External Assessment of the Feed the Future Innovation Lab for Collaborative Research Support in Sustainable Agriculture and Natural Resource Management (SANREM Innovation Lab)

Phase IV 2009-2014

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Executive Summary

The EAP (External Assessment Panel) is favorably impressed with the progress made by SANREM Phase IV. Phase IV is focused on introducing and expanding conservation agriculture practices on smallholder farms in 13 countries in Africa, Asia, and Latin America. Although the challenge is great, the need for success is even greater because there are more than 500 million smallholder farms, generally less than 2 ha, in the world and more than 80 percent of the food in Asia and sub-Saharan Africa are produced on smallholder farms. With almost one billion people in the world suffering from hunger and malnutrition and with world population increases expected from 7.1 billion today to more than 9 billion in 2050, it is critical that smallholder farms become more productive while controlling soil erosion and enhancing soil quality for sustainability. Conservation agriculture practices have the potential for achieving this goal, so this project is both timely and of great importance.

SANREM established CAPS (Conservation Agriculture Production Systems) at locations in 13 countries where CAPS had never been practiced previously or only minimally. Furthermore, most were established on highly sloping degraded soils where erosion had seriously depleted soil fertility. CAPS were initiated successfully in all locations, although the degree of success varied. There are several constraints that prevent or slow the rate that farmers change from conventional cropping systems, where intensive tillage is usually a core practice, to CAPS that greatly reduce or entirely eliminate tillage. CAPS are based on three principles: 1) continuous minimum mechanical soil disturbance, 2) permanent organic soil cover, and 3) diversification of crop species grown in sequences and/or associations. The greatest benefits from CAPS can only be achieved by all of these principles being practiced simultaneously, but it must be recognized that because of physical, biological, economic, or social issues, some farmers are reluctant to adopt CAPS that fully integrate all three principles. For example, the farmers in the hilly regions of Nepal (where CAPS were introduced) have traditionally removed crop residues to feed animals so there was little or no crop residues left on the soil surface between crops. Therefore, moving from a historical conventional tillage system to CAPS is not simply changing a practice, but changing a cultural practice that can take several years. The EAP team members clearly saw this at some of the sites visited.

There were seven LTRAs (Long Term Research Awards) and four CCRA (Cross Cutting Research Awards) initiated. The LTRAs generally had four objectives: 1) conduct research experiments to compare CAPS with conventional tillage systems on crop yields, erosion control, and soil quality; 2) provide technical guidance and necessary inputs to establish farmer managed CAPS at multiple locations so that relatively large numbers of farmers could have a chance to observe the benefits of CAPS; 3) develop and conduct training for farmers through field days and training sessions; and 4) establish relationships with national universities and organizations for capacity building. The CCRAs were to evaluate and coordinate the findings of all LTRAs as they related to 1) economic and impact; 2) gendered knowledge and perspective; 3) technology networks; and 4) soil quality and carbon sequestration. The EAP (External Assessment Panel) observed field sites, evaluated reports, and conducted interviews that clearly showed progress for each of the objectives. The

EAP was particularly pleased with the short-term training that was evident in every one of the LTRAs. In all, there were 21,950 participants of which 9,460 were women. This included an impressive number of farmers that were introduced to new ways of farming that could reduce (or in some cases increase), their labor requirements, control soil erosion, enhance soil quality, and possibly increase their income and quality of life. Although many will likely be unable or unwilling to immediately switch their present cropping systems to CAPS, most will continue to observe farmers that have adopted CAPS and adopt when they are convinced of the benefits. Therefore, the importance of the farmer managed CAPS cannot be overstated and most of the sites that EAP members had the opportunity to observe were of great interest. In some cases, farmers with CAPS on their land made changes with time in what had been recommended by the scientists, and it is important that the scientists try to understand why the farmers made the change. Based on discussions that EAP members had with some of the farmers, many seemed reluctant to grow cover crops strictly for the purpose of enhancing soil quality and tended to change the cropping system so that the crops they grew produced some immediate economic return. Results from the research trials were somewhat mixed and in most cases definitive results were not yet evident. This is not unexpected because only 2 or 3 years of data had been obtained, and for various reasons, there was high variability in many of the field trails that made statistical differences difficult to achieve. Many past studies reported in the scientific literature show that benefits from CAPS often do not occur until several years following initiation of the system. In fact, it is fairly common for crop yields to be lower for the first 2 or 3 years after switching from a conventional system to a CAPS.

The LTRAs were successful in establishing relationships with host country institutions that greatly enhanced the overall training program of SANREM IV. Long-term training and capacity building successes were numerous. A total of 74 M.Sc. and Ph.D. students completed or are in the process of completing their degrees. Thirty-five of these are women, indicating a high interest in women becoming leaders in conservation agriculture, and this is critically important for working with smallholder farmers because women play such an important role. Many of these students were jointly trained by U.S. scientists and national universities in host countries and this was an important avenue for capacity building. Several scientific papers have been published involving joint authorship between U.S. and host country scientists and some of these relationships will continue. International conferences were held in Phnom Penh and Battambang, Cambodia; Hanoi, Vietnam; and Katmandu, Nepal. Special symposiums were organized by the Management Entity for SANREM scientists to make presentations at the 2012 and 2013 International Annual Meetings of the American Society of Agronomy—Crop Science Society of America—Soil Science Society of America held in Cincinnati, OH and Tampa, FL, respectively.

Recommendations

Because SANREM Phase IV in particular, and SANREM in total, ends in September 2014, the highest priority for 2014 should be to summarize and clearly document the findings of Phase IV.

Recommendations for each of the LTRAs and CCRAs have been made in the report, but it cannot be overemphasized how important it is to clearly and succinctly document the findings. CAPS have been more successful in some countries than in others, and the reasons are sometimes clear and in other cases less so. It is highly important that the PIs state the reasons that they believe accounted for the positive as well as for the negative results sometimes encountered. Although SANREM is ending in September 2014, work on conservation agriculture will not end and it is critical that the results of SANREM Phase IV are available for future planning. Technical papers will result from some of the research, but many of the findings will not be published as professional papers for various reasons. Therefore, the 2014 Annual Reports will be of extreme importance because this will be the single most important source of information that summarizes the 5-yr findings of each LTRA and CCRA. The EAP thought that with few exceptions (e.g., Ecuador/Bolivia) the 2010, 2011, and 2012 annual reports did not present enough data for readers to clearly understand the results, so the final report should cover the entire period of the project. While most long-term studies reported in the literature show that CAPS are usually beneficial, there are a number of constraints that cause farmers to be slow or not interested in adoption. Some of the constraints are lack of access to herbicides or water for mixing/dilution, lack of or in some cases too much crop residue, limited options for cropping systems, need for using crop residues for animal feed or fuel, farm size, lack of equipment, and lack of income for input purchase. The constraints are immediate while benefits are not assured or often times require a few years for benefits to accrue. Therefore, many farmers are reluctant to quickly adopt CAPS and do so only after observing other farmers for several years, and it is critically important that the final annual reports document the results and observations of the investigators of each LTRA and CCRA.

Although the EAP does not know how much flexibility the ME (Managing Entity) has in making adjustments during the final year of SANREM, it is strongly recommended that the ME consider formulating a summary publication that pulls together data and information from the seven LTRAs, possibly for publication in some form. While the CAPS varied among the LTRAs, most of them were developed using the three principles of conservation agriculture. The LTRAs spanned 13 countries, hilly and flat lands, areas where it never freezes and those that have cold winters, recently developed cropland and highly eroded cropland, high rainfall areas and low rainfall areas, and farms with livestock and those without. The common thread is that all LTRAs were for a 5-yr period, and mostly involved farmers that had always used conventional tillage. A publication that summarizes not only how crop yields were affected but how economic and gender conditions were altered would be a valuable contribution.

Finally, some thought should be given to how ongoing work and relationships can be supported if there is no continuing formal activity under SANREM. Farmers in a number of countries expressed great interest in learning more and continuing to develop their understanding of conservation agriculture; thus, even low-cost technical advisory contacts could pay large dividends in maintaining the momentum under SANREM.

I. Introduction

In 1991, the U.S. Congress requested that the National Research Council (NRC) outline a strategy for U.S. universities to carry out research to support the needs of sustainable agriculture and natural resource management in developing countries. Recognizing the importance of multidisciplinary on-farm methodologies in the performance and sustainability of agro-ecosystems, the NRC recommended that U.S. universities collaborate with host country interest groups to employ integrated, multidisciplinary research organized across agro-ecological zones.

SANREM CRSP Phase I (1992-1997) was developed as a program of training and information exchange with landowners and decision-makers in agricultural regions of developing countries. Main projects were in the Philippines, Ecuador, and Burkina Faso, with smaller targeted activities in Cape Verde, Costa Rica, Honduras, and Morocco. The University of Georgia was the ME.

SANREM CRSP Phase II (1997-2004) was marked by the expansion of efforts to promote sustainability and natural resource management. Continuing the programs started in Phase I, SANREM expanded its reach to include key decision-makers at national, regional, and global levels. While some projects continued in the same regions, researcher efforts reflected continuing efforts to include decision-makers and apply relevant, sustainable solutions to agricultural dilemmas. Efforts were focused on the Andes region, Southeast Asia and West Africa.

In 2004, Virginia Tech was named the CRSP's new (ME), signaling the beginning of SANREM CRSP Phase III. The transition to Phase III opened a more competitive phase in project selection and the building for the SANREM Knowledgebase (SKB) providing access to sustainable agriculture (SA) and natural resource management (NRM) research. The ME continued to apply the recommendations set forth by the NRC, striving to promote stakeholder empowerment and improved livelihoods through knowledge-based sustainable agriculture and natural resource management systems. The core of Phase III was five Long-term Research Award (LTRA) activities:

LTRA-1: Decentralization Reforms and Property Rights: Work was carried out in Uganda, Kenya, Mexico, and Bolivia.

LTRA-2: An Agricultural Markets Model for Biodiversity Conservation: The project was in partnership with COMACO (Community Markets for Conservation) and conducted in Zambia.

LTRA-3: Watershed-based Natural Resource Management for Small-scale Agriculture: The project was conducted in Ecuador and Bolivia to improve farm families' lives and incomes by identifying constraints and developing alternative systems.

LTRA-4: Practices and Strategies for Vulnerable Agro-ecosystems: The project worked with small landholder farmers in Bolivia and Peru that were becoming increasingly vulnerable to environmental and market shocks and stresses.

LTRA-5: Agroforestry and Sustainable Vegetable Production: The objective was to develop economically viable and ecologically sound vegetable-agroforestry systems in Vietnam, Indonesia, and the Philippines, and to quantify their potential economic and environmental benefits.

SANREM CRSP Phase IV, the present phase, began in 2009 and is in the fourth year of the last five year phase, due to end on September 30. 2014. This phase is focused on increasing smallholder food security and adaptation to climate change through the introduction of conservation agriculture production systems (CAPS). The approach is participatory, engaging stakeholders at all levels in research problem formulation with priority areas of inquiry, focusing on multiple countries and/or regions to facilitate scaling research findings. Projects involve research, education and technology to develop locally adapted CAPS. The biophysical components include implementing approaches to improve water productivity, soil quality, and carbon sequestration, in addition to more productive cropping systems. Gender sensitivity is integral to SANREM and reinforced by gender-sensitive participant training programs. SANREM Phase IV was also organized as LTRAs, but added Cross-Cutting Research Areas to look at common issues across all LTRAs. Specifically, SANREM CRSP Phase IV promotes stakeholder empowerment and improved livelihoods through the discovery, organization, and dissemination of SA and NRM knowledge. The objectives are to:

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

Much has changed since SANREM began in 1992. Surveys conducted by Virginia Tech indicated that conservation farming systems, and many other more specific topics, which may be subsumed under conservation agriculture includes water productivity, climate change, and food security. One key resource used in the research needs assessment for Phase IV was the 2008 National Academies of Science report, “Emerging Technologies to Benefit Farmers in Sub-Saharan Africa and South Asia.” The purpose of the study was “to identify recent scientific knowledge and promising technologies that could transform the production capabilities of smallholder farmers in sub-Saharan Africa and South Asia. The study noted crop productivity in both regions lags far behind that in most agricultural areas of the world, but there also has not been a systematic application of science and technology that could improve the situation. The subsistence farming practiced in these regions results in yields and incomes that are unpredictable, leads to environmental degradation, and ultimately leads to a lack of food security.” According to the NRC report, improving soil quality was the most important current issue and water scarcity was the greatest future issue for increasing agricultural productivity in sub-Saharan Africa and South Asia. Consequently, the highest priority in the natural resources

management area was the development of soil-management and water-management applications. It is expected that Phase IV will address these two high priority needs among subsistent farmers in the countries selected for research activities.

Thus, Phase IV research and capacity building activities were selected to develop and demonstrate locally sustainable CAPS for smallholder rain-fed crop production systems that improve food security and the productive capacity and ecosystem services of degraded and productive agricultural lands. The purpose of the proposed research is to test the ability of CAPS to:

- increase food production in existing smallholder staple crop production systems;
- become adoptable and economically viable for smallholders;
- enhance the productive capacity of smallholder soils; and
- enhance ecosystem services through improvements in soil quality that promote carbon sequestration, reduce soil erosion, and reduce risks associated with climate change through improved water management and productivity.

The research in Phase IV should seek to identify and optimize locally appropriate CAPS that:

- maintain, to the extent possible, a year-round soil cover provided by residues from previous crops and/or a cover crop intended to improve food production and soil quality;
- minimize soil disturbance by tillage. Tillage should only be used when required for pest control and/or amelioration of undesirable soil conditions that cannot otherwise be corrected in a timely manner;
- utilize crop rotation systems that have been adapted to local socioeconomic and environmental conditions for the improvement of soil quality/health and control of agricultural pests. The rotation system must include a principal staple crop of the research region;
- utilize integrated pest management (IPM) options to minimize pesticide use for pest and weed control, improve profitability, and minimize potential environmental consequences;
- utilize integrated nutrient management (INM) techniques, using organic and inorganic fertilizers to improve agricultural productivity, profitability, and soil quality;
- utilize improved water management techniques, such as deficit and supplemental irrigation and other intensification techniques, to improve smallholder agricultural productivity and profitability.

It was expected that selected long term research projects would utilize the existing knowledge on conservation agriculture and generate new knowledge that could be have a near term positive effect on the soil quality and food security of rain-fed subsistent farmers. The CAPS selected for evaluation would be site specific in nature and would probably include techniques to improve soil quality include controlling grazing, mulching with organic matter, applying manure and bio-solids, and terracing. Other techniques would include the use of cover crops in the rotation cycle, agroforestry, contour farming, hedgerows, plastic mulch for erosion control, no-till or

conservation tillage, retention of crop residue, appropriate use of water and irrigation, as well as the use of integrated nutrient management, including the judicious use of chemical fertilizers.

II. Review of Long-Term Research Awards

This section will review the seven LTRAs of the current SANREM program by noting the progress of the objectives for each LTRA, appraising the accomplishments of the LTRA, and making recommendations for the remaining year of its activities.

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

Principal Investigator: Dr. Thomas Thompson, Department Head, Virginia Tech

Research Team:

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Dr. Steven Hodges, Virginia Tech

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The Haiti SANREM project was initiated in 2009. The project proposal stressed the fact that Haiti ranks in the lower quartile of every UNDP indicator of human development and has the highest population growth rate of any country in the Western hemisphere. In contrast, the yields of cereals, roots and tubers, and pulses are the lowest in the Western hemisphere. The FAO reported that 94.8 percent of Haiti's soils are classified as severely degraded because of years of producing crops using unsustainable practices. The project was designed to focus on Haiti's Central Plateau where smallholder farmers reported that lack of water is their greatest production constraint. Certainly, there is a direct link between lack of water for crop production and soil degradation, and the proposal stressed that the present low input/low output agricultural production systems are insufficient to meet the subsistence needs of the local population let alone contribute to the food security for Haiti as a whole. The premise of the project proposal was that conservation agriculture is a viable approach to building a resilient future for the Central Plateau region.

None of the EAP members visited the project site during the review. However, members of the review team heard a brief report by Dr. Thomas Thompson, present Principal Investigator, during their visit to SANREM headquarters in April, 2013. Additional information was obtained from the Project Proposal, the 2010, 2011, and 2012 Annual Reports.

1. Project objectives

The project proposal listed three objectives as a means to develop CAPS that are based on three key practices. They listed the key practices as 1) continuous minimum mechanical soil disturbance; 2) permanent organic soil cover from crop residues and/or cover crops; and 3) diversified crop rotations in the case of annual crops or plant associations in case of perennial crops. The specific objectives listed in the proposal for LTRA-6 were:

1) Assess the adaptability of existing agricultural production and livelihood systems for transformation into CAPS;
2) Increase agricultural production through development of CAPS; and
3) Increase the capacity of smallholders to adopt and improve CAPS.

Project success would largely depend on the objectives being carried out in order, rather than sequentially. The purpose of Objective 1 would essentially be to conduct informal and formal surveys to assess and evaluate present crop production systems, and then determine how they could be transformed into CAPS after carefully considering how the transformation could affect gendered agricultural practices, economic considerations, labor allocation, knowledge, beliefs and perceptions and other issues. Objective 2 would determine the benefits of the CAPS compared to the currently used systems and observe not only how crop yields were changed, but if and how soil quality was changed. Objective 3 would increase the capacity of smallholders to adopt and improve CAPS which involves the use of field days, model farms, publications, and other means to promote wide use of CAPS.

Later, a fourth objective was added and first reported in the 2011 Annual Report:

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

2. Haiti project progress

Obj 1. Although the project was approved in 2009 and planning took place in an orderly and timely manner, unforeseen and uncontrollable circumstances delayed project implementation and execution. The devastating Haiti earthquake of January 12, 2010 occurred only minutes after the Kick-Off Workshop ended in Port-au-Prince. This disaster immediately stopped the implementation of the project and once it did begin several months later, there were still many constraints that caused delays, shortage of key components, travel difficulties, and other issues. Much of 2011 was devoted to collecting survey information for 430 farm households. As discussed earlier, the primary purpose of this objective was to assess existing production and livelihood systems so they could be transformed to CAPS. Migration of people from the 2010 earthquake caused some problems with the survey and with the area as a whole, so progress with the project was still negatively affected. The survey was later completed and comprised information on over 3200 individuals, 1400 agricultural plots farmed by households, 1200 fuel wood and water collection sites, and over 3300 crop plantings. The survey showed that for 640 plots that 387 of them had no conservation practices present compared to 283 that had at least one. With the survey completed, the investigators were able to move forward to investigate

factors influencing the adoption decision for agricultural conservation practices, both with respect to the decision to adopt, and the scale of adoption for households in the Central Plateau of Haiti. Therefore, while progress on this objective was slow developing due to the devastating earthquake, the EAP believes that good information is now coming forth.

Obj 2. This objective must be coordinated closely with Obj. 1 because the smallholder producers must decide to move from their traditional systems to CAPS. In March, 2010, in spite of difficulties associated with the earthquake, some experimental farm sites were established at partner sites. The limited soil testing that was done indicated very low levels of plant-available phosphorus and zinc. It was decided to focus initial trials on maize and black beans. Improved varieties of beans were obtained from the Pulses CRSP in Puerto Rico, and improved maize varieties from CIMMYT in Mexico. Emphasis in 2011 was on finding cultivars of beans and maize that will respond in a CAPS environment, on building research capacity, and on introducing and testing cover crops suitable for the region and the farmer's situations. Information from the survey was used to help determine acceptance by farmers. In the 2011 annual report, the investigators stressed that farmers were reluctant to plant non-food cover crops, and were also opposed to using reduced- or no-till methods. In the 2012 annual report, it was stated that in some of the experiments that cover crop areas would be split and maize would be seeded on half the plot area in cover crop residue, and on half the area where the residue had been plowed as normal. To date, none of the cover crops tried have been particularly successful. The trials have shown benefits from improved cultivars. At Corporant, yield of the best improved cultivar was 26 percent higher than the best local variety. At Lachateau, yield differences were more pronounced and the yield of the highest producing CIMMYT variety was 189 percent of the highest local maize variety. At Maïssade, yields were exceedingly low. It appears that low soil fertility is more of a problem that previously thought. The investigators are considering the application of fertilizer or manure to address this issue.

Obj 3. Peasant farmers in Haiti are diverse and their needs vary by operation and location. Farmers on steep uplands are very aware of erosion as a major concern compared to farmers on floodplains that more concerned about irrigation. Proposed CAPS must be adaptable to the local environment. This objective is intended to increase the capacity of smallholders to adapt and improve CAPS. Therefore, the focus is to inform, explain, and demonstrate techniques used in CAPS. Reduced tillage practices may be much more likely to be adopted by smallholder farmers on steep and stony sites than those on relatively level land. However, the farmers must be shown tools that can be effectively and easily used. In 2011, black bean seeds of improved varieties were distributed to 300 farmers. Meetings were held during the dry season and 890 men and 710 women farmers were introduced to the topic of CA. Therefore, many more producers are being exposed to CAPS; it is too early to assess the impact of such activities. The ultimate success will no doubt largely depend on the success of Obj. 2 that must provide CAPS that are truly adapted to the environment of the Central plateau of Haiti. Not only must the CAPS be adapted to the environment so that yields are at a minimum maintained, and that labor inputs are decreased, but are also gender sensitive. The delay in getting the project implemented will certainly limit how successful this objective can be met because only three years of cropping will be carried during the life of the project, and this is

not sufficient for some of the benefits of CAPS to be manifested.

Obj 4. This objective was not part of the proposal that was approved, but was added later and has perhaps been the most successful. The purpose of the objective was to strengthen the human and institutional research and extension capacity for CAPS. Solid partnerships have been established with Zanmi Agrikol and Caritas that are active in the region. These organizations have agronomists that have taken an active role in planning and executing CAPS workshops. Cooperation has also been strengthened with the Haiti Ministry of Agriculture and National Resources.

3. Appraisal project accomplishments

Based on the our limited opportunity to review the project, we believe that in spite of a turbulent beginning due mostly to the devastating earthquake that happened simultaneously with the launching of the project that the project is now on sound footing and good progress is being made. However, the number of cropping seasons will be fewer than planned, and this will certainly limit the success of the project. Developing CAPS for a given environment is not done quickly, and measuring the impact of CAPS on yield and soil quality normally requires several years even under favorable conditions. Considering the severely degraded soils of the Central Plateau of Haiti, the challenging climatic conditions, and the social and economic conditions, the investigators have faced enormous constraints and challenges. Therefore, the progress that they have made is commendable.

4. Recommendations for the last year of the project

Efforts should continue on the field work for developing CAPS that will have some beneficial effects on reversing the soil degradation processes that have been so devastating to the arable land in the Central Plateau of Haiti. The maize yield trials should contain primarily open pollinated varieties that could be made available to farmers by local organizations. The present project will likely end before definitive measurements can be made to show that soil quality has been improved. However, if the field studies can show that crop yields were at a minimum maintained, and hopefully increased, and labor requirement were reduced with CAPS, this can be a giant step forward in obtaining additional funding to continue this important work.

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

Principal Investigator: Dr. Jeffrey Alwang, Professor, Virginia Tech

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Dr. Robert Sean Gallagher, Associate Professor, Penn State University

Dr. Richard Stehouwer, Professor, Penn State University

Dr. Sarah Hamilton, Associate Professor, University of Denver

This SANREM project has focused on developing and testing CAPS crops and practices appropriate for steep Andean farmland and on introducing these practices among smallholder families farming at mid-level and high-level altitudes in Bolivia and Ecuador. LTRA-7 is the continuation of a project of the previous SANREM program (2004-2009) implemented in Ecuador and Peru. USAID funding for the SANREM Bolivia project was discontinued earlier this year (May 2013) because the government of Bolivia expelled USAID from the country. Due to this early closure and the fact that the Bolivia project site had been active for only three years, it was decided to limit this review on the work in the Ecuador site. Since most of the gender-focused activities of LTRA-7 were carried out in Bolivia, this assessment reports minimal activity on gender issues.

All four members of the External Assessment Panel visited the Ecuador site of this project during the period 3-8 August 2013. The Ecuador coordinator of the project, Victor Barrera of INIAP (Instituto Nacional de Investigaciones Agropecuarias), arranged field trips to the two project areas in the Bolivar Province. They are located in the watershed of the Rio Chimbo: Alumbre in the lower altitude zone (1700-2200 m.a.s.l.) and Illangama in the upper altitude zone (3000-3800 m.a.s.l.). The site visits allowed the EAP to inspect the field trials of CAPS practices, to discuss project accomplishments and problems with technical personnel of the project and with INIAP officials, and to discuss with farm families their experiences with the project.

1. Project objectives

LTRA-7 project objectives, as listed in the project proposal (Alwang et al. 2009) are:

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

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

3) Promote adoption of the most appropriate CAPS by identifying mechanisms to increase their profitability;

4) Design and evaluate mechanisms for disseminating results to similar areas;

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

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

2. Bolivia and Ecuador project progress

Obj 1. The Ecuador team and stakeholders, because of funding from the previous SANREM phase, was already quite advanced in identifying and evaluating crops and production practices and farming components for a CAPS production system in both the upper-altitude and mid-altitude zones. Although INIAP had not conducted extensive work in these highland areas, they had carried out considerable soils research, especially on soil fertility, in similar highland areas of Ecuador. The Ecuador team, including soil scientist Franklin Valverde, made considerable use of this previous research in identifying best bet CAPS for evaluation. While not all practices developed in the previous SANREM cycle were incorporated into the current set, it was evident that the farm families in both zones were familiar with and generally accepting of the CAPS approach. It is a most difficult environment to establish multifactor research trials because of the extreme slopes and high rainfall. The research team did a good job of designing and managing the research trials. It would be difficult if not impossible to use larger plots and increased replications to minimize experimental error in these trials. The farmer trial plots were larger and had fewer treatments and were well established. Key elements in managing the trials were the input and supervision of the faculty and students of the Universidad Estatal de Bolivar. There was great interest by farmers in these trials and will no doubt serve as great demonstrations plots for field days and other dissemination activities.

Obj 2. Rapid progress was made on this objective. Based on previous experience and through consultations with scientists at Penn State, the Cross Cutting Research Activities 9 (Soil quality and carbon sequestration), Dr. Delgado of USDA Agricultural Research Service, and local partners, high elevation sites in the Illangama sub-watershed and low elevation sites in the Alumbre sub-watershed were selected for Ecuador. At the high elevation sites, potato-based CAPS were designed that compared conventional tilled potatoes with reduced tilled potatoes grown in various rotations that include barley, Faba bean, oats-vetch, and a forage mix. Samples were taken to gather baseline data for soil characteristics. All of this was completed in 2010, the first year of the current SANREM study. In 2011, a protocol was developed for evaluating soil and crop sustainability for both Ecuador and Bolivia. The conservation agriculture studies continued although some revisions of the experimental design were implemented. In 2012, considerable effort in both Ecuador and Bolivia was devoted to soil analyses of chemical, physical, and biological soil indices. While there is good reason to expect that CAPS will improve overall soil quality, such changes generally only become significant after several years. The field trials comparing conservation agriculture (CA) systems to conventional systems began to show differences. In 2012, the yields for CA treatments were statistically higher than for the conventional systems. The Review Team visited several of the project sites at both the low-elevation maize based systems and the high-elevation potato based systems on August 6-7, 2013 and were largely pleased with the design and execution of the farm-based trials.

Obj 3. Several tasks fall under this objective, such as improving the design of various CAPS to increase their profitability via reduced local inputs costs and higher-valued rotation crops and

improved access to markets and market information. In the former case, the project in its early years undertook a number of associated activities to refine and improve farm management. For example, the project examined a number of opportunities for local production of farm inputs used in CA and other farming practices (Bolivia), focusing primarily on biocontrol and bio-inputs in collaboration with PROINPA. Related efforts in Ecuador addressed reforestation and planting of local species in at least one watershed (Alumbre). Also in Ecuador, the project looked at increasing access to irrigation in place of flood-based systems as a way of increasing water use efficiency and raising profitability. More recently (Annual Report 2012), the project has been recognizing the role of labor availability as a determinant of the profitability of CA practices; rising wages in the study area should make CA more attractive to the extent it reduces labor demand for land preparation and planting (with adoption of seed drills). In relation to market access and information, the project has been collecting market input and output price information for several years and has looked at ways to improve the marketing of plantation trees to maintain the profitability of these stands and stave off liquidation.

In addition to the above, the LTRA-7 proposal sets out a number of mostly economics-related analyses. One such activity was to be an investigation of the potential for producer associations and this was the subject of an undergraduate thesis concerned with dairy production. Another proposed analysis was to investigate opportunities for payments for ecosystem services (PES) schemes, but this was dropped when it was realized the institutional obstacles to implementation were too great. For other proposed analyses the progress is less clear; these include rapid appraisal of credit supply, value-chain analysis, a structural multiplier model, soil loss externality valuation, feasibility of carbon sequestering supply groups and trade-off analysis of multiple objectives associated with CA.

Obj 4. The project's principal attempts to disseminate successful CAPS crops and practices have been by organizing field days where farmers from neighboring areas, community authorities, government officials, and NGOs are invited to witness the project's trial farm parcels. While we did not witness these field days, we did visit a number of farms in both zones not officially participating in the project that were adopting minimum-tillage, mulching and/or residue retention, and rotation of crops with legume crops.

Obj 5. During the first year (2010), baseline soil samples were taken on the farmer fields but no analyses were done. Some of the analyses will be done locally, but some were planned for analysis at Virginia Tech as part of the CCRA-9. The 2011 Annual Report stated that some soil analyses had been completed but listed no specifics. The 2012 Report did show some results and stated that analyses would continue. The EAP did visit the INIAP soils laboratory in Ecuador where the analyses are conducted. The EAP members were very pleased with the equipment and personnel. It is not clear from our review just how many of the farmer fields have been sampled and how often since the baseline samples were taken in 2010 and while it may be worthwhile to continue the soil analyses as proposed, statistically significant changes in chemical and physical properties as a result of conservation agriculture practices often do not occur for several years.

The 2012 Annual Report emphasized that training on the use of a nitrogen index had been

conducted as a tool for adjusting nutrient application recommendations to changing conditions. This was also discussed during the EAP review and the nitrogen index was developed by cooperative work with Dr. Delgado of the USDA Agricultural Research Service.

A baseline survey of 286 households was carried out in 2006 under the previous SANREM program. The baseline survey contained socio-economic data that was utilized to determine the livelihood strategies and well-being of smallholder farm families in the upper and lower watershed sites (Andrade 2008). The results of this analysis revealed four different livelihood strategies and different levels of well-being (using consumption expenditures as indicator) in each of the two sites. A follow-up survey by the IPM CRSP was carried out in 2010 containing ten questions on conservation agricultural; the dataset is currently being analyzed.

In addition, market price data has been collected for several years (see Objective 3), together with various farm level production data in association with CCRA-6 (Economic and Impact Analysis). The project proposal indicated that the project would undertake several economic impact-related activities, including (i) livelihood impact analysis, (ii) assessments of the adoption of CAPS and (iii) an evaluation of off-farm impacts of CAPS adoption. Livelihood impacts have been investigated via the partial budget exercises examining the profitability of the various proposed CAPS but also via an analysis of risk, in part, using the market price data that have been collected. This activity has resulted in several papers. In addition, a M.Sc. study (A. Nguema, Virginia Tech) developed a linear programming model to determine the role of CAPS within an optimal farm management plan. Published in a journal paper, the study reveals that they indeed could play such a role. Measuring adoption of a new agricultural technology is always challenging in the early years of the technology's development. The project has overcome this challenge to some degree by using hypothetical choice experiments that pose alternative possible adoption scenarios to farmers, and then analyze the results to determine preferred CAPS and potential adoption rates. This analysis was undertaken by a Ph.D. student based at Virginia Tech, in collaboration with a group of six undergraduate students to help with data collection. Off-farm impacts of an economic nature were to be assessed using the structured multiplier model described in Objective 3, but it is unclear whether this has been carried out yet.

During the first year of the project (2010), gender sensitivity training was carried out among project personnel. As a result, bilingual assistants were hired when it was noted that many of the women in the Illangama site do not speak Spanish.

Obj 6. This project has contributed to INIAP's skills and abilities to develop CAPS in Ecuador's highlands, an important contribution taking into consideration the importance of agricultural production and the rural population in that region. We were able to observe this in our discussions with INIAP personnel in the field, in INIAP laboratories, and with INIAP research groups. Project collaboration with the local State University of Bolivar in Guaranda also contributes to skill and knowledge acquisition among faculty and students of the study area.

3. Appraisal of project accomplishments

Obj 1. This objective is well advanced, and for purposes of this project is practically complete.

Obj 2. This objective was to validate the CAPS in terms of soil health, carbon and nutrient balances, sustained productivity, the environment and other issues. As worthy as this objective is, it is not realistic to anticipate that all the analyses proposed in this objective can be completed within the time left. The 2012 Report indicated that most of the soil analyses have not yet been completed. Therefore, since only 1 year is left for the study, it is suggested that the project investigators determine what analyses can be realistically completed that have the greatest probability of showing differences considering that the CAPS have only been implemented for about 3 years. The part of the objective that focused on evaluating yields was more focused and could be evaluated visually as well as with measurements.

The EAP members were favorably impressed with most of the trials on farmer fields they observed in Ecuador. They were also pleased to visit with some of the farmers and learn from them. The reduced tillage systems have the distinct advantage of requiring significantly less labor than conventional tillage systems. The biggest problem with the reduced tillage systems that the EAP members observed was emergence problems as a result of poor seed-soil contact in some of the fields because of high amounts of residue. Some high-elevation farmers that have potato based systems reported that they often observed smaller potatoes in the reduced tillage treatments than in the tilled treatments. Thus, considerable progress has been made on the part of the objective that compares reduced tillage and conventional tillage treatments. The investigators should perhaps focus their remaining time and effort to this part of the objective.

Obj 3. Progress on this objective appears to be adequate but unclear for two reasons. First, the activities that have been carried out in relation to this objective, as reported in the Annual Reports, are more indirectly than directly tied to the advancement of CA practices. That is, they are more peripheral to the main thrust of the SANREM program, e.g. biocontrol/bio-input development, analyses of pine plantations and irrigation development. This is not to argue these are not worthwhile activities—the success of some of these interventions speaks for itself—but the re-emphasis in 2011-12 on labor market conditions as a factor influencing CA profitability is more directly focused on promotion and adoption of CAPS.

Second, the long list of analyses listed in the project proposal suggests an overly ambitious program of work that might not reasonably be expected to be completed within the relevant time frame. That said, it is possible that several of these analyses are either completed now but not reported in the Annual Reports, or are underway and will be completed by project end. For example, the extensive market price data collected presumably will be used in various analyses related to market access that are yet to be undertaken. However, some recalibration of what can/cannot be done from the list of analyses (such as occurred with the PES analysis), might be advised.

Obj 4. Since Ecuador does not have a government extension system, and there does not appear to be a healthy and accessible (for smallholder farmers) private extension services, it is difficult

to see how these CAPS production systems will be widely disseminated. At present, NGOs from other similar areas attend field days sponsored by the project and are able to take away the successful experiences with crops and production practices. This dissemination method, however, does not have national coverage or continuity that an extension system offering technical assistance can offer.

Obj 5. This objective focused on two major sub-objectives. The first was to validate CAPS in terms of impacts on soil health, soil retention, carbon and nutrient balances profitability, environment and other issues. The second was to establish experiments with CA components, component combinations and full CAPS. Considerable progress has been made on the second and there is evidence that the use of reduced tillage systems has increased crop yields, decreased labor inputs, and reduced soil erosion. Little progress has been made on the first sub-objective, however, because even though the soil samples on farmer fields were taken at the beginning to the trials, few analyses have been completed and most of the impacts that were to be evaluated require several years of implementation before differences can be measured. A continuation of the trials on some or all of the farmer fields will be required for this sub-objective to be successfully completed.

Data on farm costs and production show that income from farm production has increased with the adoption of CAPS practices. For example, it was not difficult to convince farm families in the Ecuador Andes to incorporate legumes as a rotation crop since they are a staple food crop for these communities and therefore was not an added cost. It also appears that they are favorably disposed to adopt zero or reduced tillage since that means a significant reduction of labor by male farmers, reducing production costs. There has been little data collection and analysis, however, on whether increased income translates into improved social conditions such as improved well-being, higher education levels for children, better health, or greater gender equity. There is some minimal data with regard to household labor allocation revealing that male labor (in the plowing and preparation of soil for planting) is reduced due to minimal or zero cultivation, but there is no indication on how women's labor has been impacted. The number of households that have adopted CAPS is very small, of course, and reliable outcomes would be difficult to estimate at this point.

While it may take years to see all of the impacts of the CAPS being evaluated in these two highland areas of Ecuador, the immediate impact of deviation ditches on soil erosion was very obvious. The reduction in soil erosion was evident in all trials where this was a factor being evaluated. Some visible impacts of fertilizers, rotations and increased ground cover were seen in several sites. The interaction effects of the factors were less obvious, but the uptake by farmers of multiple factors may be some of the best evidence of these effects.

Obj 6. The many years of collaboration with INIAP has strengthened that institution's ability to develop CAPS (both appropriate crops and farming practices). The linking of SANREM with the IPM CRSP should further develop research skills and interest at INIAP. The issue of dissemination in the absence of an agricultural extension system has not been adequately

addressed.

4. Recommendations for the last year of the project

As mentioned previously, this Ecuador project has benefitted greatly from two antecedents: the many years of work by INIAP in the project area and the work carried out on natural resource management (CA practices and crops) during the previous SANREM program (2004-2009). This history gave the project a head start with regard to agronomic and soil health factors compared to some other project sites we have reviewed. During the last year of the project, we recommend that the following areas be addressed:

Dissemination program for CAPS in Andean smallholder agriculture: How the project results are to be disseminated and adoption by smallholders encouraged should be forcefully discussed by INIAP and project personnel with Ministry of Agriculture officials. This is an issue that needs to be addressed at levels beyond the project site and the project itself. Without a dissemination program the positive results of this project will not reach beyond the few communities involved in the project.

Assessment of the social impacts or outcomes of CAPS and cash-crop production: use and investment of higher incomes, allocation of family labor, intra-household decision making, children's education, food consumption, among others. The past work on livelihood strategies and well-being should be replicated utilizing the 2010 follow-up survey to determine the outcomes of CAPS adoption differentiated by livelihood strategy and/or asset levels.

On a related point, further consideration should be given to completing the various economic and impact-related analyses proposed under Objective 3. If more sensible, this list s should be narrowed and refined so that available resources are not spread too thin. For example, if the structured multiplier analysis has not commenced, it may make sense to defer this since it is too early in the dissemination process to know how extensive will be adoption of CAPS and, consequently, the eventual off-farm impact.

There appeared to be a positive effect of increased organic material from various crop residue treatments, but one issue of these treatments was the reduced stands of beans. The increased amount of crop residue was improving the soil and reducing erosion, but did appear to cause a reduction in germination of beans in this environment. Probably good soil contact was not being made in planting and some seeds dried out. Planting methods should be investigated to help alleviate this problem.

The major focus for the final year of the project is to clearly and succinctly summarize the findings of the trials on farmer fields that were initiated at the beginning of the project. The focus of the report should be on comparing reduced tillage systems to conventional tillage systems on yield, labor inputs, and erosion. The various farmer fields should be carefully assessed and identified as those that should be continued in future years if feasible. A major part of the summary report should be devoted to comments and suggestions by the farmers, particularly what they see as the positive and negative attributes of CAPS. Two of the EAP

members held discussions with groups of farmers and found them very willing to express their thoughts about CAPS. Since it is obvious from the backlog of soil samples that have not been analyzed, the impact of CAPS on chemical and physical properties will be limited. It is recommended that perhaps only two or so farmer fields from the low-elevation and the high-elevation sub-watersheds be selected and a limited set of measurements made.

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

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SANREM LTRA 8 is promoting conservation agriculture in the West African countries of Ghana and Mali. Its intention is to answer some key questions associated with the promotion of CAPS with smallholder farmers in West Africa. For example, which CAPS can contribute to farm productivity and address the needs of farmers, and under what specific conditions? What are the positive and negative aspects (trade-offs) of CAPS both in the short and long term? A key issue is whether CAPS would be adopted by smallholder farmers and if so, do the preconditions for adoption exist in West Africa (Ghana and Mali). Finally, what are the most cost-effective participatory and non-participatory research and extension mechanisms for evaluation and dissemination of CAPS? The project is working closely with the Savanna Agricultural Research Institute (SARI), which has been active in agricultural research in the Ghana project area for many years. While the project had been working with the Institute d'Economic Rurale (IER) in Mali, this component was recently suspended because of the ongoing security situation in Mali. Instead, the project has shifted some of its activities to an existing program in Upper East Region in Ghana, also supported by SARI but in association with the USAID-funded Africa RISING program as well.

Field visits by the evaluation team (Knowler only) took place during the period July 13 – 19, and involved site visits to both Upper West (Wa) and Upper East (Bawku/Manga) Regions. The visits were organized by the PI, Dr. P.V.V. Prasad, and by his co-investigators from SARI in Upper West Region (Dr. J. Naab) and Upper East Region (Dr. R. Kanton). The team made field visits to the villages of Nyoli and Busa in Upper West Region, and inspected the farmer field plots and held extensive discussions with participating (and non-participating) farmers. Due to a lack of time, only the field station was visited in Upper East Region but a group of farmers met with the team and provided extensive input on their experiences with the project.

1. Project objectives[1]

LTRA-8 project objectives, as listed in the project proposal (Prasad et al. 2009) are:

1) Evaluate local conservation agriculture practices (CAPs) that are based on minimum tillage, direct seeding into residues, retention of crop residue, and incorporation of leguminous cover crops to improve soil quality, water use efficiency, and cropping system productivity and income.
2) Develop cropping systems (crop rotations and/or intercropping) that improve water use efficiency and nutrient use efficiency through integrated water (e.g., residue, seedbed type, zai system, ACN technologies) and nutrient management practices (combination of organic and inorganic fertilizers) in collaboration with farmer-experimenters.
3) Foster and advance rapid adoption of local and integrated crop, water, soil and nutrient management practices to improve system productivity, livelihoods and natural resources through participatory approaches.
4) Assess the long term effects of CAPs and improved integrated crop, soil nutrient and water management practices on system productivity, system diversity, water use, nutrient use, biotic and abiotic soil quality, carbon sequestration, and family income using both scientific and farmer-derived metrics.

5) Calibrate, assess and use crop simulation models to predict the impact CAPs on system productivity, water use, soil carbon sequestration and economic returns for the experimental sites and mainly beyond the sites and across the region.
6) Strengthen capacity of scientists, extension agents, rural communities and farmers through several gender-sensitive participatory mechanisms including training workshops, field days, mother-baby on-farm trials, farmer-to-farmer exchanges and demonstrations to document and communicate the benefits of CAPS to facilitate access to inputs, equipment and markets to make conservation agriculture practices accessible and sustainable.
7) Assess the cost and benefits of the training and transfer activities delineated above in order to contribute to broader understanding on the effectiveness of participatory approaches in CAPS.
8) Capacity building of host country scientists through short-term training workshops and long term training by providing graduate degrees (M.S. or Ph.D.) in the United States and through initiating collaboration and networking group with scientists of other countries in the region.

2. Ghana and Mali project progress

Obj 1. The project makes use of a Mother-Baby trial approach, both located on farmers' fields or village land. In Upper West Region, mother trials initially consisted of four experiments but the trial involving crop residue management was suspended due to a lack of interest in applying residues to fields. This left the trials as a 3 x 3 scheme with three tillage options (no till, tractor, hoe/minimum till) and three cropping systems (continuous maize, maize/soy, maize/sorghum). The maize being used is the 110-day QPM variety. The trial results at Wa indicate that no till with sole maize produced a much lower yield than conventional tillage in 2010 and somewhat lower in 2012. Simple benefit-cost ratios show conventional tillage having an advantage of 4:1 in 2010 and 2:1 in 2012. Thus, no till appears to be very unattractive to farmers in the short run but its attractiveness may improve over a relatively short period. Soybean yields were not much lower under no-till than conventional tillage but this was not significantly different at the 5 percent level. Overall, the trial results indicate that differences between conventional and minimum tillage were not significant. Relative differences are less with intercrop across till types than under sole crop. While statistical differences are not required to demonstrate treatments to farmers, it does provide useful information to share with other researchers.

In the Upper East Region (Bawku), the current SARI program has been in place for three years but as the SANREM activity is new there are relatively few conservation agriculture trials yet (as this component is replacing the Mali program).

[1] NOTE: There seem to have been changes in the project's objectives from the proposal stage to the recent Annual Reports, e.g. Objective 6 is now "Assess the costs and benefits of activities" and Obj. 6 and 8 duplicate. For consistency, we have stuck with the original objectives in the project proposal.

Obj 2. While CA activities have included all the components of good practice, mulching has not been popular (see above) and the project has wisely decided not to promote any approaches using crop residues. Tied ridging is being promoted in some areas where ridging is already practised and the addition of ties involves little extra labour. In addition to the standard tillage options, trials were carried out on various fertilizer and water management options once initial evaluations had weeded out less promising alternatives.

While the project initially involved five on-farm Mother-Baby trial sites, one was eliminated (Sieyiri) when it turned out the selected land was subject to water logging and initial yields were disappointing. As a result, the site was dropped.

Obj 3. Discussions with local investigators and field visits to several villages in Upper West Region (Busa and Nyoli) revealed anecdotally that many farmers are not cultivating their entire land holdings annually and find that conservation agriculture allows them to increase the area cropped because of its associated labor savings. A more formal adoption study is underway using standard bivariate methods (logit/probit). Despite the early stage of diffusion, the reported rate of adoption is very encouraging; the study survey found that 91 percent of project participants had extended some conservation agriculture practices to adjoining plots not involved in the project. Among non-participants within the project villages, the number adopting some conservation agriculture practice was 70 percent. An attempt was made to randomly select survey respondents as part of the study methodology. Thus, there is evidence of an enthusiastic response to the conservation agriculture practices developed under the project.

Obj 4. The project carried out an extensive baseline survey to establish reference points for progress on development and adoption of conservation agriculture. Longer term challenges include: availability of seeding equipment, access to herbicide tolerant seeds, continued burning of fields/residues, stray animal grazing of residues in dry season and the view of tractors as a symbol of modernization in agriculture (so progressive and attractive).

In addition, various cost-benefit analyses have been conducted using results from the various on-farm trials and using a partial budgeting approach, to assess the attractiveness of the project interventions to farmers. Initial results concerned with perceived short-term benefits and primary constraints to adopting conservation agriculture in the region are reported in a journal article in press in *Agriculture, Ecosystems and Environment* (Dalton, Yahaya and Naab).

Obj 5. Proposal indicates project would do crop simulation modeling but this had not been undertaken at the time of the evaluation visit.

Obj 6. The submitted article noted above also reports on the various capacity building and training activities undertaken by the project (farmer field schools, etc.). For example, farmer field schools were organized annually to educate farmers and provide insight on what other farmers in the district were doing as part of a broader effort to disseminate knowledge on conservation practices. In addition, the project has attempted to increase female participation in project farmer organizations by encouraging <u>all</u> female-headed households to participate in farmer groups (not just a sample). Overall, the project supported two (male) Ph.D. students and

two (female) Masters students, and trained 767 trainees over the period 2009-2013.

Obj 7. This objective is not entirely clear. However, it is evident from discussions with farmers that most participated in the project—and are contemplating adopting conservation agriculture interventions—for the cost savings. But farmers also acknowledge the farmer group approach has had additional benefits in terms of stimulating more group activities within the community (but outside the project). There is also the suggestion that more contributions are being provided to vulnerable or distressed households within the community than was happening before and this may be related partly to greater collective action thinking within the community.

Obj 8. The project identified two Ghanaian candidates to study for a Ph.D. in the USA but this was done later than planned (2012 vs. 2009 in proposal). The initial intent had been that they would identify a research topic related to project activities in Ghana. Some challenges have appeared in respect of one of these student positions and it was necessary to recruit a student from the USA instead, with the resulting research directed towards a USA-based rather than Ghanaian topic.

Collaborations between host country and international researchers thus far have resulted in several publications, including reports (Yahaya et al., 2011; Yahaya et al., 2010) and journal submissions (Dalton, Yahaya and Naab, Submitted).

3. Appraisal of project accomplishments

Obj 1. The researchers appear to have used most available resources to select the best-bet conservation agriculture practices for evaluation. The selected practices represent the three main requirements of conservation agriculture; minimum soil disturbance, crop rotations, and maximize ground cover. Moreover, the field trial research strategy developed by the LTRA 8 team is impressive. One of the most difficult aspects of on-farm research is to conducts trials in farmer's fields and to keep the experimental error low enough to detect significant differences among treatments. Conducting multifactor researcher managed on-station trials usually can be done; conducting demonstrations in farmer's fields, while difficult, is achievable. Most projects do not have the resources and supervisory personnel to conduct well run researcher managed trials, on-farm trials and demonstrations. The LTRA 8 team selected a very effective approach to conducting field trials.

That said, the issue of crop residues seems not have been addressed despite its critical role as cited in the literature. In part, this neglect is due to the loss of one of the experimental sites in Ghana (i.e. Sieyiri) where residue trials were planned but the village was withdrawn from the project because the land provided for mother trials was waterlogged. This site was the only one to include crop residue management in the on-farm trials. However, it is difficult to see a lack of attention to crop residue management entirely as a failing and perhaps could be viewed as a wise move, since crop residue management demonstrates some of the hallmarks of an intractable problem.

Obj 2. The Mother-Baby trial approach is a very cost effective way to conduct trials that generate good research information and provide a mechanism for active farmer involvement in

both research and demonstrations. It appears that this team has conducted field trials with the design and supervision that will produce good research information and provide the best method possible to involve farmers and demonstrate treatments.

The use of Mother-Baby trials permits the identification of a combination of treatments to develop greatly improved cropping systems. The cropping systems being developed appear to be suitable, with the emphasis on maize and soy. Obvious candidates for promotion have been considered and evaluated. For example, the "zai" system for conserving water and organic matter used elsewhere in West Africa was deemed not appropriate for the project sites, since the soils are sandier and there is less compaction.

Obj 3.The use of baby trials provides a great opportunity for farmer involvement and demonstration of best-bet CAPS. Initial household surveys within the farmer organizations, the project communities and even at neighboring sites not involved in the project indicate promising signs of early and rapid adoption of project interventions. Discussions with the project economist based at Wa suggest some improvements could be made in the statistical modeling of adoption and in time more sophisticated statistical procedures could be used to model adoption.

Obj 4. It is difficult to evaluate progress on long term effects of project interventions since the five year period of this project is too short to allow critical evaluation of long term effects. The proposed soil measurements can provide some indication of long term effects. Realistically, most physical and economic impact studies thus far have only addressed short term impacts and incentives.

Obj 5. Progress to date on this objective has been negligible. However, crop simulation modeling has the potential to contribute new insights to the development and promotion of innovative cropping systems and potentially could be initiated with the time remaining, particularly in light of the trial and related research information accumulated so far. However, it is recognized that this is an ambitious and highly skilled exercise and its likelihood of success depends upon having available the right information and researcher skills to complete the task in a timely way. It was not clear that this task can or should be attempted at this stage in the project's life.

Obj 6. While promises were made to involve higher numbers of women in farmers' organizations participating in the project, the organization visited at Busa had no female members. When the evaluation team spoke to several women in the vicinity who wished to join (one of whom was a sole head of household), they indicated they had been unable to do so. Asked why they wished to join the group and how the project activities might benefit them, these women cited the general benefits indicated by the men in the farmers' organization; e.g., cultivate more land (sometimes their own plots) and save land preparation costs. All three women presently are using some element of conservation agriculture on some portion of their land, mostly no till, but they are constrained by water availability and herbicide cost. All cited the rising price of agro-chemicals as an issue for farmers of both genders.

Obj 7. Increased clarity regarding this objective would have been beneficial to both project and evaluation perspectives. At this stage there is very little comment that can be offered on this objective.

Obj 8. Some issues related to the Ph.D. students recruited by the project need attention to ensure the candidate students develop appropriate research topics and are able to maintain their funding for the requisite period. These Ph.D. students were identified late in the project, and this is liable to create difficulties with continuity of funding beyond the project life (although mechanisms may be in place to address this potential problem). To date, progress on defining this research is not advanced and contact between at least one of these students and the project supervisor could be enhanced. Opportunities exist to expand on some of the initial investigations on adoption of conservations practices using more sophisticated statistical techniques.

4. Recommendations for the last year of the project

To date there is clear evidence that farmers have been enthusiastic and engaged in this project. Farmers indicated that what they liked most about the project interventions was that they lower the cost of production, allow expansion of cropped area, improve fertility without having to fallow, provide more food to eat, allow more women to farm and result in higher incomes. They expect these benefits to continue and even increase into the future. Importantly, the farmers were keen on the project's role in bringing new knowledge to the villagers. However, they expressed some concerns as well; for example, there were worries about spraying and health and a lack of protective clothing, no access to clean water for diluting herbicide or seed drills to plant and neglect of post-harvest losses. Clearly, the project has benefitted from a sound research design and good execution, particularly in its involvement of farmers as evidenced by farmers' obvious enthusiasm.

A review of the administrative aspects of the project revealed few problems, except for substantive delays in receiving funding at the field station level. At West Africa, no funds had been received so far this calendar year. Apparently, the delays in making payments to host-country partners in Mali and Ghana have been caused mainly by difficulties with obtaining the invoices on time. The SANREM ME worked to expedite the process and the SANREM director met with financial personnel in the host countries to discuss ways to speed up the invoice submissions. Despite this issue, permanent SARI project staff seem happy and there has been little turnover to date. Temporary project staff complained about not receiving payment of fuel supplements and low salaries, together with an increased work load after two NGO's left the project. In general, transport is a problem for them and training has been limited. They were clearly more "sanguine" about the project than the more enthusiastic SARI staff.

Clearly, a key item for the coming year will be to ensure some project related results can be obtained from conservation agriculture trials in the Upper East Region. While the station is an admirable facility and well-run, its very recent involvement with the SANREM project is evident in the relatively few conservation trials yet in place.

Other issues deserving increased attention from the project team include crop residue

management. Ultimately, will the project be able to say anything about this critical issue in the development and promotion of conservation agriculture in the Semi-Arid Zone? In a related sense, it was evident to the evaluation team that the availability of clean water for herbicide use was an important constraint to wider adoption of reduced tillage options. An attempt to find solutions to this problem could pay dividends.

Further assessments of the success of the project should make use of the baseline data collected initially and compare this information with conditions at the end of the project life. This analysis would depend on the quality and sound design of the original survey so that corresponding end-of-project information can be collected simply.

Finally, it will be important that the project sponsored Ph.D. students, who were recruited several years late, get a good start on their research so they can carry this over beyond the project. It may make sense to tie-in further adoption survey/analysis with this Ph.D. research since a longer time frame for this work is preferred. Some improvements to the statistical procedures used in analyzing adoption were suggested by the team and could be initiated in the coming year. Similarly, the lack of progress on crop simulation modeling may offer opportunities for longer term Ph.D. study, rather than attempting to complete this ambitious undertaking within the remaining year of the project.

D. LTRA-9, Developing Sustainable Conservation Agricultural Production Systems for Smallholder Farmers in Southern Africa

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This project was developed on the premise that smallholder agriculture, as practiced by many farmers in sub-Saharan Africa, is currently unsustainable. The use of external inputs such as fertilizers is often minimal on food crops and over time has led to a significant depletion of soil fertility and loss of essential nutrients such as phosphorus. Poor fertility results in very low yields and further reduces farmer's abilities to afford essential inputs. The investigators believed that

the lessons and principles learned from the development of no-till systems in the USA could be applied to develop more sustainable soil management systems in sub-Saharan Africa. They stated in their proposal that it is well understood that conservation agriculture systems (CAS) should be developed on research and resources available to local conditions. In the long term, CAS systems will feed a growing population and also improve soil quality, sequester carbon from the atmosphere, and reduce environmental impacts of agriculture.

1. Project objectives

1) Integrate cover crops into CAPS to protect the soil from erosion, provide weed suppression or control, include crop rotations that provide forages for livestock, improve soil quality as measured by soil carbon, decrease risk and vulnerability to drought.
2) Determine the agronomic and economic fertilizer rate for maize in both the basin and machine no-till methods.
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.

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.

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.

2. Southern African project progress

Obj 1. Legume cover crops were established in 2010 in Lesotho with the goal of producing biological nitrogen for maize. Discussions were held with collaborators in Mozambique where considerable work with conservation agriculture had already been done to determine the two best CAPS to be used in both countries. Exploratory work in 2011 in Lesotho resulted in selecting rose clover (*Trifolium hirtum*), grazing vetch, wheat, oat, and lentil as cover crops to be evaluated. In Mozambique, approximately 50 on-farm trials were ongoing in Sofala, Manica, and Angonia provinces to evaluate cover crops, intercropping, and crop rotations. An early finding was that maize intercropped with sunflower did not perform well. In 2012, the investigators reported findings of several un-replicated studies evaluating the effect of cover crops that showed very positive effects of cover crops reducing weed pressure. At Maphutseng, Lesotho, a mixture of wheat and vetch grown in the winter preceding the seeding of maize increased yields by 1 Mg/ha or more. In Mozambique, cover crops were not as effective due to high termite populations and researchers were exploring use of *Tephrosia sp.* as a plant less palatable to termites. The investigators stated that findings for Obj. 1 were more advanced in Mozambique than Lesotho, due to prior research by CIMMYT in that country. The findings in Mozambique, however, are still valuable for the work in Lesotho. An obstacle to adoption of CAPS in Mozambique is the high cost and/or availability of fertilizers and herbicides. Without herbicides,

weed control is all by hand labor, some of which is usually hired. The use of cover crops to supply nutrients and suppress weeds is a major focus for the investigators and telephone conversations by the EAP with Drs. Eash and Walker, who indicated they were very positive about this work.

Obj. 2. This objective was to determine the agronomic and economic fertilizer rate for maize in both basin and machine no-till methods. In none of the annual reports was there any mention of comparing these systems. Telephone interviews with Drs. Eash and Walker stated that basins were no longer used in their work as they were focusing on the use of mechanized no-till equipment. They reported that using the mechanized equipment with higher plant populations and 100-, 60-, 60-kg/ha of N, P_2O_5, and K_2O would achieve maize yields greater than 7 Mg/ha. This compares to farmer yields of 1 Mg/ha or less. The investigators stated their findings could blossom into a very successful CA adoption study if enough monetary support is provided to enable scaling up their studies and outreach efforts. In Mozambique, CA adoption is already on the upswing but is limited by price and availability of need inputs such as seed and fertilizer.

Obj. 3. At the outset of the project, a strong focus has been on cover crops as a provider of N and for improving soil quality. Species evaluated initially included pink seradella, rose clover, subterranean clover, sweet clover, grazing vetch, and sweet vetch. Even though some of these have been successful, they continue to efforts on cover crop selection and evaluation, particularly in Mozambique. In Lesotho, N fixed by winter cover crops provide enough N to increase maize yields by 1 to 1.5 Mg/ha, which is 2 to 3 times the average maize yield. Almost as important, the cover crop suppresses weeds, up to 90 percent of some species, and also suppresses termite infestation. In low rainfall and high temperature areas, maintaining crop covers is important for reducing soil temperature and evaporative losses.

Obj. 4a. In Lesotho in 2010, investigators discussed how to determine the impacts of CAPS and interviewed women engaged in CAPS. The team developed a baseline household survey. The surveys are still being analyzed but some of the data show a strong positive correlation of labor allocation along gender lines, but there does not appear to be any differences with respect to labor demands along technologies used (conventional tillage versus no-till practices). They also reported that women appear to be the primary decision makers for fields that are rotated to leafy green vegetable plots during the winter months. The baseline survey of approximately 535 households for Mozambique was completed in 2012. Most household heads are male and the mean head of household age for all farming groups is above 40 years old, and that the life expectancy in Mozambique is 50 years. On average, the age of CA farmers was 45 years, compared to 42 for non-adopters, which was significantly different at the 5 percent level. Educational levels of the two groups were similar.

Obj. 4b. Although from the beginning of the project, there was a strong interest in evaluating ways and means to improve fertilizer adoption rates among smallholder farmers, research was slow to develop. Little data were reported and discussed in any of the annual reports. It was reported in the 2012 Annual Report that in Mozambique, it appears that households who have adopted CA are more likely to sell maize in local markets, whereas non-adopters in

communities with demonstration plots as well as communities that do not have demonstration plots are, on average, more likely to be net purchasers of maize.

3. Appraisal of project accomplishments

It was somewhat difficult to access the accomplishments because of the lack of detailed information about trials conducted by this project. The annual work plans indicated comparisons were going to be made, but no information was given about trial design. The annual reports gave summary statements about the results but, no trial data were given. This problem was made more difficult because of the lack of opportunity of the EAP team to visit the sites in Lesotho and Mozambique.

Obj 1. The use of cover crops in CAPS was the primary focus of this project from the beginning. From all accounts, their use has been very successful. Although the basic premise for their use was to provide N and improve soil quality, the investigators are equally if not more positive about the role that cover crops play in suppressing weeds in maize fields. Results show that as much as 90 percent suppression occurs for some weed species. Therefore, there has been marked progress in accomplishing this objective.

Obj 2. As stated in the project proposal, the objective of determining the agronomic and economic fertilizer rate for maize in both the basin and machine no-till methods has not been investigated. The investigators have focused almost entirely on the use of mechanized machine no-till systems and have not had direct comparisons with basin systems that are conducted by hand labor. The mechanized systems with fairly high fertilizer inputs have resulted in maize yields of 7 Mg/ha or greater that compares to farmer yields of less than 1 Mg/ha.

Obj 3. Considerable progress has been made on the objective of evaluating the use of legume cover crops to improve soil fertility and enhance carbon sequestration. Results indicate that enough N is fixed by the legume cover crop to increase maize yield by 1 to 1.5 Mg/ha, which is 2 to 3 times the average farmer yield. This is an important and significant accomplishment.

Obj 4a. This objective has provided some preliminary data and findings based on baseline household surveys conducted in both Lesotho and Mozambique. However, the analysis, interpretation, and discussion of the results have been slow and still incomplete. While researchers have examined how CAPs affect time spent on weeding, work done mainly by women, and have postulated what effects CAPs may have on women's farm labor, follow-up surveys will be needed to determine influential factors and significant impacts on family farm-labor distribution.

Obj 4b. Progress on this objective has also been much slower than projected in the proposal. It is an important objective, but little progress has been made to date.

4. Recommendations for the last year of the Southern Africa Project

Although this project had some difficulties in the early years, particularly in Lesotho due to extreme drought at the time the project was initiated, some important findings have been obtained. The final year of the project should focus on obtaining as much data as feasible in

support of Objectives 1 and 3 where most of the actual crop yield data have been obtained. Another year of data will be very important in summarizing the findings of the project.

Hopefully, the team can use this last year also to document in detail the trials and their results. The analysis of the baseline household surveys for both Lesotho and Mozambique should be completed and summarized in a publication. Since there has been only limited information obtained relating to Objective 4b, further work on this objective is not likely to be beneficial unless follow-up surveys are undertaken. A summary paper describing the potential of CAPS in Lesotho and Mozambique could be of great interest and importance. The constraints for adoption, particularly as seen by the farmers, should be a very important part of any publication resulting from this project.

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

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Dr. Rita Laker-Ojok, Director, Appropriate Technology Uganda

This project selected four areas in Eastern Africa to conduct conservation agriculture research: the Tororo and Kapchorwa districts in eastern Uganda and the adjacent Trans-Nzoia and Bungoma districts in western Kenya. Tororo and Bungoma are highly degraded lowlands with sandy soils of low fertility. In contrast, Kapchorwa and Trans-Nzoia are highlands with more commercial agricultural systems, but which face serious soil erosion challenges. Kapchorwa and Trans-Nzoia are generally more innovative and accepting of new technologies, while in Tororo and Bungoma work on conservation tillage has been undertaken for quite some time using farmer field schools with limited impact.

Duncan Knowler and Ron Cantrell of the External Evaluation Panel visited the project sites in Tororo, Kapchorwa and Kitale (in the Trans-Nzoia district). Dr. Rita Laker-Ojok and Grace Tino arranged the field visits in Uganda. Dr. Dominic Sikuku arranged the field visit in Kenya which was limited to the Kitale site because of time constraints of the EAP team. The EAP

visited on-station and on-farm trials in all three areas that were visited. Also, Grace and Dominic arranged farmers to meet with the EAP members in all three areas.

1. Project objectives

1) (Pre-experiment): Compile information for prototype CAPS development. Assemble advisory group of stakeholders from each area. Information gathering in support of developing complete CAPS will include three tasks:
   1. Gather information on local/regional CAPS development programs
   2. Develop detailed survey instrument and carry out baseline field interviews, including cursory soil fertility and crop yield/quality samples from fields farmed by a subset of interviewees
   3. Identify and enlist members of stakeholder advisory groups in each study area based on existing relationships of NGOs and host-country universities, and on people met during baseline interviews.
2) (Pre-experiment): 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. The research team and farmer-advisory group will use data from the survey in Objective 1 to jointly refine and/or design CAPS. Prototype CAPS will incorporate, where appropriate, crop rotations, minimum tillage, organic and inorganic amendments, integrated nutrient management and integrated pest management. They will also build upon local knowledge of environmental, resource, and economic constraints, and consider limits to acceptable change. This process will foster two-way learning as farmers teach PIs reasons for traditional practices and resistance to change, and are taught soil processes underlying CA approaches.
3) (Experiment): Evaluate agronomic, ecological, and economic sustainability of CAPS compared to traditional practices. This phase of the study will generate data on the performance of prototype CAPS, and provide outreach and training opportunities. CAPS will be implemented alongside traditional production practices, as replicated plots, on university and/or government research institute farms, and the farms of cooperating NGOs and small holders in Uganda and Kenya. Parameters evaluated will include: 1) soil biological, physical, and chemical properties; 2) trace gas emissions; 3) crop and forage growth, yield and quality; 4) labor requirements; 5) economic viability; and 6) adoption and adaptation of CA technologies and approaches. Following initial trials, during pilot farm visits and outreach activities, on-the-ground university and NGO reps will encourage more farmers to establish on-farm plots, with less intensive data collection, to generate more feedback from "early adopter" farmers, and increase the project's visibility within the farming community. Project teams will develop feedback loops in the co-design process to ensure that any new knowledge of relevance is incorporated in the ongoing project.

2. Uganda and Kenya project progress

Obj 1. It was obvious that the team has been successful in achieving Project 1 objective. The

host country partners are very impressive. They are all well qualified and dedicated to achieving success in this project. The best example of this dedication has been their continuation of work on the project when funds are repeatedly delayed, many times as much as six months. The staffs of Alternative Technologies, Manor House, and Sacred Africa were all familiar with the farmer groups, location of all trials and demonstrations, and most importantly their knowledge of the best bet CAPS. Advisory groups were established in all four study areas and meetings were held with farmers to obtain information on traditional farming methods and potential CAPS for evaluation. These advisory groups identified four on-farm sites in each of the four study areas. The baseline survey data was taken in 2011.

Obj 2. The only issue in this objective was the delayed analysis of the base line survey and sharing of this information with all partners. The results of the baseline survey were not made available to the research team on a timely basis so that this date could not be used in developing prototype CAPS. The project staff used a very iterative and inclusive process to define local farming practices and the major constraints that farmers had to deal with in the selected study areas. Host country staff and farmer group all expressed their satisfaction with the process and their inclusion in the identification of the most important constraints. The research team relied heavily on the information obtained from the farmer advisory groups. The prototype CAPS addressed the constraints identified by farmers and the three main characteristics of conservation agriculture: minimum soil disturbance, crop rotations, and maintaining ground cover.

Obj 3. All of the on-station and on-farm trials were planted and planned data taken for 2011 and 2012. The NGO staffs were very diligent in taking the requested data on all field trials. It was not evident that this data was analyzed and shared with all team members on a timely basis. One exciting innovation by this project was the development of a new animal drawn implement that can function in ripping, chiseling, weeding, and seeding. This Multi Functioning Implement (MFI) was developed in cooperation between project staff and farmers. The farmers indicated that this implement reduces labor cost and greatly reduced soil loss. The demand for this implement is great and project staffs are working with local manufacturing companies to produce them locally. Transfer of this new technology will also greatly enhance the adoption of other components of conservation agriculture.

3. Appraisal of project accomplishments

A core objective of the research project was to facilitate training and capacity building on central components, including participatory co-innovation, scientific analyses of fundamental components of sustainability, and effective dissemination that supports adoption. Eight students were funded for advanced degree training and over 1600 individuals were provided short-term training. This project was very successful in providing both degree and short-term training. The staffs of the three NGO partners in Africa were very professional and were recipients of this capacity building and also were actively involved in training others. The senior staffs of the three NGOs were very knowledgeable about all aspects of the project.

Obj 1. The requirements for this objective were accomplished and has permitted the team to

develop the prototype CAPS and begin their evaluation in 2011.

Obj 2. This objective was accomplished, but without the benefit of the results of the baseline survey, due to data entry problems caused by incompatibility of computer programs.

Obj 3. Based on the observations of the EAP team, determining the agronomic performance of the prototype CAPs vs. traditional practices may be difficult to achieve, because of the large amount of variability in both the on-station and on-farm trials. The sites for the on-station trials at Tororo and Kapchorwa had a high degree of plot to plot variability and a large number of missing plots due to insufficient stands. The on-station trial at Kitale has less variability and significant differences may be detected among treatments at this site. A greater number of replications would be required for this level of variability, but this may not have been possible because of land constraints. As expected, the on-farm sites had a high degree of variability and replication across three farms will probably not be sufficient to detect significant differences among treatments. The crop yield data for 2011 and 2012 showed with few exceptions, no significant differences among treatments.

It was interesting to note that in 2011, the maize yields for the on-farm trial at Kapchorwa were twice that of the on-farm maize yields at Kitale and the next year on the same sites the maize yields in Kitale on farm trials were twice that of Kapchorwa. There could be climatic conditions to explain this, but other possibilities need to be examined.

Another possible issue with the trials in Tororo concerns the farmers' practice treatment. In most cases the variety used was a hybrid that was not available for farmers in that area. Also, the fertilizer application rate was sometimes higher than the farmers normally used. The interaction of good hybrid seed and higher fertilizer rate may not give an accurate evaluation of traditional practice.

These trials were also used as an outreach activity as demonstration sites. Based on discussions with local researchers and farmers this part of objective 3 has been accomplished.

4. Recommendations for the last year of the Kenya and Uganda project

During the last year of field trials, special attention should be given to adequate borders for on-station trials and especially minimizing factors affecting adequate plant populations. High priority should be given to continued interaction with local manufacturing companies for local production of the MFI.

Reflection workshops and field days should be continued, as well as other activities which promote interactions with farmers. The farmers were most excited about the conservation agriculture trials and they all hoped that they would be continued in the future. Even if the project is not funded for another phase, it is hoped that the local organizations can find ways to continue to have interactions with the farmers in these four areas.

F. LTRA-11, Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS) (India and Nepal)

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Nepal and India are the south Asian countries participating in SANREM's SMARTS (Sustainable Management of Agroecological Resources for Tribal Societies) project. The project focuses on researching and promoting CAPS agricultural practices with tribal ethnic groups. These groups are smallholder farmers and marginalized communities, who tend to practice a subsistence type of agriculture. Two members of the EAP visited Thumka, one of the three project sites in Nepal but did not visit any of the India sites. Nepal is made up of three ecological regions. The Mountain Region accounts for 35 percent of the area, the Hilly region for 42 percent, and the Terai region (marshy lowlands) for 23 percent. The project sites are in the Hilly area and 83 percent of the maize is grown in the Hilly and Mountain Regions. According to Bikash Paudel, a project graduate student at the University of Hawaii, there are variations in micro-climate and rainfall, soils, and slope in the three Nepal project sites, but no socio-economic variation—all households are tribal and of the same ethnic group, Chepang. These areas are difficult to farm and infrastructure is severely limited because of the rugged terrain. The Thumka site that the EAP members visited was on a hill where the top was almost 1000 m higher than the bottom and was accessible only by walking up a very narrow and precarious trail. All inputs and outputs were essentially carried by people and much of the limited cropland was at the higher locations on the hill. Access to a road to the nearest town involved crossing a river on a two-person aerial gondola.

1. Project objectives

The proposal for LTRA-11 listed five activities, but these were changed and reported as objectives in the annual reports. However, the objectives in the annual reports were not always numbered the same from one year to the next and some activities were not always reported. The project activities as listed in the proposal are as follows:

1) Determine the set of CAPS to study, using PRA (participatory rural appraisal) and risk analysis;

2) Explore stakeholder preferences for CAPS;

3) Implement preferred CAPS and conduct training on production, management, and product marketing;

4) Use a participatory action research (PAR) approach to promote reflection, evaluation, and continuous improvement of implemented CAPS; and

5) Build capacity of farmers, local NGOs, regional universities to scale up CAPS development through workshops, training, publication of technical reports and outreach materials, and presentations at conferences, symposia, and other meetings.

2. Nepal and India project progress

Obj 1. In India during 2010, the research team completed farm household production surveys for three villages, consisting of 64, 50, and 24 households. Based on information gathered from these surveys, experimental plots of potential CAPS were established on the Keonjhar KVK station in India. An important finding used in developing potential CAPS was that three types of intercropping are generally practiced: maize and mustard; maize, cucumber and cowpea; and maize, cucumber and pumpkin. Seventy-four percent of households retained their seeds, and 44 percent used manure, 29 percent used compost and 17 percent used urea. The majority of households have some bulls, goats, and chickens; and the average size of owned cropland is 2.1 ha.

In 2011, research data collected from the studies at the Keonjhar KVK station were used in conjunction with the 2010 survey results to do an economic analysis for the three CAPS that consisted of maize with minimum tillage; maize/cowpea intercrop with plowing; and maize/cowpea intercrop with minimum tillage. Focus groups were identified to look at risk and opportunities for farmer adoption. In addition, consultations were held for women's groups to identify preferences and risks.

In Nepal, three villages were selected for CAPS based on predominance of shifting cultivation and sloped landscape, site accessibility, tribal culture, and microclimate variation. Farmer focus groups from the selected Nepali villages were conducted in each of the three villages to assess current farming practices and determine the most appropriate CAPS options. Farming practices, cropping patterns, and livelihoods were observed by teams from University of Hawaii and LI-BIRD (Local Initiatives for Biodiversity, Research, and Development) that is the partner organization for the Nepal part of the project.

Field trials were initiated in Nepal in 2011 and soil samples were collected and analysis begun. In 2012, the Nepal field trials were in their second year, but a severe drought occurred at time of maize planting causing severe germination problems.[2] Summer season treatments were sole-maize with conventional tillage and sole-maize with strip tillage; rainy-season treatments were sole-millet with conventional tillage, sole-black gram with conventional tillage, millet plus black gram with conventional tillage, and millet plus black gram with strip tillage. In India, a field experiment was conducted during the rainy season of 2011 and post rainy season of 2011-

2012. The four treatments were conventional tillage with sole-maize; conventional tillage with maize plus cowpea; minimum tillage with sole-maize; and minimum tillage with maize plus cowpea.

In the 2012 annual report, it was stated that for Nepal it had been verified that appropriate adoption of CAPS has potential for increasing profitability of the maize-based hill farming system by $329 to $509 per ha. However, the data presented to support this statement were not sufficiently clear and complete enough to fully understand. The cropping system for the conventional system was maize-millet while the strip-tilled CAPS treatment system was maize-millet + cowpea, and the other conventional plowed treatments were maize-legume and maize-millet + cowpea. The increased profit apparently came from the sale of the legume, primarily cowpea, which was not part of the conventional system. The investigators in their economic analysis considered the two conventional tilled treatments that included a legume as CAPS although in the proposal, only the strip-till treatment was identified as a CAPS. The legume was apparently used as a cash crop in the economic analysis. In all the treatments, maize was the primary crop and the maize yields for 2011, 2012, and 2013 are presented in Table 1. The 2013 maize was harvested after members of the EAP visited the Thumka location. There were no significant differences in maize yields for any of the treatments in any of the years for any of the locations. It is not clear what data were used in the economic analyses. If maize yields were not statistically different, using different treatment yields for obtaining revenue would be questionable. As indicated by the standard deviation values, there was a lot of variation in the yield data. This is not surprising considering the size of the plots and the highly variable soil and topographic conditions.

[2] It should be mentioned that the Nepal sites are strictly rainfed with no access to irrigation in contrast to some of the other sites such as Cambodia, Philippines, and Ecuador

Table 1. Maize yield (Mg/ha; mean and standard deviations) for fourdifferent treatments in three study villages, Nepal

Year	Treatment*	Thumka	Hyakrang	Kholagaum	Overall
2011	T1	1.96 ± 0.81	2.63 ± 0.68	1.72 ± 1.06	2.13 ± 0.91
	T2	2.36 ± 0.96	2.50 ± 0.50	1.74 ± 1.10	2.21 ± 0.90
	T3	2.11 ± 1.08	2.38 ± 0.67	2.09 ± 1.06	2.20 ± 0.91
	T4	1.96 ± 0.86	2.30 ± 0.59	1.90 ± 0.95	2.07± 0.79
2012	T1	1.75 ± 0.73	2.21 ± 0.26	1.88 ± 1.01	1.94 ± 0.73
	T2	1.67 ± 0.93	2.92 ± 0.42	1.99 ± 0.87	2.19 ± 0.92
	T3	1.77 ± 0.79	2.48 ± 0.55	1.72 ± 0.59	1.99 ± 0.72
	T4	1.31 ± 0.56	2.22 ± 0.66	1.47 ± 0.88	1.66 ± 0.79
2013	T1	2.08 ± 0.61	2.01 ± 0.68	1.28 ± 0.49	1.79± 0.68
	T2	2.14 ± 0.69	2.04 ± 0.75	1.19 ± 0.47	1.79 ± 0.75
	T3	1.84 ± 0.61	1.80 ± 0.77	1.35 ± 0.54	1.66 ± 0.66
	T4	1.70 ± 0.54	1.54 ± 0.85	1.14 ± 0.64	1.46 ± 0.70

*T1 = maize-millet with conventional tillage; T2 = maize-legume with conventional tillage; T3 = maize-legume + millet with conventional tillage; T4 = maize-legume+ millet with strip tillage.

For India, they reported that the potential of increasing maize under minimum tillage with intercropping by 12 percent, and that the best CAPS can increase profits by about $286.5 per ha per year. Again, the economic data were not presented in enough detail to clearly understand how the increase profits were achieved, the crops included in the various treatments were not the same and it appears that the increase was from cowpea which was not included in the conventional treatment.

Obj 2. This objective was to explore stakeholder preferences for CAPS to promote adoption. Nothing was reported in the 2010 annual report. In the 2011 report, it was reported that they were not able to employ the AKT or FALLOW models as planned to assess the agronomic or agroforestry potential of the project sites because there were not enough graduate students to help. Instead, site visits were used to select farm communities to make observations, hold discussions with farmers, and meet with local university and NGO partners.

In Nepal, focus groups were conducted with farmers in each village to discuss cropping patterns, project objectives, methodology, and duration. Based on these discussions, treatments for the on-farm trials were selected and consisted of: full tillage maize with a cowpea relay crop; full tillage maize with cowpea and finger millet relay crop; full tillage maize with finger millet

relay crop; and strip tillage maize with cowpea and finger millet relay crop. The 2012 annual report showed that development workers and researchers preferred sole maize with millet plus cowpea intercrop with strip tillage to all others. However, farmers at Hyakrang and Thumka villages ranked sole maize with cowpea with conventional tillage much higher than other systems indicating that farmers perceive conventional tillage as having more monetary and edaphic value than strip tillage. The investigators concluded that the full benefits of legume intercropping and strip tillage may be unclear to village farmers. Moreover, labor savings is not a primary factor motivating the adoption of conservation agriculture production systems.

In India, 15 farmers visited an on-station experimental site and learned about the concept of CAPS and were enthusiastic about the minimum tillage concept.

Obj 3. This objective is to implement CAPS in controlled research setting and in farmer fields. While this objective in some ways is similar to objective 1, it goes further in that it is to monitor crop production and quality, soil and water quality, economic impacts, and influences on gender participation and equity within farm households. Therefore, this objective is so broad and inclusive that it is not likely that all of these issues could be adequately addressed.

The 2010 annual report stated that in India soil samples were collected at the KVK station site in Keonjhar and analyzed at two depths for pH and bulk density and some samples had been air-dried for further chemical analysis. The 2011 report stated crop and soil data had been collected from the field experiment and results presented at a two-day workshop. Another experimental plot site was established in Kendujhar District and CAPS were selected using surveys and PAR. Soil samples were collected.

It was also reported that following several visits to project sites in India and Nepal and discussions with university and NGO partners, the LTRA-11 team decided to alter the soil and water conservation strategy from the original plan. In India, the maize-based cropping systems occur on areas with minimal slope. Even then, fields are normally bordered with earthen bunds so erosion is not likely to be a severe problem. In Nepal, where farming systems do occur on steeply sloping land, runoff and erosion plots will be installed at select locations as described in the proposal. In 2012, a change in cropping systems was made in Nepal. Cowpea had been selected to intercrop with millet for the first year, but was replaced by black gram in the second year because shading issues were experienced when cowpea outgrew millet. In India, CAPS performance was assessed based on key economic, agronomic and soil quality indicators. The assessment was done through the analysis of the first year data and focus group discussions. Data indicated that maize and cowpea intercrop with minimum tillage produced about 9.7 percent higher profitability, but no data were presented in the annual report to see what system components were improved. It was also reported that maize and cowpea intercrop along with minimum tillage and followed by cover crop had positive influence on bulk density, pH, organic carbon, and nutrient availability of soil. Although the actual changes were statistically not significant, the pattern of favorable changes in soil properties attributed to minimum tillage was visible.

Obj 4. This objective is to use a participatory action research approach to promote, reflect, evaluate, and continuously improve CAPS. Little was reported in 2010 other than there had been site visits and discussions with various groups. In 2011, it was reported that this approach had been used for the India project to focus the project on maize-based cropping systems, involving legume intercrops and residue management as being most desirable and feasible for improved CAPS and farmer acceptance. In 2012, the plan of organizing events with women's groups in Nepal was modified because of the unavailability of organized women's groups in the communities. The field facilitators met with the women several times to discuss the relevance of CAPS for them. In India, a focus group was organized to discuss CAPS to evaluate the effects of CAPS on soil physical, chemical and organic properties. Initial results indicate no significant effects of CAPS on soil organic matter and nutrient status.

Obj 5. This objective is to build capacity of farmers, local NGOs and universities to scale up CAPS development for wider dissemination. Although nothing was reported for this objective in the 2010 annual report, considerable activity was reported in 2011. In India, the regional universities and communities formed focus groups and other activities to promote CAPS. In Nepal, LI-BIRD staff worked closely with village farmers. In 2012 CAPS awareness in Nepal was raised about the importance of maintaining soil fertility and health. In India, training was conducted to teach the principles of soil, water, and weed management as they relate to CAPS. In addition, training for 66 men and women farmers was conducted in Tentuli village to enhance local knowledge of CAPS; the gender breakdown of this training was not reported. In 2013, Dr. Keshab Pande, of the Institute of Agriculture and Animal Science in Nepal, joined as a collaborator in the SMARTS project.

3. Appraisal of project accomplishments

This project is one of the most challenging projects that the reviewers have ever encountered because of: extreme physical characteristics of the study sites, particularly the Nepal sites; the severely degraded soils; the low education level of the farmers participating in the project; the lack of transportation and social infrastructure at the sites (at least in Nepal), and the extreme poverty level of the households. Therefore, the investigators are commended for efforts. That being said, the project has fallen quite short in making a lot of progress toward accomplishing the objectives listed in the proposal.

In Nepal, the SMARTS project is working in three villages (Thumka, Hyakrang, and Kholagaum) in the Hilly region of Pokhara where the cropland area per household ranges from 0.43 to 0.68 ha; average annual income per household from U.S. $554 to U.S. $627; and average household size from 5.75 to 9.6 members. This information was obtained from surveys done by the investigators and the reviewers were pleased with this phase of the project. During the first two years of the SMARTS project, Keshab Thapa of LI-BIRD reported that maize yields on the project fields ranged from approximately 1.2 to 1.5 Mg/ha which is only about 50 percent of the country average.

The premise for the SMARTS project in Nepal is that current farming practices on sloping lands are not sustainable because of mono-cropping and frequent cultivation. There is extensive soil

degradation and annual soil losses have been estimated to range as high as 105 Mg/ha resulting in a soil degradation and reduced productivity spiral. The project rationale is that conservation agricultural production systems (CAPS) can sustain production through improving yield, enhancing soil quality, and reducing risk of crop failure.

The cropland soil at the three sites in Nepal—Thumka, Hyakrang, and Kholagaum—are typical of the small villages where most of the population in this hilly ecological zone lives. The villagers are representative of about 50 percent of Nepal's population. While there are 59 groups of indigenous ethnic groups recognized in Nepal and these groups differ in their practices, all three of the SANREM project sites are inhabited by Chepang. The Chepang community totals around 100,000 and is considered one of the marginalized and socio-economically deprived indigenous ethnic communities. They have lived a semi-nomadic life, and have depended enormously on the natural forest resources over a long period of time. Forests are the most important source for them in terms of foods, fibers, fodders, medicines, housing materials and various other needs. Hunting and wild foods collection has been their traditional living for subsistence and shifting cultivation is the only feasible way to farm the steep slopes inhabited by them (Prakash Limbu and Keshab Thapa, Chepang Food Culture, LI-BIRD, Pokhara, Nepal).

Two members of the EAP were able to visit the Thumka site in Nepal. There are approximately 30 households in Thumka with the average household consisting of 9.9 persons with 0.68 ha of cropland; each household also has access to (mostly communal) land that is not suitable for cropland. The farmers use little or no fertilizer and this was certainly visible by observing the maize fields. Each household had some livestock and manure was applied to the fields; however, the application was extremely variable and areas closest to the household clearly received more manure than more remote areas.

Eight of the nine SANREM Thumka fields (one producer did not participate in 2013) were visited and all of them were seeded to maize since the timing of the visit was during the first crop (summer) season. Following the maize harvest, a legume crop or legume plus millet will be grown. The maize crop on SANREM plots had been seeded later than many of the surrounding fields in order to ensure adequate rainfall, still the germination on some of the plots was not good. The low germination seemed to be more evident on the strip-tilled plots because the seed were planted in rows on this treatment as opposed to random throwing of the seeds in the conventional seeded treatments. With rare exceptions, the maize plants on the strip-tilled treatment (considered the conservation agriculture treatment) were fewer and less vigorous than the conventional seeded treatments.

It was our consensus that the reason was a result of the soil fertility being affected by the treatment. Manure was supposedly applied to all treatments about 2 or 3 weeks prior to seeding at the same application rate. The strip tillage treatment plot was not plowed while the other plots were. Thus, the manure was incorporated into the plowed soil where it was less vulnerable to washing away, and was also more available for microorganisms to mineralize the organic N and P to make them available for plant uptake. In comparison, it was evident that some of the

manure had been eroded from the strip tilled plot and the maize plants clearly showed visible differences in color and vigor. Although the strip-tilled treatment is considered by the project as a conservation agriculture treatment, it is lacking many conservation aspects because approximately half of the soil surface is still tilled to some degree, and it is our understanding that essentially all of the maize stalks and other crop residues are removed from the plot following harvest for use as animal feed. There was no visible crop residue on the soil surface of any of the eight fields visited.

Although the constraints are easily identified, finding practices that will alleviate them are indeed challenging. The project treatments focus on reducing tillage and including legumes. These appear sound but the baseline survey conducted reported that 51 percent of the households already use a maize-cowpea cropping system and 28 percent use a maize-black gram system, so 79 percent of the farmers already include a legume in their cropping mix. The strip-till treatment as being implemented by SANREM minimally reduces the amount of tillage, so it is likely several years will be required for differences in the soil to occur, and as discussed above, the interaction between strip tillage and manure application may counteract any beneficial effects of reducing tillage. Because of availability and cost, chemical fertilizers are not being used to any extent, and since lack of fertility is the primary constraint, the management of legumes and livestock waste is critical. Furthermore, it appears that most of the legume residue is removed from the field for livestock feed, so it is even more important to concentrate on manure management.

It appeared that every household had several livestock, and that they were fairly constrained. Two cows and two hogs per household should easily excrete more than 75 kg of N and 20 kg P (45 kg P_2O_5) and while much of the N will be lost by volatilization, careful management of the livestock manure along with household waste could be extremely beneficial for households' small plots. Therefore, it seems that more educational emphasis should be given to proper methods of manure retention and application practices. Phosphorus deficiency was readily visible on many of the maize plants, and a few maize plants of more than 30 cm height were observed with purple leaves almost to the top of the plant which is seldom seen.

Dr. Keshab Pande, Institute of Agriculture and Animal Science, showed the field for his study, which is in its first year, comparing eight maize varieties, including hybrids. The germination of all varieties was generally good, and it appeared that positive results would be achieved. Following harvest of the corn, eight soybean varieties will be compared. This study appeared to be well managed and the participating farmer was very interested and cooperative.

In summary, the reviewers think that the agronomic trials fell short in several aspects. Again, it is recognized that the constraints, along with a severe drought for one of the years, made the study environment extremely difficult. The reviewers also think that some of the statements in the annual reports, particularly with regard to Nepal, were perhaps more positive about the benefits of CAPS than there was actual data to support the statements.

With regard to gender issues, it appears from the annual reports that the project was more

successful in integrating women farmers in project activities in India than in Nepal. This may be due to the PIs more extensive experience in India tribal areas compared to Nepal tribal areas. Nonetheless, the project team is to be commended for its data analysis on the gendered labor implications of CAPS. Women already contribute over half of agricultural labor hours in both India and Nepal tribal sites. The adoption of CAPS has increased women's agricultural field labor in India and in Nepal while it has decreased men's field labor; in other words, women are contributing considerably more than half of the conservation agricultural labor. The impacts of this increased labor output by women on the successful adoption of CAPS and on the welfare of women and children (who are dependent on women) need to be studied.

The Nepal project sites (and most likely the India sites also) are truly subsistence agriculture with long fallow periods and no significant commercial farming. In addition, the sites do not have transportation infrastructure for accessing either product or input markets; all products and inputs are transported to the sites by animals or humans. This is quite different from the other sites we visited in Asia and Latin America where smallholder agriculture was oriented towards commercial markets, not just household consumption, and roads reached all farm communities and even most households. And, as we saw, many CAPS practices were not easily accepted because of the households' strong reliance on crop residue (for animal feed) and because of lack of cash income for purchase of inputs, such as fertilizer. The question should be asked whether CAPS is appropriate for subsistence farm households and communities that lack cash income for commercial inputs, generally farm poor and marginal lands, and that often lack transport infrastructure for the delivery of inputs and marketing of harvest output.

4. Recommendations for the last year of the project

The focus should be on the field trials comparing the CAPS treatment to the plow-based treatments. For whatever reasons, there was highly variable data from several of the maize trials in 2013. The EAP reviewers observed poor stands on several of the maize plots at Thumka and since the plots were small, the yield data were highly variable. It is vital to get some meaningful comparisons the final year of the project, particularly if the investigators plan to seek support for continuing the project into the future. There is no question that additional work is needed in the region, and good agronomic data for the last year of the project would be very important for planning this work. The survey results and the knowledge gained from the field trials, even though they have not been as successful as hoped, can be valuable for planning future strategies. Additional details are needed in the annual report regarding how economic data are obtained and analyzed.

The survey data should be analyzed regarding the implications of women's increased and considerable labor investments in conservation agriculture for (1) the successful adoption of CAPS in tribal areas, (2) women's health and leisure time, and (3) women's reproductive responsibilities (i.e., who takes on these responsibilities when women have to spend more time in the field).

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

Principal Investigator: Dr. Manuel R. Reyes, Professor, North Carolina Agricultural and Technical State University

Research Team:

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Dr. Charles E. Kome, USDA-Natural Resources Service, Greensboro, NC

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Kou Phally, PADAC

Dr. Osei Yeboah, Associate Professor, North Carolina Agricultural and Technical State University

The rural areas of parts of Cambodia and the Philippines are made up of some of the poorest people in the world. Many of the soils are low in fertility, and some are on very sloping terrains, particularly in the Philippines. In an attempt to improve the livelihood of people in these areas, SANREM in 1994 started developing solutions for arresting soil and water degradation in a small farming community in Lantapan in southern Philippines, and in 1996, the World Agroforestry Centre (ICRAF) and the Agencia Española de Cooperación Internacional (AECI) facilitated the establishment of Landcare Foundation Philippines, Inc. In Cambodia in 2004, efforts to develop practices to promote conservation agriculture were begun with funding by the Agence Française de Développement (AFD), a French Development Agency. Findings from these projects and the opportunity to partner with some of the organizations and investigators led to the proposal for the present project in Battambang in northeast Cambodia that was approved in 2009 and began in January 2010.

Two of the four EAP members, Drs. Susana Lastarria-Cornhiel and B.A. Stewart visited some of the Cambodia sites during June 16-19, and Philippine sites June 20-22, 2013. Dr. Manuel Reyes, Principal Investigator, arranged the schedule and also accompanied us during our visit to the sites. The visits allowed the EAP members to observe several of the research sites and farmer fields and to visit with researchers and discuss progress, constraints, and problems. Perhaps even more importantly, there were several opportunities to visit with the farmers. In several cases, the farmers were women, so this allowed the reviewers to investigate gender issues as well as production issues.

1. Project objectives

LTRA-12 project objectives, as listed in the project proposal are essentially the same as listed

in the annual reports, but with some minor changes and with the order of the objectives significantly changed. The listing of the objectives below is as they are listed in the annual reports:

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;
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;
3) Technology 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; and to find out whether a proposed micro-credit approach, and a method to facilitate access for mechanized direct seed drilling and spraying will be successful in promoting adoption of conservation agriculture in Cambodia; and
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.

2. Cambodia and Philippines project progress

Obj 1. This objective deals with gender issues and has been carried out in a timely manner since the beginning. During 2010, baseline surveys were designed and conducted in both countries. In the Philippines, two females and two males and in Cambodia two males were trained as enumerators and surveys were conducted. Of 60 households in the Philippines, 40 percent of respondents were CAPS farmer-cooperators while 60 percent were non-cooperators. Of the farmers, 53 percent were males and 47 percent females; 40 percent were indigenous and 60 percent were migrants from other areas of Cambodia; 68 percent owned their land while 32 percent did not; 64 percent were members of Landcare and 24 percent were members of women-groups.

In Cambodia, preliminary trends suggested that 1) women play an important role in decision making for household management; 2) most of the leaders of the community based organizations are women; and 3) sowing and weeding is often done by women, but spraying crops is never done by women. In the 2011 annual report, it was reported that in Cambodia, due to the recent post-war situation and men's migration, there was a high rate of single women's households in the Battambang area.

Most upland cropping systems in Cambodia on the farms operated by women begin with hired disc plowing, which leads to increased production costs, weed pressure, and the mobilization of children and women in poor households for weeding. Farmers claimed there was generally equity between the role of husband and wife. Men are responsible for plowing, line tracing and harrowing. Women are more likely to implement lighter tasks such as sowing, post-harvest

processing of vegetables, weeding, and off-farm activities.

In the Philippines, the average age of respondents is 50 years old, with an average of 27 years of farming experience. The average farm size was 2.2 hectares, and not surprising, maize farmers reported higher yields for wet years (3439 kg/ha) than for dry seasons (2005 kg/ha). Gendered data collection was planned for 2012. The 2012 annual report did not report many additional findings but indicated that women continued to be a viable force. Researchers found no gender bias between women and men farmers on the knowledge of use of cover crops, but did note differences in knowledge about tillage practices. While women are knowledgeable of soil types and make decisions based on soil quality, men tend to have knowledge of implementation tools for land preparation and favor the availability of tractor or draft animals in making decisions. In general, it was found that women do not normally participate in land preparation and men are completely responsible for draft animals. Women also do not spray herbicides. Female participation is somewhat equal to male participation for planting, often higher for liming and fertilizing, and mostly dominant for post-harvest activities.

The EPA members had an opportunity to visit with both men and women farmers during their visit to Cambodia and the Philippines and their discussions support the findings reported in the annual reports.

Obj 2. Although one of the primary objectives of CAPS is to reduce erosion and enhance soil quality, adoption usually depends on minimizing smallholder risks and maximizing benefits. Therefore, information about economics of the systems is vital. The baseline survey conducted for Objective 1 was also used here. A recordkeeping protocol to quantify farm input activities including labor, seeds, fuel, machinery, fertilizer, and herbicide use; and output activities like yield and market prices were developed. In both Cambodia and the Philippines, some conservation agriculture systems were being evaluated prior to the beginning of this project. The SANREM External Evaluation Panel at the time the project was approved explicitly recommended changes in the Philippine treatments to more closely follow some of the ones in Cambodia. In both countries, treatments were designed and researcher-managed experiments were established and, in addition, farmer-managed trials were initiated in both countries. The early work in Cambodia was done largely by Stéphane Boulakia based on the direct-seeding mulch-based cropping system developed in Brazil. Scientists from the Philippines visited the Cambodia sites prior to developing their treatments.

The 2011 annual report stated that in Cambodia, the CAPS yields and gross profit margins were lower in 2010 than the plow-based systems. The decrease could have been partly caused by late sowing, technical inexperience, variety choice, and incomplete understanding of the proposed technologies. Weed problems and low fertility were also evident. In the Philippines, plow-based maize yields were also higher than for the CAPS. In the 2012 report, it was stated that in Cambodia the CAPS gross profit margin will be higher than for plow based systems by the third year. Therefore, the investigators felt that there is potential for CAPS adoption in Cambodia if subsidies can be provided to augment CAPS low yield in the first two years as soil capital is being restored. In the Philippines (2013 semi-annual report), the researcher-managed CAPS

provided the highest net returns. The highest return was from the maize + cowpea/upland rice + cowpea treatment and the lowest from the conventional monocropped maize treatment. The low return from the maize treatment was less gross revenue and high cost of labor involved in plowing and harrowing the land as well as for weeding. There were problems with some households participating in the farmer-managed experiments since some farmers plowed their CAPS fields and others gave up participation in the study. Replacements were made for some of the farmers that dropped out of the program.

Obj 3. Technology networks are essential for the introduction and eventual adoption of new systems. The adoption of CAPS is often constrained by the lack of equipment, particularly when mechanized systems are involved. The baseline survey described in Objective 1 also was used for implementing activities for this objective. The results provided valuable information that could be used in meetings and field days. Beginning in the first year of the project, field days and meetings were held in both countries to explain to farmers and local government leaders about CAPS and the potential positive impact that they could have on food security and land resources. In the 2011 annual report, it was reported in Cambodia that market accessibility and price are the major causes for cropping systems evolution, but that farming choices were also limited by ecological conditions and socioeconomic situations. As labor costs increase, there is a movement toward mechanized equipment. In the Philippines, it was found that access to different support and services are from agrichemical vendors and agricultural researchers. Training about CAPS was provided mainly to farmers who were members of the Landcare Foundation of the Philippines. The 2012 annual report reported for Cambodia that gross profit margin was less for the CAPS than for the plow-based system in the first and second years of the project but greater in the third year. Moreover, CAPS were being adopted by the farmers. That is a quite remarkable achievement for the project. Results from the Philippines were not as dramatic, but there was interest in CAPS. Farmers ranked vendors of agricultural products next to agricultural researchers as most trusted for obtaining information. Therefore, it is extremely important that researchers work closely with vendors in getting technologies adopted by farmers. Respondents to a survey indicated that farmers believed that inorganic fertilizer is the best way to improve soil quality, and that subsidies for farm inputs is a key incentive in CAPS participation.

Obj. 4. Conservation agriculture is based on not-tilling the soil, keeping the soil surface covered with crop residues or a cover crop, and crop rotations. If these principles are practiced, it is generally perceived that soil quality will be enhanced and soil carbon content will increase. There are many studies in various parts of the world that support this view, but the extent and time required for statistically significant changes to occur vary considerably. In Cambodia, soil samples were obtained from 15 randomly chosen farm households that decided to adopt new CAPS on part of their land. Samples were also taken from 15 farms with plow-based systems. Bulk density measurements were made to provide good baseline information on the impact of CAPS. In the Philippines, soil samples were taken on both researcher and farmer managed sites. A schedule and sampling protocol for monitoring and measuring selected soil and plant

characteristics was finalized. Experimental plots for crop modeling of maize under conservation and traditional plow-based system were also established at the researcher-managed plots. The 2011 annual report for Cambodia reported biomass yields for various treatments, but did not report any information about soil sample analyses. In the Philippines, soil analyses for bulk density, soil organic matter, N and P concentrations and pH obtained during the soil sampling performed in December 2010 and April 2011 did not differ substantially from the July 2010 baseline levels for all CAPS. On the farmer-managed trials in Cambodia, the farmers clearly noticed the resilience of CAPS to dry spell when compared with their traditional plow-based practice.

3. Appraisal of project accomplishments

The review team members that visited the sites were generally pleased and impressed with the project. There was some question about the extent that cover crops were being produced strictly for enhancing soil quality rather than also producing some income. The technologies being used, as indicated above, were based on Brazil studies. However, there are large differences in the amount of available land and the socioeconomic conditions. The review members detected some reluctance on the part of some of the farmers in growing crops strictly for the purpose of providing soil cover. In both Cambodia and the Philippines, there were examples of producing sequential crops of maize without tilling the soil between crops. This provided more income and also appeared to enhance soil quality. In one of the site visits, pigeon pea of 2-m height was being chopped near ground level strictly for enhancing soil quality. Although this is an important part of conservation agriculture, there may be better adoption of CAPS that provide more immediate benefit. This was evident in the Philippines where two of the farmers that had agreed to use CAPS that involved following maize with a cover crop had modified the system to follow maize with another maize crop but using no tillage between the crops. This is one of the benefits of having farmer-managed trials because they will tend to modify them to maximize what they consider the benefits. All in all, however, the panel review members were favorably impressed with the progress of the project, particularly the development and trials of the various CAPS treatments.

The gender surveys provided valuable information and there were many positive results from the technology information activities. In the Philippines, there is evidence of soil organic carbon decline at 0-5 cm depth in the plow-based treatments compared to CAPS (Fig. 14 in Ella 2013) although the time span of the study was too short to make definitive conclusions. It is not clear what the status is of the Cambodia soil samples, and although some differences were noted for the Philippine samples, the length of the study is very limited for obtaining definitive differences in most soil characteristics.

4. Recommendations for the last year of the project

The main focus should be on getting another year of data comparing the CAPS to the plow-based system. The third year of CAPS in Cambodia showed increased yields, and it is very important to see if this holds true for the fourth year as well. It is also critical that good

information is gathered regarding labor saving. The adoption of CAPS is most likely to depend on crop yields and labor saving changes. Even though farmers may see benefits to soil quality, their adoption of CAPS will not be based on this factor. In the event that work with CAPS in Cambodia continues beyond the end of the present project, it is highly recommended that replicated treatments be included in the researcher managed trials. However, this is not to say that the present demonstration plots have not been effective in stimulating great interest and potential in CAPS.

III. Cross-Cutting Research Areas

Phase IV of the SANREM program, in addition to the seven LTRAs, also implemented research in four cross-cutting areas: economics, gender, technology, and soils.

A. CCRA-6, Economic and Impact Analysis

Principal Investigators:

Dr. Michael Bertelsen, Director of the Office of International Research, Education, and Development (OIRED), Virginia Polytechnic

Dr. George Norton, Professor, Department of Agricultural and Applied Economics, Virginia Polytechnic

The goal of the Economic Analysis and Impact CCRA is to evaluate the effects of introduced CAPS with respect to farm and regional income as well as to identify the optimal mix of conservation agriculture technologies for farmers in the SANREM study areas in economic terms. The activities rely on collaboration between faculty and students at Virginia Tech and researchers in the individual LTRAs, since funding for this CCRA is too small to allow much independent analysis. Even so, the Economic Impact CCRA has carried out some innovative and interesting work in addition to the more routine crop budget assessments of the various CAPS. As with other CCRAs, no formal proposal was submitted, so that this review follows the stated objectives that were initially provided in the 2010 Annual Report.

1. CCRA-6 objectives

The objectives for this CCRA are set out in the first Annual Report (2010), and consist of the following:

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

2) Identify optimal CAPS and the sequencing of CAPS elements for each cropping system being researched.

3) Identify broader economic and social impacts of wide-scale CAPS adoption.

4) Identify any policy changes required to enhance CAPS adoption in each cropping system.

2. Progress of Economics CCRA

Obj 1. Quite sensibly, initial activities under this objective consisted of consulting with LTRA project personnel to develop a consistent data gathering approach for impact analyses. The main approach adopted for analysis is partial crop budget analysis with an additional focus on assessing constraints to CAPS adoption within the representative cropping systems. As a result of the more advanced stage of field work in Ecuador (due to earlier progress under SANREM's precursor phase), this was the first project for which crop budget information was collected and has continued to be the project with arguably the largest collaboration with this CCRA. For example, crop production and cost information was collected from 100 Ecuadorian farmers who were surveyed in 2010-11. Further data collection occurred later in other LTRA countries due to the delay in getting field sites up and running sufficiently to be able to generate any useful data. To aid with ensuring consistency in data collection a crop budget template was developed and circulated to the LTRAs.

Obj 2. The main thrust of the research under this objective has been the development of linear programming (optimization) models to determine which CAPS are preferred on economic grounds. This modelling involves setting up an objective function (profitability) that is subject to a large number of constraints, parameterizing the model and then running it under various sets of assumptions to determine what activities contribute to maximizing the objective. Work commenced in Ecuador (see Obj 1.) as an M.S. thesis and has resulted in a published paper that shows several CAPS can be part of an optimal farm plan. The researchers have been working with LTRA-11 to set up a linear programming model using the model developed in Ecuador as a template and also with LTRA-8 in Ghana.

Obj 3. In this objective, economic surplus analysis is used to assess the contribution of CAPS adoption to regional economic welfare. In undertaking such analysis a large amount of data must be collected, including: input cost and yield data from the regional projects, supply and demand elasticity estimates, price and quantity data and research costs. In addition, since the projects interventions are still too new to provide firm estimates of ultimate adoption rates, assumptions must be made about long term adoption (e.g., the analysts projected benefits for 1 percent, 3 percent, and 5 percent adoption rates). Economic surplus analysis has been completed for three countries (Lesotho, Ecuador and Nepal) and demonstrates that for some – but not all – CAPS can produce net benefits at the regional level.

Obj 4. No progress to date.

3. Appraisal of Economics CCRA accomplishments

Obj 1. One concern that can emerge from cross-cutting activities involving economics that are intended to support general science research is that they become subordinated and economists carry out only routine cost-benefit calculations to determine if the more substantial science research is profitable. As a result, little innovative and original research work on the economics side is done. The main thrust of this objective was this more routine cost-benefit type assessment of the proposed CAPS which, notwithstanding the above comment, must still be

carried out. Overall, this objective seems to have been done in a logical way, recognizing the initial delays in getting started (other than in Ecuador) while individual LTRAs were setting up. Results have been presented in several of the Annual Reports.

Obj 2. In contrast with the previous objective, there is evidence of more innovative and substantive economic analysis being undertaken by the CCRA team under this objective. The interesting farm-level optimization research carried out in Ecuador, which makes use of a linear programming model and has been published in *Experimental Agriculture*, demonstrates the use of more advanced methods; here, the use of simulation and optimization to derive potentially optimal farm plans is a cut above the more passive and limited partial budget approach. This work is commendable, as are efforts to integrate risk assessments into the research, possibly using advanced game theory methods.

Obj 3. Efforts on this objective appear to be picking up as the project proceeds, with several sets of analyses now completed. The approach taken is appropriate and the analyses should give a broader regional sense of the impact that conservation agriculture could have, depending upon the ultimate rates at which CAPS are adopted. Since the CAPS interventions are still recently introduced, the expectations for long-term adoption are quite important to these regional analyses. The Economic Impact CCRA researchers have been working closely with economists involved at the LTRA level to study adoption. The use of innovative methods, such as choice experiments in Ecuador and Uganda, are commendable. Again, the Economic Impact CCRA is using advanced research methods (see Obj 2.) to undertake interesting and rigorous economic research related to conservation agriculture.

Obj 4. This objective has not exhibited any progress to date but logically would be carried out later in the project as results under the other objectives accumulate. An initial plan to examine a "payments for ecosystem services" (PES) scheme associated with carbon sequestered by the various CAPS, has been dropped. This modification makes sense, given the ambitious nature of such a proposal and the challenges in establishing the necessary institutional framework.

4. Recommendations for the last year of the Economics CCRA

Cross-cutting economic analysis components in larger research programs/networks need to be integrated into the research plan right from the RFP stage and adequately funded to ensure innovative work can be done. Otherwise, these components can turn out to be the equivalent of consulting reports that carry out simplified profit/loss analyses and not much more. Funding needs to be sufficient to allow extensive use of graduate students – this CCRA has supervised four graduate students to date and one more is anticipated – as this leads to cutting edge research and high quality publications. Overall, this CCRA seems to be progressing appropriately, especially considering the modest budget, and to be using suitable methodologies that extend beyond the routine application of partial budget analysis. Annual funding for CCRA-6 has been about $100,000 per year, although a portion was initially used to cost-share a position in the ME. Later, the total funds were allocated to research activities and graduate student support under the Economics CCRA.

In the coming year, it will be logical to complete ongoing work with the linear programming (optimization) models in Ghana and Nepal and the regional economic surplus analyses already completed in a few countries, but not all. Initial exploration into methods to analyse risk more rigorously (e.g., game theory models) should be supported as this element has been demonstrated in some of the LTRA research to be critical to understanding on-farm responses to the CAPS (e.g. Ecuador). Finally, a decision will need to be made about whether/how to address Obj 4, since no progress has been made to date. Even limited analysis of policy could be useful. It makes sense to have dropped the PES exercise and perhaps to concentrate more on collaborating with the various LTRA teams in the study of adoption of CAPS. Longer term monitoring and analysis of adoption could logically be nested in this CCRA team.

B. CCRA-7, Gendered Perspectives for Conservation Agriculture: Local Soil Knowledge and Crop-Livestock Interaction

Principal Investigator:

Maria Elisa Christie, SANREM Management Entity, Virginia Tech

This SANREM cross-cutting theme has focused most of its work on three project sites, Bolivia, Cambodia, and the Philippines, collaborating closely with CCRA 9, Soil Carbon and Soil Quality. In addition, the CCRA-7 team has collaborated with all the LTRAs in organizing a wide series of activities to increase gender research and the integration of gender into project design and activities such as gender training, gender sensitization, rapid assessments, and qualitative research methods.

1. CCRA-7 objectives

This cross-cutting theme has three objectives, as listed in the SANREM 2010 Annual Report (pp. 121-124) and in *Gendered Knowledge CCRA* (Christie, 2010):

1) To identify gendered agricultural practices and participation that shape local knowledge.

2) Demonstrate how gendered beliefs, knowledge, and perceptions provide constraints and opportunities for CAPS.

3) Propose recommendations that build on gendered findings for CAPS.

These objectives have been modified since 2010.

2. Progress of Gender CCRA objectives

Obj 1. The gender CCRA has utilized qualitative research methods to identify gendered knowledge and practices, particularly those related to soil (quality, fertility, use, erosion, etc.) in Bolivia and the Philippines. Qualitative methods have included: community-level focus group discussions and activities to map community soils; household visits to carry out the same activities at the farm level; transect walks and participatory mapping; participant observation of farming practices. Farmers, disaggregated by gender, identify and describe different soil types, including their "best" and "worst" soils. Samples were then collected from those soils and

analyzed in collaboration with the Soils CCRA. Farmers' soil descriptions are to be compared with lab results and examined for gender differences. In addition, focus group discussions, with men and women separately, were used between 2009 and 2011 to gather gender disaggregated data in Mali, Ghana, Uganda, and Kenya by asking respondents to describe photos and soil samples.

Gender research in Bolivia and the Philippines and in other LTRA sites confirmed that women and men undertake different agricultural and animal husbandry tasks, that women have less access to land and other resources, and that they have fewer training opportunities than men.

Obj 2. Gendered access to resources and agricultural and animal husbandry practices may result in gendered opportunities and constraints to adoption of CA practices. For example, in Bolivia and the Philippines, men have access to plow animals and tools and women do not customarily do plowing. Because men engage in plowing for additional income, this practice could act as a constraint for minimum tillage adoption. Also, in Cambodia, where farmers contract disc plowing which lead to greater weed growth, this adoption can place additional burdens upon women who are customarily responsible for weeding (Harman et al., 2012). In several of the sites visited by the EAP, farmers mentioned that no- or minimum-tilling resulted in increasing weeding, a task usually done by women.

Obj 3. While this objective must obviously await the results of objectives 1 and 2, one important recommendation that has already been put forward is to include more women in project activities, particularly in meetings and training, and to find ways to encourage women to participate in these activities.

3. Appraisal of Gender CCRA accomplishments

The qualitative research on gendered knowledge regarding soils revealed that both women and men have extensive knowledge of soil quality, fertility, and other aspects; that women use less technical terms to describe soils than men (perhaps a result of lower educational levels for women?); and that women's knowledge of soils was more related to use (field vs. horticultural crops, crops vs. animal grazing) than specific agricultural practices. The results regarding soil knowledge seem to be closely related to access to land and other resources. In other words, one's access to land would appear to color one's perception of soil use. While these results are potentially very useful for successful CAPS adoption, they will need to be translated into recommendations and included in project design.

In addition to this CCRA's qualitative research, the CCRA-7 team also assisted the LTRAs in the design of their gender-differentiated baseline and follow-up surveys. The most common use of this gender-differentiated data by the LTRAs has been to include descriptive statistics with a gender breakdown in their reports. The collection of gender-disaggregated survey data is one of the most important gender accomplishments of the SANREM program, providing gender-disaggregated data regarding, for example, access to resources and labor allocation. Some of the projects (e.g., Ecuador, Nepal, and Cambodia) have used the gender-differentiated data to describe their site population. Actual gendered analysis of CAPS (e.g., impact on labor

participation) was not attempted with the exception of India. Nor is it apparent that there are plans to determine gendered outcomes or impacts (e.g., labor participation, benefits, decision-making, and access to resources) of the project in the sites where follow-up surveys have been or will be undertaken.

4. Recommendations for the last year of Gender CCRA

In the final year of the program, the gender CCRA may want to consider consolidating and analyzing the research results from different sites on gendered knowledge of soil use and quality in order to present some working hypotheses for future CAPS programs. These programs could regard (1) those factors that influence gender differentiated soil knowledge and
(2) the impacts of gender differentiated knowledge and practices on CAPS.

The other recommendation relates to the gender-differentiated survey data collected by each LTRA. While this may not be the purview of the gender CCRA, the SANREM program may want to consider encouraging some initial analysis of the survey data, perhaps by providing research assistance to organize the datasets and carry out come basic descriptive results (not all LTRA sites have explored the descriptive utility of their gender-differentiated datasets). The perception by the EAP team is that the LTRAs, with the very few exceptions, collected the gender-differentiated data but then dropped the issue of gendered agricultural systems, failing to carry out the needed analysis and incorporating the results in project activities where possible (taking into consideration the short five-year time period).

C. CCRA-8, Technology Networks

Principle Investigator:

Dr. Keith Moore, SANREM Management Entity, Virginia Tech

The goal of this CCRA is to identify priority knowledge transmission points, network connections, and knowledge leaders leading to widespread and sustainable innovation and adoption of CAPS technologies. The transfer of technology and subsequent adoption by farmers is the ultimate goal of all of the LTRAs. This CCRA will try to determine how research findings enter knowledge networks and the flow of information within networks. This work is being done in collaboration with the LTRAs and other CCRAs. The theoretical foundation for this research was presented in the SANREM CRSP Working Paper (01-10), ”Research Framework for Technology Network and Gendered Knowledge Analyses” by Sarah Swenson and Keith H. Moore. This paper organizes and synthesizes the range of global experiences with the establishment of CAPS.

1. CCRA-8 objectives

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

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

3). Determining critical network pathways and opinion leaders facilitating technological change

among farmers and their service sector partners.

2. Technology Networks CCRA progress

Obj 1. The working paper provided a foundation for the development of a methodology to collect information needed for Objective 1 from the baseline surveys at the LTRA locations. This led to the development of a Likert-scale questionnaire for characterizing the three farmer perspectives of conventional, risk-adverse, and conservation. Focus groups for answering this questionnaire were held in Mali, Ghana, and Kenya in 2010. In 2011 the questionnaire was completed in Haiti, Lesotho, and the Philippines. Information from the questionnaire in the baseline survey from all LTRAs and Focus group meetings was used to identify knowledge and attitudes concerning agricultural production practices in the research sites of the LTRAs.

Obj 2. The working paper outlined a methodology for obtaining information from Focus groups about potential persons and institutions involved in social networks for exchanging information about agriculture technologies. Focus groups to address this objective were held in Mali, Ghana, and Kenya in 2010 and Haiti, Lesotho, and the Philippines added in 2011. Analysis of this data permitted the investigators to quantify and describe structure and resource flows of agricultural sector networks.

Obj 3. Work on this objective did not begin until the data had been collected for objectives 1 and 2.

3. Appraisal of Technology Networks CCRA accomplishments

Obj 1. In 2012 the information analyzed from LTRA 10 in Uganda and Kenya revealed that agro-ecological zones played a key role in shaping the knowledge and perspectives of farmers. Also, non-farm agents were not active in adapting new scientific knowledge to local conditions. For CAPs to be adopted, these non-farm agents need to more carefully listen to concerns and priorities of farmers in each agro-ecological zone. In addition, factor analysis has been used to understand differences in knowledge bases and at a gender level. While factor analysis can be useful, it might be appropriate to combine this with cluster analysis to see if natural groupings of respondents emerge with similar knowledge and attitudes towards the adoption of CAPS.

Obj 2. Analysis of the Kenya and Uganda data revealed differences among sites for number of network contact points and sources of information. Farmers in Tororo had significantly fewer contact points than the higher potential areas of Kapchorwa and Kitale. Farmers in Kitale had more sources of information and the Extension service played a greater role in providing information than at other sites. The work has been extended to include the identification of key actors and contacts in the dissemination of information within relevant knowledge networks. Ultimately, these agents will play an important role in fostering technology information flows under objective 3.

Obj 3. Analysis of findings from Kenya and Uganda provided information on network pathways and identification of key opinion leaders facilitating change in these two areas. Feedback sessions were held in Uganda and Kenya in 2012. Information was exchanged

concerning: 1) most cited farmer contacts, 2) network map, 3) graphs of distribution of beliefs between small farmers, large farmers and service providers, and 4) finally the network maps were used to discuss beliefs about key issues in conservation agriculture such as use of tillage and ground cover. A key output from this objective is the production of various network maps that visually display the relationships studied in objective 2 with the intent of providing insight on the knowledge network pathways that should be exploited when promoting CAPS technologies. This methodology uses highly advanced software and the CCRA appears to be using it appropriately. Demonstrations and test runs to display the methodology and software`s capability for promoting CAPS will be helpful in convincing non-experts of its usefulness.

4. Recommendations for the last year of the Technology Networks CCRA

The CCRA team on Technology Networks has made good progress to date in fulfilling their three major objectives, especially on the information from LTRA 10. During the remaining time of the project, the data obtained from the other LTRAs still needs to be analyzed. Based on the analysis of all LTRAs, useful information can be provided on the use of technology networks to promote the adoption of CAPS.

D. CCRA 9, Soil Carbon and Soil Quality

Principal Investigator:

Dr. Michael Mulvaney (replaced by Dr. Tom Thompson in April 2013)

The overall goal of this CCRA is to determine if dryland smallholders in the developing world can increase soil organic C, and hence soil fertility, by adopting Conservation Agriculture. The investigators hypothesized that CAPS in developing countries will increase SOC and soil fertility in less than five years after implementation, compared to conventional practices. It was proposed to use SOC as an indicator of soil quality and fertility, but basic soil fertility parameters such as total N, available P, K, Ca, Mg, pH, cation-exchange capacity (CEC) and other soil characteristics would also be measured. The idea was to coordinate the soil and agronomic investigations among all 13 developing countries involved in the LTRAs by having soil data before and after implementation of Conservation Agriculture Production Systems (CAPS). The 2010 Annual Report listed two objectives, but three goals were listed in 2011 Annual Report.

1. CCRA 9 Objectives

The specific objectives of the soil CCRA are:

Obj. 1: Quantify Soil Organic Carbon (SOC) in host country project sites before and after CAPS implementation;

Obj. 2: Identify CAPS cropping systems or biophysical elements that improve soil fertility; and

Obj. 3: Relate increased soil fertility to site-specific socioeconomic environments.

2. Soil Quality CCRA Progress

Obj 1. The 2010 Annual Report outlined some of the challenges. The apparent plan was to import the soil samples from the various country studies and have them analyzed at a private soil testing laboratory in Virginia. Discussions were held with the SANREM Technical Committee to develop a streamlined minimum dataset. The minimum dataset was to be further discussed with the SANREM Management Entity. The report stated that an increase of 0.4 percent soil carbon could be expected after 4 years, but that this might be too small to detect given normal variation in soil C across fields and landscapes. Therefore, consideration was being given to sampling at shallow depths to increase the likelihood of determining differences. In the 2011 Annual Report, it was stated that a USDA permit to import foreign soils, and 226 samples from Bolivia, Ecuador, Philippines, and Cambodia had been received and were currently undergoing analysis for SOC and fertility determinations. In the 2012 Annual Report, it was documented that additional Time 0 soil samples had arrived from Haiti and Lesotho and would be analyzed the coming year. The report also stated "While we anticipate receiving Time 0 soil samples from all the project sites, it is possible that LTRAs or their project partners will not be able to send us soil samples from their project sites and/or may collect the samples in an inappropriate manner. Depending on availability of funds, the project investigator may travel to the project sites to collect the samples in an appropriate manner. In the event that in the end the dataset is unbalanced, the data will be analyzed using appropriate non-parametric statistical methodology." Table 2 lists the samples received from various countries and results for the samples that have been analyzed. Samples from Kenya and Uganda were destroyed at the U.S. Customs, and for various reasons all the planned samples were not obtained from several of the countries. Still, it may still be possible to make some pre- to post-treatment comparisons for some of the countries. A poster with information for soils in Ecuador and Bolivia was presented at the 2012 International Meetings jointly held by the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America.

Table 2. CCRA-9 samples received in U.S. for analysis as of 4 October 2013

		Analyses completed				
Country	**Samples received**	**Soil testing**	**C and N**	**Density fractionation**	**NEXAFS***	**Bulk Density**
Bolivia	54	54	36	24	20	18
Ecuador	12	12	12	12	12	12
Philippines	32	30	7	7	3	0
Cambodia	76	76	0	0	0	76
Kenya	4	4	0	0	0	0
Uganda	8	8	0	0	0	0
Lesotho	28	28	28	0	0	3

Bolivia Gender	30	30	30	NA	NA	0
Philippines Gender	52	52	52	NA	NA	0

* Near Edge X-ray Absorption Fine Structure

Carbon dioxide flux measurements are being taken with ACE equipment at the LTRA-10 site in Kitale, Kenya. This research is intended to provide an indirect measure of the carbon balance with different tillage systems. The results will be compared to results from chamber studies at the University of Wyoming as part of a Ph.D. study conducted by Judith Odyambo so there will be training benefits as well as research.

Obj 2. This objective necessitates the implementation of researcher-recommended CAPS trials at project locations. During 2010, conservation agriculture plots had not yet been developed for some of the countries while other countries had trials underway that had been established several years previously. In the 2011 report, plans were presented to 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. In some LTRAs, on-farm trials have been implemented before researcher-managed trials and data and information will also be collected for these trials. However, the investigators stated that the focus would be on the researcher-managed trials. No information is given in the 2011 annual report regarding specific data that were gathered. However, one of the challenges listed was that this objective requires the completion of Objective 1 and based on the accomplishments reported so far for Objective 1, it is not likely to be completed within the length of the present project. The 2012 Annual Report did not report any significant accomplishments for this objective. It stated that most projects have identified parameters that will be included in "best-bet" CAPS trials or already have full CAPS treatments in place, and that data have been collected on cropping systems used in project areas for which Time 0 soil samples have been received. It was reported that these data will be geospatially cross-referenced to determine agro-ecological suitability of CAPS elements that may successfully be considered to other parts of the world. There was, however, no specific plan or timetable mentioned.

Obj 3. This objective was first mentioned in the 2011 Annual Report and the goal was to relate increased soil fertility to site-specific socioeconomic environments. They reported that soil sampling teams in Bolivia were collecting data to quantify gendered knowledge of soil fertility. Also, soil survey activities have been initiated in Haiti to determine if soil fertility impacts household economic efficiency. A second goal for the Haiti work was to create a high resolution (>1 km^2) soil fertility map of 100 km^2 within the project area of operations. The 2012 Annual Report made no mention of the Haiti work but did report that a complete dataset had been obtained in Bolivia for determining gendered knowledge of soil fertility, but no specific information was stated. The report also mentioned that there were currently teams in the Philippines to quantify gendered knowledge of soil fertility.

3. Appraisal of Soil Quality CCRA Accomplishments

Obj 1. The goal of this objective was clear: Quantify the SOC in host country project sites before and after CAPS implementation, but the methodologies and challenges to accomplish the objective were everything but clear. The principal investigator was aware of many of the problems, but continued to implement the project without fully addressing them. In the 2010 Annual Report, it was stated "Due to the intrinsically slow nature of soil morphology and pedogenesis, five years may not be long enough to determine which CAPS elements improved soil quality. For example, conservation tillage, which is used as an experimental treatment in all of the LTRAs, is known to sequester C at a rate of approximately 0.1 percent per year after conversion from conventional tillage practices. After four years, an increase in soil C in surface horizons to about 0.4 percent can be expected, which may be too small of a change to detect in these experiments, given normal variation in soil C across fields and landscapes." It is difficult to fully appraise the progress because no data were ever presented. There were a substantial number of samples collected and sent to the U.S. for analysis, but none of the data were ever presented, or even statements about the findings. The investigators in some of the host countries also took soil samples and analyzed them in their own countries. There was never any discussion about how these two different sets of data would be compared or coordinated. While it is critically important to know the impact that CAPS have on SOC, using one experiment that involves taking samples by multiple people in 13 different countries containing different cropping systems to look for significant changes in SOC after only 3 or 4 years of conservation agriculture practices is indeed challenging.

Obj 2. This objective is to identify CAPS or biophysical elements that improve soil fertility. In actuality, however, the LTRAs for the various countries usually only implemented "best-bet"

CAPS to compare with the commonly used tillage-based system. As the investigators pointed out in the annual reports, the success of this objective depended on the completion of objective 1. Therefore, Objectives 1 and 2 were closely intertwined except that Objective 1 was specifically limited to SOC while Objective 2 looked at the broader issue of soil fertility.

Obj 3. The goal of this objective was to look at the impact of soil fertility on gender and socioeconomic issues. However, there were specific plans presented to meet this objective. The investigators apparently plan to rely on information gathered by the investigators of the various LTRAs and then glean gender and economic data from those projects to identify and analyze common threads relating to soil fertility. The investigators did make some inputs to the survey used in the Philippines.

4. Recommendations for the Last Year of the Soil Quality CCRA

Based on information reported in the 2010, 2011, and 2012 Annual Reports, the objectives of this project cannot be fully met. However, it is clearly documented that a significantly large number of soil samples at Time 0 for LTRA projects in several of the 13 countries were obtained, shipped to the U.S., and analyzed for SOC and other soil fertility characteristics. These

data should be carefully evaluated to identify the locations where the data appear to truly represent the conditions based on standard error of analysis and other validation means. Once those locations are identified, the principal investigator should work with the LTRA investigators in those countries to see if soil samples can be obtained at the end of the final year of the project. It is clear that the project cannot be completed as originally planned, which would have had starting and ending samples for all 13 countries. Therefore, the last year should focus on a few locations. However, it is important that a "Final Report" be prepared which compiles all of the soil analysis data for all samples shipped to the U.S. and analyzed in the private laboratory used for the project. The final report should also document the results of all studies conducted. We understand, for example, that CCRA-9 is working with Virginia Tech to construct a map identifying regions of the world that have similar agro-climatological parameters where SANREM currently works. The expected outcome is a map identifying regions of the world that have similar agro-ecological conditions, and thus where CAPS should be adaptable. Therefore, the investigators should focus their efforts for the final year on summarizing the most meaningful data and discussing some of the challenges they faced so that future studies can be planned in a more efficient manner.

IV. Overall Appraisal of SANREM IV Program

A. Importance and Timeliness of the SANREM Innovation Lab

Between 1961 and 1974, world population grew from 3.1 billion to 4.0 billion, a 29 percent increase, but cereal production increased from 876 Mt to 1327 Mt, an increase of 51 percent. This led Henry Kissinger, U.S. Secretary of State, to state in his 1974 address to the first World Food Summit in Rome that "no child will go to bed hungry within ten years." In 2000, when millions of children woke up hungry, the United Nations Millennium project set a goal to reduce the number of hungry people from 840 million to 240 million. In 2012, nearly one billion people still suffered from hunger and malnourishment. There is much work to do.

The world population is 7.2 billion people, and FAO (2009) estimated that there would be 9.1 billion in 2050. Because of increasing prosperity resulting in diet changes, particularly increased meat consumption, 70 percent more food would need to be produced. Furthermore, about 97 percent of the increased population will be in developing countries. There are more than 500 million smallholder farms, generally less than 2 ha, in the world and more than 80 percent of the food in Asia and sub-Saharan Africa is produced on smallholder farms (Nwanze, 2011). In Latin America, peasant production units numbered about 16 million in the late 1980s, occupying close to 60.5 million hectares, or 34.5 percent of the total cultivated land; the peasant population includes 75 million people, representing almost two-thirds of Latin America's total rural population. The average farm size of these units is only about 1.8 hectares; however, the contribution of peasant agriculture to the general food supply in the region is significant. In the 1980s, it reached approximately 41 percent of the agricultural output for domestic consumption, and mainly is responsible for producing, at the regional level, 51 percent of the maize, 77 percent of the beans, and

61 percent of the potatoes. In Brazil alone, there are about 4.8 million traditional family farmers (about 85 percent of the total number of farmers) that occupy 30 percent of the agricultural land of the country. Such family farms control about 33 percent of the area sown to maize, 61 percent of that under beans, and 64 percent of that planted to cassava, thus producing 84 percent of the total cassava and 67 percent of all beans. In Ecuador, the peasant sector occupies more than 50 percent of the area devoted to food crops such as maize, beans, barley and okra (Altieri and Koohafkan, 2008).

More than 75 percent of the world's food is generated from just 12 plants and 5 animal species (Altieri and Koohafkan, 2008). Altieri and Koohafkan (2008) also stated that women comprise an average of 43 percent of the agricultural labor force of developing countries and almost 50 percent in Eastern and Southeastern Asia and sub-Saharan Africa. They suggested that if women farmers had the same access to productive resources as men, they could increase yields on their farms by 20 to 30 percent which would lift 100 to 150 million people out of hunger.

Ironically, many of the World's malnourished people are farmers. FAO (2013) reported that 75 percent of all hungry people live in rural areas, mainly in the villages of Asia and Africa. Overwhelmingly dependent on agriculture for their food, these populations have no alternative source of income or employment. As a result, they are vulnerable to crises. Many migrate to cities in their search for employment, swelling the ever-expanding populations of shanty towns in developing countries. FAO (2013) calculates that around half of the world's hungry people are from smallholder farming communities, surviving off marginal lands prone to natural disasters like drought or flood. Another 20 percent belong to landless families dependent on farming and about 10 percent live in communities whose livelihoods depend on herding, fishing or forest resources.

Phase IV of Feed the Future Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management initiated in 2010 and being reviewed by the EAP could not have been more timely or on a more important issue. Projects were initiated in 13 countries: Bolivia, Cambodia, Ecuador, Ghana, Haiti, India, Kenya, Lesotho, Mali, Mozambique, Nepal, Philippines and Uganda. Eight of the countries—Cambodia, Ghana, Haiti, Kenya, Mali, Mozambique, Nepal, Uganda—are among the 20 countries designated by USAID as Feed the Future countries. The Phase IV activities were selected to develop and demonstrate locally sustainable CAPS for smallholder rain-fed crop production systems that improve food security and the productive capacity and ecosystem services of degraded and productive agricultural lands. Seven LTRAs and four CCRAs were identified and implemented with the expectation that they would utilize existing knowledge on conservation agriculture and generate new knowledge that could have short-term positive effects on soil quality and food security of rain-fed subsistence farmers.

B. Establishment, Benefits and Constraints of CAPS

The seven LTRAs were implemented in thirteen countries that differed greatly in terms of climate, soils, cultures, and social and economic conditions. The central focus for all the LTRAs was to develop and demonstrate CAPS. CAPS vary greatly but all are supposed to embrace

conservation agriculture that is characterized by three linked principles: 1) continuous minimum mechanical soil disturbance; 2) permanent organic soil cover; and 3) diversification of crop species grown in sequences and/or associations (FAO, 2012). In reality, it is not always feasible to implement all three principles in some situation because of physical, biological, economic or cultural conditions. This was certainly the case in the LTRAs being reviewed, but this should not be considered a failure.

There are a number of constraints for implementing CAPS that encompass all three principles. Minimum disturbance of the soil is generally considered the easiest step to implement, but this can require increased labor for weed control or use of herbicides. The lack of tillage to soften the seedbed also makes seeding more difficult in many cases particularly when seeding is done by hand using dibble sticks or hoes. In addition, low soil fertility is a major limitation in many cases and lack of tillage often reduces mineralization of nutrients from soil organic matter. Reduced crop yields are often found for the first few years following implementation of CAPS. Maintaining a permanent organic soil cover is a tremendous challenge in many areas. The lack of sufficient precipitation makes this almost impossible to achieve in semi-arid regions, and the high demand for crop residues for feeding livestock or for use as cooking fuel or heating often results in little crop residues being left on the soil surface. Cover crops are often included in CAPS, but these are also very challenging in some regions because of lack of adequate precipitation or the reluctance of farmers to grow a crop solely for the purpose of improving soil quality without immediate benefit compared to an immediate benefit from harvesting the cover crop.

CAPS were initiated successfully in all of the LTRAs, although the degree of success varied, which was not surprising. For example, LTRA-7 in the Andes and LTRA-12 in Cambodia were partially based on work in Phase III, so there was some experience and results to build on. There was no previous work with CAPS in other locations, such as the hilly lands of Nepal that are part of LTRA-11. Also, the soil and climatic resources were much more limiting for some of the LTRAs. The hilly areas of Nepal where CAPS were initiated were extremely low in fertility and the culture was to utilize the crop residues for animal feed. Therefore, there was little or no organic soil cover visible. In contrast, cover crops two meters in height were being grown in Cambodia and shredded strictly for improving soil quality. In the eastern Uganda sites, the soils are sandy and low in fertility and this led to highly variable trials in some cases. High variability, particularly with trials on farmer fields, was a common problem in several of the visited sites of most of the LTRAs that made it difficult to show statistical differences between treatments. This was not surprising, and does not mean that the trials were not managed adequately. In many cases, the limitations because of small fields on highly sloping terrains and highly variable soils made it extremely difficult to have uniform plots. The most important reason for trials on farmer fields is to make them available for other farmers to see and share information. In the end, farmers adopt practices that they see on neighbor fields that appear to be performing better than they are using. The review panel members were very pleased with the number of field days held by the various LTRAs and large numbers of both men and women farmers. This is the key to CAPS being adopted by smallholder farmers even though it may take

longer than desirable.

The three principles of Conservation Agriculture are well established and the importance if each is well understood. It is also commonly accepted that maximum benefits from CAPS can only be achieved when all three principles are interacting simultaneously. At the same time, it should be recognized that because of physical, biological, economic, or social reasons, it is not always feasible to implement CAPS that fully address all three principles. Again, this does not mean there was poor planning or poor management and it is not reason for not establishing or abandoning CAPS.

Moving from a conventional tillage system to a conservation agriculture system is not changing a practice; it is changing a culture and generally a lot of time is required. Faulkner (1945) questioned the need for tillage many years ago and as early as the 1960s, scientists in the U.S. began experimenting with herbicides to reduce tillage. However, it was not until the Arab oil embargo in 1973 resulted in large increases in energy prices that widespread interest in shifting from tillage to conservation tillage and no-till developed in the U.S. Many research studies, farmer trials, and industry promotions began to show benefits for controlling wind and water erosion, water conservation, and enhanced soil quality. However, yields were sometimes increased and sometimes decreased, and the effectiveness of the herbicides was not always assured. Also, in many cases the equipment that farmers had was not adequate for dealing with the surface residues and the changes in soil temperature. Therefore, even four decades later, conservation agriculture is practiced on only 16.5 percent of the total cropland in the U.S., even though with 26.5 Mha, the U.S. has the largest area of conservation agriculture (Friedrich et al., 2012). Argentina has 25.6 Mha, and Brazil has 25.5 Mha, which make up 67 and 36 percent of the total cropland, respectively. However, Brazil and Argentina have added large amounts of cropland in recent years and much of this land was developed using conservation agriculture practices so there was not a need for a culture change. From 1975 to 2011, U.S. cropland area decreased 15 percent compared to an increase of 46 percent for Argentina and 71 percent for Brazil.

Worldwide, conservation agriculture has increased steadily from 2.8 Mha in 1974 to 45 Mha in 1999, to 72 Mha in 2003, and to 125 Mha in 2011 (Friedrich, 2012). However, this accounts for only about 9 percent of the total cropland area of 1396 Mha (FAOSTAT, 2013). More importantly, the percentage of cropland in conservation agriculture continues to increase in every continent of the world. Friedrich et al. (2012) summarized the main reasons for adoption of CA as follows: (1) better farm economy (reduction of costs in machinery and fuel and time-saving in the operations that permit the development of other agricultural and non-agricultural complementary activities); (2) flexible technical possibilities for sowing, fertilizer application and weed control (allows for more timely operations); (3) yield increases and greater yield stability (as long term effect); (4) soil protection against water and wind erosion; (5) greater nutrient-efficiency; and (6) better water economy in dryland areas. Also, no-till and cover crops are used between rows of perennial crops such as olives, nuts and grapes.

The LTRAs carried out by SANREM Phase IV have introduced CAPS into some areas for the first time, and even though the results have not always been as uniform and statistically significant as desired, the record is clear that men and women farmers in several countries have been introduced to the potential benefits that can result from adoption of these practices. Based on what has happened in other countries and regions, adoption of these practices will take place over time.

A major emphasis of SANREM Phase IV at the beginning was to evaluate the effect of CAPS in the various countries on improving soil quality. In retrospect, this may have been a somewhat optimistic objective because of the difficulties in obtaining truly representative samples and the fact that measurable changes in soil quality indices often require more than 3 to 5 years to detect. The logistics and budget constraints of getting samples collected and shipped to the U.S. for testing were also underestimated. However, as part of the CCRA-9 project, some samples were obtained from most of the countries and some analyses have been completed, but little or no analysis of the data has been completed or conclusions drawn. Some of the LTRAs also sampled soils prior to initiating CAPS and have taken samples periodically. In particular, LTRA-7 in Ecuador and LTRA-12 in the Philippines have obtained data that indicates enhanced soil quality after only short periods of time following initiation of CAPS.

C. Gender, Social Issues, and Economic Results

With very few exceptions, CRSP programs have tended to focus on strictly agronomic/livestock and technical problems and solutions to improving agricultural production in developing countries; more recently, environmental problems have been included as CRSP issues. Socio-economic factors, particularly gender and class/status, of the human producers were mostly ignored. Beginning about two decades ago, CRSP programs have focused more strongly on smallholder farm production, overwhelmingly benefitting resource-poor and low-income farmers. More recently, CRSP programs are also addressing gender differentiation in program design and implementation as they realize that (1) women are the majority of smallholder farmers in most of Asia, the Caribbean, and sub-Saharan Africa, and approach half of smallholder farmers in Latin American, and (2) programs that focus just on male farmers are unlikely to reach women farmers. The realization that women and men have differentiated access to land rights and other resources, that changing practices and culture can affect women and men differently, and that women's objectives in agricultural production may differ from men's has begun to inform CRSP programs. These efforts should result in more realistic agricultural and environmental and more socially equitable programs.

SANREM IV is to be commended for approaching the gender issue from both a quantitative and qualitative perspective. The gender CCRA has worked with all the LTRAs in their efforts to increase gender sensitivity in data collection and in project objectives, activities, and implementation. More specifically, the gender CCRA has worked intensively with several of the LTRAs to generate qualitative data and analysis regarding gendered knowledge of soil types, use, and quality. These results are important contributions to a program that has as one of its

major objectives the improvement of soil quality and erosion. We assume that the gender CCRA will continue to extract the implications of these findings for conservation agriculture practices and program design and the formulation of recommendations during the last year of the program.

In addition, all the LTRA projects collected gender-differentiated data in their baseline and follow-up surveys. This was an important effort on the part of the LTRAs and they are to be commended for their success in implementing these gender-differentiated surveys.

Unfortunately, however, with the exception of very few projects (e.g., the India site of LTRA 11), gender differentiated analysis of the data and integration of the results into the implementation of the project has not occurred. In hindsight, it may have been helpful to have the gender CCRA work with the LTRAs in the gendered analysis of the data or to have required that a person with the necessary skills be included in each LTRA to carry out the gendered analysis. There is potentially a very rich lode of gender-differentiated data sets that scholars can analyze in the future, but it is unlikely that this analysis will be completed in time for this program.

The discussions in the field visits revealed lingering gendered attitudes regarding agricultural labor. Without little exception, male researchers, technicians, and farmers who commented on the gendered division of labor characterized men's work such as plowing and soil preparation as "hard" work and women's work such as weeding as "lighter" work. This was the case even when they were observing women bent over weeding rice or maize fields by hand.

In reviewing progress with economic analyses of the CAPS under SANREM, there is evidence of commendable work being done. A concern that can arise with inter-disciplinary programs involving economics as a smaller component is that this work becomes subordinated to the science, and so only routine partial budget analyses are carried out with the limited intent of showing profitability. As a result, little innovative and original economics research work is done. While this form of analysis was necessarily performed within the SANREM LTRAs and the Economics CCRA, there is evidence of more innovative and substantive economic analysis being undertaken as well. For example, the farm-level optimization research carried out in Ecuador, which made use of a linear programming model and was published in *Experimental Agriculture*, demonstrates the use of more advanced methods.

Similarly, with analyses of adoption of CAPS there can be a temptation to simply survey adopters and non-adopters then perform a fairly routine statistical analysis of the factors influencing adoption. There are several issues here, one being the relatively limited time elapsed since introduction of the CAPS so that the snapshot of adoption is very incomplete. In reality, adoption is a dynamic process that occurs sometimes over decades. Thus, the usefulness of such analyses can be limited. Various approaches are available to improve adoption studies, such as using more sophisticated statistical modeling that captures the dynamic adoption process (e.g. duration models). Another approach is to accept the limitations of short elapsed time since CAPS introduction and use hypothetical modeling approaches, such as discrete choice experiments (Ecuador, Uganda) or paired comparison (Kenya). SANREM researchers

appear to have used at least the latter approach in studying adoption and this is to be commended. Remaining adoption analyses have attempted to use more sophisticated statistical models, while remaining within the single snapshot mode of analysis based on data collected from project surveys. One opportunity is the use of Ph.D. projects that may extend beyond the confines of the SANREM project life as a means to undertake more dynamic forms of analysis (e.g. Ghana).

D. Training and Capacity Building

There was a balance of effort for every LTRA between research, training, and capacity building. SANREM complied in all cases with the USAID mandate to allocate at least 50 percent of its funding to work in host-countries. In particular, SANREM Phase IV enhanced the research and information exchange activities of the Haiti Ministry of Agriculture/Natural Resources, the Instituto Nacional de Investigaciones Agropecuarias (INIAP) in Ecuador, the Universidad Mayor de San Simón in Bolivia, the Savanna Agricultural Research Institute (SARI) in Ghana; the National University of Lesotho, the School of Agriculture at Moi University (Now Eldoret University) in Kenya, the Makerere University in Uganda; the Institute of Agriculture & Animal Science in Nepal, the Orissa University of Agricultural Technology (OUAT) in India, the University of the Philippines-Los Baños, and the University of Battambang, Cambodia. The interaction between scientists and other professionals at these institutions and those from U.S. universities and organizations resulted in synergistic effects that will be long-lasting.

As important as enhancing the capacity of these universities and institutions is, the long-term and short-term training carried out by the LTRAs (Table 3) is probably even greater. The training of 21 Ph.D., 53 M.S., and 19 B.S. students about conservation agriculture will be important for advancing the scientific and practical information required to educate more farmers about the importance of conservation agriculture for controlling soil erosion and enhancing soil quality. Even more important is the short-term training of almost 22,000 men and women who were predominantly smallholder farmers.

Table 3. Long-term & short-term numbers of men (M) & women (F) trainees for SANREM Phase IV by LTRAs & CCRAs, 2009-2013.

	Long-Term Trainees						Short-Term Trainees	
	Ph.D.		Master		Bachelor			
	M	F	M	F	M	F	M	F
LTRA 6, Haiti	1			1			1408	1009
LTRA 7, Andes	1	4		3	12	6	2295	1296
LTRA 8, West Africa	2			2			514	253
LTRA 9, South Africa	1	8		2			4565	4389
LTRA 10, East Africa	1	1	4	2			907	772

LTRA 11, South Asia	1	4	7	7			958	553
LTRA 12, Southeast Asia	4		4	2			1843	1188
CCRAs	1		4	7	1			
Total	12	9	27	26	13	6	12490	9460

The importance of this cannot be over-emphasized because as pointed out earlier the shift from conventional tillage to conservation agriculture is not simply a change of a practice but a change of culture. Many of these short-term trainees saw and heard about conservation agriculture for the very first time, and this was the beginning for many of them toward a change of culture which in many cases will take several years to complete. There was a good balance between the numbers of men and women short-term trainees which is very important for adoption of conservation agriculture of smallholder farmers because the switching from conventional tillage to conservation agriculture often changes the labor requirements. Tillage, traditionally done by men, is reduced while weeding, often done by women, is generally increased unless herbicides are used that greatly increase input costs. Thus, it is important that both men and women learn as much as feasible about how adoption of CAPS will change labor distribution, equipment needs, and cash flow.

E. Management Entity

SANREM Phase I (1992-1997) and Phase II (1997-2004) were managed by University of Georgia, and Phase III (2004-2009) and Phase IV (2009-2014) were managed by Virginia Tech. The Management Entity for Phase IV includes Dr. Michael Bertelsen, Administrative Principal Investigator; Dr. Adrian Ares, Director of the Innovation Lab; Dr. Keith Moore, Associate Director of the Innovation Lab; Dr. Jennifer Himmelstein, Assistant Director of the Innovation Lab; Dr. George Norton, Economic Assessment Coordinator; Maria Elisa Christie, Gender Coordinator; Christina Brannan, Financial Coordinator; Julia Katz, Editor/Communications Coordinator; and Mark Ohland, Web Specialist. There was a change in the directorship of the Innovation Lab in July, 2011 when Dr. Ares became Director.

It is the opinion of the EAP that the Management Entity has performed effectively and efficiently. In all of the discussions the EAP had with Principal Investigators and with representatives of universities and organizations involved with the LTRAs and CCRAs contacted, the feedback was always positive. There were some frustrations expressed regarding funding delays but the ME always kept them fully apprised of the situations and worked with them to the fullest extent feasible. The EAP also found the ME well organized and efficient in providing necessary materials and logistical support for conducting the review.

The ME, and Director Ares in particular, are commended for organizing and holding several workshops and conferences. International conferences were held in Phnom Penh and Battambang, Cambodia; Hanoi, Vietnam; and Katmandu, Nepal. Special Symposiums were also organized and

presented at the 2012 and 2013 International Annual Meetings of the American Society of Agronomy—Soil Science Society of America—Crop Science Society of America held in Cincinnati, OH and Tampa, FL, respectively. These symposiums presented research results from several of the LTRAs as well as an overview of all aspects of SANREM Phase IV. In both years, the symposiums were well attended and received by scientists from many parts of the world.

F. Recommendations

Because SANREM Phase IV, in particular, and SANREM, in general, ends in September 2014, the highest priority for 2014 is to summarize and clearly document the findings of Phase IV. Recommendations for specific LTRAs and CCRAs have been listed earlier in Sections II and III.

The numerous soil analyses planned should be prioritized for the final year because of the lack of differences between treatments in many of the field trials. It cannot be overemphasized how important it is to clearly document the findings. CAPS have been more successful in some countries than in others, and the reasons are sometimes clear and in other cases less so. It is highly important that the PIs state the reasons that they believe accounted for the positive as well as for the negative results sometimes encountered. Although SANREM is ending in September 2014, work on conservation agriculture will not end. It is critical that the results of SANREM Phase IV are available for future planning. Technical papers will result from some of the research, but many of the findings will not be published as professional papers for various reasons. Therefore, the 2014 Annual Reports will be of extreme importance because this will be the single most important source of information that reports the findings of the entire life of Phase IV. The EAP thought that with few exceptions the 2010, 2011, and 2012 annual reports did not present enough data for readers to clearly understand the results. While most long-term studies show that CAPS are beneficial, there are a number of constraints that cause farmers to be slow or not interested in adoption. Some of the constraints are lack of access to herbicides, lack of or in some cases too much crop residue, limited options for cropping systems, need for using crop residues for animal feed or fuel, farm size, and lack of equipment. The constraints are immediate while benefits are not assured or often times require a few years for benefits to accrue. Therefore, many farmers are reluctant to quickly adopt CAPS and do so only after observing other farmers for several years.

Although the EAP does not know how much flexibility the ME has in making adjustments during the final year of SANREM, it is recommended that consideration be given to formulating a summary publication that would pull together data and information from the seven LTRAs. While the CAPS varied among the various LTRAs, all of them were developed using the three principles of conservation agriculture. The LTRAs spanned 13 countries, hilly and flat lands, areas where it never freezes and those that have cold winters, recently developed cropland and highly eroded cropland, high rainfall areas and low rainfall areas, and farms with livestock and those without. The common thread is that all LTRAs were for a 5-yr period, and mostly involved farmers that had always used conventional tillage. This publication would summarize

not only how crop yields were affected, but how economic and gender conditions were altered would be a valuable contribution.

G. References

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V. Appendices

Appendix A. Scope of Work

Scope of Work: External Evaluation Panel Program Review of the Sustainable Agriculture and Natural Resource Management Collaborative Research Support Program (SANREM CRSP)[3]

Award Number: EPP-A-00-04-00013

Introduction

Objectives

The objectives of this assessment of the SANREM CRSP are to:

- review programmatic focus and the effectiveness of the scientific balance of research toward achievement of objectives;
- determine how successful are project activities in achieving their intended outcomes at this stage of the program;
- assess balance between effective research and capacity building for development of

institutional research capability;

- assess the balance of domestic versus overseas activities in terms of effectiveness in removing constraints in developing countries;
- evaluate the dissemination of research results

The team members

The SANREM CRSP External Assessment Panel (EAP) is composed of four members with different disciplinary expertise. The team members are:

- Ron Cantrell, former Director General of the International Rice Research Institute
- B.A. Stewart, Director of the Dryland Institute, West Texas A&M University
- Susana Lastarria-Cornhiel, Emeritus Professor, Department of Urban and Regional Planning, University of Wisconsin
- Duncan Knowler, Associate Professor and former Associate Dean, School of Resource and Environmental Management, Simon Fraser University, Canada

Background

The Collaborative Research Support Programs (CRSPs)) were created under Title XII of the International Development and Food Assistance Act of 1975, which authorized USAID to engage U.S. land grant and other eligible universities to address the needs of developing nations while also contributing to U.S. food security and agricultural development. In 2000, Title XII was reauthorized, enabling the continuation of the CRSPs as one of several types of U.S. university

[3] The name of the program is being changed to Feed the Future Food Security Innovation Lab: Collaborative Research on Sustainable Agriculture and Natural Resource Management research efforts helping "to achieve the mutual goals among nations of ensuring food security, human health, agricultural growth, trade expansion, and the wise and sustainable use of natural resources".

Description of the SANREM CRSP

Purpose

The 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 current phase of SANREM CRSP is focused on increasing smallholder food security and adaptation to climate change through the introduction of conservation agriculture production systems (CAPS). The approach is participatory, engaging stakeholders at all levels in research problem formulation within priority areas of inquiry, focusing on multiple countries and/or regions to facilitate scaling research findings. This effort involves research, education and technology to develop locally adapted CAPS. The biophysical component of SANREM CRSP include implementation of promising approaches to improve water productivity, soil quality, carbon sequestration as well as developing more productive crop rotations. 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 social and economic concerns of local populations.

The SANREM CRSP is in its fourth year of a second and last five year phase, due to end on September 30, 2014. The SANREM CRSP is one of ten CRSPs conducting collaborative research with eligible U.S. universities[4] that are supported by USAID's Bureau for Food Security.

SANREM CRSP activities

The SANREM CRSP conducts and disseminates applied research on CAPS at 25 sites; documents increases in productivity and resilience to drought, improvements in soil quality and sequestered carbon; and promotes adoption of production systems that are gender sensitive, economically viable and socially scalable to both highly-productive farmers and marginal groups. The SANREM CRSP supports graduate students (including many women) at U.S. and host-country universities, and provides short-term training through workshops, farmer field schools, and trainings of trainers. The SANREM CRSP also introduces and demonstrates technological innovations (e.g., oxen and tractor-drawn implements for minimum tillage and no-till seeding, hand tools, crop nutrient management decision tools), and equipped laboratories and other research and outreach facilities.

[4] Eligible universities are land-grant universities, sea-grant colleges, Native American land-grant colleges and others as spelled out in Section 296(d) of Title XII.

Geographic focus

The SANREM CRSP works in the following countries:

Feed the Future Core Countries: Cambodia, Ghana, Haiti, Kenya, Mali, Mozambique, Nepal, Uganda

Feed the Future Strategic Partner Country: India

Non-Feed the Future Countries: Philippines, Bolivia, Ecuador, Lesotho

Status of associate awards

During this current phase the SANREM Innovation Lab has received an Associate Awards from the Ethiopia USAID Missions, though this award is not the subject of this evaluation.

Additional information on the SANREM Innovation Lab can be found on their web site: http://www.oired.vt.edu/sanremcrsp.

Scope of Work

This review will include the following stages:

1. **Assessment of the progress of the seven Long-term Research Awards (LTRAs) and the four Cross-Cutting Awards (CCRAs) through March 2013.** This portion of the review considers what the PIs originally proposed, how their research evolved, and what the accomplishments to date are and the potential for future accomplishments. Review materials are:

    - Original research proposals
    - Annual and semi-annual reports
    - Work plans
    - Trip reports
    - Other materials as requested by the EAP

Review criteria are:

- How successful was each individual project in achieving its intended outcomes at this stage of the program?
- What is the potential for achieving future impacts, and what are those likely to be?
- Based on review of goals and expected results of each proposal, what are the most significant outcomes achieved to date?
- What are the strengths and weaknesses of projects?
- How well does each project achieve a SANREM-type integrative approach?
- How can project activities be improved?
- What are the overall recommendations for the program portfolio?

2. Overall program review following objectives on page 1

Evaluation methodology

The evaluation will be based on the following: A) telephone conference calls with the ME and other relevant stakeholders, B) a desk review of SANREM CRSP documents, publications and web sites, C) telephone interviews with SANREM CRSP principal investigators, host-country collaborators and other stakeholders, D) travel[5] by EAP members to visit host country partner programs. Specifically, the EAP will do the following:

A) Visit and/or conference calls with the Management Entity

The SANREM ME will schedule a call with the EAP members to review the statement of work and ensure understanding of the SOW and time table. The EAP will later visit and/or schedule conference calls with the ME which includes the SANREM CRSP Director and other key staff, to discuss the ME's responsibilities, request needed information and answer questions. The ME serves as the lead U.S. University organization for the SANREM CRSP and is responsible for program implementation, financial and administrative management, reporting and quality of research results.

B) Desk review

The EAP will review key SANREM CRSP documents including, but not limited to, the Leader Cooperative Agreement, funded research proposals, annual and semiannual reports, work plans, trip reports, and web site. The material to be examined will be related to the current five-year phase of the SANREM Innovation Lab and will be made available by the ME. The purpose of the desk review is to provide background, context and determine necessary interviews and travel sites to successfully complete the evaluation.

C) Telephone interviews with principle investigators and other stakeholders

The EAP will select several principal investigators, host-country coordinators and other stakeholders to interview over the telephone. The purpose of these interviews is to help gather the needed information to answer the questions listed above in the Scope of Work.

D) Visit to host country partners

The EAP and the ME will determine which host country partner programs would be most advantageous to visit. The purpose of these visits will be to gather the needed information to answer the questions poised above in the Scope of Work. The EAP and SANREM ME will decide jointly how many trips are necessary and how many EAP members will travel, with an eye towards limiting travel costs.

[5] All travel arrangements, including airfare, are to be handled by the SANREM CRSP Management Entity and Disaster Assistance and must be in accordance with U.S. Government travel regulations.

Evaluation report

The evaluation report will be a synthesis of the topics and questions outlined in this Scope of Work. The EAP may include other topics that are deemed relevant.

The report may be submitted in any format that effectively addresses the substance of this Scope of Work. The report should include the following components:

Title Page
Table of Contents
List of
Acronyms
List of
Tables List
of Figures
Executive Summary
Synthesis of Findings and Conclusions
Recommendations for SANREM CRSP, USAID and the donor community

Appendices

A. Statement of work
B. List of persons contacted
C. List of materials reviewed
D. Locations and dates of field visits

A draft report will be submitted electronically in MS Word format to SANREM CRSP ME by September 30, 2013. The ME will review the draft and return comments and suggestions for consideration to the EAT by October 30, 2013. The final report should be submitted by December 30, 2013. The final report will be made publicly available.

Level of effort and time frame

The level of effort for the entirety of this Scope of Work will consist of no more than 22 billable days for the Team Leader and 17 billable days for each of the other EAT members. All billable work is to be performed between March 1 and December 30, 2013.

Appendix B. Persons Contacted

1. List of persons contacted for LTRA-6, Haiti

Dr. Thomas Thompson, PI

2. List of persons contacted for LTRA-7, Ecuador

Jeffrey Alwang, Professor, Virginia Tech

Víctor Barrera, SANREM Ecuador project coordinator, INIAP

Franklin Valverde, soil scientist, INIAP Experimental Station Santa

Catalina Monserrathe Bejarano, Director of Research, INIAP

Luis Mendoza Coronel, Director of Planning,

INIAP Luis Escudero, SANREM field site

(Bolivar) coordinator Moazir Celleri, field

technician for SANREM field site José Ochoa,

plant pathologist, IPM CRSP, INIAP Margarita

Lema, farmer, Alumbre

Vinicio Paguay, farmer,

Alumbre Mario Calvache,

farmer, Alumbre Luis Ilbay,

farmer, Alumbre

Fanny Toalombo, farmer, Alumbre

Nelson Moran, Dean of Agricultural Sciences, Universidad Estatal de

Bolívar Carlos Monar, agronomy professor, Universidad Estatal de

Bolívar

David Silva, agronomy professor, Universidad Estatal de

Bolívar Franco Cordero, veterinary medicine, Universidad

Estatal de Bolívar Monica Suquilanda, USAID, Ecuador

Mission

3. List of persons contacted for LTRA-8, Ghana

Vara Prasad, Professor, Kansas State University (KSU)

Stephen Nutsugah, Director, Savanna Agricultural Research Institute (SARI)

Jesse Naab, Officer-in-charge, Savanna Agricultural Research Institute (Wa), Upper West Region

Iddrisu Yahaya, Economist, Agricultural Research Institute (SARI), Wa, Ghana and Ph.D. student, Kansas State University (KSU)

S.S. Seini, Savanna Agricultural Research Institute (SARI),

Wa, Ghana M.A. Askia, Agricultural Research Institute

(SARI), Wa, Ghana

Mr. Kobo-bah, NGO, Nandom District, Upper West Region

Philip Kotia, Chairman, Farmers' Organization, Busa (Wa), Upper West Region

Roger Kanton, Officer-in-charge, Savanna Agricultural Research Institute (Bawku), Upper East
Region

4. List of persons contacted for LTRA-9, Southern Africa

Dr. Neal Eash, Associate Professor, Dept. Biosystems Engineering & Soil Science, University of Tennessee

Dr. Forbes Walker, Associate Professor, Dept. Biosystems Engineering & Soil Science, University of Tennessee

5. List of persons contacted for LTRA-10, Kenya and Uganda

Dr. Jay Norton, Associate Professor, University of Wyoming

Dr. Bernard Bashaasha, Associate Professor, Makerere

University Mr. Emmanuel Omondi, Director, Manor House

Agriculture Center Dr. Rita Laker-Ojok, Director,

Appropriate Technology Uganda (AT) Ms. Grace Tino – AT

Mr. Joshua Ouko – Kenya, Manor House Agriculture Center

Mr. Jeremiah Okeyo – Kenyan graduate Student at University of

Wyoming Ms. Ketty Nambozo –Field Extension Coordinator, AT

Uganda,

Mr. David Chemusto Mwanga – Field Officer, AT

Uganda Ms. Susan Mugala – Research Assistant,

AT Uganda

Dr. Dominic N. Sikuku, Ph.D. (Crop Ecophysiology), SANREM EA Field Coordinator

6. List of persons contacted for LTRA-11, India and Nepal

Dr. Catherine Chan-Halbrendt, Professor of Natural Resources and Environmental Management, University of Hawaii, and Principal Investigator of Sustainable Management of Agroecological Resources for Tribal Societies (SMARTS)

Keshab Thapa, Local Coordinator of the SANREM Project & Programme Coordinator for Climate Change, LI-BIRD

Dr. Keshab Raj Pande, Associate Professor of the Institute of Agriculture and Animal

Science Bikash Paudel, Ph.D. student at University of Hawaii

Dr. Pashupati Chaudhary, Interim Director of LI-BIRD

Bir Bahadi Tamang, SAMREM Project Scientist, LI-BIRD staff

7. List of persons contacted for LTRA-12, Cambodia and the Philippines

Dr. Manuel Reyes, North Carolina A&T State University, Principal Investigator

Dr. Rada Kong, Nepal Coordinator of the SANREM project in Cambodia

Dr. Stéphane Boulakia, CIRAD, co-PI of Cambodia project

Dr. Touch Visalsok, President of the University of Battambang

Don Immanuel Edralin, Ph.D. student at North Carolina A&T State University

Mr. Ren, local technician for Cambodia SANREM site

Mr. Gipala, instructor provided by ADDA/Cambodia for drip-irrigation vegetable project

Ree, Suat, Dawn, Talium, and Mita, peri-urban women vegetable farmers in Cambodia

Dr. Agustin (Jun) R. Mercado, Research Manager for ICRAF (International Center for Research in Agroforestry), co-PI for Philippines site

Dr. Victor Ella, Professor, Land and Water Division, Institute of Agricultural Engineering, University of the Philippines at Los Baños

Dr. Isidra Bagares, economics of conservation agriculture

Dr. Maria Elena Chiong-Javier, professor, DeLaSalle University in Manila

Kent C. Tangcalagan, graduate student, DeLaSalle University in Manila

Apolinario Gonzaga, technician at Philippinessite

Nena, Rebecca, Anastita, Samuel, Rolando, farmers in Claveria, Philippines

8. List of persons contacted for Economics CCRA

Dr. Michael Bertelsen, Director of the Office of International Research, Education, and Development (OIRED), Virginia Polytechnic

Dr. George Norton, Department of Agricultural and Applied Economics, Virginia Polytechnic

Appendix C. List of Materials Reviewed

1. Materials reviewed for LTRA-6

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3. Materials reviewed for LTRA-8

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5. Materials reviewed for LTRA-10

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6. Materials reviewed for LTRA-11

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Appendix D. Locations and Dates of Field Visits

1. Locations and dates of field visits for LTRA 7 (Ecuador)

3 August	Arrival in Quito
4 August	Ground travel to Guaranda
	Work meeting and presentations with Ecuador project team
5 August	visit with farmers from middle-altitude communities along Rio Alumbre
	Visit to Universidad Estatal de Bolivar
6 August	visit with farmers from high-altitude communities along Rio Illangama
	Work meeting with Ecuador project team

7 August Ground travel to Quito

Visit to INIAP Soil & Water Management Dept. in Sta. Catalina

8 August Visit to INIAP Headquarters, Quito

Visit to USAID/Quito

Departure from Quito

2. Locations and dates of field visits for LTRA 8 (Ghana)

13 July Arrival in Accra

14 July Team arrives in Tamale and drives to Wa

15 July Wa meetings and field visits

(i) Presentations – Dr. Jesse Naab and Iddrisu Yahaya

(ii) Discussions with partners and farmers

(iii) Field visit to Nyoli

16 July Field visit to Busa

17 July Team departs for Upper East Region

18 July Discussion with farmers and field visit

Team departs for Tamale and flight to Accra

19 July Flight from Accra to Entebbe via Nairobi

3. Locations and dates of field visits for LTRA 10 (Kenya & Uganda)

19 July Arrival in Entebbe

20 July Ground travel to Tororo

Meetings with farmers from Kisoko and Osuna

21 July Visit to Tororo on station

Meetings with farmers in Molo

Ground travel to Kapchorwa

22 July Visit Kapchorwa on station

Meetings with farmers in Kwosir and Kapchesombe

Ground travel to Tororo

23 July Ground travel to Kitale

Meeting with farmers in Kitale

24 July	Meeting with farmers in Kitale
	Ground travel to Tororo
25 July	Ground travel to Kampala Meeting with Dr. Rita & others
	Ground travel to Entebbe
	Departure from Entebbe (Uganda)

4. Locations and dates of field visits for LTRA 11 (Nepal)

12 June	Arrival in Kathmandu
	Meeting with Nepal project team
13 June	Work meeting and presentations with Nepal project team
	Air travel to Pokhara
14 June	Meeting with LI-BIRD Director and project staff
	Ground travel to field site vicinity
15 June	Ground travel to Thumka site
	Visit with Thumka project farmers
	Ground travel to Bharatpur
16 June	Visit with Dr. Keshab Pande, Institute of Agriculture and Animal Studies, Rampur
	Air travel from Bharatpur to Kathmandu
17 June	Departure from Kathmandu

5. Locations and dates of field visits for LTRA 12 (Cambodia & the Philippines)

18 June	Arrival in Siem Reap
	Ground travel to Battambang
	Work meeting and presentations & some farm sites outside of Battambang
19 June	Visit to University of Battambang and Dr. Touch Visalsok, Univ President
	Visit with farmers in field sites outside Battambang
20 June	Ground travel to Siem Reap
	Visit to vegetable gardens with drip irrigation outside Siem Reap
	Departure from Siem Reap, Cambodia
21 June	Arrival in Manila, Philippines

22 June	Air travel to Cagayan de Oro
	Ground travel to Claveria
	Visit of CAT Centre with Dr. Agustin Mercado Work meeting and presentations with Philippine team
23 June	Visit to field sites and project farmers around Claveria
24 June	Review of visit meeting with Philippine team
	Ground travel to Cagayan de Oro
	Air travel to Manila
25 June	Departure from Manila

Appendix E. Acronyms

AECI	Agencia Española de Cooperación Internacional
AFD	Agence Française de Développment
CAPS	Conservation Agriculture Production Systems
CCRAs	Cross Cutting Research Awards
CIRAD	Agricultural Research for Development
CRSP	Collaborative Research Support Program
CIMMYT	International Maize and Wheat Improvement Center
LTRAs	Long Term Research Awards
EAP	External Assessment Panel
FALLOW	Forest, Agroforest, Low-value Landscapes or Wasteland
FAO	Food and Agriculture Organization
IER	Institut I'Economie Rurale De Mali
INM	Integrated Nutrient Management
INRAP	Instituto Nacional de Investigaciones Agropecuarias
IPM	Integrated Pest Management
LI-BIRD	Local Initiatives for Biodiversity, Research and Development
ME	Management Entity
MFI	Multi Functioning Implement
NEXAFS	Near Edge X-ray Absorption Fine Structure
NGOs	Non-govenmental Organizations
NRC	National Research Council
NRM	National Resource Management
PADAC	Project to Support Agricultural Development in Kampong Cham (Cambodia)
PAR	Participatory Action Research
PES	Payments for Economic Systems
PIs	Principal Investigators
RISING	The Africa Research in Sustainable Intensification for the Next Generation

SA	Sustainable Agriculture
SANREM	Sustainable Agriculture and Natural Resource Management
SARI	Savanna Agriculture Research Institute
SKB	Knowledgebase
SMARTS	Sustainable Management of Agroecological Resources for Tribal Societies
SOC	Soil Organic Carbon
UNDP	United Nations Development Program
USAID	United States Air for International Development
USDA	United States Department of Agriculture
WAC	World Agroforestry Centre