SANREM CRSP Semiannual Report 2012

October 1, 2011 – March 31, 2012

Sustainable Agriculture and Natural Resource Management

Collaborative Research Support Program

Report coordinators:

Adrian Ares, Program Director

Keith M. Moore, Associate Program Director

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Executive Summary

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

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
- promote the functioning of sustainable resource-based local enterprises in national, regional, and global markets

The majority of SANREM CRSP research is conducted through its Long-term Research Award (LTRA) programs. The SANREM CRSP Phase IV LTRA activities were initiated in 2010 and this semiannual report describes their accomplishments to from October 1, 2011 to March 31, 2012. Each of the projects has established a set of field trials testing their 'best bet' CAPS practices and some initial findings are emerging. On-farm and on-station research trials were established nearly simultaneously in most sites.

The semiannual report also reports on progress of the four cross-cutting research activities (CCRAs) dealing with economic impact analysis, gendered knowledge, soil quality and carbon sequestration, and technology networks, and describes the accomplishments of the management entity (ME) during the first six months of FY 2012.

Training and knowledge dissemination

SANREM CRSP training, publications, and other knowledge dissemination products for the first half of fiscal year 2012 (FY2012) included the following:

- 17 students supported for Ph.D. training (7 women and 10 men)
- 24 students supported for master's training (13 women and 11 men)
- 4 undergraduate students supported (2 women and 2 men)
- 2,980 short-term training participants (1,250 women and1,730 men)

- 9 refereed journal articles
- 1 working paper
- 16 papers or seminars presented
- 28 electronic presentations
- 30 posters
- 2 reports
- 9 abstracts
- 1 survey instrument
- 1 website

Phase IV Long-term Research Awards (LTRAs)

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

The goal of this LTRA research project is to understand the socioeconomic and biophysical constraints to CAPS (Conservation Agriculture Production Systems) adaptation and adoption in the Central Plateau of Haiti, to design and test strategies to work around those barriers in ways that increase agricultural productivity, and to work with smallholders to discover pathways to adoption. We are focusing on CAPS systems that include crop rotation, reduced tillage, and cover crops. During the past six months, Thompson became P.I. of the project in place of Hodges, who continues on the project. Three team members have traveled to the Central Plateau on two trips during 2012 thus far. These meetings have strengthened ties with our in-country partners. We hired a full-time Assistant Coordinator for SANREM Haiti. This individual is an Agronomy graduate of FAMV, State University of Haiti, and will facilitate communication and ensure that the activities in-country are properly coordinated. One graduate student (M.S.) involved with the project is nearing graduation at Virginia Tech, one continues to make progress toward a Ph.D., and we are recruiting two more graduate students (M.S. and Ph.D.). Maize was harvested at two experimental sites (Corporant and Lachateau) and the data have been received from our partners in Haiti. Cover crop-tillage interaction experiments were successfully initiated at three locations (Corporant, Lachateau, and Maissade). Soil samples were collected from the plots for 'baseline' characterization of soil properties before the experiment was initiated. During April, a local maize cultivar will be planted into these plots and improved cultivars from CIMMYT will be planted in separate plots at the three locations.

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

Our project is intended to test the concept of conservation agriculture (CA) for smallholder farmers in high-altitude, fragile areas of the Andean Region (Ecuador and Bolivia). As the concept is tested and successful conservation agricultural production systems (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, off-farm damages from on-farm practices, farm incomes and their variability, food security, gender relations and other social considerations. CA trials have been established in Ecuador and Bolivia. Trials in both countries are well established, and we are mid-way through our second planting cycle (Ecuador) and finished our first planting cycle (Bolivia).

SANREM researchers have built a strong base of collaboration with local stakeholders and identified a number of agricultural technologies with potential for incorporation in the CAPS. We now have: (i) established research designs for on-farm CA experiments; (ii) conducted baseline evaluations of soils and socioeconomic conditions; (iii) well-established protocols for collecting cost and economic information from our experiments and preliminary information about costs; (iv) functioning soils laboratories in both countries, each of which benefited greatly from interactions with SANREM scientists (particularly those from Penn State); (v) 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; (vi) improved management of woodlots to enhance incomes for farmers; and (vii) solid networks between researchers and other stakeholders to facilitate research and generate local buy-in. We also have several publications in press or under review.

Our field research is ongoing as research plots are established on farmer fields and we are mid-way through the second agricultural 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 most-likely CAPS and we are using them to measure erosion under different CAPS alternatives. We also have field trials and laboratory experiments to examine cost-of-production-reducing biological agents for pest and disease control and to stimulate plant growth.

In our last report on Bolivia, we noted that in Waylla Pujru and Sancayani we had problems due to late and inadequate rainfall, which prevented establishment of a solid cover crop (using *Vicia dasycarpa).* In contrast in "15 de Octubre" activities had progressed well. In the current campaign, we are continuing with the second crop in our rotation in "15 de Octubre"—potatoes, planted from Sept 2011 and harvested in January 2012. Following harvest, in February 2012, we started a third rotational crop–vetch mixed with oats. In Waylla Pujru and Sancayani we began with vetch and oats, which are currently reaching their last stage of development. These plots are focused on the viability of vetch and oats as cover crops, animal feeds, and soil fertility enhancements. Since adoption of new forages depends on farmer preferences, we have examined these preferences with our partners at CIF (Centro de Investigación Forrajera). We used results of this analysis to further refine our CAPS treatments. Our partnership with CIFEMA (Centro de Investigación, Formación y Extensión en Mecanización Agrícola) has been fruitful. CIFEMA is evaluating an animal-drawn quinoa direct seeder and three prototypes are currently being evaluated in farmer fields.

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

The first objective of documenting local conservation agricultural practices, baseline surveys and base line soil sample collection were completed in both Ghana and Mali. Analyses of soil samples are still in progress and continuing. Several components of CAPS were included in mother tests and are being tested . In Ghana, our research showed that across cropping systems, there were no statistical differences in maize grain yield between conventional tillage, manual tillage and minimum tillage (pre-emergence herbicide and one hand-weeding). When averaged across tillage systems, maize following soybean produced greater yield (grain and residue) than continuous maize or intercropping systems. Maize following soybean without fertilizer under minimum tillage produced greater grain yield than maize following soybean without fertilizer under conventional tillage. Similarly, maize following soybean with application of either P fertilizer or compound (NPK) fertilizer under minimum tillage produced greater grain yield than the same treatments under conventional tillage. There was clear evidence of preceding legume (soybean) effects on maize crop residue or grain yield. In Mali, research showed that minimum tillage along with tied ridging and mixed cropping (millet and cowpea) produced greater yield (15%) on millet compared to farmers practice in Mopti region. There was no influence of crop residue on millet or cowpea yield (as there was for the first year). However, tied ridges increased millet yield by 26% compared to farmer practices in the Cinzana region. Contour ridging and water harvesting techniques improved grain yield of sorghum by more than 50%.

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

The University of Tennessee team continues conservation agricultural production systems (CAPS) research, outreach, and extension activities in Lesotho and Mozambique. In Lesotho, we continued project upscaling by assessing how to adapt CAPS to farmer conditions and farmer questions drawing on the data collected from the baseline household survey taken in 2010. We continue to monitor carbon sequestration at our field research site in Maphutseng using soil and micrometeorological data to calculate Bowen's Ratio, a ratio that can be used to determine whether soils managed under CAPS is a sink or a source for carbon dioxide. Basic agronomic research continues at the research sites in Maphutseng and Roma; field studies evaluating fertilizer rate, seeding rate, yield, weed control and management, and winter cover crop selection is ongoing. Throughout much of Lesotho there will be a dismal harvest due to drought in contrast to last year where little was planted due to excessive rainfall in December and January. We again expect to harvest in excess of 7 tons of maize per hectare from our research plots due to early planting and continual soil cover that limits soil erosion and conserves moisture. This yield is approximately twenty times greater than the average maize yield in Lesotho.

CIMMYT, our partner in Mozambique, continues on-farm demonstrations evaluating varieties, tillage method, fertility level, and cover crop species. This past year UT supported their work

by analyzing more than 3000 soil samples and will continue to provide soil analysis and technical support to their conservation agriculture work in several districts surrounding Chimoio. Recently, we completed a baseline survey in several districts in Mozambique. The districts covered include Angonia (with four sites; Calomue, Domue, Mpandula, and Ulongue), Macanga, and Tsangano (with four sites; Banga, Nsaladzi, Ntengombalame, and Sede).

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

During the first half of year 3 we remained on schedule in implementing objectives 1, 2, 3 of our CAPS development and implementation project in Kenya and Uganda. For objective 1, large stakeholder advisory groups developed during year 2 actively participated in on-going research work and demonstrated excellent understanding of on-going work by taking turns to accurately describe every step of research establishment, management, and basic data collection, including timing of these activities, during the Reflection and Training Workshops held in November, 2011. Under objective 2, Reflection and Training Workshops revisited training on erosion and soil depletion processes as caused by conventional tillage practices and reviewed CAPS and CA definitions and processes. Two prototype multifunction implements (MFI) designed by a U.S. engineer to increase the efficiency of minimum tilling operations were shipped to East Africa in March 2012 and tested with oxen and donkeys in both countries. Tests revealed that the MFI exceeded expectations and will be playing a key role in all future CAPS operations. Under objective 3, we collected agronomic data and second phase soil samples, and successfully prepared and planted each of our nine treatments at each of the 20 study areas for the second phase implementation of the study. Preliminary agronomic data, suggesting that tillage practices in Uganda may not be as critical as generally believed, were shared among stakeholders. The six Kenyan and Ugandan graduate students involved in the project have all taken active roles in each stage and will visit all the sites and participating farmers frequently.

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

Most of the planned activities for the reporting period have been completed successfully as per schedule. During the reporting period, baseline data on socio-economics and farm practices have been collected for an additional village in India. The agronomic as well as socio-economic data collected by the project has been already analyzed. Results suggested that intercropping improves yield and food and nutritional security, whereas the effect of tillage differs between Nepal and India. Analysis of on-farm trial data from Nepal showed that sole cropping of cowpea provided higher protein yield and profitability, whereas the cowpea-millet intercrop system provided a significant yield advantage in terms of land equivalent ratio (LER). The crop and soil data collected from on-farm field experiment in India are in the process of analysis. Analysis of data from on-station trials in India indicates that maize-cowpea intercropping under minimum tillage recorded the highest net profit with a revenue-to-cost ratio of 2.13, which is 17.6% higher than yield of maize grown under conventional tillage. Conservation tillage provided some labor savings in both countries. Analysis shows that there were no differences in labor requirement by conservation practices in Nepal, but in India there was substantial

increase in land preparation, weeding and harvesting labor associated with intercropping. The effect of the CAPS on soil has not been analyzed yet, but the project plans to use an innovative in-field measure of water stable aggregates as the key soil quality indicator. However, multivariate analysis of soil parameters suggests micronutrient deficiencies are important in Nepal.

There has been substantial progress in terms of design and implementation of the research activities during the reporting period. The Institute of Agriculture and Animal Science (IAAS) has begun on-station research trials for selected CAPS in Nepal. After consultation with farmers and analyzing the results of the analytical hierarchical process (AHP), cowpea has been replaced by black gram as the legume intercrop. We identified a knowledge gap regarding the benefit of strip tillage by conducting three AHP exercises in Nepalese villages. The preference survey and stakeholder consultation done by using AHP identified yield and environmental quality as the most important factors for conservation agriculture for farmers in India and Nepal, respectively. In Nepal, cognitive mapping indicated that soil nutrition was perceived as being important for crop yield and adoption.

Short-term training of host country research teams and other professionals focused on: tools for participatory investigation like AHP and Mental-Model; and CAP practices in the reporting period. From the experience of participatory research with farmers, it was realized that the inter-disciplinary approach is important for developing effective research strategies. Multi stakeholder participation is important for preference identification and developing effective interventions.

Two Ph. D. students, one each from India and Nepal enrolled at the University of Hawaii-Manoa.

Several pipeline reports and papers generated from analysis of the research trials and three extension papers, one journal article, five abstracts, four posters, and one factsheet have been or will be published. The project also focused on networking and scaling up of the outputs from the results.

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

Year 3 progress showed the promising potential of conservation agriculture production system (CAPS) for food security in Cambodia and the Philippines. Year 3 results indicated increasing yield of maize in CAPS compared with decreasing yield of maize grown in plow-based systems. Furthermore, CAPS has been shown to be more resilient to drought compared with plow-based systems. Moreover, soil organic matter was measured to be higher in CAPS than in plow based systems and increased from 2010 to 2012. Gross profit margin of CAPS was less than plow-based practices in years 1 and 2 but greater than plow-based practices by year 3. There are indications that farmers are seeing the potential of CAPS and will shift to it. CAPS sowing-machines were purchased by farmers for use and for rent with 30 additional farmers preregistering to convert their land from plow-based to CAPS. *Stylosanthes guanensis* and *Arachis pintoi* were found to be promising legume cover crops in the Philippine site, while

Cajanus cajan and *Vigna umbellata* did well in the Cambodian site. Also, it was found that resilient 'Adlai,' which comes from a family of grasses and was once considered as a weed, has prospects to be a CAPS crop that can substitute for corn and upland rice. As a spin-off, CAPS for urban vegetable home garden production study funded by the United States Department of Agriculture has been set-up at the campus of North Carolina A&T. From SANREM phase III results two books about vegetable agroforestry were launched. Lastly, our research team was requested to assist by French research agency, CIRAD, in the Third International Conservation Agriculture Conference in Southeast Asia to be held in Hanoi, Vietnam, December 2012.

Cross-cutting Research Activities (CCRAs)

Economic Impact Analysis CCRA

The Impact Assessment program proceeded along two lines during the past six months.

First, the analysis presented in the Nguema master's thesis based on data from LTRA-7 was summarized in a journal article manuscript and submitted for review to *Experimental Agriculture*. The model in the article was also designed as a template for use in other sites to identify optimal CAPS elements and cropping systems to be assessed. "Optimal" in the model is defined in terms of profitability of rotation-practice combinations, subject to varying amounts of carbon sequestration and limits on soil erosion. The linear programming model for the Ecuador trials found that specific cover crops, crop rotations, and reduced tillage designed to reduce soil erosion and increase soil organic matter should lead to increased incomes for farm households in a time period as short as two years. It appears that conservation agriculture practices have the potential to improve the livelihoods of the rural poor in Ecuador because conservation agriculture activities entered the revenue-maximizing model solution for both sub-watersheds.

Second, each LTRA was contacted to assure that cost of production and yield data are being collected for subsequent impact assessment. These data will be used by each LTRA to conduct CA profitability analyses and impact assessments. Over the next year, they will be combined with CA adoption projections to assess potential project benefits. In LTRA-8, data are being collected by economists at Kansas State to assess profitability of reduced tillage, cover crops, and rotations for maize, beans, sorghum and millet in the northern region of Ghana. A linear programming model is planned there to analyze the set of optimal practices. Some cost and yield data exist for cover crops, tie ridges for water management, intercropping for sorghum, millet, and brassicas. In LTRA-9, costs and yield data for maize cover crops and no-till are being collected in Lesotho and Mozambique by the economist at the University of Tennessee. Baseline surveys were completed in Lesotho and Mozambique. In LTRA-11, yield and labor use data have been collected for rotations and intercropping by economists at Hawaii and a format was provided to them for collection of additional cost of production and yield data. In LTRA-7, costs and yield data were gathered for experiments on quinoa, beans, and potatoes with direct seeding, cover crops, and rotations. In Ecuador, cost and yield data were collected for potatoes,

maize, barley, beans with cover crops such as oats and vetch, rotations, and reduced tillage. Results from the linear programming model provide information on the optimal set of practices for two sub-watersheds. In LTRA-12 in the Philippines, cost and yield data are available for researcher managed trials and are being collected on farmer managed trials with an emphasis on maize, cowpeas, rice and beans. Practices include cover crops, reduced tillage, and rotations. In Cambodia, maize and cassava are the primary crops and the Ministry of Agriculture has cost and yield data that have been collected over multiple years with the help of a CIRAD project.

Gendered Knowledge CCRA

The Gender CCRA continued Phase IV activities for Fiscal Year 3 through analysis of gendered soils knowledge, practices, and space data from Bolivia and pretesting data collection instruments in the Philippines LTRA sites. Research methods were adapted and modified for future work in the Philippines and other LTRA sites. In addition, the CCRA furthered ongoing collaboration with the Soils CCRA, disseminated knowledge products, and collaborated with visiting scholars. Presentations were given at various academic conferences on fieldwork from Bolivia and preliminary research in the Philippines. A student thesis from Bolivia fieldwork and data is in progress. Planning is underway for a graduate research assistant to carry out fieldwork on gendered knowledge and space and GIS mapping in the Philippines from July through August 2012.

Technology Networks CCRA

Two data collection activities were completed during the past six months. These focused on the technology network modules identifying network contacts of agricultural service sector and community agents and indicators of their agricultural knowledge and perceptions. The first involved completing the service sector/community agents' survey for two communities of farmers around Botha Bothe in Lesotho building on the work of LTRA-9. The second involved completing interviews with the service sector/community agents in the region of Mopti, Mali (LTRA-8). These data have been entered into Excel files for subsequent analysis in SPSS and UCINet. Only household level data has been collected by LTRA-6 economics graduate students in Haiti and the technology networks modules have not been completely entered yet. A second type of activity involved preparing and providing feedback to network partners in the four communities of LTRA-10 in Kenya and Uganda. The foundation for this feedback was based on the working paper documenting the research findings concerning the four communities. This lead to the development of separate (one per community) extension type handouts used during the workshops discussing these findings.

Jeni Lamb completed her master's Degree in Applied and Agricultural Economics during the Fall 2011 Semester and continued on with the work in Lesotho, Kenya and Uganda during the first half of 2012.

The technology networks research is interested in two key areas: 1) knowledge and beliefs about agricultural production and 2) size, composition, and structure of farmer and agricultural service sector networks. This implies the utilization of two different types of statistical analysis.

The following research progress report summarizes key findings for the Kenyan and Ugandan communities for these two types of analyses. A working paper on the social network analyses of these four communities provides more extensive detail on the findings and implications of the research.

Soil Quality and Carbon Sequestration CCRA

The hypothesis of this CCRA is that CAPS in developing countries will increase labile 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 (total nitrogen (N), available phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), pH, cation exchange capacity (CEC), etc.) will also be measured.

Coordination of soil and agronomic investigations among all 13 developing countries before and after conservation agricultural production systems (CAPS) are implemented is critical to measuring soil fertility and carbon sequestration changes due to CAPS. We are coordinating all long term research activities' (LTRA) data collection so that we can make meaningful and scientifically verifiable comparisons across all project sites. We have successfully modified a United States Department of Agriculture (USDA) soil import permit to allow hand-carrying of soil samples, and continue to receive soil samples from project sites. These will be used to establish a common dataset so that scientifically valid comparisons among project sites can be made.

We have finished analyzing soil samples for collaborative work with the Gender cross-cutting research activity (CCRA) to establish gendered knowledge of soils in Bolivia.

We distributed cover crop seed to the Haitian partners and have collected Time 0 soil samples for the researcher-managed experiments. We have also begun efforts to determine soil fertility variability within and among fields in collaboration with the Haiti LTRA, which will also provide insight into the link between household economic efficiency and soil fertility. 25 no-till seeders and three weather stations have been purchased for the project. A Haitian agronomist has been hired as the Assistant Country Coordinator to facilitate our research objectives in that country.

Continuous soil CO_2 monitoring units were tested in both the field and the laboratory. Modifications were requested from the manufacturer, and we have since ordered six units for deployment in Kenya in collaboration with LTRA-10.

We have developed a work plan for the investigation of soil organic carbon (SOC) increases due to soil and water conservation measures along a chronosequence in Mali.

Phase IV Long-term Research Awards (LTRAs)

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

Lead PI: Thomas Thompson, Virginia Tech

Host Country: Haiti

Research Progress by Objective

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

Progress toward completing critical Annual Work Plan tasks—Collection of our baseline economic survey data is complete. We surveyed 603 households in the lower plateau, concentrating on rural farm households and following random stratified sampling methods discussed in the previous report. The survey data comprise information on more than 3200 individuals, 1400 agricultural plots farmed by households, 1200 fuelwood and water collection sites, and more than 3300 crop plantings. The rejection rate among participating households was 1.4%, which is low considering sampling was conducted during the harvesting season. A follow-up survey effort will be implemented in May-June 2012 to collect final harvest data for households who participated in the survey.

Significant research findings—

- Preliminary survey results show an average age of approximately 25 years for all participants, with 84% of households headed by a male.
- Five percent of the population sampled indicated that they were earthquake refugees, while 5% reported being affected by the cholera epidemic.
- A summary of plot data is shown in the attached figure. The most important planted crops were corn, millet, and pigeon pea, although there is considerable diversity across plots and for different types of households.
- Average plot size is 1.63 hectares and the average household has 2.3 plots. Some plots (7.3%) are irrigated when near rivers. Households spend on average $48 per plot per season, and 20% of plots are burned prior to planting.

Changes in research design or methods, obstacles encountered, and actions—none

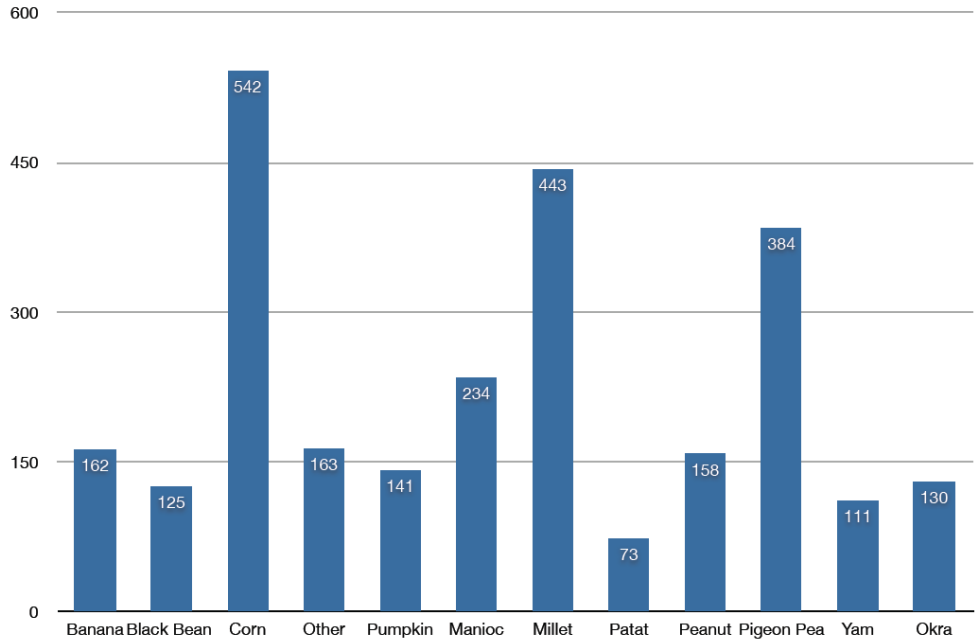


Figure 1: The most frequent crops found in household survey plots

Objective 2. Increase agricultural production through development of CAPS.

Progress towards completing critical Annual Work Plan tasks—The Virginia Tech team visit during January 2012 was focused on strengthening connections with agronomist teams at Zanmi Agrikol and Caritas Hinche, and preparing for the upcoming growing season. Successful maize cultivar trials initiated by Caritas were observed at Maissade. One-hour training sessions for agronomists were held at Corporant, Lachateau, and Maissade. During these training sessions, cover crop seeds and protocols for cover crop-tillage interaction trials were distributed. These trials were initiated successfully in January by partner agronomists with the seeding of three cover crop species to be compared with a no-cover control. At each of the three experimental sites, crimson clover (*Trifolium incarnatum* L.), spring oats (*Avena sativa* L.), and velvet bean (*Mucuna pruriens* L.) were planted in a split plot experimental design. In preparation for maize planting (during April), each of these cover crop areas will be split and ½ of the cover crop residue will be left on the surface as a mulch and ½ will be plowed as normal. Crop germination and vigor, early season weed suppression, and other agronomic factors will be assessed. These studies were established in the dry season and were provided supplemental irrigation. In the future, these cover crops will be established in the fall after cash crop harvest or fallow. During the team member visit in Feb. 2012, successful initiation of these experimental designs was confirmed, thus indicating progress toward the following tasks (Tasks 2.1, 2.3, and 2.5 from our 2011-12 work plan): *building research capacity to conduct agronomic trials, introduction and evaluation of cover crops (on-station);* and *integrate cover crops, planting practices, and rotations into the on-station testing protocols.* The APSIM crop simulation model has been purchased and is being evaluated for a variety of conditions, and weather stations have been purchased, indicating progress toward the task: *cover crop and cropping system modeling*.

Significant research findings

- Harvest of maize cultivars best suited to CAPS systems occurred in Fall 2011 at Corporant and Lachateau experimental sites.
- At Corporant, yield of the best improved cultivar was 26% higher than that of the best local check.
- At Lachateau, yield differences were more pronounced and the yield of the highest producing CIMMYT line was 180% that of the highest local check maize entry.

Changes in research design or methods, obstacles encountered, and actions taken—Because of unavoidable delays caused by the 2010 earthquake and the 2011 cholera epidemic in the Central Plateau, the field experiments are about 1.5 years behind schedule. However, we have made positive progress in the past three months, with more involvement from our Haitian partners and cover crop trials now in place at three locations. We hired an in-country Assistant Coordinator who will travel frequently to the Central Plateau to facilitate and monitor progress of the field experiments.

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

Progress towards completing critical Annual Work Plan tasks—During January 2012 our team was able to spend more than one hour with approximately 50 farmers from the area near the Maissade farm, of which approximately 50% were female. Topics of discussion included the major barriers to crop production and conservation practices currently in use. We shared key elements of conservation agriculture (crop rotation, reduced tillage, cover crops), and explained the basic features of our project with Caritas. The successful initiation of the cover crop-tillage interaction trials by Zanmi Agrikol and Caritas agronomists illustrates progress toward effective demonstration and research projects to benefit local farmers.

Significant research findings—none

Changes in research design or methods, obstacles encountered, and actions taken—none

Objective 4. Strengthen human and institutional research and extension capacity for CAPS

Progress towards completing critical Annual Work Plan tasks—The research farm sites provide a model for testing a private/NGO system for national agricultural outreach/extension. With research trials now in place, progress has been made toward creating more capacity for research and demonstration in CAPS. Each farm center (Corporant, Lachateau, Maissade) offers a focal point for locally adapted CAPS technological innovation and outreach, as well as for future research.

Significant research findings—Two of the research sites have supplied useful maize yield results:

- Harvest of maize cultivars best suited to CAPS systems occurred in Fall 2011 at Corporant and Lachateau experimental sites:

- At Corporant, yield of the best improved cultivar was 26% higher than that of the best local check.
- At Lachateau, yield differences were more pronounced and the yield of the highest producing CIMMYT line was 180% that of the highest local check maize entry.

Changes in research design or methods, obstacles encountered, and actions taken—None, except as already noted above.

Significant Training, Capacity Building, and Networking Activities

- Two degree training students are being supported (one MS and one PhD)
- Eight short-term training events provided training for 238 men and 181 women.
- No publications have been developed.
- List any special events or networking activities—None

Research Strategy and Development Objectives

1. Describe progress achieving research milestones.

    - Successful cultivar trials at Corporant and Lachateau will help our partner agronomists become familiar with improved cultivars adapted to their areas. A cultivar trial planted at Maissade was not successful; nevertheless this is progress that can be built upon in the future.
    - The implementation of cover crop-tillage interaction trials during January 2012 is critical for the evaluation of CAPS systems for the Central Plateau.
    - Completion of the baseline survey

2. Indicate how this contributes to progress along the development impact pathway

    - Enabling Haitian agronomists to conduct on-farm research will create more capacity in extension.
    - The baseline survey data will be used to estimate econometric and economic models explaining decisions farmers make concerning practices. Production functions estimated from these models will also be compared to plot-level trial data from other parts of the project to determine the upper bound on production costs that must exist for more intensive conservation agriculture to be productive for Haitian farmers in the Central Plateau. Other uses of the data will be to determine how households respond to shocks, drivers of efficiency and conservation decisions, and the impact of markets and networks on farmer decisions.

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

Lead PI: Jeffrey Alwang, Virginia Tech

Host Countries: Bolivia, Ecuador

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

Accomplishments under this objective were reported in the annual report.

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

Task 2.1: Create protocols for evaluating soil and crop sustainability in experiments: physical, chemical and biological changes over time and due to differences in agricultural practices.

These protocols were designed in prior years. We are continually making adjustments based on ongoing experience and input from host-country and US university partners. In both countries we have established a data base for soil data and are collecting soil data as needed. We are also collecting cost of production data for the economic analysis of CAPS.

Task 2.2: Establish experiments for CA components, component combinations and full CAPS

We are continuing the on-farm research as reported in earlier periods. Data for the second year of production are not yet available and we will report on this at a later date.

In Ecuador, a new cropping cycle began between February and March. Farmer field plots were planted according to the established design. As noted above, in the Bolivia site, we are recovering from an erratic first-year of rainfall. We have also added quinoa as a focal crop as, due to high prices, farmers are increasingly interested in growing quinoa. We have thus established a fourth treatment in our 15 de Octubre site—including quinoa in a CAPS rotation.

A major accomplishment in the past six months was recruiting Kathleen Webber as a master's student in Soil Science at Penn State. Kathleen's research will be conducted in Ecuador and will focus on the problem of phosphorus fixation in the Andisols of the Illangama study site. Kathleen will also contribute to the overall CAPS experiments primarily by assisting with data management and analysis. Kathleen is fluent in Spanish so will also be able to facilitate communication with our Ecuadorian collaborators. Kathleen Webber's stipend and tuition for the first two semesters of her program were paid for by the Penn State Crop and Soil Science Department, the remainder of her program will be covered by SANREM.

We discussed on-site review of the CAPS field experiments at the Illangama and Alumbre sites, and discussed problems and potential resolutions. During a trip to Ecuador, Kathleen was introduced to INIAP collaborators, received a complete review of the CAPS experiments, visited all field sites, discussed her involvement with the CAPS experiments and a greenhouse experiment to investigate phosphorus fertility problems in the andic soils of Illangama and Alumbre and made plans for an extended (~2 mo) visit. Soil samples were collected at the Alumbre and Illangama field sites and returned to Penn State University for soil characterization and initial laboratory investigation of phosphorus sorption/desorption.

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 to increase the capacity of this facility to conduct the key soil and plant analysis necessary to measure the progress in building sustainable CAPS. The primary soil measurements included: 1) total carbon [C], nitrogen [N] and phosphorus [P], 2) plant available N and P, 3) available cations, 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 indictors of the stored fertility that can occur with cover crops and the application of 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 indicators for the erosion potential of soils. To conduct these analyses, some basic field and laboratory equipment, as well as reagent 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 has 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 Dr. Soraya Alvarado has taken the lead in overseeing these analyses. Dr. Alvarado has considerable experience in the evaluation of soil quality and is a

great asset to our progress. Gallagher has been working with Drs. Alvarado and Barrera to further increase the efficiency and capacity of this laboratory.

Complementary soil health experiments

Developing sustainable methods to enhance crop nutrition is essential for achieving high yields with low environmental impacts. The use of microbial biofertilizers is one such method of enhancing crop nutrition. Microbial biofertilizers can either synthesize a needed plant nutrient, such as nitrogen fixation by *Rhizobia*, or microbial biofertilizers can alter soil conditions to make plant nutrients more available, such as how phosphate solubilizing bacteria provide phosphate to plants. Phosphate solubilizing bacteria make soil phosphorus more available to plants through the production of organic acids, phosphatases, or acidification through proton efflux. The most commonly studied genera of soil bacteria that are able to solubilize phosphate are *Pseudomonas*, *Rhizobia*, and *Bacillus*.

We have focused on *Bacillus* species that are able to solubilize phosphate. We focus on *Bacillus* because it is able to form environmentally stable endospores, which have a long shelf life when used as biological products. Also, our collaborators at Foundation PROINPA have the fermentation capacity and experience to produce *Bacillus* for commercial use. We have isolated *Bacillus* from *Chenopodium album* (lambsquarters) due to its close relationship to quinoa in Pennsylvania and from quinoa from Ecuador and Bolivia. *Bacillus* isolates were obtained from roots, stems and leaves and identified to species or species group using 16S DNA sequencing. These isolates were then qualitatively tested for their ability to solubilize phosphate using a standardized methodology.

171 *Bacillus* isolates from *Chenopodium album* were qualitatively tested for phosphate solubilization and 100 isolates (58%) were able to solubilize phosphorus. 327 *Bacillus* isolates were tested from Ecuadorian quinoa plants and 204 isolates (62%) were able to solubilize phosphorus. 342 *Bacillus* isolates were also obtained from quinoa plants from Tiraque Province, Bolivia and these isolates will be tested for their ability to solubilize phosphate. A high percentage (nearly 100%) of *Bacillus pumilus*, *B. subtilis*, *B. megaterium* and *Paenibacillus* isolates obtained in this study are able to solubilize phosphate, whereas members of the *B. cereus* group are weak phosphate solubilizers. This knowledge allows our collaborators to focus their efforts on groups of *Bacillus* that are more likely to be able to solubilize phosphate.

Commercially available *Bacillus* isolates with known biological control and plant growth promoting properties were used in field trials in Pennsylvania. No measurable effects were detected in these trials, but trials were ended early due to heavy rains. Colonization trials with commercially available and Bolivian obtained *Bacillus* isolates are ongoing to look for possible plant growth promotion and biological control abilities of the *Bacillus*. 342 *Bacillus* isolates were isolated from Bolivian quinoa and will be transferred to PROINPA collaborators for further screening. The next stage of this research is to test the effects of phosphate solubilizing *Bacillus* on quinoa growth.

Biocontrol of key diseases

Twenty-four field isolates of *Botrytis fabae* and two of *Botrytis cinerea* were isolated from *Vicia faba* and *Phaseolus vulgaris* respectively. Both species of fungi are known to cause chocolate spot of *V. faba.* The strains' identity was confirmed by sequencing the IGS region and comparing to known sequences in GenBank. Of the 25 isolates, 12 were found to be pathogenic in detached leaf assays and whole plant assay repeats are in progress.

Three suspected isolates of *Alternaria spp.* we also isolated from the field and sequencing to confirm their identity is also in progress. *Alternaria fabae* is the second most destructive disease that affects *V. faba* in South America.

Field trial results show almost 100% colonization of vesicular arbuscular mycorrhizae (VAM) in *P. vugaris* and *V. faba* roots, high level of nodulation on *V. faba* and high colonization rates of *Bacillus subtilis* (GB122) on *P.vulgaris* roots. Foliar disease in *V. faba* was significantly reduced in the field (compared to controls) where seeds were inoculated with Rhizobia (R) + Bacillus (B), VAM + R, B only and R only. Root disease was reduced in MB inoculated seed, but this was not significantly different from controls. Emergence was increased in MB and B inoculated plants. CFUs/g root was the most in RB and MRB inoculated roots.

In *P. vulgaris* shoot vigor was significantly increased in MB shoots compared to controls. Shoot disease was reduced in MRB and RB plants, but this was the same as controls. Nodule number was significantly increased in RB compared to MR and R plants. Root fresh weight was significantly greater in MB and MRB roots compared to controls. Shoot fresh weight was highest in MB and B plants, and yield was highest in B and R plants. Colonization of roots (CFU/g) was highest in RB and B plants, and was still larger than the control in MRB, but significantly lower than RB and B.

Task 2.3: Create and follow protocol for measuring economic dimensions of CAPS.

We are collecting cost of production data in both countries and will conduct an analysis when we have sufficient information.

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

Initial calibration was done last year, but we are continuing to enter data as it becomes available. The model is undergoing evaluation as more data become available.

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

A protocol for this research objective has been designed; we are continuing to collect cost of production information throughout the production cycle. In Bolivia, SANREM scientists are seeking ways to exploit PROINPA's potential for producing bio-inputs. We are continuing to evaluate the cost-effectiveness of bio-input production at different scales.

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

No activities to report on.

Objective 5: Evaluate the overall impacts of the CRSP research program along several dimensions including soil health, productivity, economic, social and environmental; establish means of evaluating tradeoffs between multiple objectives

Dr. Wills Flowers is collaborating with the SANREM team in Ecuador to monitor the quantity and quality of water in important indicator streams. They are focusing on fecal coliform and macroinvertibrate.

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

We are addressing a gender imbalance in our research team in Ecuador. We have added two female engineers as a part of their undergraduate training. We continue to conduct gender training in both sites.

Significant Training, Capacity Building, and Networking Activities

Six women and three men are involved in long term degree training.

We are including 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.

PSU recently arranged for a five-week traineeship for Mayra Claros from our partner PROINPA Bolivia (SANREMME is supporting most of the costs) to develop high throughput technologies to isolate and identify plant associated microbes that enhance plant growth in nutritionally depleted soils (key target crops are quinoa, faba and common bean). The traineeship will begin in early June and extend into July at the University Park Campus and its department of Plant Pathology.

We have established important networks between participating scientists and our research team and local stakeholders. All participating US 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 our 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 our research team, the Bolivar Provincial government, the Guaranda city government, the local University (where Carlos Monar, former SANREM researcher is now an academic dean) and 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. Our professional

linkages between PROINPA and CIFEMA and CIF have strengthened our capacity to evaluate different dimensions of the CAPS (notably, mechanization and forages).

- Víctor Barrera (INIAP) submitted a proposal to the Secretaría Nacional de Educación Superior, Ciencia y Tecnología SENESCYT to extend SANREM research under the name "Generación de alternativas tecnológicas para el manejo integrado de recursos naturales en las áreas de mayor vulnerabilidad y riesgo de la subcuenca del río Chimbo". Amount of the proposal was USD 350,000.
- Víctor Barrera and Jeffrey Alwang presented to the McKnight Foundation a proposal entitled "Agricultura de conservación como una potencial vía para promover el manejo de recursos, incrementar la productividad y mejorar las condiciones socio-económicas en la Región Andina del Ecuador". This proposal was for USD 300,000.
- The team in Ecuador continues to use SANREM-produced knowledge to evaluate natural resource management activities in the Project "Manejo y conservación del capital natural que disponen las comunidades de Saraguro como mecanismo de adaptación al cambio climático". This Project is being conducted in Saraguro-Ecuador, with funding from the Ministry of Agriculture and UNDP.
- Víctor Barrera and Luis Escudero are conducting the project "Asociación de Desarrollo Comunitario San Francisco de la Bola de Oro", within the broader effort "Conservación del ambiente a través de la elaboración de fertilizantes orgánicos para la producción de cultivos en agricultura de pequeña escala". This Project is being funded by USAID.

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

Lead PI: P. V. Vara Prasad, Kansas State University

Host Countries: Ghana, Mali

Research Progress by Objective

Objective 1: Evaluate local CAPS

Progress towards completing critical Annual Work Plan tasks

Ghana and Mali: This objective is completed.

Objective 2: Develop cropping systems

Progress towards completing critical Annual Work Plan task

Ghana: Four on-farm mother trials were harvested, data were analyzed and results were summarized.

Mali: A total of eight on-farm tests (four agricultural systems of Mali and 52 farmers) have been harvested.

Changes in research design or methods, obstacles encountered, and actions taken

Ghana: In the mother trial in Nandom, pigeon pea was replaced with a perennial leguminous shrub, *Gliricidia sepium* because of its drought and fire or grazing tolerance. The mother trial which was located in Busa-Tanzu village was re-located further away in the distant fields to avoid destruction by animals. In the mother trial at Gbanko, the soybean plots were not rotated with maize as planned; instead soybean was planted on the same plot for the second year.

Mali: The mother and test plots in Cinzana zones had very poor results due to severe drought stress and delayed planting. In addition, in some sites in Sikasso region the establishment of *Bracharia* was a problem due to seed quality. In addition, at some sites when *Bracharia* was planted with the main crop it significantly decreased establishment of main crop. Keeping these lessons in view, adjustments will be made in planting time relative to main crop so that it does not overtake the main crop.

Significant research findings

Ghana: Averaged across cropping systems, there were no statistical differences in maize grain yield between conventional tillage, manual tillage and minimum tillage (pre-emergence herbicide and one hand-weeding).

Averaged across tillage systems, maize following soybean produced greater yield (grain and residue) than continuous maize or intercropping systems.

Maize following soybean without fertilizer under minimum tillage produced greater grain yield than maize following soybean without fertilizer under conventional tillage. Similarly, maize following soybean with application of either P fertilizer or compound (NPK) fertilizer under minimum tillage produced greater grain yield than the same treatments under conventional tillage.

There was clear evidence of preceding legume (soybean) effects on maize crop residue or grain yield.

Mali: Experiments from last year were statistically analyzed. These results are from 2010 harvested plots. Use of minimum tillage along with tied ridging and mixed cropping (millet and cowpea) produced greater millet yield (15%) compared to farmers practice in Mopti region.

There was no influence of crop residue on millet or cowpea yield (as this was the first year). However, tied ridges increased millet yield by 26% compared to farmer practice in the Cinzana region. Contour ridging and water harvesting techniques improved grain yield of sorghum by more than 50%.

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

Progress towards completing critical Annual Work Plan task

Ghana: Forty baby trials comprising sub-sets of the mother trials treatments were harvested; data were analyzed and summarized.

Mali: Fifty two (52) baby trials comprising sub-sets of the mother trials treatments were harvested, the data is currently being pooled and summarized.

Changes in research design or methods, obstacles encountered, and actions taken

Ghana: There were no major changes on research design. However, several farmers were dropped from the trials because of failure to follow the research protocol. In another community, some participating farmers' lands were taken away by the land owners. Women were the majority who were affected. Affected farmers who had access to other land were supported to continue with the trials.

Mali: There were no major changes on research design.

Significant research findings

Ghana: Minimum/reduced tillage continued to show comparable grain yield as conventional tillage in all baby trials.

Legume-cereal rotation effects on grain yield were observed in this second year of the trials.

Tied ridges or tied ridges with grass strips produced greater yield (grain and residue) than planting on flat plots. The differences in grain yield were supported by evidence of differences

in soil moisture content measured during drought periods. Maintaining greater than 30% soil cover with crop residues, bush fires and animal grazing remain as challenges.

Mali: Data are still being analyzed.

Objective 4: Assess long term effects of CAPS

Progress towards completing critical Annual Work Plan task

Ghana: Analysis of soil samples taken prior to the start of the trials in 2010 has now been completed at the SARI laboratory.

Mali: Analysis of soil samples taken prior to the start of the trials are being analyzed.

Changes in research design or methods, obstacles encountered, and actions taken

Ghana: There was no change in research methods, a 'minimum data set' has already been collected. The agricultural economist that was on the field research team has started his PhD program at Kansas State University, and, therefore, the cost-benefit analysis of the trials for the 2011 season will be a challenge. Efforts will be made to train a newly recruited agricultural economist for SARI.

Mali: No changes were reported.

Significant research findings

Ghana and Mali: Soil analysis has been completed and the results indicate the soils are generally low in organic carbon (about 0.6%) and total N (0.06%) with pH ranging from 5.7 to 6.2. Soil texture is predominantly sandy. Soil sample analyses from Mali are continuing.

Objective 5: Modeling to predict impacts of CAPS

Ghana and Mali: This objective was not being pursued during the period under review. Now that soil analysis is complete, and some crop growth data available, these will be input into the DSSAT cropping system model for initial simulation runs.

Objective 6: Strengthening capacities – workshops and demonstrations

Ghana: Three field days and training sessions were organized in September. The field days brought together both collaborating and non-collaborating farmers and the media. The field day was reported on the national radio and the official website of the Ghana government.

Objective 7: Capacity building – short and long (degree) term training

Ghana: Two students were identified for long term training. One student obtained admission at Kansas State University and will begin studying in the fall in Agricultural Economics. The second student is also identified and is currently in the US and will be starting his research in Fall 2012 and will official start his Ph.D. program in Spring 2012.

Mali: No short and long (degree) term training was performed during this year of the project.

Significant Training, Capacity Building, and Networking Activities

Ghana: One field day integrating SANREM and INTSORMIL was organized for training, capacity building and networking of farmers during this semi-annual period. Three field days and training sessions were organized in September. The field days brought together both collaborating and non-collaborating farmers and the media. The field day was reported on the national radio and the official website of the Ghanaian government.

Mali: Not reported.

Research Strategy and Development Objectives

1. Progress in achieving research milestones

Farmers have shown interest in adopting technologies related to minimum or reduced tillage, crop rotation with a legume crop (such as groundnut, soybean or cowpea) and improved soil fertility (application of N or P) and water management practices (tied ridges or contour ridging). Long term experiments to assess impacts of CAPS on soil quality and crop yields are continuing. Minimum data set have been collected on 'mother trials' at the start of the experiment. Baby trials initiated as on-farm test in selected villages and are continuing.

There were some problems with pigeon pea genotype (it was photoperiod sensitive), and, therefore, we will have to change genotypes or find an alternative crop. There were also problems with seed quality for *Bracharia*, and we are working on finding a better source.

Farmers' visits are continually organized to foster and advance adoption of CAPS.

2. Lessons learned

Research: Minimum tillage is showing a potential for adoption. Crop rotations with cereal – legume seem better than intercropping or continuous cropping. Farmers are showing an interest in use of some components of CAPs (particularly – minimum tillage, crop rotations (including legumes in the systems), water harvesting techniques (tied ridges, contour ridings, grass or legume strips), use of application of fertilizers (particularly P and N along with compost). Weed control and availability of herbicide is a continued problem in no-tillage or minimum tillage. Availability of implements to plant under no-tillage is a continuing challenge.

Administrative Problems: Ghana: Delays in reimbursement of funds after submission of invoice and receipts is hampering the timely implementation of activities. Expenses for some activities were pre-financed from other sources in anticipation of re-imbursement by SANREM. This has not happened till date and has the potential to stall things in the future.

Mali: Continued problems with submission of receipts and also submission of progress reports and other related activities.

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

Lead PI: Neal Eash, University of Tennessee

Host Countries: Lesotho, Mozambique

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.

Cover crops have been planted again in Lesotho and will be continually evaluated during winter and into spring. A graduate student will evaluate cover crop establishment, grazing durability, and carbon cycling rate. Cover crops continue to reduce winter annual weed populations by more than ninety percent when established early. Discussion with collaborators in Mozambique continues on how to have cross-cutting research between Lesotho and Mozambique once the analysis of data from Lesotho is complete.

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

This work continues in the current growing season, exploring the interactions between fertilizer rate, plant density, and mechanical and chemical weed control strategies. Following harvest, we will again evaluate the data to determine how this study should be changed for next season. Initial observations suggest that yields will probably surpass at least 7 t/ha. Discussions with collaborators in Mozambique are continuing regarding cross-cutting research analysis.

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.

Based upon earlier stakeholder discussion, we are continuing work on cover crop selection for weed suppression, biomass production, grain production, and residue cover. Wheat, rye, and oats are the leading grass candidates for winter cover crops mix whereas we continue to evaluate several vetch and clover species as the legume species. We continue work with oats due to the fact that oats are not a food staple crop and is self-reseeding within our cropping systems

Similar cover crop evaluation trials are occurring in Mozambique. However, new trials have been implemented due to the continuing pesky issues with termites. In the absence of any surface crop residues termites are attacking live maize plants and any plants lodged by storms must be harvested within one week else all biomass and grain will be immeasurable due to termite consumption. In some areas it is impossible to do CAPS, in Mozambique due to termites consuming the residue cover mandated by CAPS system definition.

Objective 4a: Determine the short and long-term impacts of CAPS on gender equity especially in terms of

household income and economic impact and to involve women in decisions that impact their welfare.

Data entry, cleaning and analysis for the survey of 435 Botha Bothe District farm households continues. These results will aid in addressing several gender issues, including time allocation and resource access, as well highlight various economic issues associated with CAS. Issues identified in the baseline survey will be examined further through participatory techniques (e.g., focus groups) and additional surveying. Upon completion of the baseline activities, we will further refine the adaptive transformation phase activities which will be evaluated in the final project survey in 2014.

A household survey was completed last week in Mozambique. The districts covered include Angonia (with four sites; Calomue, Domue, Mpandula, and Ulongue), Macanga, and Tsangano (with four sites; Banga, Nsaladzi, Ntengombalame, and Sede). A total of 559 households were interviewed from four sites. Analysis of this data by two graduate students will be ongoing throughout the upcoming year.

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

Field research in Lesotho during the current growing season will provide a third year of data to assist with understanding fertilizer economics in smallholder maize production. During this season, we have initiated several on-farm trials evaluating cover crops, fertilizer rates, and nutrient source (fertilizer, compost, termite soil). These trials were set up as binary trials using our one "best guess" fertilizer rate as the base rate. This layout will provide a control plot (-fertilizer, -cover crop), a fertilizer plot (+fertilizer, -cover crop), a cover crop plot (-fertilizer, +cover crop), and a fertilizer and cover crop plot (+fertilizer, +cover crop). In subsequent years we may, for example, consider a higher fertilizer rate based on farmer focus group input and overall data analysis.

Significant Training, Capacity Building, and Networking Activities

We have three U.S. M.S. students working on this project with several Lesotho and Mozambique candidates beginning in Summer 2012. We continue to contact the U.S. Embassy in Maseru and USAID personnel during our visits to update our previous contacts regarding our program as well as meet their new replacements. Short-term training activities involved 171 men and 176 women.

Our training, research, and extension work in Lesotho has been fundamental in developing a 5-year national plan for Conservation Agriculture (CA) under the National CA Task Force of the Lesotho Network of Conservation Agriculture organizations and individuals. Our progress reports and workshop/conference papers have informed this strategy, a strategy our partner Dr. Marake (National University of Lesotho) was commissioned to develop with FAO funding. Dr. Marake is also leading a team to review and integrate CA into the curriculum for the Lesotho College of Education and Lesotho Agricultural College (LAC). This past year our partner Growing Nations trained LAC teachers and extension agents on practical aspects of CA; Dr.

Marake from NUL trained this same group on the technical and scientific principles of CA. Due to the emphasis on farm activities by all producers and trainers alike, only 347 people were trained in CA of which 51% were female. Last, NUL has signed a MOU with World Vision that will facilitate collaboration between our partners as we further upscale CA during the next growing season.

Research Strategy and Development Objectives

We continue to broaden our understanding of the overall potential of CAPS in Lesotho and Mozambique. The principal lessons continue to be repeated 1) you can never have too much seed or fertilizer on hand prior to the planting season; and 2) early planting is essential for higher yields regardless of whether it is a wet or dry season. As one farmer in Mozambique, noted, "No fertilizer, no profit." In Lesotho yields will be small this year due to low rainfall resulting in lots of areas unplanted as of mid-March; this will appear to result in higher wheat acreages due the amount of land preparation completed.

Following analysis of the survey data and evaluation of the results, we will develop a process to elucidate cultural, gender, or economic drivers/barriers to CAPS adoption and consider pathways to overcome these two practices that severely limit maize yields. Data from the first two years of research have already been used to develop a first iteration of a CAPS tested in on-farm trials in three areas of the Maphutseng Valley this year.

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

Lead PI: Jay Norton, University of Wyoming

Host Countries: Uganda, Kenya

Research Progress by Objective

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

Critical Research Accomplishments: We held reflection workshops at each location that were attended by men and women opinion leaders of each community. These farmers, along with on-station research managers, constituting the core of our advisory groups reflected upon first-year research activities, highlighted main learning points, and identified key problem areas. These lessons learned informed detailed training and planning for subsequent research activities.

Reflection and Training workshops in November 2011 brought over 50 total men and women, creating broad understanding of and engagement in the 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;

Farmers were re-introduced to weeding and guidelines for approved pesticide use in the East Africa SANREM project (PERSUAP 1 and 2) developed last October by Research Associate Omondi in partnership with Research Associate Sikuku, PI Norton, and Dr. Mike Mulvaney and approved by USAID. This was the first time that USAID approved a Class 2 herbicide attesting, not just due to our efforts, but to the seriousness with which all stakeholders hold for this project. Issues of safe use and handling of pesticides was emphasized and heightened awareness on the consciousness of the project on safety of users and the environment.

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, 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.

Two prototype multifunction implements (MFI) designed by a U.S. engineer, James Norton of Iowa, that would substantially increase the efficiency of minimum tilling operations, were shipped to East Africa in March 2012 and intensively tested at on-farm and on-station sites in Tran Nzoia, Kenya, and Kapchorwa, Uganda. Performance of the MFI exceeded expectations and will be playing a key role in all future CAPs operations. Over 100 men and women attended the trials at the four sites and offered many suggestions for use and improvement of

the implement. We are in the process of manufacturing two more for use/testing at the other two research sites.

Farmers in Kapchorwa had a better understanding of herbicide and other agrochemical utilization than at all other sites. For example, application of Touchdown several weeks before planting to suppress initial high density weeds, then Touchdown mixed with Dual Gold just before planting was an ingenious decision by the farmers and resulted in near-total control of weeds in no-till plots. Sites in Uganda also reported better performance of maize and beans in minimum and no-till compared to farmers' practice both in terms of weed suppression and also crop yields (Figure 1). These results were corroborated by preliminary statistical analyses using SAS PROC GLM, which showed that no differences between tillage or cropping systems for maize yields or residue dry matter in Tororo and Kapchorwa on on-farm trials even though minimum and no-till plots tended to have higher yields similar to the farmers' findings in Figure 1.

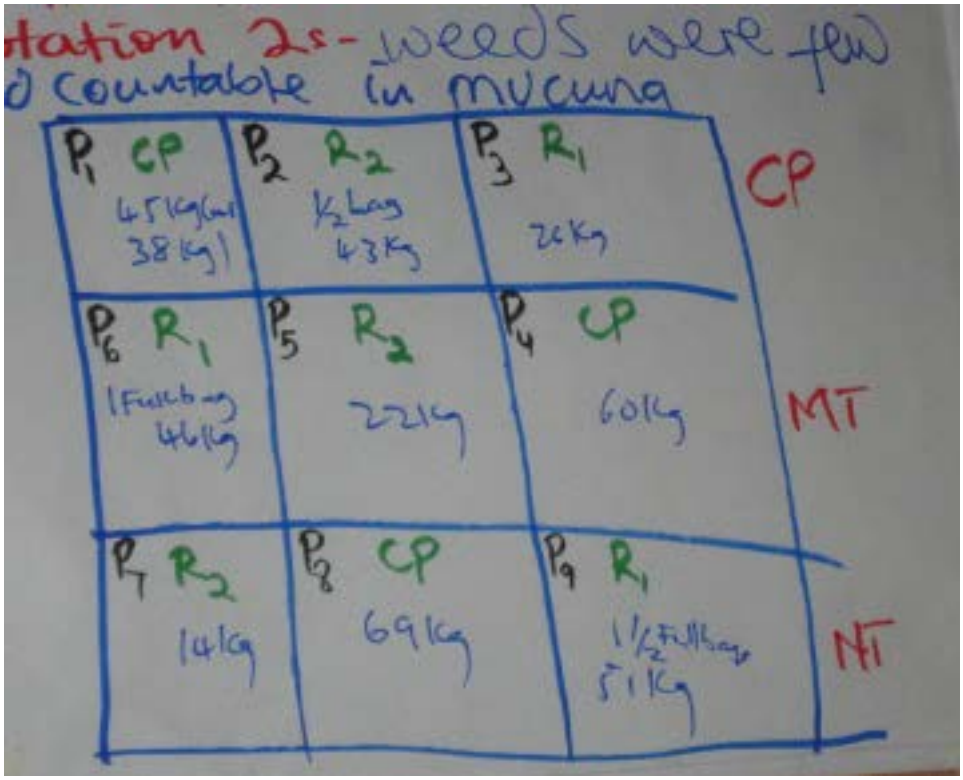


Figure 1: Total yield per plot in Chris Kaptekin's on-farm study. Other on-farm sites had similar results.

Development Impact: During Reflection and Training Workshops, farmers demonstrated excellent understanding of on-going work by taking turns to accurately describe every step of research establishment, management, and basic data collection including timing of these activities. Field research staff without prior training in agricultural courses, especially in Uganda also demonstrated excellent understanding of activities accomplished during the first year of implementation. This implied that ongoing CAPS activities are building the capacity of

farmers and support players that are improving understanding of soil degradation issues and setting the stage for co-innovation and participatory evaluation of CAPS components.

Challenges and Responses: Among the challenges cited at each reflection workshop were: lack of adequate and appropriate tools to perform minimum- and no-till practices such as weeding and planting; inadequate joint planning between researchers and farmers, which often inconvenienced host farmers; insufficient participation in establishment and maintenance of on-farm research plots; and insufficient information on correct herbicides to control weeds. Many of these challenges were addressed in the Refection and Training workshop whereby, among other things, farmers were re-introduced to weeding and guidelines for approved pesticide use in the East Africa SANREM project. Attention was drawn to the participants on the fact that all pesticides that are USAID approved for this project are contained in PERSUAP 1 and 2 documents developed last October by Research Associate Omondi in partnership with Research Associate Sikuku, PD Norton, and Dr. Mike Mulvaney. Issues of safe use and handling of pesticides was emphasized and heightened awareness on the consciousness of the project on safety of users and the environment. Data collection protocols were also presented at the workshops, which provided farmers and field research staff with better understanding of the importance of the study and their participation in it. Contacts made during these workshops increased the level of participation and engagement that will be enhanced and maintained in all aspects of the study.

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

Critical Research Accomplishments: A detailed overview of the SANREM CRSP project (background, aims, and goals) as well as CAPS was revisited during the Reflection and Training workshops in each site, facilitated by Research Associates Emmanuel Omondi and Dominic Sikuku assisted by Research Coordinators of each sub-awardee. Components of CA were outlined as including minimizing soil disturbance, maintaining crop residue cover on soil surface, building soil organic matter, and precise use of agricultural inputs. Several examples and definitions of CA methods were discussed including no-till, strip-/minimum-till, ridge-till, and mulch-till.

Development Impact: Reflection workshops revisited training on erosion and soil depletion processes as caused by conventional tillage practices and a detailed overview of CAPs. This re-energized participants to discuss workable solutions for evaluating and implementing CAPS. Two prototype multifunction implements (MFI) designed by a U.S. engineer, that would substantially increase the efficiency of, especially, minimum tilling operations, were shipped to East Africa in March 2012 and intensively tested in both countries using both donkeys and oxen. Tests revealed that the MFI exceeded expectations and will be playing a key role in all future CAPs operations. Use of donkeys for draft is not common at these locations but draft animal trainer Joshua Ouko of Manor House Agricultural Centre was able to harness and train local donkeys to pull the implement in a very short time. This impressed attending farmers who

were apparently unaware donkeys could be used in this capacity. One advantage of using donkeys over oxen is that they are much cheaper to feed. Each test was carried out as a co-innovation activity in which farmers, including women farmers, took turns operating the implement with various tillage, weed cultivation, and subsoiling attachments, followed by a facilitated discussion of possible improvements of the machine. Most noted possible improvements included soft, rounded handle bars and resistance to breakage by rocks.

Challenges and Responses: One of the major challenges cited across the board was inadequate participation of farmers in decisions regarding planning and execution of research design, management, and data collection and analysis. Reflection workshops provided farmers with an opportunity to freely express their concerns, challenges, and misgivings about first-year CAPS project implementation. More intensive training to equip farmers with skills needed to manage research work coupled with closer supervision by field research staff was proposed. Success of the reflection workshops was evident in the enthusiasm noted among farmers at each research site at the February technology network meetings and March visits by University of Wyoming team members.

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

Critical Research Accomplishments: Farmers in each project site were generally satisfied with implementation of first-year research work. A general consensus began to emerge, based on preliminary observations and results, that intensive tillage may not be as critical in growing maize and beans as originally assumed. Preliminary results and observations in Kenya indicated that traditional/conservation tillage performed somewhat better compared to both introduced conservation tillage practices. Farmers in Bungoma and Trans Nzoia were therefore not convinced that minimum or no-till was a viable option to conventional tillage. However, they were all willing to do it again, and some noted that maize following mucuna had improved yields. Farmers in Uganda observed either better performance of crops in conservation tilled plots at best, or no difference with traditionally tilled plots at worst. We attribute much larger participation of farmers at these reflection workshops in Uganda compared to Kenya to good results observed in their fields during first year of research implementation. In each area, however, there was a general consensus that potential savings from eliminating or reducing tillage was an adequate incentive to carry this research to its logical conclusion. Farmers in all regions, except Kapchorwa, were quite happy with observed performance of *Mucuna* as a cover and/or rotation crop given the observed good performance of maize intercropped or grown in rotation with it. Its ability to suppress weeds and to provide mulching was also noted. All farmers, including those in Kapchorwa, expressed a desire and readiness to give *Mucuna* another chance. In addition, farmers in each region are open to scaling up some treatments to larger parts of their fields, and several are already planning to do this. We'll work with each one to possibly scale up their favorite one or more treatments next season.

Soil sampling was undertaken in mid-January by Dr. Sikuku assisted by UW and Moi University students. Soils were sampled at 0-15 cm and 15-30 cm from four spots randomly

selected using a zigzag design. Samples were collected from plots receiving +N and –N treatments. Although land preparation was completed by the end of February 2012, planting was delayed to mid-April due to a delay in the onset of long rains in all study sites. Dr. Omondi provided instruction on weeding and guidelines for approved pesticide use in the East Africa SANREM project during the Reflection and Training Workshops. Participants were reminded that all pesticides that are USAID approved for this project are contained in PERUSAP 1 and 2 documents, copies of which would be made available to all participating host farmers.

Agronomic, soil, and trace gas data were collected from the twenty research sites by the end of the first season research study. Analyses of these data are ongoing. Research study for the second phase was established in those same sites with help of participating farmers and local residents at each area, including soil sampling, tillage treatments, and planting. Clear communication of responsibility for managing and monitoring rainfall, weeds, and input activities continued to engage farmers and local workers in ways we think will support a successful long-term project.

Development Impact: More inclusive and participatory planning, establishment, management, monitoring, and data collection in the second phase implementation of the study strengthened the foundation for a successful long-term project. Participating farmers that received rain gauges, notepads, and pencils for recording daily rainfall and reading the Tru-Chek rain gauges were quite enthusiastic about continuing to carry out these tasks.

Challenges and Responses: Delays in key management aspects like planting, weeding, and topdressing that may have contributed to poor performance of research crops especially in the second season were attributed to insufficient participation of farmers in decisions regarding planning and execution of research design, management, and monitoring as well as inadequate supervision, especially in Kenya. During first year implementation, there was relatively less supervision of these activities in Bungoma and Trans Nzoia by Research Associate Sikuku, because of presence in those sites of field research coordinators with adequate training and experience in all aspects of Agronomic research. However, it was decided that supervision would be intensive and uniform in all study sites during the second phase of implementation.

While farmers will no longer need to wait for SANREM field staff instructions before managing farmer-practice treatment plots, no-till and minimum-till plots will be managed in consultation with SANREM field and/or research staff. There will also be more involvement of farmers in planning and executing future activities. An advance planning program/schedule of activities including detailed research supplies and suggested time of acquisition would be prepared by field coordinators in each site. All inputs for the following season would be purchased well in advance. The need to strictly adhere to instructions as prescribed and to constantly consult in case of any doubts was given strong emphasis. Farmers were instructed never to undertake any management activity unless they were certain that such an activity would be completed on an entire block within a given day. Results from preliminary statistical analysis of crop yields were shared during testing of the MFI in March 2012.

PhD student Judith Odhiambo spent the fall and spring period on site monitoring trace-gas emissions once per month at each study area. This coupled with other visits by NGO partners, students, and PIs, maintained a presence for continuing discussion of the research work. One major challenge noted was uneven application among study sites of some practices, partly due to reliance on insufficiently informed hired labor coupled with inadequate supervision thereafter. This was remedied during one-week MFI-testing visit in March 2012 by PI Norton, Co-PI Urszula Norton, Sikuku, and Omondi in which field research staff were instructed to redesign the orientation of affected plots in a way that did not substantially affect their original layout and to note other plots that could not be remedied for future accounting in statistical analyses. Affected responsible NGO partners also agreed to increase contact and better management. Sikuku is following up to assist them in fulfilling this commitment.

Significant Training, Capacity Building, and Networking Activities

Primary training involved graduate degree education for two PhD students and one MS student at the University of Wyoming, two MSc students at Moi University, and one MSc student at Makerere University. Farmer training on CAPS and general research implementation strategies were conducted in November 2011 during Reflection and Training Workshops at each study site. A total of 28 men and 14 women participated in these workshops.

PhD student Judith Odhiambo presented a poster reporting preliminary results of greenhouse gas emissions measurements at the 2011 American Society of Agronomy meetings in San Antonio, TX; PD J.B. Norton presented a departmental seminar at the University of Wyoming reviewing the project and early results; newspaper articles on the MFI were published in the Waterloo Iowa Courier.

The University of Wyoming SANREM group of PIs, research associates, and graduate students meet regularly to discuss progress and related research. PI J.B. Norton, Research Associate Sikuku, and on-site project partners participated in follow-up sessions present at each research site by Virginia Tech grad student Jennifer Lamb in which she reported and led discussions on results of her technology networks research. These meetings had excellent participation and resulted in lively discussions of the SANREM project, CA, and how to implement change at each study area. The meetings broadened and strengthened engagement of local people in the project.

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

Lead PI: Catherine Chan-Halbrendt, University of Hawaii

Host Countries: India, Nepal

Research Progress by Objective

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: Collect socio-economic baseline surveys of one additional village of Kendujhar District of Odisha State, India

Socio-economic baseline surveys were completed for 61 households in Kendujhar, Talachampei.

Task 1.2: Collect crop yield, cost of production, labor and agronomic data of on-farm trials in Tentuli Village, India

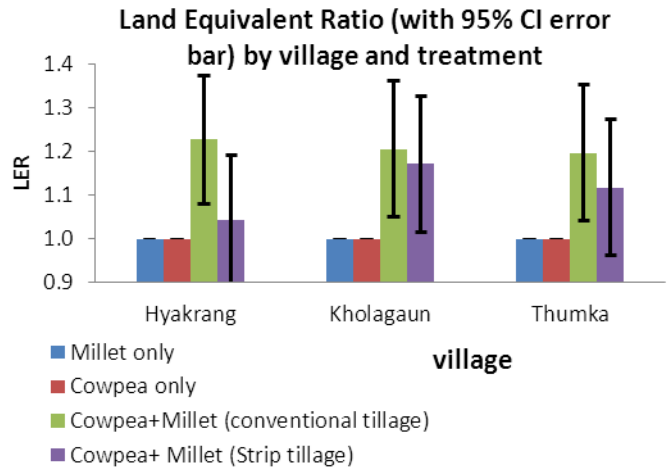
An on-farm field experiment involving selected CAPS has been established in Tentuli involving 20 households.

Task 1.3: Collect socio-economic baseline surveys of two villages in Nepal

The baseline survey of remaining farm households will be completed by the end of the next reporting period.

Task 1.4: Collect crop yield, cost of production, labor and agronomic data of on-farm research trials in Nepal

The crop agronomic, yield, and cost of production data, as well as labor and agronomic characteristics have been collected for the 2011 season. The preliminary results show that the land equivalency ratio (LER) for yield in the millet-cowpea intercropping system with full tillage was significantly higher (20%) than sole crops. The LER of the millet-cowpea intercropping with conventional tillage was found to be significantly higher than millet and cowpea sole cropping. These results provide evidence on potential of CAPs to increase yield and contribute to food security while sustaining agro-ecosystem function long-term.



LER is the total land area required for a single crop to give yield obtained in intercropping mixture. The results of CAPs in Nepal shows the LER of cowpea-millet intercrop is significantly higher than sole crop cowpea and sole crop millet. Although, LER of cowpea-millet intercropping with strip tillage is higher than sole crops, but statistically they were comparable.
Source: Paudel et al, 2012.

Task 1.5: Conduct initial Farmer knowledge Gender survey based in Nepal

Results from the survey to map gender knowledge of CAPS conducted in three project villages have been used to develop a follow-up cognitive mapping survey and to design further gender studies to be conducted in the summer of 2012.

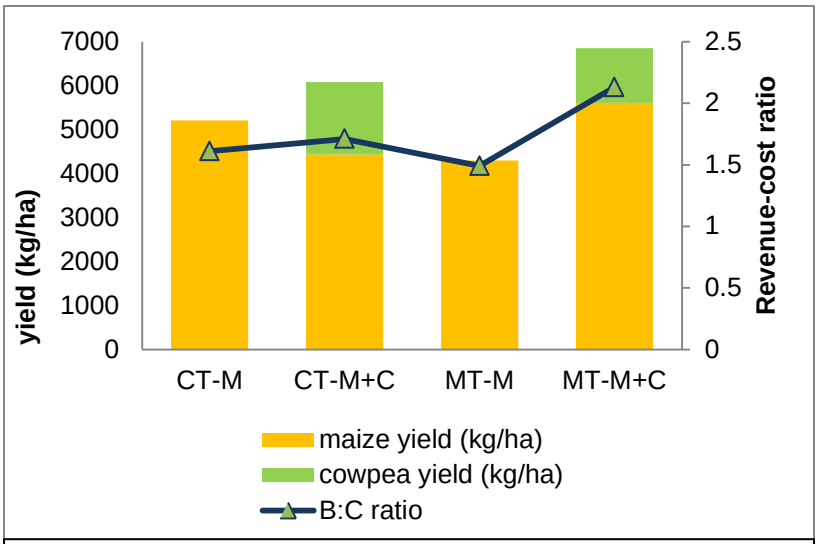
Task 1.6: Conduct village and town market surveys in Nepal

Grain prices included in the analysis of on-farm trials were collected by LI-BIRD in consultation with farmers, local traders and cooperatives. Remaining information relating to the market will be collected soon.

Task 1.7: Design and implement experimental trials on tillage practices, cover crops, agroforestry on University Research Stations

IAAS has designed and established on-station trials on CAPS. The designed trials involve *tillage-compost* interaction treatments, in a full 3 by 4 factorial split plot design with 4 replications, 3 levels of tillage treatments (dibble, full-plow and strip-plow) in main plots, and 4 Farm Yard Manure (FYM) application rates as subplots. IAAS has also planned to: study the performance of maize intercropped with legumes and non-legumes in the mid-hills of Nepal; establish an observational cover crop trial with 10-15 species; and to identify species to be replanted and replicated later to take advantage of residual moisture.

The CAPS experiment conducted in the Regional Research and Technology Transfer Station (RRTTS) at Kendujhar, India was laid out in a strip plot design with 4 treatments, replicated three times. The treatment combinations were comprised of two factors each at two levels: tillage (minimum and conventional), cropping system (maize and maize + cowpea). Data on crop growth, yield, production economics, and soil properties have been recorded. The analysis found that maize yield in maize+cowpea under minimum tillage (5610 kg/ha) was the highest and statistically similar to that of only maize under conventional tillage (5210 kg/ha). Maize+cowpea intercropping under minimum tillage recorded a highest net profit of $ 655/ha with a revenue-to-cost ratio of 2.13, which is 17.6% higher than maize grown under conventional tillage.



The figure shows that the yield of maize is comparable among all treatments. The advantage of intercropping is the cowpea yield without reducing the maize yield. Source: Pradhan et al, 2012

Task 1.8: Development of a laboratory-based water stable aggregate facility to measure soil aggregates of different CAPS treatments

The establishment of the facility and capacity building for data recorders has been planned for summer, 2012.

Task 1.9: Weather station and field sensor monitoring

The weather stations and field sensors in project villages of Nepal are working properly and the data generated are being compiled.

Task 1.10: Collection and analysis of data on gender perceptions in Nepal and India.

This activity has been planned for the second half of the year.

Task 1.11: Analyze and publish results from the data collected

Most of the data collected from the research trials and surveys have been analyzed and, are several reports and papers are being generated. Three extension papers, one journal article, six abstracts, five posters, and one factsheet have been or will be published.

Objective 2: Explore stakeholder preferences for CAPS to promote adoption

Task 2.1: Implement "Sustainable Management of Agro-ecological Resources in Tribal Societies" workshop in Nepalese villages to inform farmers of the agricultural and environmental benefits of CAPS.

The workshop was organized in all three villages using the "Analytical Hierarchy Process" method to determine farmers' preference for CAPS. Information about CAPS was presented to farmers. Overall, yield, soil fertility and environmental health were identified as the most important factors in farmer decision making regarding CAPS. Farmers preferred full-till and cowpea mono-crop, because of their preference to short term profits, which was in contrast to the preference of extension agencies i.e. strip-till with cowpea/millet intercrop, indicating some gap in understanding between farmers and extension workers regarding conservation farming. It also indicated that there is a knowledge gap among farmers regarding the advantages of minimal-till and soil fertility.

Task 2.2: Post-workshop focus group meeting with farmers to discuss the effects of implementing CAPS (i.e. trade-offs based on gender) as they relate to CAPS knowledge, agricultural activities, and market transactions in Nepal

Three interaction workshops were organized on farms to discuss the benefits of CAPs, while doing AHP in villages. On the basis of farmers' preference the project has improved the CAPS practices identified in the first year, by replacing cowpea with black gram in millet-legume intercropping.

Task 2.3: On-farm workshop to train farmers on implementing the selected and preferred CAPS and identify the benefits and costs to trial farmers in Nepal

Project trained 40 farmers, including 15 women, on the knowledge and skills to adopt and implement the CAPS in Nepal. As a result, the up-scaling of CAPS in project and surrounding villages has already been started. A group of 15 farmers visited the on-station experimental site in RRTTS, Kendujhar, India on 3 January 2012 and were introduced to the concept of Conservation Agriculture. The trip was organized by the Department of Soil Conservation, Government of Odisha. The farmers were enthused about the minimum tillage concept.

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

Task 3.1: Revise and adapt on-farm experiment in Odisha State, India incorporating results from the research station and AHP on new plots.

The data processing for the 2011-12 on-farm trials in India is in progress and if there are any improvements to be made they will be done in collaboration with farmers.

Task 3.2: Revise and adapt on-farm experiment of *bari-lands* in Nepal incorporating results from the research station and AHP on new plots.

The project has already revised the CAP treatment on the basis of farmers' preference as presented during the AHP and other participatory investigations. Cowpea has been replaced by black gram as the legume crop for the second year. The major reasons for change are because of the shading effect on millet from a very high vegetative growth of cowpea, hence farmers wanted to change from cowpea to black gram. For the 2012 season the treatments will be as follows.

Treatment 1: maize – millet (with conventional tillage)
Treatment 2: maize – black gram (with conventional tillage)
Treatment 3: maize – millet + black gram (with conventional tillage)
Treatment 4: maize- millet + black gram (with stripped tillage)

Task 3.3: Gender-segregated focus group meetings in India to discuss effects of on-farm CAPS on labor and household responsibilities.

The survey to map gender knowledge of on-farm CAPS implementation is scheduled to be done in summer 2012.

Task 3.4: Harvesting and post-harvest assessment of CAPS based on key economic indicators (soil and profit) for the on-farm trials in India.

Focus group meetings with the participating farmers have been planned for the second half of the year. The main purpose of the discussion is to learn from farmer feedback about economic sustainability of the CAPS.

Task 3.5: Harvesting and post-harvest assessment of CAPS based on agronomic indicators

The cropping season has just completed. The focus group discussions have been planned to be conducted after analysis of the data recorded on-farm trials is in progress.

Task 3.6: Prepare participating farmers with training on data collection methodology for the on-farm trials in Nepal.

The project has trained 27 farmers about the principles and processes of PAR. These farmers will be directly involved in managing the research trials on their farms.

Task 3.7: Oversee and monitor university research station experimental plots in Nepal and observe the effects of CAPS practices on crop growth, weed, pest and disease pressures.

The monitoring and data recording of the CAPS trials have been effective in 2011, which is reflected in the quality of data generated.

Task 3.8: Perform soil analyses at ADSC/ VT for comparison with the LI-BIRD data.

The soil samples from the research plots have been collected and sent to the ADSC/VT lab. The results of the entire sample were analyzed by the VA Tech soil lab and are ready for comparison with LI-BIRD data.

Task 3.9: Oversee monitoring of on-farm trial plots in India and observe the effects of CAPS practices on crop growth, weed, pest and disease pressures.

The extent of crop growth, and weeds, pests and diseases in on-farm plots were monitored throughout the cropping season. Farmer's feedback regarding weed, pest and disease pressure will be taken into consideration regarding any improvement of the on-farm CAPS program.

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

Task 4.1: Focus group meeting with farmers in India to discuss current CAPS on-farm trials, areas of improvement, and adaptations.

The research protocol for a focus group meeting is being developed and planned for the second half of the year. The meetings will identify potential areas of improvement in the research designs for next years.

Task 4.2: If necessary, return to research station trials to improve the selected CAPS based on farmers' feedback and preferences to develop optimal CAPS.

The project meeting of all implementing partners and including host country nationals was scheduled for 11-12 April 2012. The workshop is expected to review the project progress, research outputs and plan for the future.

Task 4.3: Training on principles of PAR and their application by host-country researchers and villagers

Researchers in host countries have been oriented on three participatory research tools. In Nepal, about 49 students and researchers, of which 25 were women, from universities and host country partners have been introduced to participatory investigation tools like AHP, Mental-Model; and CAPS practices. The workshop evaluation showed that researchers found the tools very relevant and useful for PAR analysis. But they also realized that they need to follow up and further orientation with in-field demonstrations.

Task 4.4: Meeting with women's groups to discuss their current adaptive management strategies and adaptation for CAPS

The field facilitators continuously work with women and discuss about the CAPS formally and informally. Informal discussions have been important to identify what women think about the CAPS and what needs to be done for improvement.

Task 4.5: Begin to determine adaptive management practices for current CAPS and evaluate economic impacts

The research protocol for a focus group meeting is being developed and planned for the second half of the year.

Task 4.6: Begin to evaluate effects of CAPS on soil physical, chemical, and organic properties.

The baseline data for soil physics, chemistry and fertility status are being analyzed. The initial results show a lot of variation in soil characteristics by villages. Interestingly, micro-nutrients came out as the major deficiency in the soils of project villages. The data are being analyzed with multivariate techniques.

Soil samples from all 25 farmers' field trials in Nepal have been taken to compare the effects of CAPS on soil physical, chemical and organic properties. The analysis of these samples will be compared with the baseline reference established in the first year of the project. Soil organic matter and nutrient status of three on-farm trials has been continuously monitored. The analysis of the on-station CAPS trial from India has suggested no significant treatment effect of CAPs on soil organic matter and nutrient status but we expect the effect to be significant after a few more years.

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

Task 5.1: Communities: engage local OUAT staff to train and support CAPS in local villages in India

OUAT organized one workshop on "Conservation agriculture" on 24 December 2011. A presentation, on "Sustainable tribal farming through conservation agriculture- SMARTS experience in Kendujhar" was presented by the host country PI and lead co-PI. The workshop

was attended by 300 participants involving OUAT faculty and students, ICAR scientists, and Govt. of Odisha officials.

Sixty-six farm men and women were trained in Tentuli village, Kendujhar, India in harvesting, post-harvest and crop residue management of a mustard cover crop on 21December 2011.

Task 5.2: Local institutions: establish NGO-university network around CAPS

The network of NGO-University to explore and extend CAPS in Nepal, where the LI-BIRD, our partner NGO leads the farmers' field trials and adaptive studies; while IAAS conducts controlled research trials. A similar model of partnership is being envisaged in India between OUAT and PRADAN.

Task 5.3: Training of UHM and host-country graduate students

Two students, one each from Nepal and India, have enrolled in Ph.D. programs in UHM from spring 2012, and another graduate student is expected to enroll in Fall 2012. In Nepal, 4 students, including 1 female, have been supported as the research fellows and 3 in IAAS. In India, 3 students have been supported as research fellows.

Task 5.4: Joint (India and Nepal) reporting of socio-economic analysis of CAPS practices

Project has finished the collection of baseline information of the socio-economic data and the joint analysis has been planned for upcoming months.

Task 5.5: Joint (India and Nepal) publishing of training manuals of CAPS (from SMARTS Workshops)

One project brochure has been developed in Nepali. The brochure is published to communicate the basic principles of CAPS to the farmers and extension workers.

Task 5.6: Begin to compile reports and refereed articles that complement research and development on gender issues for US, India and Nepal students.

Literature review and survey development is occurring. Data will be collected in a few months

Task 5.7: Semi-structured interviews with key informants and focus groups regarding: institutional context, historical context, knowledge systems and community organization.

The research protocol is being developed and data collection is planned for the second half of the year.

Significant Training, Capacity Building, and Networking Activities

The progress and outputs of the project were shared at a meeting organized by USAID Nepal. The meeting was useful to share the initial results of the SMARTS project in the Chepang villages of Nepal with USAID Nepal and partners.

Four hundred and sixty-two men and 174 women have been trained during this period. In particular, OUAT organized one workshop on "Conservation agriculture" on 24 December 2012. A paper on "Sustainable tribal farming through conservation agriculture- SMARTS experience in Kendujhar" was presented by the host country PI and lead Co-PI. The workshop was attended by 300 participants involving OUAT faculties & students, ICAR scientists, and Govt. of Odisha officials.

Two students, one each from Nepal and India, have enrolled in Ph.D. programs in UHM from spring 2012, and another graduate student is expected to enroll in fall 2012. In Nepal, 4 students, including 1 female, have been supported as the research fellows and 3 in IAAS. In India, 3 students have been supported as research fellows.

A bulletin, "Sustainable management of agroecological resources for tribal societies (SMARTS): a conservation agriculture based participatory research in Kendujhar of Odisha" was released on the occasion of OUAT golden jubilee celebration which contained introduction, objectives of the CAPS program along with the results of CAPS on-station experiment conducted in 2011 at RRTTS, Kendujhar.

One leaflet and one article have been drafted for publication.

Research Strategy and Development Objectives

1. Describe progress achieving research milestones.

For both India and Nepal, progress has been achieved in extending CAPS into the villages and working with local farmers. Data collection continues, analysis begun, and significant findings have been identified which can be disseminated to project partners and integrated into the program activities for the coming year. Important steps have been achieved this year in directing the agronomic research toward locally appropriate and ecologically suitable CAPS, as well as in the collaborative implementation of the project.

2. Indicate how this contributes to progress along the development pathway.

Finding optimal CAPS treatments that meet project goals and are also compatible with farmer preferences are critical steps toward developing recommendations for policy and future agricultural interventions, as well as for promoting the long-term adoption of CAPS interventions by farmers. Research this year has narrowed the focus of CAPS field experimentation, while promoting the input of farmers and local partners, placing the project on track towards developing optimal CAPS and increasing local capacity building.

3. Discuss any lessons learned relevant to development goals

It is important to map what farmer's perceptions are regarding certain farming practices such as tillage to productivity or soil moisture to yield changes. Without knowledge of farmer's biases, which sometimes are contrary to scientific evidence, extension staff might question why farmers do not readily adopt the best practices. Also, on-farm trial expectations might differ from trial performances, which require necessary follow up adjustments.

Having our local partners from 2 countries and UH meet face-to-face and share results and discussions are useful for 3-way learning and provide useful feedbacks on project progress and adjustments.

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

Lead PI: Manuel Reyes, North Carolina Agricultural and Technical State University

Host Countries: Cambodia, the Philippines

Research Progress by 'GETS' Objectives

Goal: To show that conservation agriculture (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 increase labor burden on women in Cambodia and the Philippines

Progress towards completing critical Annual Work Plan tasks

For the Philippines results on gendered division of labor and knowledge of agricultural practices were reported. Schedule for further study July 2012 has been mapped out in partnership with SANREM Gender expert, Dr. Christie. In Cambodia, no further progress has been reported than what was observed last year. It is still too early to conclude on what is the current impact of CAPS on women's labor burden in Cambodia.

Changes in research design or methods, obstacles encountered, and actions taken

None

Significant research findings

In the Philippines, women tend to decide similarly with men, for example, on when and how to use of cover crops. Decision making of men and women may differ in the application of tillage practices: women emphasize the importance of their knowledge of soil types, while men focus more on the availability of tractor or draft animals.

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

Progress towards completing critical Annual Work Plan tasks

For both countries progress is satisfactory in completing work plan for year 3.

Changes in research design or methods, obstacles encountered, and actions taken

In the Philippines, it was difficult for the University of the Philippines Los Baños (UPLB) team to implement this objective since team members are far from the site. Hence, the responsibility

for this task was moved to the on-site team of Claveria Research Development Foundation Incorporated (CRDFI). Also, the on-farm research CAPS treatments were changed from the one's chosen by the farmers in year 1, to CAPS that were found from the researcher- managed studies that have good prospects of success. The on-farm trials were reduced from 24 to 15, with treatments reduced from eight to three, with five participating farmers per treatment. The treatments are T2, T3 and T5 of researcher managed study described in objective 4. In Cambodia, no change in research design was done. A structured baseline survey instrument was developed to generate information about the characteristics of the farming households in selected villages in July 2010. Survey data with 60 key informants was finally analyzed and reported. The characteristics included patterns of gendered tasks by cropping season among others. Of the 60 respondents, 24 participated in on-farm trials from 2010 to 2011. fFifteen (15) out of the original 24 continued in 2011 to 2012. Because results from the initial household surveys were inconclusive, another baseline survey was conducted in October 2011 including the farmers who adopted CAPS.. The fifteen farmer-co-operators are middle-aged (60%) and retiring-aged (40%) with 8 of them who have at least reached college. All of the fifteen farmer-co-operators are primarily farming with 10 of them engaged in secondary occupations. In addition, sample respondents located on the transect within the Cabulig Watershed were interviewed. Transect points were selected according to land uses, thus the respondents were based on the soil sampling strategy. The total number of respondents interviewed was 32 along the transect. The respondents interviewed were from 11 Barangays of Claveria. Baseline survey report in Cambodia was completed last year.

Significant research findings

In Cambodia, the economic assessment showed an increase with time in the Gross Profit Margin (GPM) for CAPS. Yield increased from year 1 to year 3 while expenses decreased. The GPM for CAPS is slightly lower than traditional plow-based practices during the first two years. Yield decreased from year 1 to year 3 observed in the plow-based system led to drop in the profit margins that by year 3, CAPS-GPM was higher than plow based one.

Objective 3: **T**echnology Network

Quantify the effectiveness of SANREM-supported farmer groups in Cambodia and the Philippines in training knowledge leaders, in being knowledge transmission points, and in facilitating network connections leading to widespread adoption of CAPS.

Progress towards completing critical Annual Work Plan tasks

Tech network survey was broadened in the Philippines. For both Cambodia and the Philippines appropriate CAPS machinery is being tested.. CAPS are being implemented in Cambodia by farmer groups. In the Philippines, CAPS is being integrated in Landcare farmer groups. Subsidy for production inputs are being provided for all participants. Sixty-one farmers have preregistered to participate in the 2012 cropping season for a total area of 151 ha under CAPS. In 2011, 31 farmers participated for a total CAPS farmed area of 58 ha. GIS reference database has been completed for Cambodia. Farmer organization CAPS members in Cambodia produced and sold cover crop (Pearl millet) seeds for 2012 new members who will

move from plow based to CAPS. CAPS site field visits have been conducted for both countries. Authors for draft of electronic CA textbook for wet tropics have agreed to contribute but progress for this effort has been slow.

Changes in research design or methods, obstacles encountered, and actions taken
None

Significant research findings
Cambodia

- Farmers who gave up on CAPS in 2010 were 25% and in 2011 were 22%. In 2011, reasons given by farmers who abandoned CAPS were allocation of land for perennial crop and low economic return.
- Farmers participating in CAPS were subsidized. Repayment of subsidized loan is a function of yield. Loan repayment was at 91% and will likely be as high as 100%.
- Two farmers have purchased sowing machines (one by each farmer) from Brazil and will start to "retail" CAPS sowing services to other farmers during cropping season 2012.

Philippines

- Women participants identified neighbors or friends, and NGO agents as the important sources of farm inputs and information, while men identified the the village chief, vendors in agrichem shops and extension agents.
- Men always receive quality resources/info from a neighbor/friend, and from a vendor in agrichem shop; while women always get quality resources and information from agricultural researchers

Objective 4: Soil Quality

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

Progress towards completing critical Annual Work Plan tasks
Critical work plan tasks are being completed satisfactorily for both countries.

Changes in research design or methods, obstacles encountered, and actions taken
In Cambodia, the farmers' network, initially composed of 15 plow-based (control) and 15 CAPS plots, has some farmers leaving the network for various reasons. To date, only eight plow and nine CAPS plots remained. Soil quality samples are being taken in these plots.

Significant research findings
Cambodia

- The eight remaining plow-based plots had an average maize yield decrease from 4.0 tons/ha in 2010 to 2.8 tons/ha in 2011; while in the nine CAPS plots average yield increased, despite

drought constraints in 2011, from 3.0 tons/ha to 3.7 tons/ha in the same period. *Cajanus cajan* (Pigeon Pea) and *Vigna umbellata* (Rice bean) have been found to be promising legume cover crops in the basic soils of Battambang.

Philippines

- Soil profile description of the research site in Claveria, Misamis Oriental, Philippines was updated March 2012.
- Regardless of fertility level, the soil organic matter content remained generally higher under CAPS than under the plow-based system with *Cassava+stylo*, *Maize+stylo-stylo-fallow* and *Arachis pintoi+Maize-Arachis pintoi* systems exhibiting the highest observed soil organic matter for the upper soil layers at 6.9%, 6.6% and 6.5%, respectively, compared to 5.1% for the conventional plow-based system.
- The soil organic matter appears to generally increase over time under conservation agriculture production systems and decrease under conventional plow-based systems based on four soil sampling and analysis performed at the researcher-managed site from 2010 to 2012.
- The residual moisture content under conservation agriculture production systems proved to be generally higher than under the conventional plow-based system with *Maize+stylo-stylo-fallow* exhibiting the highest mean volumetric water content at 25.1% compared to only 18.2% under conventional plow-based systems. This shows CAPS resilience to drought.
- In our NPK omission experiment, we found that no application of N resulted in the reduction of maize yield up to 67%, omission of P resulted in a 59% reduction and omission of K resulted in a 21% reduction. The results suggested that N is the most limiting nutrient, followed by P and K. We found out that the optimum rate of N application was 120 N kg/ha hectare, and optimum rate of P at 45 kg/ha of P_2O_5 (about 20 P kg/ha).
- Different varieties of "Adlai" for CAPS as substitute to rice and corn were evaluated. Adlai is a very promising crop because of its potential as food and feed sources and its medicinal properties. We found that the Kiboa variety produced the highest grain yield of 3.5 tons per hectare and total dry matter yield (TDMY) of 8.8 tons per hectare, followed by the Ginampay variety with a grain yield of 3.0 tons per hectare and TDMY of 7.4 tons per hectare. The Tapol variety was the poorest performer. Our results showed that Adlai has promising potential for CAPS particularly on the sloping acid upland soils.
- Evaluation of cassava cultivars for CAPS showed that that Rayong 72 cultivar from Thailand had the greatest yields both in fresh roots and aboveground biomass, followed by VISCA 4 which was selected at Visayas State University (VSU) in the Philippines. Other promising varieties were Lakan and local yellow gold.

Significant Training, Capacity Building, and Networking Activities

- Meeting with the Claveria Landcare Association (CLCA) on integrating CA on their farms
- Various meetings with United Rubber Producers Association (URPA) on conservation agriculture with trees using rubber trees

- Collaboration with Xavier University Sustainable Agriculture (XUSA) Research Collaboration particularly on socio-economic component of CA
- Launching of: 'Vegetable Agroforestry Systems in the Philippines' book at the University of the Philippines Los Baños
- Launching of: 'Holding their own: smallholder production, marketing and women's issues in Philippine agroforestry' book at De La Salle University, Philippines
- Development of the scientific committee of the Third International Conservation Agriculture Conference in Southeast Asia, Hanoi, Vietnam, December 2012
- Implementation of CAPS for urban vegetable production study at the NCA&TSU campus
- The proposed third international CA-SEA SANREM sponsored conference in May 2013 will be postponed to May or June 2014 with the venue moved from Thailand to Cambodia. CIRAD French partners requested postponement of SANREM sponsored International CA-SEA conference in May 2013 since they are holding the CA-SEA international conference in Hanoi, Vietnam, December 2012. SANREM is represented by Reyes as part of the scientific and organizing committee in this conference.

Research Strategy and development objectives

1. *Describe progress achieving research milestones.*

There is biophysical evidence that the CAPS being developed in Cambodia and the Philippines are progressing. Yield, biomass and profit have increased and drought resilience has been enhanced when compared with plow-based systems. Farmers' responses to CAPS are encouraging, with farmers in Cambodia purchasing CA equipment to use and to rent, however actual adoption is not yet evident.

2. *Indicate how this contributes to progress along the development impact pathway.*

The goal is to increase yield, income, sustainability and resilience of small holder farmer through the application of CAPS technology. From the two year results, there is progress in this development pathway. A major challenge will be to convince the farming community to adopt CAPS, which the team hopes to achieve by the end of the project.

3. *Discuss any lessons learned relevant to development goals.*

Some participating farmers have not been able to continue their participation. We will need to address these socio-economic issues if we are to succeed. Some discontinued because of unclear land ownership, requiring the farmer to plow to demonstrate ownership. Others gave up toplant Longan fruit trees or common annual crops using the conventional plowbased system.

Cross-cutting Research Activities (CCRAs)

Economic Impact Analysis

Lead PIs: Mike Bertelsen and George Norton, Virginia Tech

Research Progress by Objective

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

Task 1.1: Work with LTRAs to identify CAPS elements and farming programs to be assessed. Researchers in each LTRA were contacted to obtain status of cost and yield data collection. These data will be used by each LTRA to conduct CA profitability analyses and impact assessments. Over the next year, they will be combined with CA adoption projections to assess potential project benefits. In West Africa, data are being collected by economists at Kansas State to assess profitability of reduced tillage, cover crops, and rotations for maize, beans, sorghum and millet in the northern region of Ghana. A linear programming model is planned there to analyze the set of optimal practices. Some cost and yield data exist for cover crops, tie ridges for water management, intercropping for sorghum, millet, and brassicas. In Southern Africa, costs and yield data for maize cover crops and no-till are being collected in Lesotho and Mozambique by the economist at the University of Tennessee. Baseline surveys were completed in Lesotho and Mozambique. In South Asia, yield and labor use data have been collected for rotations and intercropping by economists at University of Hawaii and a format was provided to them for collection of additional cost of production and yield data. In Latin America, costs and yield data were gathered for experiments on quinoa, beans, and potatoes with direct seeding, cover crops, and rotations. In Ecuador, cost and yield data were collected for potatoes, maize, beans, barley, beans with cover crops such as oats and vetch, rotations, and reduced tillage. Results from a linear programming model provide information on the optimal set of practices for two sub-watersheds. In Southeast Asia in the Philippines, cost and yield data are available for researcher-managed trials and are being collected on farmer managed trials with an emphasis on maize, cowpeas, rice and beans. Practices include cover crops, reduced tillage, and rotations. In Cambodia, maize and cassava are the primary crops and the Ministry of Agriculture has cost and yield data that have been collected over multiple years with the help of a French project.

Task 1.2: Modify the template from the Latin American site and gather budget data for the CAPS elements to be evaluated in a second site (West Africa). Using the (Linear programming) model template developed for the Latin American site, develop an impact model for the second site

Kansas State economist Tim Dalton has recruited a graduate student from Ghana who will use the budget data from the SANREM site in northern Ghana to conduct a linear programming analysis similar to the one completed in Ecuador.

Task 1.3: Continue to interact with the other LTRAs on additional impact work that they wish to perform.

Email contact and follow-up phone calls were made to LTRA Lead-PIs or economists from West Africa (LTRA-8), Southern Africa (LTRA-9), Southeast Asia (LTRA-12), South Asia (LTRA-11), and Latin America (LTRA-7) to discuss planned impact assessment work. All sites are collecting budget data. Analyses of baseline data are being performed in Lesotho and Mozambique to assess adoption of CAPS.

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

Task 2.1: Use the linear programming model in the Ghana site to assess optimal CAPS in that region.

The study in the Ecuador site provides a template for the linear programming model to be developed in Ghana at Kansas State. Because Tim Dalton has recruited a graduate student to conduct the analysis, it will not be done at Virginia Tech. At Virginia Tech, we are focusing our efforts now to collect the budget data from various sites so we can calculate profitability of CAPS and then combine these data with adoption projections to provide ex ante estimates of potential short run SANREM economic benefits.

Task 2.2: Prepare journal article manuscript out of the MS thesis being completed in the Latin American site.

An article manuscript out of the MS thesis was prepared and submitted to the journal: *Experimental Agriculture*.

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

Task 3.1: See modification to Task 1 under Objective 2, which implies we have started an analysis of broader economic impacts of SANREM.

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

No activity planned in year 3

Changes in research design or methods, obstacles encountered, and actions taken

Decision made to refocus efforts this year on gathering cost of production data across several sites to use in assessing profitability of CAPs in several countries and for projecting broader economic benefits.

Significant research findings

The linear programming model for the Ecuador trials found that specific cover crops, crop rotations, and reduced tillage designed to reduce soil erosion and increase soil organic matter

should lead to increased incomes for farm households in a time period as short as two years. It appears that conservation agriculture practices have the potential to improve the livelihoods of the rural poor in Ecuador because conservation agriculture activities entered the revenue-maximizing model solution for both sub-watersheds included in the project.

Significant Training, Capacity Building, and Networking Activities

Ms. Abigail Nguema has continued to work on the project in the short run after she finished her MS degree in the fall. An article manuscript out of the MS thesis was prepared and submitted to the journal: *Experimental Agriculture*.

Research strategy and development objectives

Based on the findings of this study, it appears that conservation agriculture practices have the potential to improve the livelihood of the rural poor in Ecuador, since those practices appeared in the revenue-optimizing solutions of the models for both sub-watersheds. Innovative conservation agriculture practices—either alone or in combination with current practices, depending on the watershed— provide higher net revenue than do current practices alone.

This study makes a contribution to the literature on the impact of conservation agriculture by examining the short run profitability of this still-evolving approach to agriculture in a controlled, experimental setting. The cropping systems being tested as part of the SANREM CRSP research and development program in Ecuador allow a systematic analysis of the benefits and costs of conservation agriculture, currently in the short run and eventually in the long run. Farm level and off-site benefits of conservation tillage are expected to be greater in the long run than the short run. This study does not estimate those benefits, but unless farmers benefit in the short run, either from the practices or from subsidies, they are not likely to adopt them. This study indicates which practices are most likely to be adopted, and hence might be around to eventually provide long term benefits. As additional data become available over time, a more dynamic long term assessment of the benefits of conservation agriculture will be possible.

Gendered Knowledge CCRA

Lead PI: Maria Elisa Christie, Virginia Tech

Research Progress by Objective

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

Progress towards completing critical Annual Work Plan tasks

An analysis of data gathered in Bolivia during Fiscal Year 2 on men and women's soil knowledge, beliefs, and perceptions, and soil management practices data gathered is in progress. Expected outcomes from this case study include a student thesis and manuscripts for publication. The Soils CCRA performed soil analysis and PROINPA on texture and bulk density.

The research template and methodology from the Latin American site are being adapted and modified to apply to research on soils knowledge in the Philippines and other interested LTRA sites. These methods focus on collecting gendered soils knowledge, beliefs and perceptions of soil, soil management practices, and gendered spaces from local men and women smallholder farmers. This methodology draws from literatures in political ecology, feminist political ecology, and ethnopedology. A gender dimensions analysis framework (GDF) used in USAID projects was also used to collect, inform, and analyze data. Outputs of this task include a data analysis model for combining qualitative with laboratory techniques, as well as, a prototype for current Gender CCRA research. This prototype includes descriptive and in-field methods; documents for mapping community soils knowledge by gender on a satellite image; household interview and participatory mapping on farm resources, practices, and soils; GPS mapping of household plots identified by farmers; and for a community, gender-separate focus group on men's and women's activities, including information related to CAPS.

In February, the Lead-PI performed preliminary research in the Philippines site to test and adapt the research template and assess existing literature and data on the current methods used in Bolivia. The PI conducted a focus group session, field exercises, including GPS and participatory mapping, and interviewed farmers at the SANREM test plots in the Philippines. As a result, we have identified soil sampling sites and key participants for upcoming student fieldwork this summer. In addition, we have also identified and obtained aerial imagery for the Philippines, in addition to the Bolivia aerial imagery. This imagery is the basis for community soil mapping and focus group exercises, and student thesis work. As mentioned, the community soil mapping on a satellite image was pretested during the PI visit in February. Outputs from the focus group and field exercises include a list of community soil types and descriptors by gender, a description of soil samples, and GPS points of the 'best' and 'worst' soils identified by farmers at the community level. We continue to coordinate with the Soils CCRA for soil sampling at the farm level in order to correlate laboratory analysis with qualitative data. Analysis of final samples from Bolivia is pending.

We have disseminated knowledge products on the Bolivia data and preliminary Philippines data, focusing on gendered soils knowledge and spaces in the landscape. These knowledge products include presentations at academic conferences, SKB entries on additional gender resources, WID presentations, and student class papers.

Changes in research design or methods, obstacles encountered, and actions taken

We have made changes in the research methods to adjust to the Philippines site. Changes were also made to questions in the interview schedule to allow for more questions about describing and managing soils at the community and household levels. For the interview schedule for the community focus group on mapping soils, we changed three questions: 1. "How would you classify this soil?" 2. "Please describe your classification." and 3. "What do you cultivate here?" to 1. "How would you classify this soil?" 2. "How would you describe this soil?" and 3. "What do you use this soil for?" We also integrated an opening discussion question "What is soil?" into the focus group. This was changed to capture gendered perceptions of soil in addition to local soils knowledge. For listing soils, we also changed the question "What is this soil type?" to "What is the name of this soil?" in order to avoid language translation barriers, and to eliminate technical jargon or misinterpretation among farmers and researchers.

We adapted the household interview and mapping method documents to include the questions listed above as well as more questions to obtain information on decision-making, planting, tilling, and harvesting at the household level by gender. This document also asks more questions about knowledge and practices related to CAPS. This adapted methodology was tested in the Philippines in February. Adapted methods for mapping community soils were successful. Fieldwork in the Philippines showed that participation and discussion of soils among farmers could be related to land tenure, access to land, and if the farmer is or is not currently working the land. A key issue came up in the Philippines regarding sample selection of farmers and questions about local knowledge. It was agreed to include "Indigenous People" and "Migrants" (this is how the government classifies people in their demographic information) but to be sure to work with farmers who had worked the land they were on for several generations rather than assume that Indigenous People had been on the land for several generations and were not recent "Migrants." The population will include farmers who are not SANREM collaborators, and target smallholder farmers who currently own land they work on.

Significant research findings

From Bolivia:

- Women's soils knowledge and space is constructed partly by tying sheep in plots or shepherding them across the mountains, as well as, their roles in planting and production of food.
- Men's soils knowledge and space is related to working the land through activities such as tilling, building houses, and irrigation.
- Men and women distinguish soil types or names by color, texture, water content, workability, rock content, or crop-livestock use.

- Men and women have shared labor agreements among other community households on soil types only deemed as "good" or productive soils.
- Gendered soil knowledge and space is related to the sense of place men and women form in certain spaces, in addition to gendered roles.

From the Philippines:

- Men and women had different criteria and list of soils, and also drew boundaries around named soils differently than men on the satellite image. Men also named nine soils, while women named five soils, though women said the men repeated themselves. Men based description of soils on physical characteristics (color, texture) while women based them on landscape: slopes and topography. Women also referred to ease of weeding in two types of soil.
- Men have more access to NGO trainings and technical information.

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

Progress towards completing critical Annual Work Plan tasks

Analysis of the gendered landscape data from fieldwork in Bolivia from June-July 2011 is in progress. Outputs of this analysis include a sense of place study, a student thesis, and manuscripts for publication. We have also integrated and analyzed this qualitative and quantitative data (including GPS data) with Geographic Information Systems (GIS). Outputs of this analysis include methodology for showing data overlaps and gaps as well as GIS methods to incorporate social science data.

We have adapted the mapping gendered landscapes methodology from Bolivia to field work for the Philippines and other LTRA research sites, producing a research prototype for correlating gendered spaces with gendered soil knowledge, beliefs, perceptions, and management practices. We have also reviewed previous soils research in the Philippines from a gender perspective in order to build on previous SANREM soils research and identify research gaps. Related to this task, we have also obtained multiple data points for qualitative GIS in the Philippines to test a qualitative GIS model.

In correlation with Research Objective 1, we have also obtained culturally appropriate photographs showing crop-livestock interaction in the Philippines site and tested them during a trip in February 2012. These methods will be further tested and modified in upcoming student fieldwork in the Philippines during July-August 2012.

We have generated and disseminated knowledge products in correlation with Objective 1. We have disseminated knowledge products on the Bolivia data and preliminary Philippines data, focusing on gendered soils knowledge and spaces in the landscape. These knowledge products include presentations at academic conferences, SKB entries, WID presentations, and student class papers.

Changes in research design or methods, obstacles encountered, and actions taken

See Objective 1.

Significant research findings

From Bolivia:

- Participatory mapping is important for men and women's equal participation and also for documenting gendered soil knowledge, space, and labor practices.
- Using geospatial techniques to 'map' gendered soils knowledge and space helped show patterns in men's and women's resource and livestock use and decision-making practices.
- Gendered soil knowledge and space is unique and situated. It has mutually informed the different ways men and women make or define their livelihoods and spaces in the landscape, both practically and symbolically.
- Chuño and sheep, in addition to soil knowledge, showed gendered sense of place. We found this reflected in everyday life and the maps.

Significant Training, Capacity Building, and Networking Activities

Graduate student, Keri Agriesti, is continuing progress on her degree in Geography by completing coursework and writing her thesis. Another graduate student, Mary Harman, is also making progress towards her Geography degree, completing her second semester of coursework, and now writing her research proposal and preparing for fieldwork this summer in the Philippines.

Dr. Antoinette WinklerPrins was a visiting scholar in January (2012) where she gave a talk titled, "Urban Homegardens in the Rainforest: Women and the Circulation of Plants in an Amazon City." She was funded by OIRED/SANREM, the Geography department at VT, and the Women and Minority Artists and Scholars Lecture Series (WMASLS).

Dr. Dianne Rocheleau was also a visiting scholar during March for a special Women's Month Event. She gave a talk titled, "Gender, Environment, and Development: Toward a World in which Many Worlds are Possible." She was funded by OIRED/SANREM, the Geography department at VT, WMASLS, and Women's and Gender Studies.

There was a Spotlight on SANREM graduate student, Keri Agriesti during the month of February. She was interviewed and had an article written about her field work during the summer of 2011 which was posted on Virginia Tech's homepage. It is titled, "Graduate student researches gender roles in the Bolivian Andes" and can be accessed at: http://m.vt.edu/spotlight/impact/2012-01-09-bolivia/gender-roles.html

An independent study was conducted on the Andes, gender, potatoes with an undergraduate student, Sara Diaz. Her research contributed to the case-study in Bolivia.

There were 15 SKB entries from October 1, 2011 – April 3, 2012.

Research Strategy and Development Objectives

Progress to achieving research strategy and development objectives include successful analysis of data from the case-study in Bolivia, revisions to research design and methodology, student fieldwork plan, and collaboration with South Asia, South East Asia, and Caribbean LTRAs. Continued planning for future fieldwork is underway and will be carried out in the second half of this fiscal year.

Lessons from the field in the Philippines include: training events should be adapted to encourage more women; it needs to be acknowledged that women have less access to technical information; and men and women's knowledge, beliefs, and perceptions need to be documented in order to address soil issues. In addition, note-takers are an essential part of the research team, particularly in cases when other team members do not speak the local language. For future research, two note-takers should be included in order to have enough time for writing notes and reflecting. Tape recording has also proved beneficial from fieldwork in Bolivia for gathering data on local knowledge, beliefs, and perceptions.

In data analysis from Bolivia, lessons learned include: language and translation challenges need to be anticipated and addressed. In addition, accessing relevant and secondary GIS data was difficult and proved that collaboration with other LTRAs and institutions is necessary for ancillary data. Furthermore, data variability revealed challenges and illuminated assumptions that need to be addressed for future research. This realization was particularly helpful towards planning upcoming research using GIS data in the Philippines.

Technology Networks CCRA

Lead PI: Keith M. Moore, Virginia Tech

Research Progress by Objective

Objective 1: Identifying the knowledge and attitudes (technological frames) concerning agricultural production practices held by actors in the network.

Preliminary analyses indicated that there were no consistent patterns of correlation among the responses with respect to Conservation Agriculture (CA). Respondents saw each of the three principles of CA as independent concepts, indicating that a conservation agriculture technological frame is not-fully formed amongst survey respondents. As such, in the following section these items are examined independently of one another to understand predispositions for CA among these three factors.

Items for the Conventional and Risk Averse Agriculture technological frames were found to provide more coherence when analyzed together as evidence that they were often seen as interrelated, albeit sometimes opposed, perspectives as formulated in day-to-day discourse. Using varimax rotation, two underlying dimensions were identified and extracted. These two dimensions of agricultural production norms and practices cut across the four localities, linguistic/cultural differences, and various roles in agricultural production. The first factor can be described as characterizing conventional modern farming using purchased inputs. It can be formulated in this way – "successful farming requires the use of modern chemical inputs and machinery". After accounting for the dimension of conventional chemical based farming, the second factor accounts for co-variation associated with traditional mixed farming food security systems. It can be summarized as indicating that "cash cropping should contribute to livestock and poultry production".

The analysis of the difference in mean values for the two factors for general agricultural production norms and practices indicates that size of farm and contact with extension agents have little impact on these technological perspectives of farmers. However, the analysis does demonstrate a significant difference between the perspectives of farmers and those of service sector/community agents. Service sector/community agents are more likely than farmers to agree that successful farming requires the use of modern chemical inputs and machinery. Whereas these agents are less likely than farmers to believe that cash cropping should be integrated with livestock and poultry production. Size of farm has a weak negative effect although significant correlation (at the .05 level) with the mixed farming factor, suggesting small farmers may be more comfortable with this traditional practice. Modern chemical-based farming is not correlated with farm size.

These findings indicate that there is a fundamental gap between the perspectives of farmers and those of the service sector/community leaders with respect to agricultural production norms and practices across the four sites. The general pattern remains when these data are analyzed within each community, although statistically significant differences are rare, and only in Kenya

(modern chemical-based farming in Bungoma at the .01 level, and mixed farming in Kitale at the .05 level).

Turning to CA indicators we find that crop rotations are perceived by nearly all agricultural sector actors (farmers, service sector and community agents) as a best practice. There is a shared consensus on the importance of crop rotations in all four study communities. On the other hand, the perspectives on permanent vegetative soil cover are polarized. Respondents were asked whether they agreed or disagreed with the statement that "One should maintain a permanent crop cover". Seventy-three percent of the service sector/community actors agreed, while over a third of farmers (more often the larger ones) disagreed; and another third were uncertain. There is clearly a major disagreement between farmers and their advisors over the issue of maintaining crop cover. The third principle of CA appears to be the most controversial issue with respect to agricultural knowledge, norms and practices. There is much substantial disagreement over whether "Tillage causes land degradation" and much less uncertainty than for the soil cover indicator. These disagreements, however, appear to be within categories of actors, rather than between them. In this case, the agricultural service sector/community agents are less in agreement than with the other two CA propositions. In contrast, many more farmers are in agreement than was the case for maintaining soil cover (from nearly 40 to 50 percent). However, the distributions are such that there is no statistical difference in mean values, either across localities or within any particular one.

The investigation of the distribution of these technological frame perspectives on conservation agriculture is more instructive at the local level where scientific and local knowledge meet the ecology and production systems. Each locality has its agro-ecological specificity. This specificity has an impact on the development of relevant local knowledge for farming and how each farming population integrates (often scientifically or commercially based) knowledge and practices coming from elsewhere. To introduce new concepts or practices to a specific locality requires taking these factors into account. Let's look again at these indicators of agricultural production knowledge and practice from this perspective.

Adherence to the perspective that successful farming requires the use of modern chemical inputs and machinery increases from Kapchorwa, Kitale, and Bungoma (in that order) to Tororo where it achieves its highest level. Interestingly the greatest disparity is found between the frontier environment of Kapchorwa and the older industrial/rail center of Tororo and appears consistent with their histories. With respect to systems integrating cash cropping with livestock and poultry production, these two localities are likewise distinguished, as are Bungoma and Kitale. Tororo and Bungoma are less likely to advocate for the integration of cash cropping with livestock and poultry production than Kapchorwa and Kitale. This is also consistent with local cultures and histories, as the people of both Kapchorwa and Kitale have a stronger pastoral tradition. In Kapchorwa, integration of cattle and crop systems facilitates production as the slope and terrain in much of the area is ill suited to tillage by tractors.

Let's consider the similarities and differences between these localities for the two controversial CA items we've been analyzing above. With respect to whether "one should maintain a

permanent crop cover", Kitale stands out with a majority in agreement with the statement and the highest mean value. In contrast, half of the Bungoma agricultural sector actors disagree with the statement. This is consistent with a concern expressed by several non-farm agricultural agents and farmers that the climate in Bungoma is too dry to produce cover crops in addition to food crops or to harvest enough biomass to provide adequate ground cover. Tororo and Kapchorwa are significantly more neutral on the issue, signifying that the use of cover crops may simply be an unfamiliar production method in these areas.

As for whether "tillage causes land degradation", Kapchorwa stands out as the strongest supporter of that perspective with a strong majority agreeing and the highest mean value. Likewise, reports during focus groups and qualitative interviews with service sector providers in Kapchorwa indicate that reducing soil erosion is a major concern for these farmers. A majority of respondents from Kitale and a plurality from Tororo also agree with the statement. However, both of these localities have significant minorities who disagree. Bungoma is most uncertain on the issue.

Objective 2: Describing the structure of information and physical resource flows between these actors.

Analyzing the composition and structure of agricultural production networks across the localities is a multi-step process. First, we were interested in describing the general involvement of farmers in agricultural production networks across the sites and which members of the network were the most important to farmers as sources of agricultural information and resources. Second, to conduct the network analysis, the data collected regarding farmer contacts with agricultural service sector/community agents during the household survey was matched up to the data from service sector/community agents. While the network surveys collected data regarding both resources and information/knowledge exchange, the focus for analyzing network structure in the working paper is on knowledge and information exchange as the more inclusive network.

Farmers in Tororo report the fewest network contacts of any of the sites (2.8), and generally farmers in Kenya report significantly more contacts for agricultural resources than farmers in Uganda. In the higher potential areas of Kapchorwa (7.1) and Kitale (7.5), farmers report significantly more contacts for agricultural information than agricultural resources. This means that farmers in Tororo are exposed to far fewer sources of information than the farmers in the other three sites. Indeed, increasing activity in farmer networks through outreach programs will likely be a key initial step for stimulating innovation in agricultural networks in Tororo.

The next step in the analysis was to identify the most important/influential individuals in the network. Measures of such power and influence in network analyses are typically described as measures of centrality. For our analysis, two measures of centrality were deemed especially important: degree centrality and betweenness centrality. Degree centrality is simply a measure of the number of connections between a given actor and other actors in the network and is measured as a count of the number of contacts for any given actor based upon their self-report and the report of others being in contact with that particular actor. Betweenness centrality

reflects the extent to which an individual can facilitate or limit communication between other nodes in a network.

For the communities in Kenya the findings demonstrate that extension takes a lead role as a central actor accompanied by the microfinance institutions in Kitale. Because of the higher potential of the region, it appears that extension agents have a more important role in the network. Overall, however, the agricultural production network of Kitale appears to have a wide range of different agents, but often organized in a variety of organizations. In contrast, in Bungoma, there appears to be a break between the two most central actors and a number of non-farm agents. Both the farm organization leader and the chief are highly connected and serve a key gatekeeper function in facilitating communication between other agents in the network. The local veterinarian and youth leader play a secondary role, followed by the pastor, market vendor, and extension agent.

In Uganda, actors in Tororo who have the most contacts also exercise the most control over the information flows between contacts. Clearly, the local farm organization leader, the governmental parastatal Tororo Datic, and agrovet suppliers are the most central actors in transmitting agricultural information and knowledge within the agricultural production network in Tororo. These actors represent key individuals to be engaged in efforts to promote knowledge of conservation agriculture production and practices. In Kapchorwa, the actors who have the most contacts do not necessarily exercise the most control over the information flows between contacts. The chief, NAADS coordinator, women's group leader, and local agrovets appear in the top four scores for both measures. These actors represent key individuals to be engaged in efforts to promote knowledge of conservation agriculture production and practices.

Objective 3: Determining critical network pathways and opinion leaders facilitating technological change among farmers and their service sector partners.

The feedback sessions in Kenya and Uganda provided valuable insights into how each community could move forward with facilitating technological change among farmers and their supporting service sectors. Research Associate Jennifer Lamb, facilitated the Technology Network Discussions. The first section of the network presentation highlighted the importance of involving various members of the agricultural production network in the promotion of conservation agriculture. Then the most frequently farmer-cited contacts to obtain agricultural resources (seeds, fertilizer, agrochemicals, plowing services, veterinary services, loans/financing, etc.) and information were introduced. Following this, the presentation introduced the network map, and measures for identifying the centrality of particular agents. Next, graphs of the distribution of beliefs between small farmers, large farmers, and service providers were presented and impacts of extension contact on farmer knowledge and beliefs discussed. Finally, the network maps presented above, which bring together network structure and existing beliefs about agricultural production were presented and discussed for the ideas of "tillage causes land degradation" and "maintaining a permanent soil cover". Throughout the workshop, participants were encouraged to provide feedback and ask questions about the

results presented. In this section, reflections on the local workshops in each of the sites are provided interspersed with the network maps as presented in each workshop.

Significant Training, Capacity Building, and Networking Activities

The feedback sessions in Kenya and Uganda involved four workshops with local partners (service sector and community agents as well as farmer leaders). Fifty-four men and 30 women participated in these sessions during early February 2012.

Masters student, Jennifer Lamb completed her thesis and degree in Agricultural and Applied Economics. Three undergraduate students have been employed part-time to manage the SANREM Knowledge Base and assist in literature reviews.

A working paper has been drafted documenting the Technology Networks research findings for the LTRA-10 sites in Kenya and Uganda, four community-targeted extension brochures distributed during workshops in February, and two papers are being prepared for presentation at meetings this summer (Rural Sociological Society and World Congress of Rural Sociology).

Research Strategy and Development Objectives

The research strategy is being implemented as revised last year and proceeding steadily. The following describes some of the lessons we are learning along the way.

During the restitution of the findings with stakeholders in Kenya and Uganda, questions were raised about the meaning of 'crop cover' as posed to respondents. A review with enumerator supervisors about how this concept was translated revealed strong consistency across sites for the initial statement and subsequent clarifications made when requested by respondents. "Crop cover" was generally translated as leaving residues on the field, or immediately planting another crop after harvest. The ultimate goal was assuring that bare soil was not exposed. It was acknowledged that a more appropriate formulation of the statement in English would be "one should maintain a permanent soil cover".

During the feedback workshop in Kitale, an important insight was gained concerning the high centrality measures for the Ministry of Agriculture as a central figure in information and resource networks. One of the host farmers for the SANREM experimental plots pointed out that during the year of data collection the MOA required that all farmers come in and sign up in order to receive a fertilizer subsidy, thus creating an artificial relationship. This requirement positioned the MOA between the farmer and his usual supplier. To the extent that the MOA continues these programs they can assure themselves not only of having influence because of their authority positions in the social structure, but also because of their structurally central position in the agricultural input supply network of Trans Nzoia.

Data collection at the household level for Haiti is proceeding, but data entry has not been complete. Some questions concerning the implementation of the network contact generator instrument have been raised and will be further investigated with the completion of data entry and follow-up survey work.

Soil Quality and Carbon Sequestration CCRA

Lead PI: Michael Mulvaney, Virginia Tech

Research Progress by Objective

Quantify soil organic carbon (SOC) fractions in host country project areas before CAPS implementation.

Critical Research Accomplishments

- The CCRA PI (Mulvaney) has obtained a modified USDA permit to hand-carry foreign soils.
- We currently have Time 0 soil samples from sites in Bolivia, Ecuador, Philippines, Kenya, Uganda, Lesotho, and Cambodia. The Kenya and Uganda samples are only from the 0-5 cm depth, and the Lesotho samples are from uncertain depths due to the nature of the 2:1 clays at that site and the soil moisture at the time of sampling.
- All samples are currently undergoing laboratory analyses for SOC and fertility determination. SOC from the samples is being fractionated at <1.8, 1.8-2.0, and >2.0 g cm^{-3}. The bulk soil and each of the fractions are being analyzed for carbon speciation by Near Edge X-ray Absorption Fine Structure (NEXAFS) spectroscopy to determine the chemical stability of the soil organic matter (SOM). NEXAFS will only be conducted on those samples where best-bet CAPS will be placed and on traditional practice controls. We expect these parameters to change with the implementation of CA. A summary of the samples we have analyzed to date is shown in Table 1.
- Basic soil fertility parameters have been completed on all soil samples received to date.
- We have completed approximately half of the total C and N analyses on the samples received so far.
- Density fractionation has been completed on 11% of the samples received so far.
- Cover crop seed was distributed to on-station research sites in Haiti for the no-till cover crop trials in conjunction with the Haiti LTRA.
- Three weather stations and 25 no-till "Li seeders" were purchased for our work in collaboration with LTRA-6. They will be delivered during our next trip.
- Assisted with cover crop selections for implementation in on-station research trials in collaboration with LTRA-11.
- Field- and laboratory-testing has been completed for continuous soil CO_2 flux monitors for deployment in Kenya, in collaboration with LTRA-10. We requested an algorithm re-write to include linear regression calculations and goodness of fit statistics in addition to the Pedersen algorithm. A purchase request has been submitted for six ACE units. We are currently waiting on shipment of the order.

Table 1. Summary of select site characteristics from localities contained within the CCRA-9 Time 0 soil library.

Country	Bolivia	Ecuador	Philippines	Cambodia	Kenya	Uganda	Lesotho	Bolivia Gender CCRA
Samples received	54	12	30	76	4	8	16	30
Analyses completed:								
Soil testing	54/54	12/12	30/30	76/76	4/4	8/8	16/16	30/30
CN	24/54	12/12	8/30	0/76	0/4	0/8	16/16	30/30
Density fractionation	12/54	3/12	7/30	0/76	0/4	0/8	0/16	N/A
NEXAFS	12/54 (24)	3/12	3/30 (16)	0/76	0/4	0/8	0/16	N/A
Bulk density data?	no	yes	no	yes	no	no	N/A	no

Development Impact

A soils library from project research sites analyzed within a single laboratory will allow scientifically rigorous comparisons of soil quality 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 Mg 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 Mg 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 Mg C ha^{-1} yr^{-1}, such that after three years we may accumulate approximately 2.3 Mg 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 from tropical locations. Sisti et al. (2004) found that after 13 years in Southern Brazil, rotations that included vetch (*Vicia villosa*) 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 most of our locations do not enjoy. 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 will not be able to send us soil samples from their project sites and/or

may collect the samples in an inappropriate manner. The Soils CCRA 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. Soil fertility parameters will be measured and compared to those at Time 0, and changes in soil fertility will be correlated to treatment effects, as well as those parameters listed above.

A work plan is under development for the investigation of soil and water conservation practices in Mali along a long-term chronosequence. This project has been halted by USAID due to recent political developments in that country.

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.

Soil and water conservation measures in place in Mali offer a unique chance to determine soil fertility increases due to those conservation measures over a long-term chronosequence (12 years).

Should host countries be compelled to participate in a carbon trading mechanism, the sequestration of soil carbon via CAPS may have economic ramifications for those countries. Currently, no trading mechanism exists where soil carbon is incorporated into economic models, but since soil carbon is the second greatest carbon 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.

A recent military coup has prompted USAID to suspend all activities in Mali. We plan to resume this portion of our work as soon as the State Department clears the suspension.

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 completed soil sampling in Bolivia to quantify gendered knowledge of soil fertility 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 georeferenced data from the gendered survey. Soil samples from the survey have been received and analyzed for pH (1:1 soil:water), buffered pH (Mehlich buffer), available P, K, Ca, Mg, Zn, Mn, Cu, Fe, B (Mehlich 1), CEC, acidity, base saturation, Ca saturation, Mg saturation, K saturation, and total C and N (dry combustion).

We have initiated soil survey activities in Haiti in coordination with the household economic survey currently underway in the Central Plateau. The objective is to determine within- and among-field soil fertility variability in farmer fields. We will also quantify crop density and diversity in the sampled fields.

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. We will gather preliminary data on how soil fertility affects household economic efficiency, which 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?

Quantification of soil fertility variability within our area of operations will allow determination of nutrient deficiencies of the area, how they are related to landscape position, aspect, soil type, cropping system, and household economic status. Without the knowledge of which nutrients are limiting, fertilizer recommendations are merely a guess.

Challenges and Responses

The Soil Quality CCRA PI will augment the research objectives from the socioeconomic studies in Haiti, relating household economic status to soil quality, fertility, and agronomic practices. The Soil Quality CCRA PI will depend heavily on the experimental design and methodology implemented by the LTRA socioeconomic collaborators.

There are no 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 that will correlate soil nutrient extraction with plant nutrient uptake and will calibrate the soil test value to yield response. We currently do not have the resources to conduct correlation and calibration experiments.

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

Significant Training, Capacity Building, and Networking Activities

Student training:

The Soil Quality CCRA PI serves as co-major professor for one PhD candidate within the Department of Crops, Soils, and Environmental Sciences. He is working on field experiments in Haiti as well as the Time 0 soil sample library.

The Soil Quality CCRA PI serves on the graduate student committees of two degree-seeking students at Virginia Tech. One student, Ryan Stewart, is working on his Masters of Science in the Department of Crops, Soils, and Environmental Sciences under the direction of one of our project LTRA agronomists, Wade Thomason. The other student, Nathan Kennedy, is working on his PhD in the Department of Forest Resources and Environmental Conservation under the direction of Gregory Amacher.

Publications:

- Articles Published in Refereed Publications: 1 accepted with major revisions, not yet published.
- Papers/Seminars Presented: 1
- Posters: 1

- Proceedings: The PI is the lead Editor for a Proceedings publication resulting from the Second International Conservation Agriculture Workshop and Conference in Southeast Asia in Phnom Penh. We hope to have the publication printing in June 2012.

Special events or networking activities

- Assembled and met with leading soil scientists with experience in Haiti to discuss appropriate soil extractants for use in Haiti.
- Participated in the ASA-CSSA-SSSA International Annual Meetings in San Antonio, Texas
- Met with Haiti LTRA partners and newly hired agronomists.

Research Strategy and Development Objectives

The overarching goal of this CCRA is to determine if dryland smallholders in the developing world can increase SOC, and hence soil fertility, by adoption of conservation agriculture (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.

Our development objective is to determine which CA parameters increase soil fertility in small households in the developing world. Our research strategy is designed to monitor sensitive short-term indicators of soil fertility, since we hypothesize that only labile carbon will be increased over the interval of this project. However, with continued funding, our soils library will serve as a reference point by which the long-term effects of CA on soil fertility can 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 LTRA Lead-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.

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.

Management Entity Activities

The SANREM CRSP Management Entity has been supporting the implementation of Phase IV Long-Term Research Awards (LTRAs) and Cross Cutting Research Activities (CCRAs) during the first half of Fiscal Year 2011. 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. During this six-month period, Communication Coordinator Lindsey Sutphin resigned to pursue a graduate degree at Georgetown University and a search for her replacement was launched. Program activities have continued to move forward without disruption.

Highlights of these supportive activities include the following:

- Two Graduate Research Assistants (GRAs) completed their theses and graduated. Two GRAs are in various stages of data collection and analysis for their Master's theses for the Economic Impact Analysis, Gendered Knowledge, and Technology Networks CCRAs.
- The *SANREM CRSP 2011 Annual Report* was prepared and submitted to USAID.
- A PERSUAP has been approved by USAID/Washington for the LTRA-10 in Kenya and Uganda and LTRA-7 sites in Ecuador and Bolivia.
- Seventy-four (74) new information resources were entered into the SANREM Knowledgebase (SKB).
- One hundred eighteen (118) new SKB entries originated from SANREM-funded activities.
- Fourteen (14) missions have been taken by US-based PIs to work with host-country counterparts at SANREM research sites.
- The Soil Quality CCRA conducted missions to sites of LTRA-6 in Haiti to collect soil samples and observe the establishment of research trials.
- Technology Networks CCRA conducted missions to LTRA-9 site in Lesotho to collect agricultural service sector and community agent data, and to LTRA-10 sites in Kenya and Uganda to conduct restitution workshops on technology network findings.
- The Gender CCRA conducted a mission to LTRA-12 site in the Philippines to prepare for intensive summer research to be conducted by a graduate student.
- SANREM CRSP co-sponsored the 2011 Soil and Water Assessment Tool (SWAT) Southeast Asia Conference in Ho Chi Min City, Vietnam.
- SANREM CRSP ME was invited by USAID to participate in the three inception workshops for the Africa RISING sustainable intensification projects. Ares attended the workshops in Tamale, Ghana, and Addis Ababa, Ethiopia with the PIs of LTRAs 8 and 9 (Prasad and Eash, respectively), and Moore participated in the workshop in Dar es Salaam with the PI of LTRA-10 (Norton).

- Ares and Eash travelled to Mozambique to visit SANREM field experiments in Manica (carried out in collaboration with CIMMYT), the Feed the Future priority areas of Nampula and Zambezia (including UniZambezi) and the USAID Mission in Maputo.
- Ares participated in the 12th National Conference on Science, Policy and the Environment. National Council for Science and the Environment in Washington D.C., and participated in a mentoring session on sustainable natural resources management with university students.

Appendices

Long-term Degree Training

Table 1: Long-term degree trainees

Student Name	Sex	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
Aida Cossitt	F	American	Environmental Policy & Planning	Global	N	Aug-11	May-13	BS	Y	Y	ME	Moore	Virginia Tech
Aliza Pradhan	F	Indian	Soil Science, Agronomy	Nepal	N	Jan-12	Dec-14	PhD	Y	N	11	Idol	University of Hawaii-Manoa
Anna Testen	F	American	Plant Pathology	Bolivia & Ecuador	N	Aug-10	Dec-12	MS	Y	Y	7	Backman	Penn State University
Arnulfo Portilla	M	Ecuadorian	Chemistry	Ecuador	N	Oct-10	Dec-11	Eng.	Y	N	7	Alvarado	Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP)
Bhagini Nabanita	F	India	Soil Science	India	N	Aug-11	Jul-12	MS	Y	Y	11	Mishra	Orissa University of Agriculture & Technology
Bikash Paudel	M	Nepal	Env. Economics	Nepal	N	Jan-10	Jan-12	PhD	Y	N	11	Chan-Halbrendt	University of Hawaii at Manoa
Brinton Reed	M	American	Ag. Economics	Global	N	Jan-11	Dec-12	MS	Y	N	11	Chan-Halbrendt	University of Hawaii-Manoa
Carl Yoder	M	American	Soil Science	Mozambique	N	Aug-11	Aug-13	MS	Y	N	9	Eash	University of Tennessee
David Moposita	M	Ecuadorian	Agronomy	Ecuador	N	Oct-10	Dec-11	Eng.	Y	N	7	Barrera	Instituto Nacional Autónomo de Investigaciones Agropecuarias (INIAP)
Don Immanuel Edralin	M	Filipino	Energy & Environmental Systems	Philippines	N	Aug-11	May-14	PhD	Y	Y	12	Reyes	North Carolina A&T State University
Emily Pfeufer	F	American	Plant Pathology	Bolivia & Ecuador	N	Aug-10	Dec-14	PhD	Y	Y	7	Gugino	Penn State University
Erine Thornburgh	F	American	Agronomy	Global	N	Summer 2011	Fall 2013	MS	Y	N	8	Prasad & Garrett	Kansas State University
Forrest Fleischmann	M	American	Public Policy	Global	N	Sep-07	May-12	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
Hilary Kessler	F	American	Plant Pathology	Ecuador	N	Aug-10	Dec-14	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-10	May-12	MS	Y	N	10	Bashaasha	Makerere University (Uganda)
Jacqueline Marie Halbrendt	F	American	"Gender, Tech, Transfer, Agronomy"	Global	N	Jan-11	Dec-13	PhD	Y	N	11	Idol	University of Hawaii-Manoa
Jennifer Lamb	F	American	Agricultural Economics	Kenya & Uganda	N	May-10	Dec-11	MS	Y	N	CCRA-8	Moore	Virginia Tech
Jeremiah Okeyo	M	Kenyan	Soil Science	Kenya	N	Aug-10	Jun-14	PhD	Y	Y	10	J. Norton	University of Wyoming
Jessica Schultz	F	American	Human Nutrition & Agricultural Sciences	Global	N	Apr-11	May-12	BS	N	N	ME	Moore	Virginia Tech
Jocelyn Tabili	F	Filipina	Strategic Studies	Philippines	N	Jun-11	Apr-12	MS	Y	N	12	Dayo	University of Philippines Los Baños

Student Name	Sex	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
Judith Odhiambo	F	Kenyan	Soil Science	Kenya & Uganda	N	Jan-11	Dec-14	PhD	Y	N	10	U. Norton	University of Wyoming
Kathleen Weber	F	American	Soil Science	Ecuador	N	Aug-10	Aug-13	MS	Y	Y	7	Stehouwer	Penn State University
Keri Agriesti	F	American	Geography	USA & Bolivia	N	Aug-10	May-12	MS	Y	N	CCRA-7	Christie	Virginia Tech
Linsey Shariq	F	American	Human Dimensions	India & Nepal	N	May-11	May-14	PhD	N	Y	11	Chan-Halbrendt & Gray	University of Hawaii-Manoa
Lyda Hok	M	Cambodian	Energy & Environmental Systems	Cambodia	N	Aug-11	Sep-14	PhD	Y	Y	12	Reyes	North Carolina A&T State University
Mary Harman	F	American	Geography	USA & Philippines	N	Aug-11	May-13	MS	Y	N	CCRA-7	Christie	Virginia Tech
Matt Bruns	M	American	Soil Science	Lesotho	N	Jan-10	Dec-11	MS	Y	N	9	Eash & Walker	University of Tennessee
Michael W. Graham	M	American	Soil science	Haiti	N	May-11	Sep-14	PhD	Y	N	CCRA-9	Mulvaney & Thomason	Virginia Tech
Moses Obbo Owori	M	Ugandan	Agricultural Economics	Uganda	N	Aug-10	Jun-12	MS	Y	N	10	Peck	University of Wyoming
Nadezda Amaya	F	Bolivian	Agricultural Economics	Bolivia	N	Aug-10	Aug-13	PhD	Y	Y	7	Alwang	Virginia Tech
Nathan Kennedy	M	American	Forestry	Haiti	N	Mar-10	May-13	PhD	Y	N	6	Amacher	Virginia Tech
Patrick Samba Oluka	M	Kenyan	Soil Science	Kenya & Uganda	N	Aug-10	Jan-13	MS	Y	N	10	Okalebo	Moi University (Kenya)
Paul Tarnate	M	Filipino	Land/Water Resource Engineering	Philippines	N	Nov-06	Oct-11	MS	Y	N	12	Ella	University of Philippines Los Baños
Pharnice Adikinye Ongonga	F	Kenyan	Soil Science	Kenya	N	Jan-10	Jan-13	MS	Y	N	10	Okalebo	Moi University (Kenya)
Plabita Ray	F	India	Agronomy	India	N	Aug-12	Jul-12	MS	Y	Y	11	Roul	Orissa University of Agriculture & Technology
Priyabrata Bhoi	M	India	Ag. Economics	India	N	Aug-11	Jul-12	MS	Y	Y	11	Naik	Orissa University of Agriculture & Technology
Rafael Padre	M	Filipino	Land/Water Resource Engineering	Philippines	N	Jun-08	Apr-12	PhD	Y	N	12	Ella	University of Philippines Los Baños
Romina Manalo-Bondad	F	Filipina	Land/Water Resource Engineering	Philippines	N	Nov-06	Oct-11	MS	Y	N	12	Ella	University of Philippines Los Baños
Roshan Pudashaini	M	Nepal	Soil Science	Nepal	N	Jan-12	Dec-13	MS	Y	Y	11	Chaudhary	Tribhuvan University, Institute of Agriculture & Animal Science
Sarita Gautam	F	Nepal	Ag. Economics	Nepal	N	Jan-12	Dec-13	MS	Y	Y	11	Chaudhary	Tribhuvan University, Institute of Agriculture & Animal Science
Ryan Stewart	M	American	Crop & Soil Environmental Sciences	Haiti	N	Aug-10	Sep-12	MS	Y	N	6	Thomason	Virginia Tech
Suman Dhakal	M	Nepal	Agronomy	Nepal	N	Jan-12	Dec-13	MS	Y	Y	11	Chaudhary	Tribhuvan University, Institute of Agriculture & Animal Science
Wendy Jones	F	American	Soil Science	Lesotho	N	Jan-10	Dec-11	MS	Y	N	9	Eash & Walker	University of Tennessee

Short-term Training

Table 2. Short-term training (October 2010-March 2011)

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Bolivia						
Field Day	2/8/2012	Farmers in Waylla Pujru community	7	5	PROINPA	Evaluate farmer preferences for forage varieties
Field Day	2/21/2012	Farmers in Waylla Pujru and Sancayani Alto communities	12	9	PROINPA	Evaluate farmer preferences for forage varieties
Ecuador						
Conference	10/20/2011	Professor and students of State University of Bolívar, and technicians	50	30	Penn State (Dr. Gallagher)	Learn conservation agriculture techniques and practices.
Workshop	08/11/2011	Farmers	4	2	INIAP	Learn irrigation and water management
Conference	11/28/2011	Professors and students of Cuenca Catholic University	88	40	INIAP (Víctor Barrera)	Analyze adaption of agriculture to climate change in the Andes.
Workshop	12/23/2011	Farmers of Culebrillas, and technicians.	8	4	INIAP (Moazir Célleri)	Analyze CA practices in potato-pasture systems
Workshop	01/17-19/2012	Technicians	12	2	INIAP-CIP (Víctor Barrera)	Anlyze of agriculture to climate change in the Andes
Workshop	01/25/2012	Technicians and professors of State University of Bolívar	8	2	SANREM CRSP (Wills Flowers)	Learn about biological evaluation of soils.
Conference	03/06/2012	Professors and students of State University of Bolívar (Ecuador)	25	10	INIAP (Víctor Barrera)	Analyze adaption of agriculture to climate change in the Andes

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Guatemala						
Workshop	12/22/2011	Farmers of Bola de Oro, technicians (Guatemala)	12	6	INIAP (Luis Escudero)	Learn about CA practices in maize-bean systems
Haiti						
Short course	10/12/2011	Farmers of Bois-Joly	50	50	Zanmi Agrikol agronomists	Obtain education on soil conservation methods
Short course	10/18/2011	Farmers of Bois-Joly	60	40	Zanmi Agrikol agronomists	Obtain education on soil conservation methods
Short course	10/30/2011	Farmers of Morne-Michel	55	45	Zanmi Agrikol agronomists	Obtain education on green manures in conservation agriculture
Short course	11/12/2011	Farmers of Bois-Joly	30	20	Zanmi Agrikol agronomists	Obtain education on green manures in conservation agriculture
Workshop	01/10/2012	Agronomists and technicians of Zanmi Agrikol at Corporant	4	1	Virginia Tech	Obtain training in establishment and planting of cover crop trials
Workshop	01/11/2012	Agronomists and technicians of Zanmi Agrikol at Lachateau	3	1	Virginia Tech	Obtain training in establishment and planting of cover crop trials
Workshop	01/12/2012	Agronomists of Caritas-Hinche at Maissade	2	0	Virginia Tech	Obtain training in establishment and planting of cover crop trials
Short Course	01/12/2012	Smallholder farmers near Maissaide experimental site	26	24	Virginia Tech Caritas-Hinche Agronomists	Learn key elements of conservation agriculture

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
India						
Workshop	21-Dec-11	*(India)* Tentuli Village Farmers	36	30	OUAT / University of Hawaii	Train on the management of harvest, post-harvest, and crop residues in CAPS; Focus group discussion on the first year of on-farm CAPS intervention
Workshop	24-Dec-11	*(India)* OUAT faculty and students, scientists, State govt. officials	220	80	OUAT / University of Hawaii	Present the findings of CAPS interventions for the first two years of the project; Collect feedback from local agricultural experts
Kenya						
Workshop	25 /11/ 2011	Farmers/Technical persons	7	1	MHAC (NGO, Kenya)	Reflect on year one trial, elaborating CAPs, way forward
Workshop	14 Feb 2012	Agricultural service providers, community agents and farmers in Bungoma, Kenya	14	10	Virginia Tech	Report and discuss network research conducted in 2011
Workshop	16 Feb 2012	Agricultural service providers, community agents and farmers in Kitale, Kenya	11	5	Virginia Tech	Report and discuss network research conducted in 2011
Field Day	March 14, 2012	MHAC students and staff	10	10	U. Wyoming; J. Norton, J. Norton Sr., U Norton	Operate and provide input on performance of MFI tillage implement; inform agricultural students about CA principles

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field Day	March 15, 2012	Kitale Farmers	8	1	U. Wyoming; J. Norton, J. Norton Sr., U Norton	Operate and provide input on performance of MFI tillage implement; inform local farmers about CA principles
Lesotho						
FGW In-field mentoring	Oct 1-9 2011	Farmers in Mpharane	18	13	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain 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	Analyze conservation ag. systems in Lesotho. Explain 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	Analyze conservation ag. systems in Lesotho. Explain 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	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA, management keys, field demonstrations
Workshop	Oct 11 2011	F.T.C, Prisoners Training	39	0	Growing Nations Trust	Analyze conservation ag. systems in Lesotho. Explain the three principles of CA, management keys, field demonstrations, field scale layout
Field day	Oct 31 2011	Farmers from Thabana-Morena	2	0	Growing Nations Trust	Analyze conservation Ag. Systems in Lesotho. Demo-farm visual display

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	October 31, 2011	Farmers	6	2	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	November 9, 2011	Extension officers from SA	8	5	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	Nov 14-18 2011	Ministry of Forestry & Agriculture	6	13	Growing Nations Trust	Learn CAPS in Lesotho. Explain the three principles of CA, Management keys, field demonstrations
Workshop	November 16-18 2011	Mohale's Hoek Farmers	10	15	NUL	Learn CA in Climate Change Adaptation
Workshop	November 17, 2011	Extension officers (FORESTRY)	5	14	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	November 17, 2011	Extension officers (Ministry of FORESTRY	5	14	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	November 22, 2011	Farmers	10	0	Growing Nations Trust	CA principles, step by step procedures of applying CA, management keys
Workshop	November 23-25 2011	Mafeteng Farmers	10	10	NUL	Analyze CA in climate change adaptation
Workshop	December 6-9 2011	Thaba-Tseka Farmers	15	9	NUL	Analyze CA in Climate Change Adaptation
Workshop	January 22, 2012	Mcc SwaLeSA service workers (Southern Africa)	20	3	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Workshop	February 13,2012	Extension officers (F.A.O)	7	7	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	February 24,2012	Farmers (THABA TSEKA) BFJ Group	6	4	Growing Nations Trust	Learn CA principles, step by step procedures of applying CA, management keys
Field day	March, 2012	Khalo,Mootsinyane, Stanteng,Poqa (farmers)	5	6	Growing Nations Trust	Learn about weeding, cover crops, fertilizer trials, cover, stalk borer, problems of rabbits on beans
Seminar (Sensitization)	March, 2012	M/hoek Presibetry (Mohalinyane)	30	42	Growing Nations Trust	Learn about CA, weeding, cover crops
Field Day	March, 2012	Mpharane,Stanteng, Poqa and Mootsinyane (Farmers)	11	13	Growing Nations Trust	Learn about cover crops, silage making
Workshop	March 13-14th 2012	Members of the Conservation Agriculture Network in Lesotho	10	15	NUL	Prepare oCA5-Year Strategic Plan
Workshop	March 15-16 2012	Lesotho College of Education Lecturers	5	7	NUL	Prepare for Review of curricula on CA in the College
Workshop	Aug 2011-Aug 2012	Soil Science Majors in the Faculty of Agriculture NUL	8	10	NUL	Supervision on Bsc. Research Projects
Mozambique						
Short course	Oct 3 2011	Graduate Student	1	0	University of Tennessee	Learn how to use SAS for survey data analysis
Workshop	3/12/12	Enumerator Candidates	12	3	UT, CIMMYT and IIAM	Familiarize candidates with survey instrument and Finalize survey for field testing.
Workshop	3/13/12	Enumerator Candidates	12	3	UT, CIMMYT and IIAM	Play roles in exercises conducted for and between trainees to enhance survey efficiency and hone local language vocabulary.

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field Day	3/14/12	Enumerators	6	2	UT, CIMMYT and IIAM	Field testing of Survey instrument
Nepal						
Workshop	19-Dec-11	*(Nepal)* Thumka Village Farmers	9	0	Li-Bird	Orient farmers on the action research of the SMARTS Project
Workshop	20-Dec-11	*(Nepal)* Thumka Village Farmers	8	5	Li-Bird	Orient farmers on CAPS and the importance of improving soil and crop yield
Workshop	21-Dec-11	*(Nepal)* Hyakrang Village Farmers	7	2	Li-Bird	Orient farmers on the action research of the SMARTS Project
Workshop	22-Dec-11	*(Nepal)* Hyakrang Village Farmers	10	6	Li-Bird	Orient farmers on CAPS and the importance of improving soil and crop yield
Workshop	24-Dec-11	*(Nepal)* Khola Gaun Village Farmers	7	4	Li-Bird	Orient farmers on CAPS and the importance of improving soil and crop yield
Workshop	25-Dec-11	*(Nepal)* Khola Gaun Village Farmers	8	1	Li-Bird	Orient farmers on the action research of the SMARTS Project
Workshop	2-Jan-12	*(Nepal)* TU/IAAS Project Associates and Master's students	20	6	University of Hawaii / IAAS	Present an introduction to CAPS and conduct AHP and cognitive modeling surveys / Presentation of project field activities and observations
Workshop	3-Jan-12	*(Nepal)* LI-BIRD Research Associates, IOF Master's students	16	11	University of Hawaii	Present an introduction to CAPS and conduct AHP and cognitive modeling surveys
Workshop	5-Jan-12	*(Nepal)* Thumka Village Farmers	11	8	University of Hawaii	Conduct AHP and cognitive modeling surveys

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	7-Jan-12	*(Nepal)* Hyakrang Village Farmers	9	10	University of Hawaii	Conduct AHP and cognitive modeling surveys
Demonstration	8-Jan-12	*(Nepal)* IOF Master's Students, LI-BIRD research associate	4	1	University of Hawaii	Explain and demonstrate the weather station functioning, maintenance and data off-loading methods
Workshop	9-Jan-12	*(Nepal)* Khola Gaun Village Farmers	7	10	University of Hawaii	Conduct AHP and cognitive modeling surveys
Philippines						
Workshop	October 8, 2011	Farmers and Academe	12	7	ICRAF- Claveria	Enhance knowledge on rubber agroforestry systems
Workshop	October 25- 27, 2011	Farmers, LGU, Academe	22	14	ICRAF, USAID	Participatory Bio-Diversity Conservation and Agroforestry Development for Environment Services Projects identification for Mt. Apo Natural Park
Workshop	Nov 19, 2011	Rubber planters in Northern Mindanao	27	10	CRDFI, URRPA and ICRAF	United Rubber Planter and Processor Association (URRPA) exposure and training to expand rubber plantation in Claveria and in Mindanao
Workshop	6-8 February 2012	Farmers, LGU technicians, PO and NGO officers	18	9	CRDFI, ICRAF, SEARCA, USAID	Gain knowledge on various Conservation Agriculture with Trees Agroforestry Practices and Technologies to control soil erosion, sedimentation and pollutants
Focus Group	February 14, 2012	Farmer Cooperator (SANREM-CAPS)	12	18	ICRAF-Claveria, Dr. Christie, Ms. Dayo	Facilitate gender perspective for Conservation Agriculture

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field Day	February 24, 2012	Professors and students from Agusan Sur State College of Agricultural Technology	49	37	CRDFI ICRAF	Gain knowledge on various Conservation Agriculture with Trees Agroforestry Practices and Technologies implemented in Claveria
Field Day	February 24, 2012	Farmers form Sumilao, Bukidnon with LFPI project coordinator	9	7	CRDFI ICRAF	Gain knowledge on various Conservation Agriculture with Trees Agroforestry Practices and Technologies implemented in Claveria
Field Day	February 24, 2012	Professors and Students from Mindanao State University of Marawe	18	32	CRDFI ICRAF	Gain knowledge on various Conservation Agriculture with Trees Agroforestry Practices and Technologies implemented in Claveria
Field Day	March 8, 2012	Professors and students from Mindanao State University of Marawi	4	8	CRDFI ICRAF	Gain knowledge on various Conservation Agriculture with Trees Agroforestry Practices and Technologies implemented in Claveria
Uganda						
Workshop	Oct 12-13 2011	Farmers, local government and NGO representatives in Tororo and Kapchorwa	22	6	AT Uganda Technical Advisor (TA), M&E, Field Extension Coordinator (FEC), and Field Research Assistants (FRA)	Assess implementation constraints and progress evaluation
Field Days	Oct 18-20 2011	Farmers in Tororo (S), Kisoko (F), Molo (F)	10	11	AT Uganda FEC	Learn about fertilizer application at top dressing and knowledge sharing on fertilizer types, application methods in relation to plant stages, CA, and yield

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field Days	4 & 8 Nov. 2011	Kapchorwa Farmers	7	14	AT Uganda FEC and FRA	Enhance farmers' understanding of best agronomic practices and CA
Field Days	5 & 9 Nov. 2011	Kwosir and Kaplak Farmers	9	16	AT Uganda FEC and FRA	Safe use/ application of agrochemicals and CA
Field Days	10 & 11 Nov	Kapchorwa Farmers	13	13	AT Uganda FEC and FRA	Properly harvest and thresh of maize. Maintaining ground cover for CA
Field Days	5 Dec. 2011	Kapchorwa Farmers	3	7	AT Uganda FRA	Properly harvest and thresh maize. Maintaining ground cover for CA
Field Days	6 Dec. 2011	Kapchorwa Farmers	3	7	AT Uganda FRA	Properly harvest and thresh maize. Maintaining ground cover for CA
Field Days	12 Dec. 2011	Kapchorwa Farmers	5	2	AT Uganda FRA	Properly harvest and thresh maize. Maintain ground cover for CA
Workshop	11 Nov. 2011	Tororo Farmers	14	6	AT Uganda FEC and FRA	Increase awareness about SANREM CRSPS and share knowledge on CA
Workshop	14 Nov. 2011	Kisoko Farmers	5	15	AT Uganda FEC and FRA	Increase awareness about SANREM CRSPS and share knowledge on CA
Workshop	16 Nov. 2011	Tororo Farmers	10	8	AT Uganda FEC and FRA	Enhance data collection and record keeping
Workshop	17 Nov. 2011	Kisoko Farmers	4	12	AT Uganda FEC and FRA	Enhance data collection and record keeping
Workshop	18 & 19 Nov. 2011	Tororo Farmers	8	15	AT Uganda FEC and FRA	Plan for 2012 activities
Workshop	22 Nov 2011	Kapchorwa Farmers	5	11	Manor House and AT Uganda Ltd	Review and reflect on 2011 year's performance
Workshop	28 Nov 2011	Tororo Farmers	6	10	Manor house and AT Uganda Ltd	Review and reflect on 2011 year's performance
Field day	24 Nov 2011	Kwosir Farmers	5	13	AT Uganda FEC and FRA	Share CA lessons learnt from the trials

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field day	25 Nov 2011	Kaplak Farmers	4	9	AT Uganda FEC and FRA	Share CA lessons learnt from the trials
Field day	29 Nov 2011	Tororo Farmers	2	0	AT Uganda FEC and FRA	Bean harvesting processes
Field day	30 Nov 2011	Molo Farmers	6	0	AT Uganda FEC and FRA	Bean harvesting processes
Mentoring	21 Nov 2011	Tororo Farmers	2	0	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	24 Nov 2011	Tororo Farmers	2	1	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	25 Nov 2011	Tororo Farmer	0	1	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	26 Nov 2011	Tororo Farmers	3	0	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Mentoring	26 Nov 2011	Tororo Farmers	2	1	AT Uganda FEC and FRA	Maintaining mucuna by preventing it from climbing and choking the maize crop in the trial sites.
Workshop	9 Feb 2012	Agricultural service providers, community agents and farmers in Tororo	16	8	Virginia Tech	Report and discuss network research conducted in 2011
Workshop	10 Feb 2012	Agricultural service providers, community agents and farmers in Kapchorwa	13	7	Virginia Tech	Report and discuss network research conducted in 2011

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Mentoring	11 & 13 Feb 2012	Kapchorwa Farmers	8	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	16 Feb 2012	Kwosir Farmers	4	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	14 & 15 Feb 2012	Kaplak Farmers	4	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	26 Feb 2012	Tororo Farmers	4	0	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	27 Feb 2012	Molo Farmers	3	5	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	28 Feb 2012	Kisoko Farmers	4	3	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	25 Feb 2012	Kapchorwa Farmers	2	1	AT Uganda FRA	Establish of 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Mentoring	27 Feb 2012	Kwosir Farmers	2	2	AT Uganda FRA	Establish 1st season experiments, share knowledge with farmers on importance of CA, herbicide application and handling
Mentoring	28 Feb 2012	Kaplak Farmers	2	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	8 March 2012	Tororo Farmers	4	0	AT Uganda FEC/FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	9 March 2012	Kisoko Farmers	1	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	12 March 2012	Molo Farmers	3	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	13 March 2012	Kisoko Farmers	3	2	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Mentoring	14 March 2012	Molo Farmers	0	3	AT Uganda FRA	Prepare plots in the current practice strip (ploughing) of all the experimental/trial sites
Field Day	14 March 2012	Molo Farmers	1	0	AT Uganda FEC/FRA	Prepare the plots in the No till and minimum till strips for 1st season's planting including herbicide application

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Field Day	19 March 2012	Kaplak Farmers	14	13	Wyoming University, Manor House & AT Uganda Ltd	Introduce the MFI to the farmers, test how it works and it's effectiveness compared to the common ox plough
Field Day	20 March 2012	Keere Farmers	23	11	Wyoming University, Manor House & AT Uganda Ltd	Introduce the MFI to the farmers, test how it works and it's effectiveness compared to the common ox plough
Field Day	20 March 2012	Kwosir farmers	30	14	Wyoming university, Manor House & AT Uganda Ltd	Introduce the MFI to the farmers, test how it works and it's effectiveness compared to the common ox plough
Field day	22 Feb 2012	Tororo Farmers	2	11	AT Uganda FRA. Moi University	Getting soil samples from on-stations for study
Field day	23 Feb 2012	Kapchorwa Farmers	17	0	AT Uganda FRA. Moi University	Getting soil samples from on-stations for study
Field day	25 Jan 2012	Tororo Farmers	2	2	AT Uganda FRA & ME	Harvest , thresh, weigh and collect data of the maize in the different trial sites in Tororo.
Field Day	26 Jan 2012	Kisoko Farmers	4	21	AT Uganda FRA & ME	Harvest , thresh, weigh and collect data of the maize in the different trial sites in Tororo.
Field Day	27 Jan 2012	Molo Farmers	7	14	AT Uganda FRA & ME	Harvest , thresh, weigh and collect data of the maize in the different trial sites in Tororo.

Program type (Workshop, seminar, field day, short course, etc.)	Date	Audience	Number of Participants		Training Provider (US university, host country institution, etc.)	Training Objective
			Men	Women		
Workshop	13 March 2012	Kisoko Farmers	1	8	AT Uganda FEC/FRA	Farmers to understand the relationship between costs, income levels and profit across the tillage systems in CA in comparison with the farmers' current practices
Workshop	29 March 2012	Kisoko Farmers	3	15	AT Uganda FEC/FRA	Farmers to understand the relationship between costs, income levels and profit across the tillage systems in CA in comparison with the farmers' current practices

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Publication No. 6b, World Association of Soil and Water Conservation (WASWAC), Beijing, China and the World Agroforestry Center (ICRAF), Nairobi, Kenya, 457 pp.

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Acronyms and Abbreviations

ACT	African Conservation Tillage network
AHP	Analytic Hierarchy Process
ASABE	American Society of Agricultural and Biological Engineers
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
AT	Appropriate Technology, Haiti
AVRDC	World Vegetable Center (formerly Asian Vegetable Research and Development Center)
BARC	Bangladesh Agricultural Research Council
BIFAD	Board for International Food and Agricultural Development
BMP	Best Management Practice
CAPRi	CGIAR Systemwide Program on Collective Action and Property Rights
CCRA	Cross-Cutting Research Activity
CF, CFU	Conservation Farming, Conservation Farming Unit
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical, Ecuador
CIMMYT	International Maize and Wheat Improvement Center
CIP	Centro Internacional de la Papa (International Potato Center)
CIPCA	Centro de Investigación y Promoción del Campesinado
CIRAD	Centre de Cooperation International en Recherche Agronomique pour le Development, National University of Lesotho
CPA	Community Participatory Assessments
CRC	Collaborating Research Centers
CRSP	Collaborative Research Support Program
DABAR	Department of Agriculture-Bureau of Agricultural Research, the Philippines
DEM	Digital Elevation Model
DRIFT	Diffuse Reflectance Fourier Transform Infrared Analysis
EGAT	USAID Bureau for Economic Growth, Agriculture and Trade
ERP	External Review Panel
ESPOCH	Escuela Superior Politécnica de Chimborazo, Ecuador
ESRI	Environmental Systems Research Institute
FAMV	Faculte d'Agronomie et de Medecine Veterinaire, Universite d'Etat d'Haiti
FAO	Food and Agriculture Organization of the United Nations
FFH	Food for the Hungry, Title II USAID
GEF	Global Environment Facility
GIS	Geographic Information System
GMO	Genetically Modified Organisms
GPB	Gobierno de la Provincia de Bolivar, Ecuador
GPS	Global Positioning System
GRA	Graduate Research Assistant
IARC	International Agricultural Research Center

ICM	Integrated Crop Management
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
IDE	International Development Enterprise
IER	Institut d'Economie Rurale du Mali
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
INIAP	Instituto Nacional Autónomo de Investigaciones Agropecuarias, Ecuador
IPCC	Intergovernmental Panel on Climate Change
IPM	Integrated Pest Management
IPNI	International Plant Nutrition Institute
IRB	Internal Revue Board
IRRI	International Rice Research Institute
ISU	Iowa State University
KACOFA	Kapchorwa Commercial Farmers Association
KENDAT	Kenyan Network for Dissemination of Appropriate Technology
KSU	Kansas State University
LFPI	Landcare Foundation of the Philippines, Incorporated
LGU	Local Government Unit
LTRA	Long-Term Research Award
MARD	Ministry of Agricultural Research and Development
ME	Management Entity
MHAC	Manor House Agricultural Center
MOSCAT	Misamis Oriental State College of Agriculture and Technology
MOU	Memorandum of Understanding
MRV	Measurement, reporting, and verification
MSI	Minority-Serving Institution
NAC	National Advisory Council
NARS	National Agricultural Research Service
NCA&T	North Carolina Agricultural and Technical State University
NCI	Net Complementarity Index
NEPAD	New Partnership for Africa's Development
NGO	Non-Governmental Organization
NIR	Near Infrared
NRM	Natural Resource Management
OUAT	Orissa University of Agriculture and Technology
PA	Participatory Appraisal
PADAC	Projet d'Appui au Developpement de l'Agriculture du Cambodge
PAR	Participatory Action Research
PES	Payments for Environmental Services
PI	Principal Investigator
PMCA	Participatory Market Chain Approach
PR	Participatory Research

PRA	Participatory Rural Appraisal
PROINPA	Promoción e Investigación de Productos Andinos
PROMIC	Programa Manejo Integral de Cuencas
RMA	Rapid Market Appraisal
RUA	Royal University of Agriculture, Cambodia
SA	Sustainable Agriculture
SANREM	Sustainable Agriculture and Natural Resource Management
SARI	Savanna Agricultural Research Institute
SEA	Southeast Asia
SENACYT	Secretaria Nacional de Ciencia y Tecnología, Ecuador
SENAGUA	Secretaria Nacional del Agua, Ecuador
SIGAGRO	Sistema de Información Geográfica Agropecuaria
SKB	SANREM Knowledgebase
SNA	Social Network Analysis
SRTM	Shuttle Radar Topography Mission
SWAT	Soil and Water Assessment Tool
TC	SANREM CRSP Technical Committee
Title XII	Title XII Amendment to the International Development Food Assistance Act of 1975 and subsequent amendments
TraiNet	On-line USAID system for tracking training activities for foreign nationals)
TSBF	Tropical Soil Biology and Fertility Institute
UNDP	United Nations Development Program
UPLB	University of the Philippines-Los Baños
USAID	United States Agency for International Development
USAID/W	USAID's Washington headquarters
USDA	United States Department of Agriculture
USGS	United States Geological Survey
VT	Virginia Tech
WAC	World Agroforestry Center
WFP	World Food Program
WVC	World Vegetable Center