Report of the
External Evaluation Team (EET)
of
Feed the Future Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management (SANREM Innovation Lab)

Phase IV (2009-2014)

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(A) A maize field in Haiti, (B) Layout of an experimental site in Haiti, (C) Maize seedlings emerging through the mulch of Sunn hemp in an experimental plot in Haiti, (D) Discussions by EET with a farmer group in Haiti, (E) Mixed cropping on a mounded seedbed in Ghana, (F) A mechanical roller being used to roll down a cover crop in Cambodia, (G) No-till upland rice directly seeded through a cover crop (*Stylosanthes*) mulch on a demonstration farm in Cambodia, (H) Two women CAPS adopters viewing the project's maize trials in Cambodia.

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I. EXECUTIVE SUMMARY

A. Assessment of the SANREM Innovation Lab

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management (SANREM Innovation Lab), its Management Entity (ME), and its partners (Principle Investigators (PIs) and cooperators have done a commendable job in advancing the goals of Feed the Future initiative in 13 countries where it has implemented Phase-IV of the on-going program since 2009. It has brought conservation agriculture (CA) to resource-poor farmers in the Global South. SANREM has been successful in identifying key collaborators, selecting representative sites, obtaining baseline data, initiating long-term experiments, conducting training programs, procuring research data, establishing cooperation with host-country and international organizations, providing graduate training, and strengthening human resources and institutional capacity building.

SANREM Innovation Lab has demonstrated success at transferring Conservation Agriculture Production Systems (CAPS) to farmers in several regions where soil losses, poor soil heath, and low soil fertility are enormous problems. Clearly, such efforts must continue because developing healthier soils is a long-term enterprise. Protecting and improving soils is paramount to achieving higher yields, maximizing profitability of farms, increasing nutrient output of farming systems, and developing resilience of agroecosystems against harsh and changing climate. In the future, linkages should also be made between sustainable intensification (SI) programs and human nutrition and health because the only sustainable ways of reducing malnutrition is through productive and sustainable agricultural enterprises focused not only on increasing yields and improving the environment, but also on the nutritional health of the societies they serve. All food systems are dependent on agriculture and all nutrients ultimately have their sources in agricultural food products. All of these goals are dependent on soil health and conservation. It is imperative that programs directed at decreasing soil losses and improving soil fertility and health be supported for years to come. Research from such programs could greatly help reduce the tremendous burden of malnutrition in rural communities dependent on agriculture for their sustenance. Notable among the SANREM Innovation Lab's achievements are the following:

1. Generating credible site-specific information about CAPS on biophysical and social/gender factors, and operationalizing CAPS for small landholders with specific reference to:

    - Preparing land without burning of biomass,
    - Controlling weeds with mulch cover and judicious applications of herbicides,
    - Identifying and managing (roll down) cover crops (sunn hemp, *Stylosanthes*, pigeon pea, sorghum Sudan, etc.), and seed procurement,
    - Managing soil fertility and plant nutrients,
    - Managing periods of peak labor demand,
    - Developing gender-relevant tools,
    - Designing simple seed drills and other Multi-Farming Implements (MFI) for CAPS,
    - Identifying region-specific cropping systems,
    - Encouraging formation of farmer interest and self-help groups for men and women,

- Creating nucleus of support services for the needed inputs (e.g., seeds, herbicides, fertilizers), and
- Developing tools of technology transfer.

2. Developing a 4-step iterative protocol towards up-scaling the CAPS to larger areas: diagnosis, adaptation, validation, and demonstration.

3. Providing training to undergraduate and graduate students from the U.S. and host countries, extension agents and farmers,

4. Including gender issues and integration in all projects,

5. Having female PIs and graduate students produced better environments for women farmers to become adopters

6. Strengthening institutional capacity and supporting curricula related to CAPS,

7. Assessing increase in agronomic yields by adoption of CAPS,

8. Establishing cooperation with other Innovation Labs (Integrated Pest Management, Horticulture, Nutrition),

9. Strengthening the SANREM Innovation Lab knowledgebase, and providing metadata on CAPS (e.g., books, journal articles, reports, videos), and

10. Developing a Policy and Operating Procedures Manual for an effective management of the complex project.

Despite the impressive achievements, there is a scope for further improvement as follows:

1. Strengthening process-oriented research to understand and improve the science of biophysical, social and gender issues, and human nutrition,

2. Integrating irrigation and soil fertility management treatments, including those related to micronutrients,

3. Establishing academic centers at the host-country universities, and supporting their curricula,

4. Identifying biophysical and social niches where CAPS are easily adaptable,

5. Promoting faculty exchanges for long-term involvement of PIs in the host-country institutions, and also inviting faculty from abroad to teach at U.S. universities for a semester,

6. Increasing cooperation with Mission-based and other centrally funded in-country projects (e.g., Africa RISING), and

7. Advocating the use of modern innovations because mere hard work in agriculture, as has been done by small landholders for millennia, is not enough. Farming must also be supported by improved technology (e.g., fertilizers, irrigation, no-till (NT) seeders, new cultivars and cropping systems) to obtain satisfactory crop yields and to realize the goals of Feed the Future program. Modern agricultural chemicals with high efficiency and low losses to the environment (e.g., nano-enhanced fertilizers and ultra-low volume herbicide formulations and sprayers) must be tested.

B. Recommendations for the SANREM Innovation Lab

Specific recommendations for the SANREM Innovation Lab include the following:

- Keep the technological options open to new ideas or suite of tools available to improve soil quality and promote agricultural intensification in the Feed the Future countries,
- Avoid a rigid definition of CAPS because of the site-specificity of key determinants,
- Minimize dependence on herbicides, which may not always be the best option and the cash needed for inputs may not be available to all small landholders (e.g., women farmers in various areas),
- Remember that these projects have significant benefits in the U.S. With more buying power, the host-country will need less aid from the U.S., but also can increase bilateral trade (trade versus aid). In addition, the human and institutional capacity of the host countries to participate in international agricultural issues and conduct their own research programs is vastly improved, and there are numerous opportunities for domestic students studying abroad,
- Appoint the in-country coordinators on full-time basis,
- Obtain basic data on soil quality, etc. from replicated field experiments,
- Assess the attainable yield potential of staple crops for the region under the best case scenarios,
- Establish recommendations for use of fertilizers and amendments on the basis of soil tests and the desired yield,
- Identify reasons for the lack of spontaneous adoption of CAPS,
- Strengthen communication with Mission programs (e.g., WINNER, HARVEST)and other centrally funded USAID programs (e.g., Africa RISING, other Innovation Labs),
- Conduct research on fewer sites and on crops of mandate by CGIAR Centers and other Innovation Labs (former CRSPs),
- Revisit mission of CCRAs, and integrate these with the in-country programs,
- Address human nutrition through improvement of soil quality,
- Step up training in business and financial management for women
- Work with host countries and partners to ensure secure land tenure for women
- Obtain comparative data of findings of SANREM and other host-country projects on gender
- Seek more quantitative analysis that is disaggregated by gender, including cost-benefits related to adoption of CAPS.

C. Recommendations for USAID

The USAID office is strongly encouraged to implement the following:

1. Establish close links between SANREM and other Innovation Labs (e.g., IPM),
2. Strengthen communication with in-country Mission and familiarize them with new initiatives and projects, and learn about their programs and priorities, and
3. Develop a mechanism for a strong dialogue between the projects initiated by USAID Washington, In-country Missions, and the Innovation Labs.
4. Include CAPS's gender emphases in the new SI Innovation Lab
5. Emphasize science and scientific agriculture in all training and capacitation projects for women

II. OBJECTIVE AND SCOPE OF WORK

A. Objective:

1. Purpose

The purpose of this external evaluation of the Feed the Future - Innovation Lab for Collaborative Research on Sustainable Agriculture and Natural Resource Management (hereafter referred to as the SANREM Innovation Lab) is to assess the program management, training and research performance, and to provide recommendations on possible program direction for the U.S. Agency for International Development (USAID). This evaluation will help inform USAID on the design of a new Sustainable Intensification Innovation Lab focused on sustainably intensifying agricultural production systems.

2. Scope of Work (SOW)

This evaluation will serve two purposes: an evaluation of the program's past performance and a forward looking analysis of potential research focus areas of a new Sustainable Intensification Innovation Lab. The first component will provide USAID and the Management Entity (ME) with constructive feedback on the past research performance and management of the SANREM Innovation Lab. Second, as this Innovation Lab is drawing to an end of its 10 year project life, the External Evaluation Team (EET) should take a forward looking view and provide guidance to USAID as to the potential research focus of a new Sustainable Intensification Innovation Lab on sustainably intensifying agricultural production systems, with special consideration as to the strengths of the U.S. university community in this area. Specifically, the EET will: A) assess the management by the ME of the SANREM Innovation Lab, B) evaluate the research program focus and outputs against the stated research and development program, C) assess the level and effectiveness of human and institutional capacity building, D) examine how collaboration, outreach and technology dissemination are accomplished and what have been the results, E) explore how gender is incorporated into the research and capacity building programs, F) assess the degree and adequacy of project level monitoring and evaluation, and G) provide recommendations to USAID on how a new Sustainable Intensification Innovation Lab could be structured and what are potential research focus areas in accordance with the Feed the Future research priorities and complementing the Feed the Future Food Security Innovation Center programs**.**

III. APPROACH AND EVALUATION METHODOLOGY

The evaluation is based on the following: A) a desk review of SANREM Innovation Lab project document, publications, and websites, B) telephone conference calls with the USAID AOR and other relevant USAID officers, C) visit to Management Entity, D) telephone interviews with SANREM Innovation Lab principal investigators and stakeholders, E) a survey of host country principle investigators, F) viewing the webcast of the Board on International Food and Agriculture Development (BIFAD) meeting March 14-15, 2013, and G) international travel to Haiti, Ghana, and Cambodia.

A. BIFAD Meeting

The BIFAD meeting held on 3/15/2013 was attended by two members of EET (Professors Rattan Lal and Anita Spring) via a video link. The meeting was held at the University of Missouri in Columbia. The development of new Sustainable Intensification Innovation Lab by USAID and follow up to the BIFAD commissioned review of the CRSPs were discussed at the meeting.

B. Desk Review

The EET reviewed key SANREM Innovation Lab documents (See References) including the Leader Cooperative Agreement and Associate Award, annual reports, work plans, program operation documentation, funded research proposals, a list of principal investigators and key stakeholders, and Innovation Lab websites. The material review is related to the current five-year phase of the SANREM Innovation Lab and was made available by the AOR and the ME.

C. Conference Calls with USAID

The EET scheduled a call with the USAID evaluation manager, AOR, and other Research Division staff to review the statement of work and ensure understanding of the SOW and timetable. The EET also scheduled a second conference call with the USAID evaluation manager, AOR, and other USAID staff after a preliminary desk review. The purpose of this call was to discuss USAID's role in the funding and management of the SANREM Innovation Lab and to understand the implementation and delivery of the evaluation. A call was also made to discuss the report outline, and the final conference call was made to present the recommendations.

D. Visit and conference calls with the Management Entity

The EET visited the ME on 4/4 - 4/6/2013 at Blacksburg (VT) to discuss with Innovation Lab Director and other key staff members, the ME's responsibilities, as well as to obtain information and ask questions. VT is the lead U.S. University for the SANREM Innovation Lab and is responsible for program implementation, financial and administrative management, reporting, and quality of research results.

E. Telephone and Conference Calls with the Management Entity

The EET selected seven principal investigators and stakeholders for interviews by telephone during the week of 1st - 5th July 2013. The purpose of these interviews was to help collate the needed information to answer the questions listed in the Scope of Work.

F. Survey of Host Country Principal Investigators

The EET sent a survey form to the seven project principal investigators. The survey forms contained questions on soils and natural resources, human nutrition, and social and gender issues (Appendix VIII reports on social and gender issues). The survey reports were compiled and synthesized to collate information on some achievements and identify emerging issues.

G. Visit to Some Project Countries

EET members visited host country partner programs as follows:

1. Haiti (4/28-5/3): Lal, Spring, Welch
2. Ghana (5/15-5/21): Lal, Spring
3. Cambodia (6/15-6/23): Lal, Spring

Detailed trip reports are presented in Appendices IV-VI

IV. BACKGROUND AND RESEARCH PROGRAM

A. Background

A U.N. report published in 2013 estimated that the world population may exceed 11 billion by 2100. If the statistics are correct, the world will have another 4 billion people by the end of century. What is more alarming about the statistics is that three-quarters of this growth would occur in Africa. With the projected world population of 11 billion, the population of Africa is projected to be 4.1 billion by 2100. Population of some African countries may increase by a factor of 3 to 5 between 2013 and 2100. For example, the population of Uganda was 5 million in 1962 and is projected to be 205 million by 2100.

The number of undernourished and food-insecure populations, declined from 1020 million in 2009 to 925 million in 2010, and is already unacceptably high and may be exacerbated considerably by 2100. Food insecurity is most prevalent in Asia and the Pacific (578 million) especially in South Asia (SA), Sub-Saharan Africa or SSA (239 million), and Latin America and the Caribbean (53 million). These are also the regions characterized by the traditional farming based on extractive practices, predominance of degraded and depleted soils and harsh climates, as well as large numbers of women farmers with limited access to essential inputs. Soil degradation in tdeveloping countries is caused through accelerated soil erosion by water and wind, nutrient depletion and imbalance, crusting and compaction exacerbated by decline in soil structure and aggregation, salinization and waterlogging, and contamination or pollution by industrial/urban wastes. With the projected increase of population in Africa and wherever the natural resources are already under great stress, both food insecurity and malnutrition may worsen with a 'business as usual' scenario. Food shortages are experienced by small landholders (e.g., Ghana, Haiti) at the end of the dry season, when the previous harvest is finished and the new crop is just being planted.

Small (land holding size 1-2ha), medium (land holding size 2-5ha) and large (land holding size >5ha) farmers predominate in developing countries of the tropics (Table 1) in which the SANREM Innovation Lab is operating (Fig. 1). These regions are characterized by resource-poor farmers with meager incomes. Agriculture in these countries, and specifically in the regions where SANREM projects are sited, is subsistence and characterized by the low inputs (e.g. fertilizer, herbicides, machinery) and low crop yields (Table 1). Thus, the focus of SANREM Innovation Lab on Conservation Agriculture Production Systems (CAPS) is fully justified.

Table 1: Key parameters of the countries in which SANREM is conducting the conservation agriculture (CA) research. (Source: R. Lal, 2013)

Parameters	Unit	Bolivia	Cambodia	Ecuador	Ghana	Haiti	India	Kenya	Lesotho	Mali	Mozambique	Nepal	Philippines	Uganda
Total Area-2011*	10^3 ha	109858	18104	25637	23854	2775	328726	58037	3036	124019	79938	14718	30000	24155
Land area -2011*	10^3 ha	108330	17652	24836	22754	2756	297319	56914	3036	122019	78638	14335	29817	19981
Agr. Land area -2011*	10^3 ha	36965	5655	7497.7	15800	1770	179759	27450	2326	41021	49400	4256	12000	14062
Irrigated area-2011*	10^3 ha	128.2	317.2	619.9	30.27	65.42	62286	103.2	0.067	175.8	40.06	1909	1471	12.08
Total Population-2011*	10^3 person	10088	14305	14666	24966	10124	1241492	41610	2194	15840	23930	30486	94852	34509
Total Agr. Population+	10^3 person	4002	9363	2832	13375	5895	594571	29163	846	11764	18121	28323	31251	25139
**Population growth rate-2007 ** **	% per year	1.8	1.7	1	2	1.6	1.5	2.7	0.6	3	2	2	1.9	13.2
Life expectancy (at birth)***	Years	66.9	63.6	75.8	64.6	62.4	65.8	57.7	48.7	51.9	50.7	69.1	69	54.5
**Annual GDP growth rate ** **	%	5.2	7.1	7.8	14.4	5.6	6.3	4.4	4.2	2.7	7.1	3.9	3.9	6.7
GDP from Agriculture**	% of total	12.5	36.7	7	25.6	N.A	17.5	28.5	7.8	39.7	29.8	31.8	12.8	23.4
Farm size ++	ha	N.A	N.A	14.66	N.A	N.A	1.33	N.A	1.44	N.A	1.28	0.79	2.05	3.24
Total Fertilize use -2002*	10^3 Mg	13.74	0.00	229.52	31.03	13.93	16122.58	142.76	11.30	42.00	24.90	89.04	723.02	9.31
Total cereal Production -2011*	10^6 Mg	2.23	9.50	2.49	2.62	0.60	285.52	4.06	0.10	5.78	2.85	8.61	23.66	4.23
Crop yield - Maize -2011 *	Kg/ha	2974	2240.6	1667.2	1645.8	809.4	2967	1584	634.4	1403.7	1292.7	2281.4	2739.6	2399.8
Crop yield - Rice-2011 *	Kg/ha	2678.8	3000.3	4479.2	2349.5	2324	3530.6	3968.1	N.A	2097.1	988.2	2980.5	3677.6	2588.9
Crop yield - Cowpea-2011 *	Kg/ha	N.A	N.A	N.A	N.A	695.3	N.A	411.8	N.A	530	N.A	N.A	2536.5	950.2
Crop yield - Soy beans-2011 *	Kg/ha	2246	1623.6	1613.6	N.A	N.A	1234.4	2500	N.A	678.6	N.A	965.9	1323	1200
Crop yield - Cassava-2011 *	Kg/ha	8571.5	21294.8	2834.6	16012.5	4195.8	36477	11230.9	N.A	15300	6424.4	N.A	9987.9	11154.4
Crop yield - Sorghum-2011*	Kg/ha	3605.8	N.A	1444.5	1179	840.3	948.7	629.1	509.2	706.7	787.1	N.A	4451.2	1200.5
Crop yield - Millet-2011 *	Kg/ha	N.A	N.A	N.A	1029.4	N.A	1210.5	659.6	N.A	640.3	523.3	1121.8	N.A	2033.4

* http://faostat3.fao.org/home/index.html#DOWNLOAD and http://www.fao.org/nr/water/aquastat/data/query/results.html

** http://unstats.un.org/unsd/demographic/products/socind/

*** http://hdrstats.undp.org/en/countries/profiles/KEN.html

++ Farm size - caculated based on 2000 World Census of Agriculture Published by FAO (FAO statistical series -11, 12)

\+ http://faostat3.fao.org/home/index.html#DOWNLOAD

Feed the Future(FTF) countries are: Cambodia, Ghana, Hait, Kenya, Mali, Nepal and Uganda. India is a strategic partner in the FTF initiative (as are Brazil, Nigeria and South Africa)

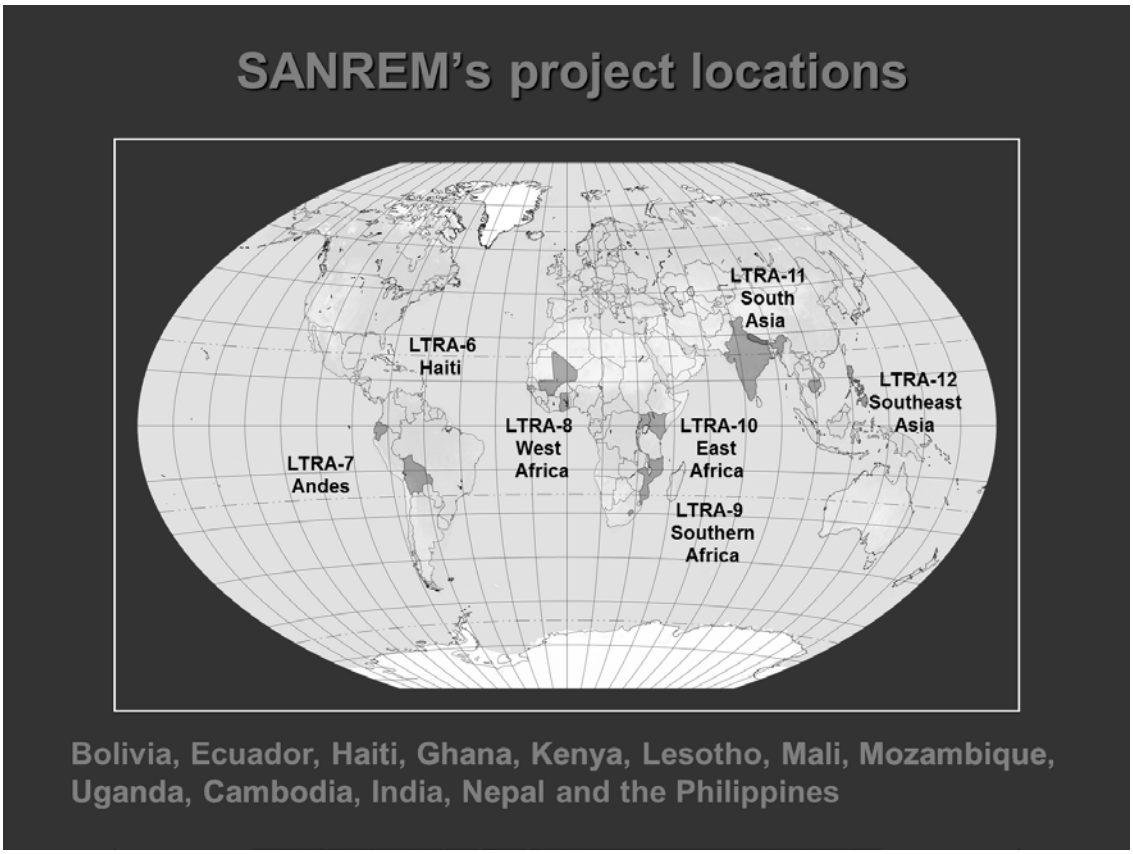


Figure 1. Global distribution of project sites implemented by the SANREM Innovation Laboratory (Courtesy SANREM-ME, VT)

SANREM's in-country field research is conducted through s Long Term Research Awards (LTRA) sited in 13 countries (Fig. 1, Table 2). In addition, SANREM has four cross-cutting research awards (CCRAs) that work with the LTRAs to test hypotheses and conduct research on a wide range of sites and socio-economic conditions (Table 2). They also fund graduate students and conduct short-term trainings. Examples of cross-cutting collaboration are the work on technology networks in Lesotho, Uganda, and Kenya (CCRA-8 and LTRA-10), on gendered knowledge of soils and farming practices in Bolivia, Cambodia, and the Philippines (CCRA-7 and LTRAs 7 and 12), and on economic impact (CCRA-6 and most LTRAs). In addition, CCRA-9 developed a time-zero soil library- by collecting soil samples before CAPS treatments in the different locations.

Table 2. Organization of SANREM Research Program by LTRAs and CCRAs

LTRAs			CCRAs		
#	**Location**	**PI**	**#**	**Theme**	**PI**
6	Central Plateau: Haiti	Thomas Thompson, VT	**6**	Economic Analysis and Impact	M. Bertelsen and G. Norton
7	Andean Region: Ecuador, Bolivia	Jeffrey Alwang, VT	**7**	Gender Knowledge	M. E. Christine
8	West Africa: Ghana, Mali	V. P. Vara Prasad, KSU	**8**	Technology Networks	K. Moore
9	Southern Africa: Lesotho, Mozambique	N. Eash, UT	**9**	Soil Carbon and Soil Quality	T. Thompson (M. Mulvaney)
10	Eastern Africa: Uganda, Kenya	J. Norton, UW			
11	Tribal Societies: Nepal, India	C. Chan-Halbrendt, UH			
12	Southeast Asia: Cambodia, Philippines	M. Reyes, NCA&T			

V. Issues

Predominant issues and the principal drivers of the degradation of natural resources, including poverty, lack of resources, social/gender inequity, fragile and degraded soils, and drought stress caused by harsh and changing climates, are described below.

A. Food Insecurity

Today about 1 billion people are food insecure (i.e., hungry). By 2050, the world's population is expected to be 10 billion rising from about 7 billion today. Thus, at least another three billion people will need to be fed within four decades. This will have to be done on less cultivated land, with increased climate variability and with more agricultural production going into the development of biofuels. The President's Global Hunger and Food Security Initiative (under Feed the Future) has the goal of reducing hunger and poverty. This will require a 70% increase in agricultural productivity by 2050, according to the Food and Agriculture Organization of the United Nations. Therefore, it is necessary to provide more support for scientific technologies that will increase agricultural productivity without degrading the environment or increasing rates of malnutrition. The United Nations Millennium Development Goals (MDGs) of reducing poverty and hunger cannot be met unless agricultural productivity is increased greatly in the coming decades. Nearly all of the growth in population will be in the developing world where poverty and hunger are already widespread.

The ability of agriculture to provide more food is dependent on productive soils. Conserving soil resources is, therefore, paramount to success in meeting the goals of Feed the Future and the MDGs. Soils must not only be conserved but must also be made more productive by enhancing their fertility. Not only must the essential nutrients (14 elements excluding H, O, and C) for plant growth be met but also the mineral nutritional needs of people must be met from soils (either directly through plant food or via livestock or fisheries dependent on plants) if we are to reduce the widespread incidences of malnutrition sustainably especially in developing regions of the world. Therefore, it is necessary that more research be conducted to determine how to achieve these goals and this will require that linkages be formed between agriculture, nutrition and health, soil quality as well as other disciplines.

B. Nutritional Insecurity

Malnutrition is the greatest risk for premature death in the world today. Approximately 30 million deaths a year occur globally from malnutrition including diseases caused by under-nutrition (not enough nutrients to meet human needs) and from diet-related chronic diseases associated with non-communicable disease (obesity, cancer, heart disease, strokes, diabetes, osteoporosis, etc.). Thus, deaths from malnutrition far exceed all other causes. Agricultural systems are the primary source of all essential nutrients (excluding water) entering food systems particularly for resource-poor rural farm communities in the Global South. Soils provide the mineral nutrients needed by the crop and also for livestock and humans. Pasture forage and food crops grown on the soil produce the vitamins and phytochemicals that are required for healthy animals and humans. Fertile soils produce crops which are rich sources of these nutrients and

beneficial compounds. Therefore, agriculture and agricultural policies, as now practiced, must be contributing to malnutrition and elevated death rates globally because agriculture in the past had a limited goal of improving human nutrition and health. The foundation of all nutrients entering food systems is the soil upon which food crops are cultivated. Fertile soils produce food and feed crops that are more nutritious and productive (Lal, 2009). Maintaining fertile soils is therefore a major driver of good nutrition and health especially for rural families dependent on what they grow for sustenance. It is imperative that agriculture, human nutrition, and health be closely linked to assure that all people have access to affordable, nutritious food.

Protecting soil loss from farmlands and improving soil health and fertility is the key to providing enough nutrients to satisfy human needs for now and into the future. However, this cannot be achieved without cooperation between many disciplines including agriculture, soil science, nutrition, health, sociology, anthropology, economics, political science and biological science. The problem requires a system approach to finding affordable and sustainable solutions that will be adapted by targeted groups. The world needs to start to think about "nutrient security" and not just about "food security" as in the past. Providing enough food to meet human needs will not guarantee enough nutrients to meet nutritional demands. Agricultural policies must be directed at meeting nutritional health goals and funding organizations should mandate that agricultural projects include nutrition and health objectives as part of their ultimate goals.

The Feed the Future program has focused on 19 countries, all of which have high rates of malnutrition. These nations also have high birth rates, lower educational attainment, diseases, lost worker productivity, decreased economic development potential, political unrest and social malcontent. Eight of these countries are part of the current SANREM program (Haiti, Ghana, Kenya, Mali, Mozambique, Uganda, Cambodia and Nepal, see Fig. 1). The goal of sustainable intensification is now one of the focuses of USAID's Feed the Future funding priorities. It must be recognized that sustainable intensification can only be achieved if agricultural production systems are designed to meet human nutrition and health needs. No agricultural system is sustainable if it cannot meet the basic nutritional and other essential needs of the people it supports

There are many nutrition-enhancing tools within the agricultural "tool box" that can be used to improve the nutrient output of cropping systems. First and foremost is preserving soil and building soil fertility and health through sustainable CAPS and other techniques. The judicious use of correct fertilizer types applied at the right time, right place, and right amount can increase the nutritional value of food crops dramatically. This is especially true for certain micronutrient fertilizers such as zinc, iodine, and selenium that have been used to reduce the potential of deficiencies in both livestock and humans in many countries. Designing cropping systems that maximize nutrient output to meet nutritional needs and build soil health can also be employed. Including edible legume species (whose seeds are rich in nutrients) as cover crops or in crop rotations is an important aspect of designing cropping systems. Legumes can also help build soil fertility and soil health. Selecting micronutrient efficient genotypes of crops and using biofortified varieties enriched in micronutrients (iron, zinc, and vitamin A) are also tools that can be used. Selecting and using soil amendments (e.g., lime, gypsum, organic matter) where needed that build soil health and improve fertility are also important. Establishing limiting nutrients in the soil for crops selected to grow is another important aspect of improving crop productivity and

also nutrient density within the edible portions of the crop. Biotechnologies can be used to address both biotic and abiotic stress resistance, as well as nutritional quality. All of these tools have already been developed and do not need large investments in research to maximize their potential benefits to both the soil and to human nutrition and health.

C. Soil Degradation/Depletion and Other Soil-Related Constraints

Degraded/depleted soils (Lal, 2008), no or low rate of fertilizers, lack of modern tools (seed drill, sprayer), and vulnerability to drought contribute to low productivity, food insecurity, and poor nutritional quality. Crops and livestock are also being strongly affected by drought and harsh climates. Whereas some farmers use manure, its use is ineffective. It is dumped as open heaps, and exposed to direct sun and rain leading to losses of nutrients (especially nitrogen-N). Principal among soil-related constraints to achieving high crop yields and agronomic productivity are low soil fertility and nutrient imbalance, low soil organic matter content, accelerated soil erosion, compaction, drought stress, weed infestation and nematodes. In West Africa, Striga is a serious problem for cereals and most soils are infected. Poor seeding method (broadcasting) and lack of availability of good seeds are also contributors to low productivity.

Accelerated soil erosion and water runoff are serious problems on sloping lands of even gentle slope gradient (<5%). The problem of soil erosion is exacerbated by the lack of protective crop residues. For example, Lesotho has some of the highest gully erosion rates. Erosion is also a serious problem in Mozambique, Ghana, Tanzania, Uganda, Nepal, India, Philippines (Mindanao), Ecuador, Bolivia, and Haiti. Soils of the semi-arid regions are prone to both water and wind erosion. Wind erosion is especially severe in West Africa (Ghana, Mali). Over and above the effects of soil degradation, low productivity is also caused by the harsh and changing climate, poor infrastructure, lack of technical and institutional support, social and gender inequity, land tenure issues, poor access to markets, and other issues pertaining to the human dimensions. Hunger and malnutrition are attributed to poor soil quality and deficiency of essential nutrients in the agricultural produce (Lal, 2009).

Haiti is an example of a country that has lost prodigious amounts of fertile soils mostly through soil erosion resulting from poor soil management practices (deforestation). Haiti also has the highest percentage of malnourished children in the Latin American region. Unfortunately, soil erosion and degradation in Haiti has led to less productive soils that must be contributing to a lower nutritional value of food crops grown on them. Possibly, the high rates of malnutrition in Haiti today may be somewhat attributable (among multiple other problems) to poor soil management practices in the past (see Welch and Graham, 1999).

Thus, adoption of CAPS would alleviate some of these constraints, enhance productivity, reduce risks of food and nutritional insecurity, and increase resilience of agroecosystems to the changing climate. Restoration of soil quality by CAPS farming would also improve human health because a healthy soil supports healthy plants, animals, and people dependent upon it.

D. Traditional Methods of Seedbed Preparation

Small landholders in Asia and the Caribbean plow fields to a shallow depth (10-15cm) often with a wooden plow (equipped with an iron shear), and pulled by draft animals. Farmers with larger land size (>5ha or more) also use small (walk behind) or medium size tractors (30-40HP) to plow fields by using a moldboard or disk plow after the harvest, and a disk or rotovate again before seeding. In general, male farmers do the plowing and female farmers do the sowing, weeding, and harvesting. Farmyard manure is also mixed in the soil with plowing. In raised seedbed, cereals (maize, sorghum, millet) are sown in furrows or on the sides of the mounds, and root crops (cassava, yam) are planted on the top of the mound or ridges. Some fields are also ridged (either manually or by tractor) with and without ties across ridges to store rainwater and allow more time for the water infiltration into soil. In SSA and the Caribbean, farmers with only 1-2 ha use hoes to make mounds and ridges to control weeds and turn over the soil. Constructing mounds is time consuming, labor-intensive, and a truly backbreaking practice. Mounds are capped with some biomass mulch, which is protected by a large soil clod.

Burning of crop residues/biomass is still common in the Caribbean and SSA. Rice straw is also burned in some regions of South Asia, and fields are plowed after burning. The widespread practice of biomass burning has numerous adverse pedological, ecological and environmental effects. While destroying the protective vegetation cover, it disrupts nutrient elemental cycling, increases soil's hydrophobicity, accelerates water runoff and erosion, increases summertime soil temperatures, and emits black carbon (BC) or soot in the atmosphere. However, burning crop residues is on the decrease as most farmers have been educated not to burn their crop residues; and in some places burning is outlawed.

In West Africa, the Striga weed is a serious issue in cereals. Its devastating effect is true to its popular name: witchweed or witches weed. The parasitic weed reduces production by 30% to 100%.

E. Awareness About No-Till Farming and Conservation Agriculture Production Systems (CAPS)

Traditionally farmers in developing countries have used a kind of minimum tillage (MT) involving a scratch plow (called an 'ard') pulled by draft animals, dibble stick, or machete to sow without any prior intensive seedbed preparation. Few farmers are aware of the modern forms of CAPS. The level of awareness or the knowledge about CAPS may be scanty or fragmentary. Farmers are often not familiar with the modern and science-based concepts (e.g., cover crop, mulch, no-till (NT) seeder, herbicides). Modern NT seeders are rare and often not available among the rural communities. For example, some farmers in Nepal have practiced MT (strip tillage), and some in India are aware of the NT farming. Many farmers cultivating the sloping lands in Mindanao, Philippines are practicing a form of MT: spraying herbicides for weed control and making a furrow by using a single moldboard plow (pulled by cattle), and then planting the maize in the furrow. In 2010, when the SANREM Innovation Lab project started in Ghana, farmers were not familiar with NT farming. The baseline survey indicated that 60% of farmers did not think that it was possible to do NT or direct seeding. Now farmers involved in SANREM projects are familiar with NT farming mostly through field days, and also via television coverage of field days. Those who are aware of CAPS in the tropics have seen it being practiced by their neighboring farmers, through SANREM Innovation Lab projects, or by

attending training offered by SANREM (e.g., Haiti, Ghana, Philippines). Many farmers have heard about CAPS from research centers (e.g., CGIAR), government institutions, herbicide companies, and other farmers.

Those who have attended training courses by the SANREM Innovation lab, repeat merits of CAPS that they heard from extension agents and researchers, rather than from their own experiences. However, it is widely recognized that CAPS, in combination with mulch, cover crops, and trees, control erosion and land slippage, conserve water, and reduce weeding, particularly aiding women farmers who are responsible for the task from one to three times for each plot.

F. Factors Limiting the Adoption of CAPS

There is a wide range of biophysical, social, economic, and cultural issues restricting the adoption of CAPS by resource-poor small size landholders and especially by women farmers in developing countries (Lal, 2007). CAPS adoption has not widely happened in SA, SSA, Caribbean, and Andean Region. Yet, these are the regions where CAPS are needed the most because soil resources are degraded and depleted, climate is harsh, farmers are small landholders and resource-poor, productivity is low, and perpetual food insecurity persists. These factors can and must be addressed.

1. Herbicides

In some cases, costs of doing CAPS, especially for herbicides, are higher and agronomic yields are lower because soils have been severely eroded, and are highly crusted and compacted. However, in some countries, herbicides are available even in village markets and shops; they are also comparatively cheaper than hiring manual labor for weeding. In communities involved in the SANREM Innovation Lab, farmers know how to use herbicides although handling is often not satisfactory. In others, herbicides are not available, or are available only in large packages. Yet in still others, farmers are not skilled about the use of herbicides. Even if available, farmers (especially the women farmers) cannot afford them, and have a poor understanding of their use. Protective clothing is not available and injuries (skin burn) are common. Where available, protective clothing (plastic) is too hot to wear in the tropics. The heavy weight of a knap sack sprayer tied on the back is a major problem for women farmers. There are fears among women farmers about health hazards, and a common perception that CAPS needs more chemical fertilizers when in fact, they may require less.

2. Crop Residues

Adoption of CAPS is severely constrained by the lack of crop residues. There are numerous competing uses of crop residues. They are fed to livestock, either by grazing or collection and carried for stall-feeding. Residues are also used as fuel and for fencing and home construction (roofing material). Further, crop residue burning is a common practice, often for cultural and traditional reasons (to drive away snakes). In some countries (e.g., Ghana), farmers leave crop residues mostly on their bush farms (far away) partly because of the distance from the homestead and partly because the vegetation is still dense in these areas and farmers can get fuel wood from the bush.

3. Farm Size

Farm size is an important factor to the adoption of CAPS. Medium and large farmers (>2ha) have resources and the prospects of experimenting with CAPS knowing that they can keep part of their land under the familiar plow or hoe-based system. Farmers with smaller holdings and high poverty farmers with few assets (e.g., Andean farmers and those in SSA) lack access to finance to fund new equipment and use off-farm inputs.

4. No-till Seeder

Under most conditions, the lack of a seed drill is a major issue. The NT seeder imported from Brazil and China is being tried in Cambodia, and the so-called Pantnagar seed drill is used in India. These tractor-pulled drills may not be suitable for small plots on steep slopes (Ecuador, Nepal). In some cases, however, a cutting knife (Mindanao, Philippines), a 'used up' digging tool (Ecuador), or a 'digo' (Haiti), can be used as a NT dibbling tool for small farms (<2 ha).

5. Mixed Cropping Systems

Crops and cropping systems are also important considerations in the adoption. CAPS may not be suitable for the traditional mix-cropping systems where as many as six crops (Ghana, Haiti) may be grown simultaneously on the same parcel of land. However, CAPS can be used for orderly inter-cropping comprising alternate small strips (2-4m wide) of different crops on the same field. Some root crops (e.g., potatoes grown by the Andean farmers) are not easily adapted to CAPS because the entire topsoil is loosened for seeding potatoes. With specific planting techniques, however, CAPS can also be used for potatoes. Farmers in Haiti indicated that crops that can be grown with CAPS are maize, cassava, sweet potatoes, black beans, and vegetables. However, peanut cannot be grown using CAPS because of high humidity. Agronomic productivity of mixed cropping systems must be assessed by computing the land equivalent ratio.

G. Use of Cover Crops

Mixed farming combinations of crops and livestock necessitate production of fodders and feedstock. In the context of sustainable land use and food security, mixed farming is an important system for the small-size landholders and the resource-poor farmers of the tropics and sub-tropics. However, crop residues and the biomass from cover crops are needed as feedstock and fodder for the livestock. Cover crops (legumes and cereals) are highly valued by smallholder farmers as feed for livestock. Yet, both (crop residues and cover crops) are also integral components of CAPS. Therefore, a judicious timing and proper choice of cover crop(s) may be critical to produce enough biomass for use as a cover crop, source of mulch, and much needed fodder for the livestock. Thus, cover crops can play an important role in the CAPS. While farmers understand numerous uses, most small landholders do not grow cover crops because they compete with food/cash crop. Some cover crops, such as *Stylosanthes* and *Arachis pintoi* tried in Mindanao, Pilippines are not successful. A good cover crop is the one that also provides some income to the farmers over and above improving soil quality. In this regard, cowpea and pigeon pea (in South America) can be used as cover crops. Although there is some interest if a cover crop is of dual purpose with some food value, obtaining cover crop seed is also an issue hindering its adoption. Economic analysis is needed to assess feed value versus roll-down mulch; and life cycle analysis is required to assess the ecological footprint (growing N versus buying N) of cover crops.

Despite numerous benefits, cover crops can also have some agronomic issues (competition with food crops, habitat for insects and pests, etc.). There are also risks of more damage by insects and pathogens to crops grown under CAPS. Farmers in Haiti informed the EET that insects such as locusts eat the planted maize because they hide under the mulch. That is why, they opined, burning is useful. They also noted that too much humidity under the mulch causes disease (such as in peanuts). There are also problems with rodents (mice) and reptiles under the mulch.

H. Farmer's Perception of Soil Quality

Understanding and managing soil quality are essential to enhancing and sustaining agronomic productivity and environmental quality. However, soil quality is an elusive property. Credible measurement is the first step to its control and eventually to its management- Soil quality, like other properties, is also prone to the so-called "observer effect." The procedures used to measure soil quality can strongly alter the measurements. Thus, it is important to identify key properties as indicator (surrogate) of soil quality. As Albert Einstein noted, "not everything that counts can be counted, and not everything that can be counted counts." Therefore, soil quality must be perceived as a property that researchers can quantify and farmers can understand and relate to. In this context, soil organic matter (SOM) content (soil organic C or SOC concentration) are key parameters and important indicators of soil quality (Lal, 2004). Concentration of SOM is especially important for smallholders who either cannot or do not apply chemical fertilizers (women farmers have no access to them) (e.g., Haiti, Nepal, Cambodia) because they are not yet sure about their effectiveness. Concentration of SOM can be visually judged by the soil color; those with a higher concentration are relatively darker in color.

Thus farmers relate to soil quality mostly by color, softness (feel), and cohesiveness (tilth). Darker and heavier soils are perceived to be fertile soils. Farmers in Haiti use the terms "fat" (fertile) and "thin" (infertile) soil. Black and grey soils, in the valley, are "fat" soils. In contrast, soils on sloping terrain (with coarse texture and gravels) are "thin" soils. Maize, rice, yam, and other staples or cash crops are grown on fat soils, whereas cassava, beans, and raising of livestock (grazing) are practiced on thin soils. In Ghana, compound/household waste is used on a fat soil, crop yields are high, and soils are darker in color. Thin soils that may be far from the homestead, are more likely to be given to women to grow legumes and when they become thicker due to the nitrogen reclaimed by men.. Soils that are light in color have low agronomic yields, and animals graze on these lands;. Tractors are not used on thin soils because these are shallow and stony. In Mindanao, women farmers grow maize and banana on a good (fat) soil, and beans and potato on a poor (thin) soil. Similar perceptions about fertile soil, based on color, exist for farmers in Nepal, India, and Cambodia. Farmers also relate soil quality to its depth and texture (loamy or clayey). Stony/gravely and shallow soils are thought to be infertile, hence the reason for mounding. In the Southwest U.S., however, traditional/native farmers believe that a coarse-textured soil (sandy, loose) is better, because it is not hard and is easy to plow. The traditional concept of good soil quality is that it supports a good crop as evidenced by its color (green), size of stalks, height, panicle or cob size, and agronomic yield.

Color and softness are the indicators of soil quality, and adoption of CAPS over long-time (5 years and more) can visibly change soil color, and thus farmers' perception of soil quality. Change in color of soil under CAPS for rice cultivation was noticeable in some experiments conducted in Cambodia by CIRAD and SANREM.

I. Threshold of Soil Quality Parameters

It isimportant to develop practical indicators of soil quality that presently do not exist. Farmers must understand that improving SOM concentration is an important strategy because it is a key component of soil quality, agronomic productivity, and nutritional security. Indeed, food security, climate security, and soil security depend on SOM security or its maintenance above the threshold level. However, the threshold level of SOM concentration and those of other parameters in the root zone (0-30cm depth) for soils of the tropics are not known. Soil functions and ecosystem services are severely curtailed when SOC concentration falls below the threshold level. Most soils of small landholders under extractive farming practices for a longtime contain SOC concentrations in the root zone of < 0.5% ; or even 0.1%. Both crop response and use efficiency increase with increased SOC concentration.

In conditions of severely depleted/degraded soils, even the benefits of improved varieties and other inputs (fertilizers) cannot be fully realized because the even water and nutrients are severely jeopardized. Thus, maintenance of SOM/SOC concentration is of critical importance because of its numerous benefits to soil, water, and climate conditions. Yet it is also difficult to maintain or enhance SOC concentration because of the limited resources. The SOM-induced improvements in soil quality and ecological factors also lead to notable benefits to agronomic productivity, farm income, and wellbeing of the farm household. Thus, identifying techniques to enhance SOM remains to be a high priority.

It is in this context that the focus of the SANREM Innovation Lab on CAPS is relevant to addressing numerous challenges facing smallholder farmers of the tropics. Properly implemented, in conjunction with the use of mulch/cover crop along with complex rotations and integrated nutrient management or INM (including manure), long-term use of CAPS can improve SOM concentration in the surface (0-20cm) layer leading to numerous benefits. Thus, the focus of SANREM on CAPS and soils are fully justified.

J. Drought Stress

The number one issue raised by farmers in Haiti and Ghana was drought stress and the lack of irrigation facilities. Most soils in the West African regions are predominantly sandy with low water holding capacity. Further, soils are structurally unstable and are susceptible to erosion by water and wind. An experiment conducted on CAPS in upland rice in Cambodia by CIRAD/SANREM team indicated that the rice in the plowed treatment had to be replanted because of the drought experienced soon after seeding. Indeed, periodic drought stress during the growing seasons (including during both winter and spring in Nepal and northern India) is a common problem throughout the tropics, and especially during the short second season when crops must mature on the residual soil moisture. Sometimes unpredicted and prolonged drought occurs during the summer (June, July) such as in Nepal, India, Haiti and Ghana. Irregular monsoon rains can cause drought stress either early or late in the maize-cropping season. Without any supplemental irrigation, post monsoon crops can be grown only if soil moisture storage is adequate. Even when equipped with irrigation facilities, such as in the Indo-Gangetic Plains, drought can cause excessive withdrawal and thus depletion of the ground water (~1m/yr)

or secondary salinization because of the poor quality of irrigation water, lack of adequate drainage, and inundation. The problem of drought stress is strongly exacerbated by supra-optimal soil temperatures. In plowed and raised seedbeds, soil temperatures during the summer months can exceed 50° C at 2-cm depth. Combination of low moisture reserves and high soil temperatures severely reduces agronomic productivity on degraded/depleted soils.

Furthermore, the drought stress is likely to become even more severe with the predicted climate change and the increase in frequency and intensity of extreme events. Rainfall distribution during the growing season is already changing with highly intense rains followed by long dry spells. The need to make smallholder agriculture less prone to drought stress is more critical now than ever before, and must be integral component of the new SI Innovation Lab

K. Traditional Biofuels and Resource Degradation

Rural communities in developing countries, even in the three countries visited by the EET (i.e., Haiti, Ghana, and Cambodia), are heavily dependent on traditional biofuels for their household energy use. The source of energy for cooking primarily includes firewood, charcoal, crop residues, and animal dung. While traveling through Ghana, the EET observed piles of firewood along the road in every rural community, and occasionally charcoal kilns and bags full of coal for sale. Animal dung is widely used in SA and eastern Africa. Large and frequent piles of rice husk discarded along the road side and among house hold compounds were also observed by the EET in Cambodia, and were used neither as biofuel (controlled pyrolysis for energy and bio char production) nor for industrial uses (brick making, silica extraction). Use of these traditional biofuel and feedstocks have strong adverse impacts on natural resources, and particularly on soil, water, and atmosphere, as well as on human health. The atmospheric brown cloud (ABC), which exerts severe impact on regional climate, is caused by the extensive use of traditional biofuels in SA and SSA. Onsite, cutting of firewood and removal of crop residues exacerbate the problems of surface runoff and erosion by water and wind, soil structural decline leading to crusting and compaction, and disruption in biogeochemical cycles of water and nutrients (i.e., N, P, and S). Offsite, use of these traditional biofuels (animal dung, crop residues, and firewood) leads to emission of soot or BC and other byproducts of incomplete combustion (aerosol) with strong impacts on atmospheric chemistry, radiative forcing, climate change, environmental quality, and human health. Soil and environmental degradation can be partly alleviated by identifying clean cooking fuels so that crop and animal residues can be used as soil amendments.

There is also a strong interest in developing and using modern biofuels in the countries where SANREM Innovation Lab is operating. The latter comprises of the first generation biofuels such as ethanol from maize grains or sugar (sugarcane and sugar beet) and biodiesel (from soybean, oil palm). These biofuels also impact natural resources, and compete directly with availability of grains for human food, as has been indicated by repeated spikes in food prices such as in the Caribbean and elsewhere. The second generation biofuels consist of cellulosic ethanol (from crop residues) and gas from bio digester (animal dung and biomass), which can also be hazardous to natural resources and the environment. The EET visited a large Jatropha plantation in northern Ghana, and large rubber plantations in Cambodia. The uses of traditional biofuels have a strong and a direct bearing on the adoption of CAPS. Removal of crop residues and animal dung for household fuels degrades soil and renders them unsuitable for CAPS.

L. Climate Change, Resource Degradation, Conservation Agriculture Nexus

The extractive farming practices followed by the resource-poor and small landholders of the tropics as observed by the EET during visits to the field projects (Haiti, Ghana, Cambodia), are a are a source of greenhouses gas (GHG) emissions. Indeed, traditional farming (deforestation, shifting cultivation, biomass burning) have been the source of CO_2 ever since the dawn of settled agriculture (circa 10,000-12,000 B.P.). Cultivation of rice paddies and domestication of livestock have been the source of CH_4 (methane) since about 5,000 B.P.

Therefore, conversion of traditional farming to CAPS (based on elimination of plowing, use of residue mulch, and growing cover crops such as sunn hemp, *Stylosanthes*, sorghum) can sequester atmospheric CO_2 as SOM or humus. Similarly, the establishment of forest plantations (e.g., rubber in Cambodia) and use of agroforestry system can sequester atmospheric CO_2 in forest biomass and also as SOM. Direct seeding of rice (rather than puddling and flooding) through residue mulch and rolled down cover crop can mitigate CH_4 emission and sequester CO_2 as SOM. In addition to advancing food security, conversion to CAPS and restoration of degraded soils can offset anthropogenic emissions and reduce GHG emissions (Lal, 2004). However, the farmers that SANREM Innovation Lab is addressing are severely constrained by the lack of resources that are essential to creating the positive soil and ecosystem C budgets. These innovations can be adopted by small landholders through incentivization and policies which promote "carbon farming" (see section N below). This issue is also discussed under sections XI and XII.

M. Farmer Interest Groups and Associations to Promote CAPS

The adoption of CAPS also requires support of several interest groups, which are still in their initial stages under the best case scenario throughout the developing world. However, some farmer groups and associations are being created, and these organizations can be motivated to enhance the advocacy of CAPS. In the Philippines, for example, the Philippine Land Care Foundation that can be very helpful in CAPS adoption. There are also women's groups (Ghana, Kenya, Uganda) which can be useful, because adoption of CAPS reduces weeding and the drudgery of numerous farming tasks primarily performed by women. Further, there exists a strong farmers-to-farmers transfer of new technologies in villages. The existence of functional interest groups is critical to adoption of CAPS. These groups can also serve as nucleus to liaise with the private sector and industry (e.g., herbicide companies, farm machinery dealers). Farmer Field Schools (FFS) and training programs can also be organized through these groups.

N. Trading Carbon

Soil carbon sequestration is one of the numerous benefits of CAPS. Trading carbon credits can generate another income stream for farmers (Lal, 2004). Farmer associations and interest groups, including women groups, can be enrolled jointly in carbon-offset projects provided that total area under CA in an aggregated community is large (>1000ha). To make it happen, tools and protocols must be developed so that World Bank, UN-REDD program, Kyoto's CDM, local industry, and other voluntary markets can be involved in trading carbon credits. Research data and specific examples of change in soil/ecosystem C stocks are needed to develop a methodological protocol for trading C credits. Soil carbon trading may not be a possibility in the near future given numerous issues dealing with farm sizes, land tenure, measurements and

verification, and reporting. Thus, much emphasis is currently on forestry (e.g., REDD), not even agroforestry. However, if there are policies in place and a real market is created, it will provide new income streams for farmers.

O. Promoting Conservation Agriculture Program Systems

Conversion of traditional methods of seedbed preparation and farming to CAPS is a paradigm shift. Rather than an incremental increase of some specific components (e.g., change fertilizer rate or type, develop supplemental irrigation, adopt new variety), conversion to CAPS is a new way of farming. It is a gateway to sustainable intensification or SI. This is the strategy to reverse the downward spiral and improve human wellbeing while restoring the environment.

But numerous challenges lie ahead in improving the adoption of CAPS. While spontaneous adoption has been impressive (the so-called "Cerrado Miracle") in large-scale and commercial agriculture in South America (e.g., Brazil, Argentina, Chile, Paraguay), there is little if any progress in its adoption by smallholders in SA, SSA, the Andean region, the Caribbean, etc. There is need for an objective assessment of impediments to technology transfer for adoption of CAPS by small landholders (see Section VIII).

Payments to farmers for the provisioning of ecosystem services (carbon credits) is one of the strategies of promoting adoption of CAPS. In this context, favorable policy interventions, which do not yet exist, are critical to judicious and sustainable soil governance. Important among other strategies are changing the education curricula to include CAPS in agricultural programs at secondary schools, as well as at undergraduate and graduate degree levels (See Section VII). Weak institutional capacity for both research and extension is a major issue. Private sector inputs (e.g., machinery, seed drill, sprayers, fertilizers, herbicides) and credit facilities are lacking, thereby limiting the access to essential inputs for conversion to CAPS. Once the research phase is adequately advanced, up-scaling of CAPS would require establishment of demonstration plots and organizing farmer associations/interest groups. Pilot projects, involving several hundred hectares of land area and the most representative crops, would require institutional support so that farmers could learn from real time practical experiences. Involving women farmers and other minority groups is essential to the success of CAPS' adoption and realizing its benefits.

VI. ACCOMPLISHMENTS

The SANREM Innovation Lab staff at the ME, the project scientists (PIs), and the host country partners have done a commendable job in identifying collaborators, choosing sites, and initiating experiments often under difficult situations (e.g., Haiti, Mali), obtaining baseline data, conducting surveys, identifying interest groups, establishing cooperation with international organizations (e.g., CIRAD in Cambodia), and building human resources and institutional capacity (see Section VII).

Specific achievements with reference to science and practice of CAPS are discussed below.

A. Soil and Natural Resources

1. Establishment of Long-Term Experiments

Well-designed long-term experiments involving CAPS have been initiated under diverse agroecosystems. The CAPS experiments in Haiti involve replicated treatments of tillage systems implemented with and without cover crop (sunn hemp). The choice of sunn hemp is good because of the ease in seed production and stand establishment, and good growth even during the dry season on residual soil moisture. Other cover crops tested included *Sesbania* and Sudan sorgum. These experiments are generating the much needed data on soil properties, and filling important knowledge gaps.

The on-farm CAPS demonstration plots established in cooperation with farmers in northern Ghana are among numerous accomplishments. Cooperation with scientists from SARI (Dr. Roger Kanton, Dr. Jesse Naab, and Dr. Fosu Mathias) is generating useful data on the application of CAPS under semi-arid conditions of West Africa.

Cooperative CAPS programs established with CIRAD in Cambodia are examples of synergism and mutual program enhancement. This type of synergistic cooperation should be strengthened, and followed elsewhere within the SANREM Innovation Lab and in other Innovation Labs. These long-term CAPS experiments (involving direct seeded upland rice, maize, soybean) grown through rolled down cover crops (e.g., *Stylosanthes*, pigeon pea, Sudan-sorghum) are generating valuable data on soil quality, SOC sequestration, agronomic yield sustainability, and other important social/economic parameters. Similar experiments established in Nepal, India, Philippines, Ecuador, etc. are important to generating the information towards scaling up the CAPS for a widespread adoption.

2. Documenting and Quantifying CAPS Benefits

The SANREM-CAPS Program has generated site-specific and relevant data on the effectiveness of CAPS on erosion control, water conservation, SOC sequestration, and gender. These data are important to developing a “decision support systems” for policy makers, farmers, stakeholders, and the private sector. Quantification of the parameters for these remote sites, with difficult working conditions and poor logistics, is also important to the global scientific community

interested in understanding the processes, properties, factors, and causes underpinning the adoption of CAPS in the developing countries.

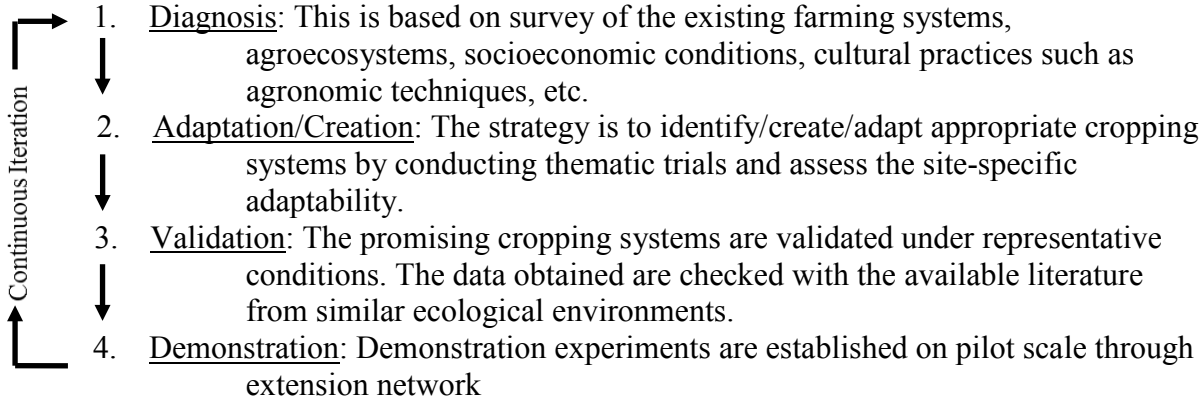
3. Operationalization of CAPS

An important outcome of CAPS implementation across three continents is the development of *modus operandi* in operationalization of CAPS under diverse soils, climate, economic, social, cultural, and ethnic conditions. These experiments have generated the much needed information towards operationalizing CAPS for small landholders with specific reference to:

1. Preparing seedbed without burning of biomass,
2. Controlling weeds with mulch cover and judicious applications of herbicides,
3. Identifying and managing (roll down) of cover crops (sunn hemp, *Stylosanthes*, pigeon peas, sorghum- Sudan, etc.), and procuring seed,
4. Managing soil fertility and essential nutrients (macro and micro),
5. Managing peak labor demand,
6. Developing gender-relevant tools,
7. Designing simple seed drills and other Multi-Farming Implements (MFI) for CAPS,
8. Identifying region-specific cropping systems,
9. Initiating farmer interest and self-help groups,
10. Creating a nucleus of support services for the needed inputs (e.g., seeds, herbicides, fertilizers),
11. Developing tools of technology transfer, and
12. Initiating CAPS-based curricula at some universities (e.g., Cambodia, Philippines).

4. Development of a Protocol for Large-Scale Adaptation

Both SANREM and CIRAD have developed a four-step protocol towards large-scale implementation of CAPS as follows:



The 4-step process undergoes a continuous iteration through appropriate feedback mechanisms.

Figure 2. A 4-step model up scaling protocol

5. Closing the "Yield Gap" Through Soil Restoration by CAPS

An effective implementation of CAPS is an important strategy to close the yield gaps that exist in developing countries. Indeed, the conversion to CAPS provides opportunities for sustainable intensification by small landholders operating under harsh conditions. Visits by the EET to Ghana and Cambodia indicated substantial yield increase of maize and rice (often by a factor of 2 or more) through adoption of CAPS. Similar observations have been reported for highlands of Nepal and Ecuador, tribal regions of eastern India, and from other sites where the SANREM Innovation Lab is operating. Improving agronomic yields is especially important to female-headed households, which are food insecure at the end of the dry season, such as those households in northern Ghana.

6. Alleviating Drudgery and Enhancing Human Well-Being

Many farmers interviewed in Ghana, Haiti, and elsewhere indicated thatthey would not encourage their sons or daughters to undertake farming. An important reason is drudgery (building mounds and ridges, plowing under hot (45˚C) and dry conditions, puddling of water under hot and humid (100% humidity) environments, and repeatedly weeding the crops with severe weed infestation such as done by woman farmers often with babies tied on their backs. Despite these back-breaking and arduous tasks, there are only meager harvests and extremely low yields. Faced with these issues, the CAPS technology saves labor, eliminates plowing/puddling, and reduces other strenuous tasks of building mounds and ridges. These advantages are especially important to woman farmers, as was repeatedly mentioned by those interviewed in Haiti and Ghana.

7. Adaptation to Climate Change

The SANREM-CAPS program, implemented on several sites in the tropics, also is a strategy to adapt smallholder agriculture to climate change. Conversion to CAPS moderates the adverse effects of extreme events (e.g., drought in Haiti), prolongs the growing season duration by saving in the time required for traditional seedbed preparation, and assures the minimum agronomic yield even under the most adverse conditions. CAPS are naturally amenable to the women farmers who are most vulnerable to the adverse effects of climate change.

8. Training of the Trainers (See also Section VII)

The SANREM-CAPS initiative has enlarged, expanded, and strengthened the human resource capacity. Trained personnel can provide training to farmers, land managers, and practitioners. Lack of specifically trained extension agents, a serious constraint to CAPS adoption in the developing country, is being effectively addressed by the SANREM-LTRA projects.

9. Cooperation with Other Innovation Labs

The partnership between SANREM and the Nutrition Innovation Labs is very exciting. Joint projects developed with the HORT and IPM Labs in Cambodia and Ecuador are steps in the right

direction. Similar inter-Innovation Lab (Across-CRSP) cooperation must be strongly encouraged.

B. Social and Gender Issues: Women Farmers and CAPS

1. Gender and CAPS Training

Data on women's and men's attendance in workshops and training courses are given in Table 3. Women's interest in CAPS training courses was remarked on in all three projects (Haiti, Ghana, and Cambodia). A quote from one LTRA-12 partner was that "Women farmers are interested, they attend; they seem to be good students." However, this does not always correlate with them adopting CAPS. The SANREM LTRAs examined women's reasons for liking the training but not actually adopting CAPS. In Ghana, for instance, the project director told us that 28 women adopted CAPS practices in the first year and farmed on land loaned by local chiefs and husbands, but they could not continue thereafter because the land was taken back. In Cambodia, both women and men farmers who adopted CAPS needed to have at least 2.5 hectares of land; those with smaller holdings could not be adopters because it put them in too much risk (Ricard 2012). Project PIs noted women's reasons for liking the training but not actually adopting CAPS, but they could not solve such factors as land availability and farmers' risk factors.

In Haiti it seems as though training is leading to adoption, but it is too early in the project to tell. Additional interviews and focus groups will help discern the reasons for participation or lack thereof. The other LTRAs not visited had good adoption rates according to their annual reports. The EET was told that an analysis of those who were trained and those who were adopters (realizing that there are a number of technologies and stages in the adoption process) was in process. Adoption of CAPS is a multi-year series of changes in farming practices, and data from 2009-2013 are being tracked and assessed in order to provide quantitative data. The USAID Common Indicators form was required annually of all LTRAs, and collects data on the following: Short-term Training (male and female participants); and well as on the many technologies and their steps (increase in crop yields; decrease in production costs; new management practices, being field tested, and available for transfer; farmers adopting new technologies; hectares under new technologies, etc.).

2. Women and participation in CAPS

Most LTRAs were aided by farmer-based organizations and LTRA partners who could identify women farmers interested in participating in CAPS training. Table 3 shows constraints that women face, and changes that CAPS bring to women's farm work (usually lessening weeding and tillage, while allowing for expansion of lands cultivated). Also noted is women's participation in research trials, in which the LTRAs were careful to include women and men as trial cooperators.

Table 3. Women Constraints, CAPS Changes for Women's, Participation in Trials and Workshops

	Women's constraints	Changes for Women and Men due to	Trial #s women & men	Women in workshop & focus groups	Women CAPS adopters

CAPS					
LTRA-6 Haiti	Less fertile Land than men	Less weeding, more time to generate income off farm	M>F	F>M	M + F
LTRA-7 Bolivia Ecuador	Mostly potatoes	Less weeding			F + M
LTRA-8 Ghana Mali	Land taken away after 2nd of yr of project	Less tillage and weeding, so can buy more land to expand	M = 36 F = 28	M = 414 F = 198	M>F
LTRA-9 Lesotho Mozambique					
LTRA-10 Kenya Uganda		Can use donkeys to prepare land Less weeding More income for some Uganda>Kenya	Equal #s	Equal #s	M, F
LTRA-11 India Nepal	Men migrate due to reduced till	India : no-till Men have time for off farm Nepal min till Labor requirement similar for strip tillage and conventional tillage, but less labor required at peak season	Cannot be categorized (HH as unit for trial and both M and F contribute)	40-50% F	
LTRA-12 Cambodia Philippines	Need >2.5 ha For CA	Less tillage and weeding, so can buy more land-expand	30-40%		

Based on the EET visits, women in one part of Haiti noted that they helped prepare the land along with the men and looked forward to participating in trials and planting their own fields using CAPS methods (the project had been delayed due to the earthquake, cholera, etc.). When asked about constraints, the women noted their lack of funds to hire labor and obtain irrigation. The women also did not like using the various mulches between rows due to the fact that the mulches harbored insects. In Ghana, a new group of women farmers the EET met were thrilled with CAPS and were increasing the number of hectares they plant (from one to four hectares) due to NT (they do not have to use the traditional hoes), ground covers, and herbicides to reduce weeds.

In Cambodia, women farmers lauded NT to all visitors and in a film made by CIRAD because they no longer had to pay men to plow and their heavy weeding burdens were reduced. They estimated that they saved about $300 for four hectares by doing CAPS and not hiring tractor

services. In terms of herbicides and pesticide costs, they were able to switch to non-toxic and less expensive products. The EET heard many comments about the high toxicity of horticultural crops due to intensive herbicides and pesticides, however, agronomic crops such as pigeon pea might also have fairly high levels. It would be useful if SANREM coordinates with the IPM Innovation Lab to determine the optimal types of the herbicides and pesticides, giving consideration to women's usage. In Cambodia an important finding is that community and family networks are important vectors for transmitting information about CAPS and their adoption (Table 4). There was an observation by project staff that NT agriculture production also gave women more time to attend meetings.

Also noted in both Haiti and Cambodia was that women prefer cover crops to be food crops. In Cambodia, women said they were constrained by funds to hire labor (they pay other women $3-$6 a day and they need income for those payments). CIRAD included a revolving credit fund and women talked about the difficulty of doing CAPS without getting the loans at low interest rates. The USAID Mission in Cambodia told the EET about its $1.5 million project credit guarantee projects working with banks but it does not seem to have been linked with the SANREM project.

Table 4 provides qualitative data on the types of CAPS' practices that women adopted in each LTRA (ranging from MT, NT, and use of residues, crop covers, herbicides, CAPS' tools.

Table 4. CAPS Practices that Women Adopted

	Minimum Tillage MT	No tillage NT	Residues Mulch	Cover Crops	Herbicides	CAPS' Tools Used
LTRA-6 Haiti	(x)	(x)	(x)	(x)		(still use scooped plow-like hoe)
LTRA-7 Bolivia Ecuador						
LTRA-8 Ghana Mali	X	X	X		X	Rent ox plows and tractors
LTRA-9 Lesotho Mozambique						Hand tools
LTRA-10 Kenya Uganda	X X		X	X	X	Shallow hoe Donkeys to plow Multi Farming Implement (MFI)
LTRA-11 India Nepal	X	X				Hand tools
LTRA-12 Cambodia Philippines*	X	X X	X X	X X	Change to less toxic & lesser dosage	Fitarelli seeders (F) Vencetudo seeders (M) in Cambodia Animal pulled plow and hand-held bolo in Philippines

(x) Farmers are just beginning to adopt some aspects of CA

3. Women and CAPS Technology

Technology for CAPS varies across the LRTAs. Haiti presented an interesting case, in that the traditional tilling implement, a scooped plow-like hoe ('digo'), does not help at all to do NT or MT. The project has a few flat blade hoes for demonstration. In Ghana, the EET did not get any information on farm tools as the interviews took place at SARI, not in the communities. However, the third version of the MFI, an animal-drawn tool that performs farming tasks such as ripping, chiseling, weed sweeping, and seeding will be tested in northern Ghana.

In Cambodia some women were buying a type of seeder called the "Fitarelli seeder," that are less expensive than another type, the Vencetudo seeder, purchased by men. Women were glad to get away from ox plows, and some community members thought cattle were becoming something of a nuisance to the farmers as it was difficult to keep them out of the maize fields. Some owners were loaning their animals to others for care and maintenance. SANREM projects need to keep better track of the farm tools such as hoes, seeders, low tillage, sprayers, and pumps that are used in the project areas and determine whether men, women, or both have access and ownership of the tools. For example, widows (heads of female-headed households) actually bought sprayers in some areas in Cambodia.

a. SANREM's Cross-Cutting Theme CCRA 7 Gendered Knowledge

This CCRA has assisted the LTRAs, other CCRAs, and various partners with methodologies to work with gender issues and constraints in their projects and regions. It also has identified women and men for graduate training who have done their field work in some SANREM countries (Bolivia, Ecuador, Philippines, Cambodia) on gender issues. The EET met a male student collecting data for his master's degree on gender issues in Cambodia. He also had two assistants (a man and a woman, both undergraduate students at the University of Battambang).

In both Ghana and Cambodia, and somewhat unlike Haiti, capital-intensive crops are believed not be unsuitable for women because they require fertile land and soils. Women only receive or have access to marginal lands with infertile or sub-fertile soils, where more sub-subsistence type crops can be grown. Crops with high value such as peanut and ground bean can be sold for good prices, but only in very limited quantities (bowlfuls). This, however, is touted as women's "income-generating potential," an ironic notion since these high protein foods would then be removed from the household diet.

4. Gendered knowledge about soils

In Haiti, both men and women know the difference between rich, dark soil versus thin, flat, light-colored soils. Legumes, such as the peanut, do best in the latter, while maize does best in the former. The red, dry, sandy soils often on slopes are more likely to be allocated to women than to men. It is important, therefore, that LTRA-6 should be looking at the differences and similarities in terms of ownership of plots by men and women and asking: Are women's plots more likely to be on slopes? Are women relegated to plots with red or sandy, or thin soils more so than men?

In Ghana, both men and women agreed that men obtained the best soils for their maize and soybean crops and that when those soils "wear out" after four or five years of continuous

cropping – sometimes monocropped and sometimes intercropped -- some portion of the land is allocated to women to plant legumes with the idea that it will restore the land somewhat.

In Cambodia, farmers differentiate between black, red, and sandy soils, as well as dividing soils into water-logged and clay. Both women and men seem to have the same knowledge of the soils. The master's degree student who did CIRAD's baseline study mapped out farmers typologies and soil types, and then related them to farmers' abilities and propensities, as well as their cropping system, to be able to practice CAPS (Ricard, 2012).

CCRA-7 initially worked with LTRA-7 Bolivia and Ecuador, and identified differential knowledge of soils and usages by women and men. In the Andes, women grazed sheep, while men grazed cattle, and each knew about the different soils and their properties related to difference types of pastures. The CCRA found a similar differentiation in the Philippines. Women and men categorized soils differently depending on usage and different spheres of action. Women think that the soils in their kitchen gardens, which also receive water and refuse inputs, are the most fertile, while men believe that pasture plots, which receive the animal manure, are more fertile.

SANREM soil labs should carry out more analysis on these soils related to genderized categories, and women's and men's CAPS and other plots to enable the design of better research trials and better communication for women and men farmers. The standard diagnostics of soil pH, nutrient deficiencies, and composite plot fertility could be disaggregated in terms of plot ownership/usage and yield results. Once the LTRAs delineate the differences in soils and relate that back to the actual farmers, they can then follow through in terms of CAPS methods, yields, and income produced.

5. Decision-Making, Income, and Empowerment: The Women's Empowerment in Agriculture Index (WEAI)

The Women's Empowerment in Agriculture Index (WEAI), released in 2012 by IFPRI and USAID, Feed the Future, is being modified for data collection and implementation by CCRA-7. With five domains of empowerment and many sub-indices, operationalizing it in diverse cultures, languages, and field collection situations presents quite a challenge. The Gender Coordinator and her team of students in Cambodia are working to create the protocols that are accurate and can be used to train a series of enumerators to collect and process reliable data on the following topics: input in productive decisions, autonomy in production, household decision-making, ownership of assets, purchase, sale, and transfer of assets, access to and decisions on credit, control over use of income, group membership, speaking in public, workload, and leisure.

VII. *HUMAN RESOURCES AND INSTITUTIONAL CAPACITY BUILDING*

The SANREM Innovation Lab has done a commendable job in providing training opportunities at different levels. Indeed, short- and long-term training activities are a key component of the SANREM program.

A. Undergraduate and Graduate Training

A significant part of the SANREM program includes short- and long-term training. During SANREM Phase IV (2009 to 2013) a total of 96 (50 women and 46 men) undergraduate and graduate students (BS/BA, M.S. and Ph.D.) were funded to study in U.S. and host-country universities; 99% of the students performed well in their programs (Table 5). About 60% of the students were nationals of the LTRA host countries, and all students conducted field research in these countries. In addition, SANREM contributed to development of a curriculum in conservation agriculture at the National University of Lesotho, to improved soil and water analysis labs in Bolivia, and to conservation agriculture (planned for the University of Battambang in Cambodia). The EET saw a number of such newly-returned individuals who were working with their research institutes, development projects, and SANREM itself.

B. Short Term Training of Farmers

Over 20,000 farmers (48% women) were trained during field days, focus groups, reflection meetings, demonstrations, and other activities. These targets exceed those set in the LTRA annual work plans numbers and are shown in Table 5.

Table 5 Training: Long-Term (PhD, MA, BS/BA) and Short Term by Gender

Long-term Trainees for 2009-2013	**PH.D.**		**Master**		**Bachelor**		**Short- term Trainees or 2009-2013**	
	Men	Women	Men	Women	Men	Women		
							Men	Women
LTRA-6 Haiti	1			1			1408	1009
LTRA-7 Andes	1	4		3	12	6	2295	1296
LTRA-8 W. Africa	2			2			514	253
LTRA-9 S. Africa	1		8	2			4565	4389
LTRA-10 E. Africa	1	1	4	2			907	772
LTRA-11 S. Asia	1	4	7	7			958	553
LTRA-12 SE Asia	4		4	2			1843	1188
CCRAs	1		4	7	1			
Total	12	9	27	26	13	6	12490	9460

Experience gained by the U.S. students of working overseas is also important. The EET visited with one graduate student conducting her field experiments in Haiti (Madelyn Lynch, VT) and two in Cambodia (Don Immanuel Edralin, NCA&T State University and Daniel Sumner, Gender CCRA, VT). Another graduate student from KSU will be working with the Africa RISING project in the Tamale region of Ghana with Dr. Vara Prasad as his academic advisor. A total of about 93-96 students (some are not yet finished) exceeds the target listed in annual work plans (SANREM 2012 Semiannual Report; Ares, Moore, Kelly, and Mulvaney 2012).

VIII. TECHNOLOGY TRANSFER

A. Technology Transfer in LTRAs

Technology transfer activities were planned in the LTRA projects since their inception. So far, 78 technologies suited to different biophysical and socio economic conditions have been field-tested and 22 are available for transfer to farmers. Examples of technologies are crop systems with various combinations of rotations and mixtures, cover crops, strip tillage, low-cost drip irrigation, biological control agents/phosphorus solubilizing bacteria, hand and animal-drawn implements, vegetated strips for soil conservation, improved varieties of perennial grasses, living mulch for maize production in acidic soils, and optimum planting time and spacing. Some of the technologies were modifications of existing ones whereas others were new. Among the latter, the best example is the Multi Functioning Implement (MFI), an animal-drawn tool that performs farming tasks such as ripping, chiseling, weed sweeping, and seeding. These accomplishments show that the ME is meeting its obligations to transfer technologies that will aid in the adoption of conservation agriculture by farmers in the targeted regions.

SANREM technologies are promoted during group and individual meetings and demonstration with farmers groups, cooperatives, extension personnel, private sector, and other stakeholders.. Technologies introduced by SANREM are being used in Bolivia, Cambodia, Ghana, Haiti, Kenya, Mozambique, and the Philippines. In the case of the MFI, SANREM has provided funds to perform additional field tests to refine the equipment, developed a business strategy and interacted with the USAID-funded Partnering for Innovation program.

The MFI increases the efficiency of farming operations, reduces labor costs, and conserves the soil. The MFI operator can switch applications easily, safely, and rapidly. It was designed through an interactive, co-innovation process with smallholder farmers to find workable solutions for their systems, and has been tested extensively in Kenyaand Uganda with oxen and donkeys. A third version of the MFI will be also tested in northern Ghana and Mozambique. The MFI represents an improvement over existing farmtools for CAPS such as rippers, knife rollers and no-till seeders which have been developed in Malawi, northern Tanzania, Zambia, and Zimbabwe. The final goal is manufacturing and marketing the MFI in Africa through partnerships with the private sector.

SANREM collects information yearly from the PIs about adoption of technology using the USAID Form 19 Common Indicators, as noted above. Additional information is reported in annual reports and other documents. This includes farmers collaborating in SANREM projects and other farmers in the target region who may adapt one or more conservation agriculture practices. Factors that promote or not adoption (e.g., farmer education level, income, distance to markets, input availability) have been addressed in several theses. According to Dr. George Norton, SANREM coordinator for Economic Analysis and Impact, a full analysis of conservation practices will not be possible until the end of the SANREM Innovation Lab when more solid information will be available.

B. Cooperation with International Organizations

The SANREM Innovation Lab has established cooperation with CIRAD. The Montpellier – based French organization has long-term CAPS programs in Cambodia and elsewhere in the tropics. This cooperation is useful because of its continuity, good infrastructure, and good human resources capacity. Similar types of cooperation exist with CIMMYT and ICRAF, and needs to be developed with other organizations (see Section XI). This cooperation has allowed the ME to use knowledge generated previously by their highly qualified cooperators thus saving time and investments by the ME. It also allowed continuity within the international movement to introduce CAPS technologies to these regions.

IX. MANAGEMENT ENTITY

A. Management

The SANREM Innovation Lab's Management Entity (ME) is comprised of eight people (five men and three women) located on the campus of Virginia Tech University (VT) within the International Affairs offices in Blacksburg, VA. The ME manages all activities (collaborative research, education and outreach) of this project (Fig. 2). The following individuals participate in the ME: Michael Bertelsen, Administrative Principal Investigator (PI); Adrian Ares, Director of the SANREM Innovation Lab; Keith Moore, Associate Director; George Norton, Economic Impact Assessment Coordinator; Maria Elisa Christie, Gender Coordinator; Christian Brannan, Financial Coordinator; Amy Loeffler, editor / Communications Coordinator, and; Mark "Amado" Ohland; Web Specialist. There was a change in the directorship of SANREM which resulted in a smooth transition from one director to another with the support of an interim director.

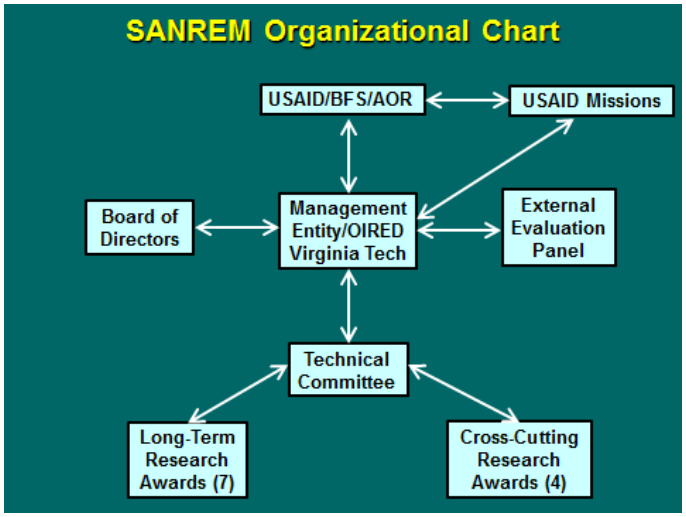


Figure 3. The SANREM Innovation Lab organizational chart (Courtesy of SANREM – ME).

SANREM-ME holds an annual meeting, regional planning meetings and special sessions on CAPS and SI at the annual meetings of the ASA/CSSA/SSSA held in various locations in the USA. They have held conferences on CAPS at four international locations (Phnom Penh, Hanoi, Kathmandu, and Battambang).

The LTRAs under ME direction perform research to generate knowledge, promote innovation, build capacity and engage stakeholders to develop sustainable CAPS. The cross-cutting research awards include: economic and impact analysis, gendered knowledge, technology networks, and quality and carbon sequestration. These projects address common research elements in LTRAs to generalize and expand findings to a wider set of conditions.

The ME partners with seven U.S. universities, ten host country universities, 11 host country NGOs, seven host country government organizations, six CGIAR centers and other international organizations and two Innovation Labs

Overall, the organization and dedication of the ME program managers, principal investigators (PIs) and associated collaborators are to be commended on a "job well done." They have been efficient and dedicated to accomplishing their mission. It was apparent from the communications, documentation, and presentations given that the ME and the PIs have made good progress towards reaching their work plan goals for this project. This management team is aware of the importance of their project at improving the ability of Global South countries to provide enough food to feed their populations by saving and improving their soil resources through CA practices. The ME is meeting its stated objectives and work plans as documented in their reports (SANREM Annual Reports 2009-2012).

The ME has been effective at communicating with its collaborators and in disseminating important findings and information to the public and other interested parties through conferences -, presentations at their annual meetings and important national and international meetings, developing pamphlets summarizing activity within the program, website development (SANREM Knowledgebase), and publishing papers in scientific journals. Further, the ME leadership has visited field sites and host-country organizations to communicate their ideas, programs and challenges. The ME has also developed connections with CAPS networks and developed stakeholder listservs. The ME has also promoted communication and collaboration within projects via ensuring the participation of host-country in the development of work plans and their implementation within and among projects through annual meetings, emails and telephone communications. Collaboration among sub-awardees has been encouraged by holding interactive events at annual meetings and by providing funding for specific initiatives. The ME has been effective at communicating with partners using an open communication approach via email and telephone calls along with postings on their website. The ME stated that one area that needs improvement is better engagement of PIs and sub-awardees in SANREM's external communication efforts. The SANREM ME is continuously working with PIs to get information out in multiple venues. The main limitation is the multiple commitments of PIs (teaching, participation in other research projects, etc.).

B. Financial Management

From 09/30/04 to 09/30/09 the ME administered a budget of $13,463,103 in the phase III of the SANREM project. In phase IV, from 09/30/09 to present, the ME is administering a projected budget of $16,706,048. However, because of budget cuts from 2010 to 2013, the actual annual budgets decreased as follows: 2010 – $3.06 million; 2011 - $3.00 million; 2012 - $2.80 million; 2013 – $2.80 million. The budget for 2014 has not been established to our knowledge. Leveraged funding for 2011 totaled $529,770. This included non-tracked funding or support contributions to SANREM activities and funding or support for non-SANREM activities resulting from SANREM activities. For 2012, leveraged funds totaled $923,670 from both sources. Leverage for SANREM Innovation Lab Phases III and IV was $4.6 million. The EET does not have leveraged funding figures for 2013.

Because of the budget cuts, the ME downsized and absorbed parts of the cuts. They advised the PIs and their partners about changes in the funding priorities. The formation of the Feed the Future program, which came after the start of phase IV SANREM Innovation Lab initiation, resulted in changes to the focus countries within the SANREM Innovation Lab. They focused on maintaining graduate students and projects conducted in eight of the 19 Feed the Future priority countries which included Haiti, Ghana, Kenya, Mali, Mozambique, Uganda, Cambodia and Nepal. These changes in the focus of SANREM seem appropriate for this project given the budget cuts incurred.

Transfer of funds to the field project has been simplified and made time-effective. The transfer-of-funds chain begins from USAID → VT → Contracting U.S. University → Host country organization/collaborators. The time frame in transfer of funds in a long chain can be an issue. The partnership may be:

(i) University with Ministry of Agriculture
(ii) University with university
(iii) University with NGO
(iv) University with a research institute

CIRAD had developed a double signatory process. Payments are normally made as 50% in advance, and 90% of the remaining 50% is paid on the basis of invoice. Time frame is important issue with the financial transaction. Sometimes, salaries do not get paid for two months.

The administrative costs for SANREM have been less than the allowable 20% of the annual budget. They appear to make wise decisions concerning the management of their project and judicious use of the funds available to them. They also split ME staff and faculty positions with other Office of International Research and Development (OIRED) projects at Virginia Tech which reduces the burden of management cost to SANREM.

C. Reward System for Cooperators

The ME does not pay participating farmers. The ME does provide farmers with seeds, fertilizers, herbicides, farming implements, labor and technical assistance depending on specific situations and project goals. The ME has a standard protocol for interactions with partners in communities titled "Rules of the Game" and is used to guide early interactions with partners (see below).

The ME collaborates with many organizations including non-government organizations (NGOs), universities, Consultative Group on International Agricultural Research (CGIAR), and government institutions to which sub-awards are granted. All cooperators submit a work plan and budget narrative. Funds are paid for inputs, salaries, transportation, meetings, etc. Some sub-awards are managed by the ME while others are managed by the university where research in the Long Term Research Agreement is executed (e.g., University of Wyoming, University of Hawaii).

D. Rules of the Game

1. Principles and procedures for working with local partners

In working with SANREM partners in the farming communities, the ME has targeted on conducting research for the development of adapted CAPS, it is important to keep in mind the value of all activities for community members and how they perceive the value of these contributions.

The SANREM Innovation Lab is first and foremost a research program. The objective is to develop new knowledge that can be used by local partners to improve their production systems, and consequently their livelihoods and well-being. SANREM is not a development agency and cannot deliver the inputs and means for achieving development. The goal is to learn from the community members about their production systems. In the process, SANREM is also helping the community learn more about their own resources and potentials, which should they choose to they can modify for improved community well-being.

SANREM's program with individuals and communities is on a voluntary basis. No one is forced to participate in SANREM activities. Successful learning occurs when individuals choose of their own accord to think and act in new ways. The goal is to present and test new ideas and technologies with those communities and community members who are interested in actively learning about new ways to manage their resources.

E. Complementarity and Synergism with other Innovative Labs

The SANREM Innovation Lab is working closely with other organizations such as CIRAD in Cambodia and the CGIAR centers. It has also developed projects with host country universities and NAROs. The SANREM-ME must establish closer ties with other in-country projects. It also needs to understand modalities and work with the programs implemented by USAID Missions (e.g., HARVEST, WINNER), centrally funded projects (e.g., Africa RISING, other Innovation Labs), and other international programs (e.g., FAO, UNDP). During visit to Haiti, the EET met Prof. Cesar Cruz, Universidad ISA, Santiago (DR). He has been involved in organizing training courses on CAPS in Haiti. Thus, a collaboration between ISA and the SANREM Innovation Lab would be synergistic and complementary.

X. RESPONSES TO THE USAID SOW QUESTIONS

A. Management

a. Technical Leadership

1. *What are examples of technical leadership displayed by the ME?*
   The ME has shown leadership in managing the program by designing applications for long-term research awards and for cross-cutting activities that would support LTRAs. The ME was the leader in the formulation of a more detailed set of research projects that stated objectives, methods, timetables and deliverables for the selected LTRAs. Annual meetings were held for PIs that focused on themes that helped the development of collaborations among LTRA projects. The ME also organized sessions for conservation agriculture at the several annual national meetings of the ASA/CSSA/SSSA as well as in Cambodia, Vietnam and Nepal. The ME held regional planning meetings that promoted joint studies and publications. They supported the development of a multifunctioning implement used for CAPS. They participated in meetings for the development of Africa RISING and other activities of Feed the Future. They reviewed annual work plans to assure scientific rigor and conformity to work plan goals. They have supplied reporting guidelines to PIs and placed past and existing knowledge into a searchable data base. All of these activities demonstrate that the ME has shown technical leadership.

2. *How well has the ME balanced research, implementation activities, training and capacity building?*
   The ME has demonstrated that all of the projects administered by them have a good balance between research implementation activities, training and capacity building as shown by the following activities. They have conducted numerous field trials (>350). Further, they have trained in excess of 7700 farmers including 4000 women in 2012 alone. Forty-eight percent of the total are women, and they attended short courses, workshops, focus groups, and demonstrations. Some also were trial cooperators. They have supported the training of 93-96 (some are still completing) long-term degrees (doctoral, masters, and bachelors). Institutional capacity building was accomplished by strengthening institution personnel through short- and long-term technical training programs for host country partners, mentoring Co-PIs throughout the project cycle, and strengthening financial personnel through regular report monitoring and consultations.

3. *How has the ME built on earlier investments? What can be done to capitalize on these to broaden or accelerate progress?*
   The ME developed a website containing a knowledgebase (SANREM Knowledgebase) which contains information gained from the first three phases of the project. In phase IV of the project, two of the projects have the same PIs that are working in the same geographic area as focused on during the first three phases of the project. The ME staff has participated in both Phase III and IV of the project. They have used past projects based on research at a large scale in this current phase to develop further studies at the village or farm scale. The contacts they have made with other countries, NGO, CGIAR Centers, international

governments, and international and national universities are noteworthy. Such contacts help broaden and accelerate conservation agriculture programs. Any new sustainable intensification lab should strive to build upon these activities.

4. *How does the ME continue to be forward thinking about research ideas and plans, including improving alignment with the Feed the Future Global Hunger and Food Security Research Strategy?*
   By attending national and international meetings, connecting to a multitude of conservation agricultural networks, developing stakeholder communications through listservs and through other professional associations, the ME is forward thinking about research ideas and plans. They also consult with the AOR and USAID-Feed the Future administrators to keep informed about the plans of these organizations. This resulted in the ME redirecting funding and modification of existing research goals in order to more closely connect to Feed the Future goals. They have promoted strong conformity to Feed the Future strategies within their program.

5. *How has the ME promoted and maximized values such as collaboration, capacity building and outreach among sub-awardees?*
   The ME has included host-country participation in annual meetings and in the development of work plans and their implementation which has helped to foster collaborations and communications with partners. The ME provided funding for specific initiatives by partners for participation in Feed the Future meetings and promotion of the Multiple Farming Implement to other regions. These activities have help promote and maximize impact of the project among cooperators.

6. *What are the mechanisms that the ME developed to ensure that local, national and regional needs and priorities will continue to be incorporated into the development of the research agenda? How effective are these mechanisms?*
   USAID's instructions for the development of Long-Term Research Awards (LTRAs) supplied to the ME required that PIs take local, national and regional needs and priorities into account when designing research and building local partnerships. Given this directive, all proposals were evaluated with respect to this criterion. Only proposals that met these criteria were accepted by the ME as long-term research projects. Their collaborative annual work plan development process has accommodated emerging local, national, and regional priorities and opportunities. From the information provided, it appears that the activities of the ME assure compliance and that they are effective at achieving this requirement.

7. *How well has the ME facilitated the participation of new partners?*
   The ME has enabled the involvement of new partners by including either individuals (e.g., hiring one gender expert to work on the Asia project), institutions (e.g., two CGIAR Centers, ICRISAT and IIAM), or programs (e.g., Feed the Future Innovation Labs in Integrated Pest Management, Horticulture and Nutrition). The ME is also discussing the involvement of the private sector in MFI manufacture and marketing throughout Africa. Therefore, the ME is making a concerted effort to bring in new partners to their project.

8. *What strategies has the ME used to balance core program activities with the additional management demands of Associate Awards?*
   The ME obtained one associate award from the USAID/Ethiopia in Phase IV which had little impact on the ME management. SANREM obtained three associate awards (Madagascar; South Sudan; and Payments for Environmental Services) in Phase III. Additionally, USAID/BFS (Bureau of Food Security) invited the SANREM Innovation Lab to conduct the Biodiversity Symposium. The EET is not sure of what other strategies the ME is using to assure balance with core program from additional duties required by Associate Awards.

9. *How has the ME engaged USAID bilateral Missions, other donors and partners (i.e., World Bank, BIFAD, FAO, CGIAR, NGOs, the private sector) in the SANREM Innovation Lab's research and capacity building activities? Give examples. How might engagement be increased?*
   The ME has strongly encouraged its researchers to become involved in participating in the USAID's Africa RISING initiative on sustainable intensification and in collaborating with IFPRI, IITA and other CGIAR centers. Further, the ME has encouraged collaborations of their projects with other Feed the Future Innovative Labs (HORT, IPM, and Nutrition in Cambodia, Ecuador, and Nepal). Nearly all project sites have collaborated with NGOs and CGIAR centers. The manufacturing and marketing of the MFI required collaborations with private companies in Africa. In collaboration with USAID in Tanzania, the ME contributed to short-term training of partners in social network analyses. The ME requires that PIs visit and keep USAID missions informed of their activities within the host countries. At certain locations difficulties were encountered in getting active involvement of host country USAID missions because the SANREM Innovation Lab project was viewed by the mission as small compared to other agricultural activities within the mission. In the future, new Innovation Labs should make every effort to stay abreast of new developments in linking agriculture to human nutrition and health and foster contacts with a diversity of disciplines related to food-based systems approaches to solving the malnutrition problem in developing nations.

b. <u>Administration</u>

1. *What systems are in place to keep research activities on track according to SANREM Innovation Lab program goals?*
   The ME is strongly dedicated to reporting all activity within the SANREM Innovation Lab. They require a semi-annual report and an annual report due in March and September. They use required USAID indicator reporting as a part of this process. The Associate Director and Director review reports carefully and their reviews are returned to PIs with comments. After all corrections and clarification are made, the reviews go to the final editing phase. Additionally, trip reports are due 15 days after completion of each trip and they are also reviewed and edited. The project activities are reviewed against Feed the Future goals and reviewed periodically with the PIs during individual discussions and group meetings. These activities seem to keep the research activities of the project focused and on track.

2. *What are the roles and functions of advisory committees? Have they been effective and efficient?*

SANREM advisory committees are developed according to the Policy and Procedures (POP) Manual, which establishes how the SANREM advisory committees are selected. There is a Board of Directors (BOD) and a Technical Committee (TC). The BOD members meet to discuss policy issues (e.g., changes in the POP manual, changes in project PIs). TC members meet by a conference calls or face–to-face meetings to discuss project issues and evaluate work plans which are presented by each PI. The TC members and some BOD members also participate in the SANREM Annual Meeting. The meeting held in Cincinnati in October 2012 was attended by 70 participants. There are local advisory committees in some projects constituted by SANREM stakeholders such as farmers, extension agents, agro-dealers and others. These activities of the advisory committees have been effective and efficient relative to the benchmark while allowing the ME to make significant progress towards reaching their stated goals.

3. *What major challenges has the ME faced and how have they been addressed? Give examples.*
   The biggest challenge to the ME was budget reductions during years 3 and 4. The ME responded by reducing some of their activities and absorbing parts of the cuts. They advised PIs and other partners of these changes in funding priorities. The ME gave priority to maintaining graduate student support and to work conducted in Feed the Future countries that the ME worked in. Because the Feed the Future program was started after the start of Phase IV, the ME changed its focus to eight of the 19 Feed the Future priority countries that included Haiti, Ghana, Kenya, Mali, Mozambique, Uganda, Cambodia and Nepal. These changes seem appropriate given the budget cuts incurred.

   Another challenge to the ME was the change in directors. There was a smooth transition to the new director through the efforts of an interim director. The ME is currently excellently directed and working efficiently.

4. *In general, what has been the management style of the ME regarding principle investigators and sub awardees? Are there any areas that could be improved?*
   The PIs and sub awardees have good relationships with the ME. The ME responds well to criticisms, making adjustments when necessary to maintain good relationships. They regularly communicate with their PIs and sub-awardees, using frequent visits to field sites and host-country organizations, holding annual and regional planning meetings and using conference calls and emails. The ME recognizes that they need to improve the involvement of PIs and sub awardees in the external communication efforts of the ME. They did not suggest how they could do this better. However, having more workshops per year in country (one at the beginning of the planting season and one after the growing season) would help. Possibly, providing incentives to do so or requiring work goals that explicitly require documentation of outreach activities to the communities served would help. Encouraging PIs to visit the field program for an extended period (one season) would help.

5. *Is the administrative cost of the SANREM Innovation Lab appropriate for its size and functions? Is the present structure adding value to the program, cost effective and efficient?*
   The ME uses less than the allowed 20% of the annual budget which is mandated. The ME is making appropriate use of available resources. By splitting some of the ME staff and faculty

positions with others in the Office of International Research, Education and Development (OIRED) projects, the ME reduced some management costs. Therefore, the structure of the ME is cost effective and efficient.

6. *Has communication by the ME with collaborating partners been effective?*
The communications by the ME management team with collaborating partners is effective. The ME has an open communications policy with all partners through email and telephone calls, as well as postings on their website. All partners are kept informed about SANREM Innovation Lab events, initiatives, meetings, budget and other important aspects of the program. The ME encourages feedback from partners on issues relevant to the project.

c. <u>Financial Management</u>

1. *How well has the ME managed the financial aspects of the SANREM Innovation Lab? Are the U.S. and host country collaborators satisfied with financial management by the ME? How have problems been resolved? Give examples.*
The ME staff is highly qualified and well managed, taking an active interest in the success of the project. The U.S. and host country collaborators appear to be satisfied with the management of the project. Issues did arise with respect to late invoicing of some partners for payments. Therefore, the ME needed to encourage some partners to submit invoices on a timelier basis, allowing the ME to comply with USAID rules on appropriate oversight of balances and payment. The ME also incurred some difficulty on occasion in obtaining supplemental invoice documentation from host country collaborators (e.g., those in Ghana and Haiti). However, all outstanding issues were resolved. The ME is doing an excellent job of managing the project.

2. *How are project resource allocations made? Are the allocations appropriate?*
The ME uses the 5-year budget plan developed during the application for the award of the Phase IV project. Modifications of the budget are made if requested by partners if appropriate for additional research needs and if funds are available. Budget changes have been made for additional research travel, supplies and equipment. Changes in budget plans have been appropriate that allowed the ME to advance their most important goals without too much disruption in achieving their overall mission.

3. *Has the system for reimbursement of expenditures been efficient for all collaborators? What areas need to be improved to address pipeline issues or payment lags?*
The reimbursement system has worked efficiently. However, problems have developed which have been mostly the results of host countries having inadequate tools to provide proper documentation (e.g., internet issues, insufficient bandwidth to upload documents). By working with their partners on obtaining other methods to submit documents, the ME has resolved these problems. The ME also meets with host country administrators to resolve problems that occur.

4. *Has cost matching requirements been met by all partners?*
The cost matching requirements have been met and exceeded by the ME according to information available from the Sponsored Programs Office at Virginia Tech University.

B. Research Program Focus and Output

1. *Are the depth, breadth and rigor of the research and development activities sufficient to achieve stated program goals and objectives? How could the major themes or topics be refined to increase impact?*
   In general, the objectives of SANREM-CAPS are on track, and very pertinent information is being generated for CA adoption and impact. The targets of strengthening human resource and institutional capacity, through workshops and training courses, are being met effectively and impressively. The data being obtained from several CAPS sites (e.g., Cambodia) can be scaled up on regional basis. However, there have been some situations beyond the SANREM Innovations Lab's control such as: (i) the delay in implementation of the project in Haiti because of unforeseen circumstances (e.g., earthquake, cholera outbreak), (ii) disruption of the program in Mali by political situation, and it had to be discontinued and partly shifted to Ghana, and (iii) closing down of activities in Bolivia.

2. *What have been the significant accomplishments in terms of research and technology dissemination?*
   The visit by EET members to Ghana and Cambodia indicated the positive response to CAPS by both men and women farmers. The documents made available to EET also indicate adoption of best practice CAPS in eastern and southern Africa, Philippines and in the Andean region (see Progress Reports listed in the Reference Section XV). However, a full analysis of CA adoption has not been done, and can only be done when more solid information is available as noted above.

3. *Among the projects making significant progress, which ones are scalable for a greater impact?*
   Interviews with farmers in Ghana and the data presented for sites in Cambodia indicated a strong increase in yield of maize, rice, and cassava through the adoption of best practice CAPS. Substantial yield increases have also been reported in Lesotho and Philippines. However, farmers in Haiti were reluctant to provide EET with yield data because farmers harvest crops for consumption as it is being grown. They could provide estimates of money earned rather than yields obtained. Thus, projects with scaling up potential include those in SubSaharan Africa (Ghana, Kenya, Uganda, Lesotho, Mozambique), Asia (Cambodia, India, Philippines) and the Andes (Ecuador, Bolivia).

4. *Which activities have not been as successful as planned and why?*
   As discussed under B-1, program implementation had some setbacks (Haiti, Mali, Bolivia). There are also logistical problems (difficult access) in Nepal and elsewhere. In addition, there are difficulties with identification of an appropriate cover crop that has cash value and is attractive to farmers such as those in Ghana and Uganda. There are also challenges in adoption of CAPS because of social issues (e.g., gender inequity, land tenure), access to inputs (e.g., seed drill, herbicides), and the mindset. The latter refers to cultural attitude towards traditional method, and government subsidies that support certain practices.

5. *How well are the research activities strategically sequenced to ensure targeted development outcomes within a known period?*
   The implementation of SANREM-CAPS on all sites is strategically sequenced to ensure targeted development outcomes within the specified period because the projects are systemic, multi-disciplinary, process-based, and participatory in nature.

6. *How does the ME ensure that research activities or themes complement and do not duplicate other development initiatives in the regions where the SANREM Innovation Lab is active?*
   Working through the grass root networks is the strength of the SANREM Innovation Lab, because it is difficult to work with the farmers directly. The SANREM-ME has established contacts and linkages with other agencies operating in the region (e.g., CIRAD in Cambodia) to ensure synergism and complementarity. Initial linkages have also been established by other USAID initiatives (e.g., Africa RISING in Ghana managed by IITA). However, additional linkages and cooperation are required such as with WINNER and DAI projects in Haiti, and the HARVEST program in Cambodia. Regular discussions must be held with the in-country USAID Missions to strengthen cooperation with the host-country projects.

7. *Do research goals have national policy implications? If so, how are they addressed? Give examples.*
   Host country institutions are actively involved in implementation of SANREM-CAPS. Specific examples of host country institutions visited by the EET are: (i) Centre de Formation Fritz Lafontrant (CFFL), a church organization called CARITAS, and Zanmi Agrikol (ZA) in Haiti, (ii) SARI in Ghana, and (iii) CIRAD and the University of Battambang in Cambodia. In Haiti, the SANREM Partner CFFL has identified 1,500 farm families who are being contacted by students trained in CAPS at the Center, and have promoted cultivation of peanuts (for an enriched peanut butter product to alleviate malnutrition in children) and the use of peanut shells as a mulch. In general, women farmers come for training more than do men farmers.

8. *What was the process for sub-award selection? How effectively did the process yield a high quality, relevant portfolio of activities?*
   The sub-awards to U.S. universities and other partners were made by issuing an RFP, and following the process of external evaluation. The selection criteria included the scientific merits of the proposal, institutional strength, ecological niche of the proposed sites, and existing networks. Judging upon the team assembled, the ME was successful in selecting good partners comprising 40 organizations including U.S. and host-country universities, CGIARs, NGOs, and NAROs.

9. *Assess the balance of domestic versus overseas research in terms of effectiveness of solving constraints in developing countries. Are changes needed in the balance?*
   The SANREM-ME has endeavored to achieve a good balance between the U.S. and overseas research. It has allocated 60% of the total program resources to overseas partners, including those for degree-related training. In general, the field research and greenhouse trials are conducted overseas and the specialized laboratory analyses are carried out at the U.S. institutions. The results obtained overseas are also relevant to smallholders in the U.S. One of the best examples is the work in partnership with ARS USDA to benefit minority farmers in

the U.S. principles of CAPS, and is used in North Carolina to grow vegetables in "high tunnels" increasing the length of the growing season, reducing pesticide application. and boosting productivity. More funds for this project are expected from the USDA-Evans-Allen program.
In other projects, the same principles are utilized to promote conservation agriculture techniques in university campuses and eight high schools also in North Carolina to replace cement and turf areas with vegetable production areas involving students in the process. USDA has contributed funds for two projects that test NT, and summer and winter cover crops in 240 experimental units. These projects contribute to the education of students on agriculture and natural resources and open the possibility for improved greening and sustainability of urban areas as well as for carbon sequestration as referred in the book Carbon Sequestration in Urban Ecosystems (Lal and Agustin, 2011). Experience gained at SANREM Innovation Lab projects with cover crops (e.g., pigeon pea) is also used for local applications.

10. *Please comment on the balance within the SANREM Innovation Lab's portfolio on basic research, applied research, implementation, and human and institutional capacity building?*
A major strength of the SANREM approach is to support and maintain a good balance between basic, applied and adaptive outreach research. Through training (of farmers, extension, agents, bachelor, master and doctoral degree students) and workshops, it has also strengthened the human resources capacity. Improvements in analytical facilities, curriculum development and dialogue towards establishment of CAPS Centers (e.g., Philippines, Cambodia) are successful examples of institutional capacity building.

As is indicated under Recommendations (Section XI), more work remains to be done in process-based basic research, gender-related soil analyses, in-depth study and scaling up.

11. *How does the SANREM Innovation Lab respond to the Title XII "Famine Prevention and Freedom from Hunger" Amendment to the Foreign Assistance Act of 1961?*[1] *How has the United States benefited from the SANREM Innovation Lab's research? Give examples.*
The strategy of enhancing and restoring soil quality and adaptation to climate change by using CAPS is in accord with the Title XII "Famine Preventative and Freedom from Hunger" Amendment to the Foreign Assistance Act of 1961. Yet, with still 925 million food-insecure people around the world (mostly in SA, SSA, RA and the Caribbean), the problem remains, and may even be exacerbated, because of climate change and increases in population. The CAPS program is also aimed at alleviating the drudgery and improving human well-being.

The SANREM Innovation Lab Research has benefited the U.S. by involving faculty, staff and graduate students of the participating universities, promoting U.S. trade in agroindustry, and enhancing good will among the host countries. The CAPS technology for small landholders being validated overseas is also relevant to small landholders and family farms in the U.S.

C. Alignment with Feed the Future Research Priorities

1. *How has the SANREM Innovation Lab aligned with Feed the Future research and development priorities as outlined in the Feed the Future Global Hunger and Food Security Research Strategy and the Food Security Innovation Center program areas? Give examples.* Several SANREM-CAPS sites are located in Feed the Future countries (Cambodia, Ghana, Haiti, Kenya, Mali, Nepal, and Uganda). Thus, promotion of CAPS in these Feed the Future countries is in accord with Feed the Future research and development priorities.

   Yet, much closer association with the Mission-managed in-country programs is required such as WINNER in Haiti, and HARVEST in Cambodia. The Africa RISING program, centrally funded and operating in five countries (Ghana, Mali, Ethiopia, Tanzania, and Malawi) should be a good partner for the new SI Innovation Lab.

2. *In what areas has the SANREM Innovation Lab not aligned with Feed the Future priorities (both research themes and geographic focus)? Where could alignment have been improved?* The SANREM project also supports CAPS in non- Feed the Future countries (e.g., Bolivia, Ecuador, Lesotho and the Philippines). Nonetheless, the strategy in these countries is also strongly aligned with the –Feed the Future Global Hunger and Food Security Research Strategy and the Food Security Innovations Center program areas. (It should be noted that SANREM work in Bolivia, Ecuador, Lesotho, and the Philippines precedes the Feed the Future program). Thus, it is natural to build on and work with some relevant on-going projects.

3. *How well do the SANREM Innovation Lab research and capacity building activities fit under one or more of the seven programs of the Feed the Future Food Security Innovation Center? What are the relevant program areas? How can this fit be improved?*
   The SANREM-CAPS is partly aligned with the section 7 of the Feed the Future programs (Sustainable Intensification). However, there are several recommendations to improve its fit for SI (refer Section XI-C) which need to be addressed.

D. Human and Institutional Capacity Building (HICD)

1. *How has the SANREM Innovation Lab been effective at building the capacity of host country researchers, policy makers and practitioners?*
   The SANREM Innovations Lab has an impressive record in human and institutional capacity or HICD building (refer section VII). However, more needs to be done with regards to placement of additional students from the U.S. and overseas, especially in the realm of process-oriented research, which would require substantially large resources. The SANREM Innovations Labs have invested about 35% of its budget in students.

   The impact can be measured by the following indicators: (i) number of host-country nationals trained, (ii) subsequent employment of trained personnel on key positions in industry, extension, research and academia, (iii) ecological, economic, and societal (social, gender, cultural) impacts in the host country.

However, these are long-term indicators. These impacts cannot be measured over the short time that the SANREM has operated. The SANREM Innovation Lab has the potential to develop long-term research/outreach partnership with the NAROs to have long lasting effect which can endure beyond the immediate project activities.

2. *How well has a pipeline of students been cultivated for long-term degree training opportunities?*
   SANREM has been successful in training graduate students from host countries and the U.S. These students were involved right from the implementation stage, and will be able to successfully complete their degree programs. These students have achieved good academic performance, and also demonstrate commitment and dedication to their projects.

3. *Has the program been successful in selecting the right mix of students from appropriate institutions? Are these graduates returning to their home countries to continue work in their respective fields?*
   From the documents provided to EET, students recruited by the SANREM Innovation Lab are academically meritorious and represent diversity in discipline and geographic region. All students from overseas are expected to return to the home countries upon completion of their degree program.

4. *Compared to the research activities, what has been the level of effort and investment in training and institutional capacity building? Is it sufficient?*
   The ME estimates that about 30% of the total budget is used solely for graduate training. In addition, a large proportion of the travel budget also contributes towards graduate training.

5. *Noting the BIFAD CRSP review recommendation on institutional capacity building, how has the SANREM Innovation Lab performed in this area? How could it improve?*
   SANREM has mostly focused on collaborative research and training (degree and short-term). But, the SANREM Innovation Lab has provided only limited support towards institutional capacity building (e.g., some lab equipment) and in curricula development in sustainable agriculture towards selected universities in SSA. It would be important to encourage U.S. faculty to teach for a semester overseas, and invite host-country faculty to teach at the U.S. universities. This would be an important mechanism to strengthen curricula for all universities. South-South cooperation must also be promoted.

6. *How can impact of institutional capacity building be captured and measured more effectively?*
   The SANREM Innovation Lab has identified some performance indicators above in D1 (e.g., number of host country students, etc.). However, it is too early to assess the impact of institutional capacity building on biophysical, economic, and social factors on regional basis.

E. Collaboration, Outreach, and Technology

1. *What outreach strategies have been integrated into project design to increase the likelihood of uptake and utilization of research results? What have been the most effective strategies for outreach at the country level?*

SANREM Innovation Lab projects were designed to work with diverse partners and a wide range of stakeholders depending on each country's needs and the types of partners that existed in various locations, as well as with the persons there who were interested and available to work on CAPS. The array of partners that SANREM Innovation Lab was able to incorporate reflects a great deal of thought and effort to produce a diverse set of stakeholders and assistance in project execution. These can be grouped into the following four categories.

- The first group is a large array of farmers' organizations (AT Uganda), agricultural cooperatives (e.g., KACOFA, Uganda), and NGOs (e.g. AT Uganda; Manor House and Sacred Africa--Kenya; LI-BIRD--Nepal; Growing Nations-Lesotho) from national to local (community) levels. Also included are international NGOs and relief organizations (e.g., World Vision Haiti).
- The second group is a comprehensive set of research institutes and centers (including NAROs--e.g., SARI, Ghana, West Africa and the CGIAR-e.g., IFPRI).
- The third group consists of universities, colleges, and training institutions (e.g., Makerere University in Uganda; Moi University in Kenya; University of Lesotho; Tribhuvan University in Nepal; Orissa University of Agricultural Technology in India; University of the Philippines-Los Baños; and the University of Battambang in Cambodia).
- The fourth group includes agencies similar to USAID (e.g., the French development agency AFD (Agence Francaise de Developpement), which works through CIRAD in Cambodia.

2. *How have research outputs been disseminated at the regional and global level? What tools have been used (i.e., hosted events, publications, web sites) and how effective have they been? Give examples.*

   LTRA projects and CCRAs include a diversity of outreach activities that have brought in farmers for field days, focus groups, co-design activities, workshops, farmer-to-farmer visits, and other interactions in which over 20,000 farmers have participated since 2009. Field days and workshops have been among the more effective strategies for outreach. Collaboration with cooperatives to allow scaling up dissemination efforts has been done. In addition, outreach to farmers and the partners' networks has been able to target thousands of other households and individual farmers using students, as well as extension and agency staff members who regularly work with local communities has been tried. For example, in Haiti alone 1,500 households received information about CAPS from students who regularly work with their local communities as part of the program at the Zanmi Agrikol (ZA) and the Centre Formacion Fritz La Fontant training center.

   As noted earlier, the SANREM Innovation Lab has collected the data using Common Indicators (Form 19), along with detailed case studies and gender-disaggregated tallies of farmers' participation and technology uptakes, and is in the process of correlating all the data for this year's annual report. Uptake of technologies occur over several years due to farmers' keen observations of results, as well as varying weather conditions (climate change issues) through the cropping seasons.

3. *Does the SANREM Innovation Lab have a plan for technology dissemination? How effective is it?*

The SANREM Innovation Lab projects have hosted events, conferences, and websites, as well as produced a significant number of scholarly works. its researchers have published books and papers related to their projects in both refereed and non-refereed journals, popular publications, and proceedings of meetings, as well as making presentations at scientific conferences, technical meetings, and outreach events. The SANREM Innovation Lab organized the Second International Conservation Agriculture Workshop and Conference in Southeast Asia in Phnom Penh in 2011, and the third in Hanoi in 2012. The Fourth Conference on Conservation Agriculture will be held in December of 2013 at the University of Battambang, Cambodia.

SANREM's ME has organized special sessions of Agronomy, Crop Science and Soil Science at international annual meetings. The ME has displayed program achievements at the National Council for Science and Environment annual meetings in Washington, D.C. SANREM scientists and graduate students routinely present research findings and project overviews in national and international venues. The ME has provided funds for editing and publication of meeting proceedings and books related to SANREM work.

The SANREM Innovation Lab maintains a comprehensive website that contains its large array of project publications, information on and for partners' activities, articles for lay audiences, as well as videos, news, and other materials. A full-time public information officer is part of the ME staff and produces briefs, brochures, and videos, and coordinates social media activities. All materials generated in the SANREM Innovation Lab projects are stored in an online repository called the SANREM Knowledge Base (SKB). Outreach efforts are effective, and according to the ME, have often generated possibilities for networking and further collaboration (e.g., with CIRAD in Cambodia).

In terms of technology dissemination plans, the LTRAs are responsible for building local networks to disseminate CAPS knowledge and practices. A wide range of stakeholders noted above have been brought in to help, thereby expanding what a project can accomplish on the one hand, and laying the foundation for continuation and up-scaling, on the other hand. Efforts at broad-based stakeholder mobilization have been implemented in LTRA-9 (Lesotho and Mozambique), LTRA-11 (India and Nepal), LTRA-10 (Kenya and Uganda), and LTRA-12 (Cambodia and Philippines), as well as those that are developing in LTRA-6 (Haiti) and LTRA-8 (Ghana).

4. *Has the SANREM Innovation Lab partnered with the right collaborators to implement and disseminate the outputs of the research program? Who else should they partner with?*
   It appears that the SANREM Innovation Lab has partnered with the right universities and NGOs, although there is always benefit from additional partners and collaborators. The SANREM Innovation Lab 's links to the CGIAR centers and other such research organizations (e.g., SARI) has allowed them to reach many participants in the agricultural networks in the target areas. Increased interactions with NAROs and NARIs and universities would be beneficial.

5. *Are there any unexplored areas of collaboration between projects that are feasible and have potential? Give examples.*

It would be beneficial to foster more peer-to-peer horizontal communication between and among the SANREM Innovation Lab projects. This would enhance synergies among projects; e.g., create synthesis on CAPS utilizing intercropping/relay crops in farming systems having common features; i.e., maize-beans-cover crops systems in southern, eastern and western Africa; testing and promotion of innovative farming implements for small householders. This would promote the sharing of information between and among the LTRAs in terms of methods and techniques that have been successful and constraints that have been found. Here are some examples.

a. CAPS tools and techniques: A variety of tools (hoes, shallow plows, seeders, etc.) for CAPS methods (NT, MT, seeding, mulching, etc.) have been developed and used in each of the LRTAs, However, information and actual tools do not seem to be well shared among the LTRAs. Similarly, information on adjustments in CAPS procedures such as methods of minimum tillage when farmers cannot accomplish NT, and use of various plowing strategies has not been generally shared.

b. Women CAPS adopters: Information on gender strategies also needs to be shared, especially the demographic and financial characteristics of CAPS women adopters and the project methods used to work successfully with women compared to working with men. As the EET collected the answers to its questions on this topic (see Appendix VII), some of the LRTAs had many successful strategies, while others had but few. Participation in trials and adoption by women appears to be lower in the LTRAs that have focused more on technical aspects and not as much on social issues. Also having female PIs and graduate students working with the farmers has produced better environments for women to become adopters.

Communication between SANREM and other projects.

a. In each country visited, discussions with the USAID Mission and with SANREM partners revealed a number of USAID projects focused on dissemination more than on research (e.g., WINNER in Haiti, HARVEST in Cambodia). A coordinated effort such as proposed by BIFAD and others would help in the development of tech packages, and help to provide more services to the types of farmers that SANREM has been working with. (More will be said about this in the section on recommendations).
b. Excellent cooperation in terms of personnel, trials, and dissemination to both women and men farmers was found in Cambodia between LTRA-12 and CIRAD (the Centre de Coopération Internationale en Recherche Agronomique pour le Développement, the French Agricultural Research Centre for International Development). Such examples might be found elsewhere.

F. Gender Inclusion

1. *Does the SANREM Innovation Lab have a formal plan for integrating gender in all of its activities?*

   The SANREM Innovation Lab has gender (CCRA-7 Gendered Knowledge) as one of its cross-cutting research activities. As a result, there is a formal plan to integrate women and

gender issues in all LTRAs and other CCRAs, long-term degree training, short-term farmer training workshops, and project staff members' understanding. A Gender Coordinator is part of the ME, and she also supervises graduate students at Virginia Tech working on gender studies. Students have been sent to Bolivia, Cambodia, and the Philippines to carry out research for their degrees (M.A. and PhD) and to work with farmers. The Coordinator also helps guide the gender components of the other LTRAs.

2. *How has gender been taken into consideration in research design, training and outreach strategies? What have been the results? What areas could be improved and how?*
The aim of the SANREM Innovation lab has been to include gender issues and integration in all projects. A major focus has been on gendered knowledge that was initially outlined in the original RFA and the LTRAs agreed to work to include this topic, as well as with the other CCRAs. Beginning with each project's first year, the ME carried out rapid rural assessments in the field looking at gender and other social issues. This served as a research and a training opportunity for regional team members; this was accompanied by presentations and training in gender-sensitive, participatory methodology in each country. Strategies for increasing women's participation were one of the main topics addressed.

The LTRAs are required to report data on gender (participation mostly), as well as their strategies, successes, and constraints on targeting women farmers and addressing gender issues in CAPS endeavors. LTRAs are also tasked with examining the gender composition of long-term training and reporting on project personnel. The Gender Coordinator and her students have given presentations on gender issues at annual meetings of national and international conferences. These presentations and other articles are part of the gender resources are available on the SANREM website to guide the LTRAs and host-country partners.

Besides participation, the main focus of CCRA-7 is gendered knowledge. It was originally focused on women's and men's knowledge of soils in terms of types and fertility variables, as well as in relation crop-livestock management. One methodology has been qualitative case study-based research and eliciting local beliefs and perceptions about women's and men's knowledge. These findings are linked to farming practices so as to shape access and control over farm resources such as land, labor, capital, and inputs. The objective is then to relate local knowledge (differential or similar by gender) to scientific research data. Quantitative data are only generated in connection to technology networks (CCRA-8 and CCRA-6).

CCRA-7 initially focused on gendered knowledge in Bolivia where women's and men's knowledge of soils used for livestock grazing (of sheep and cattle, respectively) was linked to their cropping systems and potential to be CAPS adopters. A Chart of Research Questions and Methods provides an excellent guide to research questions on knowledge of soil descriptors, access and control of better and worse plots, care and use of soils, and usage of diverse landscapes. The CCRA studied similar engendered conceptualizations in the Philippines for crops and livestock that similarly affected the farming system. The EET noted that many of the reports from the LRTAs did not mention much on gender issues and women's issues. Further investigation showed that although this was true in some report

writing, in the actual project work, gender balance and women participants in all endeavors was followed very carefully. One example was in LTRA-10 Kenya and Uganda, where women participants were high and included most of the adopters.

The EET recognizes the qualitative aspects of this research. Some quantitative work was also performed during the economic studies in all projects. Yet, EET finds fault in limiting the quantitative data mostly to network mapping. It seemed to the EET that the LTRAs have a rare chance to link gender analysis to soil analyses variables (based on lab analysis of soil samples). However, this requires the soil scientists in the LTRAs to take the results of soil analysis data and link them back to the gender of the farmer. Links could also be established to nominal variables such as participation in training, adoption of the different aspects of CAPS, land ownership and plot size, livestock ownership, farm income produced, use of inputs, credit and financial aspects, and labor variables.

The CGIAR and USAID recently released the Women's Empowerment in Agriculture Index (WEAI) (sectionVII-5) for use in estimating decision-making by women and men. The CCRA 7 is currently trying this in Cambodia, with its graduate student and the Gender Coordinator working to define the local characteristics to input into the Index's model.

G. Monitoring and Evaluation

1. *What types of monitoring and evaluation have been undertaken by the ME? Are social scientists used to conduct broad impact assessments?*

The ME has been monitoring performance of all SANREM Innovation Lab's's LTRA and CCRA projects through annual and semi-annual reports, review of work plans, and country site visits for the seven regional programs. Progress has been measured against the expected output, result or impact stated in the work plans, and assessment in terms of responsible partners (the U.S. based PI and the Host Country partner); data on numbers trained have exceeded targets set in the POP Manual and annual work plans. Items measured include: baseline surveys, data collection of all types, identification of partners, farmers' training programs by gender participation and content, long-term graduate student training, M&E of field experiments and studying the effects on soils, methods of dissemination with farmers, and project budgets. However, there are no aggregate figures on total adopters for Phase VI because these are being compiled. The ME rationale is that so far only three years of adoption of CAPS data in many of the LTRAs (1-2 years in Haiti and Mali), and the LTRAs need to complete a few more growing seasons to incorporate these data into the results.

The SANREM Innovation Lab's social scientists also carry out specific and more comprehensive impact assessments. In the SANREM Innovation Lab's Phase IV, each regional project has economists on its team to help with the design and implementation of assessments. There is also a cross-cutting project on Impact Assessment, headed by economists who work with the regional programs. Two cross-cutting projects, CCRA-7 Gender Analysis and CCRA-8 Technology Networks , are headed up by a gender specialist and a rural sociologist, respectively. They use various indices (e.g., WEAI) and network

analysis to measure the benefits for women adopters and farmers' networks to obtain and disseminate agricultural information and innovation.

2. *Did the SANREM Innovation Lab put in place a system to capture the impact of its research investments, and if so, how effective was it?*
In the SANREM Innovation Lab's Phase IV, the paradigm switched to CAPS) as the main cross-cutting theme. Hence, a new impact assessment was put in place that works with each regional program. The key questions that are addressed by the assessments include the following questions:
   - Are particular CAPS designs in specific countries profitable in the short run? And year by year subsequently?
   - If profitable, what are the optimal CAPS methods in each setting?
   - What are the potential and economic, social, and environmental impacts of wide-scale CAPS adoption? What are the actual economic, social, and environmental impacts?
   - What are constraints to CAPS adoption for men and women farmers and for poorer and wealthier farmers?
   - What are the adoption rates of CAPS over time?
   - What policy changes encourage CAPS adoption, especially if the CAPS are beneficial in the long run but not profitable in the short run?

The issue of short-term profitability is important for impact assessment, because if the CAPS practices are not profitable in the short-term, there will be little adoption and hence no long-run impacts of the project without additional interventions. LTRAs are using income information from the on-farm field trials to assess CAPS profitability, but, of course, these may differ from actual findings from specific farmers' fields. In Ecuador and Nepal, optimization models were run to test the optimal mix of CAPS practices. In other sites, income and budget data were collected for profitability analyses as were data on soil carbon content to study environmental benefits of CAPS.

As of yet, all the data have not been analyzed on these benefits by region, but they need to be done now, even if preliminary, while surveys continue to collect information on the constraints to CAPS adoption at each site. The benefits and adoption of CAPS practices developed through the entire project should be looked at comparatively within the LTRAs. CAPS may require additional policy and financial interventions to encourage more adoption, such as payment for environmental services, and farmers' financial capacitation).

Some examples of preliminary calculations by the LTRAs based on projections demonstrate the benefits of CAPS. For example in Lesotho, maize with fertilizer is projected to return $7.5 million per year assuming a 5% adoption among current maize producers and a net present value of $38 million over 12 years. In the Ecuadorian highlands, CAPS is projected to return almost $20 million per year and a net present value of almost $100 million over 12 years for the maize part of the rotation assuming only a 1% adoption rate. CAPS in Ecuador is projected to return $500,000 per year with just a 1% adoption and a net present value of $3.3 million over 12 years for the part of the rotation with beans. In Nepal, CAPS with a maize-based rotation is projected to return $1.5 million per year with only a 1% adoption rate and a net present value of $13.1 million over 12 years.

Economic analyses are underway in the other sites and some show short-run profitability. In one site in Ecuador, joint experiments are being conducted in collaboration with the Feed the Future Innovation Lab in Integrated Pest Management (IPM) and data will be collected so that joint economic benefits of CAPS and IPM can be assessed together. One impact study in Ecuador found that the optimal set of CAPS in a potato-based rotation (with other crops) in an upper watershed yielded an additional $2,280 for an average farm parcel (> 1 hectare). An optimal set of CAPS practices in a mid-mountain watershed yielded a $7,700 annual benefit for an average farm parcel of less than 1 hectare (planting maize, oats-vetch, and beans rotation with reduced tillage, manual weeding, and cover crop).

3. *Are the indicators used effective at capturing and communicating the outcomes and impacts of research activities? Are there appropriate indicators for each stage in the research continuum? Have indicators capturing impacts and outcomes on higher levels been developed.*

   Developing a CAPS project involves research over several years before recommendations can be made to farmers. The question is how to best assess both the process and the outcome. The LTRAs have data measuring hectares covered (less useful during the early research phase of the project), the number of farmers and other stakeholders participating disaggregated by gender, and the types and numbers of CAPS and their components being tested in an area/region. Projections of economic benefits per hectare from the project's trials and experiments are useful indicators of potential impacts. Combining these measures with potential adoption rates gives an early indication of potential market level impacts in the future.

   However, reliable numbers can be generated only after several years of diffusion of CAPS, so that the actual rather than the potential impacts at the farm and market (higher) level can be measured. Thus far, only projects that have had several years of trials, farmer adoptions, and farmer's remuneration from sales have enough data on a per annum basis for analysis. As noted above, quantitative data are being compiled that will include all three years, 2010 to 2013.

4. *Have baselines been established? If not, why? Are data collected valid and of proper quality for reporting?*

   Baseline surveys were designed to be part of all LTRAs and most were undertaken in the regional programs to gather the data against which future adoption of CAPS developed by the project could be measured. Over 2500 farmers were surveyed. Surveys have been completed in Ecuador, Bolivia, Lesotho, Mozambique, Ghana, Haiti, Nepal, Kenya, Uganda, and Cambodia.

   However, these surveys are not consistent in content. Some surveys were done by project staff, some by partners, and some by graduate students (e.g., Cambodia, Haiti, Kenya). The sampling methods and sample sizes by locals within the regions tend to be good and well thought-out. However, only some are genderized and only some take into account the various types of farmers in terms of farming system, land holdings and tenure systems,

livestock ownership, family composition (male-, joint-, and female-headedness), family and hired labor, and other wealth or poverty factors.

The surveys do provide data for assessing factors that may influence the adoption of CAPS. In addition, several studies are being conducted that relate to impact assessment. For example three graduate students are currently completing theses (using Choice experiments) to assess the tradeoffs that farmers make with respect to profitability versus risk, short-term versus long run profits, and income versus environmental benefits, as each of these factors may influence CAPS. These students are gathering their data from Latin American and East Africa sites.

Another student completed a study of the profitability of CAPS in Ecuador and optimal implementation of CAPS. Other impact studies with graduate students in the regional programs are underway in Mozambique, Haiti, Ghana, and Cambodia. These graduate studies are of great benefit to the students and the projects. However, they produce surveys that differ in disciplinary focus, methodology, and topics covered, thereby limiting comparisons between both sites and cross-cutting themes (including gender and technology networks).

Data collected from baseline surveys on input and yield data from the field experiments in each regional program tend to be meticulously done. However, replicated experiments set up in cooperating farmer fields are analyzed in aggregates, and almost never disaggregated for greater accuracy by categories of farmers (e.g., wealth level, holding size, soil quality, gender, CAPS training and knowledge, etc.).

While scientists might like to randomize farmers' experiments and where they are placed in fields (and soil types), this has not been possible given the need to have farmers agree to participate during several years. So the LTRAs are left with projections in early year evaluations on adoption of CAPS practices. The real need is for measurement of actual adoptions but that requires several years of the same farmers doing CAPS. It is difficult to pack in trials adoption and time depth for adopters in a five-year project where the first 1-3 years require scientific experiments and careful data collection, then 1-2 years of dissemination work, and then 2-3 years of data for the adopters.

XI. RECOMMENDATIONS

A. SANREM Innovation Lab

1. Soils and Natural Resources

The research, training, extension, and outreach done by the SANEM Innovation Lab over a short period are impressive and highly commendable. Yet, there is no cause for complacency, and much more remains to be done. The following recommendations are made towards any future endeavor in the present or any new SI Innovation Lab that may emerge.

a. Conservation Agriculture

i. *Sites*
Rather than numerous countries and many sites within each country, the focus should be on fewer sites located in key biomes and ecoregions which are representative of large areas so that results can be up scaled and extrapolated even with data from limited sites. The regional focus on SSA and SA may be appropriate.

ii. *Process-oriented*
The much needed in-depth assessment of CAPS-induced alterations in ecosystem properties and processes (biophysical and the human dimensions) require highly focused programs involving key disciplines. With fewer sites, research should be in-depth study/analysis of underlying processes (e.g., soil quality, impact of climate change and on soil and water resources under CAPS, and agronomic/forest productivity, decisions-making processes, gender dynamics). In combination with biomes/ecoregions, extrapolation and scaling up must also involve key soil properties and processes (e.g., SOM/SOC dynamics and quality, and greenhouse gas emissions). Inter-disciplinary research does not mean lacking in-depth disciplinary research. Conducting in-depth disciplinary research is essential to ensuring that broad-based research does not fall apart under its own weight.

iii. *Scalable technologies*
Within the CAPS, it is important to identify the site-specific scalable components (e.g., cover crops, manuring, seed drill, herbicide) which are critical to extrapolation to large areas.

iv. *Choice of management options*
Fertilizer rate and kind must be based on soil test and the desired agronomic yields. In addition to soil, analysis of plant tissues obtained at the critical stage of crop growth must also be done to identify specific nutritional constraints.

v. *Drought stress*
Soil water deficit, in combination with supra-optimal soil temperatures (~50° C at 2cm depth where the growing point of cereal crops lies for several weeks), is a critical issue.

Thus, implementation of CAPS along with drip sub-irrigation done through water harvesting and recycling should be an important priority.

vi. *Seed drill*
The lack of appropriate seed drill, which cuts through the crop residues and ensures a good crop stand, is the major hindrance to adoption of CAPS. This constraint must be addressed in close cooperation with the private sector.

vii. *Specific Crops*
Rather than working on a range of crops, selecting key food staples (maize, rice, wheat, cassava) is a recommended strategy. These crops may be the same as those researched by the CGIAR Centers and other Innovation Labs (former CRSPs).

viii. *Fertilizer Treatment*
Fertilizer treatment should be integral to CAPS experimentation. Not using chemical fertilizers in Haiti, though of some relevance to resource-poor farmers, leaves out an important option which may become relevant in the near future. Poor and stunted growth of maize crop without chemical fertilizers, visited by EET at one of the sites in Haiti, is a strong indication that a judicious use of fertilizers must be included as an experimental treatment for testing on CAPS sites.

ix. *Conservation Agriculture Center*
Establishment of CAPS Centers for both undergraduate and graduate degree programs is needed for key biomes/ecoregions (humid, semi-arid and arid/irrigated tropics). These centers must be multi-disciplinary, and involve distant learning to avail benefits of faculty at far away institutions.

2. Human Nutrition

The SANREM Innovation Lab should continue to strive for improving soil health and reducing soil losses through CAPs efforts. This is a long-term strategy that cannot be accomplished in a few years. Building soil health to fertile conditions takes years of sustained effort. The SANREM Innovation Lab should strive to determine all limiting nutrients in the soils where its projects exist. Not only macronutrients (e.g., N, P, and K) but also micronutrients should be part of this effort. Many of the micronutrients are required for efficient utilization of macronutrients, such as N, P, and K, by crops. Inadequate available levels of some micronutrients, such as zinc, can result in the need to use excessive amounts of macronutrients to achieve yield increases, and maximum yields will never be achieved without correcting the deficiencies of micronutrients first. Not knowing what these limiting nutrients hinders progress in building healthier, stable soils. Once identified, means need to be found to supply limiting nutrients in ways that are affordable and attainable by farmers, especially resource-poor farmers.

To be successful in the future at attracting funding from the Feed the Future initiative, SANREM Innovation Lab should broaden its scope to form closer ties with nutrition and health. It should develop food system thinking (from farm to plate) and strive to help maximize nutrient output of farming systems through improvements in soil health and cropping systems. It is recommended

that the program closely collaborate with the Feed the Future nutrition and health efforts. Feed the Future has several important objectives related to improving dietary quality and nutrition. These as stated under Feed the Future Global Hunger and Food Security Research Strategy of May 2011, include:

i. Increase the availability of, access to, and consumption of nutrient-dense foods (animal source foods and legumes, by women and children, and increasing the nutrient content of key staples through bio fortification (using both plant breeding and agronomic strategies).
ii. Design sustainable intensification technology, management practices and policy research to ensure that water and other system factors promote nutrition and health and complement interventions that underpin food security for marginal and vulnerable communities.

It was also clear from the answers to the questionnaires that the SANREM Innovation Lab should pursue closer linkages with the nutrition community to align with the goals of Feed the Future programs. It should broaden its scope to include food systems thinking to increase the nutrient output of farming systems through sustainable intensification research with focus on nutrient deficiencies that occur in people in their study regions. Possibly, nutrition education for farmers and families could also be given in their training programs.

3. Gender Recommendations

1 .Step up training in business and financial management for women

Many aspects of the SANREM Innovation Lab projects ensure that women are being contacted and participate in training courses and workshops, as well as that they receive training and learn correct information to become CAPS adopters. However, women need training in agricultural economics and management, as well as methods to manage agricultural businesses as they move into commercialization.

2. Work with host countries and partners to ensure secure land tenure for women

A main deterrent to carrying out enhanced CAPS practices for women is the lack of secure land tenure. Problems are often cited as cultural. Women in the project in Northern Ghana who were trial participants and started to adopt CAPS had the land taken away from them and had to drop out of the program in a male-dominated culture. To avoid this kind of indignity, the SANREM Innovation Lab needs to help women in negotiations with male leaders and consider policy/legal work within the mandate given by USAID. Before new USAID projects provide funds, it needs to have assurances from the host country that land tenure and access will be continued for women during the entire course of the project. For women to expand their reach they must also be able to make land purchases that will not be revoked.

3. Have better comparative data and comparisons of findings of LRTAs on gender

The cross-cutting themes, with gender in particular, would benefit by having more comparisons of the LTRAs' data. Appendix VI compares the answers on the EET's Socio-economic and Gender Questions, and Tables in Section VI-B compare participation and adoption of CAPS. Much more of this is recommended and could include access and control of resources such as land and farm machinery; and farm as well as yields and incomes from CAPS.

4. Prepare more quantitative analyses that are disaggregated by gender

The CCRA-7 focused more in quantitative and case-study based work. It gained excellent data on participation, cultural categories (especially of soils), and technology networks. However, greater use of quantitative data from the soil analysis labs that relate back to gender of farmer and the conditions of soils in farmers' plots would provide better analysis of yields and constraints to production. More quantitative data on gender similarities and differences in the following variables is recommended.

- Farmer typologies and wealth levels,
- Land holding size and land tenure,
- Soil fertility or nutrient depletion,
- Farm machinery usage and ownership,
- Use of cover crops and mulching, and
- Use of personal and community-based networks to receive information about CAPS and to give information to other farmers

B. USAID

1. Soils and Natural Resources

In all three countries visited (Haiti, Ghana, and Cambodia), the lack of communication and of any interaction among different stakeholders was obviously a major hindrance to an effective/coordinated program planning, and it must be addressed. Specific issues regarding communication and cooperation are as follows:

a. Collaboration Among Innovation Labs

The SANREM and IPM Innovation Labs must work together. Weed and pest control in CAPS can be achieved only through appropriate use of IPM. These two Innovation Labs should be justifiably merged.

In addition, commodity or crop-oriented Innovation Labs (sorghum, beans, etc.) must provide input into SANREM/IPM Innovation Labs for appropriate varieties, crop combinations, and innovative management systems.

b. Communication Among Projects

USAID's in-country Missions are managing several projects. In Ghana, for example, there is ADVANCE, RING, etc. There is also a centrally-funded Africa RISING program. Despite overlapping objectives, there seems to be little communication or cooperation among them, and

greater coordination between larger and small projects would be desirable.

c. USAID-Based Programs Emerging from Washington

Programs emerging from Washington may not be well vetted with the in-country USAID Missions. Thus, there is often no prior communication with the Mission regarding the objectives of any specific delegation or a team visiting the country. Consequently, none or poor communication causes confusion, misunderstanding and difficulties in proper implementation of programs. The goal is to enhance synergism and cooperation (Refer Section IX-E).

d. Projects Without Borders

The need for a strong dialogue between Washington, in-country Mission, and the Innovation Labs (e.g., SANREM) would create the much-needed "Projects Without Borders." Presently, however, most projects are being implemented with little if any interaction among different stakeholders, leading to avoidable duplication and redundancy.

2. Human Nutrition

USAID should recognize that saving soils and improving soil health is paramount to increasing agricultural production in the future and should continue to support research directed at this. Commitments to doing require a the long term because building soil health and reducing soil erosion requires many years to achieve successful outcomes. Increasing soil health and fertility is also required to produce nutrient-dense food crops. Research projects should focus on ways to improve the nutrient output of farming systems in order to reduce the tremendous burden of malnutrition, especially in resource-poor communities. The agency should invest heavily in food system thinking and recognize that "nutrient security" not "food security" as the real focus of agricultural production efforts.

Agriculture is the only way to find sustainable means to eliminating malnutrition and the maladies associated with it: diet related non-communicable diseases, stagnated development efforts, lower worker productivity, lower education attainment, earlier marriage, higher population growth rates, and increased morbidity and mortality rates especially among the under privileged poor.

3. Social and Gender Aspects

a. Include CAPS in the new SI Innovation Lab

The new SI Innovation Lab should continue a focus on CAPS. Although it represents a significant paradigm shift for researchers and U.S. agricultural institutions, as well as for host-country farmers and partners, it has the potential to bring excellent benefits to small farmers in terms of improved income, a more reliable food supply, and reduced labor requirements; these benefits are difficult to achieve with other traditional methods.

NT and MT agriculture allow for substantial cost savings on farm services. Since there are no tillage fees for hiring oxen and tractor services, as plowing is not required. In some cases, CAPS may also reduce the need for pesticides, and can help achieve increased incomes in the market value chains by producing much better yields. The main purpose of using CAPS is to increase

soil fertility, reduce the need for costly fertilizers, and reduce soil erosion through carbon sequestration and decreased soil disturbance. Many CAPS practitioners go on to increase their land holding size because they can manage larger holdings due to the use of no-till practices and less weeding.

CAPS has a number of benefits particularly for women farmers in that it reduces weeding, due to the use of cover crops, mulches, and herbicides. Women farmers are the ones who do the weeding, and most planted fields are weeded two to three times per season. Although time-allocation studies measured weeding in conventional agriculture in the 1980s and 1990s, as documented in the women in development literature, such time-allocations measurement (that require extensive periods of time have not been repeated with CAPS. Rather the data now come from case studies (such as in SANREM Innovation Labs LTRAs) of women farmers who discuss these labor reductions. The EET heard repeatedly from women how much they appreciated the NT or MT agriculture and how much they appreciated the significantly reduced weeding required for the first weeding (the more difficult one), and that the second weeding required even less time. Weeding a third time was usually not necessary. Some women whom the EET met with in Ghana and Cambodia were able to double and triple their land holdings (through land purchases using income gained by CAPS) due to NT and less weeding tasks.

b. Enlarge the graduate training program in the new SI Innovation Lab
To train future CAPS experts, the new SI Innovation labs should endeavor to locate the "best of the best" students in Feed the Future project countries to receive advanced academic degrees such as doctoral, masters, and bachelor degrees. Students who have completed their programs can then return to their home countries to provide much-needed scientific expertise in agriculture and also assist with cultural issues in working with farmers on such aspects as gender equity in inputs, training in new technologies (including CAPS), and leadership in farmers' organizations.

c. Link Feed the Future funding initiatives and future small projects
Even though SANREM Innovation Lab received funding since the inception of the initiative and is integral to the Feed the Future Research Strategy, the EET found the USAID Missions had little contact with the SANREM Innovation Lab LTRAs. A frank discussion with USAID Mission staff in Cambodia revealed the balance between projects configured and funded by USAID in Washington, on the one hand, versus projects managed by USAID Missions, on the other. Representatives and evaluators of projects planned and monitored by Washington, were thought to be constantly "thrust" upon local and understaffed USAID Missions at short notice.

USAID Mission officers that the EET visited praised Feed the Future initiatives such as the $200 million WINNER project in Haiti, the $65 million HARVEST project in Cambodia, and the new series of projects in Ghana under Africa RISING. They lauded their objectives such as: increased competitiveness of major food value chains; improved resiliency of vulnerable households; and improved nutritional status of women and children. They were enthusiastic about Sustainable and Broadly Shared Economic Growth projects whose objectives were: increased competitiveness of major food value chains; improved resiliency of vulnerable households; improved enabling environment for private sector investment; and increased government accountability and responsiveness. It is suggested that R&D components be included in future

projects. How to link the Feed the Future projects to US universities (under the BIFAD model) needs to be determined.

As well, the new SI Innovation Lab would certainly benefit from working with the private sector in terms of tools and machinery fabrication and sales for CAPS. It could also assist in farmer baseline studies, women's participation and technology usage, and technology networks.

d. Emphasize science and scientific agriculture in all training and capacitation projects for women

One thing that the EET liked about the SANREM Innovation Lab's-LTRAs is that both women and men received the same technical information and assistance. Methods, tools, and machinery were not reserved for one sex. Women were not segregated into doing a reduced type of CAPS; rather they received the technical aspects in the exact same manner as men. Some women may have been limited in their land size holding more than men and therefore CAPS could not be adopted or all aspects of CAPS could not be, but others were not.

The emphasis on science, and doing scientific trials and farming methods that are not genderized is important. Scientific agricultural knowledge and activities must not be dumbed-down in new USAID project programming. Women and girls need training in scientific agriculture, and need to be included as equal partners in trials and experiments.

XII. CONCLUSIONS

A. Achievements

1. Operationalizing the CAPS

The planned programs of CAPS have been implemented at all sites, despite setbacks at some locations (e.g., Haiti, Mali and Bolivia), and difficult logistics at others (e.g., Nepal). This is a commendable achievement. Operationalizing the CAPS has been facilitated by identifying the site-specific package of CAPS, establishing modus operandi with all stakeholders, organizing workshops and training courses, facilitating the procurement of essential inputs, and providing logistic support to faculty and graduate students (Fig.4). However, the last step of "Scaling up" has not yet been operationalized.

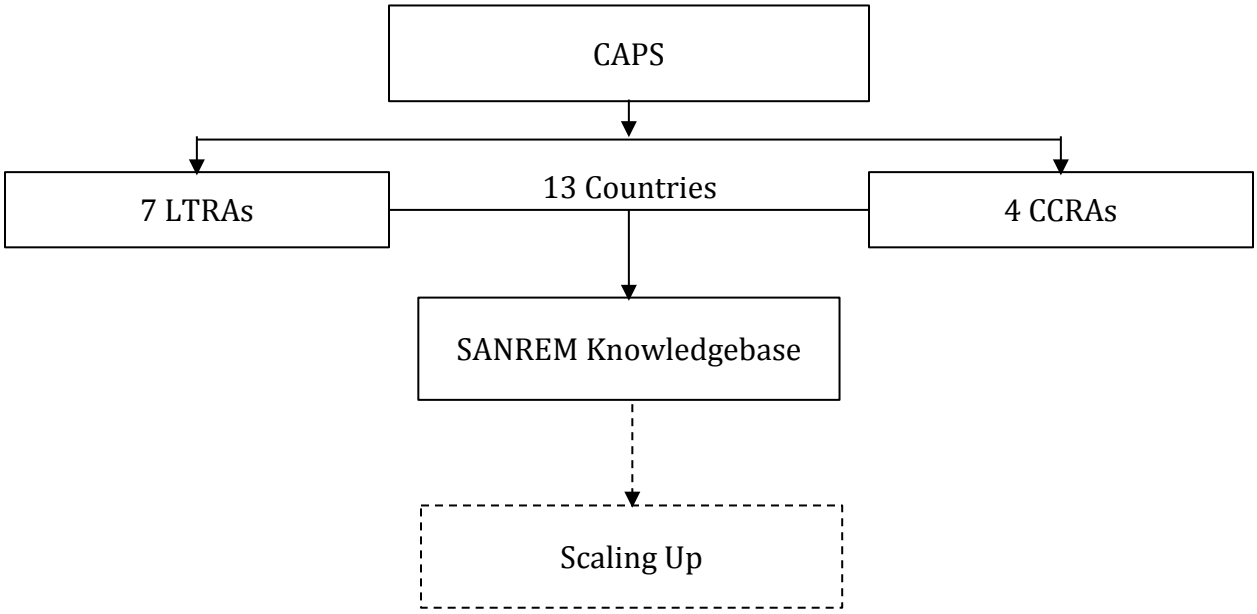


Fig. 4 Operationalizing the CAPS in 13 countries, involving 7 LTRAs and 4 CCRAs culminating into the creation of SANREM Knowledgebase. The last step of "scaling up" remains to be operationalized.

Other issues which need to be operationalized include identification of appropriate dual-purpose cover crops (with harvestable grains) and their management, and NT seeder at a price affordable by the rural communities.

2. Scientific Information

All LTRAs (except Mali and Bolivia) and CCRAs are generating scientific data on ecological, biophysical, agronomic, economic and social parameters. Alternative arrangements are being

made for sites faced with political and logistic issues. For example, some aspects of the program planned for Mali are being shifted to Ghana.

Some issues with regards to the scientific information which need to be reconsidered are:

- Testing a broad-based and generic hypothesis which may be difficult to prove over a short period of 5 years,
- Determining a soil quality index on meager data and the lack of information on key parameters (e.g., SOC concentration, soil bulk density, available water capacity),
- Evaluating adaptability of CAPS when the most severe limiting factors (e.g., drought stress, micronutrients) have not been adequately considered, and
- Assessing the importance of key parameters (e.g., biophysical, social, gender) without adequately understanding the underpinning scientific process.

3. Training and Institutional Capacity Building

SANREM Innovation Lab has made significant progress at training farmers on how to use CAPS to conserve soils and develop soil health. They have organized an international team of experts that work well together and meet their work plan goals. This was done even though some LTRAs had extreme hardships because of natural disasters and civil unrest (e.g., earthquake in Haiti). They should be commended on a job well done. Their focus on conserving and enriching soils is truly an important task and one that must be accomplished if we are to provide enough food to feed the greatly expanding world population.

SANREM has made commendable progress in providing training opportunities to undergraduate and graduate students, extension agents, and farmers. However, the training program can be strengthened by:

- Creating CA Research Centers at appropriate universities,
- Facilitating long-term (up to one semester) involvement of U.S. faculty with the host-country program and universities, and vice versa,
- Providing facilities for distance learning so that students can avail expertise of faculty with specialization in specific disciplines, and
- Promoting South-South cooperation whereby faculty from India, Brazil, etc. can provide technical support to the Caribbean or SSA, and those from SSA (Ghana, Nigeria, Uganda) can assist program in Haiti.

There has been only a modest progress in strengthening institutional capacity. Rather than bringing soil/plant samples for analysis in the laboratories of the U.S. universities, it would be a good strategy to provide funds for some basic analytical facilities for laboratories at the host country universities/institutions.

4. Inter-disciplinary Collaboration

The programmatic outline depicted in Fig. 4 promotes and facilitates inter-disciplinary collaboration, both within LTRAs, and among LTRAs through CCRAs. In this context, it would be extremely relevant to identify a few sharply focused projects with more but highly diverse

scientific disciplines. The need is for in-depth research on scientific processes. Yet, the importance of in-depth disciplinary research must never be underestimated in favor of the disciplinary research. Maintaining a good balance between both is essential.

B. Knowledge Gaps

1. Soils and Natural Resources

a. Biophysical Issues

Despite the great progress and impressive achievements, several knowledge gaps exist. Important among these are the following: (i) resilience of CAPS against biotic and abiotic stresses, (ii) processes, factors and causes of tillage-induced soil degradation, (iii) critical determinants (parameters) of soil quality and their threshold values, (iv) impact of CAPS in terms of ecological, economic, social and cultural, (v) opportunity costs of crop-residues and cover crops as determined by the life cycle analyses or LCA, (vi) modus operandi of making payments for ecosystem services provisioned through adoption of CAPS, (vii) safety in pesticide use, and in reuse of containers for domestic purposes, (viii) soil analyses on land owned/managed by woman farmers, and statistical analyses of soil data based on gender, (ix) soil correlation calibration of fertilizer recommendations for land managed by women farmers, (x) sampling strategies on soils that are designed as important by women farmers, (xi) soil research by taking gender variables into account, (xii) interpretation of soil's analyses data with due consideration of social factors, (xiii) relating human health and nutrition to soil health, (ivx) establishing empirical relation between soil quality (SOC/SOM) and agronomic productivity, and (vx) using modern innovations to break the agrarian stagnation in SSA,SA and the Caribbean. Modern agricultural chemicals with high efficiency and low losses into the environment (e.g., nano-enhanced fertilizers and ultra-low volume herbicides formulations and sprayers) must be tested.

b. Adoption of CAPS

Whereas research projects may enhance awareness about merits of CAPS, they may also create special conditions through subsidies (the Hawthorne effects) which are not sustained without the project, leading to "disadoption." In some situations, farmers may adopt a specific component without considering the systemic (holistic, system) nature of CAPS. Agronomic and economic factors being system features, it is appropriate to consider collective decision-making of multiple diverse actors rather than reliance on single indicators.

2. Human Nutrition

Apparently, not all sites in the programs supported by the SANREM Innovation Lab have knowledge about the possible limiting plant growth nutrients (both macronutrients and micronutrients) at all locations within the project. Further, soil-available sources of these nutrients should be studied and affordable ways identified to supply them if needed. Additionally, the program has little information regarding nutrient deficiencies in the targeted populations in their study regions. This type of information should be obtained in order to design

research strategies that can provide ways to increase the consumption of food crops rich in limiting nutrients. Cover crops have not been selected for improving nutrient output of the farming systems. Knowledge is needed to find suitable edible cover crops that will not only protect the soil and build soil health but also provide needed nutrients to the farmers and their families. Information is required to determine what types of cropping systems can be developed within various regions that can meet both economic production goals, environmental goals, and nutritional needs of farmers.

On a larger scale, knowledge is needed to design whole farming systems (including cropping , animal, and aquiculture productions systems) that can meet the economic and nutritional needs of farm families, the urban poor and the general population. These systems must be designed around sustainable intensification goals to meet the challenges of climate change and population growth in a long-term viable way. Changing food sheds and associated food systems within regions to improve health outcomes will require that close associations be formed between the agriculture, nutrition, and health sectors. Cooperation among farmers, agriculture experts, economists, sociologists, anthropologists, biologists, political scientists, and climate experts will be required.

A review of the responses to the nutrition related survey questions given to the P.I.s leading the SANREM Innovation Lab's LTRAs, shows that not much thought has been given in the past to nutrition and health issues in the current projects. In any future projects, it is highly recommended that such thought be given to sustainable intensification programs using a food systems perspective and better nutrition and health as an outcome. How can CAPS programs link to nutrition and health issues in ways that will help increase the output of essential nutrients form farming systems that will help reduce malnutrition in people?-How can the farming communities be educated as to the importance of agriculture to nutrition and to the importance of nutrition to their lives and the lives of their loved ones? Further, the responses to the questions indicated that there is a potential for micronutrient deficiencies in the crop production systems under study. Nor is it known, within the study groups, what essential nutrients are lacking in the diets of the people living in these regions. This should also be addressed in any future

Feed the Future sustainable intensification programs. Not having such knowledge has great potential to limit the long term success and impact of these programs. It was also clear that affordable fertilizers (both macronutrient and micronutrient fertilizers) should somehow be made available to farmers. Further, farmers should be informed about how to apply them at the right time, in the right place, in the right form and in the right amounts in ways that have low risk of polluting the environment

The research performed by the SANREM Innovation Lab team has shown that more information is needed to understand the limiting nutrients in the soils of their study areas. Soil tests need to be performed and diagnostic plant tissue tests need to be obtained in order to assure that there are no deficiencies of macronutrients or micronutrients in the soils. Selection of cover crops to use in crop rotations need to be further studied to include edible legumes that can perform well at test sites in protecting soils from erosion, are liked by farmers and that grow well in those environments. Ways need to be found to deliver water to crops during the dry seasons that can be affordable and available to farmers and to supply affordable fertilizer for farmers along with the

knowledge of how to use them. Crop varieties need to be found/developed that grow well at the study sites. Nutrition deficiencies in the targeted human populations need to be known so that agricultural strategies can be developed to help reduce their occurrence.

SANREM Innovation Lab should continue to keep a strong focus on sustainable intensification. It should also develop more linkages with the nutrition community so that they can direct some parts of their programs at helping solve malnutrition problems that afflict the developing world. Food systems thinking should be included in all decisions made in the projects in the future and an important focus should be on nutrient output of farming systems. Food-based programs have the best chance of solving diet related malnutrition and sustainable intensification should play a role in these efforts.

The SANREM Innovation Lab should find ways to closely link to food system programs that have a focus on improving human nutrition and health. This will require finding new collaborators at Virginia Tech and within their study site countries. They also need to find collaborators that can help them determine limiting nutrients in their study areas. They should not depend totally on soil testing to determine nutritional needs of crops.

From the answers given by P.I.s in the various LTARs, it is apparent that more research should be done to determine the potential for limiting available soil nutrients (especially micronutrients) at their project sites to enhance efforts to select cover crops that are productive and diagnose the potential presence of micronutrient deficiencies.

XIII. ACKNOWLEDGEMENTS

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2. FAS, Washington, D.C.
   Derek Brown, Marcy Shader-Lauinger, Tiffany Ruefly

3. Management Entity, VT, Blacksburg
   Adrian Ares, Keith Moore, Guru Ghosh, Mike Bertelsen, Amy Loefler, Annie Millet, Maria Elisa Christie

4. University of Missouri, Columbia
   Christy Copeland, Deidre C. Anderson, William H. Meyers

5. USAID Mission, Haiti
   Steven G. Olive, James Edwin Wooley

6. SANREM- Haiti
   Thomas Thompson, Roberto Badio, Gillaine Warne, Fr. Jacques Volcius, and faculty and staff of CFFL and Zanmi Agrikol including Jean Philippe, Reginald Cean, Senio Louis-Jeune and Ferreste Sonneus

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   Belay Megistu, Samson Konlan, Justice Odoi

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   Kimberley Lucas, Sak Sambath, Teffera Betru, Megan O'Rourke

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11. University of Battambang, Cambodia
    Touch Visalsok

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    Jeffrey Alwang, Neal Eash, Catherine Chan-Halbrendt, Jay Norton, Vara Prasad, Manuel Reys, Thomas Thompson

13. OSU Staff

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XIV. LIST OF ACRONYMS

ABC	:	Atmospheric brown cloud
ACIAR	:	Australian Centre for International Agricultural Research
ADVANCE	:	Agricultural Development and Value Chain Enhancement
AGCD	:	Administration Generale de la Cooperation au Developpement
AT	:	Uganda, Agri-Hub, Uganda, Ltd.
BC	:	Black Carbon
BFS	:	Bureau of Food Security
BIFAD	:	Board for International Food and Agricultural Development
BOD	:	Board of Directors
CA	:	Conservation agriculture
CAPS	:	Conservation agriculture production systems
CCRA	:	Cross Cutting Research Agenda
CDM	:	Clean development mechanism
CFFL	:	Centre de Formation Fritz Lafontrent
CGIAR	:	Consultative Group on International Agricultural Research
CIDA	:	Canadian International Development Agency
CIRAD	:	Centre de Coopération Internationale en Recherche Agronomique pour le Développement (Agricultural Research Center for International Development)
CRSP	:	Cooperative Research Support Program
DAI	:	Development Alternatives, Inc.
DCM	:	Direct Seeding Mulch Based Systems
EET	:	External Evaluation Team
FAO	:	Food and Agricultural Organizations of the United Nations
FBO	:	Farmer based organization
FFS	:	Farmer Field School
GHG	:	Greenhouse Gas
GTZ	:	German Agency for Technical Cooperation
HARVEST	:	Helping Address Rural Vulnerabilities and Ecosystem Stability
HICD	:	Human and institutional capacity building
IARC	:	International Agricultural Research Center
IITA	:	International Institute of Tropical Agriculture
IFPRI	:	International Food Policy Research Institute
ILCA	:	International Livestock Center for Africa
INM	:	Integrated nutrient management
IPM	:	Integrated Pest Management
IT	:	Information Technology
JAICA		Japan International Cooperation Agency
KACOFA	:	Kapchorwa Commercial Farmers Association, Uganda
KSU	:	Kansas State University
LCA	:	LifeCycle Analysis
LACRD	:	Langmaal Centre for Rural Development
LAP	:	Lassia Tuolo Agricultural Project
LI-BIRD	:	Local Initiatives for Biodiversity, Research and Development, Nepal
LTRAs	:	Long-Term Research Awards

ME	:	Management Entity
Mha	:	Million hectare
MT	:	Minimum Tillage
MFI	:	Multi Farming Implement
NARI	:	National Agricultural Research Institute
NARO	:	National Agricultural Research Organization
NGO	:	Non-Government Organization
NORAD	:	Norwegian Agency for Development Co-Operation
NT	:	No-till
ODA	:	Official Development Assistance (UK)
OIRED	:	Office of International Research and Development
PI	:	Principal Investigation
POP	:	Policy and Procedures
REDD	:	Reducing emissions from deforestation and forest degradation
RFA	:	Request for application
RFP	:	Request for proposals
RING	:	Resilience in Northern Ghana
RISING	:	The Africa Research in Sustainable Intensification for the Next Generation
SA	:	South Asia
SANREM	:	Sustainable Agriculture and Natural Resources Management
SARI:	:	Savanna Agricultural Research Institute
SI	:	Sustainable intensification
SIDA	:	Swedish International Developmental Agency
SKB	:	SANREM Knowledge Base
SOC	:	Soil organic carbon
SOM	:	Soil organic matter
SSA	:	Sub-Saharan Africa
TC	:	Technical Committee
UN	:	United Nations
UNDP	:	United Nations Development Program
USAID	:	United States Agency for International Development
VT	:	Virginia Tech
WINNER	:	Watershed Initiative for Natural National Environmental Resources
WEAI	:	Women's Empowerment in Agriculture Index
ZA	:	Zanmi Agrikol, Haiti

XV. REFERENCES

Abigail Nguema, George. Norton†, Jeffrey Alwang, Daniel B. Taylor, Victor Barrera and Michael Bertelsen. Farm-Level Economic Impacts of Conservation Agriculture in Ecuador. *Expl Agric.* **(2013), Volume 49 (1), Pp. 134–147 C** Cambridge University Press 2012 **Doi:10.1017/S0014479712001044**

Alwang, J., Norton, G.W., Barrera, V., and R. Botello. 2013. Conservation agriculture in the Andean Highlands: Promise and precautions. S. Mann (ed.), The Future of Mountain Agriculture, Springer-Verlag Berlin Heidelberg, p. 21-38.

Ares, A., Moore, K.M., Kelly, M. and Mulvaney M. (eds.). 2012. Research Strategy Report. SANREM Working Paper 1/2012, Blacksburg, VA, 93 p.

Barrera, V.H., Cardenas, F.M. and L. Escudero. 2012. Metodología del muestreo aplicada para la encuesta estática en la subcuenca del Río Chimbo, Ecuador. INIAP, 5 p.

Bassett, Lucy. 2010. Promoting Nutrition Security in Haiti: An Assessment of Pre- and Post-Earthquake Conditions and Recommendations for the Way Forward. World Bank, Washington, D.C.

Bassett, Lucy. 2010. Promoting Nutrition Security in Haiti: An Assessment of Pre- and Post-Earthquake Conditions and Recommendations for the Way Forward. World Bank, Washington, D.C

Bisangwa, E. 2013. The influence of conservation agriculture adoption on input demand and maize production in Butha Buthe, Lesotho. MS thesis. Knoxville, TN: University of Tennessee.

Chankakada, C.2011.Agrarian diagnosis and characterization of farming system in Rattanak Mundul district, Battambang province. M.S. thesis, Royal University of Agriculture, Cambodia.

Chiong-Javier, Elena. Semi-Annual Report, LTRA-12. April 12, 2013.

Christie, Maria Elisa. Trip Report: Cambodia. 7-21 January 2013.

Dalton, T., Yahaya, I., and J. Naab. 2013. Perceptions and performance of conservation agriculture

Feed the Future. 2011. Feed the Future: Global Research Strategies. USDA, Washington D.C.

Gender in SANREM CRSP Projects, 5 April 2013.

Hylkema, Amy L. 2011. Haiti Soil Fertility Analysis and Crop Interpretations for Principal Crops in the Five WINNER Watershed Zones of Intervention. Department of Soil and Water Science, University of Florida.

Lal, R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science, 304:1623-1627.

Lal, R. 2007. Constraints to adopting no-till farming in developing counties. Soil and Tillage Research, 94:1-3.

Lal, R. 2008. Food insecurity's dirty secret. Science, 322:673-674.

Lal, R. 2009. Soil degradation as a reason for inadequate human nutrition. Food Security, 1:45-57.

Lal, R., Augustin, B. (Eds.) 2011. Carbon sequestration in urban ecosystems. Springer, Dordrecht, Netherlands, 383 p.

Lamb, J., Moore, K.M., and Christie, M.E. 2010. Research Framework for Technology Network and Gendered Knowledge Analyses. Blacksburg, VA, 33 p.

Larochelle, C., and J. Alwang. 2013. The role of risk mitigation in production efficiency: A case study of potato cultivation in the Bolivian Andes. Journal of Agricultural Economics 64:363–381.
Larochelle, C., and J. Alwang. 2013. The role of risk mitigation in production efficiency: A case study of potato cultivation in the Bolivian Andes. Journal of Agricultural Economics 64:363–381.
McNair, W. E. 2013. Assessing the influence of conservation agriculture on household wellbeing and maize marketing in Tete and Manica, Mozambique. MS thesis. Knoxville, TN: University of Tennessee.

Nadezda, R., Amaya, U., and J. Alwang, J. 2012. Women rule: potato markets, cellular phones and access to information in the Bolivian highlands. Agricultural Economics 43: 403–41.

Nguema, A., Norton, G.W., Alwang, J., Taylor, D.B., Barrera, V., and Bertelesen, M. 2013. Farm-level economic impacts of conservation agriculture in Ecuador. Experimental Agriculture 49: 134-147.

Owori, M. O. 2013. Conservation agriculture in Eastern Uganda and Western Kenya: assessment of beneficiaries' baseline socio-economic conditions. M.S. thesis. Laramie, WY: University of Wyoming.

Penot, E. 2011.Technical support mission for the implementation of a farming system reference monitoring network in the province of Battambang province, Ratanakmundul district, Cambodia.
Penot, E. 2011.Technical support mission for the implementation of a farming system reference monitoring network in the province of Battambang province, Ratanakmundul district, Cambodia.
Prasad, P.V.V. Improving Soil Quality and Crop Productivity through Farmers Tested and Recommended Conservation Agricultural Practices in Cropping Systems of West Africa SANREM CRSP Long-Term Research Award Application – Phase IV. (no date)

Research Strategy Report, Working Paper No. 01-12, April 2012.

Ricard, B. 2011. Agrarian diagnosis and characterization of farming systems in two villages in Battambang province (Cambodia) with the setup of a farming systems reference monitoring network. M.S. thesis IRC-Montpellier.

SANREM 2009 Annual Report. Blacksburg, VA, 225 p.

SANREM 2010 Annual Report. Blacksburg, VA, 169 p.

SANREM 2010 Semiannual Report. Blacksburg, VA, 83 p.

SANREM 2011 Annual Report. Blacksburg, VA, 204 p.

SANREM 2011 Semiannual Report. Blacksburg, VA, 81 p.

SANREM 2012 Semiannual Report. Blacksburg, VA, 105 p.

SANREM CRCP Policy and Operating Procedures Manual, June2012.

SANREM CRSP Annual Report 2012, 1 October 2011 – 30 September 2012.

SANREM CRSP Assessment & AMR Report, 30 April 2008.

SANREM CRSP external evaluation panel program review. January 2008

SANREM CRSP policy and operating procedures manual. June 2012.

SANREM CRSP work plan. 1 October 2012.

SANREM CRSP, External Evaluation Panel Program Review, January 2008, SANREM CRSP Long-Term Research Awards, FY 2007.

SANREM CRSP, External Evaluation Panel Program Review, January 2008, SANREM CRSP Long-Term Research Awards, FY 2007.

SANREM Knowledge Data Base. Gender References for SANREM CRSP themes (no date).

SANREM Management Entity. 2011. Gender Assessment for SANREM CRSP RFAs. Blacksburg, VA, 3 p.

SANREM Management Entity. 2012. Sustainable Agriculture and Natural Resources Management Policy and Operating Procedures Manual. Blacksburg, VA, 43 p.

SANREM Phase IV Renewal Application. 2004. Stakeholder Empowerment through Knowledge-Based Sustainable Agriculture and Natural Resource Management (SANREM CRSP). 80p.

Spring, A. 2009a. African Women in the Entrepreneurial Landscape: Reconsidering the Formal and Informal Sectors. Journal of African Business, 10:1:11-30.

Spring, A. 2009b. Empowering Women in the African Entrepreneurial Landscape. In M. Ndulo, ed. Power, Gender and Social Change in Africa. New Castle upon Tyne: Cambridge Scholars Publishing. 293-326.

Spring, A. ed. 2000. Women Farmers and Commercial Ventures: Increasing Food Security in Developing Countries. Boulder, CO: Lynne Rienner Publishers. 417 p.

Steven Brandt, Anita Spring, et al. 1997. The Tree Against Hunger: Enset-Based Agricultural Systems in Ethiopia. Washington DC, American Association for the Advancement of Science.

Spring, A. 1995. Agricultural Development and Gender Issues in Malawi. Lanham, and London: University Press of America. 316 p.

Sustainable agriculture and natural resource management collaborative research support program (SANREM CRSP). 6 July 2009.

Sustainable Agriculture and Natural Resource Management: Collaborative Research Support Program, FY 2013 Work Plan, 1 October 2012 – 30 September 2013.

United Nations, Department of Economic and Social Affairs, Population Division. 2013. World Population Prospects: The 2012 Revision, Key Findings and Advance Tables. Working Paper No. ESA/P/WP.227.

USAID 2004. SANREM Cooperative Agreement with USAID, Washington DC, 83 p.

USAID. Form 19. Common Indicators. 2 p.

USAID. Women's Empowerment in Agriculture Index. Feed the Future. March 2012.

Using Qualitative GIS to Explore Gendered Dimensions for CAPS in the Philippines: A Mixed Methods Approach, 4 April 2013.

Welch, Charlotte Johnson and Veasna Chea. Gender Assessment, USAID Cambodia, September 2010.

Welch, R.M. and Graham, R.D. 1999. A new paradigm for world agriculture: meeting human needs – productive, sustainable, nutritious. Field Crops Research 60: 1-10.

XVI. APPENDIX

Appendix I: Team Members

1. Dr. Rattan Lal (Team Leader)

Rattan Lal is a distinguished university professor of soil physics in the School of Environment and Natural Resources and Director of the Carbon Management and Sequestration Center, Food, Agricultural, and Environmental Sciences/Ohio Agriculture Research and Development Center, at The Ohio State University. Before joining Ohio State in 1987, he was a soil physicist for 18 years at the International Institute of Tropical Agriculture, Ibadan, Nigeria. In Africa, Professor Lal conducted long-term experiments on land use, watershed management, soil erosion processes as influenced by rainfall characteristics, soil properties, methods of deforestation, soil-tillage and crop-residue management, cropping systems including cover crops and agroforestry, and mixed/relay cropping methods. He also assessed the impact of soil erosion on crop yield and related erosion-induced changes in soil properties to crop growth and yield. Since joining The Ohio State University in 1987, he has continued research on erosion-induced changes in soil quality and developed new projects on soils and climate change, and sustainable intensification of soils and agroecosystems of the tropics. He has demonstrated that accelerated soil erosion is a major factor affecting emission of carbon from the soil to the atmosphere. Soil-erosion control and adoption of conservation-effective measures can lead to carbon sequestration and mitigation of the greenhouse effect. Other research interests include soil compaction, conservation tillage, mine soil reclamation, water table management, and sustainable use of soil and water resource of the tropics for enhancing food security. Professor Lal is a fellow of the Soil Science Society of America, American Society of Agronomy, Third World Academy of Sciences, American Association for the Advancement of Sciences, Soil and Water Conservation Society, and Indian Academy of Agricultural Sciences. He is a recipient of the International Soil Science Award of the Soil Science Society of America, the Hugh Hammond Bennett Award of the Soil and Water Conservation Society, the 2005 Borlaug Award and 2009 Swaminathan Award. He also received an honorary degree of Doctor of Science from Punjab Agricultural University, India, from the Norwegian University of Life Sciences, Aas, Norway, and the Alecu Russo Balti State University in Moldova. He is the past president of the World Association of the Soil and Water Conservation, the International Soil Tillage Research Organization and Soil Science Society of America. He has been a member of the U.S. National Committee on Soil Science of the National Academy of Sciences (1998/2002, 2007-2010). He has served on the Panel of Sustainable Agriculture and the Environment in the Humid Tropics of the National Academy of Sciences. He has authored and coauthored about 1650 research papers. He has also written 15 and edited or co-edited 50 books. He received the Nobel Peace Prize certificate shared by the members of the Inter-Governmental Panel on Climate Change (IPCC). He is a convenor of an international conference on "Sustainable Intensification to Mitigate Climate Change and Advance Food Security in Africa" held at Morogoro, Tanzania from 13-16 November 2013.

2. Dr. Anita Spring

Dr. Anita Spring is a Professor Emeritus of the Department of Anthropology at the University of Florida. She is past president of Culture and Agriculture and vice president of the International Academy of African Business and Development. Currently, she is President of the Association for Africanist Anthropology. Previously she served as Chief of

the Women in Agricultural Production and Rural Development Service for the Food and Agricultural Organization of the United Nations and Associate Dean of the College of Liberal Arts and Sciences at the University of Florida. She has worked as a consultant for USAID, USDA, the Office of Technology Assessment (U.S. Congress), FAO, GTZ, and private development assistance firms. Her research topics include agricultural intensification and food security; gender issues in international development; entrepreneurship; and policy and management styles. She carried out R&D in Zambia (3 years), Malawi (2 years), and Ethiopia (1 year), and also worked in Botswana, Cameroon, Eritrea, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Senegal, Somalia, South Africa, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. She has worked on natural resource management, participatory appraisals, and gender and development in Jamaica, St. Lucia, and Trinidad. She is the author or editor of 11 books and over 60 articles and monographs. Her books include *The Sub-Saharan Business Environment* (with R. Rolfe), *China and Portuguese Speaking Africa: Business Approaches and Management Models* (with N. António, et. al.); *Women Farmers and Commercial Ventures*; *African Entrepreneurship: Theory and Reality* (with B. McDade); *The Tree Against Hunger: Enset-Based Agricultural Systems in Ethio*pia (with S. Brandt et al.); and *Agricultural Development and Gender Issues in Malawi*. Currently, she is the director of the Sub-Saharan African Business Environment Project (SABER) that provides business environment information on the major economic, agricultural, business, political, and social indicators and trends for the 20 largest Sub-Saharan African economies. *SABER 2011* and *SABER 2012* are also available on the web.

3. Dr. Ross M. Welch

Dr. Welch was a plant physiologist and Lead Scientist employed at the USDA-ARS, Robert W. Holley Research Center for Agriculture and Health, located on the Cornell University campus (now retired). He has a courtesy faculty appointment (Professor of Plant Nutrition) within the Department of Crop and Soil Sciences at Cornell University and co-teaches a graduate and an undergraduate course in plant nutrition. Dr. Welch's research is directed at improving the nutritional quality and safety of food crops for humans using sustainable food-based system approaches. His Laboratory's mission was to closely link agricultural production to human health and nutrition issues. His efforts focus on improving micronutrient bioavailability and density of limiting micronutrients in edible portions of important food crops. He is also interested in improving the nutritional quality and increasing health-promoting substances (e.g., selenium, vitamin E, ascorbate) in fruits, nuts and vegetables, and in developing holistic food system solutions to malnutrition globally. Reducing the accumulation of toxic heavy metals (e.g., Cd) in edible seeds and grains was also a research focus of his. He was a co-organizer of the Food Systems for Improved Health (FSIH) program within the College of Agriculture and Life Sciences, Cornell University, and has cooperative international research programs with colleagues in Australia, Bangladesh, India, Nepal, Egypt, and Turkey. He also cooperates with several CGIAR Centers including IFPRI, CIAT, CIMMY, CIP and IRRI on a global project (HarvestPlus) directed at increasing the micronutrient (iron, zinc, iodine, selenium, provitamin A caroteniods) density of staple plant foods (i.e., rice, wheat, maize, beans, sweet potato and cassava) through plant breeding and genetic modification to enhance human health globally.

Appendix II: BIFAD Meeting on 3/15/13 at the Univ. of Missouri, Columbia

The meeting comprised of two sessions: BIFAD Board, and the International Program of the Univ. of Columbia.

1. BIFAD Board

a. Issues discussed were

1. Human and Institutional Capacity Development or HICD,
2. Alliance for Green Revolution in Africa (AGRA),
3. IPM-Innovation Lab. program in Cambodia,
4. Globalization and Sustainable Intensification versus Ecological Intensification
5. Feed the Future and global food security,
6. Strategies to engaging U.S. universities in international agriculture, and
7. Sustainable Intensification: A new Innovation Lab.

2. International Program of Columbia University

a. Issues discussed were

1. Achieving sustainable development,
2. Making policy makers more sensitive to global long-term perspective,
3. Achieving global convergence,
4. Encouraging ethical market economics,
5. Addressing threats of view and emerging diseases and resistance of microbes to antibiotics,
6. Improving human well-being by changing status of women,
7. Meeting growing energy demands safely and effectively,
8. Accelerating scientific and technical breakthroughs
9. Incorporating ethical consideration into development programs

b. Specific programs discussed were

1. International programs,
2. Inter-Disciplinary Plant Group,
3. College of Food, Agric. And Natural Resources,
4. Multi-Disciplinary Team Approach,
5. Innovative ways to develop international collaboration,
6. Young people to take farming as their career choice, and
7. Role of soil scientists in international programs.

Appendix III: Visit to Management Entity at VT, Blacksburg (4/4 – 4/6/2013)

1. External Evaluation Team Schedule

Management Entity Contacts (Office of International Research, Education, and Development – OIRED)
Logistics: Annie Millet (540) 231-6338; debra56@exchange.vt.edu
Director: Adrian Ares (540) 231-3227; (540) 629-5875 (cell); aresa@vt.edu
Administrative PI: Mike Bertelsen (540) 231-9665; (540) 494-5804 (cell); **bertel@vt.edu**
Communications: Amy Loeffler (540) 231-5356; amyll8@vt.edu

Thursday April 4, 2013	
Various times	Committee arrives at Roanoke airport. Transportation arranged to Holiday Inn, Blacksburg, 900 Prices Fork Road (540) 552-7001

Friday, April 5, 2013	
7:50	Review team picked up from hotel
8:00-8:15	Introduction of review team and management entity; Mike Bertelsen, interim executive director, OIRED
8:15-8:30	Welcoming remarks; Guru Gosh, associate vice president, International Affairs
8:30-9:00	Presentation of key SOW elements; Rattan Lal, evaluation team leader
9:00-10:00	Overview of SANREM; Adrian Ares, SANREM Director
10:00-10:30	Financial management, Christina Brannan, Financial Coordintor
10:30-11:30	SANREM PI presentations • Maria Elisa Christie (Gender coordinator, CCRA-7 PI) • George Norton (Impact Assessment Coordinator, CCR6-PI) • Jeffrey Alwang (SANREM TC Chair, LTRA-7 PI)
11:30-12:00	Questions from review team for PIs
12:00-1:00	Lunch
1:00-3:00	Question and answer work session with Management Entity including field trip plans
3:00-3:30	Capacity building

3:30-4:30	Scope and focus for future USAID investment in Sustainable Intensification
4:30-5:00	Wrap-up session including requests for supplemental information
5:15	Transportation to the hotel
6:30	Dinner with review team
Friday, April 6, 2013	
As Needed	Transportation to Roanoke Airport from Blacksburg arranged according to individuals' schedules

Appendix IV: Visit to Haiti: LTRA-6 (4/28 -5/4)

1. Institutes and personnel visited include the following

a. Centre De Formation Fritz Lafontrant (CFFL). The CFFL has 13 faculty (who mostly have B.S. degrees) of which two are women. Some faculty has contacts with University of Georgia, University of Florida, and VT. Faculty visited were: Jean Philippe Dorzin, Reginald Cean, Stenio Louis-Jeune, and Ferreste Sonneus. The Center has three academic programs: wood work, building construction, and agriculture.
b. Visit to the Maissade Site Managed in Cooperation with Caritas. The staff visited included:
    - Augustin Guedry
    - Evans Bien Aime
c. Visit to the USAID Mission: The EET was accompanied by Dr. Thomas Thompson, SANREM PI and Mr. Robert Badio (the in-country coordinator). At the USAID Mission, we met:
    - Mr. James Woolley and Mr. Steve Olive
d. We also met with Mr. Dilou Propere, a research assistant with the project.

2. Soils and Natural Resources

a. Adoption of CAPS

The CAPS is important because 60% of the country is hilly and soil erosion is a serious problem. Until the program started by VT about two years ago, no one in Haiti has used CA. Soil and water conservation are the main advantages. When farmers plow the land with oxen, there is erosion. Further, there is no irrigation and drought stress is serious. There is also saving in labor and farmers do not have to pay the hired labor. However, there are several limitations:

- Limited knowledge among farmers such as regarding the use of mulch,
- Weed control is the biggest problem,
- There are also insects and diseases under CAPS

In order to enhance soil fertility, the Center has been recommending the use of crushed peanut shells. In addition, the Center also recommends cover crops (crotolaria, sorghum Sudan). There are not too many fertilizers being used. Sometimes plastic sheets are used to sterilize the soil.

b. Crop response to CAPS

Crop yields are low because there are no inputs and crops suffer from drought, which is a perpetual problem. Most crops are sown at the end of the dry season, and farmers wait for rain. Irrigation by pumping is useful, however, pumps are not available and may cost as much as H$ 500(US$12) per day to rent. A pump can irrigate 2 ha per day in close proximity to a river.

Field preparation, at the end of the dry season and to make mounds or ridges is mostly done by men and only sometimes by women. Women prepare the field when men are working on some

off-farm jobs. In a community operation, 10 men can prepare 0.25 ha of land in one day. Once the field has been prepared women mostly do the seeding. The field preparation, digging with a hoe, is mostly done by women.

Whereas CAPS does not require the difficult task of preparing the seed bed, yet most farmers have not fully adopted CAPS. Of about 100 farmers who attended the workshop last summer, a large number of them do not remember. When questioned, the farm manager of the site (an agronomist), mentioned that four farmers (about 11 km from the site) do not burn the residues and follow some components of CAPS. Rather than the entire package, farmers may be able to adopt some specific component (e.g., eliminate burning, grow a cover crop) and follow a sequential approach.

In addition to farmers' perception of CAPS, its adoption also depends on the soil type and the crop to be grown. Digging holes is necessary for some crops such as plantain, yam, manioc, sugarcane, mangoes, and avocados. While, nothing is specifically added into these seedbeds, digging is a strenuous task.

c. The Experimental Design at Lachateau and Other Sites

The experimental design, being followed here, is the same as that followed at all the three sites. It consists of a split plot design with tillage as the main plots and the cover crops as the subplot. The plot size is 4m x 4m with 3 replications. The two cover crops being used are sunn hemp and sorghum-Sudan. The test crop is maize, and the second maize crop has just been planted. No fertilizers are used, and the traditional maize variety grown is called "ti bourik" Improved varieties from CIMMYT are grown as separate test plots.

d. What Can Be Done to Make Agriculture a Rewarding Profession

This question raised a very lively debate and most farmers were very vocal that they have been forgotten by the government and international organizations. Most believed that government and international organizations do not work together. Whatever the aid provided by the international organizations, it never reaches the farmers.

With regards to the status of the women, they can also work off farms. But there are no factories or industries in the countryside.

Most farmers said that they seed the crop and then pray for rain which never comes. What we need is a pump. How can a pump help, if there is no water to pump? The problem is that water is not available when plant needs it, just after the seeding or during the flowering stage. Should there be a project on water harvesting and recycling, whereby a community (~100 farm families) can contribute labor to dig a reservoir and the rain water thus harvested and stored can be recycled for gravity irrigation downslope. Even if 25 ha can be irrigated with drip sub-irrigation, each farm family can have 0.25 ha of irrigated plot.

e. What Are The Most Urgent Needs To Improve Farming And Productivity

Among urgent needs to improve the farming and productivity are the following: irrigation/pump, improved seeds, tools (including an improved hoe with a long handle), fertilizers/compost, cattle feed and good rotation (maize-bean).

When asked whether nutrition can be improved through better farming and improving soil quality the answer was yes, better soils can grow nutritious food (e.g., fruits, maize, beans).

f. Lessons Learned

Field experiments at three sites have been very useful as follows:

- Despite the short time, a lot of progress has been documented. An earthquake, malaria outbreaks, and political unrest caused a delay of almost 18 months. It was a major setback to the project. Yet, three seasons of cropping would be completed before end of the current phase of SANREM.

- Seeding a cover crop (sunn hemp) during the last month of the rainy season (mid-September) has been very effective in providing a good soil cover, controlling weeds, and improving soil fertility. Cover crop is cut in mid-April and the maize is seeded through the stubbles.

- Publishable data has been gathered involving 3 years and 3 locations. In addition, the biomass harvested and N accumulated in the biomass is assessed. The baseline survey was also done.

- These sites have provided training for two M.Sc and one Ph.D. students.

Several issues have emerged:

- To partners and agronomists helping with the project, this activity is a sideline and not a major task. The SANREM funds are an equivalent of one agronomist and one technician. A fulltime agronomist must have been assigned to the project. With the existing arrangement, the SANREM project is not a top priority of the project.

- Linking up with the existing network of 1500 farm families is the major advantage. For the three workshops organized last years, 300 farmers participated. This is a big achievement.

- The question of slow adoption of CAPS must be addressed.

- The plot approach has its own merits and limitations. This approach provides 3–years of plot work. There must be one year of scaling up at a larger plot size.

- Would a farmer managed and on-farm participatory approach be the next step for scaling up?

- A select group of farmers should be provided with farm tools and essential supplies. However, do farmers really know what they need to effectively adopt the CA technology (pumps, seed, fertilizers, tools)?

- Is soil test needed to decide the fertilizer rate and amendment applied to obtain the desired yield?

- Plant tissue test would provide useful data and guidelines on the missing nutrients, both to enhance crop yield and also to improve human nutrition.

- While yield of maize has been doubled (from 500 to 1000kg/ha) it can easily be quadrupled with additional inputs.

3. Human Nutrition

a. The Severity of the Problem:

Historically, rates of under nutrition in the Haitian population have been extremely high, being among the highest in Latin America and the Caribbean (http://www.unicef.org/infobycountry/haiti_62654.html?p=printme). In 2005, UNICEF reported that 33% of children less than five years of age were stunted with 10% being wasted and 60% being anemic. One-fourth of babies born were of low birth weights. A recent survey in 2012 performed after the horrendous earthquake in 2010, using the Standardized Monitoring and Assessment of Relief and Transitions (SMART), has shown improvements in nutritional heath resulting from emergency nutrition interventions. These interventions included education and counseling on optimal infant and children feeding practices. UNICEF also provided micronutrient supplements (including iron and folic acid) for mothers and children, multiple micronutrient powders and tablets, vitamin A supplements and deworming tablets. These interventions were delivered throughout Haiti using 198 baby tents and centers. The interventions were also provided at 24 hospitals and 290 community-based therapeutic feeding programs for malnourished children and through mass distribution campaigns.

This recent SMART survey demonstrated positive results from these interventions in improving nutritional health of the Haitian people. The prevalence of malnutrition levels in children from 6 to 59 months declined after the interventions. Stunting rates decreased from 33% to about 23% and acute and severe malnutrition decreased to about 1% from 4%. Underweight children fell from 18% to about 11%. Thus, interventions to improve nutrition can work in Haiti. However, current types of interventions may not be sustainable because they have to be provided by outside sources that may or may not continue their support for such programs into the future. Indeed, a recent report (Improving Child Nutrition. the achievable imperative for global progress, UNICEF, April, 2013) states that "The international community, which rallied around Haiti in the crisis, is phasing out its emergency support. This leaves Haiti with the critical task of providing basic health and nutrition services with insufficient qualified personnel and an infrastructure that is still recovering" Accordingly, the apt rout to sustainable nutrition in Haiti can only come from their agricultural sector; strategies to this end should be initiated.

Soils are the foundation for all agriculture and ultimately all nutrition. They provide the mineral nutrients that enter food crops and forage. The crops and animals produced on these soils, in turn, provide all the other nutrients need to support human life. Without fertile soils, food crop and livestock productivity is reduced and nutrient output of farming systems declines, malnutrition ensues and people suffer becoming less productive, morbid and many die from nutrition related diseases Thus, conserving fertile soils is the mainstay of all nutrient fluxes into food systems and adequate nutrition for all. Unfortunately, many of the soils in Haiti are degraded and eroded from overuse without attention to conservation practices or to improving soil fertility. The programs being initiated in Haiti by the SANREM Innovation Lab team are focused on trying to prevent soil losses by utilizing appropriate conservation agriculture production systems (CAPS) through efforts to incorporate the use of cover crops and no-till cultivation practices to decrease soil losses and increase soil organic matter. This is the first step in developing more fertile soils, productive agriculture and improved human nutrition in Haiti.

b. General Observations

Discussions with Dr. Tom Thompson and his research collaborators to research sites in the Central Plateau of Haiti at the Corporant, Lachateau, and Maissade locations were very informative. The training of local farmers by the SANREM team at all locations was impressive. They have done an excellent job of informing and training the farmers about conservation agriculture and the use of reduced tillage, cover crops and crop rotations to promote the development of more fertile soils and to reduce soil erosion. The condition under which the SANREM team has been conducting research and training farmers and agricultural specialists in Haiti is challenging, especially after the severe earthquake in 2010. However, they have succeeded in doing so and should be commended for their efforts. Because of the delays caused by this natural disaster some experiments were hindered but have been initiated. These experiments will take several years to develop and provide findings because conservation agriculture techniques that improve soil structure, fertility and stabilize soil are not a short term approaches but require several years to show sustained success. It is imperative that support for those efforts continue because degradation of soil resources in Haiti is among the most critical problems facing future Haitian agricultural development. Fertile soils are required to provide the Haitian people with balanced nutrition needed for healthy, productive lives that drive economic development.

Maize crops growing at Maissade displayed signs of severe phosphorus deficient. Also, signs of nitrogen deficiency were evident. As a result, yields of maize plants were very low as reported by the agriculturalists accompanying our EET. Thus, soil fertility is a problem and fertilizer applications are warranted. However, apparently, no systematic studies have been made to evaluate the limiting nutrients in the soils of the Central Plateau for the crops planted there. SANREM is aware of the phosphorus deficiencies in these soils but more information on other possible limiting nutrients in these soils was not available. Further, apparently, no plant tissue tests had been made of diagnostic tissues in the crops grown there to determine nutrient deficiencies that may exist there. This is the first step in determining what limiting nutrients exist in these soils.

Discussions with the farmers at all locations were very worthwhile and informative. They displayed interested in CAPS but it was too early to tell if they would adopt many of these practices although some had stopped burning their fields. It is difficult for these farmers to start to use cover crops because they feel they lose production of food crops that they need to survive. Possibly, edible legume cover crops could be recommended to the farmers if suitable legume crops could be shown to be effective at building soil organic matter and reducing soil degradation in Haiti.

When asked "why do we have agriculture?" the farmers answered - "to survive". They did not say that they did it to generate income, which surprised me. They also indicated that they would do anything but farm if jobs were available. They did appear to understand that they need nutrients from their food to survive. Thus, they appear to have been exposed to some nutrition learning.

When asked what they would want provided to them by the government they responded – "water pumps". This suggests that irrigation during the dry season is a very critical issue for these farmers. They also requested more conservation tillage tools to help them practice conservation agriculture. Ways to store water for use in the dry season seems to be a critical need for the Haitian farmers. Possibly drip irrigation could be promoted along with techniques to store rainwater from dwelling roofs and to build irrigation dams for irrigation purposes. This might require the formation of irrigation cooperatives among the farmers.

c. Suggestions For Additional Focus Areas in the USAID Agricultural Development Efforts in Haiti

There are none or few data on limiting nutrients (both macronutrients and micronutrients) in crops and soils of the Central Plateau of Haiti based on plant tissue analyses and soil fertility tests. Some data using the Mehlich-3 soil extraction method are available for Western Haiti [see Amy Hylkema, 2011 report prepared for the Watershed Initiative for Natural National Environmental Resources (WINNER) project] but is limited to soil analyses and to macronutrients without micronutrient data included in the report. Certainly, phosphorus and nitrogen are limiting. Other nutrients, especially micronutrients (zinc, manganese, iron, copper, and molybdenum), may be also limiting. If such data are not available, then such data should be collected along with ways to supply limiting nutrients to these soils in affordable ways. Specifically, not only soil analyses but also diagnostic crop tissue tests should be included in any studies. Improving soil fertility along with soil conservation practices will have the greatest impact on agricultural productivity and on reducing hunger and improving human nutrition and health in Haiti.

In 2010, the World Bank published a report on nutrition security in Haiti (Bassett, Lucy. 2010. Promoting Nutrition Security in Haiti: An Assessment of Pre- and Post-Earthquake Conditions and Recommendations for the Way Forward. World Bank, Washington, D.C.). Widespread micronutrient deficiencies were evident in the Haitian population. Focus was on iron, vitamin A and iodine micronutrient deficiencies but other micronutrient deficiencies are surely there. Certainly zinc deficiencies are wide spread especially for children stricken with diarrheal diseases which are common in Haiti. Thus, agricultural approaches to increasing micronutrient

output of farming systems and increased intake of micronutrients in Haitian farm families are greatly needed. Using bio fortified staple food crops is recommended (e.g., orange fleshed sweet potato, cassava and bananas along with high zinc rice and high iron and zinc beans). Possibly, the HarvestPlus program could be approached to start developing micronutrient rich bio fortified crops that are high yielding and adapted to the Haitian environment. Diversifying cropping systems to include more nutrient dense varieties of crops especially edible legumes is also warranted. Using foliar zinc fertilizers during reproductive growth stages to increase zinc in edible portions of food crops is also highly recommended. This will not only improve zinc intake in the population but also increase productivity of the food crops in that adequate zinc is required to promote resistance to both abiotic and biotic environmental stresses that are common in Haitian soils.

Information on how to design home gardens that maximizes micronutrient output should be provided to farm families along with training to be successful at producing such crops. Nutrition education should also be part of such programs. The use of compost is also recommended for these gardens. Our visit to Maissade and their demonstration of locally fermented compost material was interesting. This type of compost could be further developed to provide growth media enhanced in micronutrients to propagate home garden crops enriched in micronutrients for consumption by farm families.

4. Social and Gender Issues

LTRA-6 Haiti is technically behind schedule in its CAPS activities due to the 2010 earthquake. Nevertheless, according to the project documents, including the household survey carried out by graduate student Nathan Kennedy (who will get his PhD in December 2013), 35% of plots had at least one conservation practice, and 40% of households believed they had at least one conservation practice on one or more plots.

a. Awareness about CAPS

It seems that the term CAPS was frequently used by men and women farmers as if everyone knew all the procedures, steps and main principles, and everyone agreed on the main principles and actual techniques. The term CAPS, as a general principle ,was mentioned over and over again by researchers and project staff, technicians and farmers. We were not sure they all meant the same thing and included all principles and methods and steps.

Principles of CAPS include: MT, direct planting of crop seeds, soil cover, especially by crop residues and cover crops, and crop diversity and rotation. We suspect that farmers understood more about fencing their plots and not burning crop residues, and were beginning to understand the need for mulch and cover crops more than they understood and accepted the lack of soil disturbance and NT methods.

Yet in Haiti, men and women farmers were intrigued by the new paradigm and thought they were participating in CAPS by making living plant barriers or hedgerows, commonly termed “live barriers,” and “dead barriers” from rocks, rock walls/terraces and trash barriers, both

necessary since so many plots were on slopes. Other farmers thought that by not burning off crop residues that they were doing CAPS**. F**armers in the Maissade area stopped burning and had begun to consider this as CAPS. Technically barriers and not burning residues are not considered part of the four steps in CAPS, but we might call them “preludes to CAPS "in this culturally specific environment. In one area, Corporant, of the 100 farmers who had studied CAPS, the LTRA counted 4% who had adopted CA, but was not clear which techniques they had adopted.

The local partners, Zanmi Agrikol (ZA) and the Centre Formacion Fritz La Fontant (CFFF), a training school for 70 students (only 6 of them female) and 13 faculty (2 are women) had added CAPS as part of its curriculum as a result of SANREM. The school was interested in carrying out the multiplier effect to reach farmers, and has become a good partner of SANREM. Students worked with about 25 farmer households each, coming from their own local communities -- the goal is to reach 1,500 families in a year. However, the EET found that types of families and households (in terms of gender of household head, wealth levels, and land holding size) were not specified, nor was the mixture of farm versus off-farm work and income. The ETT heard from the women and men farmers about their constraints in farming and also that they would have liked factory jobs to support their farms (they would then hire laborers to do the work).

b. Baseline Survey

The baseline study listed 1,500 households visited and 600 surveyed, providing information on 3,282 people. Households ranged from one to 15 persons, with a mean of 5.5. 83% of the 600 households were reported as being “led by a male.” and 91% of surveys were completed by interviewing the household head, whose average age was 47.8 years. Over 27% were headed by a single or widowed person but there was no information on the gender of the household head.

The average household had 3.23 plots averaging 20 min away by foot, and the average land holding was 1.09 karos (1 karo = 1.3 ha.). Only 7.3 plots were irrigated during the 2011 growing season, with less than 6% of households using irrigation (mostly canal infrastructure), with motorized pumps (all farmers asked the project for these) being used by 36% of this 6%. Farmers (men more than women) actually used ox plows on 40% of plots. The average cost was $134 per karo. 30% of farmers burned during planting season. Less than 0.5% used manure; 1% used insecticide; less than 0.5% used urea. Compound fertilizer was applied to about 6% of all fields, with the input available due to a donation in 2011. Women thought CAPS would relieve some weeding tasks.

c. Traditional Farming

The ETT visited the 3 sites where the LTRA is working. The LTRA has to deal with traditional Haitian cultivation methods where ground preparation is done either with a hoe or ox plows. In Corporant and La Chateau, farmers agreed that men prepared the soil. In Maissade, women said they also prepared the land, but recognized that women in other areas of Haiti did not. A major constraint to CAPS is the standard cultivating implement--a long-handled hoe with a large scooped, plow-like blade. With its deep curved, plow-like form, this hoe cannot be used even for minimum tillage, although it was good for making government-approved ridges that farmers made for planting maize and beans. For CAPS, a short flat blade hoe would be needed. These

were unavailable, except for a few that had been given to each project site for demonstration. Hence a prototype for manufacturing locally (private sector?) would be recommended. One CAPS practice is to make a hole where the seed is to be planted and keep the topsoil mostly intact to prevent erosion. The farmers we talked to seemed to understand this concept, but there was no data about practices.

d. Traditional Knowledge

Women and men farmers had similar knowledge of soils and differentiated two main types: black, wet soil (good for making ridges for maize) and light brown, dry soil (good for planting peanut). The former were in plots that tended to be owned by men and the latter soils were often in plots owned by women (women and men both have land ownership). Women seemed to own land with less fertile soils, with probably more being on slopes, both of which would limit their adoption of CAPS.

Farmers heaped crop residues for potential mulch around tree bases, on the edges of rows, and in unplanted fields, both in shade and open sun. Farmers of both genders are acutely aware of the need for mulching but there was confusion concerning the amounts, depths, and types of mulch, especially as compared to the efficacy of cover plants being grown in the project's trials. Problems the farmers noted and the ETT observed were grasshoppers and mice in the mulch. Farmers remarked that mulching caused too much humidity and condensation, so they were apprehensive about covering the soil too much. SANREM trials on mulch depth are underway (7 cm to 10 cm in thickness). The project was also working with pesticides regarding insect infestation in the mulches and residues. The project was doing many trials on cover crops to replace the mulch (sun hemp and sorghum Sudan).

e. Adoption of CAPS

In response to the ETT's questions on gender, the project director wrote: "Our partners know the elements of CAPS, but have never successfully practiced it. We have learned a lot during the past four years about the constraints to CAPS adoption in Haiti, about practices that will and will not work, and how to foster successful partnerships on the ground. I expect that with a continuation of the project we could make significant progress in all aspects mentioned above, but especially on CAPS adoption and gender inclusion."

Appendix V. Visit to Ghana: LTRA-8 (5/15 – 5/21)

1. The institutions and organizations visited are the following

a. USAID Mission:
   i. The Mission staff visited were:
      - Peter C. Trenchard : Office Director, Economic Growth
      - Belay Mengistu : Agric. Development Officer
      - Justice O. Odall : Environment Specialist
      - Samson Konlan : Food Security Specialist
      - P.V.V. Prasad : PI, KSU

b. Africa RISING
   i. Asamoah Larbi IITA

c. SARI
   i. Dr. S. K. Nutsugah
   ii. Rev. Gilbert Yaw Nachim
   iii. Dr. Esther Wahaga
   iv. Dr. Fosu Mathias, Soil Scientist
   v. Dr. Jesse Naab, Soil Scientist, Upper West Region, SARI (Reading, U.K. Peter Gregory)
   vi. Dr. Roger Kanton, Upper East Region
   vii. Mr. Hashim Ibrahim (Statistics)
   viii. Mr. Thadus Kuunouri (Farmer)
   ix. Mr. Edward Prioban-Ye (Technician)
   x. Mr. Mohammed Naafiu (Technician)
   xi. Mr. Anthony Ngmentome (Farmer)

d. Farmers and heads of FBOs met
   i. Upper East
      - Men: Elias Atambire, Adrew Buleari, Sampson Ndego,
      - Women: Lydia Bukari and others
   ii. Upper West:
      - Men: Eduward Puobanye, Mohammed Naafiur, Anthoney, Hashim Ibrahim, Thaddeus

e. Other partners

2. Visit to the USAID Mission

The meeting took place in the office of Mr. Peter C. Trenchard (Office Director, Economic Growth Office). However, Mr. Trenchard was away on a mission. The meeting was chaired by Mr. Belay Mengistu (Agriculture Development Officer), Justice O. Odail (Environmental

Specialist) and Samson Konlan (Food Security Specialist). The EET comprised of Rattan Lal and Anita Spring, and SANREM team was represented by P.V.V. Prasad (KSU).

Mr. Belay Mengistu of USAID outlined the concept of sustainable economic growth comprising of the four components (Fig.1):

- Increase competitiveness of major food value chains,
- Improve enabling environment for private sector investment
- Increase government accountability and responsiveness, and
- Improve resiliency of vulnerable households in targeted communities and reduced under-nutrition.

These four issues involve the following:

- Commercial agriculture based on: technology, transfer, value chain facilitation, finance and investment, and policy reform,
- Sustainable management of marine fisheries, and
- Resiliency in northern Ghana

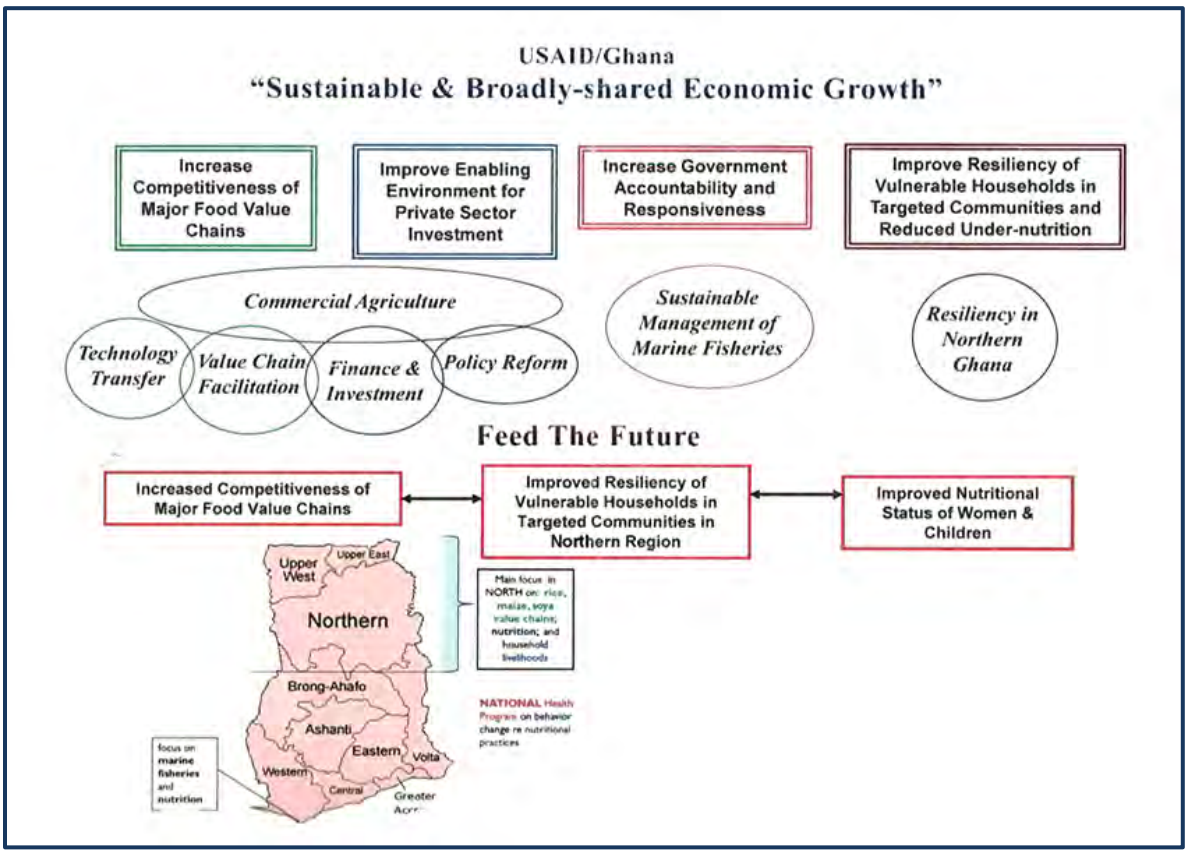


Figure 1: Current and future USAID programming in Ghana (Courtesy USAID – Ghana)

The food insecurity exists in northern Ghana, especially at the onset of the growing season,

The Feed the Future initiative involves the following: Increase competitiveness of food value

chain, improved resiliency of vulnerable households in targeted communities in northern region, and improved nutritional status of women and children.

a. Food Insecurity in Ghana

The food insecurity exists in northern Ghana, especially at the onset of the growing season, in the region north of the 8th Parallel. The region has one rainy season, compared with bimodal rain in the south. Thus, production (food storage) does not last till the next harvest. Small landholders in the north can feed their family for 6-8 months. Food-insecure households are 25-30% of the total. Thus, malnutrition is a problem during the 4-6 month period.

Therefore, Feed the Future strategy is to increase productivity, adopt alternative systems, and increase household income. Grain storage and distribution are also important.

b. Nucleus Farmer

The focus is on a "Nucleus Farmer", who owns a tractor, has access to inputs, and has contacts with small landholders. Identifying the "Nucleus Farmer" would facilitate provisioning of services to small landholders (e.g., plow, seeds, fertilizers, herbicides). The goal is to reach out to small landholders through medium size farmer.

c. The Value Chain Project

The motivation is to increase productivity by alleviating constraints, and also provide the warehouse services. The FtF is also studying the consumption patterns.

d. The Women-Headed Households

Food-insecurity (4-6 months, and 25-30% of the households) is most prevalent in women-headed households. Agronomic yields are low for the women farmers because they do not have access to inputs and services. While most men farmers are connected into the value chain, women farmers are not.

e. The "ADVANCE" Program

This comprises of enhancing the "agricultural value chain." Food-insecure farmers produce 1-1.5 t/ha of maize, while others connected with inputs and services can produce 5-10 t/ha of maize. Similarly, there is a low paddy yield of merely 2-3 t/ha. Low yields are attributed to: (i) lack of link between research and extension, (ii) no market for a bumper crop, leading to no production in the next year, and (iii) lack of a package of technology.

Thus, there is a need for a demand-driven (rather than donor-driven) program. Some important technological components are: (i) improved seed, (ii) soil fertility (N, P, and K) management, (iii) institutional capacity building, and (iv) soil-water management because both drought and floods are common. There is also a problem with uncertain and erratic rains. Total rainfall is high (~1000mm), but it is received over a 6-month period. There is a limited use of modern

technology to use the high amount of rainfall received. By enlarging productivity per unit amount of rainfall, total productivity can be increased.

f. Agricultural Development and Value Chain Enhancement (ADVANCE)

The ADVANCE project was redesigned in 2011 to comply with the Feed the Future. The goal is to facilitate transformation of Ghana's agricultural sector in selected agricultural staples (e.g., maize, rice, and soybean) to achieve food security in the North, while also increasing competitiveness in the domestic markets. The strategy is to adopt a value chain approach where smallholder farmers are linked to markets, finance, inputs, and equipment services and information through relatively larger nucleus farmers and large traders (aggregators) who have the financial capacity to invest in these chains. The goal is to build the capacity of smallholder farmers to increase the efficiency of their small business. The project involves:

- Technical contributions to specific commodity value chains,
- Improved production technologies
- Value addition technologies
- Association and cooperative development and management
- Marketing and linkages to buyers
- Training of farmers, agro-dealers etc., in irrigation, IPM, environment and natural resource management, etc.

g. Resilience In Northern Ghana (RING)

This is a US-AID funded $60 million dollar project aimed to improve the livelihood and nutritional status of those most in need (women of child-bearing age and children under five). The program will benefit more than 367,000 people in the North by increasing food security, encouraging consumption of diverse quality food, and improving nutrition.

h. Emerging Issues

- Identify scalable technologies,
- Collaborate and coordinate (collaboration among all Innovation Labs/CRSPs),
- Communication among projects (Africa RISING versus SANREM, cooperation among 10-15 projects within Africa RISING),
- Planning together as institutional rather than individual projects
- Several crops involved, making it difficult to adopt the Green Revolution approach. Thus, selecting important crops (maize, rice, soybean) is necessary, and
- Adaption and mitigation to climate change through ADVANCE.

3. SANREM in Ghana (and Mali)

The Mali project has been discontinued because of the political disturbance and unrest. In Ghana, the SANREM project is implemented in two regions, Upper East and Upper West, involving a total of about 60 farmers.

LTRA-8 operates in two regions (with 12 communities): Upper West and Upper East. We visited with farmers from Upper East. Geophysical issues of soil erosion (from water, wind, and burning) and poor nutrients/fertility for rain-fed agriculture, as well as socio-economic issues of low incomes, food insecurity, and traditional gender roles drive this LTRA. The project considers the geophysical issues-- to increase soil fertility and minimize soil disturbance, and to provide solutions on crop rotations, IPM, and water harvesting. Some local problems also include high prevalence of termites; and crops residues sold as building materials and freely grazed upon by cattle. The project used farmer-driven approaches and focused on "mother trials "(complete and on-station) and "baby trials" (aspects that needed testing on station and on farmers' fields) in terms of crop rotations, intercropping, monocropping and nutrients, seed beds and water harvesting, and IPM.

The partners are SARI, Wa polytechnic, Langmaal Centre for Rural Development (LACRD), Upper West Agro-industries (Wa municipal), and Lassia Tuolo Agricultural Project (LAP). (Also see section on partners for further explanations).

The EET had meetings with two groups of the heads of farmer organizations (from Upper West and Upper East) who explained their interests CAPS as a result of LTRA-8. The gender specialist at SARI noted that some of the women and men whom the EET members met most likely are enlightened farmers who convinced chiefs to give them land and therefore had more than just family land, unlike the food insecure farmers. All the farmers in the trials at the beginning of the project had been given land by the chiefs and (their husbands?), but all this land was taken back, and they had to withdraw from the program, a serious gender issue to say the least.

a. Soil and Natural Resources

NT farming is not always feasible in the North because of the following factors:

- Herbicides are not readily available in suitable (small size) packages,
- Non-availability of appropriate seeding equipment,
- Walking barefoot on a land covered by crop residues,
- Lack of protective wears while spraying herbicides,
- Crop residue removal for other purposes, and burning, and
- Hard and compacted soil.

Drought stress is a major problem in the North and the traditional systems are: contour ridges, tied ridges, and stone lines.

Principal crop rotations are cereal-legumes (maize-peanut, maize-soybean, sorghum-cowpea, sorghum-peanut). Most crop residues are removed for making fence, roofing, feeding cattle or selling it. Open grazing is a major issue. Sometimes, farmers take away the residues and bring it back at the time of seeding. Thus the yields are low at 1.5 t/ha for maize, 1 t/ha for sorghum, 1 t/ha for soybean.

i. Crops and Farming Practices

Women farmers grow peanuts, okra and cowpeas. Men farmers grow maize for 1-2 years on the same land. Crops are sown in May and harvested in October/November. Compost is used, but also at a low rate. Tillage is done by oxen or donkeys. Oxen are owned by men. Labor shortage is a major issue, especially since primary education is compulsory and all children are required to attend school. Inter-cropping (and organized rows of maize alternating with those of cowpea or soybean etc.) is not practiced. Rather, mixed cropping (broadcasting a mixture of seeds of maize, cowpea, sorghum, millet, and peanut) is practiced widely.

Maize, grown mostly by men, is an important crop. All inputs are used for maize (26kg PO_5/ha). Yield increase is about 30% with the fertilizers application. Women farmers have small plots and they grow okra, seeded by hand.

Thus, SANREM has introduced a package of CAPS-practices. These are farmer-driven practices, and include the following:

- Crop residues,
- Mixed cropping,
- Crop rotations,
- Water harvesting,
- Nutrient management, and
- Cover crops
-

These practices are selected through "Mother-Baby" trials.
From a large number of practices used in a demonstration setup, farmers choose whatever they prefer and then use these practices on their farms. Irrigation, based on dam etc., is not involved because SANREM cannot construct the dam. However, USAID can undertake such projects.

Table 1: Traditional Farming by Men and Women Farmers

Men Farmers	Women Farmers
1. Clearing the land by burning	1. Seeding and weeding
2. Preparing the seedbed by hoe or bullock plow, and first time weeding	2. Farming in groups and help one another
3. Harrowing the seedbed	3. Harvesting
4. Using chemical fertilizers (maize, cotton, rice, soybean)	4. Processing
5. Harvesting	5. Cooking

The classic NT farming is not possible. However, minimum tillage (MT) can be used. The MT package includes the following: pre-emergence use of roundup or glyphosate, open a small furrow for seeding, and weeding 2 to 3 times by a hoe. Roundup is cheap because its patent ran out in 2011, and it is produced in China. Jab planter is not successful because soils are too hard.

However, an animal drawn multi-functioning implement (designed at the University of Wyoming) will be tested in the region. Burning is also practiced to drive out the snakes, and other animals

ii. Principal Constraints to Intensification of Agriculture:

- **Drought:** With a little or no rain after seeding, maize suffers from drought. Ground water cannot be pumped because of the lack of electricity or diesel pumps and there are no dams to harvest rainwater.
- **Low soil fertility:** Soils are low in N, P and other nutrients. Subsidized fertilizers can be helpful.
- **Striga:** It is a problem for cereals, and most soils are infected.
- **Constructing Mounds:** It is a time consuming and labor-intensive process.
- **Weed Control:** It can be done by chemicals or by hoe. Tractors are few.

iii. Africa RISING

The USAID has initiated a program called "The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING)." The strategy is to transform African agriculture through sustainable intensification of mixed crop/livestock systems to achieve better food security, improve livelihood and enhance the environment. Under the auspices of "Feed the Future" initiative, USAID has undertaken three multi-stakeholder agricultural research projects to achieve sustainable intensification of some predominant farming systems in Sub-Saharan Africa (SSA). The Africa RISING project will create opportunities for small landholders to move out of hunger and poverty through sustainable intensification (SI) of some major farming systems. This approach can alleviate hunger and poverty by enhancing food, nutrition and income security for the most vulnerable sections of the population (women and children) while conserving and enhancing the natural resource base. These projects are implemented by 3 CGIAR Centers: IITA (West, East and Southern Africa), ILCA (Ethiopian Highlands), and IFPRI. Special objectives are:

- IITA: Sustainable intensification of cereal-based farming systems in the Guinea-Savannah Zone of West Africa, and SI of maize-legume-livestock integrated farming systems in Eastern and Southern Africa.
- ILCA: Sustainable intensification of crop-livestock systems to improve food security and farm income diversification in the Ethiopian Highlands.
- IFPRI: Identify appropriate policy interventions.

iv. The Cereal-Based Farming System in Ghana

The Africa RISING program in Ghana involves identification of specific niches for improving productivity and sustainability of site-specific interactions between crops and soil, soils and livestock, crops and livestock, and soil-crops-livestock (Fig. 2).

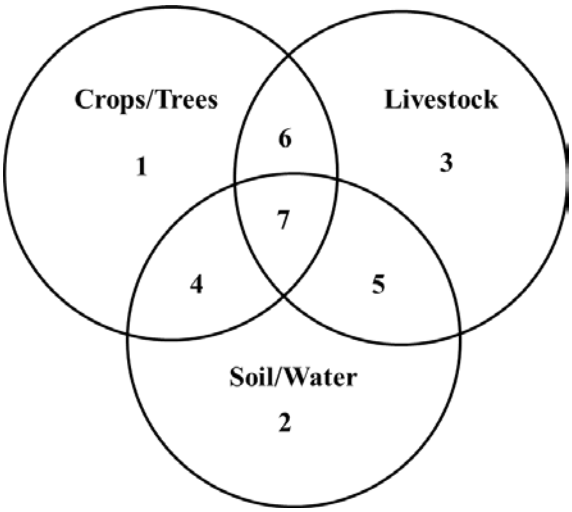


Figure 2: Specific interactions among farming system components being identified for sustainable intensification by Africa RISING program: (4) Crops/trees and soil/water, (5) soil/water and livestock, (6) crops/trees and livestock, and (7) crops/trees, soil/water and livestock.

v. Cooperation Between SANREM and Africa RISING (Mali, Ghana):

The following points emerged from the discussion between Rattan Lal, P.V. Prasad and Asamoah Larbi in the afternoon and evening of 19 May 2013.

- There has been no cooperation between SANREM and Africa RISING projects.
- There are too many actors, but no communication among them.
- Programs and plans have not been clearly defined
- While $25,000 were allocated, funds were not properly used
- There are too many projects with overlapping objectives which need to be streamlined and coordinated. There is a need to identify common interests and niches for each partner. There are many programs which must be implemented together by SANREM and Africa RISING.
- SANREM projects on assessing soil quality under CAPS is by its very nature a long-term program, especially since most of SANREM's work is under on-farm conditions.
- In the meanwhile, Africa RISING programs office, based at SARI, had to be moved to Tamale downtown because of space restrictions. This move may further hinder cooperation between SANREM and Africa RISING

Each country involved in the Africa RISING has its own specific program and the framework to implement it. An example of such a program and its framework in Ghana is presented in Fig. 3. Possible cooperation between SANREM and Africa RISING can be visualized from the outline presented in Fig. 3. The Africa RISING Project in Ghana and Mali involves 25 farming communities of men and women farmers. While SANREM is working with different communities, the approach and technological focus are similar.

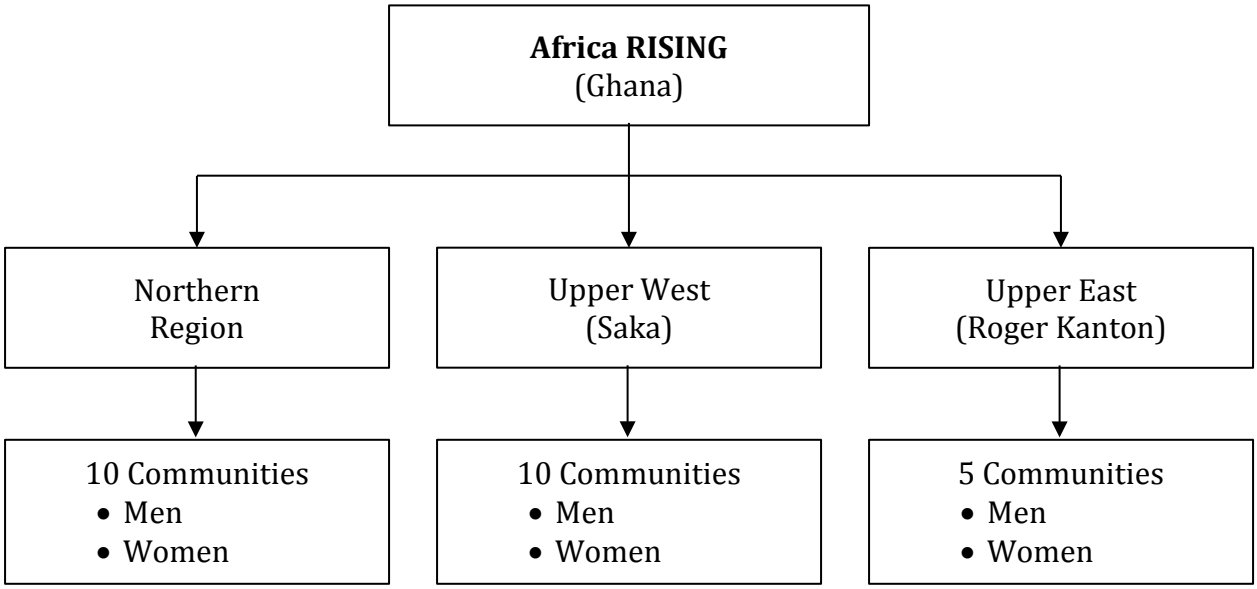


Fig. 3 The Africa RISING program in Ghana involves 25 farming communities of men and women farmers. Discussions with men and women farmers are organized separately because women farmers often do not talk in the presence of men (Islamic communities).

The Africa RISING program outlined in Fig. 3 is managed through two research assistants and a vehicle for each of the three regions. The Africa RISING project also involves graduate students. In Ghana and Mali, there are 4Ph.D and 6M.Sc students.

The discussion indicated a strong need for cooperation, especially because SANREM has discontinued its program in Mali because of the political unrest. Therefore, it was agreed upon that one graduate student, to be enrolled at KSU in crop physiology/agronomy, will be sponsored by SANREM and will work with Africa RISING in Mali. Funds for the student ($25,000/yr) will be made available by SANREM.

vi. Modus Operandi of SANREM in Ghana

The following steps were undertaken to implement the project:

- Identifying key NGOs for organizing a workshop,
- Selecting interested farming communities,
- Conducting a baseline survey involving 360 households,
- Discussing the relevance of CAPS, rotations, INM, etc. with NGOs and farming communities. Most communities (60%) did not believe that it is possible to seed without plowing, ridging, mounding, etc.,
- Explaining the practical steps (protocol) in using CAPS,
- Designing the package of CAPS practices to be used, and
- Initiating the "Mother" trial for farmers to choose specific practices of interest to them (demand-driven).

So far the SANREM has been implemented in the Upper West. It will now be started in the Upper East in view of the disruption in Mali. It is the Mali component which is being moved to Upper East.

vii. Conclusions Drawn from the SANREM Research in Mali

- Cover crop is not an option for the dry region of Mali. To be successful any cover crop must produce edible seeds (e.g., mung bean, pigeon pea, mucuna).
- Water harvesting is important (tied and contour ridges, contour bunds with establishment of grass, pigeon pea, gliricidia, etc.)
- Crop rotations are useful.
- Manuring and INM are integral to CAPS.

viii. Emerging Issues from Presentations by Roger Kanton and Jesse Naab:

Constraints in achieving high agronomic yields are:

- Low soil fertility,
- Severe drought (initial and terminal),
- Striga infestation,
- Flooding,
- Soil erosion and runoff, and
- Lack of farm traction.

These constraints are experienced in both Upper West and Upper East regions.

Strategies of achieving the Green Revolution (6-7 t/ha crop yield) include the following:

- Use of organic and in organic fertilizers,
- Principal food crop staples are maize, sorghum, millet, cassava, groundnut, and cowpea. The yields of these crops must be improved, and
- Maize is the predominant cereal in Ghana.

Soils have low pH (<5), yet no lime is used. The soil organic C concentration is <0.5% and soils have low available water capacity. Nutrient mining is a serious problem. Thus crop yields are low.

Most research experiments are based on split plot design with tillage as the main plots, which may reduce its statistical significance.

Mixed cropping is practiced, but productivity must be assessed by compiling LER and ATER indices.

The lowest yields are obtained with NT without fertilizer due to compaction and nutrient deficiency.

Crop yields are better with tied ridges

Vertical farmer exchange is adopted to promote adoption of CA. 61 farmers (45 men) are chosen.

There is a lack of water for the study in UW for spraying.

Benefits of CAPS are:

- Low cost,
- Stable yield,
- High income,
- Increase in farm size,
- Erosion control,
- Timely operations, and
- Water conservation.

Constraints of CAPS are:

- Large herbicide containers, and
- Lack of seed drill.

b. Social and Gender Issues

i. Gender: Women's and Men's Agriculture

Traditional, gender-associated crops --the so-called "women's crops" and "men's crops" were described as follows: Women grow peanut, okra, cowpeas, tomatoes, leafy vegetables, and they do not use fertilizer or other inputs. Men grow maize, yams (women cannot enter these fields, especially during menses). Both sexes are involved in irrigated rice in some areas such as Nadrongo. Women also collect and process fruits for food from unplanted trees: dowadowa nuts (processed for the seeds, although the pulp is also eaten) and shea nuts (the butter and green parts are eaten in small quantities). Shea nuts are collected, processed, and sold for cosmetic creams to local cooperatives, including one sponsored by the well-known company The Body Shoppe. Shea butter has high commercial and international value.

Land is also genderized traditionally, and in the case of the LTRA, affects uptakes for women in terms of commercial endeavors. Men control the more fertile lands that are obtained through apportionment of customary tenure from chiefs and family heads (kinship for groups like the Dagamba in northern Ghana is patrilineal, unlike the matrilineal Ashanti and Akan peoples in the central and southern parts of Ghana). On these lands they grow cash crops maize and soybean. Women gain access (but not control) of land through their husbands. They are given unfertile land that has been cropped until rendered "useless" with the idea, as expressed by the farmers the EET met, that they will grow legumes (peanut, ground bean, cowpea) on these unfertile soils to enhance them. Should fertility return, the men will then use the land to grow maize. The problem is that men only give small portions to women to enhance, so much of men's lands remain in declining soil fertility.

It was noted that some women who are heads of households may be given fertile land by the family (we do not know if is it from the husband or her own natal). Some women can "hire" land to farm, and give back a certain portion of product or "beg" land from chiefs (as was the case for the two women farmers interviewed). Generally women have constrained mobility and transport, so are limited in where they can farm. The cultural rationale for use of low fertility lands by

women is that men are responsible for feeding the family. Anthropological research stemming from the 1980s (McMillan, etc.) showed that the families would starve without women's products from these marginal lands.

The EET saw fuelwood, gathered mostly by women, in great abundance around Tamale, but in Upper East, it is such a big problem that the maize, sorghum, and millet stalks are used, making the lack of crop residues problematic for CAPS.

ii. Land-preparation, weeding, harvesting, marketing

Women do not own large animals, and few even own chickens, unlike most places. They cannot use plows. However, they can hire bullock and tractor services. As their cultivations spaces are much smaller that men's lands, their access to these services much less then men's. Many farmers, women and men, hire labor; more data are needed on gender and payments. Women can also be involved in burning the land, less-intensive than hoeing and plowing to remove residues; burning also reduces/kills snakes on farms and near shea and dowadowa trees (deaths from snakebites were said to be common). Women weed 2-3 times, but spraying herbicides as recommended by LTRA-8 has reduced the first and most intensive weeding, making farming of commercial crops desirable to middle- and upper-range women. Harvesting is done by women and girls. Farmers who have extensive acreage need threshing places to keep the seed clean and free from insects (tarps and plastic drapes, as well as cement floors are required as lands size and production increases). Women market maize, rice, peppers, and tomatoes. Men sell livestock.

iii. Soils and Gender

Capital-intensive crops are believed not be unsuitable for women because they require fertile land and soils. Women only receive or have access to marginal lands, with unfertile or sub-fertile soils, where more localized, and often sub-subsistence level crops can be grown. Crops with high value such as peanut and ground bean can be sold for good prices, but only in very limited quantities (bowlfuls). This, however, is noted as their "income-generating potential," an ironic notion since these high protein foods, would then be removed from the household diet.

iv. Recommendations

Key to greater household food security is letting women have access to lands with better soils (in areas with extensive lands this bucks tradition; in areas with little available land, this would put women in direct competition with men for such lands) and also to inputs such as herbicides and fertilizers.

v. LTRA-8 Household survey

In the project's household survey, 210 households in 12 communities in three districts of the Upper West region were interviewed (201 men, 157 women). The communities were selected based on the existence of farmer based organizations (FBOs) and their working relationship with the local NGOs. Out of the 12 communities, 7 were classified as the interventions (with) communities and 5 were as the non-intervention (without) communities. Household have 7 - 9 individuals on average. About 10% of household members migrate to the south when agricultural activities decline. Most of the household heads (97%) were involved in crop production. Data giving assets (household wealth) ranged between GH¢1,224 and GH¢ 1,729 per household.

Household wealth is highly concentrated in livestock inventory (68%) followed by non-agricultural assets (20%); and agricultural assets (12%).

Farmers also put percentages of most crops in storage (millet 40% and peanut, sorghum, groundnut etc., 10%) to serve as food and cash security measures. Most households (42%) monocrop peanuts, maize, millet, rice, sorghum, soybeans and yam. 31% mix cropping type a cereal and legume (e.g. millet and peanut). 24% practice the split plot cropping system.

Households operate on three parcels of land with a total average of 10 acres per household. Tenure on most of the land was by direct ownership (87%) of the household heads through inheritance or purchase. About 97% of cultivated lands are rain fed without irrigation, and about 28% of households use fertilizers. Labor per household were predominantly family dependent; hired labor cost per day were high (GH¢3.00 per day in Upper West to about GH¢ 9.00/day in Upper East). About 24% of the all crops produced were sold, especially. soy beans, peanuts and most households (77%) were involved in selling their produce.

61% of household heads belong to a club or a FO and 55% received some information from NGOs and governmental institutions. Male heads did not differ much from the women in the household, as 64% of the women sampled belong to women or mix group FBOs, with 29% receiving information on agricultural production. Among the women, weekly meeting were predominant with 83% being officers of their group.

The results of the benefit-cost analysis revealed that, all three treatments were profitable under farmers' condition. The implications are that, with TR+ Grass strips and the Flat treatments, for every cedi invested, a more than one cedi would be realized as benefit to the farmer and with that of only tied ridges, every cedi invested would result in a cedi equivalent as benefit to the farmer. On returns to labor, all the three treatments gave very high returns to labor. Labor productivity was also higher in all the treatments (2010 pages 5-6)

With the maize the cost reduction from conventional tillage to NT was estimated to be 20% with yield difference of 26%. Even though statistically, there were significant differences in the yield, economically, the No-tillage practice is promising. With the soybeans, the No-tillage reduced the total variable cost of production by 39% with the Conventional tillage yielding 9% higher than the NT. Furthermore, economically, the NT performed better than the Conventional tillage.

In Busa-Tangzu the yields of the NT plots were averagely better with the NPK application than with the Single super phosphate (P). Hence the No-till is promising at this site.
In Nandom yields from the tied ridges were averagely higher but less than that of the Flat and Tied Ridges with Grass strips. Economically, Tied Ridges with Grass strips performed better than the Flat which also performed better economically than the Tied Ridges only. However, the Tied Ridges and Tied Ridges with Grass strips showed great promise.

Generally, the introduced conservation practices (NT, Tied Ridges and Tied Ridges with grass strips showed great promise and would likely contribute to increasing food security and framers income (CSIR-SARI, Descriptive Report on Cropping Systems in Upper West Region, Ghana April, 2010.

The Conservation knowledge decision index was designed to test knowledge on conservation practices and with answers being true or false. Results of the index from Northern Ghana show that men and women household members sampled in all categories are knowledgeable (scoring scored above 70%) about conservation issues except on planting directly without plowing (NT), where the conservation knowledge score was still roughly the same for both genders (40% for men and 39% for women) in all categories. Household heads and their wives receive information on agricultural production through their participation in clubs and groups. Hence, knowledge on conservation practices in all categories was very high but knowledge on NT was much lower.

Table 2. Conservation Knowledge Decision Index

Conservation knowledge	Male				Female			
	With (N=71)	***Within (N=67)***	***Without (N=63)***	***Total (N=201)***	***With (N=54)***	***Within (N=57)***	***Without (N=46)***	***Total (N=157)***
Crops residue are sources of organic matter to soil								
True	*97.2*	*100*	*98.4*	*98.5*	*96.3*	*93.0*	*91.3*	*93.6*
False	*2.8*	*0.0*	*1.6*	*1.5*	*3.7*	*7.0*	*8.7*	*6.4*
Organic matter improves soil water holding capacity								
True	*94.3*	*95.5*	*91.9*	*93.0*	*90.7*	*87.7*	*93.5*	*90.4*
False	*5.7*	*4.5*	*8.1*	*7.0*	*9.3*	*12.3*	*6.5*	*9.6*
Manure is as strong as purchased fertilizer								
True	*78.9*	*85.1*	*77.8*	*80.6*	*86.8*	*77.2*	*73.9*	*79.0*
False	*21.1*	*14.9*	*22.2*	*19.4*	*13.2*	*22.8*	*26.1*	*21.0*
Manure improves soil water holding capacity								
True	*91.5*	*94.0*	*83.6*	*91.5*	*87.0*	*89.5*	*82.6*	*86.6*
False	*8.5*	*6.0*	*16.4*	*8.5*	*13*	*10.5*	*17.4*	*13.4*
One can plant directly without ploughing								
True	*40.8*	*34.3*	*44.4*	*39.8*	*38.9*	*38.6*	*39.1*	*38.8*
False	*59.2*	*65.7*	*55.6*	*60.2*	*61.1*	*61.4*	*60.9*	*61.2*
Tilling the soil assist in water infiltration								
True	*85.9*	*74.6*	*77.8*	*79.6*	*72.2*	*80.7*	*67.4*	*73.9*
False	*14.1*	*25.4*	*22.2*	*20.4*	*27.8*	*19.3*	*32.6*	*26.1*
Seed bed increases water holding capacity of soil								
True	*81.7*	*91.0*	*74.6*	*82.6*	*79.6*	*80.7*	*76.1*	*78.9*
False	*18.3*	*9.0*	*25.4*	*17.4*	*20.4*	*19.3*	*23.9*	*21.1*
Seed bed improves aeration in the soil								
True	*95.8*	*97.0*	*90.5*	*94.5*	*76.6*	*82.5*	*86.9*	
False	*4.2*	*3.0*	*9.5*	*5.5*	*23.4*	*17.5*	*13.1*	*82.8*
								17.2
Rotating cereals and legumes improves soil fertility								
True	*97.2*	*98.5*	*98.4*	*98.0*	*88.9*	*82.5*	*84.8*	*85.3*
False	*2.8*	*1.5*	*1.6*	*2.0*	*11.1*	*17.5*	*15.2*	*14.7*
Rotation prevents some plant disease								
True	*90.1*	*97.0*	*90.5*	*95.0*	*87.0*	*84.2*	*84.8*	*85.3*
False	*9.9*	*3.0*	*9.5*	*5.0*	*13.0*	*15.8*	*15.2*	*14.7*
Cover crops prevents soil erosion								
True	*88.7*	*92.5*	*90.5*	*90.5*	*85.2*	*84.2*	*91.3*	*86.6*
False	*11.3*	*7.5*	*9.5*	*9.5*	*14.8*	*15.8*	*8.7*	*13.4*
Cover crops increase microbial action in the soil								
True	*84.5*	*91.0*	*87.3*	*87.6*	*77.8*	*82.5*	*84.8*	*81.5*
False	*15.5*	*9.0*	*12.7*	*12.4*	*22.2*	*17.5*	*15.2*	*18.5*

Source: Results of field survey, May, 2010

Table 3. LTRA-8 Ghana Project data on Knowledge of CA by Gender

Exceptions include no-tillage and direct sowing.

Knowledge of Conservation Practices	Response	Male	Female
		(%)	
Crop residue are sources of organic matter to soil	True	98.5	93.6
	False	1.5	6.4
Organic matter improves soil water holding capacity	True	93	90.4
	False	7	9.6
Manure is as strong as purchased fertilizer	True	80.6	79
	False	16.4	21
Manure improves soil water holding capacity	True	91.5	86.6
	False	8.5	13.4
One can plant directly without ploughing	True	39.8	38.8
	False	60.2	61.2
Tilling the soil assists in water infiltration	True	79.6	73.9
	False	20.4	26.1
Seed bed increases water holding capacity	True	82.6	78.9
	False	17.4	21.1
Seed bed improves aeration in the soil	True	94.5	82.8
	False	5.5	17.2
Rotating cereals and legumes improves soil fertility	True	98	85.3
	False	2	14.7
Crop rotations prevents some plant diseases	True	95	85.3
	False	5	14.7
Cover crops prevent soil erosion	True	90.5	86.6
	False	9.5	13.4
Cover crops increase microbial action in the soil	True	87.6	81.5
	False	12.4	18.5

Perceptions about conservation agricultural practices were similar among male and female respondents.

Farmers were aware of importance of soil organic matter, manures, crop rotations, cover crops and water harvesting.

Farmers showed strong interest in learning about benefits and use of tillage, residue management, improved genotypes, weed control and integrated nutrient and pest management.

The CGIAR units usually keep most of the money they are given, leaving a pittance for the NAROs. Therefore, SANREM's partner SARI is delighted that it is now/will be a recipient of USAID (LTRA-8) funding under a capacity building and that the first tranche will go to it directly. The EET noted, however, that research scientists working for NAROs tend to do specific, individualized programmatic research and be divided into localized (regionalized or agro-ecological zone-specific) areas. As well, because the rewards (promotions, pay increases, vehicles, etc.) are limited, people are evaluated individually, and this works again collaborative scientific work. SARI is an example, with specific researchers and regions being linked, and publications being of a more specific rather than national content. Also, the research is more likely to appear in SARI's reports than in recognized journals in the

disciplines. For example, SARI researchers did trials on tillage techniques (hand-held hoes, bullock plows, tractors) in the early 1990s (Ref), but not until LTRA-8 were all the techniques of CAPS introduced.

SARI has many small projects, and many are not integrated with each other or in on-going programs. Scientists are keenly aware that even successful projects, such as Gate's Foundation drought-tolerant maize need to be continued, so that farmers who "bought into it, will be left without the project's inputs, and therefore will not be able to sustain what they learned. Africa RISING is seen as a parallel program to SARI, doing NARO-like research on the ground and should be integrated and transparent to enhance collaborations with other ongoing research projects such as SANREM.

Appendix VI. Visit to Cambodia: LTRA-12 (6/15-6/22)

The EET team consisted of Professors Rattan Lal and Anita Spring.

1. Staff visited included the following

- Stéphane Boulakia, CIRAD, Montpellier, France
- Manuel Reyes, PI, SANREM, North Carolina A&T State University
- Kimberley Lucas, USAID, Phnom Penh
- Teffera Betru, USAID, Phnom Penh
- Megan O'Rourke, AAAs Fellow, USAID, Phnom Penh
- Touch Visalsok, President, Univ. Battambang
- Kong Rada, CIRAD

2. Soils and Natural Resources

a. Background

There are four predominant biomes, with distinct soil types, water regimes, physiography, and farming systems.

- Perennial Culture: The ecoregion comprising plateau and hills, involves rubber plantations, timber/plantation forestry and other perennial cultures. Predominant soils are Oxisols, and Mollisols under a rainfall regime of 1200-1800mm. Maize is grown as an intercrop during the initial (3-4 years) stages of plantation. With the complete canopy development, there is a lot of earthworm activity (large worm casts, 5-10cm high and 3-4cm in circumference). Trees can be harvested in 7-10 years. Some trees can be very high (20-30m). Forest plantations are being considered for C credits but no work has yet been done.
- Rainfed Rice Along with Upland Grazing: The rainfall is about 1200-1800mm. Upland rice (rain fed) is broadcast. Soils are sandy with low agronomic productivity of 1.5 to 2 Mg/ha. There is 6-8 months of rainy season (mid-April to mid-November). Soils are sandy and >60% of the land is under rice cultivation.
- Flood Plains: These are hydromorphic soils with broadcast rice, and open grazing is practiced after rice has been harvested. Water can rise up to >50cm, and rice is harvested after the water recedes. While there is lodging, losses of grains are low because of specific varieties adapted to flooding (e.g., deep water rice).
- Floating Rice: The depth of flooding is high, and the dominant variety grown is "floating rice". Among three rice-based systems, the water regimes improve as follows: Upland Rice-Rainfed, Lowland/Deep water Rice-Floating Rice.

b. Field Experiments on CA or DCM (Direct Seeding Mulch Based Systems): 18 June 2013

Several field experiments were visited.

No-till Upland Rice: This unreplicated 2-factor experiment is sited about one hour drive from Battambang. There is a strip of plowed rice and several strips of no-till upland rice at three levels of fertilizers. Field plots were established after laser leveling of the land. NT rice was sown after

rolling down and spraying of the 4-month old cover crops (*Stylosanthes, Crotolaria*) grown during the dry season. There are three levels of fertilizers, and the fertilizer response is high. The NT rice is seeded with a special seeder/drill and produced a good stand. The plowed rice had to be re sown because of the drought that caused a very poor stand. The NT rice has perennial "torpedo grass", which is difficult to eradicate.

About 1km from the experiment, there is a large demonstration site. It had been leveled but not yet seeded. Conversion to NT will commence from the following season. The next stop was a field of rolled down crotolaria, ready for seeding. It also had torpedo grass.

c. Visit to Farm Machinery

The town office of CIRAD has a collection of farm machinery. It comprises of NT seeder, roller, sprayer, surface seeder, etc.

The EEC, comprising of Dr. B.A. Stewart and Dr. Susana Lastarria-Cornhiel, joined EET for the afternoon visit. Rolling down of pigeon pea, sorghum was demonstrated under on-farm conditions. Crops sown after roll-down of cover crops were cassava and maize.

A plot of farmer's maize (2-3 ha) was heavily infested with the tall grass (P*anicum* spp.) It looked similar to *Andropogan*. The farm household has numerous trees of tamarind. Maize grown under tamarind had a poor stand. However, maize growth was luxurious and had a good dark green color. It was double the height of the surrounding maize;Decomposing leaves from a tamarind tree apparently enhanced N availability.

d. University of Battambang: Rector Touch Visalsok (8am 6/19/13)

This is a beautiful campus, with 5000 students. There are 15 students interested in CAPS, livestock, soil science, plant growth, etc. Their focus is on integrated management of rural communities and agricultural development.
There is an interest in development of a "Center for Conservation Agriculture in Southeast Asia". While the concept of the center is a good one, there are numerous challenges. The new university has no experience and there are no trained faculty members. Thus, who will teach the classes? The Rector also is not sure about the focus. He discussed the title "Center for Sustainable Agriculture" versus "Center for Conservation Agriculture." The former is much broader in scope. The IV Conference on CA in Southeast Asia is scheduled to be held at the University in Battambang in December 2013.

Visit to the Field Site (9am to 1pm) The EET traveled with Rector Touch Visalsok. He expressed interest in visiting universities in USA, and was dismayed about the difficulties in obtaining visa. He indicated the waited in line for more than three hours and yet he was turned back.

The village site has 90 ha planned under CAPS. The 90 ha, rolling land with predominantly Mollisols developed under limestone, belong to 20 families. The NT maize was fertilized with 12kg/ha of N (comprising of 15kg/ha of DAP and 25kg/ha of 15:15:15). This large field has been sprayed but there was no cover crop.

Another large adjacent field (~ 5km away) is a farmer field. It has a 4-week old good stand of NT maize. However the growth is very uneven. There are patches of tall maize of lush green color with short maize showing symptoms of nutrient deficiency. When asked the reason for the uneven maize growth, farmers responded that good maize growth is on spots which are relatively high, well drained, and not prone to local flooding, inundation after a heavy rain. Walking through the patches of uneven growth indicated that tall/green maize was on high spots where there was a regrowth of tamarind, *zizyphus* or old termite hill. However, there are only two seed drills in the region, and there is a long wait.

The EEC separated from us after lunch. The return to Battembang included stop with rice cooked inside the bamboo. It is a sweet rice like a candy.

e. Visit to Large Scale Irrigation Scheme: (6/20/2013)

We were joined by Megan O'Rourke of USAID Mission in Phnom Penh. She has a Ph.D. in ecology from Cornell and will join VT as a faculty member in August 2013.

The large-scale irrigation system was established in mid 1970s. From the main road (Battambang to Kampung Chang), the irrigation scheme was connected with a mud road. During the rainy season, with mud puddles and deep potholes, the average speed was about 15 miles/hr. under the best-case scenario. The farming activity on both sides of the mud road involved plowing, and transplanting rice. Plowing was with bullocks and involved a wooden plow with a metal cutting blade curved to turn over the furrow slice. Because of the poor road and weak infrastructure, there have been severe problems with the maintenance of the canals and infrastructure. Leveling is essential for good irrigation. Thus, the treatments tested involved leveling vs. no leveling at three levels of soil fertility management. The cover crop (*Stylosanthes*) is established prior to seeding the rice. There is a problem with weeds such as *Cyprus rotundus* or torpedo grass. The sandy soils are strongly infested with nematodes. However, NT seeding reduces the incidence of nematode because of the improvement of soil structure (aeration) through structural porosity and increase in SOC concentration. There was a visible change in soil color though increase in SOC concentration. These sandy soils cover 1.5Mha and contain 80% sand. Grain yields of rice indicate the following trends:

- Leveling = 2600 kg/ha
- No-till + stylo + centro = 2600 kg/ha
- No-till + stylo + centro + 70 kg N/ha = 4900 kg/ha
- Traditional (unleveled, broadcast, no fertilizer) = 2000 kg/ha

Note: An additional treatment should be to feed the stylo to cattle and return dung/manure to the land.

During the field visit from 9:30am-11am, the temperature and humidity both were about 100F and 100%, respectively. It was an unbearable heat. It was not possible to tolerate the heat for more than 30 minutes.

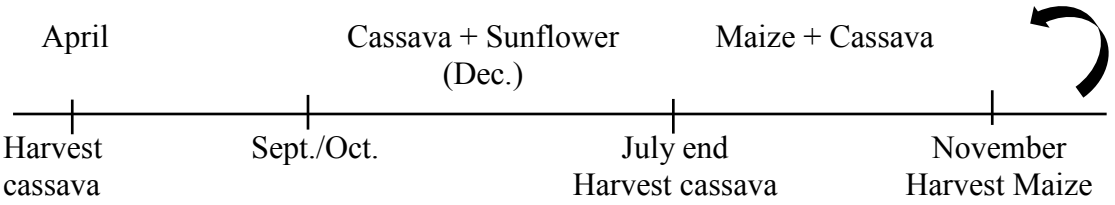
f. Visit to Rubber Plantation and Plantation Forestry

En route to Kampong Thom (Mekong River) we passed though large rubber plantations. Maize was inter-seeded though rows of young rubber trees. These plantations are established by "Open Cambodia Development" scheme or "Cambodia Open Development" scheme.

g. NT in Rolled Over Stylo, Sorghum Cover Crops

There was a demonstration of rolling down stylo and sorghum. There were also stand of cassava (6-7 months with well-developed tubers), 45-day-old (~2m tall, not yet tasseled) maize and mung bean. Cassava can produce 30Mg/ha of fresh tubers (13Mg/ha of dry) and maize up to 7Mg/ha of grains.
Stylo, sorghum, crotolaria can produce up to 7Mg/ha of biomass. Thus, stylo can fix up to 70-80 kg N/ha.
These cover crops are sprayed with 2.5 l/ha of glyphosate (900g a.i.), and 1.5 l/ha of 2-4-D (1 kg/ha of a.i.). Soybeans can be seeded about 1 month after the spray.

Rice (followed after *stylo + centro*) produces ~ 5t/ha of grains vs. 2 t/ha under traditional systems. Finger millet (*Eleusine coracana*) is another intercrop with maize. The new farming system (shown below) can lead to 250% cropping intensity



The 250% cropping intensity, involving two crops of cassava and two crops of maize over the 2-year period, also receives chemical fertilizers at the rate of 90kg/ha of N, 60kg/ha of P_2O_5 and 60 kg/ha of K_2O for maize and 90kg K_2O for cassava.

Cassava is sown with strip tillage (10cm wide strip with chisel plow). Cassava is seeded at 80cm x 100cm spacing. Because of its export as cattle feed (China, Europe) the profit margin with cassava is double than that of maize.

h. Improved CAPS-Based Cropping Systems

A thunderstorm occurred during the field visit. While waiting inside the car, the following discussions occurred with Stéphane Boulakia.
Three promising cropping systems which CIRAD and SANREM have researched comprise the following:

- Upland Cassava: Established through roll down into strip tillage, it can be adopted on about 0.8 – 1 Mha. The system includes double cropping of maize. This cropping system is recommended in regions with rainfall of 1200 to 1600mm. The system has the potential to increase the yield of maize from 2.5 to 7 Mg/ha and that of cassava from 6 t o 13 Mg/ha (dry matter).

- Rainfed Low Land Rice: This system is recommended for regions with annual rainfall of 1200-1600mm. This agro ecoregion covers a land area of 1.5to 1.7 Mha. The cropping system involves rice grown after cover crop of *Stylosanthes* and *Centrosema.* The increase in rice yield is about 1.5Mg/ha (from 2 to 3.5 Mg/ha).
- Rainfed Rice in Flood Plains: The agro ecosystem covers a total land area of 0.6Mha. The land is flooded during the rainy season. Thus, crops are grown before and after the flooding. Conversion to NT rice (with cover crop) can increase rice grain yield by about 600 kg/ha.

Whereas these systems are promising and have a large potential to enhance and sustain agronomic yields, there are also numerous constraints to adopting the DMC/CA as proposed by CIRAD/SANREM. Principal among these constraints are the following:

- The high costs of NT seeder: The cost of NT seeder is $9,000 to $14,000. The 3-row maize and 5-row soybean seeder from Brazil costs about $15,000. The local copy costs about $9,000. In addition, the roller costs about $1,000.
- Small farm size of <2 ha is not economically viable for the DMC-CA system. These small landholders work off-farm, and are concerned with day-to-day basic needs (food, clothes, etc.)
- Lack of credit is an issue for large farms (>2.5 ha). Thus, these farmers are unable to invest in seed drill and other supplies. Equipment rental services must be developed.
- The cost of renting tractor is about $320 for 4-ha farm for plowing and harrowing. Russian tractor cost about $22,000. There are only a few examples of such tractor among relatively large landholders.

i. Vision for DCM-CA in Cambodia

The cropland area is envisaged to increase from 3Mha now to 5Mha by 2030. It is hoped that 100% of the cropland may be converted to DCM/CA by 2030 with the growth rate of about 75%/yr. between 2013 and 2030. Thus, DCM/CA must begin with a pilot scheme of about 1000 ha in 2013-14. The financial investment for this program must come from the private sector. It may involve two components: (a) $3000/ha of which 95% must come from public funds, (b) $10,000/ha of which 25% must come from public funds and the remaining from private sector. In this regards, both farmers' organizations and agricultural industry must play a very crucial role. The basic model is "contract farming". Funds are needed for: machinery, soil restoration, training, infrastructure, and support services. Thus, improved credit facilities are extremely critical to achieving the vision.

3. Gender Issues: Women Farmers and Women CAPS Adopters

Although statistics on the participation of women in LTRA-12 are lacking, it is known that women participate in CAPS projects as much as men do, but there is a gender-based division of labor. Women enjoy the fact that CAPS requires less labor, and they like the fact that the costs of plowing are reduced by using NT practices. Small commercial farmers pay between 15,000 to 30,000 riels per day (US$3 – $6 per day) for hired labor (female). One woman farmer who was growing pigeon peas and maize said that it costs her about $300 for four hectares to hire someone

to plow for her. Part of her land was sloped and if she used a plow there would be water run-off and furrows. A cost of US$300 for that farmer is a significant outlay, and any technique to reduce plowing is more than welcome.

Although CAPS does not eliminate the need to pay for herbicides, it does result in much less weeding, which is highly desirable. CIRAD has subsidized herbicide costs, but CIRAD funding is ending and there is a serious question of the source of needed capital in the future. The farmers were formerly using atrazine, paraquat, and 2, 4, D; now they are using clyphasot plus 2,4, D and they must pay to spray the cover crop. In any case, they have reduced production costs in half by not having to pay for plowing and reducing herbicide costs. Moreover, with NT practices, fertilizer use is more efficient and costs are reduced. Still, initial costs of CAPS can be a barrier to adoption, and cost savings are not realized for some time, which is a problem for small farmers.

The woman farmer we spoke with had bought her land in 1998 from a high-ranking Khmer soldier and has a certificate for the land in the name of her husband and herself. In terms of decision making in the household, it seemed that both men and women made decisions, both separately and together. Cambodian society is matrilineal, and after marriage the newly-wed couple lives with the wife's parents. Reflecting the matrilineal post-marital residence, it was pointed out that women who were daughters of Khmer Rouge soldiers who had been living in the area, might marry men from the central region, then bring them back to the wife's home where land was plentiful, giving the women more decision making power. In terms of choosing husbands, because of the Khmer Rouge and the long years of warfare, there was a deficit of men; women lacked men to help in the fields.

a. Smallholder Production

About 75% of subsistence farmers have less than one hectare, while "commercial" farmers cultivate 2.5 (the minimum determined to be viable for CAPS in this area) to 20 or 30 hectares. Some of the latter had received land from the state, while others had bought their acreage in the private sector. Cambodian farmers often use irrigation and say they do not know how to intensify production without it.

Due to the country's years of warfare and decades of turbulent conditions, the country lacks supply chains and processing facilities for all types of goods, including agricultural products. About 80% of farmers are not well connected to the market for sales. Consequently 90% of raw products are exported to Viet Nam and Thailand for processing, and manufactured goods are imported. The EET thought that agro-processing and agribusiness components should be added to SANREM projects.

b. Climate Change and Agriculture Issues

Farmers the EET spoke with mentioned climate changes effects being experienced in their country. They noted that the rainy season that used to begin in March is now starting in June. They noted that forested areas which once contained a large amount of plant species, as well as elephants and tigers, was now experiencing the same climate as central Cambodia. This change is good for production of upland rice, a delay of planting dates can be a serious problem for farm production.

c. Farm machinery and mechanization

Access to needed farm machinery such as seeders and NT planters is a serious issue in CA farming in Cambodia. CAPS farmers must either buy, rent, or contract with other farmers who are the owners of the equipment to gain access to needed mechanical equipment. Stephane Boulakia, the on-site project director, had imported a NT-Planter (Vence Tudo SAS-11500) from Brazil (the epicenter of CAPS) at a cost of $15,000 and contracted with vendors in Thailand for $9,000 to get it modified for use with CAPS in Cambodia. If CAPS is to expand and receive widespread adoption, the problem of capital outlay for mechanized equipment will have to be overcome.

In one case, a woman had bought a seeder by herself, and in another case a man had bought a planter. Some farmers not in the CAPS project saw good CAPS results of their neighbors and purchased planters on their own. Still, there is a major lack of capital and for many small farmers gaining access to mechanized equipment represents a serious impediment to adoption of CAPS.

d. Comments by Farmers Participating in LTRA-12

The EET had the opportunity to see extensive trials and inspect demonstration CAPS plots in several locations around the country. During the course of these on-site tours, the team had the opportunity to speak with a number of LTRA 12 participants.

Table 1 provides a synopsis of items that farmers frequently mentioned about CA and about the SANREM Innovation Lab project as a whole.

Table 1: Comments of Farmers on Perceived Benefits of CAPS and on the LTRA 12 Project

Issues About CAPS and Benefits of CAPS	Needs of CAPS Farmers	Ending the SANREM LTRA-12 Project
CAPS is a paradigm shift instead of a piecemeal shift. Some farmers have made this shift, while others are still in the piecemeal stage	Need more financial credit for herbicides	If SANREM ends, the trained personnel will go to other projects and be lost
The market opportunities for the products under CAPS have not been fully defined, but will be soon	There are cash-flow, as well as labor constraints and lack of capital.	If SANREM pulls out, there will be a loss of farmers who have already adopted CAPS.
CAPS does not work for farmers with less than 0.5 ha, but it does work for farmers with more than 2.5 ha. which allows them to become commercial farming	Poor farmers need CAPS because of continuous mono-cropping of either maize or rice	
Farmers are used to paying for plowing services and other mechanized services.	Farmers' networks need to get more information about CAPS	

CAPS needs to scale up. We don't need any more pilot studies; we are ready to have development and spread of new technologies.	Both female and male farmers want to hire labor (mostly women laborers)	
	Farmers want to buy CAPS seeders and NT planters	

Table 2 Women and Men CAPS adopters and Cropping Operations

DMC/CAPS participation		Decision in inputs, timing cropping, and selling							
	%	Fertilizers	%	Herbicides	%	Sowing	%	Selling	%
F	30	Female	24	F	24	F	27	F	27
M	46	Male	43	M	68	M	38	M	41
Both	24	Both	32	Both	8	Both	35	Both	32

Female participation in Cropping Operations							
Spraying (% of participants)	%	Fertilizing (% of participants)	%	Manual weeding (% of participants)	%	Harvesting (% of participants)	%
0	67	0	36	0	33	0	31
25	17	25	6	25	6	25	8
50	6	50	44	50	47	50	47
75	3	75	0	75	0	75	0
100	8	100	14	100	14	100	14

e. Higher Education for Women Farmers

Manny Reyes, SANREM LTRA-12 PI is trying to establish a Center for Conservation Agriculture at the University of Battambang (UBB). The University Rector, Dr. Touch Visalsok, told the EET that he wants to establish a master's degree program for women entrepreneurs in which they can learn about business and accounting, and develop their own projects. He also was interested in linkages with Professor Lal in terms of soil sequestration and training students. Dr. Reyes also wants USAID to have a sense of what SANREM is and the benefits that Conservation Agriculture can produce. He wants to work more closely with UBB, in particular, and its current Rector Touch Visalsok; USAID officials said if the Mission is to act, the request must come from the Cambodian government and its units.

4. USAID Mission

There is poor communication between SANREM and AID-Washington. No or poor communication between AID-Washington and AID mission and these two offices are often not on the same page. Thus, when SANREM partners come to visit the country project, often no one talks to them.

a. Visit to the USAID Mission (6/21/2013)

Until 2010, the USAID was managing the programs on economic growth, agriculture, and value chains--the latter focused on swine, aquaculture, bricks and tiles, garments, ecotourism, sanitation and water supply. In 2012, the focus shifted to two activities: Feed the Future, and Global Climate Change. The latter includes Sustainable Landscape and Adaptation. These activities are focused on 4 provinces.

b. Helping Address Rural Vulnerability and Ecosystem Stability (HARVEST)

The 5-year HARVEST project is supported through Feed the Future and the Climate Change initiatives. It targets 70,000 rural Cambodian households for reducing poverty and malnutrition. It addresses problems such as low agronomic productivity, post-harvest losses, malnutrition, lack of market access, environmental degradation and the vulnerability of rural people to climate change. The program is implemented though Fintrac Inc., a U.S. Consulting firm with the overall goal of improving food security, strengthening natural resource management, and resilience to climate change, and increasing the capacity of the public and private sectors and civil society to support agricultural competitiveness. Specifically, the Cambodian HARVEST project is designed to: (i) improve incomes of 70,000 households, (ii) accrue economic benefits for 140,000 people, (iii) develop income-generating activities for 7,000 extreme poor households, (iv) diversify cropping systems for 31,500 households and (v) generate $28 million in incremental new agricultural sales.

The objective of diversification of cropping systems is to make the households more resilient, and manage the timing of what is produced. In addition to crops, the fish production is enhanced to improve nutrition through fish protein. Now, 80% of the vegetables produced are imported from Thailand and Vietnam. Thus, another goal of diversification is to increase horticulture and vegetable production and develop home gardens. Agrobusiness is also focused on home gardens. The strategy is to link up with the women farmers.
The HARVEST project is focused on 4 provinces around the Tonle Sap Lake (e.g., Battem Bang, Pursat, Siem Reap and Kampong Thom). These four provinces have a high percentage of poor and food-insecure families. The HARVEST is also focused on “rainfed low land areas” beyond flood plains. In addition, fishery-related projects will be implemented around the Tonle Sap Lake Forest activities will include mangroves, evergreen, and the deciduous dry forests.

Predominant interventions include; (i) disseminate modern agricultural technologies, (ii) increase crop diversification, (iii) promote women’s economic empowerment, (iv) introduce value adding enterprises, (v) establish new models for agricultural extension, (vii) improve knowledge about

crops and livestock farming, (viii) increase access to credit, (ix) enhance the policy and regulatory framework, and (x) enhance national capacity for adaptive research. These activities are designed to help Cambodia implement the Millennium Development Goals. The National Agricultural Consensus was conducted by HARVEST, the first census ever in Cambodia.

The climate adaptation strategies through HARVEST are designed to enhance resilience of the farming systems. For example, fish net are installed to prevent loss of fish by flooding though "Flood Netting". Trellises are installed to improve horticultural production. Payments for C credits through other donors is another option.

The MSU conducted baseline surveys with regards to income level, women empowerment, agricultural index, and gender dynamics. There is a clear difference between the baseline and the validation. First, the baseline data must be collected independently. That is why it was done by MSU rather than by HARVEST. In comparison, validation involves checking the assumption to be sure that these are correct under specific situations.

c. Interaction of HARVEST with the SANREM Innovation Lab

The HARVEST team has established links with Dr. Manny Reyes. The four provinces of Feed the Future can be and should be linked up with the SANREM. The Center for Conservation Agriculture being proposed by SANREM is of interest to HARVEST, especially in terms of the curricula and the human resource development. It must be remembered that HARVEST has a rapid turnaround time, because it has to reach out to 70,000 households.

d. Issues with Innovation Labs (CRSPS) and USAID

- There is little information provided to the mission about what the CRSPS are doing. There is no communication.
- All projects funded out of USAID Washington must talk to each other. There is a lack of coordination.
- Thus, when different personnel from Washington visit the country mission, they receive poor reception because one project does not talk to the other.
- There is a poor communication among CRSPS, especially between IPM and SANREM.

Appendix VII: Responses to the EET's Socio-Economic and Gender Survey Questions

A ten-question survey was sent to all LTRAs (LTRAs 6, 7, 8, 9, 10, 11, and 12). Their answers are summarized for each question below. The aim is to compare efforts on socio-economic and gender topics. (A compilation of all of the responses is prepared as well and available upon request.)

Question 1: *How do the LTRA research trials and methods link CA with total farming systems of participant farmers? How does it include both on-farm and off-farm income streams for both men and women?*

Most LTRA projects report a strong link between CAPS and the total farming systems of participant farmers. LTRA-8 (**Ghana**) reported a baseline survey to study CAPS and indigenous farming practices. LTRA-10 (**Kenya/Uganda**) reported studying how current farming systems operate, and designed programs that would not disrupt current practices. Trials used crop types and varieties that the farmers were previously cultivating upon the initiation of the project, therefore the links of CA practices with the farmer practice at the whole farm level were apparent. LTRA-11 (**India/Nepal**) used crop types and varieties that the farmers were previously cultivating upon the initiation of the project.

How does the project include both on-farm and off-farm income streams for both men and women?
LTRA-11 (**India/Nepal**) reported that CAPS reduces labor time for male farmers to diversity their income sources, especially from off-farm sources.

Question 2: *What techniques has the LTRA used to garner women's participation and adoption of CA? How successful have these been? How does this compare with male farmers participation and adoption?*

All LTRAs reported taking deliberate efforts to garner women's participation. LTRA-6 (**Haiti**) specifically solicited the participation of women farmers in our workshops. LTRA-7 **(Bolivia**) actively promoted women's involvement successfully. LTRA-10 (**Kenya/Uganda**) reached out to women and recruited equal numbers of women and men farmers for on-farm trials. LTRA-11 (**India/Nepal**) invited both the male and female heads of household to attend and participate in project activities, and surveyed women separately from men. LTRA-12 **(Cambodia**) deliberately picked women and men participants in pilot testing, and insured women participate in training.

How successful have these been?
LTRA-10 (**Kenya/Uganda**) reported that getting participation by women has been very successful in three of the four study areas, in part because the two NGO partners working in those areas have histories of including women in outreach and development activities and believes that women who dropped out for reasons unrelated to the project. Concerning land for expansion to do CAPS, LTRA-8 (**Ghana**), reported that in the second year, the lands of many of the women were taken over by the owners and so they dropped out of the project. Land tenure is

big issue in Ghana, and the male-headed households were not that much affected. LTRA-9 **(Mozambique**) reported that in that LTRA gender participation is nearly equal.

How does this compare with male farmers participation and adoption?
LTRA-10 (**Kenya/Uganda**) believes that they have established a "culture of equality." Women with that project "have had a great deal of input on making our CAPS implement adoptable and have pointed out that it will save labor for planting and weeding and will enable them to accomplish tillage because it can be moved more easily that traditional plows and can be drawn by donkeys. Woman farmers involved in our on-farm trials are among our most enthusiastic participants and spokespeople, scaling up their favorite CAPS components independently of our project."

***Question 3**: What constraints has the LTRA faced in terms of different technologies in CA and their adoption for the range of farmers in their project areas: in terms of (a) Reaching wealthy versus poor farmers? Female versus male farmers? (b) Working with women and men who have very small acreage versus those who have large acreage? (c) Measuring locally defined "good" and "bad" soils and conditions? Then linking them to gender of owners/users of plots? What types of quantitative data has the project collected on the types of soils that women and men use in their farm work?*

Reaching wealthy versus poor farmers? Female versus male farmers?
LTRA-6 (**Haiti**) noted that all farmers were poor. LTRA-10 (**Kenya/Uganda**) targeted smallholders who generally have only enough land for subsistence, leaving out larger commercial farmers. In LTRA-11 (**India/Nepal**), the project chose marginal and resource poor tribal people and believe they have a representative sample of farmers. LTRA-12 (**Cambodia**) has found that the wealthy farmers with large land holdings can adopt CAPS quicker and more successfully than poor farmers. LTRA-9 **(Mozambique**) reported participation by economic groups and by both genders.

Working with women and men who have very small acreage versus those who have large acreage LTRA-8 (**Ghana**) reported that women farmers dropped out because the land was taken from them; but some male farmers also had their land taken. Land tenure is a big issue in Ghana. LTRA-10 (**Kenya/Uganda**) offers farming techniques that can be scaled to very small acreage (<1 acre), which includes shallow weeding and NT planting by hand; and to large acreage (~5 acres), which includes introduction of animal drawn implements (they hire tractors or oxen to accomplish plowing). In LTRA-11 (**India/Nepal**) all project village sites consist of smallholder farmers with less than 2 ha landholding per household for India and about 0.6 ha for Nepal. LTRA-9 (**Mozambique**/**Lesotho)** reported working with women and men who have both very small acreage and those who have large acreage, especially in Lesotho.

Measuring locally defined "good" and "bad" soils and conditions? Then linking them to gender of owners/users of plots?
None of the LTRAs provided data on this question. LTRA-8 (**Ghana**) has not done any measurements on 'good' and 'bad' soils and relating them to gender, but may do this in the future. Likewise, LTRA-10 (**Kenya/Uganda**) has not studied this yet. Neither LTRA-11 **(India/Nepal**) nor LTRA-12 (**Cambodia**) had data on this issue. LTRA-7 (**Bolivia**) conducted what was said to be a "comprehensive study" no details were given on this.

In LTRA-9 (**Mozambique**/**Lesotho)** the quality of soil data was not included as part of the baseline socioeconomic surveys. It became clear that the selection of lands for CAPS was driven more by field size and distance from the domicile than by soil quality. In Lesotho, the distance from home to the field was negatively associated with the use of CAPS. Given the labor required to weed and prepare land, farmers may prefer to work intensively on fields closer to home. Smaller plots are also generally located near home. It is likely that these fields are used to produce food consumed at home because they are easier to monitor.

Question 4: *Do wealthier farmers adopt CAPS techniques more than those without resources? Do wealthier women adopt CAPS more than poor women?*

LTRA-6 (**Haiti**) believes all their participating farmers are poor. LTRA-10 (**Kenya/Uganda**) targeted smallholders who generally have only enough land for subsistence, leaving out larger commercial farmers. In LTRA-11 (**India/Nepal**) the project chose marginal and resource poor tribal people and believe they have a representative sample of farmers.

Responses to this question varied considerably. LTRA-6 (**Haiti**) was not sure; LTRA-8 (**Ghana**) did not do a wealth ranking of the farmers; and LTRA-11 (**India/Nepal**) had no data on this subject. On the other hand, LTRA-10 (**Kenya/Uganda**) reported that both wealthy and poor farmers were "eager to adopt specific practices that they believe fit best. All are especially interested in eliminating plowing, with wealthier ones more interested in herbicides and poorer ones more interested in minimum-till methods." And LTRA-7 (**Bolivia**) said both wealthy and non-wealthy groups adopt CAPS at the same rate. However, LTRA-12 (**Cambodia**) reported that wealthy farmers are adopting CAPS quicker compared with farmers who have small land areas.

<u>Do wealthier women adopt CAPS more than poor women?</u>
In Cambodia, a farmer group is led by a woman and also the only farmer who bought CAPS machinery who is part of project pilot extension was a woman. In a wealthy farming community, a rich male farmer bought CAPS seeding planter, as well but they are not part of pilot extension of SANREM. They did this on their own and CAPS adoption is not subsidized by SANREM. Hence, CAPS appears to benefit both genders. A conscious deliberate effort must be done to continue gender equality for CAPS technological benefits. LTRA-9 (**Mozambique/Lesotho**) reported that poorer farmers adopt CAPS use hoes and basins while wealthier farmers purchase NT planters.

Question 5: *How have the research trials changed through time, as project staff and partners have identified the needs for change? For specific technologies that men and women need?*

All but one of the LTRAs reported significant changes in practices during the trials. LTRA-6 (**Haiti**) reported that they had to adjust the choice of cover crops. LTRA-7 (**Bolivia**) said they had to develop a direct seeder that meets women's needs. LTRA 10 (Kenya/Uganda) reported a number of changes: (1) delaying the planting of mucuna; (2) replacing machete planting and using hoes instead; and (3) developing and demonstrating mechanized no-till planting methods. LTRA-11 (**India/Nepal**) reported changing (1) the legume variety in the intercrop due to excessive shading; and (2) in Nepal changing from cowpea to blackgram and the use of residue

retention after mustard harvest in lieu of cover cropping. LTRA-12 (**Cambodia**) reported changing from stylo as a cover crop to pigeon pea where the soil is basic; and beginning to offer subsidized credit and payments to farmers based on crop yields. On the other hand, LTRA-8 (**Ghana**) reported no changes at all. In LTRA-9 (**Mozambique/Lesotho**) reported that initially the trials were heavy on agronomics (rates, population, planting date), but later moved to farmer adaptation on farmer fields.

Question 6: *Has the LTRA carried out a cost analysis of the farmers adopting various CAPS strategies? How do women and men differ?*

For LTRA-7 (**Bolivia, Ecuador**), net economic benefits for different sustainable agriculture practices were based on surveys of 286 households. For LTRA-8, land preparation costs, income, and net returns were based on data from 334 households. For LTRAs-9 (**Lesotho, Mozambique**) and LTRAs-10 (**Kenya, Uganda**), yield and cost-benefits data that compare CAPS with non-CAPS treatments were collected and analyzed. CCRA-6 has been compiling these data from most LTRAs to conduct comprehensive ex-post cost-benefit analyses. LTRA-12 (**Cambodia**) data on Gross Profit Margin (GPM) for maize production, t found that benefits were not enjoyed until Year 3. LTRA-11 (**India/Nepal**) reported that strip tillage intercropping can generate a 67% increase in profits as compared the maize-millet conventional tillage system. LTRA-11 (**India**) found that farmers can simultaneously increase about 5% of farm revenue and reduce about 15% of the total soil loss by adjusting their current practices, but that adoption of strip tillage will ***reduce*** their revenue by about 5% in initial years. This initial reduction in yield can be recovered in long run because of higher yields from better soil health in future.

For the other LTRAs standard cost/benefit analyses of CAPS compared with conventional plow-based farming techniques was strikingly lacking. LTRA 6 (**Haiti**) reported no cost/benefit analyses. LTRA-7 (**Bolivia**) said the studies had been done but gave no details. LTRA-8 (**Ghana**) was not sure; and LTRA-10 (**Kenya/Uganda**) said such a study is underway. LTRA-9 (**Mozambique/Lesotho**) reported that these data are yet to be completed.

<u>How do women and men differ?</u>
LTRA-11 (**India/Nepal**) reported that there is a shift in the roles of men and women if they adopt CAPS: the women's role will be shifted to more of harvesting and threshing and less of manure application. Wage earning opportunities in India tend to be more widely available for men, especially in India. Adoption of practices, such as MT, that would require less time plowing (typically a male activity) may result in greater opportunity for off-farm wage earning.

Question 7: *How have the host institutions (universities connected with the LTRA) influenced research in CAPS? In general? To orient to the science needs rather than to the client's (farmers' economic and food security) needs?*

LTRA-8 (**Ghana**) is working with SARI which is aware of the value of CAPS, but its funding has been too limited to do much testing. LTRA-10 (**Kenya/Uganda**) reports "an excellent balance" between US-based researchers and host country experts, plus NGO assistance. LTRA 12 (C**ambodia**) reported that the Royal University of Agriculture and University of Battambang mainly targeted student training and capacity building and that CAPS science was primarily given through CIRAD

(French) scientists in partnership with SANREM. LTRA 11 (**India/Nepal**) reported that host institutions have been well-regarded and innovative methods for quantitatively measuring both the agronomic, soil, and social impacts of the project. Experimental trials have been designed using completely randomized block designs to ensure the capacity to effectively measure the differences in treatments. In **India**, what has: (1) worked with farmers is to determine capabilities and preferences for CAPS & crops; (2) train farmers on CAPS and provide improved crop varieties; (3) bring farmers together to share experiences/outcomes and disseminate CAPS; and (4) help upscale CAPS to the state level by getting government support for the broader effort. LTRA-9 (**Mozambique/Lesotho**) reported that the host universities are engaged and they are training nine graduate students who will improve local capacity building.

Question 8: *How are LTRA partners "bogged down" in their own cultural biases as to what CAPS is and how to carry it out with their farmer/client groups? What gender biases and barriers do they have?*

LTRA-7 (**Bolivia**) and LTRA-8 (**Ghana**) reported no problems. LTRA-10 **(Kenya/Uganda**) reported that they had "developed an excellent common understanding of what CAPS is in our contexts, that our goal is to make relatively small inroads that change farming behaviors toward improving soil quality/productivity (e.g., reduced tillage, residue conservation, and cover crops in rotations), and that farmer input in the co-innovation process is crucial to accomplishing this." On the other hand, LTRA-6 (**Haiti**) reported that their partners know CAPS elements, but have never successfully practiced them.

<u>What gender biases and barriers do they have?</u>
LTRA-6 (**Haiti**), LTRA-7 (**Bolivia**) and LTRA-8 (**Ghana**) and LTRA-12 (**Cambodia**) reported no known gender biases, but LTRA-10 (**Kenya/Uganda**) described many gender-related issues, saying: "There are clearly culturally rooted gender biases that we battle on several levels, as when we're meeting with faculty and students at a host country university and the female grad student is asked to "fetch tea" for the group, or male African students at the University of Wyoming begin ordering female African students to do specific tasks in the lab, etc. There is some disrespect felt by female PIs from male host-country partners." LTRA-9 (**Mozambique/Lesotho**) reported that people may think that CA requires draft power when in fact it can be all done with human labor.

Question 9: *What socio-economic data has the LRTA collected and linked to its CAPS trials and agronomic work?*

All the LTRAs conducted socio-economic surveys. LTRA-6 (**Hait**i) carried out one of the largest and more comprehensive surveys during 2011-12 throughout the lower plateau as part of a Ph.D. dissertation. For LTRA-7, a socio-economic survey of 300 farmers was carried out during Phase III. The CCRA-6 (**Economic and Impact Analysis**) focused on **Ecuador** to develop methodologies that was then applied to all the LTRAs. A finding was that CAPS entered the revenue-maximizing model for two watersheds. LTRA-9 completed 400 household socio-economic surveys in **Lesoth**o and 500 in **Mozambiqu**e. For LTRA-10 (**Kenya, Uganda**), 800 socio-economic surveys were carried out in four sites. LTRA-11 (**India/Nepal**) the baseline study conducted at the initiation of the project collected information regarding the size of landholdings, crop sales, input costs, household labor availability, farm practices, income and

agricultural labor hours. The project also did a survey to assess farmers' perceptions about their farming goals and how they relate to conservation agriculture. LTRA-8 (G**hana**) has been collecting socio-economic data. LTRA-12 (**Cambodia**) carried out extensive economic analysis to determine profitability of CAPS by types of farmers, soil types and qualities, and land holding size to determine fairly exact places for CAPS profitability.

CCRA-8 (**Technology Networks**) used quantitative approaches to determine beliefs about CAPS and related topics of participants in agricultural networks and flows of information.

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LTRA-9 reported the **Lesotho** survey suggested that CAPS farmers have smaller fields, higher average yields, use relatively more inputs and less labor per hectare, and use more female labor for weeding. This may be due to the relative paucity in herbicide. Cover crops were not extensively used. In general men control the conventional mechanized systems (tractor or oxen operations), and are more resistant to adopting CAPS. In almost all CAPS practicing communities, there are more women than men; the participation of women is dominant for those who do not have oxen within the household or the economic capacity to exploit tractor power.

Question 10: *How would a continuation of the project get better results in terms of: more science on CAPS?*

Each of the LTRA projects believes that continued funding would generate very positive benefits, particularly because CAPS results take many years to demonstrate. LTRA-6 (**Haiti**) believes that the project has learned much which practices will and will not work, as well as how to foster successful partnerships on the ground. It believes that a continuation of the project would make significant progress on CAPS adoption and gender inclusion. LTRA-8 (**Ghana**) believes that continuation of the project would show the benefits of CAPS to farmers and to the ecology, as well as realizing significant impacts of CAPS on soil quality. To demonstrate the long-term value of CAPS, it is necessary to continue the project for another 5 years.

LTRA-10 (**Kenya/Uganda**) believes that longer-term data collection on the CAPS components of its trials would yield better scientific results, and a continuation would enable interpretation of the results more extensively. More time would allow the project to initiate broader partnership with government research and extension organizations, as well as with NGOs. This would set the stage for wide-scale wide adoption during a second phase. LTRA-11 (**India/Nepal**) believes that the impacts of CAPS can be visible after long period (more than 7 years), so continuation of the project would demonstrate benefits of on-going CAPS trials and carry out the scaling-up to other areas of similar climate conditions. Furthermore, the project would have opportunities to test different sets of CAPS in on-farm trials for crop residue retention, manure usage, different maize, legumes and cover crop varieties, intercropping with maize, spacing, use of auto-seeder etc. A continuation would cover a much larger area and involve more farms that have greater resources (e.g., mechanization). LTRA-12 (**Cambodia**) believes that continuation would allow the project to become the center for Conservation Agriculture in Southeast Asia. Four PhD students are in progress. With more funding, Cambodia can become the center for scaling up CAPS in Southeast Asia. LTRA-9 (**Mozambique/Lesotho)** said that CAPS must be adapted to needs at the farm

level. Continuing the project would provide continuity and follow through, an effect missing from most development projects. Continuing the project would allow graduate students to return and give scientific input into the projects that would help with the cultural issues.

Appendix VIII: Questions from EET about SANREM Project

I. Conservation Agriculture Production Systems(CAPS)

1. What is the traditional method of seedbed preparation?
2. Are farmers familiar with no-till farming? I yes, through what media?
3. What are the factors limiting adoption of CA in the region/country?
4. What are the principal soil-related constraints to crop production and high yields?
5. Are herbicides available, and do farmers know how to use them?
6. Is soil erosion by water or wind a serious problem?
7. Do farmers return crop residues to the land?
8. Is burning of crop residues widely practiced?
9. Is a seeding drill/tool available for a no-till system?
10. Do farmers grow cover crops?
11. Is open grazing a serious factor to conserving crop residues?
12. Do farmers apply chemical fertilizers? If so, at what rate?
13. How do farmers relate to a fertile soil (e.g. color, depth, texture)? What is the traditional concept of soil quality?
14. Is drought stress of a common occurrence?
15. Are there farmer groups or associations through which no-till can be popularized?
16. Is soil carbon trading a possibility through industry involvement?

II. Soil Quality and Human Nutrition

1. Has there been research to determine the limiting nutrients (both macro and micro) for crop production in the soils at the study sites? If so, what are they and how did they determine them?
2. Did they only use soil tests or did they also include some diagnostic tissue analyses?
3. Have they addressed adding these nutrients to the soils?
4. Are there sources for obtaining fertilizers for these nutrients at an affordable cost to farmers? If not, what can be done to accomplish this?
5. Are they aware of the nutritional deficiencies in the target people (especially infants, young children and pregnant women) in their study areas? If so, have they thought about how to increase the output of those nutrients in there farming systems that would provide enough bioavailable levels of these nutrients to meet adequate dietary levels of these nutrients to those populations?
6. What could be done to diversify the crops grown (to include not only staple food crops but also nutrient dense crops) in the study sites?
7. Have they considered using edible legume crops as cover crops in their systems to control weeds and soil erosion? Are they aware of the fact that legume seeds are much denser in both macro and micronutrients compared to cereal crops as normally eaten?
8. Have they considered using biofortified varieties (iron, zinc and provitamin A carotenoids) of staple food crops in their study areas or selecting preferred crop varieties

according to their nutritional composition?

9. Are the farmers and their families informed about nutrition and the importance of diverse diets and adequate nutrition to disease resistance, education potential and work productivity?
10. Do the farmers know the importance of fertile soils on the nutritional quality of the food and feed crops they produce?

III. Socio-Economic and Gender Issues

1. How do the LTRA research trials and methods link CAPS with total farming systems of participant farmers? How does it include both on-farm and off-farm income streams for both men and women?
2. What techniques has the LTRA used to garner women's participation and adoption of CAPS? How successful have these been? How does this compare with male farmers participation and adoption?
3. What constraints has the LTRA faced in terms of different technologies in CA and their adoption for the range of farmers in their project areas: And in terms of:
   (a) Reaching wealthy versus poor farmers? Female versus male farmers?
   (b) Working with women and men who have very small acreage versus those who have large acreage?
   (c) Measuring locally defined “good” and “bad” soils and conditions? Then linking them to gender of owners/users of plots? What types of quantitative data has the project collected during surveys on the types of soils that women and men use and have access to in their farm work?
4. Do wealthier farmers adopt CAPS techniques more than those without resources? Do wealthier women adopt CAPS more than poor women?
5. How have the research trials changed through time, as project staff and partners have identified the needs for change? For specific technologies that men and women need?
6. Has the LTRA carried out a cost analysis of the farmers adopting various CAPS strategies? How do women and men differ?
7. How have the host institutions (universities connected with the LTRA) influenced research in CAPS? In general? To orient to the science needs rather than to the client's (farmers' economic and food security) needs?
8. How are LTRA partners bogged down" in their own cultural biases as to what CA is and how to carry it out with their farmer/client groups? What gender biases and barriers do they have?
9. What socio-economic data has the LRTA collected and linked to its CAPS trials and agronomic work?

How would a continuation of the project get better results in terms of: more science on CAPS? More adopters of CAPS? More gender inclusion in the project? More women adopting CAPS?

Appendix IX: Phnom Penh Post Article, 24 June 2013

Business
In Carbon, Gains for Agriculture
Last Updated on 24 June 2013
By Daniel de Carteret

Paying Cambodian farmers to capture carbon by not removing mulch during planting and harvesting would help support climate change mitigation, reduce soil deterioration and return higher yields in the long term, say leading agriculture experts.

Speaking at a conference in Phnom Penh last Friday, Professor Rattan Lal of the School of Environment and Natural Resources at Ohio State University, said soil erosion, leading to poorer yields over time, can be prevented by leaving biomass – foliage from crops that serves as mulch – on the ground aiding the fertility of the soil.

Biomass also forms an important part of the carbon capture process, reducing the amount of carbon in the atmosphere.

The challenge for farmers, Lal says, is balancing priorities when they can realize more immediate gains for the biomass such as feeding livestock.

"We have to develop a system whereby farmers are encouraged to leave as much biomass on the ground as possible," he said.

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