- and kebele-level road construction supervisors to oversee the construction and maintenance of rural feeder roads constructed through the PSNP public works program. Trainees were trained in the technical aspects of LBRC and maintenance as well as learning and training theory and how to be effective trainers.

Learning modules on LBRC and maintenance learning were developed from the International Labour Organization's "Training modules on labour-based road construction and maintenance" (ILO, 1991). These training modules consist of videos as well as a written "Guide to the Training of Supervisors for Labour-Based Road Construction: Trainees Manual Parts 1 & 2" (ILO, 1981). Trainees were provided with an extensive "Labor-Based Road Construction (LBRC) eLibrary" containing the ILO LBRC videos, PowerPoint presentations used in this ToT program on all of

the training module units, and public domain copies of 37 major publications (training manuals and handbooks) pertaining to rural road construction and maintenance.

An evaluation of the training program learning objectives at the conclusion of the training program found that all of the trainees made major gains in knowledge concerning LBRC and ToT techniques. Seventeen trainees rate the training program excellent, 14 rated it very good and one rated it good.

Appendixes

A. Training participants

Table 38: Long-term degree trainees

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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Abigail Nguema	F	American	Agricultural Economics	Ecuador	N	Jun 2010	Sep 2011	MS	Y	N	CCRA-6	Bertelsen	Virginia Tech
Albert Alwang	M	American	Economics	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Aliza Pradhan	F	Indian	Natural Resources /Environ. Management	US	N	Jan 2012	Sep 2014	PhD	Y	N	11	Idol	University of Hawaii-Manoa
Anna Testen	F	American	Plant Pathology	Bolivia & Ecuador	N	Aug 2010	Dec 2012	MS	Y	Y	7	Backman	Penn State University
Annah Latane	F	American	Agricultural Economics & French	Ecuador	N	May 2011	July 2011	BS	N	Y	7	Alwang, G. Norton, Bosch	Virginia Tech
Arnulfo Portilla	M	Ecuadorian	Chemistry	Ecuador	N	Oct 2010	Dec 2011	Eng.	Y	N	7	Alvarado	Instituto Nacional Autónomo de Investigaciones Agropecuarias

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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
													(INIAP) (Ecuador)
Bertrand Ricard	M	French	Agronomy	Cambodia	N	Apr 2010	Oct 2010	MS	N	Y	12	Chabierski, Boulakia, Penot	Institut Regions Chaudes (France)
Brinton Reed	M	American	Economics	USA	N	Sep 2011	Dec 2012	MS	Y	Y	11	Chan-Halbrendt	University of Hawaii-Manoa
Carl Yoder	M	American	Environmental Science	Lesotho & Mozambique.	N	Aug 2011	Aug 2013	MS	Y	Y	9	Eash	University of Tennessee
Cecilia Turin Canchaya	F	Peruvian	Rural Sociology	USA	N	Aug 2007	Dec 2010	PhD	Y	Y	4	Gilles	Universidad Nacional Agraria La Molina (Peru) & Larenstein University (Holland)
Chhoeum Chankakada	M	Cambodian	Agronomy	Cambodia	N	Apr 2010	Oct 2010	MS	Y	N	12	Chabierski, Boulakia, Penot	Royal University of Agriculture (Cambodia)

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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Cynthia Lai	F	US Resident	Social Economics	India & Nepal	N	Sep 2009	Aug 2011	MS	Y	N	11	Chan-Halbrendt	University of Hawaii-Manoa
David Moposita	M	Ecuadorian	Agronomy	Ecuador	N	Oct 2010	Dec 2011	Eng.	Y	N	7	Barrera	Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP) (Ecuador)
Don Immanuel Edralin	M	Filipino	Energy & Environmental Systems	Philippines	N	Aug 2011	May 2014	PhD	Y	Y	12	Reyes	North Carolina A&T State University
Emily Pfeufer	F	American	Plant Pathology	Bolivia & Ecuador	N	Aug 2010	Dec 2014	PhD	Y	Y	7	Gugino	Penn State University
Erine Thornburgh	F	American	Agronomy	USA	N	Summer 2011	Fall 2013	MS	Y	N	8	Prasad & Garrett	Kansas State University
Forrest Fleischmann	M	American	Public Policy	Global	N	Sep 2007	May 2012	PhD	Y	Y	1	Ostrom	Indiana University
George Mahama	M	Ghanaian	Agronomy	Ghana & USA	N	Spring 2012	Spring 2014	PhD	Y	N	8	Prasad & Staggenborg	Kansas 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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Hilary Kessler	F	American	Plant Pathology	Ecuador	N	Aug 2010	Dec 2014	PhD	Y	Y	7	Gugino & Backman	Penn State University
Iddrisu Yahaya	M	Ghanaian	Agricultural Economics	Ghana & USA	N	Fall 2011	Spring 2014	PhD	Y	N	8	Dalton & Prasad	Kansas State University
Isaac Chepkrui	M	Ugandan	Agricultural Economics	Uganda	N	Aug 2010	May 2012	MS	Y	N	10	Bashaasha	Makerere University (Uganda)
Jacqueline Marie Halbrendt	F	American	Horticulture	India & Nepal	N	Jan 2011	May 2014	PhD	Y	N	11	Idol & Evensen	University of Hawaii-Manoa
Jennifer Lamb	F	American	Agricultural Economics	Kenya & Uganda	N	May 2010	May 2012	MS	Y	N	CCRA-8	Moore	Virginia Tech
Jeremiah Okeyo	M	Kenyan	Soil Science	Kenya	N	Aug 2010	Jun 2014	PhD	Y	Y	10	J. Norton	University of Wyoming
Jess Martin	F	American	Crop & Soil Enviro. Sci. - International Agriculture	USA	N	Aug 2010	Aug 2011	BS	Y	N	CCRA-7	Christie	Virginia Tech
Jessica Boatwright	F	American	Agricultural Economics	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech

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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Jessica Schultz	F	American	Human Nutrition & Agricultural Sciences	Global	N	Apr 2011	Jul 2012	BS	N	N	ME	Moore	Virginia Tech
Jocelyn Tabili	F	Filipina	Strategic Studies	Philippines	N	Jun 2011	Apr 2012	MS	Y	N	12	Dayo	University of Philippines Los Baños
Judith Odhiambo	F	Kenyan	Soil Science	Kenya & Uganda	N	Jan 2011	Dec 2014	PhD	Y	N	10	U. Norton	University of Wyoming
Jyotsna Krishnakumar	F	Indian	Socioeconomics	India & Nepal	N	Jan 2010	Oct 2010	MS	N	Y	11	Radovich	University of Hawaii-Manoa
Katherine DuBreuil	F	American	Agricultural Economics	Ecuador	N	May 2011	July 2011	BS	N	Y	7	Alwang, G. Norton, Bosch	Virginia Tech
Kathleen Weber	F	American	Soil Science	Ecuador	N	Aug 2010	Aug 2013	MS	Y	Y	7	Stehouwer	Penn State University
Keri Agriesti	F	American	Geography	USA & Bolivia	N	Aug 2010	May 2012	MS	Y	N	CCRA-7	Christie	Virginia Tech
Kim Bothi	F	Canadian	Sociology	Zambia	N	Aug 2005	Dec 2010	PhD	Y	Y	2	Buck & Travis	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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Lauren Moore	F	American	International Studies	Ecuador	N	May 2011	July 2011	BA	N	N	7, ME	Alwang, G. Norton, Bosch, Moore	Virginia Tech
Linsey Shariq	F	American	Human Dimensions	India & Nepal	N	May 2011	May 2014	PhD	N	Y	11	Chan-Halbrendt & Gray	University of Hawaii-Manoa
Lyda Hok	M	Cambodian	Energy & Environ. Systems	Cambodia	N	Aug 2011	May 2014	PhD	Y	N	12	Reyes	North Carolina A&T State University
Mary Harman	F	American	Geography	USA & Philippines	N	Aug 2011	May 2013	MS	Y	N	CCRA-7	Christie	Virginia Tech
Matt Bruns	M	American	Soil Science	Lesotho	N	Jan 2010	Dec 2011	MS	Y	Y	9	Eash & Walker	University of Tennessee
Michael W. Graham	M	American	Soil science	Haiti	N	May 2011	Sep 2014	PhD	Y	N	CCRA-9	Mulvaney & Thomason	Virginia Tech
Moses Obbo Owori	M	Ugandan	Agricultural Economics	Uganda	N	Aug 2010	Jun 2012	MS	Y	N	10	Peck	University of Wyoming
Nadezda Amaya	F	Bolivian	Agricultural Economics	Bolivia	N	Aug 2010	Aug 2013	PhD	Y	Y	7	Alwang	Virginia Tech

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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Nathan Kennedy	M	American	Natural Resource Economics	Haiti	N	Mar 2010	May 2013	PhD	Y	N	6	Amacher	Virginia Tech
Patrick Samba Oluka	M	Kenyan	Soil Science	Kenya & Uganda	N	Aug 2010	Jan 2013	MS	Y	N	10	Okalebo	Moi University (Kenya)
Patrick Ward	M	American	Agricultural Economics	Global	N	Jan 2009	Aug 2011	PhD	Y	Y	Policy	Shively	Purdue University
Paul Tarnate	M	Filipino	Land/Water Resource Engineering	Philippines	N	Nov 2006	Oct 2011	MS	Y	N	12	Ella	University of Philippines Los Baños
Pharnice Adikinye Ongonga	F	Kenyan	Soil Science	Kenya	N	Jan 2010	Jan 2013	MS	Y	N	10	Okalebo	Moi University (Kenya)
Rafael Padre	M	Filipino	Land/Water Resource Engineering	Philippines	N	Jun 2008	Apr 2012	PhD	Y	N	12	Ella	University of Philippines Los Baños
Robert Gaffney	M	American	Agricultural Economics	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Romina Manalo-Bondad	F	Filipina	Land/Water Resource Engineering	Philippines	N	Nov 2006	Oct 2011	MS	Y	N	12	Ella	University of Philippines Los Baños

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)	LTRA	SANREM CRSP Advisor/PI	University(s) Degree Granting Institution First
Rosa Arévalo	F	Ecuadorian	Agronomy	Ecuador	N	Jan 2010	Sep 2011	Eng.	Y	N	7	Valverde	Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP) (Ecuador)
Ryan Stewart	M	American	Crop & Soil Environmental Sciences	Haiti	N	Aug 2010	Sep 2012	MS	Y	N	6	Thomason	Virginia Tech
Tin Herawati	F	Indonesian	Family & Consumer Science	Indonesia	N	Aug 2008	May 2011	PhD	Y	Y	5	Trikoesoemaningtyas	Bogor Agricultural University (Indonesia)
Trevor Simmons	M	American	Crop and Soil Environmental Sciences	Ecuador	N	May 2011	July 2011	BS	N	N	7	Alwang, G. Norton, Bosch	Virginia Tech
Tyneth Ly	M	Cambodian	Agronomy	Cambodia	N	Mar 2011	Jul 2011	MS	Y	N	12	Chabierski & Boulakia	Hanoi University of Agriculture (Vietnam)
Wendy Jones	F	American	Soil Science	Lesotho	N	Jan 2010	Dec 2011	MS	Y	N	9	Eash & Walker	University of Tennessee

Table 39: Non-degree training activities

Program type (Workshop, seminar, field day, short course)	Date	Audience	Number of participants		Training provider (US university, host country institution, etc.)	Training objective
			Men	Women		
Bolivia						
Short course	Oct 2 2010	Oscar Gutierrez	1	0	Universidad Mayor de San Simon (School of Agronomy)	Train in soil analysis
Workshop	Oct 6 2010	Municipal authorities	5	3	PROINPA	Present project activities
Workshop	Oct 10 2010	Oscar Gutiérrez, Ana Karina Saavedra	1	1	PROINPA	Train in physical and chemical soil analysis
Workshop	Nov 10 2010	Oscar Gutiérrez, Ana Karina Saavedra	1	1	PROINPA	Train in physical and chemical soil analysis
Workshop	Nov 12 2010	Local leaders	4	0	PROINPA	Present research objectives to local stakeholders Train in CA
Field Day	Jan 18 2011	Farmer group	16	7	PROINPA	Demonstrate CA techniques: different tillage methods
Workshop	Feb 11 2011	Oscar Gutiérrez, Ana Karina Saavedra	1	1	PROINPA	Train in physical and chemical soil analysis
Short course	Feb 12 2011	Farmer group	45	17	PROINPA	Train in CA: fertility management using local inputs

Workshop	Apr 11 2011	Rubén Botello, Ana Karina Saavedra	1	1	PROINPA	Train in budgets and economic analysis
Short course	May 9-10 2011	Oscar Gutiérrez Ana Karina Saavedra	1	1	PROINPA	Train in GPS applications to satellite images
Workshop	June 2011	PROINPA staff, Bolivia	2	3	Virginia Tech	Agree on methodology for workshop in Sank'ayani Alto; run through fieldwork methods
Focus Group Discussion on soils	June 2011	Members of community of Sank'ayani Alto, Bolivia	10	13	Virginia Tech and PROINPA	Gauge community knowledge of different soil types and map their location on a satellite image; learn to identify landmarks and community soils on two-dimensional format
Focus Group Discussion on activities	July 2011	Members of community of Sank'ayani Alto, Bolivia	12	13	Virginia Tech and PROINPA	Discuss gendered activities and their implications for CAPS and SANREM
Curso	Jul 14-15 2011	Farmers	23	8	PROINPA	Assist in quinoa production and development of budgets to measure costs
Cambodia						
Workshop & conference	Jul 4-7 2011	Regional and global CA researchers	60	20	SANREM, Royal University of Agriculture, CIRAD	Present state of the science on CA technology in SE Asia
Seminar	Jul 6 2011	Researchers	35	30	Cambodia SANREM	Explain real time soil carbon sequestration in CA systems
Short course	Nov 17-19 2010	13 Farmers organization members, 4 technicians, 2 community Based organization member	12	7	AVSF	Capacity building in FO management and marketing of products

Exchange visit	Dec 16-18 2010	10 farmers of RM met 40 farmers from Kampong Cham	7	3	PADAC / AVSF	Farmers' organizations development / DMC technologies in Kampong Cham
Meeting Farmers – grain trading companies	Jan 26 2011	Farmers' representative - 2 private companies of Pailin province	5	3	PADAC / AVSF	Prospective on contract farming development
Short course	Mar 28-29 2011	Farmers	12	5	PADAC	Herbicides proper use
Field day	May 24-25 2011	Farmers members of farmers organization developed by the project	8	5	AVSF	Training session on FO management and basic concept of Marketing
Second International Workshop on Conservation Agriculture in Southeast Asia	July 4-6 2011	Scientists, government staff , NGO staff, faculty, and students	77	13	USDA, CIRAD, State University of Ponta Grossa, Brazil	Soil quality and conservation agriculture
Second International Conference on Conservation Agriculture in Southeast Asia	July 7 2011	Scientists, government staff , NGO staff, faculty, and students	77	13	USDA, CIRAD, State University of Ponta Grossa, University of Hawaii, University of Tennessee, UPLB, NCA&T, World Agroforestry Center, Katsetsart University	Presentations of conservation agriculture in Vietnam, Cambodia, Philippines, Brazil and also socioeconomic papers in CA and posters as well

Ecuador						
Workshop	Jan 2 2011	Farmers of Culebrillas	5	3	INIAP	Present alternatives for integrated crop management and CA for potatoes
Workshop	Feb 2 2011	Partners of project INIAP-MAE-Sarguro	12	8	INIAP	Present on integrated watershed management; CA in NRM programming: SANREM CRSP experience
Workshop	Feb 2 2011	Professor and students of Universidad Nacional de Loja-Loja	14	12	INIAP	Present on integrated watershed management; CA in NRM programming: SANREM CRSP experience
Field training	Feb 28 2011	INIAP staff	4	1	Penn State/Virginia Tech	Train in bulk density and deep soil sampling
Workshop	Mar 1 2011	Farmers of Culebrillas and Bola de Oro, technicians	10	5	Virginia Tech and Penn State	Demonstrate techniques for soil sampling and analysis for CA
Workshop	Jun 29 2011	Farmers of Bola de Oro and technicians	29	22	Students of Virginia Tech	Report results of study of adoption of CA

Short course	Jul 25-28 2011	Farmers of Culebrillas and Bola de Oro, technicians	12	5	Virginia Tech; Prentice and Carlisle	Train in Agroforestry management
Workshop	Aug 6 2011	Farmers and technicians of Saquisilí	9	7	INIAP	Train in soil conservation management

Field day and TV interview	Aug 18 2011	Farmers, students, technical personnel, TV reporter (Channel 5, Guaranda, Ecuador), and members of the general public who watched the TV program	Field Day: 9 For TV Program: TV audience	Field Day: 2 For TV Program: TV audience	USDA-ARS (Dr. Jorge A. Delgado) Universidad Estatal de Bolivar (Agric. Eng. Carlos Monar) INIAP (Agric. Eng. Luis Escudero)	Visit with farmers at the field day about soil and water conservation practices, sustainability, increasing fertilizer nitrogen use efficiency, and soil and water quality. Emphasize nitrogen management and soil and water conservation practices and the potential of using these conservation practices and technologies for climate change mitigation and adaptation, and food security in TV interview of Dr. Delgado conducted for the Channel 5 program, *TV Cultural Municipal Guaranda*, with TV reporter Lcdo. Angel García. The importance of soil and water conservation and a reforestation program for Ecuador also discussed by Professor Carlos Monar from the Universidad Estatal de Bolivar.

Training workshop, "How to Use the Nitrogen Index with the Sustainability Index."	Aug 22 2011	Students and technical personnel	5	1	USDA-ARS (Dr. Jorge A. Delgado)	Train participants of the workshop on how to use the Nitrogen Index with the Sustainability Index.
Seminar: "Potential for Use of Nitrogen Index for Ecuador and Conservation Practices for Climate Change Mitigation and Adaptation and Conservation of Our Biosphere."	Aug 23 2011	Students and faculty of Universidad Estatal de Bolivar	35	35	USDA-ARS (Dr. Jorge A. Delgado)	Discuss recent advances in nitrogen management and soil and water conservation practices and the potential of using soil and water conservation practices for climate change mitigation and adaptation, and food security.

TV interview (live)	Aug 23 2011	For live TV program: Live TV interview transmitted to TV audience, reaching an unknown number of viewers of the live TV program.	TV audience	TV audience	USDA-ARS (Dr. Jorge A. Delgado)	Dr. Delgado was interviewed for the Channel 5 program, *TV Cultural Municipal Guaranda*, with TV reporter Lcdo. Angel García. Dr. Delgado spoke about "Climate Change and Food Security Challenges, and the Importance of Soil and Water Conservation." The program aired live on August 23rd, 2011 from 5:00-6:00 pm local time, on Channel 5, in Guaranda, Ecuador.

Field day and TV interview	Aug 23 2011	Students and faculty of Universidad Estatal de Bolivar and members of the general public who watch the TV program	Field Day: 12 TV Program: TV audience	Field Day: 2 TV Program: TV audience	For Field Day: Universidad Estatal de Bolivar (Agric. Eng. Carlos Monar and two students) For TV interviews: USDA-ARS (Dr. Jorge A. Delgado), Universidad Estatal de Bolivar (Agric. Eng. Carlos Monar)	For Field Day: Present research in N management, and their variety testing program for maize and small grains like barley and wheat. For TV Interviews: Dr. Jorge Delgado was interviewed about "Importance of Nitrogen Management and Soil and Water Quality Across Agricultural Systems in Ecuador and Other Countries with Respect to Climate Change and Food Security" for the Channel 5 program, *La Universidad Informa a la Ciudadanìa*, with the support of the program Gestiòn Universitaria, with TV reporter Jaime Leòn from Universidad Estatal de Bolìvar, in Guaranda, Ecuador. Professor Carlos Monar (Universidad Estatal de Bolivar) was also interviewed about his research program, the seed program, and the importance of soil

Training	Aug 24 2011	Worked with Rosa Arevalo, a student from Universidad Estatal De Bolivar	0	1	USDA-ARS (Dr. Jorge A. Delgado)	Collect data from field studies on a maize and oat rotation. Create files for all the plots. (These evaluations are going to be used for Rosa Arevalo's thesis.)
Ghana						
Field Day	Oct 10 2010	Farmers / extension Agents / NGOs	32	25	K-State, P.V.V. Prasad, J.B. Naab, SARI, Ghana at Nandoum	Show farmers of the region (host village and nearby villages) mother trials on minimum tillage
Field Day	Oct 11 2010	Farmers / extension agents / NGOs	21	9	K-State, P.V.V. Prasad, J.B. Naab, SARI, Ghana at Nandoum	Show farmers of the region (host village and nearby villages) mother trials on water conservations techniques
Workshop	Sep 7-9 2011	Farmers / extension agents / NGOs	26	15	J.B. Naab, SARI, Ghana, Wa	Development of measurable indicators for monitoring CAPs
Field Day	Sep 7 2011	Farmers / extension agents / NGOs	45	16	J.B. Naab, SARI, Ghana, Wa	Show farmers of the region (host village and nearby villages) mother trials for knowledge exchange and dissemination of CAPS
Training	Sep 8 2011	Farmers / extension agents / NGOs	45	16	J.B. Naab, SARI, Ghana, Wa	Train on simple record keeping for various farm related activities
Guam						
Seminar	Aug 4 2011	Researchers involved with the carbon-cycling CRSP	41	16	University of Guam	Explain real time soil carbon sequestration in CA systems

Haiti						
Short course	Dec 6-11 2010	Farmers of Morne-Michel	100	100	Zanmi Agrikol	Introduce basic agricultural conservation knowledge
Short course	Dec 6-11 2010	Farmers of Cange	25	25	Zanmi Agrikol	Introduce basic agricultural conservation knowledge
Short course	Dec 6-11 2010	Farmers of Bois-Joly	90	110	Zanmi Agrikol	Introduce basic agricultural conservation knowledge
Short cours	Dec 6-11 2010	Farmers of Balandry	100	100	Zanmi Agrikol	Introduce basic agricultural conservation knowledge
Short cours	Feb 7-9 2011	Farmers of Domond	25	25	Zanmi Agrikol	Introduce basic agricultural conservation knowledge
Seminar	Feb 15 2011	Fermier of Balandry	100	100	Zanmi Agrikol	Introduce concepts of soil conservation
Seminar	Feb 16 2011	Farmers of Morne Michel	200	100	Zanmi Agrikol	Introduce concepts of soil conservation
Field day	Feb 17 2011	Farmers of Bois-Joly	200	100	Zanmi Agrikol	Introduce concepts of soil conservation
Field day	Feb 18 2011	Fermier of Cange	25	25	Zanmi Agrikol	Introduce concepts of soil conservation
Field day	Feb 18 2011	Fermier of Domond	25	25	Zanmi Agrikol	Introduce concepts of soil conservation
Enumerator training	Jun 9 2011	ZA Agronomists	3	0	Virginia Tech (Kennedy)	Survey data collection - field test of the survey
Enumerator Training	Jul 24-26 2011	Student enumerators	6	0	Virginia Tech (Kennedy)	Survey data collection and implementation
India						
Field Day: Focus Group	Dec 14 2010	Farmers in Tentuli Village, India	10	7	University of Hawaii-Manoa	Introduce proposed CAPS activities in farmers' fields and LTRA 11 project objectives

Training	Dec 14 2010	OUAT staff in India	4	1	University of Hawaii-Manoa	Train interpreters on how to conduct household socioeconomic and agricultural baseline survey
Workshop	Mar 15 2011	University of Hawaii-Manoa, Tentuli farmers, OUAT in India	31	18	ICRISAT	Introduction of ICRISAT research on long-term conservation agriculture (CA) experiment on the Black Soil watershed
Workshop	Mar 16 2011	Tentuli Farmers, OUAT staff/students, University of Hawaii-Manoa, in India	31	18	University of Hawaii	Introduce the concept of CAPS and its agronomic and environmental benefits
Workshop	Mar 16 2011	OUAT staff/students, University of Hawaii-Manoa, in India	15	6	University of Hawaii	Train OUAT staff/students on a method of data collection of farmers' preference using the Analytical Hierarchy Process.
Workshop	Mar 17 2011	Tentuli Farmers, staff interpreters, University of Hawaii-Manoa, in India	24	16	University of Hawaii	Determine farmers preference using an AHP survey
Seminar	Mar 21 2011	College of Agriculture, OUAT, in India	20	5	University of Hawaii	Train OUAT students on the "Use of Field Leaching Studies for Pesticide Registration in Hawaii"
Field day	Mar 22 2011	Tentuli farmers, OUAT Staff, in India	0	5	University of Hawaii	Identify, select, and set up field plots in the village of Tentuli
Short course: Training	Mar 23 2011	Tentuli Farmers, OUAT staff, in India	0	4	University of Hawaii	Train on weather station equipment, attached sensors to the datalogger, and programmed the logging routine
Short course	Jun 6 2011	India SMARTS research associate and project coordinator	2	2	University of Hawaii	Train India SMARTS staff of administering the farmer knowledge and perception survey

Focus group	Jun 7 2011	Tentuli village farmers	9	2	University of Hawaii	Determine and discuss the social structure and organized groups of Tentuli village
Short course	Jun 9 2011	OUAT graduate research associates	1	3	University of Hawaii	Train OUAT staff of administering the farmer knowledge and perception survey
Short course	Jun 9 2011	India SMARTS and OUAT research associates	4	3	University of Hawaii	Train staff methodology of soil sampling
Short course	Jun 9 2011	India SMARTS agronomist and project Coordinator	2	1	University of Hawaii	Train staff of specific protocol of data collection regarding labor on experimental and on-farm plots
Short course	Jun 10 2011	SMARTS project coordinator (India) and Hawaii graduate research associate	1	2	University of Hawaii	Train SMARTS graduate assistant and project coordinator of use of weather station
Focus group	Jun 11 2011	Baikumutia village farmers	29	3	University of Hawaii	Introduce villagers to the SANREM/SMARTS project, discuss present agricultural practices, concerns, crops produced within village, and complete seasonal calendar of agricultural activities
Focus group	Jun 11 2011	Talachampei village farmers	14	10	University of Hawaii	Introduce villagers to the SANREM/SMARTS project, discuss present agricultural practices, concerns, crops produced within village, and complete seasonal calendar of agricultural activities

Short course	Jun 12 2011	India SMARTS and OUAT research associates	1	4	University of Hawaii	Train India SMARTS research fellow project coordinator, and OUAT graduate student how to administer the market survey
Short course	Jun 13 2011	India SMARTS and OUAT research associates	4	3	University of Hawaii	Train India SMARTS research associates of using the SPAD meter, implementing resin bags and assembling weather stations
Short course	Jun 13 2011	India SMARTS project coordinator	1	1	University of Hawaii	Train India SMARTS project coordinator of administering the baseline socioeconomic survey
Short course	Jun 16 2011	India SMARTS research fellow	1	1	University of Hawaii	Train India SMARTS agricultural socioeconomic research fellow of administering the baseline socioeconomic survey
Short course	Jun 16 2011	OUAT and SMARTS Hawaii graduate research assistants	0	3	University of Hawaii	Train graduate research assistants on the methodology of in lab soil sample analysis (weight, bulk density, moist/dry analysis)
Kenya						
Workshop	Oct 18 2010	Advisory committee members	9	6	Host Institution (SACRED Africa)	First meeting towards forming Advisory Committee
Workshop	Nov 6 2010	Advisory committee members	7	5	Host Institution (SACRED Africa)	Discuss details on roles of the Advisory Committee
Seminar	Jan 27–28 2011	SANREM farmers	6	2	Host Institution (SACRED Africa)	Training farmers earmarked for the SANREM On farm work on their roles in the project.
Workshop	Feb 23 2011	SACRED/Africa interviewers	2	3	Virginia Tech	Food security and social networks survey implementation skills

Seminar	Mar 14–15 2011	Field support staff	5	1	Host Institution (SACRED Africa)	Training field support staff on plot management practices for season 1, 2011
Workshop	Apr 13 2011	Manor House interviewers	0	4	Virginia Tech	Food security and social networks survey implementation skills
Field day	Jul 7 2011	Area residents	41	19	SACRED Africa & Ministry of Agriculture, Kenya	Familiarizing community members with the SANREM technologies
Seminar	Aug 9 2011	SANREM farmers	5	2	Host Institution (SACRED Africa)	Training farmers earmarked for the SANREM On farm work on their roles in the project especially season 2, 2011
Seminar	Aug 16 2011	Field support staff	4	2	Host Institution (SACRED Africa)	Training field support staff on plot management practices for season 2, 2011
Lesotho						
NUL student training in CA	Nov 2010	National University of Lesotho students	21	9	NUL, Roma, Lesotho	Train B.S. students in CA as part of their senior project
On-Farm demonstration	Dec 2010	Local farmers near Botha Buthe, Lesotho	7	3	Rural farm near Botha Buthe, Lesotho	On-farm CA demonstration
Seminar on impact of CA on lessening the impact of climate change	Jan 2011	Researchers, lay persons, politicians	85	65	National University of Lesotho, Roma	Show potential of CA to limit climate change impact on subsistence farmers
On-farm demonstration	Feb 2011	Thaba Tseka, Lesotho	6	6	NUL	Demonstrate CA principles

On-farm demonstration	Feb 2011	Taung, Lesotho	3	8	NUL	Demonstrate CA principles
On-farm demonstration	Feb 2011	Mafeteng, Lesotho	7	4	NUL	Demonstrate CA principles
Field training	Feb 3 2011	Student	0	1	Soils CCRA	Select and square research plots
Field training	Feb 4 2011	Students	1	1	Soils CCRA	Obtain composite and intact soils cores
Field training	Feb 14 2011	Students	2	0	Soils CCRA	Obtain composite and intact soil cores
Field day	Apr 14 2011	District Officer of Agriculture with Maphutseng farmers	23	12	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Demo-farm visual display
Field visit	May 9 2011	Mpharane farmers	15	4	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Demo-farm visual display
Workshop	May 31 2011	Farmers from Berea	4	5	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Field demonstrations
Field visit	Jun 1 2011	Ministry of Agriculture extension officers in Rothe	2	9	Growing Nations Trust	CAPS in Lesotho. Demo-farm visual display
Workshop	Jun 8 2011	Ministry of Forestry's DOA and farmers from Quthing	12	5	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Demo-farm visual display
Workshop	Jul 15-19 2011	Maphutseng youth group	5	4	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, Field scale layout. field demonstrations
Field visit	Jul 21 2011	Bethesda High School youth group	9	4	Growing Nations Trust	CAPS in Lesotho. Field demonstrations

Field Visit	Aug 8 2011	Farmers from Rothe	18	12	Growing Nations Trust	CAPS in Lesotho. Field demonstrations
Workshop	Aug 31 2011	Farmers of World vision ADP Sefikeng	6	19	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
Workshop	Sep 1 2011	Famers from Thaba-ts'oeu	2	4	Growing Nations Trust	CAPS in Lesotho. Field demonstrations
Workshop	Sep 6 2011	Farmers from World-Vision ADP Mapoteng	15	9	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
Field visit	Sep 6 2011	Ministry of Agriculture, DOA	5	11	Growing Nations Trust	CAPS in Lesotho. Field demonstrations
Field visit	Sep 9 2011	Makena High School	36	30	Growing Nations Trust	CAPS in Lesotho.
Field day	Sep 12 2011	Farmers from Maphutseng area	12	7	Growing Nations Trust	CAPS in Lesotho. Field demonstrations
Field visit	Sep 13 2011	Farmers from Kolo	4	6	Growing Nations Trust	CAPS in Lesotho.
Workshop	Sep 18-23 2011	Orphans from Maseru	19	0	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
Field visit	Sep 19 2011	Farmers from Quthing	2	0	Growing Nations Trust	CAPS in Lesotho. Field demonstrations
Field visit	Sep 27 2011	Presbytery Church, NY, USA	4	3	Growing Nations Trust	CAPS in Lesotho. field demonstrations
FGW In-field mentoring	Oct 1-9 2011	Farmers in Mpharane	18	13	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
FGW In-field mentoring	Oct 4-8 2011	Farmers in Liphiring	16	11	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations

FGW In-field mentoring	Oct 4-8 2011	Farmers in Maphutseng	20	27	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
FGW In-field mentoring	Oct 4-8 2011	Farmers in Ha-Mootsinyane	20	24	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
Workshop	Oct 11 2011	F.T.C, Prisoners Training	39	0	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Mgnt keys, field demonstrations. Field scale layout
Field visit	Oct 31 2011	Farmers from Thabana-Morena	2	0	Growing Nations Trust	CAPS in Lesotho. Demo-farm visual display
Workshop	Nov 14-18 2011	Ministry of Forestry & Agriculture	6	13	Growing Nations Trust	CAPS in Lesotho. Explaining the three principles of CA. Management keys, field demonstrations
Mali						
Workshop	July 7 2011	IER interviewers	4	2	Virginia Tech/IER	Baseline and technology networks survey implementation skills
Mozambique						
Workshop	Fall 2010	Farmers	125	94	CIMMYT	Short farmer trainings, facilitated by extension officers in the target communities
Workshop	Sep 27-Oct 1 2010	Extension officers	14	2	CIMMYT	CA Training course
Workshop	Oct 5-7 2010	Farmers	22	4	CIMMYT	Seed systems and seed producer training

Workshop	Nov 10 2010	Extension officers and supervisors	11	1	CIMMYT	Extension officers and supervisors from three provinces of Mozambique (Sofala, Manica and Tete) were familiarized with the project objectives, trained on the principles of CA and on participatory on-farm work.
Workshop	Nov 17-19 2010	Enumerators	3	5	University of Tennessee	Develop locally appropriate survey instrument for study on CA systems
Field tours	Feb 3-5, 14-18 2011	National and international scientist, extensionists, farmers and other participants	16	3	CIMMYT	Study tours of on-farm and experiment station trials
Workshop	Apr 12 2011	Extension officers	11	3	CIMMYT	Harvest training
Short course	May 12 2011	Graduate student	1	0	University of Tennessee	Developing a data management system using MS Access
Workshop	Sep 4-8 2011	National and international scientist, extensionists and other participants	17	4	CIMMYT	Evaluation and planning workshop
Seminar	Sep 6, 2011	Researcher, extension	76	47	Chimoio	CAPS in Lesotho and Mozambique
Field day, Mozambique	Sep 7 2011	Farmers, extension personnel and researchers	9	3	CIMMYT, University of Tennessee	Critique methods to improve CA system field and step trials in Mozambique
Short course	Oct 3 2011	Graduate student	1	0	University of Tennessee	Learn how to use SAS for survey data analysis
Meetings	2011	Farmers	180	167	CIMMYT	Awareness meetings before the start of the season

Discussion group	2011	Farmers	160	209	CIMMYT	Farmer discussion groups/ evaluation meetings (various communities)
Meetings	2011	Farmers	101	67	CIMMYT	Qualitative evaluations (End of season)
Workshop	2011	Farmers	63	46	CIMMYT	Short farmer CA training courses (extension-led)
Field tours	2011	Farmers	84	59	CIMMYT	Farmer field tours/exchange visits in communities
Field days	2011	Farmers	262	239	CIMMYT	Farmer field days
Nepal						
GPS data collection	Mar 21 2011	U. of Hawaii GRA	0	1	Mulvaney (Virginia Tech)	Achieve proficiency in GPS data collection
Weather station data collection	Mar 23 2011	LiBird staff; U. of Hawaii GRA	3	1	Crow (U. of Hawaii)	Achieve proficiency in weather station data collection and downloading data
Bulk density soil sampling protocols	Mar 23 2011	LiBird staff; U. of Hawaii personnel	2	2	Mulvaney (Virginia Tech)	Achieve proficiency in soil bulk density data collection
Seminar	Mar 20 2011	University of Hawaii-Manoa, LI-BIRD, in Pokhara, Nepal	6	6	Local Initiatives for Biodiversity Research Development (LI-BIRD)	Mini seminar titled, "LI-BIRD at a Glance" focusing on current projects and research by LI-BIRD
Training	Mar 21 2011	University of Hawaii-Manoa, LI-BIRD staff, Nepal	1	4	University of Hawaii-Manoa	Train LI-BIRD staff on how to conduct household socioeconomic and agricultural baseline survey
Training	Mar 21 2011	University of Hawaii research assistant, Nepal	0	1	Mulvaney (Virginia Tech)	Achieve proficiency in GPS data collection

Focus group	Mar 22 2011	Farmers in Thumkah Village, Nepal	11	1	University of Hawaii-Manoa	Introduce and explain proposed CAPS implementation activities in farmers' fields and LTRA 11 project objectives
Training	Mar 23 2011	LI-BIRD Staff, Thumkah farmers in Nepal, University of Hawaii-Manoa	3	1	University of Hawaii-Manoa	Train LI-BIRD staff and Thumkah Village farmers on how to use/set up weather station
Training	Mar 23 2011	LI-BIRD staff; U of H GRA, Nepal	3	1	Crow (U. of Hawaii)	Achieve proficiency in weather station data collection and download
Training	Mar 23 2011	LI-BIRD staff; U of H personnel, Nepal	2	2	Mulvaney (Virginia Tech)	Achieve proficiency in soil bulk density data collection
Training	Aug 19 2011	LI-BIRD research associates, project coordinator and TU/IAAS Master's students	5	1	University of Hawaii	Train Nepal SMARTS Research associates on the use of the SPAD meter
Training	Aug 19 2011	LI-BIRD research associates, project coordinator and TU/IAAS Master's students	3	2	University of Hawaii	Train on usage of digital scale to collect yield measurements
Focus group	Aug 22 2011	Hyakrang participants (Male)	9	0	University of Hawaii	Determine and discuss the labor divide between genders and previous experience with NGOs
Focus group	Aug 22 2011	Hyakrang participants (Female)	0	9	University of Hawaii	Determine and discuss the labor divide between genders and previous experience with NGOs

Focus group	Aug 23 2011	Khola Gaun participants (Male)	9	0	University of Hawaii	Determine and discuss the labor divide between genders and previous experience with NGOs
Focus group	Aug 23 2011	Khola Gaun participants (Female)	0	9	University of Hawaii	Determine and discuss the labor divide between genders and previous experience with NGOs
Philippines						
Field instruction	Jun 30 2011	Students and researchers	5	1	Soils CCRA	Achieve clinometer proficiency
Farmers' training on conservation agriculture with trees	Jan 15 2011	Upland farmers	12	25	ICRAF- LFPI	Learn and develop skills on conservation agriculture and agroforestry
Farmers' field day	Jan 18 2011	Farmers, Local government units, Academe, Line agencies	36	22	ICRAF- LFPI	Share progress and accomplishments of CAPS project Get feedbacks from farmers' co-operators on their experiences and problems in implementing CAPS
Student field tour	Feb 26 2011	Students from Caraga State University	25	16	ICRAF- LFPI	Learn and develop skills on conservation agriculture and agroforestry
Soil quality training	June 28 2011	Farmer leaders, technicians, academe, farmers	27	14	USDA, NCAT, ICRAF	Share methods of soil quality analysis
Farmers' visit on conservation agriculture with trees	Aug 17 2011	Farmers and technicians	7	3	ICRAF, CRDFI	Learn and develop skills on conservation agriculture and agroforestry

Farmers' visit on conservation agriculture with trees	Sept 16 2011	Farmer leaders, technicians, academe, farmers	56	12	ICRAF, CRDFI	Learn and develop skills on conservation agriculture and agroforestry
Tanzania						
Seminar	June 8 2011	Researchers	25	15	Sokoine University of Agriculture	Conservation Ag. Systems in Lesotho and Mozambique
Seminar	Sep 23 2011	Researchers	23	16	Sokoine University of Agriculture	Explain real time soil carbon sequestration in CA systems
Uganda						
Advisory group meetings	Oct 13-14 2010	Farmers, local government and NGO representatives in Tororo and Kapchorwa	28	9	AT Uganda ltd Technical Advisor	Review/ confirm on farm experimentation protocol
Workshop	Oct 21 2010	Stakeholder advisory group: Farmers, agricultural input and service providers in Trans-Nzoia County	17	13	UW, MHAC	Introduce overall goals and objectives of SANREM CRSP and CAPs concepts to stakeholders
Farmer interaction at Land preparation 1st season 2011	Feb 8-12, 14 2011	Farmers in Tororo (Station), Kisoko (F), Molo (F), Kapchorwa (S), Kwosir (F), and Kalpak (F)	19	18	Field extension coordinator	Establish of 1st season experiments, share knowledge with farmers on importance of CA, herbicide application, and handling
Workshop	Feb 13 2011	Kapchorwa interviewers	1	1	Virginia Tech	Food security and social networks survey implementation skills

Farmer interaction at Land preparation 1st season 2011	Mar 1-3, 7-9 2011	Farmers in Tororo (S), Kisoko (F), Molo (F), Kapchorwa (S), Kwosir (F), and Kalpak (F)	31	25	Field extension coordinator	Establish of 1st season experiments, share knowledge with farmers on importance of CA, herbicide application, and handling
Workshop	Mar 13 2011	Tororo interviewers	2	3	Virginia Tech	Food security and social networks survey implementation skills
Farmer interaction at Planting 1st season 2011	Mar 29-31 2011	Farmers in Tororo (S), Kisoko (F)	20	7	Field extension coordinator	Share knowledge with farmers on principles of agronomy
Farmer interaction at Planting 1st season 2011	April 1, 4-7 2011	Farmers in Molo (F), Kapchorwa (S), Kwosir (F), Kalpak (F)	27	24	Field extension coordinator	Share knowledge with farmers on principles of agronomy
Farmer interaction at Gap filling, thinning ,population count & weeding 1st season 2011	Apr 18-20 2011	Farmers in Tororo (S), Kisoko (F), Molo (F)	12	9	Field extension coordinator	Share knowledge with farmers on principles of agronomy and the importance of plant population count, thinning, and gap filling in relation to crop yield
Seminar	Apr 27 2011	USAID/Kampala staff	4	3	Virginia Tech	Food security and social networks
Seminar	Apr 28 2011	Students at Makerere University	15	5	Virginia Tech	Food security and social networks
Farmer interaction at Topdressing 1st season 2011	May 9-12, 30-31 2011	Farmers in Tororo (S), Kisoko (F), Molo (F), Kapchorwa (S)	16	12	Field extension coordinator	Fertilizer application at top dressing and knowledge sharing on fertilizer types, application methods in relation to plant stages, CA, and yield

Farmer interaction at Gap filling, thinning ,population count & weeding 1st season 2011	May 17-20 2011	Farmers in Kapchorwa (S), Kwosir (F), Kalpak (F)	16	8	Field extension coordinator	Share knowledge with farmers on principles of agronomy and the importance of plant population count, thinning, and gap filling in relation to crop yield
Farmer interaction at Topdressing 1st season 2011	Jun 1-2 2011	Farmers in Kwosir (F) and Kalpak (F)	7	6	Field extension coordinator	Fertilizer application at top dressing and knowledge sharing on fertilizer types, application methods in relation to plant stages, CA, and yield
Farmer interaction at harvesting 1st season	Jul 27-20 2011	Farmers in Tororo (S), Kisoko (F), Molo (F)	9	6	Field extension coordinator	Compare results per plot, share knowledge on importance of CA in relation to yield
Farmer interaction at Land preparation 2nd season 2011	Aug 17-20 2011	Farmers in Tororo (S), Kisoko (F), and Molo (F)	11	15	Field extension coordinator	Establish of 1st season experiments, share knowledge with farmers on importance of CA, herbicide application, and handling
Farmer interaction /training meetings	Aug 19-20 2011	Farmers in Tororo (Farms)	15	25	Field extension coordinator	Train in CA basics, use of fertilizers and agrochemicals
Farmer interaction /training meetings	Aug 24-25 2011	Farmers in Kapchorwa (Farms)	10	22	Field extension coordinator	Train in CA basics, use of fertilizers and agrochemicals

Farmer interaction at Planting 2nd season 2011	Sep 6-8, 12, 14-15 2011	Farmers in Tororo (S), Kisoko (F), Molo (F), Kapchorwa (S), Kwosir (F), Kalpak (F)	39	29	Field extension coordinator	Share knowledge with farmers on principles of agronomy
Farmer interaction at Gap filling, thinning, population count & weeding 2nd season 2011	Sep 16, 19-20 2011	Farmers in Tororo (S), Kisoko (F), Molo (F)	10	8	Field extension coordinator	Share knowledge with farmers on principles of agronomy and the importance of plant population count, thinning, and gap filling in relation to crop yield
Advisory group meetings	Oct 12-13 2011	Farmers, local government and NGO representatives in Tororo and Kapchorwa	22	6	AT Uganda ltd Technical advisor, M&E, field extension coordinator and field assistants	Assess implementation constraints and progress evaluation
Farmer interaction at Topdressing 2nd season 2011	Oct 18-20 2011	Farmers in Tororo (S), Kisoko (F), Molo (F)	10	11	Field extension coordinator	Fertilizer application at top dressing and knowledge sharing on fertilizer types, application methods in relation to plant stages, CA, and yield
USA						
Workshop	Dec 2010	Students and faculty	8	9	Virginia Tech	Prepare students and faculty for field research and train on gender methodologies
Training	Dec 11 2010	MS Graduate student	0	1	University of Hawaii-Manoa	Train new UH graduate student on how to conduct Socioeconomic baseline survey

Seminar	Jan 19 2011	University of Hawaii-Manoa, Dept. of Natural Resources and Environmental Management Graduate level class	11	7	University of Hawaii-Manoa	Raise understanding of the significance of CAPS and the economics of analyzing CAPS through SMARTS case study focusing on Tentuli, India data
Seminar	Jan 24 2011	University of Hawaii-Manoa, Departments within the College of Tropical Agriculture and Human Resources and the public of Honolulu, HI	15	13	University of Hawaii-Manoa	Introduce the conceptual framework and methodology of the economics of CAPS and its implementation
Training	Feb 7 2011	University of Hawaii-Manoa staff	0	2	University of Hawaii-Manoa	Train on Expert Choice Software for Analytical Hierarchy Process data analysis
Seminar	Feb 28 2011	University of Hawaii-Manoa, Dept. of Natural Resources and Environmental Management Graduate level class	11	7	University of Hawaii-Manoa	Introduce a quantifiable approach soliciting preferences of CAPS through the Analytical Hierarchy Process (AHP), theory and Case Study using Tentuli, India data
Training	Mar 9 2011	University of Hawaii-Manoa,	0	1	University of Hawaii-Manoa	Train on use/set up of weather station and soil equipment
Undergraduate research	Fall 2011	Undergraduate student	0	1	Virginia Tech	Prepare and train student for literature research and analysis of fieldwork data
Training	Sep 14 2011	MS Graduate student	1	0	University of Hawaii-Manoa	Train new UH graduate student on how to conduct Socioeconomic baseline survey

Vietnam						
Workshops on Map Windows, Introductory SWAT, and Advanced SWAT	Jan 4-5 2011	Scientists and students from Cambodia, Vietnam, Thailand, China and Germany	60	42	NCA&T State University, Texas A&M, Idaho State University, Nong Lam University, Chiang Mai University, UNESCO-IHE-Institute of Water Education	Introduce MapWindows a free GIS software to Southeast Asian users Train new SWAT-users Train SWAT users trained through earlier SANREM sponsored training in Southeast Asia
Second International SWAT-Conference in Southeast Asia	Jan 6-7 2011	Scientists and students from Cambodia, Vietnam, Thailand, China, United Kingdom, Netherlands and Germany	55	34	Organized by NCA&T, Nong Lam University in partnership with several universities and institutions from many countries	Present latest research and application of SWAT, especially in Southeast Asia Launch SANREM book on: Vegetable agroforestry and cashew-cacao production in Vietnam
Field trip Mekong Delta	Jan 8 2011	Scientists and students from Cambodia, Vietnam, Thailand, China and Germany	11	9	Organized by NCA&T, Nong Lam University and Can Tho University	Learn about hydrology of Mekong Delta Illustrate the devastating impact of climate change in Mekong Delta See and learn from water control structures in Mekong Delta

SANREM CRSP publications, presentations and other products

SANREM CRSP Working Papers (1)

Yahaya, I., I. Hashim, J. Naab, and T.J. Dalton. 2011. Descriptive Report on Cropping Systems in Upper West Region, Ghana. SANREM CRSP Working Paper No. 01-11.

Internet Sites and Documents (1)

Christie, M.E. CCRA-7: Gendered Perspectives for Conservation Agriculture. http://www.oired.vt.edu/sanremcrsp/professionals/research-activities/phase4/ccras/ccra7/.

Papers/Seminars Presented (13)

Barrera, V., J. Alwang; E. Cruz; L. Escudero, and C. Monar. 2011. Gestión integrada de recursos naturales en la subcuenca del río Chimbo, Ecuador. Paper presented at the VI Congreso de Ciencia y Tecnología, Sangolquí, Ecuador, 8-10 June 2011. (Spanish).

Christie, M.E. and C. Luebbering. 2011. Women as Mapmakers: Gender and Empowerment in Participatory Mapping. Presented at the Annual Meeting of the Association of American Geographers, Seattle, WA, 12-16 April 2011.

Cruz, E., E. Chela, C. Monar, F. Valverde, and Y. Cartagena. 2010. Evaluación de la pérdida productiva y económica por la erosion hídrica en tres sistemas de producción en la microcuenca del río Alumbre, Provincia Bolívar, Ecuador. Paper presented at the XII Congreso Ecuatoriano de la Ciencia del Suelo: Santo Domingo de los Colorados, Ecuador, 17-19 November 2010. (Spanish).

Escudero, L. 2011. Manejo y conservación de suelos. (Spanish). Seminar presented to the local government in Sasquisili, Ecuador.

Delgado, J. 2011. Potential for use nitrogen index for Ecuador and conservation practices for climate change and conservation of our biosphere. Seminar presented at the University Estatal de Bolivar.

Halbrendt, J., L. Shariq, C. Chan-Halbrendt, C. Lai, T. Idol, C. Ray, P.K. Roul, and K.N. Mishra. 2011. Development of an integrated approach for introducing conservation agricultural practices to the tribal communities of Odisha, India. Paper presented at the Second International Conservation Agriculture Workshop and Conference in Phnom Penh, Cambodia, 4-7 July 2011.

Moore, K.M., J. Lamb, and I. Yahaya. 2011. Predisposition for conservation agriculture in North West Ghana. Presented at the 5th World Congress on Conservation Agriculture in Brisbane, Australia. Published by the Australian Centre for International Agricultural Research.

Mulvaney, M.J. Effects of high biomass cover crops and organic mulches on soil properties and collard yield three years after conversion to no-till. Presented at the ASA-CSSA-SSSA International Annual Meetings, Long Beach, CA, 3 November 2010.

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Mulvaney, M.J., C.W. Wood, K. Balkcom, and B. Meso. Nitrogen and carbon mineralization from peanut residues under conservation and conventional tillage at two locations. Presented at the ASA, CSSA, and SSSA International Annual Meetings, San Antonio, Texas, 16-19 October 2011.

Reyes, M.R., D. Catacutan, D. Thanh, and A. Susila. Vegetable agroforestry systems in Southeast Asia. Presented at the American Society of Agricultural and Biological Engineers Annual International Meeting, Louisville, Kentucky, 10-12 August 2011.

Rubin, D. 2011. Gender dimensions framework application. Presented for Women, Environment, and Development Class (Women and Minority Artists and Scholars Lecture Series (WMASL)), Virginia Tech, Blacksburg, VA, 20 March 2011.

Saludadez, J. 2011. The technology knowledge network in the conservation agriculture narrative of a farmer. Presented at the Second International Conservation Agriculture Workshop and Conference in Southeast Asia, Phnom Penh, Cambodia, 4-7 July 2011.

Electronic Presentations (13)

Amaya, N., J. Alwang, and M.E. Christie. 2010. Are potato markets gendered? An analysis of gender networks in the potato marketing chain in the Jatun Mayu watershed of Tiraque, Bolivia. Presented at the Gender Networks Symposium, Virginia Tech, Blacksburg, VA, 15 November 2010.

Barrera, V. GIC para el manejo del capital natural: Experiencias del proyecto INIAP-SANREM CRSP. 2011. (Spanish).

Halbrendt, J. Conservation agricultural practices to the tribal communities of Odisha, India. Presented at the Second International Conservation Agriculture Workshop and Conference in Phnom Penh, Cambodia, 4-7 July 2011.

Idol, T., C. Chan-Halbrendt, and T. Radovich. CAPS options and agronomic measurements for Tentuli Village. Presented at the OUAT/UH (Orissa University of Agriculture and Technology/ University of Hawaii at Manoa) workshop, Keonjihar, India, 18 March 2011.

Lai, C. and C. Chan-Halbrendt. Farmers' preference: AHP workshop and analysis. 2011. Orissa University of Agricultural Technology, March 2011.

Local Initiatives for Biodiversity, Research, and Development (LIBIRD). Sustainable Management of Agroecological Resources in Tribal Soceties (SMARTS): Field observation in Nepal. Presented at LIBIRD on 22 March 2011.

Mercado, A.R. Conservation Agriculture with Trees (CAwT): Enhancing agroforestry economic, social and environmental benefits. Presented at the Reward for Environmental Services (RES) Forum in Mindanao, Philippines. 2011.

Mercado, A.R. Conservation agriculture with trees (CAwT): Enhancing agroforestry economic benefits and environmental services. Presented at the IGRAF-SLE GIZ Consultation Meeting, IRRI, Los Baños, Laguna, Philippines, 4 August 2011.

Mercado, A.R., M.R. Reyes, and V.B. Ella. Developing conservation agriculture in the Philippines. Presented at the Conservation Agriculture Research in the Philippines and Cambodia Workshop, 6 July 2011.

Nelson, J. Manejo integrado de los recursos naturales para agricultura de pequeña escala en la subcuenca del río Chimbo, Ecuador. Gestion de Bosques. 2011. (Spanish).

Reyes, M. Initial results on soil quality; SANREM-CRSP conservation agriculture for food security in the Philippines. Presented at Claveria, Philippines, 18 January 2011.

Reyes, M. Recommendations. Presented at the NAST Roundtable Discussion on Intensification of Agriculture, Manila, Philippines, 21 February 2011.

Rubin, D. 2011. Gender, markets, and development in Africa: Women in development. Presented for the Women and Minority Artists and Scholars Lecture Series (WMASLS), Virginia Tech, Blacksburg, VA, 20 March 2011.

Posters (21)

Agriesti, K. and M.E. Christie. 2011. Political ecology, gendered landscapes, and sense of place: Local soil knowledge and access to agricultural resources in smallholder farming communities in Cochabamba District, Bolivia. Presented at the Association of American Geographers (AAG) Annual Meeting, Seattle, WA, 12-16 Apr 2011.

Agriesti, K., Christie, M.E., and J. Martin. 2011. Gender cross-cutting research activity gendered perspectives for conservation agriculture: Local soil knowledge and crop-livestock interaction. Presented at the Annual SANREM CRSP Meeting, Blacksburg, VA, 17-19 May 2011.

Christie, M.E., C. Luebbering, K. Agriesti, M. Byrne, K. Montgomery, E. Van Houweling, L. Zseleczky, and M. Harman. 2011. Gender and participatory mapping: Local knowledge and empowerment in development research. Presented at the Southeastern Division Association of American Geographers, Savanna, GA, 20-22 November 2011.

Ella V.B. 2011. Soil quality studies under conventional plow-based and conservation agriculture production systems in Claveria, Misamis Oriental, Philippines. Presented at the Second International Conservation Agriculture Workshop and Conference in Southeast Asia, Phnom Penh, Cambodia, 4-7 July 2011.

Graham, M.W., K. Delate, C.L. Burras, R.E. Mazur, D.M. Brenner, M.M. Tenywa, D.N. Nakimbugwe, M. Kabahuma, and A. Abili. 2011. Organic grain amaranth production in Kamuli district, Uganda . Presented at the ASA, CSSA, and SSSA International Annual Meetings, San Antonio, Texas, 16-19 October 2011.

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Halbrendt, J., C. Lai, C. Chan-Halbrendt, T. Idol, C. Ray, C. Evensen, and P.K. Roul. 2011. An integrative approach for introducing conservation agriculture practices to tribal societies in India. Presented at the Second International Conservation Agriculture Workshop and Conference in Phnom Penh, Cambodia, 04-07 July 2011, and at the SANREM CRSP Annual Meeting, Blacksburg, VA, 17-19 May 2011.

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Mulvaney, M.J. 2011. SANREM CRSP soil quality & carbon sequestration CCRA. Presented at SANREM annual meeting, Blacksburg, VA, 17-19 May 2011.

Mulvaney, M.J., K. Moore, M.E. Christie, G. Norton, M. Bertelsen, and L. Sutphin. 2011. Integrating economics, technology networks, soils and gender to remove constraints to conservation agriculture in the developing world. Presented at Resilient Food Systems for a Changing World: Proceedings of the 5th World Congress on Conservation Agriculture Incorporating 3rd Farming Systems Design Conference; Brisbane, Australia, 26 - 29 September 2011.

Mulvaney, M.J., K.M. Moore, M.E. Christie, G. Norton, M. Bertelsen, and L.K. Sutphin. 2011. SANREM CRSP: Cross-cutting research adapts conservation agriculture for dryland smallholders in developing countries. Presented at the 2nd International Conservation Agriculture Workshop and Conference in Southeast Asia, Phnom Penh, Cambodia, 2-7 July 2011.

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Norton, J., E. Arnould, U. Norton, D. Peck, M. Press, R. Okalebo, E. Omondi, E. Mukhwana, B. Bashasha, R. Laker-Ojok, J. Okeyo, J. Odhiambo, M. Owori, P. Oluko, P. Ogonga, I. Chepkurui, and D. Sikuku. 2011. Development and transfer of conservation agriculture production systems (CAPS) for small-holder farms in eastern Uganda and western Kenya. Presented at the SANREM CRSP Annual Meeting, Blacksburg, VA, 17-19 May 2011.

Nguema, A., G. Norton, and M. Bertelsen. 2011. Cross-cutting research activity 6: Economic and impact analysis. Presented at the SANREM CRSP Annual Meeting, Blacksburg, VA, 17-19 May 2011.

Prasad, P.V.V., J.B. Naab, M.D. Doumbia, and T.D. Dalton. 2011. Conservation agricultural practices in West Africa. Presented at the SANREM CRSP Annual Meeting, Blacksburg, VA, 17-19 May 2011.

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Abstracts (2)

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Other (1)

J.A. Delgado, P.M. Gagliardi, E.J. Rau, R. Fry, U. Figueroa, C. Gross, J. Cueto-Wong, M. J. Shaffer, K. Kowalski, D. Neer, D. Sotomayor-Ramirez, J. Alwang, C. Monar, L. Escudero, and A. K. Saavedra Rivera. 2011. Nitrogen Index 4.4. User manual.

Reports (6)

Alwang, J., A. Boatwright, K. DuBreuil, R. Gaffney, L. Moore, A. Latané, and T. Simmons. 2011. Determining costs of conventional and conservation agricultural practices. Blacksburg, VA: SANREM CRSP.

Dayo, H. 2011. Conservation agriculture for food security in the Philippines: gender, economics, and technical knowledge network objectives. Progress report from host-country collaborator to LTRA-12 Principal Investigator.

Ella, V. 2011. Conservation agriculture for food security in the Philippines: Soil quality monitoring in researcher managed studies; and solute transport and crop modeling in plow based and conservation agriculture systems. Progress report from host-country collaborator to LTRA-12 Principal Investigator.

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SANREM CRSP leveraged funding, FY 2011

Table 40. SANREM CRSP leveraged funding

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], $
Conservation agriculture and natural resource management in Saraguro, Provincia de Loja, Ecuador	Barrera	INIAP	2010-2012	SENACYT, Govt of Ecuador	$500,000	
Graduate studies in plant pathology at Penn State University	Backman	Penn State University	2010-2011	Penn State scholarships and stipends (4 students)	$93,000	
Graduate studies in agricultural economics at Virginia Tech	Alwang	Virginia Tech	2010-2011	Department of AAEC	$40,000	
Nursery construction for reforestation, erosion reduction, and agroforestry	Barrera	INIAP	2010-2011	USAID/Ecuador small project fund	$5,000	
Establishment of a small-scale facility to produce bio-inputs for agricultural production	Barrera	INIAP	2010-2011	USAID/Ecuador small project fund	$5,000	
Support for project activities to enhance NRM in Chimbo area	Barrera	INIAP	2010-2011	INIAP-SENESCYT	$12,000	

Application of SANREM-generated NRM and CA practices to Saraguro, Loja Province	Barrera	INIAP	2010-2011	INIAP-MAE		$16,000
INTSORMIL - CRSP	Prasad	Kansas State University	Oct 2010 - Sep 2011	USAID	80,000	
USAID - Mali Mission - Research	Prasad	University of Nebraska	Oct 2010 - Sep 2011	USAID	92,000	
Borlaug LEAP Fellowship	Jay Norton/Jeremiah Okeyo	University of Wyoming	10/1/11 – 9/30/12	UC Davis	$20,000	$20,000
Thesis support for student	Stephane Boulakia	PADAC	June 2010 to May 2011	PADAC	$10,000	
Support for Dr. Agustin Mercado and Dr. Victor Ella to attend second international conservation agriculture workshop and conference, Phnom Penh, Cambodia, July 4-7, 2011	Stephane Boulakia	CANSEA	July 4-7, 2011	CIRAD	$4,000	

USAID common indicators for SANREM CRSP

Table 41: USAID Common Indicators

Indicator	Documentation (list each relevant item by indicator category)
Beneficiaries	
Increases in smallholder income	15 percent for one site
Number of male-headed rural households benefiting directly from interventions	1,558
Number of female-headed rural households benefiting directly from interventions	174
Number of partner organizations and active institutional members of those partner organizations	44 and more than 2000
Number of agriculture related firms benefiting directly from interventions	16
Number of producer organizations assisted/benefiting	35
Number of trade and business associations assisted/benefiting	27
Number of community based organizations assisted/benefiting	13
Number of women's organizations/associations assisted/benefiting	7
Number of new public-private partnerships assisted/benefiting	7

Indicator	Documentation (list each relevant item by indicator category)
Training	
Male participants in short-term training	1,097
Female participants in short-term training	935
Male participants in long-term training	19
Female participants in long-term training	20
Technologies	
Increase in crop yields	15 percent at one site
Decrease in production costs	10 percent at one site
New technologies/management practices under research	50
Technologies or management practices being field tested	47
Technologies made available for transfer	14
Hectares under new technologies	793.2
Number of farmers adopting new technologies	2,331
New surveillance systems	19