FEED THE FUTURE
The U.S. Government's Global Hunger & Food Security Initiative

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification

Annual Performance Report FY 2017

Web: www.k-state.edu/siil
Twitter: @SIIL_KSU
Facebook: /SIILKSU
Instagram: @SIIL_KSU
Tel: +1 (785) 532 7072
E-mail: siil@k-state.edu

Collaborative Research on Sustainable Intensification
FEED THE FUTURE INNOVATION LAB

USAID
FROM THE AMERICAN PEOPLE

KANSAS STATE UNIVERSITY

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification
108 Waters Hall, 1603 Old Claflin Place, Kansas State University, Manhattan, KS 66506

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification

Annual Performance Report FY 2017

This annual performance report for FY 2017 is made possible by the generous support of the American people through the United States Agency of International Development (USAID). The contents are the responsibility of Kansas State University and do not necessarily reflect the views of USAID or the United States Government.

Program activities are funded by the United States Agency for International Development under Cooperative Agreement No. AID-OAA-L-14-00006.

Table of Contents

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. P.V. 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 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 – Research Associate
Email: zachstewart@k-state.edu

Zach Stewart serves as the SIIL Research Associate. 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.

Molly Webb – Program Coordinator
Email: mmckneight@k-state.edu

Molly Webb serves as the SIIL Program Coordinator. She supports the development of subcontract awards, research project monitoring, knowledge management, and oversight of the reporting and information platform. She holds a B.S. in Food Science and an M.S. in Plant Breeding and Genetics from Purdue University. Molly has experience collaborating with international partners in Turkey, Senegal, and Haiti and has also worked for Purdue's Center for Global Food Security.

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 (MS GIS) 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. In FY 2016, 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. John Dixon

Australian Centre for International Agricultural Research

John Dixon is the Principal Advisor/Research Program Manager for the Cropping Systems and Economics program. The program aims to improve food security through enhanced productivity and sustainability of field crop farming systems using collaborative R&D partnerships for biophysical and economic research and development.

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. 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)

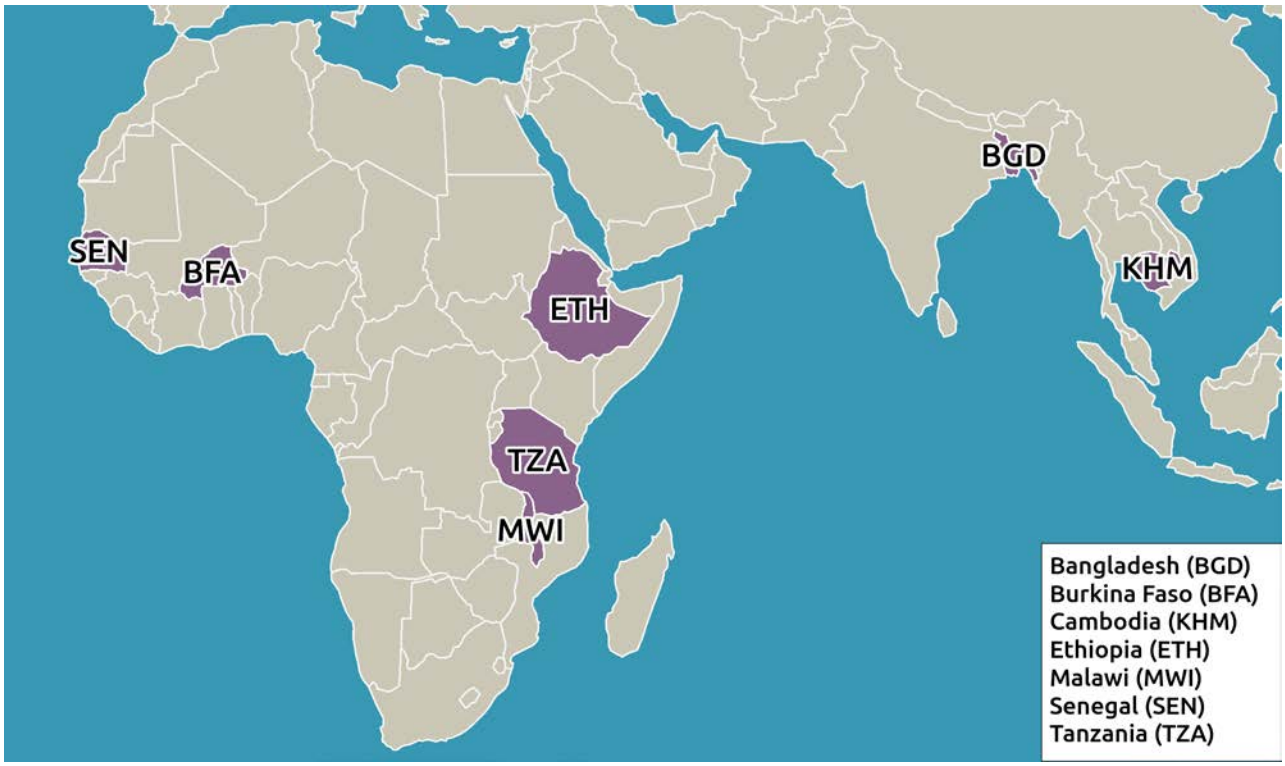
Dr. Peter Thorne coordinates the Africa RISING project in the Ethiopian Highlands. He completed his Ph.D. at the University of Nottingham in animal nutrition, with a part of his research conducted at the University of the Philippines in Los Banos. His career has allowed him to work in both public and 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.

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.

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. A new subaward, with activities focused in Malawi, was initiated in FY 2017.



D. List of Program Partners

United States
ADM Institute for the Prevention of Postharvest Loss
Africa Soil Information Service (at the Earth Institute – Columbia University)
Columbia University
Feed the Future Innovation Lab for Collaborative Research on Nutrition in Africa
Feed the Future Horticulture Innovation Lab
Feed the Future Innovation Lab for the Reduction of Postharvest Loss
Feed the Future Innovation Lab for Small Scale Irrigation
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 Illinois at Urbana-Champaign
University of Maryland
University of Tennessee Institute of Agriculture
University of Wisconsin – Madison

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

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

Cambodia
Agricultural Development Denmark Asia
AVRDC – World Vegetable Center
ECHO Asia
Kasetsart University
Royal University of Agriculture - Phnom Penh
Conservation Agriculture Service Center
University of Battambang
Ministry of Agriculture Forestry and Fisheries

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

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
International Institute for Applied Systems Analysis (IIASA)
ITC – Netherlands
Kifiya Financial Technology Plc.
One Acre Fund
Taking Maize Agronomy to Scale in Africa (TAMASA)
Wageningen University and Research Center

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
DMC – Direct Seed Mulch Cropping System
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
IDRC – International Development Research Centre
IDSS – Integrated Decision Support System
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
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)
ME – Management entity
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
PI – Principal investigator
PTOS – Power Tiller Operated System
RHoMIS – Rural Household Multiple Indicator Survey
RESOPP – Reseau des Organisations Paysannes et Pastorales du Senegal
RUA – Royal University of Agriculture
R4D – Research for Development
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
WAgN – Women in Agriculture Network

I. Executive Summary

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) successfully completed its third year since inception. All projects are now operational with two years of active research data collection in all of its focus countries (Bangladesh, Burkina Faso, Cambodia, Ethiopia, Senegal, and Tanzania). All activities aligned with the four main objectives of the SIIL: 1) using geospatial tools to identify sustainable intensification (SI) needs, opportunities for intervention, scaling and assessing impact; 2) improving nutrition using integrated and environmentally sustainable technologies (nutrition-sensitive agriculture); 3) identifying enabling conditions and social networks to support and enhance SI; and 4) developing platforms for communication, knowledge sharing and capacity building.

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 of collaborate, learn and adapt. Active and strategic collaboration is key for successful implementation of innovative research that ensures greater impact and return on investments. Multiple projects of the SIIL enhanced collaboration, leveraged partnerships and synergies with other Feed the Future Innovation Labs (e.g. Horticulture, Livestock Systems, Small Scale Irrigation, and Nutrition); programs of USAID focused on sustainable intensification (e.g. Africa-RISING; TAMASA), networking among host-country partners (e.g. R4D partnerships in Coastal Zone of Bangladesh with Bangladesh Agricultural Research Council and its organizations) along with other international organizations (e.g. CIRAD in Senegal and Cambodia). The Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) in Cambodia became fully operational and actively coordinated multiple projects funded by USAID. 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) developed and published and made available the WorldClim2 data product which includes high spatial resolution (1 km) climate data. The GFC also published global trends in dietary micronutrient supply, and estimated prevalence of inadequate nutrient intakes. The Appropriate Scale Mechanization Consortium (ASMC) completed baseline surveys, established innovation hubs, linked them with appropriate private sector partners, local entrepreneurs and farmer organizations; and coordinated gender discussions. The ASMC also developed a framework to assess technology appropriateness for local conditions. Polder communities in Bangladesh acknowledged benefits of short duration high yielding rice varieties, which enabled an additional rabi crop and decreased the fallow period. Enhanced grain and biomass yields with dual-purpose sorghum and cowpea were reported in Burkina Faso. The Cambodia project established nutrient profiles of key neglected and underutilized species and planned to include them in the home vegetable gardens using principles of conservation agriculture. In Ethiopia, project highlights included baseline household surveys and expanded participation of farmers in fodder-livestock systems and vegetable home gardens for increasing overall system productivity and resource use efficiency. Use of dual-purpose millet with increased Fe and Zn in Senegal showed not only increased biomass and yield of crops, but also enhanced animal performance in feeding trials. The Tanzania team completed their baseline surveys, and collected data on socioeconomic and soil samplings from farmers using cereal-legume cropping systems.

The SI community identified a critical need for a larger inclusive framework for assessing synergies and trade-offs of innovations. The SIIL continued to support the SI Assessment Framework, which was field-tested, and a fully comprehensive guide as well as a methods manuals were written. The human and institutional needs were recognized, and the SIIL community provided short-term training to 2274 individuals (878 women) and long-term graduate degree training to 45 individuals (16 women). In addition, the SIIL supported new and continued activities on the use of precision agriculture for smallholder farmers, research output dissemination research, sub-Saharan soil prioritization study, established the SIIL Dataverse for data management, and added new features in the reporting hub for more effective project management. 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 management team and their consortium of subawards made significant progress in FY 2017, including the following highlights:

- The WorldClim2 data product was developed, published and released to the public.
- Five weather stations were established in different agroecological zones of Senegal, and the GFC plans to establish additional stations in Burkina Faso and Cambodia in FY 2018.
- The Rural Household Multiple Indicator Survey (RHoMIS) and analysis framework has been applied to more than 10 projects in 15 countries. A second phase of the project has been initiated by the GFC to disseminate and optimize the tool.

B. Appropriate Scale Mechanization Consortium (ASMC)

The ASMC continued its efforts to sustainably intensify smallholders' cropping systems through mechanization through the following key activities:

- The four ASM Innovation Hubs developed, evaluated, and improved technologies relevant to local production practices. Engagement of students and youth was integral to the design process.
- Focus Group Discussions, led by in-country gender specialists, were conducted in the ASMC target countries on women's empowerment in agricultural mechanization.
- The ASMC initiated linkage of Innovation Hubs to appropriate private sector companies, local entrepreneurs, and farmer organizations in an effort to encourage scaling and sustainability.

C. Integrated Research Subaward Portfolio

Highlights from the six SIIL subawards include:

- *Bangladesh* – Farmers that grew high yielding and high Zn rice were able to harvest their crop early and plant an additional rabi crop to intensify their system. Several small scale machines were introduced to polder 30, but the reaper was most positively received, due to its reduction of drudgery in rice harvesting.
- *Burkina Faso* – On-farm dual purpose cowpea/sorghum agronomic trials continued and showed benefits of soil conservation techniques and manure and fertilizer application. A study of livestock management systems was conducted, as well as a trade-off analysis of different SI interventions.
- *Cambodia* – Crop nutrient profiles were developed for key neglected and underutilized species (NUS) of indigenous vegetables. Conservation agriculture practices as a component of SI adoption was expanded. Research on the diversification of rice with green manure cover crops is ongoing.
- *Ethiopia* – The baseline household surveys, as well as malaria and anemia tests, were completed. Field research on fodder-livestock systems was also expanded. The data collected in FY 2017 will be incorporated into the APEX and/or FARMSIM models, ultimately strengthening the IDSS.
- *Senegal* – Improved agronomic practices and value of dual purpose pearl millet for improved yield and feed quality was demonstrated. Research is continuing in different agroecological zones to develop best management practices.
- *Tanzania* – A survey of 630 farmers with maize or maize-legume fields, which included socioeconomic parameters and soil samples, was conducted. A baseline survey of village based advisor farmers was completed. Project leaders also engaged in a policy conference in Tanzania.

D. Associated Awards and Mission Buy-Ins

Initiated new activity on Precision Agriculture for Smallholder Systems in Africa with support from Malawi Mission; and continued activities of CE SAIN supported from Cambodia Mission.

E. Communication, Knowledge Sharing, and Capacity Building

Capacity building activities expanded significantly during the reporting period. In FY 2017, 45 long-term trainees were either partially or fully funded by the SIIL. Fifty-three short-term training events were held across the SIIL focus countries and in the U.S. The SIIL will use Dataverse for its data management.

III. Key Accomplishments

A. Strengthened Collaboration with Innovation Labs

The SIIL leverages partnerships with the Horticulture IL, Livestock Systems IL, Small Scale Irrigation IL, and the Nutrition IL to collaborate and develop mutually beneficial activities and share outcomes. The SIIL hosted the Livestock Systems IL's gender specialist, Dr. Kathleen Colverson and led a one-day workshop on the integration of gender into agricultural research projects.

B. Strengthened Collaboration with other Research Programs

Africa RISING – The SIIL team continues to collaborate and share knowledge with the Africa-RISING partners. Part of future active collaboration will be to use the SI Assessment Framework with data from Africa-RISING to evaluate and enhance functionality of the framework.

Taking Maize Agronomy to Scale in Africa (TAMASA) – Continued support and collaboration with the TAMASA in Tanzania with SIIL partners is appreciated and is mutually beneficial and demonstrates value of collaborate, learn and adapt.

C. Partnering with Host-Country Partners and Other Organizations

1. *Centre de Coopération Internationaleen Recherche Agronomique pour le Développement (CIRAD)*

The SIIL strengthened its partnership with CIRAD in both Senegal and Cambodia. In Senegal, the SIIL partnered with CIRAD to host a scientific international conference on SI in April 2017. The conference presented new approaches and research results that will ultimately improve agricultural productivity and incomes of rural populations, as well as smallholders' resilience to the effects of climate change. In Cambodia, the SIIL engaged with CIRAD through the ASMC and co-development of appropriate scale machinery for lowland rice and commercial vegetable production. CIRAD also engaged in collaborative research with the WAgN project on the diversification of rice with green manure cover crops and relay crops; and co-hosting and working with the government of Cambodia to establish one of the technology parks.

2. *Royal University of Agriculture (RUA)*

Through the CE SAIN as well as the ASMC and WAgN projects, the SIIL has strengthened engagement with RUA. Since inception of the CE SAIN, RUA has expanded its role as key facilitator for Innovation Labs and other U.S. government funded activities in Cambodia. The center also played a key role in development the strategic plan for RUA and is already seeing benefits of increased collaboration and opportunities for leveraging funding from Government and other donors (e.g. World Bank).

3. *Bangladesh Platform for Integrated R4D in Coastal Zone*

Through a new initiative titled "Toward better integration of R4D for improvement food production systems in coastal zone of Bangladesh", SIIL engaged with 11 other international R4D projects in Bangladesh, as well as the Bangladesh Agricultural Research Council (BARC), the Bangladesh Rice Research Institute, and the Bangladesh Agricultural Research Institute (BARI). The initiative aims to improve knowledge sharing among the partners and improve efficiency across all projects working in the coastal zone.

D. Completion of the Establishment of the CE SAIN

The CE SAIN was fully established in FY 2017. Key achievements included the hiring of the CE SAIN management staff and establishment of five Technology Parks in different locations in Cambodia. The USAID Mission Director and the Cambodian Minister of Agriculture, Forestry, and Fisheries attended the formal launch of the Technology Parks. The CE SAIN research grant and scholarship program was also initiated, and support was provided to the RUA for the revision of its long-term strategic plan.

E. Finalization of the SI Assessment Framework

The Guide and Methods Manual for the Sustainable Intensification Assessment Framework were finalized in FY 2017, and a book chapter was developed that focuses on the application of the SI Assessment Framework at various stages of project implementation. An initial training of SIIL subawardees took place at the 2017 Annual Meeting, followed by more specific in-country trainings in Senegal and Cambodia.

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 and economically appropriate for use by smallholder farmers 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

Six focus country subawards are currently supported by the SIIL. 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; and diversification (integration of legumes; home gardens; and new crops). The SIIL research subawards are implemented and led by collaborations of U.S. universities, NARS centers, NGOs, and CGIAR partners.

D. Developing Indicators for Sustainable Intensification

In the continuation of the initial one-year project period, the second phase continued the development, validation, and implementation of the Sustainable Intensification Assessment Framework in FY 2017. 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 tradeoff. Such analysis is critical for providing options that specific to stakeholders and understanding the overall system and determine package that will enhance overall productivity and resilience of system rather than individual components to help enhance scaling and adoption of innovations. This framework can also be used for improving programming and integration of gender, nutrition and human capacity.

V. Research Project Reports

A. Geospatial and Farming Systems Research Consortium

1. Summary of GFC activities

(1) Name: Geospatial and Farming Systems Research Consortium (PI: Robert Hijmans, University of California, Davis)

(2) Location: 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.

(3) Description & Achievements (See FY 2017 AWP Objective 2): 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.

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

(i) As a follow-up from initial activities (Geospatial Subaward II indicated later in this section), the GFC is evaluating project outcomes and developing plans to implement the spatial targeting tools in R and apply it for other SIIL countries.

(ii) A collaboration between the GFC and the University of Arkansas aims to map 'boro' rice growing areas in Bangladesh. Based on historical satellite imagery, the developed model estimated around 4 million ha of annual 'boro' rice production for Bangladesh for the last decade. Fine spatial scale information on HYV rice will greatly improve the understanding of current status of production and potential for HYV rice adoption in Bangladesh during the dry season.

(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.

(b) Improve resource use efficiency in crop production.

(i) The GFC has developed the WorldClim2 data product and made it available for the public. The product includes high resolution climate data on average monthly climate data (minimum, mean, and maximum temperature, precipitation, solar radiation, wind speed, water vapor pressure) for 1970-2000.

(ii) The GFC is developing various crop growth simulation models available as an R-package for seamless integration with spatial analysis tools available in R.

(c) Design crop growth monitoring tools.

(i) In FY 2017, the GFC completed the purchases and modifications of UAV platforms with the multi-spectral, hyperspectral and RGB cameras, for use in Cambodia, Senegal, and experimental plots at UC Davis. Efforts are ongoing to develop and optimize UAV data collection and processing systems.

(ii) The GFC has made some progress has also been made to create a harmonized database combining different satellite data for the last two decades for multiple SIIL focus countries to map crop types.

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

(i) The GFC has collected and extensively cleaned agricultural census data for all SIIL focus countries. Efforts are now focused on creating spatial databases joining census data with corresponding administrative boundaries, and the results will be released through the GFC data website and relevant SIIL data repositories.

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

(i) A spatial database of local diets from various secondary sources is being developed at a fine spatial resolution. Multiple data sources have been utilized to estimate the prevalence of inadequate intakes of 14 micronutrients for all countries. An R-package is under development to downscale the national level estimates of local diets.

(ii) A dispersion model for food production is under development to model the "travel" of food from fields to markets.

(f) Capacity building and easy access to geospatial data for agricultural development.

(i) The training site (http://rspatial.org/) is live and has been announced to the wider R and open source geospatial communities. Updates are ongoing, and additional contributors are being solicited to provide more content for the most relevant topics.

(ii) Country profiles on the GFC website (http://gfc.ucdavis.edu/profiles/) have been updated to include maize yield gaps and micronutrient trends.

(4) Collaborators: See GFC subaward reports

(5) Capacity Building: In addition to items outlined in (3)(f), the GFC is currently planning workshops on spatial data analysis and crop growth simulation models in Tanzania and Senegal in FY 2018. Unmanned aerial vehicle (UAV) trainings are also planned in Cambodia and Senegal in FY 2018.

(6) Lessons Learned:

(a) As often reported in remote sensing projects, availability of "good" quality satellite observations during the middle of the growing season continues to be an issue and likely affects the efficacy of developed models. For example, it is believed that for the year 2005, rice area is over-estimated due to unavailability of "good" quality images (see (3)(a)(ii)).

(b) Remote debugging of weather stations is complex, as there are often 1-2 week delays due to time difference, travel time of technical staff to the stations, and delayed notice of station errors. Communication is a barrier when working on highly technical issues with international staff. Keeping a translator on staff could help.

(7) Presentations and Publications:

(a) Beal et al, T. (2017). Global trends in dietary micronutrient supplies and estimated prevalence of inadequate intakes (pp.1-20). PLoS ONE, 12(4), San Francisco, California; Cambridge, UK. doi: https://doi.org/10.1371/journal.pone.0175554.

(b) Fick, S. E. & Hijmans, R. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas (pp.1-14). International Journal of Climatology, 00, Wiley Online. doi: http://dx.doi.org/10.1002/joc.5086.

(c) Ghosh, A., Mandel, A., & Hijmans, R. (2017). Developing scalable information extraction processing pipelines using R for earth observation applications. FOSS4G, Boston, United States of America.

(d) Ghosh, A., Mandel, A., & Hijmans, R. (2017). Spatial data analysis and modeling for agricultural development. USAID Workshop on Innovation for Data-Driven Agriculture, Boulder, United States of America.

(e) Mandel, A., Hijmans, R., & Ghosh, A. (2017). Rspatial.org, tutorials for learning Spatial R. FOSS4G, Boston, United States of America.

(f) Shew, A. & Ghosh, A. (2017). Using multi-temporal remote sensing data to understand the spatio-temporal patterns of dry season rice production in Bangladesh.

(i) Presentation: 2nd International Symposium on Spatiotemporal Computing, Boston, United States of America.

(ii) Publication: ISPRS Ann. Photogramm. Remote Sens. Spatial Inf. Sci., IV-4-W2, 61-68, https://doi.org/10.5194/isprs-annals-IV-4-W2-61-2017, 2017

(g) Tiedeman, K., Ghosh, A., & Hijmans, R. (2017). Agricultural expansion and reserve connectivity in Tanzania. ESA 2017 Meeting, Portland, United States of America.

2. *GFC Subaward 1*

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

(2) Location: Regional/national scale study that focuses on Kenya and Tanzania

(3) Description: 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) Collaborators: Taking Maize Agronomy to Scale in Africa (TAMASA), One Acre Fund, University of Maryland

(5) Achievements (See FY 2017 AWP Activity 2.8):

(a) High resolution data (collected by SkySat constellation) was obtained from Planet, and integration with other satellite datasets has been initiated.

(b) Improved cloud detection and radiometric corrections for SkySat imagery were developed.

(c) An improved supervised remote sensing image classification system was developed using the Random Forest algorithm with field data from the region. Progress has also been made on an unsupervised classification approach to be tested in the region and potentially in other geographic areas.

(d) Sentinel-2 multispectral imagery has been merged with high resolution SkySat data to obtain crop phenologies for individual fields at frequent interval during the growing seasons. Some progress has been made on comparing the satellite observed phenologies with crop simulation model outcomes.

(e) The project has made significant progress on running crop growth simulations for the region and developing scalable approaches to modeling yield combining satellite data and simulation models.

(6) Capacity Building:

(a) None to report in FY 2017.

(7) Lessons Learned:

(a) Clouds continue to be a challenge for acquisition of clear images during the middle of the growing season.

(8) Presentations and Publications:

(a) 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

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

(2) Location: Tanzania

(3) Description: The goal of the 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 sustainability of this intensification in Tanzania, as well as conditions that could support investments in agricultural sustainable intensification.

(4) Collaborators: ILRI, CIAT, Wageningen University and Research Center

(5) Achievements (See FY 2017 AWP Activity 2.6):

(a) Following scoping visits to Tanzania as well as a literature review, the project brought together a multi-disciplinary group of researchers and practitioners to discuss how to link household surveys with spatial data in an interactive workshop in Arusha, Tanzania. A conceptual framework for operationally quantifying SI was developed.

(b) This project collated a wide variety of geo-referenced household-level data. Data points from very contrasting systems were included and thus allowed for a robust analysis of the 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.

(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) Capacity Building:

(a) Training on the use of Targeting Tools was provided to SIIL collaborators in Arusha at CIAT. Participants worked on a case study that aimed to determine the suitability of two bean varieties for conditions in Tanzania.

(7) Lessons Learned:

(a) Follow-up is needed to help the project results reach their full potential of use and application across all SIIL focus countries. The GFC management team is addressing this need.

(8) Presentations and Publications:

(a) Notenbaert, AMO., 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

(1) Name: Geospatial Data and Analysis Support to the SIIL Geospatial and Farming Systems Research Consortium (PI: Jawoo Kim, IFPRI)

(2) Location: All SIIL focus countries

(3) Description: 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. Building on IFPRI's ongoing efforts to generate spatially-explicit knowledge products for supporting strategic agricultural investment decisions and contributing to the mission of SIIL, IFPRI's Spatial Data and Analytics theme will undertake the following activities: (i) high-resolution mapping of crop distribution and performance in SSA countries, (ii) study on the adoption of sustainable intensification practices using evidence from maize-legume farming systems in rural Tanzania, (iii) improved modeling framework for spatial accessibility and transportation cost, and (iv) improved spatial price modeling for the farm-level analysis of agricultural input-use profitability.

(4) Collaborators: IFPRI

(5) Achievements (See FY 2017 AWP Activity 2.9):

(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 analysis framework to incorporate Google Distance Matrix as an additional source of model parameters and evaluation 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. Finally, recommendations were established to further develop this analysis in the future and expand to other countries.

(6) Capacity Building:

(a) None to report in FY 2017.

(7) Lessons Learned:

(a) None to report in FY 2017.

(8) Presentations and Publications:

(a) None to report in FY 2017.

5. GFC Subaward IV

(1) Name: Generating Cropland Extent of Ethiopia from High-Resolution Imagery (PI: Andy Nelson, ITC Netherlands)

(2) Location: 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) Description: Efforts to better target research and extension for sustainable agriculture require basic information on the extent and location of fields. Effective targeting of interventions in staple and cash crop systems requires accurate spatial information on where specific crops are grown. 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 tests and assesses 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) Collaborators: International Institute for Applied Systems Analysis (IIASA), Kifiya Financial Technology PLC

(5) Achievements (See FY 2017 AWP Objective 2) and Capacity Building:

(a) 10 woredas were selected in the Ethiopian highlands to reflect the diversity of smallholder farming systems and to match the drought insurance program of Kifiya.

(b) High resolution Worldview 2 and 3 imagery from 2009 to 2016 were obtained with help from IIASA and GFC. From a pool of 60,000 1sq km image tiles, a random subset of 553 unique tiles (single dates) were selected to compare field boundary mapping methods.

(c) Two automated boundary mapping methods were refined for the project, and a manual method for mapping field boundaries based on geo-wiki web platform was developed specifically for the project. As a key component of the project, these three methods will be compared.

(d) ITC and IIASA conducted a training course for eleven Kifiya staff on May 18-19, 2017. Trainees were introduced to the project and the geo-wiki web tool. After several practice sessions, in which the concept of field composition was discussed and improvements to the tool were suggested, the trainees were timed to see how many fields could realistically be digitized per person per hour. Results of the training event suggested that an average of 120 fields per person per hour are attainable, taking power outages into account.

(e) Following the training and improvement of the geo-wiki web tool, the Kifiya staff completed the digitizing task for 500+ images, accounting for digitization of over 25,000 fields in the 10 woredas. These boundaries will be checked, cleaned, and combined to derive a single layer of field boundaries that will compared against the boundaries of the automated methods.

(6) Lessons Learned:

(a) None to report in FY 2017.

(7) Presentations and Publications:

(a) None to report in FY 2017.

6. GFC Subaward V

(1) Name: 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) Location: Global with specific focus on Feed the Future countries/zones

(3) Description: 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 sustainable intensification. The framework has been applied in more than 30 sites in 15 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) Collaborators: ILRI

(5) Achievements (See FY 2017 AWP Objective 2):

- (a) The number of applications of the RHoMIS framework has expanded further, with its first NGO partner, TreeAID, now using it as its evaluation tool in Ghana, Ethiopia, Burkina Faso and Mali.
- (b) A series of papers has been submitted or is in an advanced stage of preparation presenting analyses of individual applications (i.e. in Tanzania, Malawi, Guatamala, Ethiopia and Ghana) of the RHoMIS framework. The first cross-site analysis paper is also in an advanced stage of preparation presenting the exciting results of a revisit exercise of more than 600 farm households in Tanzania, Kenya and Uganda. The database has been renewed and now contains information on more than 7000 individual farm households. This number is likely to increase to more than 10000 in the coming months, with applications being prepared for sites in Chad, Burkina Faso, Mali, Nicaragua, DRC, Burundi and Ethiopia.
- (c) Once the database development is finalized, generic across-site analysis will be prepared, and the database will be made publicly available through publication in a data science journal. The first support activities are envisioned to take place within the SIIL community to help individual projects (e.g. GFC supported project in Cambodia) apply the RHoMIS framework.

(6) Capacity Building:

- (a) With additional funding sources, approximately 10 training sessions on utilization of the RHoMIS tool have taken place.
- (b) Multiple web-based resources have been developed to support the understanding and utilization of the tool.

(7) Lessons Learned:

- (a) None to report in FY 2017.

(8) Presentations and Publications:

- (a) Fraval et al. Making the most of imperfect data: a critical evaluation of standard information collected in cross-sectional farm household surveys. Experimental Agriculture (In review).
- (b) Fraval et al. Pathways to food security in rural Burkina Faso: importance of consumption of agricultural produce versus food purchases. Food Security (In review).

(c) Hammond et al. (2017). Farm types and farmer motivations to adapt: Implications for design of sustainable agricultural interventions in the rubber plantations of South West China (pp.1-12). Agricultural Systems, 154, Elsevier. doi: https://doi.org/10.1016/j.agsy.2017.02.009.

(d) Hammond et al. (2016). The Rural Household Multi-Indicator Survey (RHoMIS) for rapid characterisation of households to inform climate smart agriculture interventions: Description and applications in East Africa and Central America(pp.225-233). Agricultural Systems, 151, Elsevier. doi: https://doi.org/10.1016/j.agsy.2016.05.003.

(e) van Etten, J., Steinke, J., & van Wijk, M. (2017). How can the data revolution contribute to climate action in smallholder agriculture?(pp.44-48). Agriculture for Development, 30, CGIAR. http://hdl.handle.net/10568/81375.

7. GFC Subaward VI

(1) Name: Patterns and Drivers of Land Use Change in Battambang Province, Cambodia (Sanara Hor, RUA)

(2) Location: 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, Cambodia.

(3) Description: The pattern, causes and consequents 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) Collaborators: RUA

(5) Achievements (See FY 2017 AWP Objective 2):

(a) For the household survey component of the project, the RHoMIS tool is being adapted for appropriate use. The RHoMIS tool was developed previously by another GFC subward.

(b) A preliminary spatial analysis was conducted on the effect of economic land concessions in Cambodia. An abstract based on the analysis was submitted to the American Geophysical Union meeting in 2017.

(6) Capacity Building:

(a) Two Ph.D. students under joint supervision of the GFC were selected for this project. Both students were award Ph.D. scholarships from the CE SAIN.

(7) Lessons Learned:

(a) None to report in FY 2017.

(8) Presentations and Publications:

(a) None to report in FY 2017.

8. GFC Subaward VII

(1) Name: 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) Location: Bambey, Kolda, Nioro, Sinthiou, and Dahra, Senegal

(3) Description: 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 of Senegal; (2) create a high spatial resolution map of soil properties in Senegal; (3) improve the understanding of the relationship between seasonal and spatial price movements and climactic differences, transportation costs and other variables in Senegal; and (4) build capacity of Senegalese researchers and students in statistical modelling and UAV data collection systems.

(4) Collaborators: Kansas State University

(5) Achievements (See FY 2017 AWP Objective 2):

- (a) Five weather station units have been established in the targeted areas of the project. Information on wind speed, wind direction, rain, temperature, relative humidity (and dew point), and solar radiation from the five weather stations are available at 15-minute intervals.
- (b) Organic and inorganic millet fertilizer trials are ongoing in the five targeted areas of the project to update recommendations according to the environmental conditions.
- (c) 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.
- (d) Collaboration with CropNuts and QED has been initiated in an effort to develop a high resolution soil map for Senegal. QED will provide the locations for soil sample collections based on the framework developed by AfSIS, ISRA will perform 2000 sample collections from the field and 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.

(6) Capacity Building:

- (a) Three Ph.D. candidates and seven M.S. students have been selected to work on the project.

(7) Lessons Learned:

- (a) The weather station data feed from the Dahra location is not available due to a malfunctioning of the SIM card slot. Time and resources are required from US partner to ensure long-term sustainability of all weather stations implemented through their project.

(8) Presentations and Publications:

- (a) None to report in FY 2017

9. GFC Subaward VIII

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

(2) Location: Louga, Fatick, and Kaolack, Senegal

(3) Description: 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) Collaborators: CNRA/ISRA, LNERV/ISRA, IRD, CIRAD

(5) Achievements (See FY 2017 AWP Objective 2):

(a) The calibration of intercropping models has been initiated by establishing a network of farmers' fields in northern Louga and central Fatick as well as a controlled experiment at a research station in the center of the Peanut Basin.

(b) Comparative assessment of cowpea-millet intercropping and millet sole crops using simulation experiment and spatialized estimations of yields at the regional level will take place after collection of data from experimental field trials.

(6) Capacity Building:

(a) None to report in FY 2017.

(7) Lessons Learned:

(a) Difficult communication with the project's Senegalese partners, perceived as a potentially competitive and hostile research environment within different ISRA departments, delayed activities and may affect future SIIL activities.

(8) Presentations and Publications:

(a) None to report in FY 2017.

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) Location: Bangladesh, Burkina Faso, Cambodia, and Ethiopia

(3) Description: The ASMC facilitates the introduction of multifunctional and modular mechanized technologies that are technically, environmentally, and economically 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: U.S. collaborating institutions include: Kansas State University, Michigan State University, and North Carolina A&T State University, ADM Institute for the Prevention of Postharvest Loss. Additional international collaborators are listed under each ASMC country report.

(5) Achievements (See FY 2017 AWP Objective 3):

(a) The consortium has developed an evaluation framework to assess technology appropriateness for local conditions.

(b) Baseline surveys have been completed in the four ASMC target countries.

(c) Connecting Innovation Hubs and researchers with appropriate private sector companies, local entrepreneurs, and farmer organizations has been a key activity of the ASMC and will remain a priority in FY 2018 to enable technology scaling.

(d) ASMC Co-PIs have been coordinating Focus Group Discussions led by in-country gender specialists in each country. A report on the discussion results is under development.

(6) Capacity Building:

(a) The consortium initiated training programs for 11 new long-term trainees in FY 2017.

(b) Over 40 field days and training events were held in the four ASMC target countries in 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) ASM technologies will not be successfully disseminated and utilized without a profitable business model behind them.

(b) In Cambodia, farmers are still reluctant to transition to a conservation agriculture system, and they need to observe a few seasons of demonstration before they are willing to change their production practices.

(c) In Bangladesh, farmers are most interested in the mini-combine harvester for mechanization of harvesting rice, as it completes multiple functions at once.

(8) Presentations and Publications:

(a) Hansen, A. (2017). Appropriate Scale Mechanization for Sustainable Intensification. South African Institute of Agricultural Engineers Kwazulu-Natal Branch Meeting, South Africa.

(b) Hansen, A. & Rendall, T. (2017). Engagement Strategies for Enhancement of Appropriate-Scale Mechanization for Sustainable Intensification. ASABE Annual International Meeting, Spokane Washington, United States.

(c) Hansen, A. & Rendall, T. (2017). Implementation and Evaluation of Appropriate Scale Technologies for Sustainable Intensification. Soybean Innovation Lab Mechanization Webinar Series, Agrilinks.

(d) Rendall, T. (2017). Learning About and From Animal Powered Farming and Distant Places. Horse Progress Days, Lancaster, Pennsylvania, United States.

2. *ASMC - Bangladesh*

(1) Name: Appropriate Scale Mechanization Innovation Hub (ASMIH)- Bangladesh

(2) Locations

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

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

(3) Description: 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) Collaborators: Bangladesh Agricultural University (Bangladesh), Bangladesh Rice Research Institute (Bangladesh), Bangladesh Agricultural Research Institute (Bangladesh), ACI Motors Ltd. (Bangladesh)

(5) Achievements (See FY 2017 AWP Objective 3):

(a) A zero till planter, strip-till planter, bed planter, power tiller operated seeders/systems (PTOS), and power tiller were tested in the planting of mung beans in Barisal. On the basis of field performance, crop yield, and financial performance (benefit/cost ratio), the strip-till planter and zero till planter were determined to be most suitable for adoption in Barisal.

(b) Similar to (a), several CA machinery were tested for the planting and production of jute in Dumuria. On the basis of field performance, crop yield, and financial performance (benefit/cost ratio), the strip-till planter and PTOS were determined to be most suitable for adoption in Dumuria.

(c) Seedling preparation methods were tested, and seedlings raised on polythene mats were found to be more cost-effective and less labor and time consuming compared to seedlings raised in trays. Two seedling raising service providers, one in each field location, have been trained and have started their own nurseries to sustain the seedling supply to local farmers.

(d) Based on technical and financial performance (benefit/cost ratio) in the 2017 cropping seasons, the ACI Daedong DP488 and Metal Asia rice transplanters were determined to be most suitable for puddled conditions. Only ACI Daedong DP488 performed well in unpuddled conditions.

(e) Six focus group discussions (FGDs) centered on women empowerment in agricultural farm mechanization were held in August 2017. The FGDs revealed that there is a potential opportunity to engage women in helping the operators of mini-combine harvesters by loading and unloading of rice bags with the harvesting machines and the transport of rice bags and straw from the field to homesteads.

(6) Capacity Building:

(a) Training manuals for transplanting, harvesting, and CA machinery have been developed in English and Bengali. The manuals will be printed soon for distribution among stakeholders in the field.

(7) Lessons Learned:

(a) Prolonged flooding and heavy rainfall have had significant impacts on rice production and ASMIH work in Bangladesh. The use of the transplanter in the ASMIH study areas was limited during the Aman season (November-December 2016) due to prolonged floods. During this period, there was also scarcity of quality paddy seed available due to flooding and consequently reduced harvests in the previous Aman season (November-December 2015).

(b) Soils in Dumuria are a clay-loam type, which made the use of the zero till planter difficult. Selection of an appropriate rice planting method was dependent upon the environment.

(c) In the dry season, fresh water irrigation was a major challenge due to salinity in rivers and canals.

(8) Presentations and Publications:

(a) Hossain, M., Hossain, M., Amin, M., Saha, C. K., Alam, M., & Mottalib, A. (2017). Appropriate Conservation Machinery and Water Management systems for Rice based Cropping Pattern in the Southern Delta of Bangladesh. Bangladesh Agricultural University Research Progress Workshop, Mymensingh, Bangladesh.

(b) Hossain, M. et al. Appropriate Conservation Machinery and Water Management systems for Rice based Cropping Pattern in the Southern Delta of Bangladesh. Bangladesh Agricultural University Research Progress Workshop, Mymensingh, Bangladesh.

(c) Hossain, M., Amin, M., Hossain, M., Motalib, M., Alam, M., & Saha, C. K. (2017). Appropriate conservation machinery for rice based cropping pattern in the southern delta of Bangladesh.

(d) Ali, M., Alam, M., Saha, C. K., & Hasan, M. (2017). Appropriate Rice Harvesting Machinery for Southern Delta of Bangladesh. Proceedings of the Workshop of BAU Research Progresses, Mymensingh, Bangladesh.

(e) Hossain, M., M., Saha, C. K., Alam, M., & Sarker, S. (2017). Appropriate Rice Transplanting Machinery for Southern Delta of Bangladesh. Bangladesh Agricultural University Research System (BAURES) Research Progress Workshop, Mymensingh, Bangladesh.

(f) Alam, M., Saha, C. K., Hossain, M., Ali, M., M.... (2017). Appropriate Scale Agricultural Mechanization in Southern Delta of Bangladesh: A Methodical Approach. 2017 ASABE Annual International Meeting, Spokane, Washington, USA.

(g) Alam, M, et al. Appropriate Scale Mechanization Innovation Hub (ASMIH) – Bangladesh.

(h) Ali, M., Hasan, M., Saha, C. K., Alam, M., Kalita, P., & Hansen, A. (2017). Mechanizedice Harvesting Opportunity in Southern Delta of Bangladesh. 2017 ASABE Annual International Meeting, Spokane, Washington, USA. doi:DOI: 10.13031/aim.201700596.

(i) Hossain, M., Elahi, M., Sarkar, S., Saha, C. K. et al. (2017). Options for Rice Transplanting in Puddled and Un-puddled Soil. 2017 ASABE Annual International Meeting, Spokane, Washington, USA. doi:doi:10.13031/aim.201700771.

(j) M., Hossain, M., Sarkar, S., Saha, C. K., Alam, M., Kalita, P., & Hansen, A. (2017). Seedling Raising Techniques at Farmers' Level for Mechanical Transplanting. 2017 ASABE Annual International Meeting, Spokane, Washington, USA. doi:doi:10.13031/aim.201700770.

3. ASMC – Burkina Faso

(1) Name: Appropriate Scale Mechanization Innovation Hub – Burkina Faso

(2) Locations

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

(b) Field location: Koumbia, Burkina Faso

(3) Description: 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.

(4) Collaborators: Polytechnic University of Bobo-Dioulasso (Burkina Faso), Tiller's International (United States)

(5) Achievements (See FY 2017 AWP Objective 3):

(a) A single row animal-drawn planter was built and adapted to local conditions. The planter operates on the same technology as the locally available planters made with Malian gearboxes that sell for twice the price.

(b) A between-row weeder was built and adapted to local conditions. The weeder was based on a commonly available three shovel design, with new low-crown and low-angle sweeps. Testing revealed that the new sweeps contributed 20% greater coverage while requiring 21% less draft power to pull them through the field and contributed to stability and depth control. Weed knockdown and root exposure appeared to be much higher with the new sweeps as well. Reduced draft requirements contributed to animal comfort and reduced fatigue, allowing the oxen to walk in straighter rows for longer durations of work.

(c) In response to farmers' perception of more erratic rainfall, an inexpensive ripping plow with a crumbler basket was redesigned and built with local blacksmiths. This new ripper was designed around locally available and inexpensive materials (primarily concrete reinforcing rod) based on a ripper design that Tillers International had found to work well in other countries. Relative to the extant ripping plows, the new design was more stable and controllable while not requiring noticeably more force.

(6) Capacity Building:

(a) Four local blacksmiths were selected and trained in the manufacture, design, and repair of the developed technologies. This promotes long-term sustainability of the tools and continuous improvement of the designs.

(b) Project leaders from Tillers International and Michigan State University led trainings in March 2017 to instruct trainees on how to build and utilize an animal-drawn ripper and planter.

(c) Post-harvest trainings also took place in March 2017 on topics related to the principles of grain storage for smallholder farmers including grain drying, storage equipment, pest control for insect and rodents, and fumigation.

(7) Lessons Learned:

(a) In Burkina Faso, the Innovation Hub model has proved to be an effective platform for local stakeholders (farmers, researchers, students, farmers' organizations, local blacksmiths, and banks) to collaborate with U.S. university partners to make rapid progress in the area of agricultural mechanization.

(8) Presentations and Publications:

(a) None to report in FY 2017.

4. ASMC - Cambodia

(1) Name: Appropriate Scale Mechanization Innovation Hub – 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: Royal University of Agriculture (Cambodia), CASC (Cambodia), CIRAD (France), Ministry of Agriculture Forestry and Fisheries (Cambodia), University of Battambang (Cambodia)

(5) Achievements (See FY 2017 AWP Objective 3):

(a) A power tiller operated rice seeder and tractor operated seeder have been developed and transferred to CASC/CIRAD and RUA for testing. The next step is to adapt the seeders to be no-till and suited for use in CA systems.

(b) An assessment of existing bucket scrapers in Cambodia was conducted to collect feedback from stakeholders to determine opportunities for new, improved prototypes.

(c) Different rice establishment methods, including conventional direct seeded mulch based cropping (DMC), sowing using a no-till planter and broadcasting seed using two different broadcasters are currently being tested and compared. The efficiency of the methods will be assessed at the end of the rice cropping season in November/December 2017.

(d) A time-motion study and task analysis of conservation agriculture vegetable production is currently underway. The study includes development of software that applies image processing to measure joint angles of farmers to assess posture.

(6) Capacity Building:

(a) A consultation workshop for curriculum development for Agricultural Engineering at RUA was conducted. Some equipment was requested by lecturers and later purchased to add a practical element to the classroom theories.

(b) In February 2017, the Department of Agricultural Engineering, Ministry of Agriculture, Forestry and Fisheries organized a machinery/equipment demonstration to stakeholders at Kbal Po Agricultural Engineering Center. The prototypes of the seeders developed by ASMC Cambodia were demonstrated with other equipment such as a laser leveling system, biochar kilns, rice transplanters, etc.

(c) In May 2017, 22 third-year RUA students participated in a five-day field trip to Battambang and Siem Reap to explore various machinery options for agricultural production, particularly conservation agriculture.

(7) Lessons Learned:

(a) In relation to Achievement (b), it was concluded that if CASC/CIRAD and RUA are going to test new prototypes of the bucket scraper, they must have the laser systems (which are not currently owned by the involved partners). It was also noted that too much rainfall, which causes flooding of paddy fields, obscures use of bucket scrapers.

(b) In regards to Achievement (a), the rice seeder prototypes, which were designed to be low-cost and easy to maintain, were configured to operate on well-prepared soil. It will be a challenge to adapt the prototypes to be no-till, while keeping purchasing and maintenance costs to a minimum.

(8) Presentations and Publications:

(a) None to report in FY 2017.

5. ASMC - Ethiopia

(1) Name: Appropriate Scale Mechanization Innovation Hub – Ethiopia

(2) Locations

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

(b) Field locations: Bahir Dar and Dangashita (Ethiopia)

(3) Description: 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) Collaborators: Bahir Dar University (Ethiopia), Bahir Dar Institute of Technology (Ethiopia), Feed the Future Innovation Lab for Small Scale Irrigation (United States), International Water Management Institute

(5) Achievements (See FY 2017 AWP Objective 3):

(a) Graduate students at the Bahir Dar Institute of Technology conducted initial research and designs 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 producing machine. In the future, the ASMIH will focus efforts on the PTO maize sheller, animal-drawn single line maize and fertilizer drill, and fodder producing machine.

(b) Led by a gender expert, three focus group discussions were held in different kebeles as part of ongoing research on implications of mechanization on female farmer productivity. The discussions identified some technology needs for female farmers. One is a coffee grinding machine to reduce time and energy of female farmers, and the other is an improved stove that will help in improving the efficiency of household cooking.

(c) The Majipump (solar powered, low cost, energy efficient irrigation pump), designed and manufactured in the U.S., was demonstrated for farmers in Bahir Dar as well as two communities outside of Bahir Dar. This generated high demand for the pump, and now 50 Majipumps will be purchased, disseminated, and tested in the selected communities.

(6) Capacity Building:

(a) The ASMIH-Ethiopia has created a new curriculum for the Agricultural Mechanization Engineering graduate program at Bahir Dar University, which was approved by the university senate and is now under national review.

(b) After observing potential safety issues in the previous reporting period on the use of mechanization tools and protective gear, safety protocols were developed for all lab work, including advisement of proper personal protective equipment.

(7) Lessons Learned:

(a) Initial research and development of agricultural machinery can be conducted by students at Bahir Dar Institute of Technology, but engagement of faculty and the private sector is necessary to scale work beyond the prototype stage.

(8) Presentations and Publications:

(a) None to report in FY 2017.

C. Focus Country Research Subawards

1. Bangladesh

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

(2) Location: Polder 30 in the Khulna district of Bangladesh

(3) Description: 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) Collaborators: IRRI (Bangladesh), BRAC (Bangladesh), Khulna University (Bangladesh), Kansas State University (United States)

(5) Achievements (See FY 2017 AWP Activity 4.4):

(a) The project has created an enabling environment for early establishment of rabi crops by introducing high yielding varieties (HYV) of rice in the wet season and empowering water management organizations to the water environment in polders through drainage. Most farmers who opted to grow HYV rice and were in a position to harvest early were able to achieve a rabi crop (only 28% fallow), while most farmers growing the traditional long duration rice had their land fallow (70% fallow). This suggests that there is an opportunity in similar polders to introduce a rabi crop with improved and moderately mechanized rice management.

(b) Although there was excitement with the introduction of the mechanical transplanter and mat nursery as an additional source of income, the reaper introduced to reduce the drudgery of rice harvest was received with great excitement, with a few farmers interested in purchasing the unit and taking up the role of service providers.

(c) The project arranged for the private company ACI Motors Limited to visit polder 30 to provide training on a battery operated sprayer and the PTOS. The engagement of ACI Motors Limited also prompted the project to discuss the potential for the company to consider introducing simple machinery and presenting opportunities for expansion.

(d) The project conducted demonstrations and adaptive trials on the rice and fish cultivation system, utilizing both individual farmer and community models in 2016-2017. Although the community model did not result in profit gains, it reported a better rice yield for the year. The individuals that farmed fish were able to make a modest profit. In both models, approximately 30% of the fish harvested was consumed.

(6) Capacity Building:

(a) The project has engaged primary school children as well as teachers in nutrition trainings, which have focused on creating awareness on the importance of micronutrients, high-nutrient rice, and the benefits of biofortified rice to children and their mothers.

(b) Training events were also organized to discuss the consumption of nutritious rice, mungbean (pulse crop) and sunflower oil and its impact on children, lactating and pregnant mothers.

(c) Eight M.S. students and three Ph.D. students are currently conducting research in the polders of Bangladesh with support from the project.

(7) Lessons Learned:

(a) As observed in the ASMIH-Bangladesh project, heavy flooding and rainfall events affected the project and agriculture production in Polder 30. Flooding delayed both transplanting and harvesting of rice, and excessive rains in April/May 2017 created a waterlogging environment that destroyed 16% of rabi crops. The SIIL Polder team is empowering water management organizations to improve the water environment in the polder ecosystems to alleviate some of the observed issues.

(b) In the rice and fish cultivation system, social conflict was identified as one of the barriers for proper implementation and optimization of system benefits. For example, the community model relies on proper control of fish to prevent escape from the watershed.

(c) The students recruited to conduct their graduate research in the polders do not have experience living or working in the region, so the SIIL Polder project has been mentoring the students as well as their advisors to improve their knowledge, skills and attitudes on the polder ecosystem and local communities.

(8) Presentations and Publications:

(a) Yadav, S. (2016). Polder Tidings, 1(2).

(b) Yadav, S. (2017). Polder Tidings, 2(1).

2. Burkina Faso

(1) Name: 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) Location: Dori and Ouahigouya districts, Burkina Faso

(3) Description: 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) Collaborators: Institut de l'Environnement et de Recherches Agricoles (Burkina Faso), The International Union for Conservation of Nature (IUCN) (Burkina Faso), University of Wisconsin, Madison (USA), Fédération Nationale des Groupements Naam (FNGN) (Burkina Faso), and Association pour la Promotion de l'Elevage en Savane et au Sahel (APESS) (Burkina Faso)

(5) Achievements (See FY 2017 AWP Activity 4.5):

(a) Participatory on-farm farmer-managed agronomic trials continued in FY 2017, utilizing an improved dual purpose cowpea variety (Kvx-745-11p) and improved sorghum variety (Sariasso). Incorporating experience from FY 2016, the experimental design was revised to three treatments: Control - only improved cowpea and sorghum varieties; Level 1 - Improved crop varieties with soil conservation techniques (zai and manure); Level 2 - Improved crop varieties with soil conservation, manure and fertilizer application.

(b) A study assessing the efficiency of water use for livestock production under three livestock management systems – free range, sedentary, and transhumance – was conducted in two communities in each of the two project sites. The study data is currently being analyzed.

(c) A tradeoff analysis of different intensification interventions and their possible effects on the income and food security of different farm household groups was conducted.

(d) Analysis of socio-economic aspects behind variation in natural resource management and nutrition. The building of a GIS of the location of villages within the two study provinces has been completed tied to population data from the most previous national census (2006). A supervised classification approach has been developed and tested using the Google Earth Engine to distinguish cropped/recently-cropped fallows from uncropped land (using the different seasonal timing of green-up and brown-down among these land cover types).

(6) Capacity Building:

(a) Two Master's students from the University Polytechnic, Bobo-Dioulasso have completed their thesis research, which focuses on the analysis of factors affecting costs and benefits of productivity-enhancing interventions in agro-pastoral systems.

(b) A PhD student was recruited to study the effects of intensification options on gender and household nutrition in the Sahel.

(c) Multiple short-term training events took place in FY 2017, including training of farmers in soil and water conservation techniques, training of trainers in how to operationalize farmers' field schools, educating women on best nutrition practices, and training of research and students in farming systems analysis.

(7) Lessons Learned:

(a) Market participation was the single-most influential farm-based determinant of income and was associated with both household food insecurity access score and diet diversity.

(8) Presentations and Publications:

(a) None to report in FY 2017.

3. Cambodia

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

(2) Location: Banan district (Battambang province), Puok district (Siem Reap), and Stung Chinit (Kampong Thom province)

(3) Description: 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) Collaborators: University of Tennessee Institute of Agriculture (UTIA) (United States), Agricultural Development Denmark Asia (ADDA), World Vegetable Center (AVRDC), Asia Impact Center – ECHO (Cambodia), Kasetsart University (Thailand), Royal University of Agriculture (Cambodia), Conservation Agriculture Service Center (Cambodia), University of Battambang (Cambodia)

(5) Achievements (See FY 2017 AWP Activity 4.6):

(a) A key component of SI technology and practice in Southeast Asia includes the conservation and utilization of neglected and underutilized species (NUS). During this reporting period, the project established key NUS crop nutrient profiles, secured additional funding to analyze agronomic NUS value chains, and developed a strategy to include horticultural NUS into the Wild Garden research plan. The Wild Garden project is a collaboration with the World Vegetable Center that aims to sustainably intensify underutilized land at the household and village scale.

(b) The project worked to expand conservation agriculture (CA) practices as a component of SI adoption, particularly among smallholder women farmers. The number of cooperating women farmers utilizing CA increased, key training and demonstration events were conducted in new target areas, and new collaborations were established.

(c) Research continues on the diversification of rice with green manure cover crops (GMCC) and relay crops in collaboration with CIRAD and RUA. A project-supported Master's student is currently analyzing the impact of selected green manure cover crops and relay crops on a variety of soil health parameters.

(6) Capacity Building:

(a) One B.S. student, two M.S. students, and one Ph.D. student are supported by the WAgN Cambodia project.

(b) Meetings were conducted with officials in the Ministry of Education, Youth and Sport and the Ministry of Agriculture, Forestry and Fisheries to discuss constraints and opportunities to enhance the agriculture curriculum in Cambodia's agricultural education and training system. Priority areas were identified and appropriate curriculum resources (such as 4-H training modules) will be reviewed.

(c) A series of three vegetable grafting workshops were conducted in March 2017 for farmers, Master's of Sustainable Agriculture university students, and staff of the IPM Innovation Lab. These trainings were conducted because vegetable grafting technology holds promise for the production of high value tomatoes during the rainy season in Cambodia.

(d) The project visited 3 CE SAIN Technology Parks and met with the farm managers. The project plans to developing training in SI principles for the farm managers, including a week-long training workshop in November 2017 at ECHO Asia.

(7) Lessons Learned:

(a) Forces beyond the control of the WAgN project often influence the decision-making of smallholder women. For example, market forces which influence vegetable prices often determines willingness to consider certain production practices or decisions.

(b) Sustainable intensification of rain-fed paddy rice with green manure cover crops and relay crops is an untapped opportunity for Cambodian farmers, large and small. There is still much to learn regarding GMCC establishment, performance and market engagement in Cambodia. Specifically, little is known about the value chains for key GMCC, and this is a potential key constraint to adoption.

(8) Presentations and Publications:

(a) Bates, R.M. & Bicksler, A. (2017). Crop Biodiversity: A Foundational Component of Sustainably Intensified Farming Systems. Working Session on Sustainable Intensification, Soil Health Assessment and Underutilized Species, Royal University of Agriculture, Phnom Penh, Cambodia.

(b) Bates, R. M. & Ader, D. R. (2016). 'Strengthening Informal Seed Systems to Conserve Agrobiodiversity in Southeast Asia' / 'Small Farm Resource Centers as an Important Extension Tool '. CE SAIN Lecture Series: Biodiversity Conservation, Royal University of Agriculture, Phnom Penh, Cambodia.

4. Ethiopia

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

(2) Location: Robit and Dangishta, Ethiopia

(3) Description: 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.

(4) Collaborators: North Carolina Agricultural and Technical State University (United States), Feed the Future Innovation Lab for Collaborative Research on Nutrition in Africa (United States), Feed the Future Innovation Lab for Small Scale Irrigation (United States), Bahir Dar University (Ethiopia), International Water Management Institute (IWMI), International Food Policy Research Institute (IFPRI), International Livestock Research Institute (ILRI)

(5) Achievements (See FY 2017 AWP Activity 4.7):

(a) Collaborators at the Tufts Medical School and IFPRI completed the baseline household surveys as well as malaria and anemia tests that will add an emphasis on nutrition outcomes to the ILSSI protocol and the Integrated Decision Support System (IDSS).

(b) The FARMSIM model is being expanded to have a more robust human nutrition component to better use the new data generated from Achievement (a). FARMSIM will simulate the farm family as a total system for both wet and dry seasons, moving past just irrigation assessment, to evaluate the food available to the household, including the staple crops.

(c) Field research on fodder-livestock systems has been expanded to include over 200 participating farmers in FY 2017 (up from less than 50 in FY 2016). The majority of the farmers participating in FY 2016 expanded their area of land allocated to irrigated fodder from 100m^2 to up to 1000m^2. Additionally, approximately 50 commercial home vegetable gardens have been established in collaboration with the ASMC. In Robit, farmers have grown cabbage for three seasons. In the cabbage trials, significantly higher yields, lower irrigation water use, and lower labor inputs have been required under conversation agriculture practices compared to conventional tillage. Data from both trials, fodder-livestock and commercial home gardens, will be incorporated into the APEX and FARMSIM models.

(d) Under ILSSI, a dashboard approach is being developed to provide decision makers with a readily useable method of employing the power of the IDSS in a simplified format for decisions at multiple levels of scale.

(6) Capacity Building:

(a) In collaboration with ILSSI, formal training on the IDSS is being provided to faculty and students at Bahir Dar University. Additional training on use of the IDSS with the Agricultural Transformation Agency is also planned.

(7) Lessons Learned:

(a) Field studies inherently are always subject to problems associated with farmer-induced changes in management during a given growing season.

(b) There is great value in partnering with the ASMC to continue research on commercial home vegetable gardens. However, because the scopes of the ASMC and SIPSIN projects differ slightly, each group has to closely monitor the field trials to ensure that their respective objectives and data collection processes are maintained.

(8) Presentations and Publications:

(a) None to report in FY 2017.

5. Senegal

(1) Name: 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) Location: Louga, Diourbel, Kaffrine, Kedougou, Kolda and Sedhiou regions in Senegal

(3) Description:

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

(5) Key Achievements (See FY 2017 AWP Activity 4.8):

(a) Agronomic field trials of five pearl millet accessions (two local varieties and three new dual-purpose were initiated in Bambey, Nioro, and Sinthiou Maleme. Field days allowed local farmers the opportunity to see the tested varieties and to ask the millet breeder and project agronomists about growth characteristics and cultural management practices.

(b) A sheep feeding trial was conducted using the dual-purpose millet varieties (see item (a)) at the University of Thies.

(c) Chemical analysis of five millet varieties was conducted. It was found that two of the new dual-purpose varieties contained higher zinc and iron content than the traditional varieties. Bioavailability studies of zinc and iron will be conducted by Kansas State University in FY 2018.

(d) Socioeconomists in Senegal and the U.S. finalized the baseline field surveys. Moving forward, subaward Co-PIs will work to identify barriers to adoption and to conduct an economic evaluation of the technology interventions in the project areas.

(6) Capacity Building:

(a) The project's gender and extension specialist provided training to smallholder female farmers on the topics of silage making and the enrichment of millet flour.

(b) Several graduate students are supported by the project. Their research includes: studying intercropping of dual-purpose millet with leguminous crops, dual-purpose millet root physiology, and nutrient recycling in crop-livestock systems.

(c) Madame Dieye Mbengue, the project's gender and extension specialist, was invited to spend three weeks in Kansas in September 2017 to meet with agronomy faculty, students, and gender specialists at Kansas State University and discover opportunities to improve extension practices in Senegal.

(7) Lessons Learned:

(a) None to report in FY 2017.

(8) Presentations and Publications:

(a) Min, D., Faye, A., & Prasad, P.VV. (2017). Adoption of sustainable intensification in dual-purpose millet, leguminous crops, and livestock systems for rural small holder farmers in Senegal. International Conference on Sustainable Agriculture Systems and Rural Development, Amsterdam, the Netherlands.

(b) Faye, A., Laplaze, L., & Min, D. (2017). Development of a model for pearl millet root phenotyping in field conditions. International Sustainable Intensification, Dakar, Senegal.

(c) Vayssiere, J., Wade, C., & Min, D. (2017). Multi-level (plot-farm-landscape) analysis of the role played by livestock within sustainable intensification of mixed cereal-legume-ruminant systems in the groundnut basin of Senegal. International Sustainable Intensification Conference, Dakar, Senegal.

(d) Mofini, M., Lapalze, L., & Min, D. (2017). Role of arbuscular mycorrhizal symbioses on pearl millet nutrition. International Sustainable Intensification Conference, Dakar, Senegal.

(e) Min, D., Faye, A., Sy, O., Diaw, M. T., Sall, M., et al. (2017). Sustainable intensification in dual-purpose millet, leguminous crops livestock systems for rural small holder farmers in Senegal. Sustainable Intensification Conference, Dakar, Senegal.

(f) Wade, C., Vayssières, J., Faye, A., Lecomte, P., Tandiang Diaw, M, et al. (2017). Evaluation of the role played by livestock in the sustainable intensification of mixed crop-livestock systems through multi-level analysis of the nutrient cycles. Sustainable Intensification Conference - Biodiversity and ecological engineering for sustainable intensification of agriculture, Dakar, Senegal

6. Tanzania

(1) Name: Raising crop response: bidirectional learning to catalyze sustainable intensification at multiple scales (PI: Sieglinde Snapp, Michigan State University)

(2) Location: Babati, Iringa rural, Mufindi, Wanging'ombe, Njombe rural, Songea rural, Mbeya rural, and Mbozi districts in Tanzania

(3) Description: 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) To generate improved agronomic knowledge of practices that sustainably raise maize and bean yields and crop response to inorganic fertilizer.

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

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

(d) To 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) Collaborators: Sokoine University of Agriculture (SUA) (Tanzania), Wageningen University and Research Center (Netherlands), CIAT-Tanzania, The Nelson Mandela African Institution of Science and Technology (NM-AIST) (Tanzania), International Institute of Tropical Agriculture (IITA)

(5) Achievements (See FY 2017 AWP Activity 4.9):

(a) A survey of 630 farmers and maize or maize-legume fields was conducted for the baseline year in collaboration with CIMMYT and the Tanzania national ministry of agricultural scientists. Socioeconomic parameters and soil samples were also collected and are currently 90% analyzed by the project. The yield data is being analyzed by CIMMYT and will be available soon.

(b) A baseline survey of 224 village based advisor famers was conducted, along with a two-part training on agronomy and participatory extension methodology. These activities were completed in collaboration with CIAT, FIPS (a collaborating NGO), agro-input suppliers, and the Tanzania national ministry of agricultural scientists.

(c) Thom Jayne and Sieg Snapp participated in the Tanzania 3rd Annual Agricultural Policy Conference in March 2017. During the event, they engaged in conversations with Tanzanian government officials and academic leaders about the implications of agricultural policy recommendations.

(6) Capacity Building:

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

(7) Lessons Learned:

(a) In a project that incorporates national and international scientists, an NGO, and an agro-input supplier, significant time and effort is required to build mutual understanding of the training objectives, budget, and activities.

(b) In the training of village based advisor farmers, some participants did not fully achieve the intended learning outcomes and therefore field work and data collection was difficult. Evaluation of how and why the learning gaps were generated will be necessary to prevent related issues in the future.

(8) Presentations and Publications:

(a) Jayne, T. (2016). Maize, fertilizer, and sustainable agricultural intensification. Indicators for the Sustainable Intensification of Agriculture, MSU East Lansing, MI, USA.
(b) Mason, N. & Kim, J. (2016). Sustainable intensification and nutritional impacts: nationally representative data from Tanzania. MSU working paper – student dissertation chapter, MSU East Lansing, MI, USA.
(c) Snapp, S. (2017). Bidirectional learning: Raising the maize and bean system bar. African Alliance Partnership Launch, Dar es Salaam, Tanzania.

D. Developing Indicators for Sustainable Intensifications

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

(2) Location: N/A

(3) Description: The project's primary goal is 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) Collaborators: Columbia University and Michigan State University (United States)

(5) Achievements (See FY 2017 AWP Activity 4.3):

(a) The Guide for Sustainable Intensification Assessment Framework was refined utilizing feedback from in-country trainings, as were the accompanying training tools. A number of proxy measures were added to the Guide in addition to alternative methods for collecting data to estimate an indicator.

(b) Project leaders presented at the National Socio-Environmental Synthesis Center on how the SI Assessment Framework can guide development of a new sustainable agriculture framework at the national scale to ensure holistic assessment.

(c) A book chapter focused on the application of the framework at different stages of project implementation was developed.

(6) Capacity Building:

(a) An initial training for SIIL subawardees was held at the 2017 SIIL Annual Meeting. The training introduced the subawardees to the methods and metrics of the SI Assessment Framework.

(b) In April 2017, two trainings for SIIL subawardees were conducted in Cambodia and Senegal. The trainings aimed to introduce participants to the theoretical aspect of the SI assessment framework, how it can be utilized to assess innovations, and how to use the methods manual to collect data and estimate indicators and metrics.

(7) Lessons Learned:

(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) Presentations and Publications:

(a) Grabowski, P., Snapp, S., Palm, C., Musumba, M., Chikowo, R., & Bekunda, M. (2016). Evaluating 'climate-smart' agricultural technologies with indicators of SI: Examples from Southern Africa. American Society of Agronomy, Phoenix, AZ, USA.

(b) Grabowski, P., Snapp, S., Bekunda, M., Chikowo, R., Smith, A., Anders, E., & Sirrine, D. (2016) Maize yield and profitability tradeoffs with social, human and environmental performance: Is sustainable intensification feasible?. Agricultural Systems (In review).

(c) Grabowski, P., Musumba, M., Palm, C., & Snapp, S. (2016) Sustainable agricultural intensification and measuring the immeasurable: Do we have a choice?, Sustainability Indicators. Routledge.

(d) Musumba, M., Palm, C., Snapp, S., & Grabowski, P. (2016). Sustainable Agricultural Intensification for Improved Food and Nutritional Security. American Society of Agricultural and Biological Engineering (ASABE) -- Engineering and Technology Innovation for Global Food Security conference, Stellenbosch, South Africa.

(e) Snapp, S., Grabowski, P., Palm, C., Musumba, M., Chikowo, R., & Bekunda, M. (2016). Are We There Yet? Sustainable Intensification Indicators Role in Feeding the Future. American Society of Agronomy, Phoenix, AZ, USA.

Snapp, S. (2017). Targets and metrics for sustainability: Experiences and lessons from Africa RISING. SIMLESA meeting, Arusha, Tanzania.

VI. Associate Award / Mission Buy-Ins Research Project Reports

SIIL has no new Associate Awards to report for FY 2017. The associated awards received last year from USAID-Cambodia Mission; and USAID-Malawi Mission were continued and reported in other sections in this report.

VII. 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	Hermetic storage and a community seed bank model	Producers	66	41	107
Bangladesh	Nutrition awareness	Producers	0	187	187
Bangladesh	Mechanical harvester: use of reaper for harvesting rice	Producers, civil society	84	66	150
Bangladesh	Power tiller operated seeder for sowing seeds of rabi crops	Producers	15	6	21
Bangladesh	ASM training on harvesting machines	Private sector, civil society	4	0	4
Bangladesh	ASM demonstration of reaper and mini-combine harvester	Producers, government, private sector	24	2	26
Bangladesh	ASM training and demonstration of seedling care techniques in Dumuria	Producers, civil society	7	2	9
Bangladesh	ASM training and demonstration of seedling care techniques in Barishal	Producers, private sector	9	2	11
Bangladesh	Training on conservation agriculture machinery for mungbean planting	Producers, government	12	7	19
Bangladesh	Operators and mechanic training on mechanical rice harvesting at Dumuria	Producers, private sector	11	0	11
Bangladesh	Operators and mechanic training on mechanical rice harvesting at Wazirpur	Producers, private sector	10	0	10
Bangladesh	Training on rice seedling raising for transplanting at Dumuria, Khulna	Producers, government, private sector, civil society	15	3	18
Bangladesh	Training on rice transplanter operation in Dumuria	Producers, government, private sector, civil society	14	4	18
Bangladesh	Hands on training on CA machinery for Agricultural Machine Operator, 2017	Producers, private sector, civil society	16	1	17
Bangladesh	Training on seedling raising for rice transplanter at Wazirpur, Barishal	Producers, government, private sector, civil society	10	7	17
Bangladesh	Training on rice transplanter operation at Wazirpur, Barishal	Producers, government, private sector, civil society	14	3	17
Bangladesh	Hands on training on CA machinery for Agricultural Machine Operators at Dumuria, Khulna	Producers, private sector, civil society	16	1	17
Bangladesh	Hands on training on CA machinery for Agricultural Machine Operator	Producers, government	13	1	14
Bangladesh	Food Security Monitoring Training for Household Survey in Bangladesh	Government, private sector, civil society	15	7	22
Burkina Faso	Training on reduction of postharvest losses in maize	Producers, government, civil society	16	4	20
Burkina Faso	Workshop and training of students and local artisans on rippers and planters	Producers, private sector, civil society	20	18	38

Burkina Faso	Workshop and training session on conservation cropping systems	Producers, government, private sector, civil society	5	9	14
Burkina Faso	Farmers' Field School	Producers, government, civil society	16	4	20
Burkina Faso	Training workshop on Farming Systems Analysis	Government, civil society	8	8	16
Burkina Faso	Training on fodder conservation	Producers, civil society	14	11	25
Burkina Faso	Techniques of fattening sheep and cattle (in Dori)	Producers, government, private sector, civil society	17	3	20
Burkina Faso	Techniques for fattening sheep and cattle (in Ouahigouya)	Producers, government, civil society	49	6	55
Burkina Faso	Techniques for sorghum and cowpea production (in Ouahigouya)	Producers, government, civil society	53	6	59
Burkina Faso	Techniques for cowpea and sorghum production (in Dori)	Producers, government, civil society	49	6	55
Burkina Faso	Best nutrition practices	Producers	42	167	209
Cambodia	Concepts of Sustainable Agricultural Intensification and Gender	Civil society	13	7	20
Cambodia	Promotion of neglected and underutilized perennial vegetables for improved nutrition	Producers, private sector, civil society	9	8	17
Cambodia	Use of green manure cover crops and relay crops to diversity rainfed rice and upland cassava production	Producers, government, private sector, civil society	33	15	48
Cambodia	Vegetable Grafting: An Important IPM Tool for Cambodia	Producers, government, civil society	10	6	16
Cambodia	Machinery demonstration at Kbal Po Agricultural Engineering Center	Producers, government, private sector, civil society	9	8	17
Cambodia	Mechanization in conservation agriculture training	Government, private sector, civil society	32	7	39
Cambodia	Vegetable grafting for rainy season tomato production	Producers, civil society	11	10	21
Cambodia	Employing SI technologies to improve small farm profitability	Producers, civil society	29	26	55
Cambodia	Sustainable Intensification Assessment Training – Cambodia	Civil society	18	6	24
Ethiopia	Farmers' postharvest loss training	Producers, government	136	21	157
Ethiopia	Training on Sheller machine	Producers, government	135	21	156
Ethiopia	Training on Majipump	Producers, government	10	8	18
Ethiopia	Advanced Training on the use of IDSS	Civil society	33	10	43
Ethiopia	Training in Field boundary mapping in Ethiopia	Private sector	12	2	14
Malawi	Training of Africa RISING scientists on the use of SI indicators	Civil society	12	4	16
Senegal	Effective silage making training	Civil society	19	6	25

Senegal	Millet flour enrichment training	Producers, government, civil society	15	23	38
Senegal	Effective Silage Making Training	Civil society	19	6	25
Senegal	Concepts of Food Safety and Hygiene for Senegal	Civil society	3	4	7
Senegal	Sustainable Intensification Assessment Training - Senegal	Civil society	13	8	21
Tanzania	Village based advisor farmer training on participatory extension methodologies	Producers, government, civil society	154	68	222
United States	sUAS Flight Operations Training	Civil society	7	2	9
United States	Extending QGIS	Government, private sector, civil society	10	20	40
Total			**1386** *61%*	**878** *39%*	**2264**

B. Long-term training

Name (first, last)	Sex	University	Degree	Major	Program End Date (month/year)	Degree Granted (Y/N)	Home Country
Diedhiou, Mamdou	M	University of Gaston Berger of Saint Louis	Ph.D.	Agronomy	September 2019	N	Senegal
Dieng, Ibrahima	M	Cheikh Anta Diop University of Dakar	Ph.D.	Soil Chemistry	September 2019	N	Senegal
Nareth, Nut	M	Royal University of Agriculture	Ph.D.	Agriculture Engineering	June 2019	N	Cambodia
Niang, Khaly	M	University of Gaston Berger	Ph.D.	Applied Mathematics	September 2019	N	Senegal
Retting, Erica	F	University of California, Davis	Ph.D.	Agriculture and Resource Economics	September 2017	N	United States
Saper, Robert	M	University of California, Davis	Ph.D.	Sociology	September 2017	N	United States
Smith, Jamey	M	University of California, Davis	M.S.	International Agricultural Development	December 2017	N	United States
Taingaun, Sourn	M	Royal University of Agriculture	Ph.D.	Land Management and Administration	June 2019	N	Cambodia
Tiedeman, Kate	F	University of California, Davis	Ph.D.	Transportation Studies	September 2017	N	United States

Sarker, Ayesha	F	University of Illinois	Ph.D.	Agricultural and Biological Engineering	September 2019	N	United States
Napon, Katian	F	University of Ouagadougou	Ph.D.	Gender and Nutrition	October 2019	N	Burkina Faso
Nikiema, Patrice	M	University Polytechnic, Bobo-Dioulasso	M.S.	Agricultural Economics	October 2017	N	Burkina Faso
Toe, Yolande	F	University Polytechnic, Bobo-Dioulasso	M.S.	Agricultural Economics	October 2017	N	Burkina Faso
Channaty, Ngang	F	University of Battambang	M.S.	Sustainable Agriculture	December 2018	N	Cambodia
Saren, Ry	M	University of Battambang	B.S.	Agriculture	November 2020	N	Cambodia
Sel, Rechaney	F	University of Philippines, Los Banos	M.S.	Conservation and Gender	December 2018	N	Cambodia
Asamin, Tadisual	M	Bahir Dar University	M.S.	Engineering Hydrology	January 2018	N	Ethiopia
Kuraz, Feleke	M	Bahir Dar University	Ph.D.	Water Resources Management	October 2019	N	Ethiopia
Mamo, Ayele	M	Bahir Dar University	M.S.	Engineering Hydrology	January 2018	N	Ethiopia
Wondimnew, Addisu	M	Bahir Dar University	M.S.	Environmental Engineering	January 2017	Y	Ethiopia
Ahmed, Sujat	M	Sher-e-Bangla Agricultural University	M.S.	Agronomy	December 2017	N	Bangladesh
Aktar, Nasiba	F	Bangladesh Agriculture University	Ph.D.	Gender Research	February 2019	N	Bangladesh
Biswas, Monoj	M	Khulna University	M.S.	Agricultural Economics	June 2017	Y	Bangladesh
Habiba, Umme	F	Bangladesh Agriculture University	M.S.	Socio-economics	February 2018	N	Bangladesh
Hossain, Shakwhawat	M	Sher-e-Bangla Agricultural University	M.S.	Agronomy	August 2017	Y	Bangladesh
Nath, Deb	M	Bangladesh Agriculture University	Ph.D.	Water Governance	February 2019	N	Bangladesh
Rokonuzzaman, Mohammed	M	Bangladesh Agriculture University	Ph.D.	Agriculture Extension	January 2019	N	Bangladesh
Roy, Puja	F	Khulna University	M.S.	Agricultural Economics	December 2017	N	Bangladesh

Saha, Priyanka	F	Khulna University	M.S.	Agricultural Economics	December 2017	N	Bangladesh
Ba, Thiero	M	University of Thies	Ph.D.	Animal Science	September 2020	N	Senegal
Faye, Awa	F	Cheikh Anta Diop University	Ph.D.	Agronomy	March 2019	N	Senegal
Lo, Tala	M	University of Thies	M.S.	Ruminant Nutrition	April 2017	Y	Senegal
Mofini, Marie-Therese	F	University of Thies	Ph.D.	Agronomy	September 2019	N	Central African Republic
Tine, Fatou	F	University of Thies	Ph.D.	Agronomy	September 2019	N	Senegal
Wade, Coly	M	University of Thies	Ph.D.	Soil Fertility	September 2020	N	Senegal
Hamad, Said	M	Sokoine University of Agriculture	Ph.D.	Soil Science	December 2020	N	Tanzania
Mugi, Esther	F	University of Wageningen	Ph.D.	Agricultural Systems	June 2020	N	Kenya
Nord, Alison	F	Michigan State University	Ph.D.	Agroecology	December 2019	N	United States
Hasan, Md. Kamrul	M	Bangladesh Agricultural University	Ph.D.	Agricultural Engineering	September 2019	N	Bangladesh
Motalib, Md. Abdul	M	Bangladesh Agricultural University	Ph.D.	Agricultural Engineering	September 2019	N	Bangladesh
Noby, Md. Mahamudun	M	Bangladesh Agricultural University	M.S.	Farm Power and Machinery	December 2017	N	Bangladesh
Sarkar, Surajit	M	Bangladesh Agricultural University	Ph.D.	Agricultural Engineering	September 2019	N	Bangladesh
Ganou, Fatoumata	F	Polytechnic University of Bobo-Dioulasso	M.S.	Agriculture Engineering	June 2018	N	Burkina Faso
Sayaogo, Boureima	M	Polytechnic University of Bobo-Dioulasso	M.S.	Agriculture Engineering	July 2018	N	Burkina Faso
Ye, Victor	M	Polytechnic University of Bobo-Dioulasso	M.S.	Agriculture Engineering	June 2018	N	Burkina Faso

C. Institutional Development

(1) The ASMC remains actively engaged in building institutional capacity through curriculum development in Cambodia and Ethiopia. In Cambodia, the ASMC worked with the Agricultural Engineering faculty at RUA to improve the curriculum and to purchase equipment that supports student learning objectives. In Ethiopia, new curriculum has been developed for the Agricultural Mechanization Engineering graduate program at the Bahir Dar Institute of Technology.

(2) The WAgN project in Cambodia has partnered with members of the Ministry of Education, Youth, and Sport and the Ministry of Agriculture, Forestry, and Fisheries to improve Cambodia's agricultural education and training system.

(3) The CE SAIN maintains a primary objective of building human and institutional capacity at the Royal University of Agriculture in Cambodia. In FY 2017, the CE SAIN initiated 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. In time, these partnerships will ideally promote information dissemination and serve as a catalyst for new innovations.

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

VIII. Innovation Transfer and Scaling Partnerships

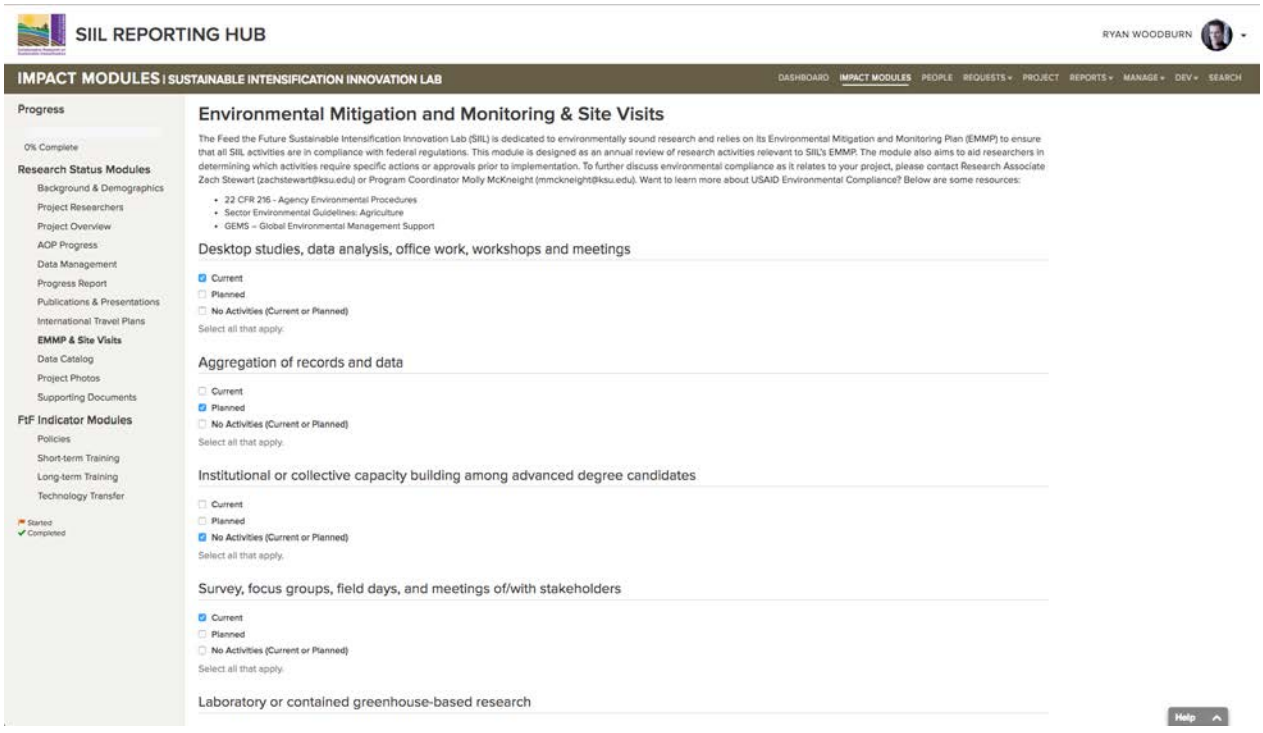
None to report in FY 2017. Most of the activities were focused on the developing and evaluating innovations that were developed collaborative with active partnerships from the host countries. Plans for innovation transfer and scaling partnerships are being actively discussed and will be emphasized in coming years.

IX. 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. Through this process, the SIIL management entity identified a need to provide subawards with greater knowledge and tools to improve EMMP compliance and reporting.

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. During a site visit of ASMC staff to partners in Ethiopia, the team identified safety concerns for individuals operating prototype machinery. In response, safety guidelines and training were provided to correct the issue.

The Piestar DPx system, which the SIIL utilizes for reporting and project monitoring, will undergo revisions of the EMMP module in FY 2018 to support this vision. The Piestar DPx updates include a new fertilizer, pesticide, and microbial inoculant purchase request/approval system. The annual environmental mitigation activity review will also be incorporated into the DPx system to ensure that project monitoring is streamlined and to optimize knowledge sharing within the SIIL management entity. A draft of the new EMMP module is shown below.



X. Open Data Management Plan

During FY 2017, the Sustainable Intensification Innovation Lab established the SIIL Dataverse to store and curate all SIIL sub-award datasets and serve as a data repository and access hub for the SI community in general. "Dataverse is an open source web application to share, preserve, cite, explore, and analyze research data. It facilitates making data available to others, and allows you to replicate others' work more easily. Researchers, data authors, publishers, data distributors, and affiliated institutions all receive academic credit and web visibility."

SIIL will require each subaward PI to upload all datasets starting in FY 2018 as part of the Piestar reporting system. Both complete and incomplete datasets will be collected biannually as part of the Piestar reporting hub system; however, only complete datasets will be uploaded to the SIIL Dataverse. Complete datasets that have been uploaded on the SIIL Dataverse will also be registered to the DDL in a timely manner - within 30 days after it has been used to produce an intellectual work or is of sufficient quality to produce an intellectual work.

Each complete dataset will be 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).

In regards to USAID's Data Development Library (DDL), the SIIL's Geospatial and Farming Systems Research Consortium submitted one dataset ("Tanzania Elevation and Surface Characteristics") in FY 2017. This dataset was used as a learning exercise, and additional GFC datasets will be submitted to the DDL once approval on the initial submission is obtained.

XI. 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 Associate 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 are below.

(1) Burkina Faso: Dr. Hamidou Traore's research aims to integrate available soil, water, plant and nutrient management practices in crop rotation to enhance sorghum yields for increasing cereal production. This research extends a long-term integrated multi-factor experiment established at the Saria research station (running for >50 years).

(2) Senegal: Dr. Aliou Faye has initiated a subaward 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.

(3) Tanzania: Jovin Lwehabura's 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. Mr. Lwehabura's study uses a geospatial approach to (1) identify locations where the introduced technologies are successful, (2) identify where farmers are interested in adoption of the technology, (3) identify biophysical and socioeconomic factors that correlate with technology success and adoption, and (4) identify potential areas of expansion with a similar enabling biophysical and socioeconomic environment for bean technology adoption.

B. Continued Expansion of Reporting Hub Tools

The SIIL Reporting Hub remains critical to the monitoring, evaluation, and learning of the program. As a result, the management entity dedicates significant time and energy contributing to its continuous improvement. To improve reporting and communication between the SIIL subawards and management entity, the following improvements to the Reporting Hub were made.

(1) Rich text support was added to certain modules of the Reporting Hub. While it is a simple change, feedback from users has been overwhelmingly positive. This modification has encouraged subawardees to develop more organized and detailed reports.

(2) A past limitation of the Reporting Hub was the lack of knowledge sharing within subaward project teams. To overcome this, a system modification was made to allow project members to view one another's reported data.

(3) A searchable database of SIIL contacts was created and embedded into the Reporting Hub to help the SIIL community track common contacts and enable future network analysis.

(4) A new budget modification request form was added to the Hub to streamline communication and protocols.

C. Growth of SIIL Communication Platforms

The SIIL website continued to attract a stable number of visitors throughout FY 2017, with over 3700+ unique visitors from 122 countries. Social media platforms expanded significantly, with the number of followers on Facebook and Twitter platforms more than doubling during FY 2017. The SIIL now has over 300 followers on Twitter and nearly 500 followers on Facebook, and regularly posts project updates, event highlights, and other announcements through the platforms. The SIIL will hire a Communications Coordinator in FY 2018 to increase engagement and project information dissemination through Agrilinks, the SIIL website and blog, social media platforms, and more.

XII. Other Topics

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

(1) Goal/Program Description

The Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) – housed in Cambodia's Royal University of Agriculture – helps improve food and nutritional security in Cambodia by supporting agricultural research and education and also fostering innovation. CE SAIN works closely with the Royal University of Agriculture (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 the quality of soil, water and biodiversity. CE SAIN's three core objectives are:

- Coordinate and leverage Innovation Labs and other USAID-funded SAIN activities.
- Build human and institutional capacity of the RUA.
- Establish Technology Parks to showcase high-potential technologies and strategies to sustainably intensify smallholder farming systems.

(2) Key Activities (See FY 2017 AWP Activity 4.1)

The five primary expected outcomes of the project include:

1. Improved communication, coordination and knowledge sharing between USAID, ILs, and other USG funded and non-USG funded projects, and the private sector within Cambodia.
2. Leveraged research and IL technologies within the Technology Parks, farmer sites, and beyond.
3. Enhanced research, extension, education, and capacity building activities aimed for smallholder farmers and other community stakeholders.
4. Increased collaboration and research activities with the U.S. and other international institutions.
5. Decreased duplication of efforts and increased focus on SAIN funded activities.

(3) Achievements

(a) Five Technology Parks were established in the following locations: RUA in Phnom Penh, Bos Knor station in the Kampong Cham province, Reasmey Sophornna High School in the Kampong Thom province, Toek Vil Agricultural Research Station in the Siem Reap province, and the Research and Training Farm at the University of Battambang (UBB). These Technology Parks showcase high-potential technologies and strategies to sustainably intensify smallholders' production systems.

(b) More than 20 technologies and innovations were demonstrated at the five TPs in FY 2017. Smallholder farmers, local partners, private companies, students, and researchers were invited to visit, engage with farm managers, and exchange knowledge.

(c) Seventeen interns and volunteers, mostly comprised of recent university graduates and fourth-year university students, were recruited to work at the TPs in FY 2017. These experiences allowed participants to gain in-depth technical and practical knowledge of field implementation of agriculture projects as a supplement to their classroom studies.

(d) Support was provided to RUA in updating the university's long-term strategic plan and research agenda.

(4) Capacity Building

(a) The CE SAIN lecture series featured 28 events in FY 2017 at the Royal University of Agriculture, with a varied audience of students, researchers, and faculty attending the events. The lecture topics ranged from horticulture and livestock management practices to community organization and agricultural engineering.

(b) The CE SAIN selected six research grants for funding and provided 5 Ph.D. and 4 M.S. scholarships to RUA faculty and staff to strengthen institutional capacity.

(5) Lessons Learned

(a) CE SAIN recognizes that youth are one of the greatest potential resources for the agriculture sector. Given this understanding, the CE SAIN plans to increase its activities that engage high school and university students.

(b) 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.

(6) Presentations and Publications

(a) None to report in FY 2017.

B. Precision Agriculture for Smallholder Systems in Africa

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

(2) Location: Malawi

(3) Description: This project features an innovative "proof of concept" 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 of work incorporates data science, machine learning and new remote sensing technologies with detailed data on farm practices, soils and climate and production conditions—and do so at unprecedented scales of analyses—in a developing economy context. In essence, the project seeks to demonstrate how to make agriculture in developing countries "smarter" through newly available tools for collecting and analyzing large volumes of data on productivity, suitability, and producer behavior. 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: Oakland University

(5) Key Achievements:

(a) The project explored the entire remote sensing archive to assess the products available and their respective utility. Approval for Planet data was obtained, and the project was approved to participate in a NASA Small Business Innovation Research (SBIR) program to distribute and make use of Synthetic Aperture Radar (SAR) data.

(b) Regulatory approval was obtained for the project's UAV operations. The individual responsible for the UAV work successfully utilized the new sensor in Israel and France, where the regulatory burden is lower.

(c) The team is working on yield survey data cleaning and organizing and is working with local partners to prepare these datasets. Co-PI Bill Burke will be visiting Malawi in October 2017 to finalize cleaning on the 2016 data and make as much progress as possible on cleaning the 2017 data, all of which will be instrumental in measuring inter- and intra-farm production and potential gains. He will also be working with local partners and Leah Mungai (student funded through a separate Feed the Future project) on continuing to catalogue the data available. Programming of models using these data to examine the potential impact of measurement error has begun.

(6) Capacity Building:

(a) None to report in FY 2017.

(7) Lessons Learned:

(a) Space and time truly mean different things across disciplines and it wasn't until well into the project design and implementation phase that concordance emerged.

(b) The extraordinary delay in receiving approval for the UAV work was a learning experience with respect to export controls, FAA regulations, and the general risk aversion regarding drones by the many administrators.

(8) Presentations and Publications:

(a) None to report in FY 2017.

C. Research Output Dissemination Study

(1) Program Description:

In the fall of 2016, the Bureau for Food Security (BFS) presented a strategy at the Feed the Future Innovation Labs (ILs) Director's meeting for better measuring outcomes and research impacts of the ILs. One of the indicator that is used in the IL reporting systems is number of technologies or management practices that are in different phases of development (Phase I, under research; Phase II, under field testing; and Phase III, made available for transfer). The SIIL is leading efforts to conduct a thorough evaluation of the uptake and dissemination of innovations in a three-stage process. The proposed stages include: (i) Research Uptake Study; (ii) Research Output Dissemination Study; and (iii) Impact Evaluation. Each stage is intended to further understand and effectively communicate the FtF research investments focusing on the ILs and Collaborative Research Support Programs (CRSPs) supported over the past 10 years. SIIL conducted the Research Uptake Study (RUS) and completed it in December 2016. The main objective of RUS was to develop a survey and analyze the dissemination and uptake of Phase III technologies. Following the RUS, SIIL initiated steps towards implementing the Research Output Dissemination (ROD) Study to be awarded competitively. The objective of the ROD study is to gain a better understanding of the dissemination, use, and adoption of research outputs after they are transferred to or taken up by an entity that is facilitating their dissemination and use by end users.

(2) Key Activities:

(a) SIIL conducted the RUS study by developing a comprehensive survey and reported the results. The survey response rate was 100% and represented 12 of the 24 ILs on 130 Phase III innovations. Results showed that the innovations were largely categorized as biological (39%), management and cultural practice (35%), and mechanical and physical (14%) in nature. Of the 130 surveyed innovations, 105 (81%) were reported as transferred to a dissemination entity. There were 182 cases of innovation uptake that involved 96 unique entities that included host country government organizations (34%), the private sector (24%), host country academic organizations (18%), and non-governmental organizations (10%). These results helped foster a better understanding of how the innovations from the ILs and CRSPs were being transferred to organizations that were facilitating their dissemination and adoption. However, the results did not elaborate on how the technologies and practice are reaching and being used by end users at scale. Therefore, SIIL has begun the implementation of stage II, the RODs.

(b) In September 2017, SIIL launched a request for Concept Note with the intent to invite selected proposals to submit a full proposal for the study. The proposed start date of the study will be January 2018.

(3) Lessons Learned:

(a) Results from the RUS indicated the need to: 1) develop better approaches for systematically tracking the outcomes of IL investments; 2) document barriers of adoption and identify entity types that are best equipped to successfully disseminate different technologies; and 3) identify and cultivate enabling environments for scaling technologies and improving management practices.

(b) There are no clear directions or strategies to support ILs in developing a specific plan for scaling up technologies and/or innovations for dissemination. Research designs must include a strategic plan as part of their design for how, when, and why to scale up technologies to reach the intended beneficiaries or end users.

D. Sub-Saharan Africa Soil Prioritization Study

(1) Program Description:

In consultation and collaboration with USAID and IFDC, the SIIL led an effort to understand barriers to enhancing soil fertility in sub-Saharan African (SSA) and to provide evidence-based recommendations to overcome these barriers. The focus regions/countries of interest were in West Africa (Senegal, Burkina Faso, Ghana, Niger, Mali), East Africa (Tanzania, Ethiopia), the Great Lakes (Rwanda, Uganda, Burundi, Malawi) region, and Ethiopia.

(2) Key Activities:

(a) Initial Survey: In May, 2017, the SIIL team compiled a comprehensive list of active scholars of multiple disciplines representing multiple stakeholders from different organizations. A survey instrument was developed to systematically identify evidence-based soil fertility barriers, suggestions to overcome these barriers, and prioritize current and future innovation for research, development and scaling. The survey sections included questions to rank a list of limiting factors regarding soil characteristics contributing to poor crop yields, rank lists of biophysical and socioeconomic limitations to enhancing soil fertility, provide recommendations to improve soil fertility five to ten years from now and report demographics. The survey was distributed to 1,157 individual, and a total of 491 individuals responded to the survey representing a 42% response rate.

(b) Summit: The summit built from the survey results and was designed to further explore the soil fertility limitations, solutions, barriers, and strategies to overcome these barriers through a facilitated process to capitalize on the expertise of the participants. In August, 2017 the SIIL team convened 35 participants for the Sub-Saharan Africa Soil Fertility Prioritization Summit in Dakar, Senegal. The participants were identified as key thought leaders on soil fertility issues in their respective regions. Participants represented international agricultural research centers (IARCS), national agricultural research and extension systems (NARES), national universities, extension agencies, developmental agencies, agronomic/soils researchers, social scientists, regulatory agencies, private sector, and farmer organizations.

(3) Lessons Learned/Key Results:

(a) The survey and summit provided a rich and diverse view of solutions, barriers, and strategies for overcoming the identified primary soil limitations. The most frequent reported limiting factors regarding soil characteristics that contribute to poor crop yields across all four regions are nitrogen deficiencies, phosphorous deficiencies, acidity, and low soil organic carbon content. For Ethiopia and the Great Lakes region, micronutrient deficiencies were also reported as part of the top five limiting factors, while low available water holding capacity was noted for West and East Africa.

(b) Summit results identified that there are key biophysical and socioeconomic barriers and strategies that can either create an enabling environment or hinder progress towards improving soil fertility across SSA. Inorganic fertilizer access, use, and related implementation issues were prominent but many related biophysical (e.g. increased access and use of quality organic materials) and socioeconomic barriers (e.g. access to resources both financial and agronomic, and access to appropriate fertility recommendations and extension support) as well as solutions were identified as equally important to building soil fertility.

(c) Overall, it was clear that plans for improving soil fertility across SSA must take an integrated approach, inclusive of the identified biophysical and socioeconomic factors. Action plans that only focus on a singular or a narrow factor, such as inorganic fertility availability or mineral fertilizer recommendations alone, will likely fall short of improving soil fertility. There were four recommendations/emerging themes (i) Strengthening Inorganic Fertilizer Systems; (ii) Increased Access and Use of Quality Organic Materials; (iii) Capacity Building along the Entire Knowledge Transfer Value Chain; and (iv) Strengthening Farming Systems across Biophysical and Socioeconomic Factors.

XIII. Issues

A. Development of a Data Management Strategy

In FY 2017, significant time and deliberation was required by the SIIL management entity to establish an appropriate data management strategy. The strategy development was complex due to the need to balance USAID's open data policy with the Lab's unique data portfolio and desire to have all project data stored in a common repository.

B. Environmental Mitigation and Monitoring Plan (EMMP) Implementation

In the annual audit of subaward activities, the SIIL management entity recognized that local partners, in some cases, did not fully understand the EMMP and the plan's implementation. It was also unclear to some teams how to gain pre-authorization for the purchase of fertilizers, pesticides, and microbial inoculants. These insights were gained only after specific inquiry, and it became clear that self-reporting of EMMP activities was not sufficient for ensuring compliance. As a result, the SIIL initiated specific actions. Formal approval processes are now being designed and integrated into the Piestar Reporting Hub. The SIIL management entity also created a guidance document for subawards (and their respective subawards) that provides practical steps for implementation of numerous contractual terms and policies, including some components of EMMP implementation.

XIV. Future Directions

A. Implementation of Data Management Plan

One of SIIL's top priorities for FY 2018 will be the implementation of SIIL's data management plan. The SIIL currently collects individual project data management plans as well as records of incomplete datasets on the Reporting Hub. In FY 2018, the SIIL will ensure that all completed datasets are uploaded to the SIIL Dataverse with any relevant embargoes. Completed datasets will also be registered to USAID's Data Development Library in compliance with ADS 579.

B. Launch of the SI Assessment Framework

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 was made available to the public at the time of the launch and has been made public on the SIIL website. In FY 2018, the SIIL management entity will lead efforts to create a website and mobile application to operationalize the SI Assessment Framework.

C. Identification of Partners to Scale Innovations

As subawards develop, test, and optimize SI technologies and innovations in FY 2018, 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.

D. 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. As part of this process, the SIIL management entity will prompt project teams to clearly and systematically define the role of each collaborator engaged in their research or scaling efforts. Strategic engagement with host country partners, NGOs and the private sector will be crucial for sustainability.

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: $1,242,819
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: $249,936
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: $224,854
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: $249,254
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: $255,276
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: $249,995
Total funding: $999,198

Title: Developing Indicators for Sustainable Intensification
Awarded institution: Columbia University
Dates: September 1, 2015- January 31, 2017
Current year funding: $52,464
Total funding: $237,454

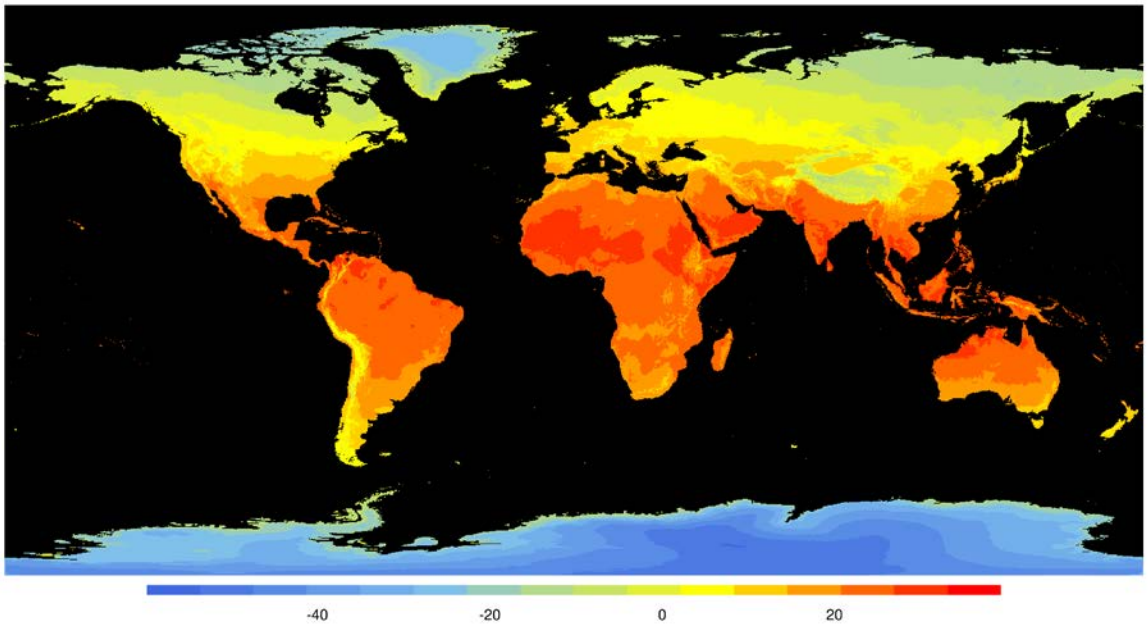
Title: Developing Indicators for Sustainable Intensification
Awarded institution: University of Florida
Dates: February 1, 2017- November 30, 2017
Current year funding: $185,622
Total funding: $185,622

Title: Developing Indicators for Sustainable Intensification
Awarded institution: Michigan State University
Dates: July 1, 2015 – August 31, 2017
Current year funding: $233,610
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: $163,483
Total funding: $507,990

Appendix B – Success Stories

Success Story 1: WorldClim 2: High Resolution Climate Surfaces for Global Land Areas



Spatial distribution of annual average temperature (°C) 1970-2000 of the world. Values aggregated to groups to aid visualization (source: http://worldclim.org/version2)

Climate and weather conditions have strong influence on crop growth and production. Smallholder farmers in developing countries are particularly vulnerable to extreme weather events or climate variability. Access to local climate information enables researchers and decision makers to make better decisions in terms of finding favorable climatic conditions for growing crops or managing risks. In general, weather stations serve as an important and dependable source of climate conditions (historical or current). However, the density of the stations is low in developing countries, and regions situated far from a station lack reliable weather information. It is often seen that a single weather station is serving data to multiple subnational units. In such cases, a spatially continuous climate data could be a better choice to fill in the information gap between sparsely located stations.

Hijmans et al., in 2005, generated a high resolution interpolated gridded climate surface for global land areas (excluding Antarctica) known as 'WorldClim version 1'. It included long-term average monthly temperature and precipitation. The data was produced at 1km^2 spatial resolution to capture environmental variation that can be lost at lower spatial resolutions, particularly in areas with steep climate gradients. With support from the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL), Fick and Hijmans (2017) refined and expanded the previous version of the WorldClim database, which is referred to as the 'WorldClim version 2' database and are available for download from http://worldclim.org/version2. No other freely available dataset currently provides this information at spatial resolution finer than 1km^2 in a consistent manner. Observations from more than 60000 weather stations across the world and multiple satellite-derived data for the period of 1970-2000 were utilized to update the current estimates of monthly temperature and precipitation and create new estimates for monthly solar radiation, wind speed and vapor pressure at 1km^2 spatial resolution.

The WorldClim version 2 will be useful for various modeling frameworks related to agricultural and ecological applications, including: estimation of yield potential and gap in a cropping system; estimation of growing degree

days and temperature seasonality; spatial targeting of intensification and implementing adaptation and interventions options based on current climate variability; modeling threats related to potential spatial distribution of agricultural pests and invasive species; and refinement of global agroecological zone boundaries. The database will also provide baseline information for agricultural and climate drought monitoring. Future work will focus on creating high spatial resolution global climate model output using WorldClim version 2. It was found that the satellite-derived covariates only marginally improved the quality of the WordClim predictions, which highlights the importance of a dense network of high-quality weather stations. As a result, the GFC started supporting installation and maintenance of weather stations in multiple SIIL focus countries (Senegal, Burkina Faso, Cambodia).

Reference:

Hijmans RJ, Cameron SE, Parra JL, Jones PG, Jarvis A. 2005. Very high resolution interpolated climate surfaces for global land areas. International Journal Climatology 25: 1965–1978. http://dx.doi.org/10.1002/joc.1276.

Fick, S. E. & Hijmans, R. (2017). WorldClim 2: new 1-km spatial resolution climate surfaces for global land areas (pp.1-14). International journal of climatology, 00, Wiley Online. doi: http://dx.doi.org/10.1002/joc.5086.

Success Story 2: Local Partnerships Advance Sustainable Intensification through Mechanization in Burkina Faso

The level of on-farm mechanization is low in Burkina Faso. Seventy percent of smallholder farmers rely on hand labor. Less than 30% use draft animal power and only about 2% use tractor power. Many farmers are neither aware of alternative cropping methods nor have affordable access to labor saving mechanization.

Young girls hand planting corn at the Ly Farm demonstration site near Koumbia, Burkina Faso.

The goal of the Appropriate Scale Mechanization Consortium (ASMC) in Burkina Faso is to assist the country's smallholder farmers in improving their quality of life by integrating appropriate technologies into crop and livestock systems that sustain profitability and boost ecosystem resilience by alleviating labor bottlenecks while reducing the drudgery of labor-intensive farm tasks.

The ASMC works with a local lead farmer, Mr. Burgui Ly, as well as students, blacksmiths, and extension educators in a process of adaptive management to evaluate a diverse set of technologies, compatible with the local economic, social and environmental conditions, to increase yields and smallholder profitability while decreasing drudgery and fatigue.

Because women are responsible for many of the most tedious cropping activities such as planting and weeding which require hand labor, there is a need to develop affordable tools for animal traction that are suitable for both men and women.

Sustainable cropping practices minimize soil disturbance, maintain a protective vegetative or residue cover on the soil surface and add organic inputs from manure, compost or cover crops. The ASMC takes a careful approach, evaluating many implements and sources of power, not simply replacing human power with animal power, or animal power with wheeled tractors. Selection of the power source is situation specific.

In Burkina Faso, the ASMC has worked closely with local blacksmiths to design and continuously improve several technologies. In one instance, their partnership has improved locally available ox-drawn planters with a low-cost seed plate drive mechanism, an improved seed plate and seed delivery system, and a furrow opener. The cost of the new planter was reduced by 30%, and the performance was greatly enhanced.

The ASMC also designed and worked with the local blacksmiths to build low-crown, low pitch-angle sweeps for conservation row crop weed control. Compared to the locally available cultivator shovels, the new sweeps increased the effective root cutting width by 20% while reducing cultivator draft (the pulling force required by the oxen) by 21%. The new sweeps also improved cultivator stability, operator comfort, and weed control. With assistance, the local blacksmiths have been able to improve various aspects of agriculture equipment. They have improved the designs of ox-drawn planters, zone tillage rippers, and low-crown, low pitch-angle sweeps for conservation row crop weed control.

Low-crown, low pitch-angle sweeps built by the local blacksmith with locally available materials reduced implement draft by 21% and improved weed control.

By fully engaging farmers, blacksmiths, extension educators, and students in the technology design and improvement process, the ASMC ensures that their work is relevant to local needs, affordable, and sustainable. In the remaining two years of the project, the ASMC will continue to target labor bottlenecks, implements and production systems that constrain productivity and profitability. Together with local partners, farm mechanization is facilitating the transition from labor-intensive to skill-intensive management for Burkinabé smallholder farmers.

Success Story 3: Making more from a diversified cropping system: A farmer's experience

By Jayanta Bhattacharya and Sudhir Yadav. This story is adapted from its original appearance in Polder Tidings.

Demonstration of BRRI dhan 52, which matures approximately one month earlier than the traditional variety (shown on the surrounding three sides of the plot).

Mihir Mondal, a 37-year-old farmer, lives with his wife, Archana Roy, their five-year-old child, and Mihir's parents and brother—a 'joint' family household arrangement. They reside in the Fultala Village in Polder 30 of Khulna Division in Bangladesh, and, as many others in their area, Mihir's main source of income is agriculture.

Their family tends 0.75 hectares of agricultural land and a small pond to rear fish. They have four head of cattle, two of which produce two liters of milk a day. They sell one of the liters for a small added income. In addition to taking care of livestock, Archana rears 20 chickens and sells about 100 eggs a month, after family consumption. Mihir and his brother work together growing traditional aman rice. They also grow sesame and mungbean in the dry season on the same piece of land. Mihir has a two-wheel power tiller that he uses to plow his land as well as rents out to other farmers for added income.

In the last aman season (2016), Mihir decided to participate in a learning hub of the SIIL-Polder project, and agreed to grow a climate-resilient rice variety —BRRI dhan52—in a small portion of land. He still grows traditional rice in 80% of his land. Mihir managed the crop very well, using recommended best management practices. He harvested the rice in the first week of December and cleared the field immediately after harvesting. He harvested 5.4 tons per hectare from BRRI dhan52—a significant increase from his usual harvest of 3 tons per hectare from the traditional variety.

Mihir had been broadcasting sesame or mungbean, or both, in the dry season, but his crops had failed in the last four years. "Rains damaged our sesame and mungbean every year," said Mihir. "I am now considering investing resources in dry-season crops instead."

After obtaining information from the learning hub, Mihir decided to try early seeding of a dry-season crop. He was able to plow the land a few weeks after harvesting rice. Mihir's family used to struggle finding feed for their livestock, especially during the dry season. Mihir decided to grow maize. The learning hub provided him training

and inputs to grow maize in a 400-square-meter area. He successfully protected his maize field from stray animals by coordinating with the community for controlling domestic animals.

Mihir hopes to harvest a good yield from the maize he planted in January. He plans to use maize seeds to feed the chickens and fish and the stalk as fodder for the cattle. The polders of the coastal zone have a high potential to "turn on" the currently "off" season by introducing diverse crops in the dry season. The high risk of crop failure can be reduced through a community approach to managing water, early harvest of rice, and early planting of dry-season crops.

The SIIL-Polder learning hub is routinely working with the farmer community to discuss and introduce various crop options and management practices to minimize their risks, with a hope to have many farmers take up the route that Mihir has taken.