Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification

Annual Performance Report FY 2018

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Cover Photos
<u>Top left</u>: Ms. Channaty Ngang, a MS student at the University of Battambang, poses next to her successfully grafted tomato plants. To reduce losses from disease during the rainy season in Cambodia, market-demanded tomatoes are grafted onto eggplant rootstock. *Photo credit: Ricky Bates.*
<u>Top right</u>: Classroom training on small Unmanned Aerial Systems (sUAS) data collection and processing for the ISRA team was conducted by Geospatial Consortium in Senegal. *Photo Credit: Zach Stewart*
<u>Bottom left</u>: Blacksmiths' partook in a training in Bobo Dioulasso, Burkina Faso. The training covered gender basics and how to conduct gender sensitive technology assessments on various mechanization tools. *Photo credit: Maria Jones*
<u>Bottom right</u>: Ethiopian woman farmer highlighting her prize goats and forage. *Photo Credit: Peter Thorne*

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Feed the Future Sustainable Intensification Innovation Lab

A. Management Entity Information

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) is housed at Kansas State University in Manhattan, KS. The management entity staff includes the following individuals:

Dr. Vara Prasad – Director
Email: vara@k-state.edu

Vara Prasad, University Distinguished Professor of Crop Ecophysiology, serves as the Program Director of SIIL. He earned his B.S. and M.S. in agronomy from Andhra Pradesh Agricultural University in India, and his Ph.D. in crop physiology from The University of Reading in England. He has extensive international experience in both Africa and Asia, and has had significant involvement with several USAID projects in these regions. His research focuses on understanding the response of food-grain crops to changing environments and management practices; developing strategies for management of crops, soil, water and nutrients for the efficient use of resources; and using farming-system approaches to provide food and nutritional security to smallholder farmers. Prasad provides leadership to SIIL and oversees all of the research, capacity building, knowledge sharing and communication activities of the program. He administers technical and financial aspects of SIIL and serves as the primary contact for donors, advisory groups and partner organizations.

Dr. B. Jan Middendorf – Associate Director
Email: jmiddend@k-state.edu

B. Jan Middendorf serves as the SIIL Associate Director. She earned her B.S. in business administration at the University of Rhode Island, her M.S. in international affairs at Ohio University and her Ph.D. in curriculum and instruction and evaluation practice at Kansas State University. Her primary interests are institutional and program improvement through strategic planning, change management and evaluation. She has over 25 years of experience in project development, management, implementation and evaluation of multi-institutional, interdisciplinary programs and projects in national and international settings. As Associate Director, Middendorf serves as the administrative officer alongside the Program Director and oversees the Management Entity (ME) in organizing activities to facilitate technical and administrative goals of the SIIL program. She conducts research and lead SIIL's impact assessment, monitoring and evaluation efforts. She is responsible for establishing and maintaining effective partnerships with other U.S. and international institutions, industry, USAID Missions and developmental partners.

Dr. Manny Reyes – Research Professor
Email: mannyreyes@k-state.edu

Manuel Reyes, Research Professor, has more than 30 years of experience working with water quality modeling, natural resources management and conservation agriculture. He is an agroecological engineer, designing food production systems that mimic nature. Reyes has extensive expertise across the globe in research, extension, teaching and project implementation. Reyes will focus his efforts in Cambodia working with the Royal University of Agriculture and University of Battambang to enhance human and institutional capacity to conduct research and training of scholars and youth. He will facilitate partnerships with other Feed the Future Innovation Labs, international organizations and private industry in Cambodia.

Dr. Jessie Vipham – Assistant Professor
Email: jessiev@k-state.edu

Jessie Vipham is a Food Microbiologist by training, and serves as the SIIL faculty hire in Global Food Systems and Nutrition. She is an Assistant Professor in the Department of Animal Science. She holds a B.S. in Agriculture Business from Kansas State University, as well as an M.S. and Ph.D. in Animal Science from Texas Tech University. While at Texas Tech, Jessie was involved with faculty members of the International Center for Food Industry Excellence (ICFIE). She is experienced in international food security research, and has spent a significant amount of time strengthening food systems in Latin America.

Dr. Zachary Stewart – Assistant Research Professor
Email: zachstewart@k-state.edu

Zach Stewart serves as the SIIL Program Manager. He is a Research Assistant Professor in the Department of Agronomy. He earned his M.S. in Control of Infectious Diseases from the London School of Hygiene and Tropical Medicine and his Ph.D. in Agronomy from the University of Nebraska-Lincoln. He has done extensive research on crop physiology and production as well as worked with smallholder farmers in East Africa on agronomic and human health topics. The 2008 recipient of the John Chrystal Award from the World Food Prize Foundation, Zach has been able to use his multidisciplinary background to advance agricultural production while keeping in mind the well-being of those impacted. As part of the SIIL management entity, Zach leads knowledge management and sharing efforts and conducts research related to global food and nutrition security for smallholder farmers.

Andra Williams – Program Administrator
Email: ajolenew@k-state.edu

Andra Williams serves as the Program Administrator for the SIIL. She collaborates with the Lab's domestic and international partners to help manage the program's monitoring and evaluation, communication, reporting, and knowledge management needs. Andra received a B.A. in French, with a minor in Community Nutrition, from the University of California, Davis, and a Master's in International Development and Sustainability from the Université Grenoble-Alpes in France. She served as a Peace Corps health volunteer in Senegal from 2013-2014 and has worked in both Senegal and Guinea as a part of USAID projects. Andra was most recently employed with the Horticulture Innovation Lab at UC Davis prior to coming to the SIIL. She speaks fluent French and passable Seereer.

Katy Bach – Business Manager
Email: katybach@k-state.edu

Katy Bach serves as the Business Manager for SIIL. She is responsible for all components of financial management, post-award accounting, procurement, travel planning, and business management of the Innovation Lab. Katy holds a B.S. in Business Administration and is licensed as a Certified Public Accountant. Prior to joining the SIIL team, she worked with Kansas State University Athletics and numerous small businesses in their accounting departments.
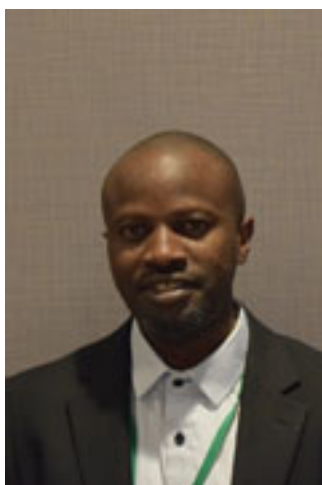
Jovin Lwehabura – Regional Coordinator, East Africa
Email: j.lwehabura@cgiar.org

Mr. Jovin Lwehabura has more than 10 years of experience working on applications of geospatial science & technology in sustainable management of natural resources. He holds an M.S. degree in Geographic Information Systems from the University of Redlands, California as well as a B.S. in Geomatics from the University of Dar es Salaam. Mr. Lwehabura is a member of Global society for Conservation Geographic Information Systems (SCGIS). He has developed several GIS Databases, guide mapping and support implementations of land use planning for more than 50 local communities in Tanzania. Mr. Lwehabura currently works for the International Center for Tropical Agriculture (CIAT) under the Sustainable Intensification Innovation Lab. He is the SIIL's Coordinator in East Africa and lives in Arusha, Tanzania.

Dr. Aliou Faye – Country Coordinator, Senegal
Email: alliouselbe11@yahoo.fr or aliou.faye@isra.sn

Aliou Faye has two decades of research experience with the Senegalese Agricultural Research Institute (ISRA), the French Institute of Research for Development and the International Centre for Cooperation in Agricultural Development (CIRAD). Faye worked also for 5 years as Chief of Agency of a Saudi group dealing with non-timber forest products in the Tambacounda and Louga regions of Senegal. Faye holds a B.S. in Tropical Forestry, a M.S. in Agronomy, and a Ph.D. in Plant Biology from the Cheikh Anta Diop University of Dakar with field experience at the Tropical Soil Biology and Fertility (CIAT) in Nairobi Kenya. Faye has published at least 20 research articles in different scientific journals. Dr. Faye is currently the head of the Soil-Water and Plant Laboratory of the Centre National de la Recherche Agronomique (CNRA) of ISRA in Bambey, Senegal and serves as the Country Coordinator of the SIIL in Senegal.

Dr. Hamidou Traore – Country Coordinator, Burkina Faso
Email: hamitraore8@yahoo.com

Dr. Hamidou Traore has over 25 years of research experience in the field of agronomy. Dr. Traore holds a PhD in Weed Science from the University of Montpellier II, Sciences and Techniques of Languedoc, France, and a Diploma of Rural Development Engineering in Agronomy from University of Ouagadougou. Dr. Traore currently serves as Director of Institut de l'Environnement et de Recherche Agricoles (INERA), Burkina Faso. He previously held the position of Regional Director of the Eastern and Sahelian Environmental and Agricultural Research Regional Centers. Dr. Traore was also a Fulbright Scholar at the Agronomy Department of Purdue University.

B. External Advisory Board

The External Advisory Board (EAB) is chaired by Jules Pretty. The EAB was actively engaged in evaluating the proposals for focus country research subawards and was responsible for making final decisions on project selection.

Professor Jules Pretty – Chair
University *of Essex*

Dr. Jules Pretty is Deputy Vice-Chancellor at the University of Essex, and Professor of Environment and Society. His 18 books include This Luminous Coast (2011), Nature and Culture (2010), The Earth Only Endures (2007), and Agri-Culture (2002). He is a Fellow of the Society of Biology and the Royal Society of Arts, former Deputy-Chair of the government's Advisory Committee on Releases to the Environment, and has served on advisory committees for a number of government departments and research councils. He was a member of two Royal Society working groups that published Reaping the Benefits (2009) and People and the Planet (2012), and was a member of the UK government Foresight project on Global Food and Farming Futures (2011). He is the founding Chief Editor of the International Journal of Agricultural Sustainability. He received an OBE in 2006 for services to sustainable agriculture, and an honorary degree from Ohio State University in 2009. More details can be found at www.julespretty.com.

Dr. Deborah Bossio
The Nature Conservancy

Dr. Deborah Bossio is the Lead Soil Scientist for The Nature Conservancy, where she is an integral member of the Global Lands team and an active member of the Science Cabinet, a collaborative group of Conservancy Lead Scientists contributing topical expertise to cross-cutting science issues for the organization. In this role she integrates new soil science expertise to support and advance existing climate, agriculture, forestry and conservation priorities and to better understand how we can scale our impact through improved soil management.

Dr. John Dixon
Australian Centre for International Agricultural Research

Dr. Dixon has over 30 years developing country experience with agricultural research and development, including cropping systems, economics and natural resource management in South, South-east and East Asia, Africa, Latin America and the Middle East, working for the CGIAR system and the FAO. He has served as Director, Impacts, Targeting and Assessment at CIMMYT, leading activities on impact assessment, value chains, impact knowledge sharing, systems agronomy and conservation agriculture; and also in various capacities with FAO in their global, regional and country programs. He also led ACIAR international program and is currently and Adjunct Professor at Queensland Alliance for Agriculture and Food Innovation, The University of Queensland. Dr. Dixon is a graduate from the University of New England with a Ph.D. (agricultural economics), Masters (natural resources), Masters (economics) and Bachelor in Rural Science.

Dr. Cornelia Flora
Iowa State University

Dr. Cornelia Flora is an Emeritus Distinguished Professor in the Department of Sociology at Iowa State University. Her research interests include international and domestic development, community, and the sociology of science and technology, particularly as related to agriculture and participatory change. Socio-technical regime changes and capitals transformations (natural, cultural, human, social, political and financial/built capitals) guide her current research includes work on the community development, sustainable agriculture and natural resource management, with particular attention to how class, gender, and ethnicity influence and are influenced by technology and policy.

Dr. Jemimah Njuki
Canada's International Development Research Center (IDRC)

Dr. Jemimah Njuki has fifteen years of experience overseeing gender-responsive and women-targeted research and development projects that link women smallholder farmers to markets, integrate gender in cooperatives, apply participatory gender-responsive research, and more. As senior program officer at the International Development Research Centre (IDRC), she manages the Cultivate Africa's Future program.

Dr. Peter Thorne
International Livestock Research Institute (ILRI)

Dr. Peter Thorne coordinates the Africa RISING project in the Ethiopian Highlands. He completed his Ph.D. at the University of Nottingham in animal nutrition, with a part of his research conducted at the University of the Philippines in Los Banos. His career has allowed him to work in both public and private sectors, focusing largely on the evolution of mixed farming systems in Africa and Asia. Prior to joining ILRI, Dr. Thorne was responsible for the national dairy benchmarking service in Britain.

C. Focus Countries

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification works in West Africa, East Africa and Asia. The six focus countries are listed and shown below, along with the Malawi Subaward that was initiated in FY 2017.

Bangladesh (BGD)
Burkina Faso (BFA)
Cambodia (KHM)
Ethiopia (ETH)
Malawi (MWI)
Senegal (SEN)
Tanzania (TZA)
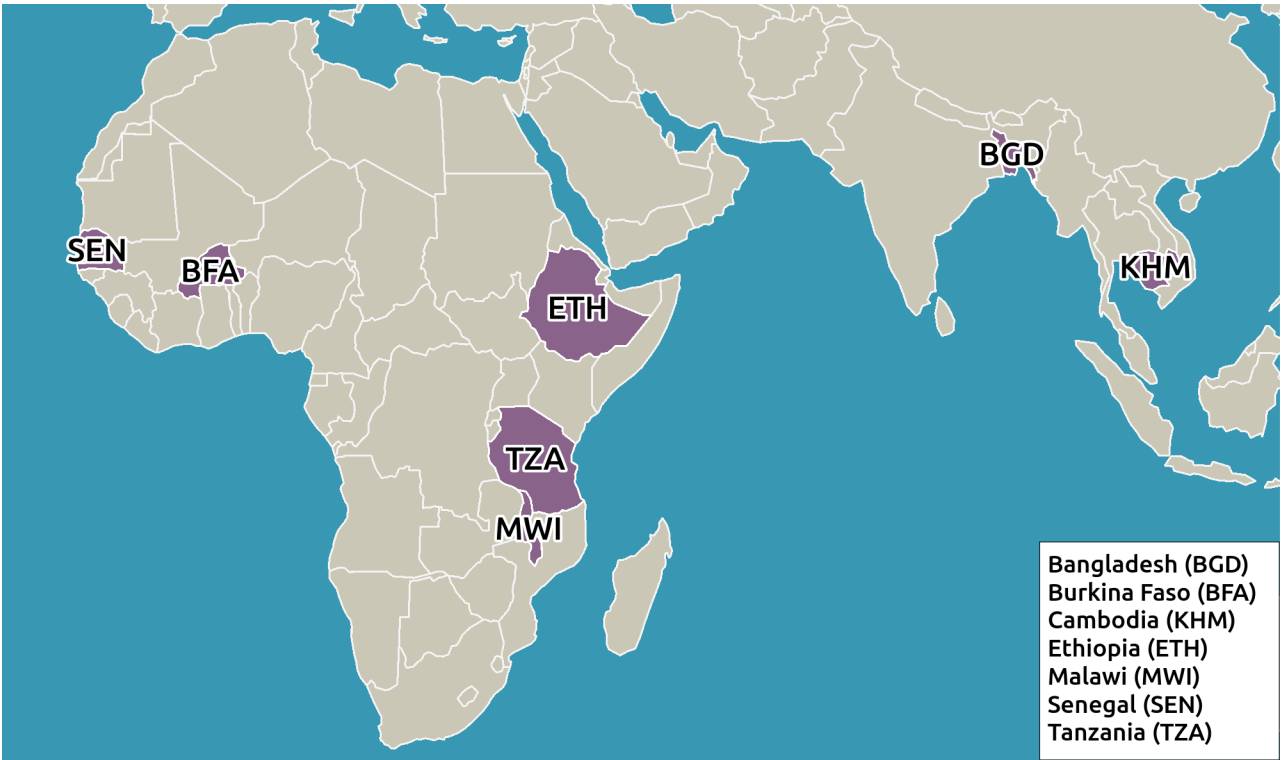
D. List of Program Partners

United States
ADM Institute for the Prevention of Postharvest Loss
Feed the Future Innovation Lab for Horticulture
Feed the Future Innovation Lab for Collaborative Research on Nutrition in Africa
Feed the Future Innovation Lab for Small Scale Irrigation
Feed the Future Innovation Lab for the Reduction of Postharvest Loss
Kansas State University
Michigan State University
North Carolina A&T State University
Oakland University
Pennsylvania State University
Stanford University
Texas A&M University
Tillers International
University of California, Davis
University of Florida
University of Illinois at Urbana-Champaign
University of Maryland
University of Tennessee Institute of Agriculture (UTIA)
University of Wisconsin – Madison

Bangladesh
ACI Motors Limited
Bangladesh Agricultural Research Council (BARC)
Bangladesh Agricultural Research Institute (BARI).
Bangladesh Agricultural University
Bangladesh Rice Research Institute
BRAC
International Maize and Wheat Improvement Center (CIMMYT)
International Rice Research Institute (IRRI)
Khulna University

Burkina Faso
Association pour la Promotion de l'Elevage en Savane et au Sahel (APESS)
Institut de l'Environnement et de Recherches Agricoles (INERA)
International Livestock Research Institute (ILRI)
La Federation Nationale des Groupements Naam (FNGN)
Polytechnic University of Bobo-Dioulasso
The International Union for Conservation of Nature (IUCN)

Cambodia
Agricultural Development Denmark Asia
AVRDC – World Vegetable Center
Conservation Agriculture Service Center (CASC)
ECHO Asia
Institute of Technology of Cambodia (ICT)
Kasetsart University
Ministry of Agriculture Forestry and Fisheries (MAFF)
Ministry of Education and Youth (MoEY)

Royal University of Agriculture - Phnom Penh
University of Battambang

Ethiopia
Africa Research in Sustainable Intensification for the Next Generation (Africa RISING)
Bahir Dar University / Bahir Dar Institute of Technology
International Food Policy Research Institute (IFPRI)
International Livestock Research Institute (ILRI)
International Water Management Institute (IWMI)
University of Twente

Senegal
Institut Senegalais de Recherches Agricoles (ISRA) – Centre National de Recherches Agrinomiques de Bambey (CNRA – Bambey)
ISRA - Laboratoire National de Recherche sur les Production Vegetales (LNRPV)
ISRA - Laboratoire National d'Élevage et de Recherches Vétérinaire (LNERV)
University of Thies – College of Agriculture
Institut de Technologie Alimentaire (ITA)
Agence Nationale de Conseil Agricole et Rural (ANCAR)
Reseau des Organisations Paysannes et Pastorales du Senegal (RESOPP)
Institut de Recherche Pour le Developpement (IRD)
Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)

Tanzania
Sokoine University of Agriculture (SUA)
Wageningen University and Research Center
International Center for Tropical Agriculture (CIAT)
Nelson Mandela African Institution of Science and Technology (NM-AIST)
International Institute of Tropical Agriculture (IITA)
Africa Research in Sustainable Intensification for the Next Generation (Africa – RISING)

Additional Partners or Collaborators
International Institute for Applied Systems Analysis (IIASA)
World Agroforestry Center
ITC – Netherlands
Kifiya Financial Technology Plc.
One Acre Fund
Taking Maize Agronomy to Scale in Africa (TAMASA)
Wageningen University and Research Center
Quantitative Engineering Design

E. Acronyms

ACIAR – Australian Centre for International Agricultural Research
ADDA – Agricultural Development Denmark Asia
ADS – Automated Directives System
Africa RISING – Africa Research in Sustainable Intensification for the Next Generation
AfSIS – Africa Soil Information Service
AGRA – Alliance for a Green Revolution in Africa
ANCAR - Agence Nationale de Conseil Agricole et Rural
AOR – Agreement Officer's Representative
APESS - Association pour la Promotion de l'Elevage en Savane et au Sahel
ASM – Appropriate scale mechanization
ASMC – Appropriate Scale Mechanization Consortium
AUC – African Union Commission
AWP – Annual Work Plan
BARC – Bangladesh Agricultural Research Council
BARI – Bangladesh Agricultural Research Institute
CA – Conservation Agriculture
CASC – Conservation Agriculture Service Center
CE SAIN – Center of Excellence on Sustainable Agricultural Intensification and Nutrition
CGIAR – Consultative Group on International Agricultural Research
CIAT – International Center for Tropical Agriculture
CIMMYT – International Maize and Wheat Improvement Center
CIRAD - Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CNRA – Centre National de Recherches Agronomiques (CNRA)
CSA – Climate smart agriculture
CSIRO - Commonwealth Scientific and Industrial Research Organisation
DDL – Data Development Library
EAB – External Advisory Board
EMMP – Environmental Management and Mitigation Plan
FAA – Federal Aviation Administration
FAO – Food and Agriculture Organization
FGD – Focus Group Discussions
FNGN – La Federation Nationale des Groupements Naam
FTFMS – Feed the Future Monitoring System
FY – Fiscal year
GFC – Geospatial and Farming Systems Research Consortium
GIS – Geographic Information System
GMCC – Green Manure Cover Crops
HYV – High Yielding Varieties
ICRISAT – International Crops Research Institute for the Semi-Arid Tropics
ICT – Institute of Technology of Cambodia
IDRC – International Development Research Centre
IDSS – Integrated Decision Support System
IFDC – International Fertilizer Development Center
IFPRI – International Food Policy Research Institute
IIASA – International Institute for Applied Systems Analysis
IITA - International Institute of Tropical Agriculture
IL – Innovation Lab
ILRI – International Livestock Research Institute
ILSSI – Innovation Lab for Small Scale Irrigation
INERA – Institut de l'Environnement et de Recherches Agricoles de Burkina Faso

INGENAES - Integrating Gender and Nutrition within Agricultural Extension Services
IPM – Integrated Pest Management
IRD – Institut de Recherche Pour le Developpement
IRRI – International Rice Research Institute
ISRA – Institut Senegalais de Recherches Agricoles
ITA – Institut de Technologie Alimentaire
IUCN – International Union for Conservation of Nature
IWMI – International Water Management Institute
LIVES – Livestock and Irrigation Value Chains for Ethiopian Smallholders
LNERV – Laboratoire National d'Élevage et de Recherches Vétérinaire
LNRPV – Laboratoire National de Recherche sur les Production Vegetales (LNRPV)
MAFF - Ministry of Agriculture Forestry and Fisheries
ME – Management Entity
MoEY - Ministry of Education and Youth
MSU – Michigan State University
NARS – National Agricultural Research Systems
NGO – Nongovernmental organization
NM-AIST - Nelson Mandela African Institution of Science and Technology
NUS – Neglected and underutilized species
PRC – Policy Research Consortium
PI – Principal investigator
PTOS – Power Tiller Operated System
R4D – Research for Development
RESOPP – Reseau des Organisations Paysannes et Pastorales du Senegal
RHoMIS – Rural Household Multiple Indicator Survey
RUA – Royal University of Agriculture
SAR – Synthetic Aperture Radar
SBIR – Small Business Innovation Research
SI – Sustainable intensification
SIIL – Sustainable Intensification Innovation Lab
SIPS – Sustainably intensified production systems
SSA – Sub-Saharan Africa
SUA - Sokoine University of Agriculture
TAMASA – Taking Maize Agronomy to Scale in Africa
TP – Technology Park
UAV – Unmanned Aerial Vehicle
UBB – University of Battambang
UPB – Polytechnic University of Bobo-Dioulasso
USAID – United States Agency for International Development
USG – United States Government
UTIA – University of Tennessee Institute of Agriculture
WAgN – Women in Agriculture Network

I.   Executive Summary

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) successfully completed its fourth year since inception. All projects are now operational with three years of active research data collection in all of its focus countries (Bangladesh, Burkina Faso, Cambodia, Ethiopia, Malawi, Senegal, and Tanzania). All activities aligned with the vision of SIIL and its four main objectives.

There are several activities, accomplishments and lessons learned detailed in this report. This executive summary provides the highlights of key activities related to the overall theme from this past year: innovate, collaborate and communicate. Identifying promising innovations from our research projects using a systems approach, actively collaborating with our strategic partners to leverage investments, and communicating our successes through our multiple knowledge management platforms has been key to successful implementation that will ensure greater impact and return on investments. The SIIL program currently collaborates with >40 national and international organizations (including 8 CGIAR and 12 US universities), and it supports >100 scholars to work towards common themes of increasing sustainable agriculture productivity, enhancing resilience of cropping systems and supporting nutritional outcomes.

Each of the projects have had important learnings and achievements. The Geospatial and Farming Systems Research Consortium (GFC) completed four of their eight subaward projects with results and added two additional project to augment their geospatial approach which is articulated in the report. The Appropriate Scale Mechanization Consortium (ASMC) connected the Innovation Hubs and researchers with appropriate private sector actors, local entrepreneurs, and farmer organizations to enable technology design and scaling. They also engaged the gender (INGENAES) team to improve gender integration into its programming. Polder communities in Bangladesh empowered its members (including women) through activities related to water management and governance, agricultural mechanization and nutrition, and in-polder water management necessary for adoption of improved production systems in the target zone. Burkina Faso continued to focus on demonstrating benefits of grain and biomass yields with dual-purpose sorghum and cowpea. The Cambodia team established nutrient profiles of key neglected and underutilized species and planned to include them in the home vegetable gardens using principles of conservation agriculture. Highlights from Ethiopia include field studies demonstrating that in sustainably intensified production systems focused on irrigation for smallholders produce more food, are more profitable, and sustainable over time with health and nutritional outcomes. The Senegal team conducted biochemical analysis of millet grain showing that two dual-purpose millet accessions showed higher Zn, Mg, and Fe than other accessions. They also conducted and currently analyzing results from bioavailability study using dual-purpose millet accessions. The Malawi team developed tools related to time-series/climate sensitive niche identification which should lead to better on-farm guidance and refined crop models in smallholder systems. Lastly, the Tanzania team analyzed their baseline surveys and collected data on socioeconomic and soil samplings to support the objective to determine soil properties and SI practices that enhance maize-bean cropping systems responses to fertilizer. In terms of other research initiatives, the SIIL awarded University of California – Davis, the research output dissemination study focused on evaluating the path from development to end-user for selected innovations produced by the Feed the Future Innovation Labs

The Sustainable Intensification (SI) Assessment Framework was officially launched at the American Society of Agronomy (ASA) Annual Meeting in Tampa, Florida in November 2017, and, over this past year was transformed into a web tool to be launched at the ASA-SI Symposium in November 2018. This framework has gained tremendous visibility and traction as evidenced by its inclusion in USAID funding initiatives, the Rural Household Multiple Indicator Survey (RHoMIS) tool, AfricaRISING's assessment tools, universities courses, and multiple publications.

SIIL continues to be committed to human and institutional capacity building as evidenced by the number of short-term trainings offered to 4,336 individuals (1,550 women, 36%) and support of long-term graduate degree training to 60 individuals (22 females). Of the 60 individuals, 26 are pursuing a Ph.D. degree (35% females), 28 Masters of Science (43% females), and 6 undergraduate degrees. In addition, the SIIL researchers produced 128 publications and presentations this past reporting period. And, the SIIL regional coordinators continued to provide support to partners on the implementation and coordination of research, capacity building activities, communication and support of ongoing research.

II.   Program Activities and Highlights

A. Geospatial and Farming Systems Research Consortium (GFC)

The GFC consortium management team and their subawards made significant progress in FY 2018, including the following highlights:

- Four of the eight subaward projects are complete with results reported per project in the subsequent sections. Weather stations were installed in the CE SAIN Technology Parks.
- Mapped locations of maize fields and estimates of productivity in eastern Africa to better understand the current level of intensification in maize systems and the constraints to raising the system's productivity. This approach leveraged newly available imagery from the European Space Agency's Sentinel-1 and Sentinel-2 satellites, ground data on crop locations and yields, and a new simulation-based approach to estimating maize yields globally.

B. Appropriate Scale Mechanization Consortium (ASMC)

The ASMC continued its efforts to sustainably intensify smallholders' cropping systems through mechanization with following highlights:

- Engaged the INGENAES team to improve gender considerations into its programming through capacity building activities and initiating a process to assess technologies in the ASMC portfolio.
- Connected the Innovation Hubs and researchers with appropriate private sector companies and actors, local entrepreneurs, and farmer organizations to enable technology design and scaling.
- Developed an Agricultural Mechanization degree program within the Institute of Rural Development at Univ. of Bobo in collaboration with the Institute of Technology in Burkina Faso.

C. Integrated Research Subaward Portfolio

Highlights from the six SIIL subawards include:

- *Bangladesh* – Empowered several members of the Polder communities through gender related activities and water management organizations on water governance, agricultural mechanization and nutrition, and in-polder water management necessary for adoption of improved production systems in the polder zone with 40% participation from women.
- *Burkina* – Completed agronomic trials with improved dual-purpose sorghum and cowpea varieties in eight project communities; feeding trials for fattening sheep to assess the effect of crop residues from these improved varieties on the growth of sheep; and feeding trials with lactating cows fed on fodder from these same varieties.
- *Cambodia* – Research on wild food plants and indigenous vegetables was augmented with nutrient analyses. Engaged with the CE SAIN to provide technical training to farm managers and prepare the parks for demonstrations of SI technologies and practices. Research on the diversification of rice with green manure cover crops is ongoing.
- *Ethiopia* – Field studies were continued and results show sustainably intensified production systems focusing on irrigation for smallholders in northern Ethiopia produce more food, are more profitable, and sustainable over time with potential nutritional and health outcomes.
- *Malawi* – Developed tools related to time-series/climate sensitive niche identification to understand on-farm guidance and refined crop models in small holder systems in target regions.
- *Senegal* – Biochemical analysis of millet grain showed that two dual-purpose millet accessions showed higher Zn, Mg, and Fe than other accessions. Bioavailability study using dual-purpose millet varieties were conducted and data is currently being analyzed.
- *Tanzania* – Data were collected for a soil and socioeconomic survey to support the objective to determine soil properties and SI practices that enhance maize-bean responses to fertilizer.

D. Associated Awards and Mission Buy-Ins

CE SAIN supported from Cambodia Mission continues to build capacity, improve coordination, and strengthen partnerships as demonstrated through increased number of grants awarded beyond USAID. The Precision Agriculture for Smallholder Systems in Africa, with support from the USAID, has mapped much of Malawi and provided information to the USAID Mission.

III. Key Accomplishments

A. Launch of the Sustainable Intensification (SI) Assessment Framework

The Guide and Methods Manual for the SI Assessment Framework were finalized in FY 2017, and a book chapter was developed that focuses on the application of the framework at various stages of project implementation. It was officially launched in October 2017 at the International Annual meeting of the American Society of Agronomy (ASA), Crop Science Society of America, and Soil Science Society of America in Tampa, Florida. During FY 2018 the SI Assessment Framework was transformed into a web tool to be launched at the ASA-SI Symposium in November 2018. This framework has gained tremendous visibility and traction as evidenced by its inclusion in USAID funding initiatives, the Rural Household Multiple Indicator Survey (RHoMIS) tool, AfricaRISING's assessment tools, universities courses, and multiple publications.

B. Implementation of Data Management Plan

One of the top SIIL priorities for FY 2018 was to implement the SIIL's data management plan. Therefore, the management entity established the SIIL Dataverse hosted by Harvard Dataverse to store and curate all SIIL subaward datasets and serve as a data repository and access hub for the SI community in general. SIIL conducted trainings with all subawardees' on how to navigate the dataverse system, requirements of the datasets, and how to upload them into the system. SIIL requires each subaward PI to upload all datasets as part of the Piestar reporting system. Both complete and incomplete datasets are collected biannually as part of the Piestar reporting hub system; however, only complete datasets are uploaded to the SIIL Dataverse. Complete datasets that have been uploaded on the SIIL Dataverse are also registered into the USAID's Data Development Library (DDL) system in compliance with ADS 579. During this reporting period, individual project accounts were set-up for all SIIL Subawards, and 19 separate complete datasets have been uploaded representing 259 files.

C. CE SAIN Accomplishments

CE SAIN co-hosted the First International Sustainable Agricultural Intensification and Nutrition Conference and Field Trips in January 2018 in collaboration with the SIIL. One hundred sixty-five individuals from 16 countries attended the conference, and over 60 individuals participated in the field trips. Seventeen collaborative research and demonstration projects were initiated with universities, private sector companies, and other funded projects. Promising technologies from U.S. Government-funded projects and other international organizations were showcased in the five Technology Parks. Specifically, 22 technologies and research trials were demonstrated along with strategies to sustainably intensify smallholders' production systems. These are all accessible to farmers, students, researchers, local partners, and private companies. More than 1,273 people (38% female) visited the technologies this year.

D. Development of Plans for Sustainability and Scalability of Research

During the SIIL Annual Meeting in January 2018, all subaward PIs were required to develop a transition plan, outlining their plans to ensure that their research will continue to be supported and integrated with other research programs in the country or region past the end date of the award. As part of this process, the SIIL management entity required project teams to clearly and systematically define the role of each collaborator engaged in their research or scaling efforts. As a result, all projects identified strategic engagement with the host country partners, NGOs and private sector for sustainability. Theme of upcoming annual meeting in 2019 will be focused on: Suitability, Scalability and Sustainability.

E. Communication, Knowledge Sharing, and Capacity Building

Capacity building activities expanded significantly during this reporting period. Sixty long-term trainees were either partially or fully funded by the SIIL. Short-term trainings doubled, reporting 99 events held across the SIIL focus countries and in the U.S. The SIIL implemented the Harvard dataverse platform for its data management with individual accounts for all subaward projects.

IV. Research Program Overview and Structure

A. The Geospatial and Farming Systems Research Consortium (GFC)

The GFC brings together leading geospatial researchers to enhance the efficiency and success of agricultural research and development. The GFC works closely with the research subaward team to enhance their capacity. Specific activities and outcomes of the members is listed separately in the next section. GFC research encompasses five thematic objectives:

- Land: To identify current patterns of intensification and opportunities for sustainable intensification.
- Inputs: To improve the resource use efficiency in crop production.
- Management: To design crop growth monitoring tools.
- Productivity: To estimate current and potential yield in the regions of interest.
- Access: To understand the impact of market socio-economic and environmental conditions on opportunities for intensification.

B. The Appropriate Scale Mechanization Consortium (ASMC)

The ASMC aims to introduce multifunctional and modular mechanized technologies that are technically, environmentally, economically and socially appropriate for use by smallholder farmers (including women) with the flexibility to accommodate different power sources. They are currently active in four countries. The specific intervention and entry point varies by country as determined by the host country partners and needs of the producers. These technologies contribute to enhanced labor productivity and increased land productivity, thus sustainably reducing poverty among smallholders. The ASMC has six key functions:

- Engage entry-point organizations to establish Innovation Hubs.
- Assess country-specific mechanization challenges, opportunities and priorities.
- Implement country-specific activities utilizing participatory research methods.
- Train and build human capacity with an emphasis on gender.
- Monitor and evaluate the impact of activities.
- Share knowledge with in-country stakeholders.

C. Focus Country Research Subawards

The SIIL is currently supporting seven country subawards. Together, the subawards investigate a diverse range of sustainable intensification practices and innovations across the SIIL focus countries. The broad focus areas being crop-livestock interaction; better management of crops and livestock to enhance resource use efficiency; diversification (integration of legumes; home gardens; and new crops); and precision and sustainable agricultural practices. The SIIL research subawards are implemented and led by collaborations between U.S. universities, NARS centers, NGOs, and CGIAR partners.

D. Developing Indicators for Sustainable Intensification

The Sustainable Intensification (SI) Assessment Framework was officially launched in October 2017 at the International Annual Meeting of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America. The framework guide and manual were made available to the public at the time of the launch. The SIIL management entity led efforts to create a website to operationalize the SI Assessment Framework. The online presence of the framework will be made available November 2018. This framework will have wide range of uses from looking at impacts of innovations across multiple domains (productivity, environment, economics, social and human conditions) and evaluate synergies and tradeoffs. Such analyses is critical for providing options that are specific to stakeholders and understanding the overall system and determine options and solution that will enhance overall productivity and resilience of system rather than individual components. Such an analyses will aid in understanding mechanisms of scaling and adoption of innovations. This framework can also be used for improving programming and integration of gender, nutrition and human capacity.

V. Theory of Change

Sustainable Intensification (SI) Farming Systems Research

Global Food Security Strategy (GFSS) – Goal: Sustainably reduce global hunger, malnutrition and poverty

GFSS Objective 1
Inclusive and sustainable agriculture-led economic growth
Intermediate Results: IR 1-4, & Cross Cutting IR 2-4, 6

GFSS Objective 2
Strengthened resilience among people and systems
Intermediate Results: IR 1-6, & Cross Cutting IR 2-4, 6

GFSS Objective 3
A well-nourished population, especially women and children
Intermediate Results: IR 7-9, & Cross Cutting IR 3, 4, 6

Appropriate SI practices scaled by farmers, national, regional or international units and private industry

Knowledge and Skills:
1. Smallholder farmers, cooperatives, partners, and women have improved technical and practical skills
2. Understanding of social/economic factors necessary for adopting SI practices
3. Awareness and strategies: to include gender, youth and nutrition issues

Practices and Behaviors:
1. Linkages with farming systems research and SI impacts and issues of natural resource management; climate change, adaptation, and mitigation
2. Local smallholders can have access to proven and promising SI innovations; change in practices
3. Participatory approaches for enhanced SI adoption and scaling

Capacity and Opportunities:
1. Increased capacity among farming communities and access to resources
2. Strengthened public-private partnerships and business entrepreneurships
3. Expanded market-based, value-added economic opportunities at local/state/regional levels

Evidence-based innovations designed to maximize impact in collaboration with key partners and change agents

Monitoring, Evaluation, Learning (MEL) and Reporting Feedback Loop

Geospatial & Systems Models:
1. Identify needs, constraints, opportunities for SI
2. Map geographies and link with potential technologies
3. Use systems modeling to enhance productivity and resilience

SIIL Objective 1:
Use geospatial tools to identify SI needs, opportunities and assessment

Innovative Options/Solutions:
1. Efficient land, crop, soil, nutrient and water management
2. Mechanization to enhance efficiency and minimize losses
3. Climate-smart, resilient and diversified farming systems

SIIL Objective 2:
Improving nutrition through environmentally sustainable nutrition-sensitive agriculture

Enhance SI:
1. Understand biophysical, economic and social barriers to SI
2. Strategic partnership for sustainability and scaling SI
3. Focus on system productivity, synergies and tradeoffs

SIIL Objective 3:
Identify enabling conditions to strengthen social capital to support and enhance SI

Communication / Capacity:
1. Effective communication strategies for dissemination
2. Open-access knowledge-sharing and data management platforms
3. Build human resources and institutional capacity

SIIL Objective 4:
Develop platforms for communication, knowledge sharing and capacity building

SIIL Goal: Lead interdisciplinary research, knowledge sharing and capacity building on SI

Creating Enabling Environments

VI. Research Project Reports

A. Geospatial and Farming Systems Research Consortium

1. *Summary of GFC activities*

(1) <u>Name</u>: Geospatial and Farming Systems Research Consortium (GFC, Principal Investigator (PI): Robert Hijmans, University of California, Davis)

(2) <u>Locations</u>: Global – Due to the nature of the consortium's research and the incorporation of remote sensing, the projects are often not location-dependent. The locations listed for each subaward report may refer to field work locations, targeted areas for remote sensing work, or a combination of the two. However, the processes and methods can be scaled globally.

(3) <u>Description and Achievements (See FY 2018 AWP Objective 2):</u> The GFC focuses efforts, through a portfolio of research subawards and independent research, on five primary objectives. The achievements listed under each objective refer specifically to the efforts of the GFC leadership team at the University of California, Davis. Their subawards achievements are listed separately.

(a) Identify current patterns of intensification and opportunities for sustainable intensification.

   (i) Progress was made in mapping rice areas in Cambodia using dense time series vegetation indices based products from MODIS sensor and developed end-to-end framework implemented in R software environment to map paddy rice fields, cropping intensity and phenological stages in Cambodia.

   (ii) Progress was made on merging information from Landsat 8 and Landsat 7 to estimate the boro rice for years 2013-2017. Data were collected on cropping practices for more than 100 locations across Bangladesh based on availability of high resolution Google Earth image for multiple years and seasons. Established partnership with BARI for collecting additional ground samples of boro rice.

   (iii) In collaboration with multiple subawards and partners, the GFC is mapping current cropland areas and predicting cropland expansion scenarios based on historic trends in population, arable land and yield in several of our target countries.

(b) Improve resource use efficiency in crop production.

   (i) R-packages have been publicly released on github (https://github.com/cropmodels). Models are being calibrated with experimental dataset on crop-trials from CGIAR and other research groups.

   (ii) Compiled a spatial database of fertilizer prices and predicted the price for unknown locations using interpolation across multiple regions in Africa. Plans include calibrating the optimization function between crop yield and N based on the experimental data in Senegal.

(c) Design crop growth monitoring tools.

   (i) In addition to trainings conducted, a workstation with GPU-support was purchased and started testing multiple image processing software for processing and analyzing sUAS data. Developed a workflow to process the sUAS image after comparing multiple software and are working on a manual based on results that will be made available on the GFC website.

(d) Estimate current and potential yield in regions of interest.

   (i) Completed crop model simulations for all of Eastern Africa, to be used in yield predictions. Partnered with One Acre Fund and TAMASA to obtain more yield data in Tanzania and Kenya. Obtained land cover field data from AfSIS to aid in crop classification, and developed methods to use Sentinel-1 or MODIS based phenology to adjust phenology parameters in crop model simulations.

   (ii) Submitted district level spatial database (2003-2016) of boro rice in Bangladesh in SIIL dataverse. Created a division level spatial database of boro rice for the time period of 1980-2016.

(e) Understand the impact of market and socio-economic and environmental conditions on opportunities for intensification.

    (i) Two new projects have been identified for subawards: a) CIMMYT-Ethiopia will lead a study on spatial profitability of alternative production strategies in maize-based smallholder farming systems in sub-Saharan Africa; b) Cropnuts-Kenya will analyze different properties (N, P, K, pH, SOM, CEC) of 2000 soil samples (1000 locations at two depths) to be collected across the crop-growing regions in Senegal.

(4) <u>Collaborators</u>: See GFC subaward reports

(5) <u>Capacity Building</u>:

(a) Led sessions at the Free Open Source Software for Geospatial [(FOSS4G) global conference](#) with 1,000 participants from over 20 countries held in Tanzania. Partnered with the CGIAR to provide 70 participants with a day-long workshop on spatial data handling with R.

(b) Organized training events on small Unmanned Aerial Systems (sUAS) based remote sensing data collection and processing in Cambodia and Senegal. In-country partners now have a complete kit, sUAS with regular color and multispectral cameras, for near-surface remote sensing data collection. They are using the instruments to collect images of the experimental plots (or study locations) at frequent intervals during the growing seasons. sUAS equipment in Cambodia is also being used to monitor an experimental plots managed by ASMC.

(6) <u>Lessons Learned</u>:

(a) Importing shipping or hand-carrying research equipment or instruments in some countries, specifically figuring out the regulations, is challenging, e.g. weather station shipping process to Burkina Faso took almost 6 months to finish and involved extensive paperwork.

(b) Unstable internet connection not only disrupts the data transfer (weather station, sUAS) but also leads to serious communication gap (unable to Skype).

(c) sUAS-technology is promising, but takes a lot of time, effort, resources, and expertise to use effectively. These platforms are great choice for repeat monitoring of small areas (e.g. experimental fields) and may replace some of the time-consuming field data collection tools. However we must be careful not to overstate the potential use cases of such technologies.

(d) Government agencies are often reluctant to share their data. In spite of our best efforts, we have not been able to collect the following information: a) commune level agriculture census data for Cambodia; b) human-wildlife conflict data around protected areas in Tanzania; and c) zilla agricultural reports for Bangladesh.

(7) <u>Peer Reviewed Publications</u>:

(a) Azzari, A., et al. (2018). Smallholder maize area and yield mapping at national scales with Google Earth Engine. Remote Sensing of Environment (In Press)

(b) Fraval, S., et al. (2018). Pathways to food security in rural Burkina Faso: importance of consumption of agricultural produce versus food purchases. Food Security (In Press).

(c) Fraval, S., et al. (2018). Making the most of imperfect data: a critical evaluation of standard information collected in cross-sectional farm household surveys. Experimental Agriculture (In Press).

(d) Cedrez, C.B., Hijmans, R. (2018). Methods for spatial prediction of crop yield potential (pp.1-9). Agronomy Journal 110(6), 2322-2330. doi:10.2134/agronj2017.11.0664

(e) Shew, S., et al. (2018). Rice Intensification in Bangladesh Improves Economic and Environmental Welfare. Environmental Science and Policy (In Press).

(f) Stirling, C.M., et al. (2018). Household methodologies to reduce gender inequality and increase household resilience to climate and other shocks: a case study from Malawi. Climate Change (In Press).

2. GFC Subaward I – *Project Complete*

(1) <u>Name</u>: Using new satellites to assess maize productivity in Tanzania (PI: David Lobell, Stanford University)

(2) <u>Locations</u>: Regional/national scale study that focuses on Kenya and Tanzania

(3) <u>Description</u>: The goal of this project is to develop and test methods to map the locations and yields of maize crops in East Africa using new high resolution satellite imagery. These maps can then be used to better understand the current level of intensification in the region and the opportunity for future gains. With fine-resolution data increasingly available through Planet, Sentinel-2, and other providers, an opportunity exists to significantly improve the understanding of smallholder agriculture.

(4) <u>Collaborators</u>: Taking Maize Agronomy to Scale in Africa (TAMASA), One Acre Fund, University of Maryland

(5) <u>Achievements (See FY 2018 AWP Activity 2.8)</u>:

    (a) Developing and testing procedures to map the location of maize fields and estimate their productivity in eastern Africa is now complete. This information is central to better understanding the current level of intensification in maize systems and the constraints to raising the system's productivity. The approach leveraged newly available imagery from the European Space Agency's Sentinel-1 and Sentinel-2 satellites, ground data on crop locations and yields, and a new simulation-based approach to estimating maize yields anywhere in the world.

    (b) Results showed considerable success in mapping both where maize is growing and how productive it is. The results of this study indicate great promise for using new satellite data, in particular from the Sentinel constellations, to map smallholder agriculture in Eastern Africa. Continued investment was recommended to realize the full potential of applying these data to sustainable intensification in the region. Future work will focus on applying these datasets to understand drivers of maize productivity in the region.

(6) <u>Capacity Building</u>:

    (a) None to report in FY 2018.

(7) <u>Lessons Learned</u>:

    (a) Clouds and cloud shadows are a more formidable problem than anticipated, even for imagery that is acquired frequently, such as the 5-day repeat of Sentinel-2. Therefore, devoted significant effort in developing our own cloud masking algorithms for Sentinel-2, and abandoned using Landsat data for historical analysis since cloud cover in Landsat imagery was high and Landsat could not provide the field-scale detail that was the emphasis of this project.

    (b) Private sector imagery from Planet (both Planetscope 3-5m data and Skysat 1m data) are improving in quality, but remain difficult to use in scientific analysis because of a lack of calibration to surface reflectance and may cause misregistration issues.

    (c) Obtaining accurate field data is a challenge, particularly for yield estimation, e.g., crop cuts are often done for a very small section of the field, and for a limited number of fields in each geography, which makes it difficult to have confidence in estimates at the field or district level.
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(8) <u>Presentations and Publications</u>:

    (a) Azzari G, Jin Z, You C, Di Tommaso S, Aston S, Burke M, Lobell DB. Smallholder maize area and yield mapping at national scales with Google Earth Engine. Remote Sensing of Environment (in review).

    (b) Jin, Z., Azzari, G., Burke, M., Aston, S., Lobell, D. (2017). Mapping smallholder yield heterogeneity at multiple scales in Eastern Africa (pp.1-15). Remote Sensing, 9(9), Basel, Switzerland. http://dx.doi.org/10.3390/rs9090931

3. GFC Subaward II – *Project Complete*

(1) <u>Name</u>: Spatial Targeting Agricultural Sustainable Intensification Investments: Linking Household Surveys with Spatial Data in Africa (PI: An Notenbaert, CIAT-Kenya)

(2) <u>Locations</u>: Tanzania

(3) <u>Description</u>: The goal of this project was to support targeting of agricultural sustainable intensification investments by identifying the locations where there is urgent need in combination with high potential of success of sustainable intensification (SI). It aimed to map the current gradient of agricultural intensification and its sustainability in Tanzania, as well as conditions that could support investments in agricultural sustainable intensification.

(4) <u>Collaborators</u>: ILRI, CIAT, Wageningen University and Research Center

(5) <u>Achievements (See FY 2018 AWP Activity 2.6)</u>:

   (a) This project collated a wide variety of geo-referenced household-level data. Data points from highly contrasting systems were included and thus allowed for a robust analysis of on-the-ground conditions for intensification and sustainability. This data was used for benchmarking and mapping a few simple SI indicators. The maps and underlying data can be used for intervention analyses to quantify the potential benefits of specific SI options and of interventions targeting specific on- and off-farm activities.

   (b) A conceptual framework was developed, describing how best to relate household level information on intensification and sustainability to the available spatial data. Some preliminary analysis was carried out within the project, while the methods, data and tools will also be made available to end-users so that they can carry out their own analysis.

   (c) A wide range of secondary spatial data, including the five domains of the SI Assessment Framework, was aggregated and linked to a user-friendly GIS toolkit.

(6) <u>Capacity Building</u>:

   (a) Project contributed to the PhD work on 'Food security in a changing world – The effects of climate-smart agricultural practices on food security at different scales considering natural resources constraints and future trends."

   (b) Conducted a two day training on the use of Targeting Tools in CIAT Arusha and worked on a case study in Tanzania whereby the suitability of two beans varieties i.e. Lyamungu 90 and Jesca for Tanzania conditions was evaluated.

(7) <u>Lessons Learned</u>:

   (a) Stakeholders working in agriculture and rural development in Tanzania can make use of the preliminary analysis that was carried out within the project. The methods, data and tools will also be made available to end-users so that they can carry out their own analysis.

   (b) Good progress was made in the separate activities and a lot of useful ideas on how to bring them together were discussed. Due to limited time allocation of each of the scientists in the project team, still a lot remains to be done to achieve the actual potential. A follow-up project, including a junior team member dedicated to implementation would be beneficial.

(8) <u>Presentations and Publications</u>:

   (a) Notenbaert, A. (2018) Final Technical Report: Agreement No. 201403286-01 *Spatial Targeting Agricultural Sustainable Intensification Investments: Linking Household Surveys with Spatial Data In Africa*

   (b) Notenbaert, A., Mutua, J., Girvetz, E. (2017). Spatial targeting of agricultural intensification investments: The use of spatial data for targeting SI investments. Arusha, TZ. International Center for Tropical Agriculture (CIAT). 28 p. http://hdl.handle.net/10568/80645.

4. GFC Subaward III – *Project Complete*

(1) <u>Name</u>: Geospatial Data and Analysis Support to the SIIL Geospatial and Farming Systems Research Consortium (PI: Jawoo Koo, IFPRI)

(2) <u>Locations</u>: All SIIL focus countries

(3) <u>Description</u>: The project aimed to provide the SIIL partners and sub-grantees with multi-disciplinary, high-resolution geospatial datasets to support analysis on targeting, priority setting, and ex-ante assessments of potential impacts and risk, as well as strategy development for scaling-up adoption of SI technologies. Results were built upon IFPRI's ongoing efforts to generate spatially-explicit knowledge products for supporting strategic agricultural investment decisions as well as contributing to the mission of SIIL.

(4) <u>Collaborators</u>: IFPRI

(5) <u>Achievements (See FY 2018 AWP Activity 2.9)</u>:

  (a) Sub-national crop production statistics for most sub-Saharan African countries were collected. The datasets were pre-processed for code harmonization, and in each country, data was scaled at all levels to match FAOSTAT averages of 2009-2011.

  (b) The adoption study found that while different socioeconomic factors affect adoption of specific technologies differently, education, access to credit and agricultural extension services, and land ownership all are positively correlated with the adoption intensity, which was measured by the count of technologies adopted per household. The study also found soil quality, food insecurity, parcel-to-homestead distance, and aridity are negatively correlated with the intensity of adoption. Overall, findings suggest the importance of policies that support agricultural capital, education, and economic infrastructure in promoting the adoption of SI practices.

  (c) The project developed a novel analytical framework to incorporate Google Distance Matrix as an additional source of model parameters and evaluating data for on-road routing. This unique approach showed the potential of providing more reliable travel time estimates for both on-road and off-road areas. Using this new framework, an updated spatial data layer of fertilizer prices for Tanzania was created. Farm-gate fertilizer price data were pooled from various surveys and used to develop a new price model.

(6) <u>Capacity Building</u>: N/A

(7) <u>Lessons Learned</u>:

  (a) A raster-based market access model provides a meaningful and reliable way to measure market accessibility, especially in remote areas where Google Distance Matrix does not apply. Google estimates of on-road travel time between settlements are extremely useful for updating road properties and calibrating the market access model. The overall accuracy of the market access estimation improves significantly.

  (b) Price information from the surveys needs to be handled cautiously in the model since standard deviations of the means are high. There are multiple reasons for this: quality of the fertilizer, randomized location of the cluster, or error in data collection.

  (c) The price model is developed based on the assumption that the price difference is driven by the distance between related variables (e.g. distance to the market, road types, travel speed). However, the IFDC reports that transport cost is only about 7-10% of the final selling price. Therefore, many factors need to be considered when estimating the farm-gate price of a commodity.

(8) <u>Presentations and Publications</u>:

  (a) Guo, Z. and Jawoo, K. (2017) IFPRI Technical Report: Accessibility and Price Mapping in Tanzania. All datasets developed from these activities are available to download here: https://www.dropbox.com/sh/iyc9x1rmxx9xhkv/AACTSHLb39108AjsUX6j__WHa?dl=0

5. GFC Subaward IV - *Project Complete*

(1) <u>Name</u>: Generating Cropland Extent of Ethiopia from High-Resolution Imagery (PI: Andy Nelson, University of Twente, ITC Netherlands)

(2) <u>Locations</u>: Ethiopia: Dangla, Womberima, Inebse Sar Midir, Kobo and Lagambo in the Amhara Region; Dugda, Sire, Liban Chukala, Lume and Dodota in the Oromia Region. In the future, Ethiopian partners will extend the scope to the rest of the country.

(3) <u>Description</u>: The spatial extent of cropland, at the level of detail where individual fields can be discriminated, is poorly defined, particularly in regions of the world with smallholder farmers (1 ha or less), extensive and diverse cropping systems and fragmented agricultural landscapes. Without this basic information on the location and extent of the agricultural land - which is the main source of income and calories for millions of low income families - there is a limit to how much impact or effectiveness can be expected from agricultural investments. Simply put, field boundary information is an essential layer of geospatial information for recommendation domains in agriculture. This project tested and assessed different methods to map field boundaries in small holder farming systems in Ethiopia as a precursor to larger scale mapping of cropland extent. It will provide recommendations for which methods would be most appropriate for cost effective field boundary mapping on a large scale in complex farming system environments.

(4) <u>Collaborators</u>: International Institute for Applied Systems Analysis (IIASA), and Kifiya Financial Technology PLC

(5) <u>Achievements (See FY 2018 AWP Objective 2) and Capacity Building</u>:

   (a) This study used high spatial resolution imagery within an online digitizing tool and trained users to manually digitize field boundaries from those images. This resulted in a unique crowd-sourced database of over 7,200 field boundaries in the Amhara highlands and Oromia region of Ethiopia.

   (b) Two semi-automated field boundary mapping techniques, gPb and eCog, were applied to the same imagery and the resulting boundaries were compared against the manually digitized boundaries. Overall, eCog is recommended over gPb for field mapping since it captures boundaries that represent objects at the field level whereas gPb seems better at capturing boundaries for larger agglomerations of fields and may be suitable for cropland extent mapping.

   (c) The study demonstrated the challenges of applying semi-automated techniques to highly variable, smallholder farming systems in Africa where field sizes are small, prior information is poor and where boundaries are unclear. This study was a first attempt at developing large "high quality" datasets on field boundaries in Ethiopia using crowdsourced methods. It was also a first attempt to compare the ability of two semi-automated methods for field boundary detection against an independent dataset.

(6) <u>Lessons Learned</u>:

   (a) More oversight and quality control of the digitizing progress in important with remedial training if needed. Moving beyond this approach, opening up classification to the general public would provide the benefit of a larger crowd-sourcing effort so that many more boundaries are generated per object with the aim of converging to a global mean.

   (b) The eCog is the superior approach, but that it is difficult to recommend either method for automated field boundary detection in this study area.

(7) <u>Presentations and Publications</u>:

   (a) Nelson, A. (2017). Technical Report: *Title Generating cropland extent of Ethiopia by capturing field boundaries from high resolution imagery*. Agreement No 201403286-05

6. GFC Subaward V

(1) <u>Name</u>: Towards Standardization of Farm Household Surveys, Phase II: Moving from a Successful Proof-of-Concept to Large Application and Outscaling (Mark van Wijk, ILRI)

(2) <u>Locations</u>: Global with specific focus on Feed the Future countries/zones

(3) <u>Description</u>: In the last two years, the Rural Household Multi-Indicator Survey (RHoMIS) framework (Hammond et al. 2016) was developed, which provides an implementation-ready solution that produces cost-effective information for planning and monitoring investments in SI across a range of rural contexts. It is a flexible digital platform built on open-source software that can be easily modified to meet a range of needs while collecting a core set of data that feeds into a global discussion on the success of SI. The framework has been applied in many sites and countries, and has been used in a wide-ranging set of projects focusing on water productivity, crop-livestock integration, bean production intensification, gender equity and climate smart agriculture. The second phase of this project aims to further improve the RHoMIS tool, promote application in several specific contexts (including SIIL, Africa RISING), stimulate uptake of the tool, and expand analysis procedures on the identification and adoption potential of new intervention. Additionally, the project will set up a new exploration type of farm household level analysis to better quantify adoption and outscaling potential of interventions and their consequences in terms of overall household level welfare.

(4) <u>Collaborators</u>: ILRI

(5) <u>Achievements (See FY 2018 AWP Objective 2)</u>:

   (a) Numerous projects have adapted RHoMIS framework to track economic, productivity, environmental, human, and nutrition related progress among others in nearly 17,000 households across 22 countries (e.g., Chad, Burkina Faso, Mali, Nicaragua, DRC, Burundi and Ethiopia). More details about the tool can be found here https://www.rhomis.org/ and the SIIL blog.

   (b) NGO TreeAID is using the RHoMIS as a standard monitoring and evaluation tool, with three applications in Ghana, Burkina Faso, and Ethiopia.

   (c) Application of an expanded RHoMIS within AfricaRISING Ethiopia has been done to also capture the indicators of SIIL's Sustainable Intensification Indicator Framework. Analysis work of this survey application are now underway. A similar application will be executed in Senegal.

(6) <u>Capacity Building</u>:

   (a) Web-based resources have been developed to support the understanding and utilization of the RHoMIS tool and uptake has been substantial in projects with other donors (i.e., BMGF, ACIAR, DFID, etc.). It was also adopted in SIIL's Burkina Faso and Cambodia projects along with AfricaRISING and GFC supported project at Royal University of Agriculture, Cambodia.

(7) <u>Lessons Learned</u>:

   (a) Despite the success of uptake, the project is exploring ways to increase the uptake across all SIIL projects to get a systematic baseline to better understand and quantify the trade-offs and synergies inherent to households adopting sustainable intensification approaches.

(8) <u>Presentations and Publications</u>:

   (a) Fraval et al. (2018) Making the most of imperfect data: a critical evaluation of standard information collected in cross-sectional farm household surveys. Experimental Agriculture (In Press).

   (b) Fraval et al. (2018) Pathways to food security in rural Burkina Faso: importance of consumption of agricultural produce versus food purchases. Food Security (44-48). Agriculture for Development, 30, CGIAR. http://hdl.handle.net/10568/81375.

7. GFC Subaward VI

(1) <u>Name</u>: Patterns and Drivers of Land Use Change in Battambang Province, Cambodia (PI: Sanara Hor, Royal University of Agriculture, RUA)

(2) <u>Locations</u>: The project analysis area transects through the lowland areas near Tonle Sap Great Lake (central Cambodia) to the upland area (western Cambodia) within Battambang. Additional locations include Pailin, Pursat, Kampong Thom, and Siem Reap in Cambodia

(3) <u>Description</u>: The pattern, causes and consequences of land use and land cover change have not been documented throughout Cambodia. In the northeastern province and other parts of Cambodia, government land policies are changing the land use and cropping systems. In this location, agricultural expansions and transitions in the farming system have the significant impacts on the forest cover. In a central Cambodia the agricultural expansion is caused by the development of irrigation systems. Given the different dynamics of land use changes across Cambodia, there is an urgent need to characterize these processes for developing land use management policies and improve the understanding of the changes in the environmental and socio-economic conditions. This study primarily focuses on land use changes of Battambang Province. The study proposes to use remote sensing image analysis and quantitative research methods to investigate the major drivers of land use and land cover changes. Medium and high-resolution imagery will be applied along-with household surveys to improve our understanding.

(4) <u>Collaborators</u>: RUA

(5) <u>Achievements (See FY 2018 AWP Objective 2)</u>:
   (a) Leveraging research with other subawardees by collaborating on projects (e.g., Dr. van Wijk and Dr. Hammond from ILRI are working with Dr. Sanara from RUA to implement the RHoMIS framework for the household survey using mobile devices.
   (b) Supported the development of two Cambodian research groups' application for grants under the Partnerships for Enhanced Engagement in Research (PEER) Program of the USAID.
   (c) Both RUA research proposals were awarded: 1) focuses on assessing impacts of climate change on rice yield leading to food insecurity; and 2) focuses on developing remote-sensing based tools to create nationwide cropland database to support sustainable intensification and land resource management.

(6) <u>Capacity Building</u>:
   (a) Two Ph.D. students under joint supervision of the GFC were selected for this project. Both students were awarded Ph.D. scholarships from the CE SAIN.

(7) <u>Lessons Learned</u>:
   (a) Despite significant funding opportunities there are still obstacles for finding candidates for various research positions.
   (b) Government agencies are often reluctant to share their data (e.g. it is difficult to collect data on commune level agriculture census data for Cambodia).

(8) <u>Presentations and Publications</u>:
   (a) None to report in FY 2018.

8. GFC Subaward VII

(1) <u>Name</u>: Updating Fertilizer Recommendations Across Rainfall Gradients and Soil Fertility Levels for Improving Dual-Purpose Millet Nutrient Use Efficiency in Senegal (PI: Aliou Faye, CNRA/ISRA)

(2) <u>Locations</u>: *Senegal* - Bambey, Kolda, Nioro, Sinthiou, and Dahra

(3) <u>Description</u>: This project aims to improve Senegal's food security through the development of appropriate fertilizer recommendations for dual-purpose millet varieties across Senegal's rainfall and soil gradients. The project objectives include initiatives to: (1) develop a geographically appropriate fertilizer recommendation model based on millet variety, climatic conditions (precipitation), management practices such as leguminous intercropping, and soil fertility gradients in the millet cropping zone; (2) create a high spatial resolution map of soil properties; (3) improve the understanding of the relationship between seasonal and spatial price movements and climactic differences, transportation costs and other variables; and (4) build capacity of Senegalese researchers and students in statistical modelling and sUAS data collection systems.

(4) <u>Collaborators</u>: Kansas State University

(5) <u>Achievements (See FY 2018 AWP Objective 2)</u>:

   (a) Millet-legume intercropping trials with cowpea and peanut have been established in the five targeted areas to evaluate the benefits on yield and soil improvement.

   (b) Yield response data across the 5 agro-ecologies have been compiled and analyzed. These data were used to guide the design of the third year's cropping cycle. After all three years data are complete, a final analysis and fertilizer response functions will be developed.

   (c) Collaboration with CropNuts and QED has continued in an effort to develop a high resolution soil map for Senegal. QED provided the locations for soil sample collections based on the framework developed by AfSIS, ISRA is collecting 2000 soil sample from the field and will provide results from a previous analysis of 500 samples, and CropNuts will be responsible for providing mobile data collection platforms, barcoding and training, shipping and permits, and soil property analysis for the 2000 samples. CropNuts will also be providing soil spectroscopy.

   (d) Developed and signed a MoU with SoilCares based at Wageningen University in the Netherlands. The MoU is an agreement that we will provide a subset of our soil samples and they will conduct spectroscopy analysis and calibrate with their field scanner to develop an in-field fertilizer recommendation platform for Senegal.

(6) <u>Capacity Building</u>:

   (a) Three students are in the process of defending their BS at University of Thies in October.

   (b) Three PhD candidates (one ISRA budget, and two from GFSCR sub awards) got their official appointment contract signed by ISRA DG in November 2017.

   (c) A scientific writing session was organized for 10 PhD candidates.

(7) <u>Lessons Learned</u>:

   (a) Communication is key for smooth collaborations. .

(8) <u>Presentations and Publications</u>:

   (a) Faye A., Stewart Z.P., and Prasad P.V.V. (2018). Closing Senegal's millet yield gap through site-specific fertilizer and plant population recommendations modeled across precipitation and soil fertility gradients. International Sustainable Agricultural Intensification and Nutrition Conference. Phnom Penh, Cambodia.

9. GFC Subaward VIII

(1) <u>Name</u>: Sustainable Intensification of Millet-Based Agrosystems Using Cowpea in the Groundnut Basin of Senegal (Laure Tall, LNRPV/ISRA)

(2) <u>Locations</u>: Louga, Fatick, and Kaolack, Senegal

(3) <u>Description</u>: Cropping systems involving different plant species can be strong assets for the development of SI of agriculture. However, due to the lack of technical references (most of them being established for monocrops), the reasoning of their management is difficult. Indeed, interactions between crops can change depending on the field's management scheme (density of sowing, varieties and fertility management), environment (soil, or plot type) and climate. Thus, there is a need for dynamic modelling tools to evaluate how wide ranges of soil conditions, various weather sequences and different management schemes, modify the yield and environmental impact of intercropped systems. This project aims to better understand the beneficial mechanisms involved in millet-cowpea intercropped system and estimate their yields in various situation of the Groundnut Basin in a context of climate variability with erratic and short rainfall period.

(4) <u>Collaborators</u>: *Senegal* - CNRA/ISRA, LNERV/ISRAI; *France* - RD, CIRAD

(5) <u>Achievements (See FY 2018 AWP Objective 2)</u>:

   (a) Multiple equipment (LiCOR plant canopy analyzer) and instruments (weather station, SPAD chlorophyll meter) essential for this project were procured.

   (b) Trials and networks of plots for data acquisition were established. Trials are located in 3 sites in the center of Senegal: 1) in the research station of CNRA Bambey (Region of Diourbel, N 14°42'47.5" W 16°28'46.6"), 2) on farmers plots in the village of Sob (region of Fatick, N 14° 29' 44.268" W 16° 27' 16.056") and 3)) in the research station of Sinthiou Malème (Region of Tambacounda, N 13°49'49.6" W 13°54'43.0"). A network of 28 farmers' plots is also monitored in the village of Diohine in the area of the IRD observatory.

   (c) As mentioned in Subaward VII achievements, collaboration between the projects is occurring to leverage research results for both projects.

(6) <u>Capacity Building</u>:

   (a) Two Ph.D. candidates have been hired to work on the project.

   (b) A mid-term workshop of the SIMCo Project (Sustainable Intensification of Millet and Cowpea) was conducted to share of results with research team on crop modeling and specialization.

(7) <u>Lessons Learned</u>:

   (a) The equipment and instruments were not directly purchased by ISRA. GFC and IRD have to purchase and ship it to Senegal. This caused significant delay in the project.

   (b) Fund transfer delays and other difficulties in financial reporting caused data collection delays.

   (c) Dry spell during the 2018 crop season added difficulty to the project.

(8) <u>Presentations and Publications</u>:

   (a) None to report in FY 2018.

B. Appropriate Scale Mechanization Consortium (ASMC)

1. Summary of ASMC Activities

(1) Name: Appropriate Scale Mechanization Consortium (PI: Alan Hansen, University of Illinois at Urbana-Champaign)

(2) Locations: Bangladesh, Burkina Faso, Cambodia, and Ethiopia

(3) Description: The ASMC facilitates the introduction of multifunctional and modular mechanized technologies that are technically, environmentally, economically and socially appropriate for use by smallholder farmers. The overall objective of the project is to sustainably intensify smallholder farmers' cropping systems and on-farm operations through mechanization. The ASMC utilizes a user-centric systems approach through an Innovation Hub model in each of their four focus countries. The Hubs identify specific mechanization needs, leverage ASMC resources accordingly, and implement innovative solutions.

(4) Collaborators: *United States* - Kansas State University, Michigan State University, and North Carolina A&T State University, ADM Institute for the Prevention of Postharvest Loss (Illinois). Additional international collaborators are listed under each ASMC country report.

(5) Achievements (See FY 2018 AWP Objective 3):

   (a) Focus country achievements are reported separately to capture the range of activities.

   (b) ASMC engaged the Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) team to improve gender considerations and integration into its programming through capacity building activities globally and initiating a process to assess technologies in the ASMC portfolio and apply findings in the research designs.

   (c) Connected the Innovation Hubs and researchers with appropriate private sector companies, local entrepreneurs, and farmer organizations to enable technology scaling.

   (d) Developed an Agricultural Mechanization degree program in the Institute of Rural Development in collaboration with Institute of Technology at University of Bobo Dioulasso in Burkina Faso.

(6) Capacity Building:

   (a) Conducted a 3-Part Webinar Series: *Making Training and Outreach Events Gender Sensitive* for over 92 participants.

   (b) Over 80 field days and training events were held in the four ASMC target countries in FY 2018, which is doubled from FY 2017. All Innovation Hubs have been established with workshop facilities with machine fabricating capabilities, which will sustain capacity building activities in the future.

(7) Lessons Learned:

   (a) Key findings from conducting the technology assessments were that women play a key role in adoption of technology and influencing husband's decision-making, and there is a strong linkage between the time saved from using labor saving tools like the planter and other income generating activities.

   (b) Innovation Hubs are still in their initial stages which may impact engagement. There could be need to focus on the social capital building and formation, especially around the co-creation of technologies and practices.

   (c) In Bangladesh, local service providers and spare parts are not easily available as the machine and spare parts are imported by very few agricultural machinery importers.

(8) Presentations and Publications:

   (a) Campabadal, C. (2018). Appropriate-scale post-harvest storage system. ASABE 2018 Annual International Meeting, Detroit, MI.

   (b) Chan, S. (2018). A comparison of direct seeding and conventional seeding for paddy in Cambodia. ASABE 2018 Annual International Meeting, Detroit, MI.

(c) Faulkner, P. E., Jefferson-Moore, K., Begum, S., Bougouma-Yameogo, V., Socheath, O., & Abate Fenta, F. (2018). Integrating gender-sensitive participation in sustainable intensification and nutrition research. Presentation at First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(d) Hansen, A. (2018). Attributes of appropriate-scale mechanization. ASABE 2018 Annual International Meeting, Detroit, MI.

(e) Harrigan, T. (2018). Taking a participatory farming systems approach to mechanizing maize production in Burkina Faso. ASABE 2018 Annual International Meeting, Detroit, MI.

(f) Schwab, B. and Manzamasso, H. (2018). Who has the time? Gender, labor and willingness to pay for mechanized technology in Ethiopia. Agricultural and Applied Economics Association (AAEA) 2018 Annual Meeting, Washington, DC.

(g) Srivastava, A. (2018). A solar-powered two-wheel multi-purpose traction platform. ASABE 2018 Annual International Meeting, Detroit, MI.

2. ASMC - Bangladesh

(1) <u>Name</u>: Appropriate Scale Mechanization Innovation Hub (ASMIH) - Bangladesh

(2) <u>Locations</u>

   (a) Innovation Hub location: Bangladesh Agricultural University, Mymensingh (Bangladesh)

   (b) Field locations: Dumuria and Wazirpur (Bangladesh)

(3) <u>Description</u>: The goal of the ASMIH - Bangladesh project is promote appropriate-scale agricultural mechanization for sustainable intensification focusing on smallholder farming systems in Southern Delta region of Bangladesh. The target equipment interventions include: Rice transplanters; rice reapers, mini-combine rice harvesters, strip-tillage planters, no-tillage planters, bed planters, and axial flow pumps

(4) <u>Collaborators</u>: *Bangladesh* - Bangladesh Agricultural University (BAU), Bangladesh Rice Research Institute, Bangladesh Agricultural Research Institute, and ACI Motors Ltd.

(5) <u>Achievements (See FY 2018 AWP Objective 3)</u>:

   (a) Inspired by the ASMC demonstrations and activities in their communities, at least two farmers have utilized government subsidy programs to purchase rice transplanters and mini-combine harvesters.

   (b) Saline tolerant variety BRRI Dhan 47 was introduced in 0.76 ha at Dumuria, Khulnaand Kalapara, Patuakhali and the rest of 3.77 ha of land was transplanted BRRI Dhan 28 variety. Seedling raising and transplanting was done using mechanical tools in high land. Protective polythene covering against heavy rainfall during seedling raising was also be done. Farm family members were involved in awareness building programs on benefits of mechanical rice transplanting to make decision of crop production jointly.

   (c) A Gender (WEAI) study was undertaken in project's new areas i.e. Kolapara Upazila of Patuakhali and Subrnachar Upazila of Noakhali district for 90 men and women farmers (36 men and 54 women).

   (d) Experiments were conducted for hybrid variety rice at the BAU farm, Dumurlya and Khulna for estimating seed rate and evaluating performance of rice transplanter in both puddled and unpuddled soil conditions.

(6) <u>Capacity Building</u>:

   (a) Training manuals for transplanting, harvesting, conservation agriculture machinery, and gender issues were developed in English and Bengali.

   (b) Multiple field days, demonstrations, and training programs were conducted for operators, mechanics, local engineering workshop owners, and farmers on harvesting machines seedling raising, and rice transplanter operations (see short-term trainings for complete list).

   (c) A week-long mechanization symposium was hosted in November 2017, which included a conference, innovation competition, field visits, and a machinery fair.

   (d) Research findings were presented in various international and national conferences and workshops.

(7) <u>Lessons Learned</u>:

   (a) In agricultural production decision both male and female members are important; therefore, in future training and awareness programs, both the family members need to be involved.

   (b) Tilling and irrigation service providers have influence on farmers' agricultural practices, (i.e. row to row spacing and land preparation). Therefore, they need to be included in field days and training programs alongside the farmers.

   (c) Student idea competition is a good practice for engaging academia and creating innovative ideas in agricultural mechanization.

(8)   Presentations and Publications:

(a)   Alam, M. (2018). Agricultural Mechanization: Status, challenges and policy issues in Bangladesh (IEB). IEB Ag. Engg. Division, IEB head quarter, Ramna, Dhaka, Bangladesh.

(b)   Alam, M. (2018). Agricultural Mechanization: Status, challenges and policy issues in Bangladesh (PKSF), BSAE seminar, KIB complex, Farmgate, Dhaka, Bangladesh.

(c)   Alam, M., Saha, C. K., Ali, M., Hasan, M., and Hossain, M. (2018) Technical performance and benefit of mini-combine harvester in southern Delta of Bangladesh. Journal of Agricultural Mechanization in Asia, Africa & Latin America. 00845841

(d)   Alam, M., Saha, C. K., Ali, M., Hasan, M., Hossain, M., and Noby, M. (2018). Performance evaluation of modified BAU self-propelled reaper for paddy (pp.171–177). Journal of the Bangladesh Agricultural University, 16(2) (Aug 2018), BAU, Mymensingh, Bangladesh. doi:10.3329/jbau.v16i2.37956.

(e)   Alam, M., Saha, C. K., Mottalib, A., Hossain, M., Hossain, M., & Amin, M. (2018). Appropriate conservation machinery for jute cultivation in the west southern region of Bangladesh. Presentation at Proceedings of the 1st International Conference on Challenges for Future Agriculture 2018, BAU, Mymensingh, Bangladesh

(f)   Alam, M., Saha, C. K., Sarkar, S., Hossain, M., & M. (2017). Mechanical rice transplanting technology in southern delta to achieve sustainable food security. National conference on Food and Nutrition Security in Bangladesh: Interdisciplinary Approaches, BARC, Dhaka, Bangladesh

(g)   Hansen, A., Kalita, P., Alam, M., Kumar Saha, C., Hossain, M. (2018). Conservation machinery for planting of mungbean and jute in the southern region of Bangladesh. 2018 ASABE Annual International Meeting, Detroit, Michigan, USA. doi:https://doi.org/10.13031/aim.201800679

(h)   Hansen, A., Kalita, P., Alam, M., Saha, C. K., Sarkar, S., Hossain, M., & M. (2018). Cost saving rice transplanting technology for puddled and unpuddled soil condition. 2018 ASABE Annual International Meeting, Detroit, Michigan, USA. doi:https://doi.org/10.13031/aim.201801043

(i)   Saha, C. K., Ali, M., Alam, M., Hasan, M., & Hossain, M. (2018). Assessment of paddy harvesting practices in southern delta region of Bangladesh. Presentation at 1st International Conference on Challenges for Future Agriculture 2018. Mymensingh, Bangladesh

3. ASMC – *Burkina Faso*

(1) <u>Name</u>: Appropriate Scale Mechanization Innovation Hub (ASMIH) – Burkina Faso

(2) <u>Locations</u>

    (a) Innovation Hub location: Polytechnic University of Bobo-Dioulasso, Bobo-Dioulasso (Burkina Faso)

    (b) Field location: Koumbia, Burkina Faso

(3) <u>Description</u>: The main objective of the project in Burkina Faso was to increase maize productivity through appropriate scale mechanization using animal draft for smallholder farmers. The targeted equipment interventions included: a refined ox yoke, single row ox-driven planter, conservation ripper (chisel plow), and an animal-drawn crop cultivator. Other tools include forage/fodder chopper and solar powered irrigation systems.

(4) <u>Collaborators</u>: *Burkina Faso* - Polytechnic University of Bobo-Dioulasso; *United States* - Tiller's International

(5) <u>Achievements (See FY 2018 AWP Objective 3)</u>:

    (a) Functional Innovation Hub was established at the University Polytechnic Bobo Dioulasso (UPB) that includes training equipment fabrication and testing facilities and land to conduct field trials as well as demonstration plots for conservation agriculture.

    (b) Three tools were developed/adapted as ripper, planter, and weeder to improve maize production and to reduce women's drudgery on the farm.

    (c) Established a solar power irrigation system to grow vegetables to increase farm income especially for women and to improve nutrition during the dry season.

    (d) Continuous improvements were made to the maize tillage and planting systems, and training on improved tillage techniques was conducted for the farmers that will receive the systems.

    (e) A small national grant was obtained to scale up the use of the maize planter developed in previous years by the ASMC and local partners, and this initiative will help produce 20 planters, train 10 local blacksmiths, and ultimately plant 40 hectares of maize.

    (f) A partnership with ILRI (SIIL subaward leader in Burkina Faso) was formed, resulting in production and transfer of eight choppers for making silage, to be used in eight villages.

(6) <u>Capacity Building</u>:

    (a) Five hundred (500) farmers were trained in six (6) different locations before the growing season on handling oxen and animal nutrition.

    (b) Multiple training sessions have been conducted for artisans, farmers, students, extension staff on topics such as yoke making, fabrication of rippers, planters, and weeders, crop storage, animal comfort and nutrition.

    (c) Twenty (20) planters were made and will be shared to 20 farmers to grow maize. Those planters were funded by National Research Funds for development (FONRID) which the impact of ASMC project on national research system.

(7) <u>Lessons Learned</u>:

    (a) Continuous, on-going communication and travel are critical to building trust, making progress, and achieving goals. As well as, collaboratively developing appropriate tools with the smallholder farmers to improve crops production.

    (b) The Innovation Hub concept has improved the project's ability to strengthen the integration between blacksmiths, farmers, students, farmers' organization, financial institution, extension service agents, and government institutions.

    (c) Sharing innovations between SIIL projects in West Africa is beneficial to avoid re-starting activities under SIIL.

(8) <u>Presentations and Publications</u>:

    (a) None to report in FY 2018.

4. ASMC - Cambodia

(1) Name: Appropriate Scale Mechanization Innovation Hub (ASMIH) – Cambodia

(2) Locations

    (a) Innovation Hub location: Royal University of Agriculture, Phnom Penh (Cambodia)

    (b) Field locations: Banan district (Battambang province), Puok district (Siem Reap province), and Stung Chinit (Kampong Thom province)

(3) Description: The main objectives of the ASMIH-Cambodia include:

    (a) To design and assess conventional and direct seeding mulch-based cropping systems.

    (b) To assess the performance of appropriate scale machinery while preserving soil capital.

    (c) To adapt and train smallholder farmers, service operators, field technicians, and students on the use of ASM and conservation agriculture (CA)-based cropping systems.

    (d) To support multi-stakeholder initiatives.

    (e) To initiate a negotiation process between farmers for the individual or collective management of fodder sources or crop diversification after wet season rice.

(4) Collaborators: *Cambodia* - Institute of Technology of Cambodia (ITC), Royal University of Agriculture (RAU), Conservation Agriculture Service Center (CASC), Ministry of Agriculture Forestry and Fisheries (MAFF), University of Battambang (UBB); *France* - CIRAD

(5) Achievements (See FY 2018 AWP Objective 3):

    (a) Analytical studies have been conducted including assessment of: (i) the impacts of contrasting rice cropping systems on root microbial and parasitic nematode communities through a partnership with the Institute of Technology of Cambodia (ITC) and the French Institute of Research for Development (IRD) at the experimental site in Stung Chinit, Santuk, Kampong Thom, (ii) soil ecosystem services in the flood plains of Battambang conducted by Mr. Sar Veng (SEARCA and Erasmus scholar), and (iii) a baseline of nematode populations in the flood plains of Banan, Battambang through a partnership with Kasertart University (KU), Thailand.

    (b) Several prototypes were developed and underwent field testing, including seeders for two- and four-wheel tractors, a no-till seeder for four-wheel tractor, and a seed broadcaster.

    (c) Hub Advisory Committee was established and has been actively meeting this past year.

    (d) E-learning on mechanization for conservation agriculture is under development.

(6) Capacity Building:

    (a) Field days were held with groups of farmers currently practicing conservation agriculture (CA) as well as two private companies to discuss benefits and constraints associated with CA practices. Field demonstrations of laser land leveling prototypes also occurred.

    (b) Cambodia team members also hosted visitor from the UBB to discuss the principles of rice cultivation under CA as well as the development of a CA course for UBB students.

    (c) RUA student started his internship with CASC team in Battambang and will be trained on all the activities including the follow-up of the experiments in the lowland and upland (CA concept, cropping system design and assessment), use of machineries (roller crimper, small and medium size imported and local made from DAEng, assessment of performance, maintenance, and operation of each machine), provision of rice and maize sowing services to smallholder farmers in Banan and Ratanak Mondul.

    (d) Field visits and short trainings for different stakeholders were organized to raise awareness and build capacity in the field of mechanization for conservation agriculture.

(7) Lessons Learned:

    (a) Hub Advisory Committee meeting is a very useful platform for sharing knowledge and learning from each other as well as receive feedback and suggestions for project direction.

    (b) Simulation game and participatory approach of CASC/CIRAD trained the gender team with the new research methodology.

(c) Website is a useful platform to storage documents, but Facebook page is a better platform for sharing and promoting the produced and efficiency prototypes as well as receive feedback for further improvement and commercialization.

(8) Presentations and Publications:

(a) Chan, S. (2018). Smart agriculture thought biochar production technology in Cambodia. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia

(b) Chan, S., Seng, S., Sar, S., Khom, S., and Chhun, M. (2018). Power tiller pulled seed planter in Cambodia. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(c) Hansen, A., and Rendall, T. (2018). Implementation and evaluation of appropriate scale technologies for sustainable intensification. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(d) Hansen, A., Reyes, M. R., Lor, L., Theng, D., Hin, L., and Litchfield, B. (2018). Demonstration test of sun buckets for agricultural suitability in Cambodia. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(e) Lor, L., Theng, D., Mean, M. C., Seng, S., Hin, L., and Yoeurng, S. (2018). Performance testing of a Cambodian-designed direct seeder equipped with power tiller. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(f) Reyes, M. R., Bates, R. M., Tivet, F., Lienhard, P., and Leng, V. (2018). Plant diversity, a central element to build resilient farming systems. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(g) Reyes, M. R., Lor, L., Theng, D., Hin, L., and Lilly, B. (2018). Demonstration test of Majipump for agricultural suitability in Cambodia. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(h) Reyes, M. R., Rendall, T., Bates, R. M., Tivet, F., Lor, L. (2018). Designing a new generation of conservation agriculture rice and annual upland cropping systems in Cambodia. First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(i) Tivet, F., Leng, V., Chheong, S., Suos, V., Chet, O. (2018). Conservation agriculture in Cambodia. 2ndLaos Initiative on Conservation Agriculture and Agro-ecology Meeting, Vientiane, Lao PDR.

5. ASMC - *Ethiopia*

(1) <u>Name</u>: Appropriate Scale Mechanization Innovation Hub (ASMIH) – Ethiopia

(2) <u>Locations</u>:

    (a) Innovation Hub location: Bahir Dar Institute of Technology, Bahir Dar University (Ethiopia)

    (b) Field locations: Bahir Dar Zuri, Bure Zuria, Dangila, (Ethiopia)

(3) <u>Description</u>: The ASMIH – Ethiopia aims to develop and refine sustainable mechanization practices with draft animals and emphasis on zone tillage, seeding, weeding, and shelling technologies for maize that will be readily transferrable to other cropping systems. The scope of activities includes prototype testing and evaluation, train-the-trainer sessions for local extension and technical service providers, on-farm evaluation and artisan training for local manufacturing and marketing of technologies, tools and custom services.

(4) <u>Collaborators</u>: *Ethiopia* - Bahir Dar University, Bahir Dar Institute of Technology; *United States* - Feed the Future Innovation Lab for Small Scale Irrigation, International Water Management Institute (IWMI), and International Livestock Research Institute (ILRI)

(5) <u>Achievements (See FY 2018 AWP Objective 3)</u>:

    (a) Research results from graduate students at the Bahir Dar Institute of Technology influenced the designs and implementation practices for the following technologies: manually operated maize sheller, PTO (power take-off) operated maize sheller, onion and pepper transplanter, animal drawn single line maize and fertilizer drill, and fodder/forage chopping machine.

    (b) Fifty Majipumps (solar powered, low cost, energy efficient irrigation pump) were purchased and have been disseminated to select communities to support the research efforts of conservation agriculture at commercial vegetable home garden scale.

    (c) Conducted baseline survey in 27 selected kebeles and have made the datasets publically available via SIIL's dataverse.

    (d) Organized a database of private maize shellers in selected Woredas for potential intervention.

(6) <u>Capacity Building</u>:

    (a) The ASMIH-Ethiopia Agricultural Mechanization Engineering graduate program at Bahir Dar University was approved at the national level and now is available for enrollment.

    (b) Conducted short-term trainings on the manufacturing and promotion of the shellers, Majipumps, and improved plowing tools for small enterprises. Conducted field demos on the use of maize shellers and held field days to demonstrate a variety of technologies for stakeholders.

    (c) Conducted gender equality training with 55 participants in relation to mechanization practices emphasizing the aspects of using appropriate agricultural tools and machinery on the reduction of women work burden to improve health conditions of women farmers.

(7) <u>Lessons Learned</u>:

    (a) Manufacturing of maize shellers with existing facilities identified challenges related to local resources, capacity, and demand.

    (b) Identifying potential demand trends for mechanization machines, tools and equipment, as well as identifying gender inequality issues contribute to understanding barriers to adoption.

    (c) Integration of work plans with private manufacturers is necessary for scaling.

(8) <u>Presentations and Publications</u>:

    (a) Degu, Y. M., Hailemesikel, S. T., and Gebeyehu, S. G. (2018). Progress of ASMC Project. Amhara Agricultural Forum, Bahir Dar, Ethiopia.

    (b) Degu, Y. M., and Gudie, A. F. (2018). Design, fabrication and testing of animal drawn multiple moldboard plough. 6th International Conference on the Advancement of Science and Technology, Bahir Dar, Ethiopia.

C. Focus Country Research Subawards

1. Bangladesh

(1) <u>Name</u>: Unlocking the production potential of "polder communities" in coastal Bangladesh (PI: Krishna Jagadish, Kansas State University; and Sudhir Yadav, IRRI)

(2) <u>Locations</u>: Polder 30 in the Khulna district of Bangladesh

(3) <u>Description</u>: The primary objective of the project is to increase farm income and nutrition security by intensifying polder farming systems through implementation of sustainable and economically viable practices. Specifically, the project aims to advocate for high yielding and stress tolerant rice varieties, improve productivity of rice and fish cultivation, and introduce high value rabi crops to increase farm income and improve household nutrition.

(4) <u>Collaborators</u>: *Bangladesh* - IRRI, BRAC, Khulna University; *United States* - Kansas State University

(5) <u>Achievements (See FY 2018 AWP Activity 4.4)</u>:

    (a) Empowered the members of the water management organizations on water governance and in-polder water management necessary for adoption of improved production systems in the polder zone.

    (b) Evaluated the potentials of integrated community rice+fish culture in polder ecosystem for improved nutrition. Due to this initiative, 44 households consumed 333 kg of fish in the reporting year.

    (c) Harvesting rice by machine (reaper) reduced both time and labor, with a few community members considering to buy reapers and to act as service providers. More units of the reaper will allow for more synchronized harvesting, making way for early establishment of rabi crops.

    (d) Introduced Learning Hub model for upscaling of improved production systems and associated technological approaches and evaluated by the SIIL-Polder Project in the polder ecosystem.

    (e) Empowered 2000 farmers, officials of water management organizations and public representatives on various aspects of crop and water management, agricultural mechanization and nutrition in the reporting year in which 40% were women.

    (f) Enhanced regional support and integration through knowledge sharing platform- volume 4 and most recent volume 5 serve as supportive documentation.

(6) <u>Capacity Building</u>:

    (a) Ten students (3 Ph.D. and 7 MS) out of 14 scholars have graduated in the reporting year. Among them, six scholars have been granted travel scholarship to participate and present their research finding in the International Rice Congress 2018.

    (b) Provided nutritional awareness training to about 300 mothers of the school children, school teachers and household members of the learning hubs to educate them on the nutritional crops introduced by the SIIL-Polder Project. Among them 70% were women.

    (c) Empowered 460 low income women and landless youth (37% women) on different aspects of agricultural mechanization and livelihood activities.

(7) <u>Lessons Learned</u>:

    (a) Extensive lessons were learned in implementing each objective related to cultural, political, economic, environmental, and other conditions. The Annual Operational Plan (AOP) details these lessons and are available upon request.

(8) <u>Presentations and Publications</u>:

    (a) Yadav, S. (2016). <u>Polder Tidings, 1(2)</u>.

    (b) Yadav, S. (2017). <u>Polder Tidings, 2(1)</u>.

    (c) Yadav, S. (2018). <u>Polder Tidings, 3(1).</u>

2. *Burkina Faso*

(1) <u>Name</u>: Sustainable intensification through better integration of crop and livestock production systems for improved food security and environmental benefits in Sahelian zone of Burkina Faso (PI: Augustine Ayantunde, International Livestock Research Institute, ILRI)

(2) <u>Locations</u>: Dori and Ouahigouya districts, Burkina Faso

(3) <u>Description</u>: The overall goal of this project is to improve household food production and nutrition, and enhance ecosystem services through better integration of crop and livestock production systems in the Sahelian zone of Burkina Faso.

(4) <u>Collaborators</u>: *Burkina Faso* - Institut de l'Environnement et de Recherches Agricoles (INERA), International Union for Conservation of Nature (IUCN), Fédération Nationale des Groupements Naam (FNGN), and Association pour la Promotion de l'Elevage en Savane et au Sahel (APESS); *United States* - University of Wisconsin, Madison

(5) <u>Achievements (See FY 2018 AWP Activity 4.5)</u>:

(a) Established and completed agronomic trials with improved dual-purpose sorghum and cowpea varieties in eight project communities; feeding trials for fattening sheep to assess the effect of crop residues from these improved varieties on the growth of sheep; and feeding trials with lactating cows fed fodder from these same varieties.

(a) Twenty-five out of the 50 households selected in each of the 8 project communities from the baseline surveys were selected for monitoring of their food consumption, household dietary diversity, especially among nursing mothers and their children between 6 and 36 months. The study aims at characterizing household nutrition and to assess the effect of different intensification options on household food security and nutrition.

(b) Nutrition data collected from the eight study sites will allow the project to evaluate the distribution of access to food not only among surveyed households but among the separate eating groups within households (often shaped by gender).

(6) <u>Capacity Building</u>:

(a) Two hundred and forty-five participants were trained in January 2018 by a nutrition expert.

(b) Establishment of Farmers' Field School (FFS) by APESS and FNGN. Four FFS have been established in each of the eight project communities. Each FFS is about 0.25 ha for improved cowpea variety and 0.25 ha also for improved sorghum variety. Each FFS consists of between 10 to 20 farmers including women. Two focal persons from the farmers in the FFS in each community were trained in improved agronomic practices.

(7) <u>Lessons Learned</u>:

(a) Households rearing livestock are most likely to consume animal products as people tend to eat what they produce in the rural areas, and this will improve household dietary diversity as evidenced in our results from the household dietary diversity score in the Seno Province.

(b) The improved sorghum and cowpea varieties not only led to a significant increase in grain yield but also higher fodder biomass of good quality compared to the local varieties.

(8) <u>Presentations and Publications</u>:

(a) Ayantunde AA, Duncan AJ, van Wijk MT, and Thorne P. (2018). Review: Role of herbivores in sustainable agriculture in Sub-Saharan Africa. Animal, doi:10.1017/S175173111800174X.

(b) Fraval et al. (2017) Pathways to food security in rural Burkina Faso: the importance of consumption of home-produced food versus purchased food. Food Security (In Press).

(c) Ayantunde et al. (2018) Opportunities and constraints to sustainable intensification of mixed crop and livestock systems in Sahelian zone of Burkina Faso. International Journal of Sustainable Agriculture (In Press).

3. Cambodia

(1) <u>Name</u>: Women in Agriculture Network (WAgN) Cambodia: Gendered- and Ecologically-Sensitive Agriculture (PI: Ricky Bates, Pennsylvania State University)

(2) <u>Locations</u>: Banan district (Battambang province), Puok district (Siem Reap), and Stung Chinit (Kampong Thom province)

(3) <u>Description</u>: The WAgN Cambodia projects aims to empower women and improve nutrition by promoting women's participation in the value chains for horticultural crops and rice produced via sustainable intensification (SI) practices. The overarching goal of the project is to provide a scientifically rigorous and comprehensive understanding of the nexus of gender and SI.

(4) <u>Collaborators</u>: *Cambodia* - Asia Impact Center – ECHO, Royal University of Agriculture, Conservation Agriculture Service Center, University of Battambang; *Denmark* - Agricultural Development Denmark Asia (ADDA); *Thailand* - Kasetsart University; *United States* - University of Tennessee Institute of Agriculture; World Vegetable Center (AVRDC)

(5) <u>Achievements (See FY 2018 AWP Activity 4.6)</u>:

(a) In collaboration with the World Vegetable Center (Siem Reap) and the UBB, eggplant rootstocks tolerant to key diseases common to Cambodia were screened and selected for grating in tomato. Three eggplant rootstock obtained from World Veg. in Taiwan, and one local Battambang province landrace were selected along with four market-demanded tomato varieties. These are currently being tested in field conditions.

(b) In collaboration with the World Vegetable Center, rainy-season and dry-season market surveys were conducted in Siem Reap province to document key information regarding the presence of wild food plants in local produce markets. Individual and group farmer interviews were also conducted to document various aspects of this important food production system

(c) WAgN planned, developed and conducted an intensive 5-day training in Thailand focused on human and institutional capacity building of CE SAIN and the development of a framework for demonstrating and extending promising SI technologies and practices.

(d) Research documenting soil improvement in conservation agriculture vs conventional tillage systems experiments were conducted on farmers vegetable production plots managed under both systems.

(e) Project Leaders conducted group interviews on farms in Siem Reap and Battambang to investigate and assess the gendered division of labor and access to leadership roles.

(f) Engaged with the CE SAIN Technology Parks to provide technical training to farm managers and prepare the parks for demonstrations of SI technologies and practices.

(6) <u>Capacity Building</u>:

(a) Two M.S. of Sustainable Agriculture (SA) students joined the WAgN project to conduct research on the tomato grafting project and wild gardens.

(b) CE SAIN farm managers and key administrative staff, along with other key stakeholders attended hands-on training covering topics including: SI Basics, Fundamentals of Research Demonstrations and Extension, Seed Harvesting and Handling, Seed Quality, Seed Storage Practices, and Agroforestry Systems. This was a key component of a broader goal to enhance the function and impact of the CE SAIN system, country-wide.

(c) Eighty-four participants were trained at the Bos Khnor Research Station bringing together farmers from different provinces, development operators, private sectors and academia. The main objectives of the training were to share information on (i) seed production and saving, (ii) soil health, (iii) integrated pest management, and (iv) rainy-season vegetable production including tomato grafting and 'Wild Gardens'. These two days training were divided in plenary sessions, technical, fields demonstrations.

(7) <u>Lessons Learned</u>:

(a) Diversification is a key to the SI of smallholder farms in Cambodia. Diversified small farm enterprises can lead to multiple income streams and can become a buffer against depressed and unreliable rice prices, and other threats such as climate change.

(b) A central element to smallholder farm diversification is the use of underutilized wild food plants. These neglected and underutilized species (NUS) can be used in traditional medicines, are valued in the local marketplace, or have a practical, functional use around the homestead.

(c) Most rural families survive on fish and the country's main crop, rain-fed paddy rice. Following the single rice harvest, much of the landscape remains idle and without vegetative cover. Wild food plants, such as indigenous trees, shrubs, vines and groundcovers, can remain productive during the difficult wet- and dry-season food gaps. These perennial species require little maintenance and can grow on marginal land, common to most villages and homesteads.

(8) <u>Presentations and Publications</u>:

(a) Ader, D. R., Gill, T., and Kaeser, A. (2018). Sustainable intensification and determinants of household food security in rural Cambodia. Presentation at First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(b) Ader, D. R., Len, S., and Gill, T. (2018). Migration, agricultural education, and rural brain drain in Cambodia. Presentation at First International Sustainable Agricultural Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(c) Bates, R., and Bicksler, A. (2017). Crop biodiversity: A foundational component of sustainably intensified farming systems. Presentation at Working Session on Sustainable Intensification, Soil Health Assessment and Underutilized Species, Royal University of Agriculture, Phnom Penh, Cambodia.

(d) Bates, R. M. (2017). Central role of species diversity in the sustainable intensification of Cambodian agriculture. Presentation at 4th National Scientific Conference on Agriculture and Rural Development Promoting sustainable agriculture and rural development for the future, University of Battambang, Battambang, Cambodia.

(e) Bates, R. M. (2018). Sustainable intensification of marginal land with 'Wild Gardens'. Presentation at First International Sustainable Intensification and Nutrition Conference, Royal Univ. of Agriculture, Phnom Penh, Cambodia.

(f) Bates, R. M. (2018). Role of NUS (Neglected and Underutilized Species) in the diversification of smallholder farms. Presentation at ACIAR Cambodia Sustainable Intensification and Diversification, Battambang, Cambodia.

(g) Gill, T. (2017). Sustainable intensification of smallholder systems in northwest Cambodia. Presentation at ECHO International Agriculture Conference, Fort Myers, FL.

(h) Huot, S. & Jensen, L. (2018). Gender and leadership: sustainable intensification in Cambodia. Presentation at Rural Sociological Society 2018 Annual Meeting, Portland, Oregon.

4. *Ethiopia*

(1) <u>Name</u>: Sustainably Intensified Production Systems Impact on Nutrition (SIPSIN) (PI: Neville Clarke, Texas A&M University)

(2) <u>Locations</u>: Robit and Dangishta, Ethiopia

(3) <u>Description</u>: The project aims to evaluate the implications of sustainable intensification of crop and livestock production systems (SIPS) on human nutrition in northern Ethiopia. The existing infrastructure and ongoing research and development of the Innovation Lab for Small Scale Irrigation (ILSSI) in the Lake Tana basin of Northern Ethiopia is used as a platform to efficiently conduct research to evaluate SIPS for crop and livestock production and their environmental, economic and nutritional consequences. This project collaborates with ASMC in evaluating the farming systems used in commercial home gardens to develop hand tools for female farmers.

(4) <u>Collaborators</u>: *Ethiopia* - Bahir Dar University, IWMI, IFPRI, ILRI*; United States* - North Carolina Agricultural & Technical State University, Feed the Future Innovation Lab for Collaborative Research on Nutrition in Africa (Tufts University), and ILSSI (Texas A & M University)

(5) <u>Achievements (See FY 2018 AWP Activity 4.7)</u>:

(a) Field studies by ILRI and ASMC were concluded and results show sustainably intensified production systems focusing on irrigation for smallholders in northern Ethiopia produce more food, are more profitable, and sustainable over time.

(b) Irrigation pumps reduce the labor required to irrigate a hectare of land from 108 and 80 person days per year to 48 and 14 person days per year for men and women, respectively. This translates into a reduction of 56% and 137% for men and women, respectively.

(c) Household surveys analyzed demonstrated improved diet diversity and nutrition outcomes in families using irrigation. Preliminary findings show children in households utilizing irrigation have higher weight for height score, indicating lower acute malnutrition (wasting). These findings will be explored more thoroughly in FY 2019.

(d) ILSSI and IFPRI methods for scaling are moving the results of SIPSIN field studies to the national level in Ethiopia where they are available for planning and evaluating new national or regional policies involving sustainably intensified production systems centered on irrigation.

(e) A second round of finger prick surveys measuring anemia and malaria in women and children (in SIPSIN households) was conducted in the rainy season. No malaria was found in the first dry season, and almost no malaria was detected during the rainy season. Slightly higher anemia levels were observed in the dry season compared to the wet season.

(6) <u>Capacity Building</u>:

(a) In collaboration with ILSSI, formal trainings on the Integrated Decision Support System (IDSS) was provided to faculty and students at Bahir Dar University throughout the year. In addition, trainings on nutrition were conducted for 50 female farmers in the Dangishta watershed community covering topics of diet diversity, crop health, human health, food handling and storage.

(7) <u>Lessons Learned</u>:

(a) The IDSS was shown to add additional value to the SIIL Sustainable Intensification Assessment Framework through the integrated assessment of farming systems and the scaling of farm level results to the national level.

(b) Aggregating common data from multiple concurrent field studies for further use in modeling requires explicit experimental design, careful ongoing monitoring, quality assurance and synthesis.

(c) Contrary to the initial expectations, farmers often sell most of their products rather than consume them and then invest in improved diets, often including higher priced commodities such as eggs and meat.

(8)   Presentations and Peer-reviewed Publications:

The following publications will be reported in both SIIL and ILSSI reports as being jointly supported by these two Innovation Labs.

(a) Moges, M.A., Schmitter, P., Tilahun, S.A. et al. (2018). Watershed modeling for reducing future non-point source sediment and phosphorus load in the Lake Tana Basin, Ethiopia. J Soils Sediments 18: 309. https://doi.org/10.1007/s11368-017-1824-z

(b) Worqlul, A., Jeong, J., Dile, Y. et.al. (2017). Assessing potential land suitable for surface irrigation using groundwater in Ethiopia. Applied Geography 85 (2017) 1-13.

(c) Dile, Y., Daggupati, P., George, C., et al. (2016) QSWAT: Introducing a new open source GIS user interface for the SWAT model. Environmental Modelling and Software. 85 (2016) 129-138. doi.org/10.1016/j.envsoft.2016.08.004

(d) Moges M.A., Schmitter P., Tilahun S., Dagnaw D.C., Akale A.T., Langan S., and Steenhuisen T. (2016) Suitability of watershed models to predict distributed hydrologic responses in the Awramba watershed of upper Blue Nile basin. Land Degradation and Development 28 (4): 1386–1397.

(e) Reyes M. (2018) Comparing vegetable yield of conventional versus conservation agriculture production systems in eight countries. First International Sustainable Agricultural Intensification and Nutrition. Royal University of Agriculture, Phnom Penh, Cambodia. Jan 10-11, 2018. – *presentation.*

(f) Fentahun, N., Tilahun, S.A., Yimer A., et. al. (2018). Evaluating water productivity and crop coefficients of cabbage crops under conservation agriculture with drip irrigation system in Robit kebe. The 2nd Amhara Agricultural Forum, Bahir Dar, Ethiopia, January 16, 2018. – *presentation.*

5. Senegal

(1) <u>Name</u>: Adoption of Sustainable Intensification in Dual-Purpose Millet - Leguminous Crops - Livestock Systems to Improve Food and Nutritional Security and Natural Resources Management for Rural Smallholder Farmers in Senegal (PI: Doohong Min, Kansas State University)

(2) <u>Locations</u>: Louga, Diourbel, Kaffrine, Kedougou, Kolda and Sedhiou regions in Senegal

(3) <u>Description</u>: The main objectives of this project are to: a) ensure food and nutritional security; b) establish resilient farming systems via a holistic approach for rural smallholder farmers, particularly women, and; c) improve nutritional and socioeconomic status in particular for women and children in the identified regions. These objectives will be achieved by using sustainably intensified production and management practices of dual-purpose millet and leguminous crops (cowpea and groundnut) with small ruminant livestock (goats and sheep) integration.

(4) <u>Collaborators</u>: *Senegal* - Institut Senegalais de Recherches Agricoles (ISRA) – Centre National de Recherches Agronomiques de Bambey (CNRA/Bambey), University of Thies, Institut de Technologie Alimentaire (ITA), Agence Nationale de Conseil Agricole et Rural (ANCAR), Le Réseau des Organisations Paysannes et Pastorales du Sénégal (RESOPP); *France* - Institut de Recherche pour le Developpement (IRD) and CIRAD

(5) <u>Key Achievements (See FY 2018 AWP Activity 4.8)</u>:

  (a) Biochemical analysis of millet grain showed that two dual-purpose millet accessions showed higher Zn, Mg, and Fe than other accessions.

  (b) Bioavailability study using dual-purpose millet varieties are being conducted. The flour samples were processed at the ITA in Senegal and samples were sent to the nutrition lab at K-State to assess how well the micronutrients such as iron, zinc, and magnesium are going to be absorbed in the infants' body.

  (c) Focus groups were held in 8 villages to understand and analyze the obstacles to adoption of the improved varieties of pearl millet.

  (d) New study components assessing the five accessions for root physiology and livestock feeding suitability were initiated.

(6) <u>Capacity Building</u>:

  (a) Co-PI Madame Dieye provided several trainings to local female farmers on millet flour enrichment and silage-making.

  (b) The project has supported 10 Ph.D. students (50% are females).

(7) <u>Lessons Learned</u>:

  (a) Communication with Co-PIs in Senegal is critical given the diversity of disciplines of the researchers in the project. Adding Dr. Aliou Faye as a Co-PI to help coordinate the project efforts has been extremely valuable.

(8) <u>Presentations and Publications</u>:

  (a) Faye, A., et al. (2018). Modèle de passage des impacts racinaires dénombrés sur profil de sol à la densité de longueur racinaire chez le mil (*Pennisetum glaucum* (L.) R. Br.). Presentation at 6èmes journées du LAPSE, Dakar, Senegal.

  (b) Mofini, M., et al. (2018). Diversity of arbuscular mycorrhizal fungi associated to pearl millet in diverse agroecosystems in Senegal. Presentation at First International Sustainable Agricultural Intensification and Nutrition (SAIN) Conference, Phnom Penh, Cambodia.

  (c) Mofini, M., et al. (2018). Etude de la diversité des champignons mycorhiziens à arbuscules associés au mil dans divers agroécosystèmes au Sénégal. Presentation at 6èmes journées du LAPSE, Dakar, Senegal.

6. *Tanzania*

(1) <u>Name</u>: Raising Crop Response: Bidirectional Learning to Catalyze Sustainable Intensification at Multiple Scales (PI: Sieglinde Snapp, Michigan State University)

(2) <u>Locations</u>: Babati, Iringa rural, Mufindi, Wanging'ombe, Njombe rural, Songea rural, Mbeya rural, and Mbozi districts in Tanzania

(3) <u>Description</u>: The project aims to improve family nutrition, reduce poverty, and enhance the use of environmentally-sound farming practices among smallholder farmers in East Africa. Specific project objectives include:

  (a) Generate improved agronomic knowledge of practices that sustainably raise maize and bean yields and crop response to inorganic fertilizer.

  (b) Evaluate bidirectional learning and effective extension approaches to promote SI technologies among researchers, extension, agrodealers, NGOs, and farmers.

  (c) Generate improved knowledge of the nutrition impacts of adoption of SI technologies through analysis of Tanzania household surveys.

  (d) Provide practical guidance to governments on staple food marketing, trade, and extension policies that support adoption of organic matter and SI technologies to support broader diffusion and scaling.

(4) <u>Collaborators</u>: *Netherlands* - Wageningen University and Research Center; *Tanzania* - Sokoine University of Agriculture (SUA), CIAT, The Nelson Mandela African Institution of Science and Technology (NM-AIST), IITA

(5) <u>Achievements (See FY 2018 AWP Activity 4.9)</u>:

  (a) Household survey was conducted with samples collected of food samples from households, and biochemical analyses is underway. This included field work on April and May 2018 (household interviews, anthropometry measurement of babies and food samples used for collection of complementary feeding). Out of 10 villages interviewed, 290 households collected 240 complementary food samples.

  (b) First year of agronomic N fixation and legume maize intercrop performance trials were completed, as well as the baseline survey in collaboration with CIAT and Farm Input Promotions Africa Ltd (FIPS).

  (c) Soil health assessment was conducted with farmers, a subset of those from the Objective 1 survey, using the LandPKS App, data analysis is underway.

  (d) An analysis of the World Bank's Living Standards Measurement Study (LSMS) survey data was completed to assess SI adoption and nutrition impacts as well as a draft of the report.

  (e) Data were collected for a soil and socioeconomic survey to support the objective to determine soil properties and SI practices that enhance maize-bean responses to fertilizer.

(6) <u>Capacity Building</u>:

  (a) Four graduate students (3 females) have started their graduate coursework and research proposal writing at their respective institutions.

(7) <u>Lessons Learned</u>:

  (a) Tanzania government rules and regulations have been changing over the past year which have affected researchers' abilities to carry out research in the area. Through this experience our teams have learned how to navigate these changing regulations including how to maximize use of institutional resources, networking and communication with partners.

  (b) Another recurring challenge during the survey activity has been around the issue of how researchers share information appropriately with farmers to avoid just being extractive with farmer information. The survey revisited a subset of farmers from a panel survey that had occurred over the previous two years. Many farmers voiced concerns with providing information over three years without receiving any information in return.

(c) These issues raised questions of what and how information may be returned to farmers to improve farmer-researcher interactions. We are committed to reporting back information including soil analyses, and are working with national partners to achieve this over time, once we are sure of our results and have sufficient feedback and confidence building among our Tanzania partners.

(8) <u>Presentations and Publications:</u>

(a) Lwehabura, J. R., and Stewart, Z. P. (2018). Increasing technology adoption and scaling through mother-baby trials paired with geospatial analysis of enabling biophysical and socioeconomic conditions. First International Sustainable Agriculture Intensification and Nutrition Conference, Phnom Penh, Cambodia.

(b) Nord, A., Snapp, S., Rubyogo, J., Lwehabura, J. R., Mariki, W., and Miller, N. (2017). Uncovering the potential of a multi-purpose legume, *Lablab purpureus* (L.) Sweet. American Society of Agronomy, Tampa.

(c) Mason, N., and Morgan, S. (2018). Do different extension approaches affect smallholder farmers' willingness-to-pay for new agricultural technologies? Experimental auction results from Tanzania. Department of Agricultural, Food, and Resource Economics Graduate Research Symposium, East Lansing, MI.

D. Developing Indicators for Sustainable Intensifications – *Project Complete*

(1) <u>Name</u>: Developing Indicators for Sustainable Intensification (PIs: Cheryl Palm – University of Florida, Sieglinde Snapp – Michigan State University)

(2) <u>Locations</u>: N/A

(3) <u>Description</u>: The project's primary goal was to develop and recommend indicators and metrics for the sustainable intensification of agriculture within a framework of domains using three scales: field level, farm or household level and landscape level.

(4) <u>Collaborators</u>: *United States* - Columbia University, Taylor University and Kansas State University

(5) <u>Achievements</u>:

    (a) The Sustainable Intensification Assessment Framework was officially launched in October 2017 at the 2017 International Annual Meeting of the American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America in Tampa, Florida. The framework guide and manual were made available to the public at the time of the launch.

    (b) Upon completion of the project, the SIIL Management Entity led efforts to create a website to operationalize the SI Assessment Framework. The online presence of the framework will be made available November 2018.

(6) <u>Capacity Building</u>:

    (a) There were no trainings provided of the SI Assessment Framework in FY 2018.

(7) <u>Lessons Learned</u>:

    (a) Through interactions with different scientists throughout the reporting year, project leaders have learned how to improve the SI indicators and training materials. It is key to a balance between making items clear and concise but also applicable to a wide range of contexts.

(8) <u>Presentations and Publications</u>:

    (a) Grabowski, P., Musumba, M., Palm, C., and Snapp, S. (2018). Sustainable agricultural intensification and measuring the immeasurable: do we have a choice? In Bell, S. & Morse, S (Eds.) *Routledge Handbook of Sustainability Indicators* (Chapter 29). New York, NY: Routledge.

    (b) Snapp, S. Grabowski, P. Chikowo, R. et.al, (2017) Maize yield and profitability tradeoffs with social, human and environmental performance: Is sustainable intensification feasible? Agricultural Systems Volume 162, May 2018, Pages 77-88.

VII. Associate Award Research Project Reports

The SIIL associated awards received in FY 2017 from USAID-Cambodia Mission (for the Center of Excellence on Sustainable Agricultural Intensification, CE SAIN at Royal University of Agriculture in Cambodia); and USAID-Malawi Mission were continued and reported in other sections of this report.

The SIIL is in the process of finalizing a new Associate Award from USAID-Washington focused on improvement of policy approaches and outcomes to support the achievement of the U.S. Government Global Food Security Strategy (GFSS) objectives. Rutgers University's (RU) Feed the Future (FtF) Policy Research Consortium (PRC) will lead the consortium with funding and support from the SIIL as a management entity. The activity will support the learning agenda on policy, systems analysis, and implementation and assist the initiative to report on the success of its efforts. The PRC is a grouping of universities and researchers across the U.S. and sub-Saharan Africa focused on policy research related to agriculture and food security. The award is anticipated to begin October 1, 2018 through September 30, 2020 and will be reported on in the FY 2019 annual report.

VIII. Human and Institutional Capacity Development

A. Short-term training

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	FGD on Women empowerment in agricultural farm mechanization at Char Wabda, Union: Char Wabda, Upazila: Subarnachar	Producers	8	7	15
Bangladesh	FGD on Women empowerment in agricultural farm mechanization at Haldibara, Union: Nilganj, Upazila: Kalapara	Producers	0	15	15
Bangladesh	FGD on women empowerment in agricultural farm mechanization at Kalapara, Patuakhali	Producers	11	4	15
Bangladesh	FGD on Women empowerment in agricultural farm mechanization at Village: Haldibara, Union: Nilganj, Upazila: Kalapara	Producers	10	5	15
Bangladesh	Field day at Subarnachar, Noakhali on mechanical harvesting of paddy	Producers, government, civil society	46	0	46
Bangladesh	Field day at Wazirpur, Barishal on mechanical harvesting of paddy	Producers, government, civil society	42	5	47
Bangladesh	Field day on CA machinery for jute planting -2018 at dumuria, Khulna	Producers, government, civil society	22	4	26
Bangladesh	Field day on CA machinery for Mungbean cultivation -2018 at Holdibaria, Kolapara, Patuakhali	Producers, civil society	18	8	26
Bangladesh	Field day on CA Machinery for Mungbean Cultivation -2018 at Mundopasa, Notun Shikarpur, Wazirpur, Barishal	Producers, civil society	20	6	26
Bangladesh	Field day on CA machinery for soybean cultivation -2018 at Al-amin Bazar, Charwapda, Subarnochar, Noakhali	Producers, government, civil society	17	11	28
Bangladesh	Field day on Reaper and Mini-combine Harvester at Holdibaria, Kalapara, Patuakhali	Producers, government, private sector, civil society	38	7	45
Bangladesh	Field day on Reaper and Mini-combine Harvester at Motbaria, Dumuria, Khulna	Producers, government, civil society, private sector	35	16	51
Bangladesh	Hands on Training on CA Machinery for Jute planting -2018 at Dumuria, Khulna	Producers, civil society	17	1	18
Bangladesh	Hands on training on Mungbean cultivation using CA machinery at Kalapara, Patuakhali	Government, producers, civil society	15	1	16
Bangladesh	Hands on training on Mungbean cultivation using CA machinery at Voroshakathi, Wazirpur, Barisal	Government, civil society	15	0	15

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	Rice transplanter field day at Mothbaria, Dumuriya, Khulna	Producers, government, civil society	18	8	26
Bangladesh	Training of Trainers (ToT) on Appropriate Scale Mechanization in the Southern Delta of Bangladesh	Producers, government, civil society	32	2	34
Bangladesh	Training on CA Machinery for Agricultural Machine Operator -2018 at Al-amin Bazar, Charwapda, Subarnochar, Noakhali	Producers, government, civil society	16	0	16
Bangladesh	Training on CA Machinery for Agricultural Machine Operator -2018 at BARI, Rahmatpur, Barishal	Producers, civil society	18	0	18
Bangladesh	Training on CA Machinery for Agricultural Machine Operator -2018 at Holdibaria, Kolapara, Patuakhali	Producers, civil society	16	0	16
Bangladesh	Training on CA Machinery for Agricultural Machine Operator -2018 at Rahmatpur, Barishal	Producers, civil society	18	0	18
Bangladesh	Training on Rice transplanter Operation and Maintenance at Dumuria, Khulna	Producers, government, civil society	14	2	16
Bangladesh	Training on Rice transplanter Operation and Maintenance at Kalapara, Patuakhali.	Producers, government, civil society, private sector	17	3	20
Bangladesh	Training on Rice transplanter Operation and Maintenance at Wazirpur, Barisal.	Producers, government, civil society	16	3	19
Bangladesh	Training on Rice transplanter Operation and Maintenance at Wazirpur, Barishal	Producers, civil society	12	2	14
Bangladesh	Training on Rice transplanter Operation at Dumuria, Khula	Producers, civil society	8	0	8
Bangladesh	Training on Rice transplanter seedling raising at lobonchora, Khulna	Producers, civil society	12	0	12
Bangladesh	Training program on Reaper and Mini-combine Harvester in Subarnachar, Noakhali	Producers, government, civil society	14	0	14
Bangladesh	Training program on Reaper and Mini-combine Harvester in Wazirpur, Barishal	Producers, civil society	14	0	14
Bangladesh	Agricultural Machinery Fair at Dumuria, Khulna	Producers, government, private sector, civil society	164	112	276
Bangladesh	Field Day at Baratia, Dumuriya, Khulna	Producers, private sector, civil society	24	14	38
Bangladesh	Field day at Kalapara-Patuakhali on mechanical rice harvesting	Producers, private sector, government	31	5	36
Bangladesh	Field Day at Mothbaria, Dumuriya, Khulna.	Producers, civil society	18	16	34
Bangladesh	Hands on training on Mungbean cultivation using CA machinery at Mundopasa, Wazirpur, Barisal	Government, producers, civil society	13	5	18

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Bangladesh	Hands on training on Soybean cultivation using CA machinery at Subornochar, Noakhali	Government, producers, civil society	15	0	15
Bangladesh	Hermetic storage—community seed bank model	Producers	124	117	241
Bangladesh	Mat nursery preparation	Producers	157	94	251
Bangladesh	Mechanical harvester: use of reaper for harvesting rice	Producers	152	59	211
Bangladesh	Nutritional awareness (Sunflower, Maize and Mung bean)	Producers	90	197	287
Bangladesh	Power tiller operated seeder (PTOS)- Strip tillage	Producers	60	28	88
Bangladesh	Rabi crops (Sunflower, Maize, Mung bean and Sesame) cultivation procedure	Producers	129	55	184
Bangladesh	Regional Symposium on Appropriate Scale Mechanization for Sustainable Intensification	Producers, government, private sector, civil society	84	8	92
Bangladesh	Safe pesticide application	Producers	25	8	33
Bangladesh	Training on seedling raising at Kalapara, Patuakhali	Producers, civil society	18	0	18
Bangladesh	Training program on Reaper and Mini-combine Harvester in Alamin Bazar, Shubarnochar, Noakhali	Producers, private sector	10	0	10
Bangladesh	Training program on Reaper and Mini-combine Harvester in Haldibaria, Kalapara, Patuakhali	Producers, private sector	11	0	11
Bangladesh	Troubleshooting of agricultural machineries (Rice Transplanter, Sprayer, Reaper, Axial Flow Pump, PTOS)	Producers	112	56	168
Bangladesh	Water management and climate resilient and nutritious rice production	Producers	161	42	203
Bangladesh	Field day at Subarnachar-Noakhali on mechanical rice harvesting	Producers, government, private sector	41	0	41
Burkina Faso	Best Nutrition Practices (Seno Province)	Producers	20	104	124
Burkina Faso	Best Nutrition Practices (Yatenga Province)	Producers	20	101	121
Burkina Faso	Gender Integration into Agricultural Value Chain	Civil society	19	15	34
Burkina Faso	INGENAES: Technology Assessment Toolkit Training	Civil society	6	5	11
Burkina Faso	Nutrition Training	Government, civil society	9	6	15
Burkina Faso	Training of focal persons for APESS Farmers' Field School Seno province	Producers	8	0	8
Burkina Faso	Training of making rippers and use of planter and rippers by farmers	Producers, private sector	10	4	14
Burkina Faso	Training of Women on Nutrition Garden (Bani)	Producers	0	25	25
Burkina Faso	Training of Women on Nutrition Garden (Tougou)	Producers	0	25	25
Burkina Faso	Training session on gender integration into agriculture	Government, private sector	19	15	34

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	F	Total
Burkina Faso	Training of focal persons for APESS Farmers' Field School Yatenga province	Producers	7	1	8
Cambodia	Field day of current CA farmer group in Stung Chinit irrigation scheme	Producers	8	7	15
Cambodia	Field day of GRET's agronomist	Civil society	4	0	4
Cambodia	Field trip of 2nd and 3rd year students of Faculty of Agricultural Engineering, RUA	Civil society	41	6	47
Cambodia	Field trip of 2nd year-students of faculty of agricultural engineering, RUA	Civil society	25	4	29
Cambodia	Field trip of ADG's farmers	Civil society	10	6	16
Cambodia	Field visit of FAO's team	Producers	10	1	11
Cambodia	Field visit of lectures from University of Battambang (UBB) and CIRAD's expert	Government, civil society	6	2	8
Cambodia	Field visit of new farmer group in Stung Chinit irrigation scheme	Producers	5	5	10
Cambodia	Sustainable Intensification and Diversification in the Lowland Rice System in Northwest Cambodia: Field visits and First Annual Meeting: CSE-2015-044	Private sector, government, civil society	23	7	30
Cambodia	Bos Khnor Research Station Training	Government, private sector, civil society, producers	55	35	90
Cambodia	Diversifying Agricultural Systems for Improved Nutrition and Income	Producers, government, civil society	25	36	61
Cambodia	ECHO Asia—CE SAIN Training farm manager training	Producers, private sector, civil society	19	3	22
Cambodia	Field visit of SOMA group's team	Private sector, civil society	19	6	25
Cambodia	High School Gardens Teacher Training	Government, civil society	30	7	37
Cambodia	Tomato Grafting for Improved Disease Resistance	Civil Society	38	17	55
Cambodia	Unmanned aerial systems field training	Civil society	12	5	17
Cambodia	Consultation workshop on Establishment of Hub Advisory Committee for ASMC project	Private sector, government, civil society	12	2	14
Cambodia	Field visit of RMA Company's team	Private sector, civil society	14	5	19
Ethiopia	Manufacturing of motorized maize sheller for local manufacturers	Government	21	0	21
Ethiopia	Demonstration and participatory evaluation of engine driven maize sheller with farmers	Government, producers	344	81	425
Ethiopia	Entrepreneurship Training	Private sector	9	13	22
Ethiopia	Data Collection Training	Civil Society	2	2	4
Ethiopia	Gender Mainstreaming and the roles of Agricultural Mechanization for Gender Equality	Government, producers	59	40	99
Ethiopia	IDSS Training - Texas A&M University	Civil society	4	0	4
Ethiopia	IDSS Training with the Ethiopian Agricultural Transformation Agency	Government	23	3	26
Ethiopia	Nutrition Training for women farmers in Dangishita Kebele, Dangila, Ethiopia	Producers	0	50	50

Country of Training	Brief Purpose of Training	Who was Trained	Number Trained		
			M	**F**	**Total**
Myanmar	Myanmar Seed Saving Workshop	Producers, private sector, civil society	44	29	73
Senegal	Field day with farmers to visit, evaluate and learn how to intensify the cultivation of pearl millet varieties	Producers, government, private sector	20	15	35
Senegal	Producer training on conducting tests and agricultural best practices	Producers, government, civil society	12	9	21
Senegal	Training on transforming millet into complimentary feeding powder	Producers, government, private sector	2	22	24
Senegal	Implementing on-farm trials	Producers	28	25	53
Senegal	Oral and poster presentation skills	Civil society	5	5	10
Senegal	Writing workshop	Civil society	5	5	10
Senegal	Training and extension on enriched flour production	Producers	0	60	60
Senegal	Mid-term workshop of the SIMCo Project (Sustainable Intensification of Millet and Cowpea)	Civil society	15	6	21
Senegal	Training in root phenotyping	Civil society	7	4	11
Senegal	Creating Enabling Environment to Enhance Innovation Adoption	Civil society	22	15	37
Senegal	UVA and data collection training	Civil society	17	4	21
Tanzania	Spatial data handling and modeling with R	Private sector, government, civil society	49	18	67
Total			**2786**	**1550**	**4336**
			M	**F**	**Total**
			64%	36%	

B. Long-term training

Name (first, last)	Sex	University	Degree	Major	Program End Date (month/year)	Degree Granted (Y/N)	Home Country
Patrice, Nikiema	M	University Polytechnic, Bobo-Dioulasso	M.S.	Agricultural Economics	October 2017	Y	Burkina Faso
Yolande, Toe	F	University Polytechnic, Bobo-Dioulasso	M.S.	Agricultural Economics	October 2017	Y	Burkina Faso
Addisu, Wondimne	M	Bahir Dar University	M.S.	Chemical Engineering	October 2017	Y	Ethiopia
Jayanta, Bhattacharya	M	Patuakhali Science and Technology University	Ph.D.	Agronomy	October 2017	Y	Bangladesh
Aziz, Simian	M	University Polytechnic, Bobo-Dioulasso	B.S.	Animal Science	November 2017	Y	Burkina Faso

Name (first, last)	Sex	University	Degree	Major	Program End Date (month/year)	Degree Granted (Y/N)	Home Country
Jamey, Smith	M	University of California, Davis	M.S.	International Agricultural Development	December 2017	Y	United States
Shah, Shah	M	Patuakhali Science and Technology University	Ph.D.	Agronomy	December 2017	Y	Bangladesh
Noby, Mahamudun	M	Bangladesh Agricultural University	M.S.	Farm Power and Machinery	December 2017	Y	Bangladesh
Asamin, Tadisual	M	Bahir Dar University	M.S.	Engineering Hydrology	January 2018	N	Ethiopia
Ayele, Mamo	M	Bahir Dar University	M.S.	Engineering Hydrology	January 2018	Y	Ethiopia
Ahmed, Sujat	M	Sher-e-Bangla Agricultural University	M.S.	Agronomy	February 2018	Y	Bangladesh
Habiba, Umme	F	Bangladesh Agriculture University	M.S.	Socio-economics	February 2018	Y	Bangladesh
Puja, Roy	F	Khulna University	M.S.	Agricultural Economics	February 2018	Y	Bangladesh
Priyanka, Saha	F	Khulna University	M.S.	Agricultural Economics	February 2018	Y	Bangladesh
Aaron, Shew	M	Arkansas State University	Ph.D.	Environmental Dynamics	March 2018	Y	United States
Agumas, Chale	M	Bahir Dar University	B.S.	Mechanical Engineering	June 2018	Y	Ethiopia
Yared, Wondie	M	Bahir Dar University	B.S.	Mechanical Engineering	June 2018	Y	Ethiopia
Fatoumata, Ganou	F	Polytechnic University of Bobo-Dioulasso	M.S.	Agriculture Engineering	June 2018	N	Burkina Faso
Victor, Ye	M	Polytechnic University of Bobo-Dioulasso	M.S.	Agriculture Engineering	June 2018	N	Burkina Faso
Boureima, Sayaogo	M	Polytechnic University of Bobo-Dioulasso	M.S.	Agriculture Engineering	July 2018	N	Burkina Faso
Rechaney, Sel	F	University of Philippines, Los Banos	M.S.	Conservation and Gender	August 2018	Y	Cambodia
Mohammed, Ali	M	Bangladesh Agriculture University	M.S.	Social Science	August 2018	Y	Bangladesh
Tapati, Roy	F	Bangladesh Agriculture University	M.S.	Agronomy	August 2018	Y	Bangladesh
Gashaw,Muluwork	F	Bahir Dar University	B.S.	Industrial Engineering	August 2018	N	Ethiopia
Kebede, Woldabib	M	Bahir Dar University	M.S.	Industrial Engineering	September 2018	N	Ethiopia

Name (first, last)	Sex	University	Degree	Major	Program End Date (month/year)	Degree Granted (Y/N)	Home Country
Melkamu, Kirkos	M	Bahir Dar University	M.S.	Manufacturing Engineering	September 2018	Y	Ethiopia
Alebachew, Worku	M	Bahir Dar University	B.S.	Industrial Engineering	September 2018	N	Ethiopia
Ayele, Lijalem	M	Bahir Dar University	M.S.	Mechanical Engineering	October 2018	N	Ethiopia
Channaty, Ngang	F	University of Battambang	M.S.	Sustainable Agriculture	December 2018	N	Cambodia
Biswajit, Baidya	M	Khulna University	M.S.	Water Governance	December 2018	N	Bangladesh
Mohammed, Rokonuzzaman	M	Bangladesh Agriculture University	Ph.D.	Agriculture Extension	January 2019	N	Bangladesh
Alam, Nazira Binte	F	Bangladesh Agriculture University	M.S.	Agricultural Extension & Education	January 2019	N	Bangladesh
Samiul, Basir	M	Bangladesh Agriculture University	M.S.	Farm Power & Machinery	January 2019	N	Bangladesh
Nasiba, Aktar	F	Bangladesh Agriculture University	Ph.D.	Gender Research	February 2019	N	Bangladesh
Deb, Nath	M	Bangladesh Agriculture University	Ph.D.	Water Governance	February 2019	N	Bangladesh
Awa, Faye	F	Cheikh Anta Diop University	Ph.D.	Agronomy	March 2019	N	Senegal
Nut, Nareth	M	Royal University of Agriculture	Ph.D.	Agricultural Engineering	June 2019	N	Cambodia
Sourn, Taingaun	M	Royal University of Agriculture	Ph.D.	Land Mgtt & Admin.	June 2019	N	Cambodia
Elsabeth, Tsegaye	F	Bahir Dar University	M.S.	Engineering Hydrology	June 2019	N	Ethiopia
Chantha, Thay	M	University of Battambang	M.S.	Horticulture	August 2019	N	Cambodia
Mamdou, Diedhiou	M	University of Gaston Berger of Saint Louis	Ph.D.	Agronomy	September 2019	N	Senegal
Ibrahima, Dieng	M	Cheikh Anta Diop University of Dakar	Ph.D.	Soil Chemistry	September 2019	N	Senegal
Khaly, Niang	M	University of Gaston Berger	Ph.D.	Applied Mathematics	September 2019	N	Senegal
Ayesha, Sarker	F	University of Illinois	Ph.D.	Agricultural and Biological Engineering	September 2019	N	United States
Biya, Chhorn	F	University of Battambang	M.S.	Sustainable Agriculture	September 2019	N	Cambodia
Marie-Therese, Mofini	F	University of Thies	Ph.D.	Agronomy	September 2019	N	Central African Republic

Name (first, last)	Sex	University	Degree	Major	Program End Date (month/year)	Degree Granted (Y/N)	Home Country
Fatou, Tine	F	University of Thies	Ph.D.	Agronomy	September 2019	N	Senegal
Kamrul, Hasan	M	Bangladesh Agricultural University	Ph.D.	Agricultural Engineering	September 2019	N	Bangladesh
Abdul, Motalib	M	Bangladesh Agricultural University	Ph.D.	Agricultural Engineering	September 2019	N	Bangladesh
Surajit, Sarkar	M	Bangladesh Agricultural University	Ph.D.	Agricultural Engineering	September 2019	N	Bangladesh
Katian, Napon	F	University of Ouagadougou	Ph.D.	Gender and Nutrition	October 2019	N	Burkina Faso
Feleke, Kuraz	M	Bahir Dar University	Ph.D.	Water Resources Management	October 2019	N	Ethiopia
Alison, Nord	F	Michigan State University	Ph.D.	Agro-ecology	December 2019	N	United States
Rufina, Fredrick	F	Nelson Mandela African Institute of Science and Technology, Tanzania	M.S.	Nutrition	May 2020	N	Tanzania
Esther, mugi	F	University of Wageningen	Ph.D.	Agricultural Systems	June 2020	N	Kenya
Saovanneary, Huot	F	Penn State University	Ph.D.	Rural Sociology	August 2020	N	Cambodia
Ba, Thiero	M	University of Thies	Ph.D.	Animal Science	September 2020	N	Senegal
Coly, Wade	M	University of Thies	Ph.D.	Soil Fertility	September 2020	N	Senegal
Ry, Saren	M	University of Battambang	B.S.	Agriculture	November 2020	N	Cambodia
Said, Hamad	M	Sokoine University of Agriculture	Ph.D.	Soil Science	December 2020	N	Tanzania

C. Institutional Development

(1) **Kansas State University – SIIL, ISRA, and Peace Corps Partnership**: In December 2017, Peace Corps (PC) Senegal entered into a partnership with SIIL and the Senegalese National Institute for Agricultural Research (ISRA). Each organization brings its own unique strength: PC Senegal has a substantial network of volunteers working as agricultural extension agents in rural and urban communities; ISRA has the regional technical expertise and provides the latest local solutions and technologies appropriate for Senegal; and SIIL brings the capacity-building expertise and the resources of a world-class research university. This collaboration forms an important link between organizations working towards the same goals of agricultural development and achieving food security in Senegal. This partnership program will support farmers in communities as they work to develop pilot farms as a space for demonstrating new technologies and trainings in collaboration with Peace Corps Volunteers (PCVs). In addition to improved diffusion of information, PCVs will collect essential feedback on technologies from smallholder farmers across Senegal and relay the information to researchers at ISRA. This partnership is designed to increase overall dissemination and increase adoption rates. Each organization, SIIL, ISRA and PC has involved their own extended networks in the partnership. Master Farmers and PCV counterparts have been engaged through the assessment of need to identify technologies on which to train and disseminate. Senegalese graduate students have been involved through capacity building and collaboration on participatory research. PCVs are at the center of the partnership, providing that important link between Senegalese communities and ISRA researchers.

(2) **CE SAIN Institutional Development**: The SIIL management entity and CE SAIN co-hosted the First International Sustainable Agricultural Intensification and Nutrition Conference and Field Trips in January 2018. One hundred sixty-five individuals from 16 countries attended the conference, and over 60 individuals participated in the field trips. The CE SAIN also continues to build human and institutional capacity at the Royal University of Agriculture in Cambodia. The CE SAIN implements its scholarship and research grant program to increase faculty teaching, research, and extension capacity through long-term training and degree enhancement. The Center, through its five Technology Parks, has also played a key role in linking RUA faculty and students and the private sector, NGOs, Innovation Labs, and other networks. These partnerships support the promotion of information dissemination and serve as a catalyst for new innovations.

(3) **Institutional Sustainability**: The regional coordinators funded projected in Senegal and Burkina Faso has also helped with continuing some of the critical research initiated by the NARS (ISRA and INERA) and supported institutional capacity building to sustain long-term research.

IX.   Innovation Transfer and Scaling Partnerships

None to report in FY 2018. Most of the activities were focused on the developing and evaluating innovations that were developed collaborative with active partnerships from the host countries. As subawards develop, test, and optimize SI technologies and innovations, the SIIL management entity will require all PIs and their partners to identify which successful innovations are appropriate for scaling. Projects will also be required to identify partnerships that will be necessary for successful scaling. Plans for innovation transfer and scaling partnerships will be emphasized in FY 2018 - FY2019.

X.   Environmental Management and Mitigation Plan (EMMP)

An annual environmental mitigation activity review was conducted by the SIIL management entity across all subawards. The review entailed an evaluation of all activities outlined in the EMMP. Given the previous year's focus providing subawardees' with greater knowledge and tools to improve EMMP compliance and reporting, there were no issues to highlight during this reporting period. Mitigation and monitoring activities took place in accordance with the EMMP. In cases of fertilizer and pesticide purchase and use, project partners provided appropriate personal protective equipment and training for the safe use of the materials. The SIIL ME conducted a site visit to Ethiopia and verified that safety guidelines, training, and signage were addressed in accordance to the concerns raised in the previous year.

In addition, the Piestar DPx system, which the SIIL utilizes for reporting and project monitoring, underwent significant revisions of the EMMP module to support SIIL's compliance enforcement. The Piestar DPx updates included a new fertilizer, pesticide, and microbial inoculant purchase request/approval system. The annual environmental mitigation activity review also is incorporated into the DPx system to ensure that project monitoring is streamlined and to optimize knowledge sharing within the SIIL management entity. The current EMMP module is shown below. Categories not shown in the screen shot include: a) conducting applied research not exceeding 4 ha in a single location and NOT involving support for procurement or use of chemicals pesticides or fertilizers; b) conducting research not exceeding 4 ha in a single location that DOES involve the procurement and use of use of chemicals pesticides or fertilizers; c) conducting applied research exceeding 4 ha in a single location; d) conducting applied research with microbial inoculants.

XI. Open Data Management Plan

The SIIL management entity established the SIIL Dataverse to store and curate all SIIL subaward datasets and serve as a data repository and access hub for the SI community in general. SIIL conducted trainings with all subawardees' on how to navigate the dataverse system, requirements of the datasets, and how to upload them into the system. SIIL requires each subaward PI to upload all datasets as part of the Piestar reporting system. Both complete and incomplete datasets are collected biannually as part of the Piestar reporting hub system; however, only complete datasets are uploaded to the SIIL Dataverse. Complete datasets that have been uploaded on the SIIL Dataverse are also registered into the DDL system. During this reporting period, individual project accounts were set-up for all SIIL Subawards, and 19 separate complete datasets have been uploaded representing 259 files. The complete datasets are found in the SIIL's Dataverse (https://dataverse.harvard.edu/dataverse/SIIL), hosted by Harvard Dataverse. Below is a screen shot of the SIIL Dataverse site.
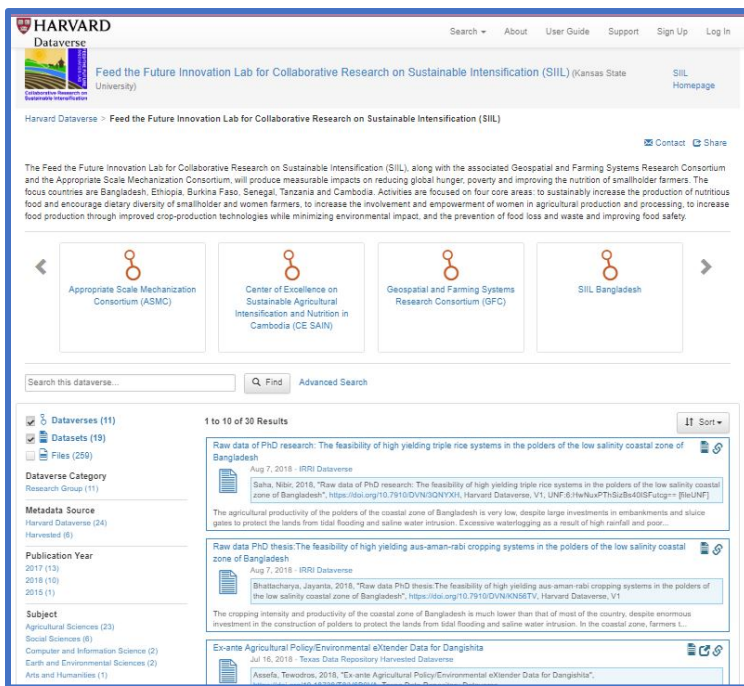
Each complete dataset are required to, at a minimum, include: codebooks; metadata; data dictionaries; forms, templates, and data gathering tools; explanations of redactions, when applicable (e.g. anonymization, removal/redaction/masking of personally identifiable information); notes on data quality, data limitations, or data context; and data gathering methodologies, dates, points of contact, geolocation(s).

The SIIL is in continual discussions with USAID's Data Development Library (DDL) staff to resolve issues related to the Geospatial and Farming Systems Research Consortium and the Precision Agricultural project on how to submit datasets given the excessive size of these geospatial datasets.

The SIIL also has continued to utilize CGSpace as a repository for sharing informal publications and outputs from SIIL funded work. SIIL established this repository with CGSpace in 2017 to share SIIL funded outputs that otherwise did not have formal publishing platforms for public sharing. To date, 42 communications materials such as presentations, videos and other media, management documents, reports, training materials, newsletters and stories, and other communications materials have been shared on the SIIL CGSpace repository.

XII. Governance and Management Entity Information

A. Regional and Country Coordinator Activity

The SIIL coordinators in Senegal, Burkina Faso, Tanzania, and Cambodia continue to monitor in-country activities, represent the SIIL in various capacities, and organize SIIL-funded events. Under guidance of the SIIL's Research Assistant Professor, Dr. Zach Stewart, the coordinators in Burkina Faso, Senegal, and Tanzania also conduct research to address gaps or expand the scope of in existing in-country SIIL subawards. Descriptions of the research and accomplishments are below.

(1) Burkina Faso: Dr. Hamidou Traore and his team's research aims to integrate available soil, water, plant and nutrient management practices in crop rotation to enhance crop yields. Accomplishments include: a) completion of a survey in Northern Region with 122 farmers; b) screened sorghum genotypes for animal palatability and for *Striga*, drought and low soil fertility tolerance – 36 sorghum varieties were screened for their resistance to *Striga hermonthica* in water stress and soil phosphorus and nitrogen deficiency conditions; c) screened cowpea genotypes for fodder/grain productions – 3 preferred cowpea varieties were selected; d) implemented long-term trial related to soil nutrient management on Saria Research Station, and; e) a Ph.D. was recruited, and 3 MSc students defended their theses.

(2) Senegal: Dr. Aliou Faye and his team has continued the project with the GFC (see GFC Subaward VII report), which supports the work of the SIIL's subaward in Senegal led by Dr. Doohong Min. Other accomplishments include: a) data was collected from trials implemented in the five agro-ecological zones of Bambey, Nioro, Sinthiou Malem, and Kolda with 4 millet varieties; b) traveled to Burkina Faso to meet with INERA scholars, visit SIIL-ILRI projects, SARIA research station with the sorghum long term trials, SIIL-ASMC Bobo Dioulasso projects and met with the USAID mission; c) participated in the SMIL (Sorghum and Millet Innovation Lab) program meeting at CERAAS; d) participated in the ISRA pre-programming meeting to contribute to the ISRA/CNRA research center programming, and; e) invited to USAID Partner meeting to present SIIL activities.

Tanzania: Jovin Lwehabura and his teams research expands upon the mother-baby trials that are being conducted as a component of the SIIL's subaward in Tanzania led by Dr. Sieglinde Snapp. Accomplishments include: a) farmers' assessment was conducted on improved bean varieties and crop management options with those who participated in the randomized control trials (RCT) mother-baby demonstrations in five districts in the southern highlands; b) results from farmers' preferences promoted the commercialization of 3000 kg of dressed bean seed through the village/local community based agrodealers' network. Despite the higher costs of the dressed seeds, farmers were willing to buy these varieties due to the reduced disease prevalence and increased bean yield; c) developed a manuscript for publication, "*Increasing Bean Technology Adoption and Scaling up through Mother-Baby Trials Paired with Geospatial Analysis of Enabling Biophysical and Socioeconomic Conditions*", and; d) presented a paper, "*Geospatial Analysis to Spur Technology Adoption for Increasing Bean productivity in Tanzania*" at the FOSS4G conference.

B. Research Output Dissemination Study (RODS)

The USAID has a focused interest in improving understanding and systematic tracking of outcomes and impacts of the FtF Innovation Labs research investments. Decades of technology adoption studies and impact assessments has produced an abundant literature that documents the complexity of the adoption process and underscores the range of independent variables known to accelerate as well as impede adoption and scaling of innovation. Through a competitive process, the SIIL awarded a new subaward to University of California – Davis, entitled the "Research Output Dissemination Study" (RODS), which focuses on evaluating the path from development to end-user for selected innovations produced by the FtF Innovation Labs. The RODS project will simultaneously integrate and advance understanding of this multi- dimensional complexity and simplify it enough to allow evaluation of a broad range of innovations classified in the study as biological, management-cultural, and mechanical-physical. Initial results were presented at IL Directors meeting in Washington DC. Preliminary accomplishments included in this report (see Section C under XIII section on other topics).

XIII. Other Topics

A. Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) at the Royal University of Agriculture

(1) <u>Project Name</u>: The Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN)

(2) <u>Locations</u>: Phnom Penh, Cambodia

(3) <u>Description</u>: CE SAIN – housed in Cambodia's Royal University of Agriculture (RUA) – helps improve food and nutritional security in Cambodia by supporting agricultural research and education and also fostering innovation. CE SAIN works closely with the RUA to improve the skills and knowledge of public and private sector agricultural workers. The Center's goal is to serve as an entity that fosters private sector innovation, agricultural research, education and training, and public sector capacity building through improved collaboration and knowledge sharing that is focused on improving food and nutritional security while enhancing quality of soil, water and biodiversity. CE SAIN's three core objectives are:

    (a) Coordinate and leverage Innovation Labs and other USAID-funded SAIN activities.

    (b) Build human and institutional capacity of the RUA.

    (c) Establish Technology Parks to showcase high-potential technologies and strategies to sustainably intensify smallholder farming systems.

The five primary expected outcomes of the project include: (i) improved communication, coordination and knowledge sharing between USAID, ILs, and other USG funded and non-USG funded projects, and the private sector within Cambodia; (ii) leveraged research and IL technologies within the Technology Parks, farmer sites, and beyond; (iii) enhanced research, extension, education, and capacity building activities aimed for smallholder farmers and other community stakeholders; (iv) increased collaboration and research activities with the U.S. and other international institutions; and (v) decreased duplication of efforts and increased focus on SAIN funded activities.

(4) <u>Collaborators</u>: *Cambodia* - Conservation Agriculture Service Center (CASC); Ministry of Agriculture Forestry and Fisheries (MAFF); Ministry of Education, Youth, and Sport (MoEY); Royal University of Agriculture - Phnom Penh; University of Battambang; and multiple Feed the Future Innovation Labs (e.g. Horticulture; Livestock Systems; Integrated Pest Management).

(5) <u>Key Achievements (See FY 2018 AWP Activity 4.1)</u>:

    (a) Co-hosted the First International Sustainable Agricultural Intensification and Nutrition Conference and Field Trips in January 2018 in collaboration with SIIL. One hundred sixty-five individuals from 16 countries attended the conference, and over 60 individuals participated in the field trips.

    (b) Fifteen collaborative research and demonstration projects were initiated [e.g. 6 US universities (UC Davis, Kansas State University, University of Tennessee, University of Florida, University of Illinois, Penn State); 4 private sectors (ATEC Cambodia, PE, ASA, C.A.M.T Co LTD), and USG and Non-USG funded projects].

    (c) CE SAIN participated in a career fair and STEM ceremony organized by the Ministry of Education Youth and Sport in Phnom Penh.

    (d) CE SAIN has introduced promising technologies from U.S. Government-funded projects and other international organizations into the Technology Parks. These partner organizations include: iDE Cambodia, IRRI, the World Vegetable Center, and four Feed the Future Innovation Labs (Sustainable Intensification, Integrated Pest Management, Livestock Systems, and Horticulture). Collaborations with two private companies have also been initiated.

(e) Twenty-Two technologies and research trials were demonstrated in the established five agricultural technology parks. These Technology Parks showcase high-potential technologies and strategies to sustainably intensify smallholders' production systems, and are accessible by farmers, students, researchers, local partners, and private companies. More than 1,273 people (486 female, 38%) visited the technologies this year.

(6) Capacity Building

(a) The CE SAIN lecture series featured 52 events in FY 2018 at the RUA, with a varied audience of students, researchers, and faculty attending the events. The lecture topics ranged from horticulture and livestock to community organization and agricultural engineering

(b) Initiated second round of the competitive CE SAIN research grant and scholarship programs for RUA faculty and staff. Six small grants were also awarded earlier in FY 2018 with the intent to promote improvement of course materials and content for RUA.

(c) The CE SAIN is supporting 8 Ph.D. (1 female) and 8 M.S. (6 females) scholarships to RUA faculty and staff to strengthen institutional capacity.

(d) Forty intern position were provided, mostly comprised of recent university graduates and fourth-year university students. These experiences allow participants to gain in-depth technical and practical knowledge of field implementation of agriculture projects as a supplement to their classroom studies.

(7) Lessons Learned

(a) Drought and flash flood attacked some of the technology parks of CE SAIN this year. Some crops were damaged as well as the net house and many technologies in the parks.

(b) Engaging youth is extremely important and not easy; therefore, CE SAIN needs to expand its role at the high school level in order to inspire and motivate youth to enter in an agriculture major after completing high school.

(c) Strong technical inputs and good collaboration between the CE SAIN, SIIL, RUA, USAID Mission in Cambodia, Innovation Labs, and local partners is key to success. Promoting communication and collaboration between these groups will continue to be a core activity for the CE SAIN.

(8) Presentations and Publications

(a) Edralin, D. et al. (2017) Conservation agriculture improves yield and reduces weeding activity in sandy soils of Cambodia. Agronomy Sustainable Development (2017) 37:52 doi 10.1007/s13593-017-0461-7.

(b) Hok, L., et al. (2018). Enzymes and C pools as indicators of C build up in short-term conservation agriculture in a savanna ecosystem in Cambodia. Soil and Tillage Research 177: 125-133. https://doi.org/10.1016/j.still.2017.11.015

(c) Ket, P., et al. (2018). Simulation of crop growth and water-saving irrigation scenarios for lettuce: a monsoon-climate case study in Kampong Chhnang, Cambodia. Water 10, 666. https://doi.org/10.3390/w10050666

(d) Le, K.N., et al. (2018). Evaluation of the performance of the EPIC model for yield and biomass simulation under conservation systems in Cambodia. Agricultural Systems, 166, 90-100. doi: https://doi.org/10.1016/j.agsy.2018.08.003

(e) Le, K.N., Jha, M.K., Jeong, J., Gassman, P.W., Reyes, M.R., Doro, L., Hok, L. (2018). Evaluation of long-term SOC and crop productivity within conservation systems using GFDL CM2.1 and EPIC. Sustainability 10(8), 2665. doi: https://doi.org/10.3390/su10082665

(f) Le, K.N., et al. (2018). Evaluating carbon sequestration for conservation agriculture and tillage systems in Cambodia using the EPIC model. Agriculture, Ecosystems & Environment, 251, 37-47. doi: https://doi.org/10.1016/j.agee.2017.09.009

B. Precision Agriculture for Smallholder Systems in Africa

(1) Name: Precision Agriculture for Smallholder Systems in Africa (PI: Joseph Messina, MSU)

(2) Locations: Malawi

(3) Description: This project features an innovative approach to determine how activities can and should be scaled to promote farm productivity for millions of smallholder farmers in Malawi and elsewhere in Sub-Saharan Africa. The scope incorporates data science, machine learning and new remote sensing technologies with detailed data on farm practices, soils and climate and production conditions in a developing economy context. The project will eventually identify site-specific opportunities for improving resource efficiency and raising farm productivity while offering innovative mechanisms for transmitting actionable, timely, and data-supported agronomic practices to farmers.

(4) Collaborators: *United States* - Oakland University

(5) Key Achievements:

(a) Model development completed and manuscript under preparation—*What crops can grow where? A continuously updatable crop suitability geovisualization tool* for Google Earth Engine.

(b) Correlation established between high-resolution multispectral drone imagery (7-cm, 14-cm, and 27-cm spatial resolution), chlorophyll content measurements (SPAD), and trial farm yields.

(c) Automation framework designed to proportionately allocate fertilizer applications based on spatial measurements of crop performance, and, designed to maximize yields by allocating fertilizer spatially based on measurements of crop performance and typical maize response to fertilizer at different stages of growth.

(d) Developed tools related to time-series/climate sensitive niche identification, which should lead to better on-farm guidance and refined crop models in smallholder systems.

(e) Collected all field data with the exception of final accuracy assessment of the field site location coordinates.

(6) Capacity Building: N/A

(7) Lessons Learned:

(a) Learned how to clear a sUAS through regulatory affairs both in the USA and in Malawi.

(b) Developed a substantial simulation improvement to APSIM, which was unexpected.

(c) Local farmers have fewer decision points than anticipated.

(d) The intersection of spatial and temporal resolution of datasets, cost, and capacity make it unlikely that an operational small-holder solution is imminent. Progress, particularly around Google Earth Engine implementations are, however, promising.

(8) Presentations and Publications:

(a) Lin, S., Peter, B., and Messina, J. (2018). Remote sensing accuracy and resolution for precision agriculture in small farms, Malawi. Presentation at Spatial Accuracy 2018, Beijing, China

(b) Messina, J., Peter, B., Mungai, L., and Frake, A. (2018). Scaling agricultural innovations in Malawi. Presentation at Association of American Geographers Annual Meeting, New Orleans

(c) Mungai, L., and Messina, J. (2018). Developing sustainable intensification (SI) of agriculture indicators for smallholder farming systems: a case study in Malawi. Presentation at American Association of Geographers Annual Meeting, New Orleans.

(d) Peter, B., and Messina, J. (2018). Growing season temperature variability in Malawi (2016–2017). doi:10.7910/DVN/XLIKQF

(e) Peter, B., and Messina, J. (2018). Error propagation in time-series remote sensing and a simple data mining tool for detecting and visualizing spatial outliers using Google Earth Engine. IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing.

C. Research Output Dissemination Study

(1) <u>Name</u>: Research Output Dissemination Study (PI: Nancy Allen, University of California, Davis)

(2) <u>Locations</u>: Global – Due to the nature of the research study

(3) <u>Program Description</u>: The creation of the 24 Feed the Future (FtF) Innovation Labs (ILs) drew on the expertise of leading universities to channel research to innovations that address priority challenges of global hunger, poverty and under-nutrition. There is a need across ILs for improved understanding and systematic tracking of outcomes and impacts of IL research investments. Decades of technology adoption studies and impact assessments has produced an abundant literature that documents the complexity of the adoption process and underscores the range of independent variables known to accelerate as well as impede adoption and scaling of innovation. A singular challenge for this proposed Research Output Dissemination Study (RODS) is to simultaneously integrate and advance understanding of this multi- dimensional complexity and simplify it enough to allow evaluation of a broad range of innovations classified in the study as biological, management-cultural, and mechanical-physical.

(4) <u>Collaborators</u>: *United States* - Feed the Future Innovation Labs

(5) <u>Key Achievements</u>:

(a) Completed field evaluations in Senegal and Kenya, which provided end-user experiences for four of the innovations under study.

(b) Developed a clearer understanding of how technology transfer pathways are supported by Agricultural Innovation Systems (AIS), and continued acknowledgement of the role of Innovation Labs and university researchers within AIS.

(c) Conducted a surface-level social network analysis related to dissemination of specific innovations.

(6) <u>Capacity Building</u>:

(a) Presented preliminary findings to gathered attendees of the Innovation Lab Directors' Meeting in September 2018.

(7) <u>Lessons Learned</u>:

(a) Innovations should each be situated within the context of their operating environment (enabling or otherwise) in order to address whether there are similarities among transfer pathways. Among the innovations under investigation, there appear to be few similar 'factors of success. Many innovations are entirely dependent on some type of local adaptation in order to facilitate greater adoption. Even among "successful" adopted innovations, study results are finding that enabling support is much more precarious than first anticipated.

(b) Acquiring original project documents from Innovation Lab Directors and Principal Investigators has been more difficult than anticipated. While some projects have provided contract agreements, impact pathway plans, and progress reports from the life of the innovation, there remain substantial gaps in RODS' knowledge of the existing documentation. It is recommended that future documentation requests are coordinated in conjunction with Agreement Officer Representatives (AORs) of the funding agency (USAID).

(c) Using existing support networks from Innovation Lab partners greatly facilitates travel planning and logistics; without relying on these networks and individuals, RODS would have had much greater difficulty in accessing interviews with potential end-users.

(8) <u>Presentations and Publications</u>:

(a) None to report in FY 2018

D. Gender Integration Highlights:

During the FY 2018 reporting period, SIIL requested the Consortia and subwardees to provide additional information on how their projects were integrating gender into their research. All of them are actively integrated gender into their programs. Below are some selected highlights in some projects:

The SIIL hosted Fulbright Senior Scholar, Dr. Patrick Kilby, during January – May 2018. Dr. Kilby's degree is from Australian National University focused on Women's Empowerment. During his fellowship, he looked at the historical antecedents of the Green Revolution in the US, Europe, and Australia, and argued why including farmers, especially women, play a critical role in research. He also developed a *Gender Analysis Framework* for the Feed the Future Innovation Labs consideration.

The Geospatial and Farming System Research Consortium submitted a paper for publication on the Female Empowerment Index (FEMI) that tracks multiple domains of women's empowerment and can be used to assess both national and sub-national variation. The index was developed using data for Nigeria (very data rich) and are now applying it for all of sub-Saharan Africa.

The ASMC has partnered with the Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) project to host a webinar series. The three-part series was designed to give practitioners' practical tips to make extension and outreach trainings more gender-sensitive. The participatory webinars also solicited the experiences of the participants. Topics included 'Basics of Effective Training', 'How to Train the Right People' and 'Great Facilitation'. In total, the three webinars were attended by 79 participants from across the globe.

Additionally, in Burkina Faso, ASMC revamped their gender approach through a capacity-building, one-day gender training for faculty, staff, and students at Nazi Boni University. The training used the 'Introductory Gender and Nutrition Training' approach pioneered by the INGENAES project, and engaged participants in participatory workshops using adult learning principles such as role playing, discussions, and drawings to better understand topics such as gender myths, and power dynamics within households and its implications on their work as technology developers.

Also in Burkina Faso, the Crop and Livestock Production Systems project has been working to collect data on gender roles in the intensification of mixed crop and livestock systems in two project sites, Yatenga and Seno, with 25 households representing both traditional farming and pastoralist communities. They are currently working on a manuscript to explain their findings.

The Women in Agriculture Network (WAgN) project developed and implemented a gender-focused research strategy which includes the research project by Cambodian graduate student Sovanneary Huot and U.S. graduate student Sarah Eissler. The goal is to study two SI-oriented farmer cooperatives to gain an understanding of women's representation in leadership positions, the extent and nature of their decision-making, and any barriers to acquiring leadership roles. Additionally, WAgN conducted a 'Gender-Attentive Research Methods' 2-day training with the Masters of Sustainable Agriculture students at the University of Battambang. This training focused on the use of qualitative and quantitative methods in sustainable agriculture research, understanding on how to integrate gender sensitivity across both of these methods of data collection.

In Ethiopia, a study conducted by the Sustainably Intensified Production Systems Impact on Nutrition (SIPSIN) regarding the use of irrigation pumps in farming found that they translate to a reduction of 56% work days for men and a 37% for women. It also showed that when pumps are used in farming, men are more likely to provide the labor, with people reporting that using pumps was labor intensive (e.g. due to carrying the generator and hoses to the field) as the reason why.

E. Nutrition Integration Highlights:

During the FY 2018 reporting period, SIIL also requested the Consortia and subwardees to provide additional information on how their projects were addressing nutrition as a cross-cutting theme into their research activities. Below are the highlights from few selected projects:

From the GFC, numerous projects have adapted RHoMIS framework to track nutrition related progress among others in nearly 17,000 households across 22 countries.

As a part of the SIIL-Polder project in Bangladesh, 300 mothers of school-aged children, along with teachers and other household members, were trained on nutritional crops. About 70% of those trained were women. They also observed the nutritional benefits of rice+fish farming systems in the communities.

In Burkina Faso, the ASMC project facilitated the training of 500 farmers in six locations on proper oxen handling and nutrition, and twenty maize-growing planters were constructed, funded by National Research Funds for Development (FONRID). Crop and Livestock Production Systems project is undertaking a study of eight villages to determine the influence of intensification on food security and household nutrition. Preliminary results of the household dietary diversity surveys showed that pastoralist households in Seno province consumed more diverse diets than the households in Yatenga province who are farmers by tradition. The consumption of animal-sourced food, particularly milk and milk products, by the pastoralists in Seno province, is a major reason for the differences in household dietary diversity. Additionally, to help improve household nutrition, a moringa garden has been established in the towns of Bani and Tougou, which is managed by women from those communities.

In Cambodia, the Women in Agriculture Network (WAgN) project is working to understand and encourage increased adoption of 'Wild Gardens' is a critical step toward improving nutrition through balanced diets. Wild food plants are quite often valuable sources of nutrients, have an important documented presence in local produce markets, and can possess important medicinal properties. Thus, they are a powerful tool in the battle against malnutrition and also contribute substantially to food security and income generation via increased market access, especially by women. Overcoming nutritional insecurity in the most vulnerable groups such as pregnant and lactating mothers and young children is a challenge in Cambodia, where people's diets rely heavily on rice which is high in calories but deficient in essential macro and micronutrients. WAgN is also partnering with ECHO Asia, the World Vegetable Center and CIRAD to identify and promote neglected and underutilized species (NUS) to provide people with well-adapted seeds for home gardens.

In Senegal, a research project studying the bioavailability of dual-purpose millet varieties, using information received from the KSU's Department of Nutrition, is underway. Researchers are trying to assess how well micronutrients such as iron, zinc, and magnesium— three nutrients critical for development in those under 5 years old— might be absorbed in an infants' body.

Ethiopia project is also measuring nutritional and health outcomes of their innovations. The observed benefits of yield improvement and income on nutritional and health outcomes in the target communities.

Finally in Tanzania, a Master's (MS) student was recruited by Nutrition Scholar Neema Kassim at Nelson Mandela Institute for African Science and Technology. The MS thesis research proposal was developed and approved and training was carried out during Spring 2018. A household survey was implemented with samples collected on a variety of foods from the households and a biochemical analyses is underway. Out of 10 villages, 290 households were interviewed with 240 complementary food samples collected.

XIV. Issues
A. Political Unrest in Ethiopia

Throughout this reporting year there has been substantial political unrest in our focus countries, specifically Burkina Faso and Ethiopia. In addition, the U.S. Department of State has requested heightened awareness when traveling to Bangladesh and has instituted restrictions for U.S. government personnel. Thus far, the SIIL projects in Bangladesh are progressing with no known delays.

In regards to Ethiopia, the country declared a State of Emergency due to political unrest effective February 2018 and was lifted in June 2018. During this time, the U.S. Department of State warned U.S. citizens to defer all non-essential travel to Ethiopia. As a result, the SIIL projects in Ethiopia were in a holding pattern during this time. Once the unrest subsided and projects continued with their research activities. Despite the delays, the projects still made progress towards their objectives.

Issues in Burkina Faso were related to unpredictable terrorism in the country. Due to the risk of attacks throughout the Sahel and East regions, the U.S. Embassy restricted official government travel to Dori and Djibo, as well as to the provinces of Kmoandjari, Tapoa, Kompienga, and Gourma. Fortunately, our projects have faced minimum disruptions with the exception of a few cancelled site visits.

In the meantime to address these issues, SIIL developed safety procedures and protocols in addition to their standard institutional policies. As part of standard practice, the management entity is in constant communication with the researchers and personnel engaged in the SIIL projects to ensure safety issues are addressed and risks are minimized whenever possible.

B. Delay of Federal Funding Allocation

In FY 2018, funding allocations from USAID were significantly delayed, causing disruptions with some research activities. The SIIL management entity has had to rely on Kansas State University's willingness to support internal activities in order to distribute as much funding as possible to subawardees. Host country institutions had difficultly conducting their activities without the timely distribution of funds.

These delays have the potential to impact our budget pipeline, and corrective measures have been taken in discussion with our AOR and other administrative staff from USAID.

XV. Future Directions and Activities

A. Identification of Partners to Scale Innovations

As subawards develop, test, and optimize SI technologies and innovations in FY 2018, the SIIL management entity will request all PIs and their partners to identify which successful innovations are appropriate and ready for scaling. Projects will also be asked to identify partnerships that will be necessary for successful scaling and suitable region or geographies.

B. Development of Plans for Sustainability of Research

All subaward PIs will be required to develop a transition plan, outlining their plans to ensure that their research will continue to be supported and integrated with other research programs in the country or region past the end date of the award. We will prompt project teams to clearly and systematically define the role of each collaborator engaged in their research or scaling efforts. Strategic engagement with the host country partners, NGOs and private sector will be crucial for sustainability.

C. Evaluating System Productivity, Synergies and Tradeoffs

Last year all the project used SI assessment framework to evaluate their technologies and look at the synergies and tradeoff. We will continue these efforts and encourage researcher and implementing partners to look into further details and quantify the overall systems productivity by putting all the components of the research or package of practices. In addition, looking into the synergies and tradeoff at the farm or household scale rather than at individual plot levels with one innovations.

D. Launch Online Web Version of the SI Assessment Framework

The Sustainable Intensification Assessment Framework was launched in October 2017 at Annual Meeting of the American Society of Agronomy (ASA) in Tampa, Florida. The framework guide and manual were made available to the public. In FY 2018, the SIIL ME led efforts to create a website and online version of the framework. We plan to launch the web version at the ASA Annual Meeting in Baltimore, Maryland in November 2018. Further improvements will be continued to make it more dynamic and user friendly.

E. Implement and Operationalize the Policy Research Consortium (PRC)

The SIIL will finalize the new Associate Award from USAID-Washington focused on improvement of policy approaches and outcomes to support the U.S. Government Global Food Security Strategy (GFSS) objectives. Rutgers University (RU) will lead the consortium with funding and support from SIIL as a ME. It will support the learning agenda on policy, systems analysis, and implementation. The PRC is a group of universities and researchers across the U.S. and sub-Saharan Africa.

F. Identify Opportunities to Coordinate Soil Research

Last year the SIIL led the efforts to help USAID and IFDC (International Fertilizer Development Center) to understand priorities of soil fertility research in sub-Saharan Africa. We conducted a comprehensive analyses comprising of surveys and summits of multidisciplinary teams and stakeholders and summarizing their views. Recommendations from these efforts were shared with stakeholders and donors. We will continue these efforts to bring critical partners together and find ways collaborate, network, and leverage resources to address soil fertility in the region using a broader systems approaches.

G. Integration of Peace Corps and ISRA Research and Extension Activities

We will continue our efforts to better integrate the work of researchers and students at ISRA with activities of Peace Corps volunteers. We will continue to train Peace Corps volunteers and students and actively engage with local extension agents and farmer organizations to address needs of farmers.

Appendix A – List of Awards Given to U.S. Universities

Title: Geospatial and Farming Systems Research Consortium
Awarded institution: University of California, Davis
Dates: September 16, 2014 - September 15, 2019
Current year funding: $1,000,000
Total funding: $5,000,000

Title: Appropriate Scale Mechanization Consortium
Awarded institution: University of Illinois at Urbana-Champaign
Dates: October 1, 2015 -September 15, 2019
Current year funding: $949,817
Total funding: $4,700,000

Title: Unlocking the Production Potential of "Polder Communities" in Coastal Bangladesh through Improved Resource Use Efficiency and Diversified Cropping Systems
Awarded institution: Kansas State University
Dates: October 1, 2015 -September 15, 2019
Current year funding: $249,169
Total funding: $999,508

Title: Adoption of Sustainable Intensification in Dual-Purpose Millet - Leguminous Crops – Livestock Systems to Improve Food and Nutritional Security and Natural Resources Management for Rural Small Holder Famers in Senegal
Awarded institution: Kansas State University
Dates: October 1, 2015 -September 15, 2019
Current year funding: $240,590
Total funding: $996,360

Title: Raising Crop Response: Bidirectional Learning to Catalyze Sustainable Intensification at Multiple Scales
Awarded institution: Michigan State University
Dates: October 1, 2015 -September 15, 2019
Current year funding: $249,930
Total funding: $996,764

Title: Women in Agriculture Network (WAgN) Cambodia: Gender- and Ecologically – Sensitive Agriculture
Awarded institution: Pennsylvania State University
Dates: October 1, 2015 -September 15, 2019
Current year funding: $247,011
Total funding: $1,000,000

Title: Evaluation of the Relationship between Sustainably Intensified Production Systems and Nutritional Outcomes (SIPSIN)
Awarded institution: Texas A&M University
Dates: October 1, 2015 -September 15, 2019
Current year funding: $249,877
Total funding: $999,198

Title: Developing Indicators for Sustainable Intensification
Awarded institution: Columbia University
Dates: September 1, 2015- January 31, 2017
Current year funding: $0
Total funding: $237,454

Title: Developing Indicators for Sustainable Intensification
Awarded institution: University of Florida
Dates: February 1, 2017- November 30, 2017
Current year funding: $0
Total funding: $185,622

Title: Developing Indicators for Sustainable Intensification
Awarded institution: Michigan State University
Dates: July 1, 2015 – August 31, 2017
Current year funding: $0
Total funding: $374,548

Title: Precision Agriculture for Smallholder Systems in Africa
Awarded institution: Michigan State University
Dates: March 15, 2017 – August 31, 2018
Current year funding: $344,507
Total funding: $507,990

Title: Research Dissemination Output Study (RODS)
Awarded institution: University of California at Davis
Dates: February 1, 2018 – February 28, 2019
Current year funding: $249,704
Total funding: $499,409

Appendix B – Success Stories

Success Story #1: What mechanization means to women: Case studies from polder communities of Bangladesh

The rapidly growing economy of Bangladesh has fueled demand for labor in non-agricultural sectors, resulting in a scarcity of rural agricultural workers. This has driven wages up and is affecting farm productivity and profitability. Although women have always played a critical role in the agricultural sector, their identity has historically been only that of unpaid family labor, with the widespread perception that women's roles in farming are limited to the homestead and some postharvest operations. However, in the polders of the coastal zone, women are involved in almost all agricultural activities, in addition to all their other household duties. The women also face several constraints, such as restricted access to inputs, resources (land and labor), assets (machinery and equipment), and services (extension and advice, financial products), which restrict them from playing a leading role in most activities.
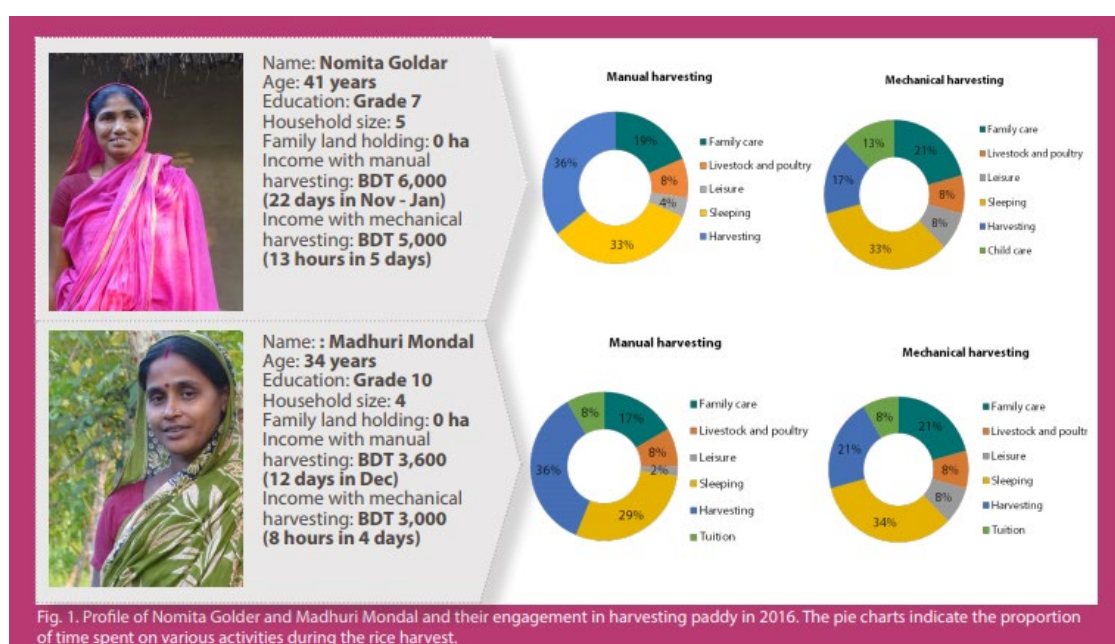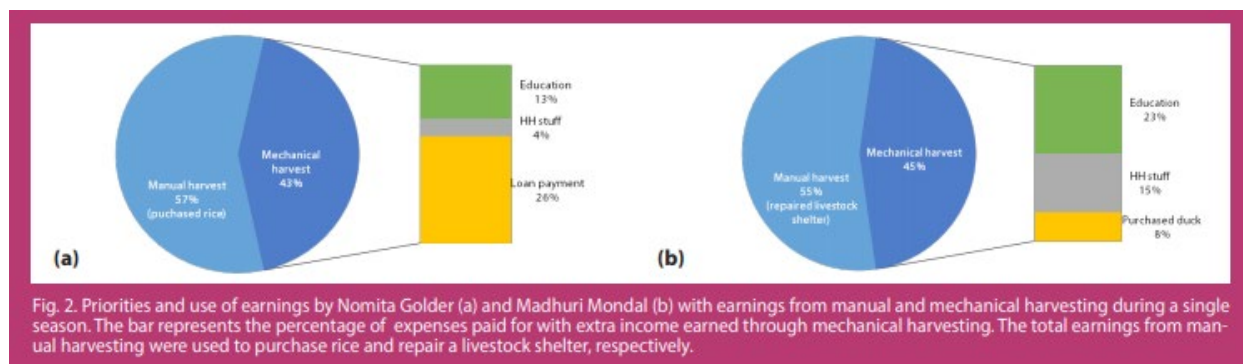

Fig. 1. Profile of Nomita Golder and Madhuri Mondal and their engagement in harvesting paddy in 2016. The pie charts indicate the proportion of time spent on various activities during the rice harvest.

Poor road networks, waterlogging, canal networks, and undulating topography are considered barriers to agricultural mechanization in this coastal region. Additionally, the limited agricultural mechanization that does exist in the coastal zone, mostly two-wheeled tractors, are mainly operated by men. Most farmers in the polders cultivate a single low-yielding rice crop in a year, and agriculture is considered as a low-input, low-risk business. Generally, poor and landless women are engaged in the annual rice harvest on family- cultivated land and on neighboring farms as wage-earning day laborers. During rice harvest, which is done mostly in December, women can work for 8-9 hours daily.

As a part of the SIIL (Sustainable Intensification Innovation Lab)-Polder Project, mechanical harvesting, using a reaper, was introduced to small and marginalized farmers to ease the physical burden on women and increase their contribution to household earnings. The project organized hands-on training, in collaboration with the ACI Motors Ltd., on using the reaper for 84 men and 65 women during the 2016 monsoon season and for 50 men and 35 women during the 2016-17 dry season. The team then worked closely with five women who showed a strong interest in learning about how to use the reapers as a business venture. The project purchased one reaper for them to work with. Of these, two, Nomita Golder and Madhuri Mondal, actually used the reapers as a way to make additional money (Fig. 1).

In a follow-up interview with the women, they provided additional information on how the use of mechanization improved their livelihoods. For example, Nomita worked 22 days during the previous season to manually harvest rice paddies (Fig. 1) and she earned BDT 6,000 (USD 72). Using the reaper not only reduced her drudgery, but also saved significant time. Both young women reckoned that it generally took 48 hours to manually harvest a 1-acre paddy field while it could be harvested in only 3 hours with the reaper. With the time saved and the money earned using the reapers, the women were able to contribute to their respective family's income by buying and raising livestock and poultry and by providing child care services or tutoring the children of neighboring families in addition to their harvesting activities (Fig. 2).

Fig. 2. Priorities and use of earnings by Nomita Golder (a) and Madhuri Mondal (b) with earnings from manual and mechanical harvesting during a single season. The bar represents the percentage of expenses paid for with extra income earned through mechanical harvesting. The total earnings from manual harvesting were used to purchase rice and repair a livestock shelter, respectively.

 As the project has only one machine, which was used extensively for training and demonstrations at an early stage of the harvesting period, Nomita and Madhuri were able to use the machine for only a few days to provide harvesting services to other farmers. In order to accommodate the lack of additional reapers, the women, instead of harvesting all day, both decided to work in the field during the morning hours only, which was sufficient for them to harvest the area that they used to harvest in 5 to 6 days. In the afternoons, Nomita could then continue providing child care services to neighborhood families. Using the reaper helped her earn money in a shorter time while continuing other income-generating activities. Madhuri spent the extra time on family care and some time for herself. Having some leisure time has significant implications for women's health and well-being. Spending more time on family care, particularly children, contributes significantly to overcoming the household's nutrition and health challenges.

Although there is a long way to go, mechanization has shown promise in helping increase household incomes, reducing women's drudgery, and improving their health and overall household well-being. Without mechanization, women either need to spend significantly more time on manual harvesting as wage laborers to meet the expenses of the family or reduce their family expenses, which might include stopping the education of their children or limiting other important family needs.

The success of this service provision model using mechanization depends on awareness, training, and access to credit to purchase machines, among other aspects. Although the capital needed to purchase the machines is seen as a major limitation, it can probably be addressed through pooled community investment in conjunction with existing organizational structures such as water management groups or through loans from self-help groups/ NGOs. Linking these groups to financial institutions might also be an option in the future. The government has introduced from 50 to 70% subsidies to acquire agricultural machinery. Linking women to these subsidies will help empower them and move the country closer to ensuring food security and better family health.

Success Story #2; Sustaining the Future of Cambodian Agriculture

Barren fields and overpopulated cities portend disaster for any country and encouraging young people to consider careers in agriculture is especially crucial in Cambodia, where 20 % of the population is food insecure.

The government and international partners are helping to guard Cambodia's future by introducing young people to agricultural education and careers.

The USAID-funded Feed the Future Innovation Lab for Sustainable Intensification (SIIL) and Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) established a technology park, which are spread throughout Cambodia for research and training purposes, on the grounds of Ramsey Sophanna High School in Phnom Penh.

Nearly 80 percent of Cambodians live in rural areas. With one-third of its citizens between ages 15 and 30, youth migration to the cities is a tangible threat to the nation's future.

Food and job insecurity are the main reasons young people leave their villages as it's easy to lure youth away with employment when they're hungry, according to Dr. Vara Prasad, SIIL director.

Cambodia is an agricultural economy and much of the business in Cambodia starts with agriculture, as expressed by Visalsok Touch, the Cambodian Undersecretary of State of the Ministry of Education, Youth, and Sports. Farming is risky and that's why a lot of young people don't want to take the risk. But in taking the risk, one can also take the lead.

The Cambodian government's goal is twofold: Keep young people in the country as contributing members to the food supply and the economy, and encourage them to attend one of Cambodia's agricultural universities.

Dr. Lyda Hok, director of CE SAIN and alumnus of the Cambodian Royal University of Agriculture (RUA) in Phnom Penh, has found that most high school and middle school students think that agriculture is just digging the soil and planting the crops. They often don't know the science behind agriculture and so teaching that science and integrating it into an activity might help them change their minds, and even decide to major in agriculture.

CE SAIN provides coordination and integration among U.S.-government funded projects, development agencies, students, university researchers, and farmers.

When Prasad and Dr. Manny Reyes, research professor at Kansas State University, contacted Touch about their plans to help establish infrastructure in Cambodia that will engage youth in agriculture, he was immediately on board.

According to Prasad, the decision regarding which profession to choose happens in high school when somebody ignites a student's interest in a subject. The group thought that bringing a technology park to a high school was the best option to ignite an interest in agriculture.

CE SAIN wanted to flip the perception that choosing an agricultural education was second best, so they proposed active engagement and competition among the high school students.

Right next to the school is a fishpond, several demonstration plots and a set of interactive plots that were planted and maintained by the teenaged students as part of an agriculture competition — with a $200 cash prize for the winning team.

During the competition, each group of students explained to the judges how they used innovations to grow their crops, including irrigation and pest-control techniques.

At the award ceremony following the competition, participants were impressed by the students' drive to win, and with so much excitement, they hope to make this an annual event.

Success Story #3: The Peace Corps-ISRA and SIIL Partnership

In 2017, Peace Corps (PC) Senegal entered into a partnership with the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) and the Senegalese National Institute for Agricultural Research (ISRA). Each organization brings its own unique strength: PC Senegal has a substantial network of volunteers working as agricultural extension agents in rural and urban communities; ISRA has the regional technical expertise and provides the latest local solutions and technologies appropriate for Senegal; and SIIL brings the capacity-building expertise and the resources of a world-class research university.

This collaboration forms an important link between organizations working towards the same goals of agricultural development and achieving food security in Senegal. For example, Keur Daouda Cisse is a small village just outside of Thies, Senegal. They continue (o rely heavily on agriculture for income and food despite shrinking farm land, making the area ideal to study, test, and disseminate technology for the sustainable intensification (SI) of agriculture, or increased output with the same or less inputs on the same or less land while protecting biodiversity and ecosystem processes.

In March of 2018, PCVs identified and prioritized major barriers to agricultural production in Keur Daouda Cisse and the surrounding communities using participatory methods introduced by SIIL trainers.   The communities were heavily involved in the identification of their strengths and barriers, using community mapping, seasonal calendars, and farmer interviews. It was decided to address soil fertility through better manure management using the Ripper, a minimum tillage plowing technology that buries manure. An agronomy graduate student was also on hand to assist in trying out the proposed solutions to address barriers that were identified. Plots created to pilot these new techniques are researcher-designed, but farmer-managed, and they will serve as demonstrations sites for new technologies as well as locations used to provide quantitative data for researcher analysis.

This partnership program will support well-respected farmers in communities as they work to develop pilot farms as a space for demonstrating new technologies and trainings in collaboration with PCVs. In addition to improved diffusion of information, PCVs will collect the essential feedback on technologies from smallholder

farmers across Senegal and relay the information to researchers at ISRA. This partnership is designed to increase overall dissemination and increase adoption rates. Each organization, SIIL, ISRA and PC has involved their own extended networks in the partnership. Master Farmers and PCV counterparts have been engaged through the assessment of need to identify technologies on which to train and disseminate. Senegalese graduate students have been involved through capacity building and collaboration on participatory research. PCVs are at the center of the partnership, providing that important link between Senegalese communities and ISRA researchers.

The partnership began with SIIL staff coming and training PC staff and PCVs, as well as ISRA researchers and graduate students and, as a result, PC has begun demonstrating new ISRA bean, millet, and sorghum varieties, eight in all, which have recently been released. With these new varieties on display at various farms around the country, local farmers are able to see traits that different varieties have to offer, and provide feedback. This feedback will eventually be relayed to ISRA Researchers and PC Senegal so that they can better serve the needs of the local farmers.