

Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification

External Evaluation Report FY 2018



Table of Contents

<i>Acknowledgements</i>	5
<i>Acronyms</i>	6
1. <i>Executive Summary</i>	9
2. <i>Introduction and Context</i>	16
3. <i>Findings</i>	19
3.1 Overall progress.....	19
3.1.1 Overall Results from implementing Sustainable Intensification	19
3.1.2 Farming Systems Agronomy	21
3.1.3 Data Management.....	26
3.1.4 Gender	26
3.1.5 Nutrition.....	28
3.1.6 Enabling Youth in SI Enterprises, Capacity Building and Entrepreneurship	28
3.1.7 Partnerships, Process and Institutional Research.	29
3.1.8 Policy Research and Engagement	30
3.1.9 Towards Scaling – Impact Pathways	30
3.2 SIIL Consortia for Research and Development	32
3.2.1 Geospatial and Farming Systems Consortium (GFC)	32
3.2.2 Appropriate-Scale Mechanization Consortium (ASMC)	35
3.3 West Africa.....	39
3.3.1 West Africa Overview	39
3.3.2 Burkina Faso Country Report	42
3.3.3 Senegal Summary Report	44
3.4 East Africa.....	47
3.4.1 East Africa Overview	47
3.4.2 Ethiopia Country Report	47
3.4.3 Tanzania Country Report	50
3.4.4 Towards a Phase II for East Africa	51
3.5 Asia	53
3.5.1 Asia Overview	53
3.5.2 Bangladesh Country Report	53
3.5.3 Cambodia Country Report	54
4. <i>Program Management</i>	58
5. <i>Opportunities for Program Future</i>	61
5.1 Foresight	61
5.2 Systems, Sustainability, and Scalability Systems	61
6. <i>Compiled Recommendations and Opportunities</i>	63
6.1 Phase I Recommendations and Opportunities.....	63
6.1.1 Technology Development.....	63
6.1.2 Stakeholder Collaboration/Communication for Enabling Environments	64
6.1.3 Scaling and Impact Pathways.....	64
6.1.4 Management Specific	65
6.2 Phase II Key Recommendations and Opportunities.....	65
6.2.1 Technology Development.....	65
6.2.2 Stakeholder Collaboration for Enabling Environments	68
6.2.3 Capacity Building	68
6.2.4 Scaling and Impact Pathways.....	69
6.2.5 Management Specific	69

7.	Annexes.....	71
7.1	Evaluation Questions, Scope of Work, Evaluation Plan.....	71
7.2	Methods and Tools.....	71
7.3	Consortia Details and Graphics.....	71
7.4	SIIL Country Synthesis for Bangladesh	76
7.5	SIIL Country Synthesis for Cambodia.....	90
7.6	SIIL Country Synthesis for Ethiopia.....	134
7.7	SIIL Country Synthesis for Tanzania.....	137
7.8	SIIL Country Synthesis for Burkina Faso	140
7.9	SIIL Country Synthesis for Senegal	146
7.10	Reports, List of Publications and Presentations	151
7.11	Survey Questionnaire	152
7.12	Travels Itineraries	153
7.13	Chronology of Interviews & ET Meetings	154
7.14	Photographs.....	159
7.14.1	Burkina Faso Photographs.....	159
7.14.2	Cambodia Photographs	160
7.14.3	Ethiopia Photographs	166
7.1	Matrix	170
7.1.1	Compiled Matrix Scoring.....	171
7.2	Evaluation Team Authors.....	172

Acknowledgements

The Evaluation Team (ET) is immensely grateful, as it would have been impossible to generate all the findings contained in this report and its annexes without the support of more than a hundred experts, from at least eight countries, for sharing their information and insights that we endeavored to capture in this evaluation. Space does not allow us to list and properly acknowledge inputs from even a fraction of the Key Informants interviewed. Yet we must mention the top sources and facilitators.

It has been a pleasure to work with the SIIL Management Entity (ME) who contributed, from the beginning to the end, support information, logistics, valuable suggestions, guidance and encouragement. We are extremely grateful to Vara Prasad and Jan Middendorf, Directors of SIIL at Kansas State University for their invaluable cooperation, which helped us immensely, and we appreciate their availability to discuss ideas that contributed significantly in completing this evaluation. We very much appreciate their understanding and consideration when there were delays in component deliverables, due to health issues within the ET. Jan and Vara were central, but there were others supporting the ET from SIIL and KSU who were working hard, indirectly and directly, behind the scenes.

We are in debt to the many Principal Investigators for the country projects, the Consortia and other key research topic areas, for their candid conceptual inputs and factual information. Again, there are far too many to list, but we would be extremely remiss were we not to mention: Consortia Managers Alan Hansen, Principal Investigator, ASMC and Robert Hijmans, Principal Investigator GSP; Aliou Faye, Country Coordinator, Senegal; Manny Reyes, Research Professor, Cambodia; Hamidou Traore, Director of INERA, Burkina Faso; Neville Clarke, PI SSIL. We thank all those whose expertise and knowledge of field research and local implementation support and assistance enabled the country visits, especially where the field site visits were conducted, demonstrating the characterization of the diverse farming systems and the very hard work they do.

It has been our honor and great pleasure to work with everyone in this evaluation project. Lastly, we are grateful to the ME for trusting us to conduct this evaluation and to USAID for concurring with our involvement.

Acronyms

ACIAR – Australian Centre for International Agricultural Research
ADDA – Agricultural Development Denmark Asia
AfDB – African Development Bank
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
AOPs – Annual Operational Plans
APESS - Association pour la Promotion de l'Elevage en Savane et au Sahel
ASA – American Society of Agronomy
ASM – Appropriate scale mechanization
ASMC – Appropriate Scale Mechanization Consortium
AUC – African Union Commission
BARC – Bangladesh Agricultural Research Council
BARI – Bangladesh Agricultural Research Institute
BFS – Bureau for Food Security
CA – Conservation Agriculture
CASC – Conservation Agriculture Service Center
CASF – The Council on Smallholder Agricultural Finance
CASI – Conservation Agriculture based Sustainable Intensification
CE – Center of Excellence
CE SAIN – Center of Excellence on Sustainable Agricultural Intensification and Nutrition
CGIAR – Consultative Group on International Agricultural Research
CIAT – International Center for Tropical Agriculture
CIMMYT – International Maize and Wheat Improvement Center
CIRAD - Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CNRA – Centre National de Recherches Agronomiques (CNRA)
CSA – Climate smart agriculture
CSIRO - Commonwealth Scientific and Industrial Research Organisation
DDL – Data Development Library
EAB – External Advisory Board
EMMP – Environmental Management and Mitigation Plan
ET – Evaluation Team
EU – European Union
FAA – Federal Aviation Administration
FAO – Food and Agriculture Organization
FGD – Focus Group Discussions
FNGN – La Federation Nationale des Groupements Naam
FtF – Feed the Future Program USAID
FTFMS – Feed the Future Monitoring System
FY – Fiscal year
GCRF – Global Challenges Research Fund
GFC – Geospatial and Farming Systems Research Consortium
GIS – Geographic Information System
GIZ – German Development Agency
GMCC – Green Manure Cover Crops
HIL – Horticulture Innovation Laboratory USAID
HORT – Horticulture Innovation Laboratory USAID (see HIL)
HYV – High Yielding Varieties
ICRISAT – International Crops Research Institute for the Semi-Arid Tropics
ICT – Institute of Technology of Cambodia
IDRC – International Development Research Centre

IDSS – Integrated Decision Support System
 IFDC – International Fertilizer Development Center
 IFPRI – International Food Policy Research Institute
 IIASA – International Institute for Applied Systems Analysis
 IITA - International Institute of Tropical Agriculture
 IL – Innovation Lab
 ILRI – International Livestock Research Institute
 ILSSI – Innovation Lab for Small Scale Irrigation
 INERA – Institut de l'Environnement et de Recherches Agricoles de Burkina Faso
 INGENAES - Integrating Gender and Nutrition within Agricultural Extension Services
 IPM – Integrated Pest Management
 IRD – Institut de Recherche Pour le Développement
 IRRI – International Rice Research Institute
 ISRA – Institut Senegalais de Recherches Agricoles
 ITA – Institut de Technologie Alimentaire
 IWMI – International Water Management Institute
 KIIs – Key Informant Interviews
 KSU – Kansas State University
 LIVES – Livestock and Irrigation Value Chains for Ethiopian Smallholders
 LNERV – Laboratoire National d'Élevage et de Recherches Vétérinaire
 LNRPV – Laboratoire National de Recherche sur les Production Vegetales (LNRPV)
 MAFF - Ministry of Agriculture Forestry and Fisheries
 ME – Management Entity
 MSU – Michigan State University
 NARS – National Agricultural Research Systems
 NARES – National Agriculture Research and Extension Systems
 NGO – Nongovernmental organization
 NM-AIST - Nelson Mandela African Institution of Science and Technology
 NUS – Neglected and underutilized species
 PI – Principal investigator
 PRC – Policy Research Consortium
 PPPs - Public/Private Sector Partnerships
 PTOS – Power Tiller Operated System
 R4D – Research for Development
 RESOPP – Réseau des Organisations Paysannes et Pastorales du Senegal
 RHoMIS – Rural Household Multiple Indicator Survey
 RUA – Royal University of Agriculture
 SAR – Synthetic Aperture Radar
 SBIR – Small Business Innovation Research
 SCD – Social Capital Development
 SEARCA – Southeast Asian Regional Center for Graduate Study and Research in Agriculture
 SI – Sustainable intensification
 SIAF – Sustainable Intensification Assessment Framework
 SIIL – Sustainable Intensification Innovation Lab
 SIPS – Sustainably intensified production systems
 SIPSIN – Sustainably Intensified Production Systems Impact on Nutrition
 SP - Service Provider
 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

USA – United States of America
USAID – United States Agency for International Development
USDA – United States Department of Agriculture
USG – United States Government
UTIA – University of Tennessee Institute of Agriculture
WAgN – Women in Agriculture Network
WB – World Bank

I. Executive Summary

Background and Context

The Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) successfully completed its fourth year since inception. Sustainable Intensification (SI) is at SIIL's core, and is based on holistic production systems enhancement. SI has recently been defined: "Sustainable intensification (SI) comprises agricultural processes or systems in which production is maintained or increased while progressing toward substantial enhancement of environmental outcomes. It incorporates these principles without the cultivation of more land and loss of unfarmed habitats and with increases in system performance that incur no net environmental cost. (Pretty, Nov 2018, Science)." A number of components of the SIIL "systems approach" (e.g., HORT, IPM) are focal areas of the other 23 USAID Innovation Laboratories. In addition to SIIL's own research outputs, at times, it is an "innovation integrator" and a successful attractor of external resources. This too is a good adjunct role to better serve the Feed the Future (FtF) Program.

SIIL's Management Entity (ME) organized this External Evaluation for an unbiased, evidence-based appraisal of tangible outputs from the diverse components of SIIL's program against the stated goals and tactics. The external Evaluation Team (ET) was also charged with providing recommendations for the last year of Phase I, ending in September 30, 2019, and for a potential future program, if funding were to be approved for a Phase II extension. This evaluation report is designed to be read in conjunction with SIIL's 2018 Annual Report (see Annex 7.10). The annual report describes SIIL's program of work with its many partners—both in the USA and in action sites—and its accomplishments, which are primarily based on reports of stakeholder partners and the continuous support and documentation contributions of the ME, including its field visits.

Evaluation Design and Methodology

The strategy and methodology (mixed methods approach) for this evaluation are described in Section 2 (Introduction and Context), and in greater detail in Annexes 7.1 & 7.2. In brief, the five-member ET engaged in an extensive desk study, reviewing documents, publications and reports. Selected research sites for five of the six host countries were visited by at least one ET member. This "ground-truthing" was critical for fact checking, evidence gathering, and capturing the partnerships and shared-ownership of SIIL's systems research.

The ET conducted Key Informant Interviews (KIIs) with Principal Investigators (PIs), their staff, graduate students, in-country stakeholders including Missions, farmer organizations, NGOs, private sector partners and cooperating institutions, including, e.g., the Peace Corps in Senegal. Focus Group Discussions (FGDs) were conducted on site and remotely. A question guide-list was used by the ET for major interviews that informed on four in-common evaluation domains, namely: 1) Overarching Issues such as, research, resilience, "goodness of fit" of university led R4D, degree of systems approaches to SI challenges, etc.; 2) Technology Development; 3) Capacity Building and Scaling; 4) Level of Stakeholder Engagement (See matrix questions in Annex 15). We contributed several questions to the ME evaluation survey and reviewed and commented on the survey report itself (see Annex 7.11).

From mid-September to mid-December, 2018 the ET met "virtually" three to five times a month for review of approaches, report drafting and planning. A summary list of interviews and ET consultations—Chronology of Interviews and ET Meetings—are found in Annex 7.13.

The ET appraised research accomplishments with respect to common FtF and SI themes of: increasing sustainable agricultural productivity, enhancing resilience of cropping systems with stewardship of the natural resource base, and supporting nutritional outcomes. We also took stock of crosscutting issues, such as capacity-building/training, partnership building, institutional innovation—including fostering shared visions of the theory of change/impact pathways—farming

systems agronomy, gender equity, nutrition, youth empowerment, enabling policies, scaling strategies and more. Highlights of some of these are provided in this summary, along with key principal recommendations. We addressed management and communication competence at the SIIL ME level, and also at thematic research Consortia (Geospatial and Farming Systems and Appropriate Scale Mechanization) and at county program levels. Last, but not least, we carefully considered and shared our collective view about the future relevance and implementation arrangements of SIIL in the context of Feed the Future's (FtF) goals, both from the perspective of SIIL's direct contribution to SI knowledge of systems enhancement and from their potential synergistic role in enabling convergence of innovations across the 24 labs through cooperative planning and implementation.

Key Findings

Technology Development—including Biophysical SI Research and Considerations

Main bio-physical farming systems innovations of SIIL's focus included: cereal/legume integration and rotations, especially in the semi-arid zone of West Africa; crop livestock integration, especially in Ethiopia and Burkina Faso; and dry-season irrigated horticulture, under permanent-raised-bed conservation agriculture approaches, especially strong in Cambodia. ***The ET recommends SIIL ME budget for and organize workshops in Phase 1 to develop Impact Pathways for the above innovations toward targeted country scaling up in alliance with other development partners, both national and international.***

With respect to scaling up, ***the ET recommends: a) future research efforts be required to consider scaling challenges from the beginning of Phase 2; and b) ME should consider launching a new research theme in Phase 2 to identify the optimal approaches to farmer-level knowledge acquisition and application (extension and scaling methods), with particular emphasis on knowledge intensive innovations, such as IPM or CA-based SI and/or multicomponent innovations, such as the CA-based, dry-season, irrigated horticulture production.***

Research on sustainable agriculture productivity and enhancing resilience of cropping systems with stewardship of the natural resource base is progressing well

In each of the six host-countries, the stakeholders, especially national public and private sector organizations (including farmers) contributed to problem and opportunity identification and to decisions on specific research components to be adapted to local context and to be pilot tested in the field. We note that SI-based systems research should be founded on farming systems approaches. SIIL ME was aware of this, which is work in progress across the six country sub-awards. Given the good progress made in much of the SI on-farm research in many sites, ***the ET recommends in Phase 1 a participatory appraisal of farm women, men and youth's evaluation of SI technologies in order to inform priorities for Phase 2.*** Details are in the 2018 Annual Report, Annex 10. Country project leaders have shown diverse levels of engagement, as have research managers (mostly US university professors). The impressive number of graduate students, predominantly local, is generally working together well; and there is scope to further strengthen teamwork planning and co-implementation, targeting holistic systems enhancement. Enabling students and stakeholders to learn to conduct research within coherent systems SI teams, should be a goal, an outcome and an output.

Collaboration, including SIIL Consortia and other Key Public Goods

SIIL's Appropriate Scale Mechanization Consortium (ASMC), coordinated from University of Illinois Urbana-Champaign, is generally integrated in local-level research for development (R4D). ***The ET recommends: in Phase I ASMC can and should expand its efforts toward creating a digitized knowledge-archiving and sharing facility—functioning in-perpetuity—on specific technologies and their implementation for Appropriate Scale Mechanization (ASM) covering global innovations to reduce “re-invention of the wheel.”***

A further recommendation for ASMC, beginning in Phase I, is to include more analysis of future needs and opportunities concerning appropriate implements for SI innovation adoption. For example, animal traction will not expand significantly beyond the limited areas now in place. Use of single axle tractors and small 4-wheel tractors will expand significantly across Africa, as they already have across much of Asia. Agronomic experimentation was often supported by innovation inputs from ASMC, such as, better hand tools for women and better cattle and donkey harnesses for animal traction-based farming, with companion equipment for reduced-tillage crop establishment. ASMC also initiated some field-level testing of single-axle tractors and associated implements, primarily in Bangladesh (polder community rice systems) and in Cambodia's rice based systems. **The ET recommends, in Phase 2, expansion in research on non-animal-traction-level mechanization in targeted farming systems that, where appropriate, will also include farmer-based supplemental irrigation (including possible use of solar pumps and of lay flat plastic pipe) to expand production cycles for SI.** ET recommends: The research dimension of smallholder irrigation should primarily be realized by the Small Scale Irrigation Lab (ILSSI), thus increasing strategic partnerships between labs. **ASMC should continue its critical role in piloting appropriate application of water-use innovations** (e.g., solar pumps, axial flow pumps, lay-flat plastic pipe, drip irrigation, etc.) in the context of selected production-systems optimization at hubs and for scaling adoption.

Comparatively, SIIL's other consortium, the Geospatial and Farming Systems Research Consortium (GFC), coordinated from UC-Davis, has contributed only minimally to SIIL's core field program, particularly in respect of farming systems analyses. But, through sub-grants to diverse university- and CGIAR-level partners, the GFC initiated research tools development intended for eventual application of geospatial information inputs into SI systems research. ET notes that over the last five years there have been massive advances in geospatial data analysis tools, in general, and including in local capacities, beyond GFC's contribution.

The ET recommends:

- a) Before further major investment in geospatial research for Phase 2, the ME should organize an appraisal of GFC's future positioning, taking into consideration the current national and regional level of capacities in this domain. This should include an assessment of where foresight activities might be located (in a repositioned GFC or elsewhere);**
- b) UC Davis continue its geospatial field engagement at field locations in East Africa to build on work implemented during Phase I, but there be a re-bidding for delivery of other priority geospatial project outcomes to be determined by ME, with guidance from a small steering committee. UC Davis can, of course, be one of the bidding candidates for any/all future work. This broadening—inclusion of other US university partners—will strengthen output delivery, including formal and informal capacity building.**

SIIL's new crosscutting SI-guidance tool—the Sustainable Intensification Assessment Framework (SIAF) developed with leadership from University of Florida and Michigan State Universities, and others—is considered a major public good contribution. It is being pilot tested and refined by several FtF projects and by wider partners, such as CGIAR centers and non-US universities, especially in consideration of future funding proposals for EU, GCRF, ACIAR. **The ET recommends: in Phase 2 the SIIL ME explore, across institutions, the best way to support broad adoption of SIAF SI-guidance tool and determine a process for continuous updating, based on lessons learned during applications.**

Social Capital Development (SCD)

SIIL has several elements of SCD elements that are rather opportunistically embedded in the field program, with wide ranging thrusts from gender empowerment and farmer-to-farmer learning in vegetable and other horticulture production, including gender-specific mechanization considerations, to nutrition education and studies on impact of quality diets on farm communities, such as in Tanzania. Recently, consideration is being given to needs for developing Service Provider (SP)

entrepreneurs through Public/Private Sector Partnerships (PPPs). In Cambodia the innovative conservation agriculture service provision based on fees, and the public private consortium for conservation agriculture are impressive. In West Africa, ASMC empowered local blacksmiths to make and maintain appropriate smallholder-farmer-based implements, through strategic provision of model workshops and training for this micro-enterprise activity. ***The ET recommends that ME foster a crosscutting assessment of the effectiveness of conventional and innovative social capital mechanisms in Phase 1 to guide investments in Phase 2.***

The SIAF as an SCD for the R4D community was highlighted in SIIL's 2018 Annual Report: "The Sustainable Intensification (SI) Assessment Framework was officially launched at the American Society of Agronomy (ASA) Annual Meeting in Tampa, Florida in November 2017, and, over this past year was transformed into a web tool and launched at the ASA-SI Symposium in November 2018. This framework has gained tremendous visibility and traction as evidenced by its inclusion in USAID and other funding initiatives, the Rural Household Multiple Indicator Survey (RHoMIS) tool, Africa RISING's assessment tools, universities courses, and multiple publications." In sum, the community of practice around SIAF application now belongs as social capital to the development community.

Capacity Building

SIIL is strongly committed to human and institutional capacity building, as evidenced by the number of short-term trainings offered to 4,336 individuals (1,550 women, 36%) and support of long-term graduate degree training to 60 individuals (22 females). Of the 60 individuals, 26 are pursuing a Ph.D. degree (35% females), 28 Masters of Science (43% females), and 6 undergraduate degrees. ***Phase II should include specific training in systems approaches for faculty in African, Asian and US universities working with SIIL students***, with regular virtual meeting of the committees overseeing the research, ***ideally supported by a systems research mentoring service*** for supervisors and students. In addition, the SIIL researchers produced 128 publications and presentations this past reporting period (2018 Annual Report). Institution enabling is particularly impressive in Senegal and Cambodia. ***There is scope for supporting further publication of SIIL results in agricultural systems-oriented journals to complement the disciplinary and commodity journal publications.***

The regional Center for Excellence, CE SAIN, supported from the USG Cambodia Mission, continues to build capacity, improve coordination, and strengthen partnerships, as demonstrated through increased number of grants awarded beyond USAID. Several African institutions, e.g., in Ethiopia and Senegal, are particularly enthusiastic about hosting such a CE, which should be pursued in Phase I with the US Mission. ***ET Recommends: "Beyond project" considerations, concerning future continuity, should be prioritized before further investments, especially for CEs.***

Management

The ET found SIIL's ME to be, overall, very sound and highly motivated with a high level of effectiveness. The SIIL Director is a well-respected scientist; this helps garner strong partnerships with general positive responsiveness. The management style is inclusive and it is clear that, as a result, most of the individual awardees regard their activities as contributing to SIIL's aims and objectives, rather than as a generator of top-up funds to support addressing their own priorities. It has enabled award and sub-award holders to focus primarily on their research, coordination and capacity building. It added tools to ease reporting and data archiving—the bespoke reporting hub, integrated with DataVerse. It has facilitated and built capacity in monitoring indicator development and reporting with local partners. Internal and external communications have been effective, and the ME has organized a number of major events at USA and international conferences on SIIL approaches, tools and outcomes. It has made frequent monitoring and stakeholder engagement visits to the field and organized effective SIIL annual reporting and cross-learning workshops in various locations. It has creatively responded to unplanned challenges coming from field programs and changes in the FtF program, and attracted additional resources to important activities aligned with,

and integral to, SIIL, notably related to the knowledge and training in Cambodia (CESAIN), African soil research priorities and SI policy research. The ME has also been responsive to opportunities for cooperation among FtF Labs and other institutions. A number of recommendations embedded in other sections above are, in fact, directed at the ME for consideration and implementation.

The ME has made concerted efforts to establish robust data management systems and procedures that are compliant with USAID's open data specifications and worked with award holders on the benefits of proper data custodianship as well as the fact that compliance with donor standards is mandatory. However, there have been delays in Consortia and Awards in the finalization and posting on-line of research data sets (baseline surveys, field research, simulation results, lab research, etc.), which should be addressed – depending on the commitment of PIs and the quality of the raw data from research. ***ME should seek to identify more effective means to reward, coerce or censure laggards as Phase I approaches completion.***

The ET also observes, in the case of Ethiopia, the Annual Reports 2017 and 2018 record strong program coherence, with combined outputs implying a Farming Systems Approach, that embrace productivity and income enhancement through dry-season vegetables, which in turn result in improved nutrition. The field site visits, however, show some diversity in stage and quality of implementation.

The ET Recommends: the ME engage with Consortia and Awards, starting in Phase I, in closer site assessment of, and possible adjustments to, field programs in order to foster integration on the ground and focus documentation and reporting on core SIIL themes.

In sum, KSU has provided high-level leadership and support to SIIL governance, strategic directions, administration and management. ***The ET strongly recommends, on the evidence of the high-quality delivery outlined above, that KSU should continue to act as SIIL's host institution in Phase 2. Similarly, the current management staff have shown competence, diligence, creativity and energy; and no changes in the ME team positions is suggested.*** For effective Lab implementation, any ME requires time to establish processes, leadership and trust. While there are opportunities for strengthening the current ME, e.g., more effective multi-directional communications with stakeholders, any major changes to the ME structure and function would be ill advised and would threaten the continued effectiveness of SIIL; because the time required for any other institution to gain operational capacity would likely squelch the current, positive flows of cooperation throughout SIIL's partnerships, which is especially critical in the field programs.

Other Selected Key Recommendations

A number of Key Recommendations has already been embedded in the Findings Section above. Below are a few additional important recommendations:

Phase I Recommendations and Opportunities

The ET recommends: GFC place greater focus on delineating and facilitating optimization of SIIL's farming systems assessments in the six SIIL core countries. Its name reflects this very intention, but there is only superficial reporting of farming systems analyses for the six core field programs in Phase I.

The ET recommends: Considering the rapid evolution of farming systems and the critical need for foresight and minimizing duplication, SIIL should budget for and implement expert and stakeholder reviews of future scenarios and issues and current knowledge, globally, on key topics/thematics central to SIIL's programs, such as on: soil health, small-holder oriented mechanization, CASI, crop/livestock systems, smallholder-based irrigated systems for SI, living fence to manage grazing, Peri-urban Horticulture, etc.

The ET recommends:

SIIL ME should, in partnership with relevant PIs, organize expert consultations (these could be virtual) to explore for Impact Pathway development, SIIL's balance between bottom-up and top-down innovation discovery and implementation approaches, discerning between demand-driven versus supply-driven innovation prioritization.

The ET recommends:

At country-level, stakeholders—where this has not already been done—must characterize the socio-economic and nutritional status of target populations at the onset of interventions, and then review periodically, including with control groups.

The ET recommends:

SIIL management should foster and document key pilot examples of innovations in SI, focused on public/private sector/microbusiness enterprise, articulating public/private sector alliances, such as those emerging at the CA Consortium in Cambodia.

The ET recommends:

Because CA—especially when combined with complementary SI technologies related to water, input-use efficiency, IPM, livestock, markets, etc., as Conservation Agriculture based Sustainable Intensification (CASI)—is one of the few proven sustainable agriculture technology clusters, and CASI is a significant part of the research in all three regions, SIIL should arrange a cross-cutting synthesis of Phase I results, including CA-based Horticulture, and their regional significance on this theme. A background paper should be presented in an Annual Workshop for discussions on Impact Pathways for scaling up.

The ET recommends:

Each Consortium and Award of SIIL should draft a scaling strategy and exit plan, which would incorporate the effective repositories of the knowledge generated during Phase I. All new innovation proposals should include an Impact Pathway concept-note on scaling of adoption, comprising notations of key partners in the process. These should primarily indicate where Phase I knowledge is embedded to support effective implementation during Phase II.

The ET recommends:

Co-location planning and implementation of field research has been mostly positive at country field sites. However, there is opportunity to take cooperative research to a higher level. SIIL management should foster joint integrated research designs by inter-connecting different SIIL partners/awards, based on a shared vision of development pathways in each research hub location. Where appropriate, this will catalyze systems deep integration across SIIL awards/partners. It will be especially beneficial for students to learn to work as researchers in teams.

Phase II Key Recommendations and Opportunities

Note: Some of these recommendations can be initiated in Phase I as a basis for major implementation in Phase II.

The ET recommends:

SIIL expand research on the systems constraints/opportunities and on scaling up and out adoption of dry-season, drip-irrigated CA-horticulture. This should likely become one “centerpiece” of SIIL's work in Phase II. This CA-horticulture approach is a major output of the current Phase I, and future research is a logical extension/continuation of Phase I. This research should be addressed as a full systems development approach, involving farming systems at hubs with engagement of SIIL's two existing Consortia, plus field level contribution from the new Policy and Soil Health initiatives within SIIL. The systems work should seek convergence with relevant Labs, such as HIL, ILSSI, IPM, Market Access, etc., and also inclusion of CGIAR (World Veg, IVMI, IFPRI etc.), the private sector, and especially with key NARES. Capacity building should be well beyond university-to-university

empowerment. Agribusiness for women should be prioritized. The way forward may include co-hosting of joint workshops for science and development partners.

The ET recommends:

As a complement to the niche horticultural development in Phase 2, it is recommended that SIIL strengthen research on **conservation agriculture based sustainable intensification (CASI)** for farmers' main fields with the inclusion of complementary SI practices which complement the basic CA principles. Such research should build on the Phase I CASI results in a majority of countries, and investigate issues of adoption, soil health, crop rotations, cover crops and climate adaptation, including labor use efficiency, 'zero tillage' mechanization service provision and efficient crop-livestock integration and enabling policies.

The ET recommends:

USAID considers SIIL to become among empowered focal point institutions to inform FtF's efforts to **scale up** adoption of innovations, based on the most efficient approaches to knowledge transfer, in the context of its development goals within the three target regions. One size does not fit all. Research on which knowledge transfer processes works best, where, with whom, and including associated costs of scaling up and out, is needed. Also, relevant knowledge needs to be archived and shared. For this purpose, it is essential to establish **regional mechanisms** for knowledge sharing for common farming systems extending across countries within a region to support the scaling out of SIIL results. These activities should be coordinated with those of other FtF investments operating at a closer to field level (e.g. Africa RISING).

The ET recommends:

SIIL management should explore creating a **Center of Excellences** (similar to CE SAIN in Cambodia) to address the opportunity to help foster SI in the context of agro pastoral sorghum/millet/livestock farming system in West Africa (Senegal, for example, could be an option) and in the context of the maize legume livestock mixed farming system in East Africa. Regional capacity building and knowledge repository would be major goals.

The ET recommends:

As a **foresight** option attention be given, at selected hubs, to smallholder (or village-level) feed production and processing to meet local and regional demands for poultry and fish feed within decentralized value chains.

The ET recommends:

Farming systems analysis and stocktaking be conducted for each prioritized farming system to help focus research on most important and promising innovations and target domains.

The ET recommends:

For each, major, prioritized farming system the ME fosters the conducting of a major **stocktaking of technologies and institutional innovations** along with an "expert" appraisal of opportunities and needs with a 10- and 20-year future perspective (based on the results of the "Foresight" dialogues). The reports and proceedings should be a major output of SIIL and guide its program of work, especially for ASMC and GFC. These outputs, if done well, will be highly valued by the broader development community.

2. Introduction and Context

The USAID-funded project Sustainable Intensification (SI) Innovation Laboratory (SIIL) is one of 24 thematic Innovation Labs (ILs) created to focus on agricultural research to target the needs for intensified food systems and poverty reduction in developing countries. SIIL explicitly embraces environmental stewardship, as proposed by Pretty 2018 (see box), and also extends into considerations of social equity, systems resilience and broader human livelihood and how these contribute to sustainability in the longer term. Wider social (e.g., gender, youth and nutrition), economic and policy considerations are also addressed, along with the biophysical constraints and opportunities. Institutional innovations are a core element of SIIL, including building pivotal alliances across key stakeholders from public and private sectors and civil society. As with other ILs, engagement of US universities is central for applied research and for educational capacity building. The ILs are key components of USAID's Feed the Future (FtF) program of work.

"Sustainable intensification (SI) comprises agricultural processes or systems in which production is maintained or increased while progressing toward substantial enhancement of environmental outcomes. It incorporates these principles without the cultivation of more land and loss of unfarmed habitats and with increases in system performance that incur no net environmental cost."

Pretty, Science 362, 908 (2018) 23 November 2018

SIIL, with its focus on "sustainable intensification (SI)," is using "systems research approaches," with considerations of both vertical integration (e.g., value chains and tailoring of policies) and horizontal integration (farming and landscape systems). In this respect, it is unique across the ILs and other agricultural R&D projects with opportunities for collaboration and synthesis, which we will attempt to highlight in this report.

SIIL is completing its fourth year. It is characterized by: 1) an active Management Entity (ME) at Kansas State University (KSU); 2) implementation of research in Africa and Asia; and 3) building strong partnerships among staff of universities in the US and in three developing regions, along with public and private sectors. The regions are: 1) agro-pastoral, semi-arid West African sorghum, millet and livestock farming systems, currently focused in Burkina Faso and Senegal; 2) East African maize-mixed farming systems, currently focused in Ethiopia and Tanzania; and 3) Asian rice-based farming systems currently focused in Bangladesh and Cambodia. The field-level programs apply systems-research approaches framed within SIIL's Sustainable Intensification Assessment Framework (SAIF). Their research outputs are intended to be relevant to broad recommendation domains across the target countries and ultimately the regions; and, indeed, have potential to enrich the action programs of other ILs. Two cross-cutting SIIL Consortia, namely, the GeoSpatial Farming Systems Research Consortium (GFC) and the Appropriate Scale Mechanization Consortium (ASMC) support, directly and indirectly, the research and capacity building in the regions. A model regional "Center of Excellence" (CeSAIN) was established in Cambodia. It focuses primarily on "capacity building" and becoming a "knowledge repository." The Sustainable Intensification Assessment Framework (SAIF) protocol is another overarching SIIL product, designed and tested to characterize the effectiveness of innovations, singular and in combinations, for their impact on productivity, environment, economic, human and social outcomes for smallholder farm families, that is, on SI itself.

SIIL management is supported by an online reporting and knowledge-sharing instrument, implemented by "PieStar." Open data requirements, in line with USAID's specifications, are being met using the online DataVerse repository. These tools are being harnessed to enhance SIIL's program management, data and knowledge sharing.

Need for a multi-disciplinary forward-looking Innovation Lab

The need to address SI opportunities and constraints through a systems-research approach is well founded through the following examples of the bases:

- Worldwide, farming systems are evolving fast. Mega-drivers include science/technology, demographics, natural resources and climate, knowledge sharing, women's and youth empowerment, trade/markets, investment and infrastructure, energy, policies and institutions, and alliances/partnerships. SIIL incorporates the basis to understand the needs of evolving and future farming systems, including productivity and resilience using appropriate mechanization technologies targeted through geospatial analyses.
- Effective combination of agricultural science disciplines requires expertise and experience of diverse scientists to implement effective approaches for collectively producing and demonstrating productive, readily adoptable SI technologies. SIIL is building capacity through the training of graduate students who are working in multidisciplinary teams. SIIL's program of work demonstrates the capacity of US universities to foster and guide multidisciplinary systems research for development in collaboration with national institutions.
- Farmer adoption is complex, whether of 'simple' technologies, such as an inorganic fertilizer, or coupled SI innovations, requiring tuning of farmer learning/discovery approaches and harnessing inputs from the broad stakeholder community. SIIL focuses on the processes and institutional innovations for effective partnerships, including (Public/Private Sector Partnerships) PPPs, ultimately required for widespread scaling and impact.
- SIIL is an important investment for its own output value and also adds value to other development projects, including the other ILs.

Purpose of Evaluation

The purpose of this commissioned performance evaluation of the Feed the Future Innovation Lab for Collaborative Research on Sustainable Intensification (SIIL) research projects is to:

- a) assess progress on activities and outcomes;
- b) improve effectiveness of ongoing activities;
- c) provide robust evidenced-based findings, conclusions, and recommendations; and
- d) assessing needs and opportunities, for tackling outstanding key research questions, and tools for scaling adoption, connected to sustainable intensification (SI) farming systems in developing countries.

The evaluation results will support evidenced-based decision-making by the Feed the Future (FtF) program of the Bureau for Food Security (BFS) under U.S. Agency for International Development (USAID) on the potential value of an extension of the SIIL award through Kansas State University for another five years.

In Section 3 (Findings) the ET elaborates details of four key areas:

- Technology Development,
- Partnership Building for Enabling,
- Capacity Building, and
- Impact and Scaling.

This is done for each of SIIL's organizational components, namely: the two Consortia (GFC and ASMC), the six country hubs, the Regional Center of Excellence (CE SAIN) in Cambodia, and SIIL's Program Management. The ET also evaluates SI's crosscutting tools development, primarily the Sustainable Intensification Assessment Framework (SI AF).

Evaluation Methodology

To accomplish this appraisal, the evaluation has assessed implementation and progress toward objectives among the different SIIL components, including relevance, effectiveness and efficiency of research (technologies, and institutional innovations, including tools), capacity building and scaling accomplishments. Furthermore, since the SIIL will be completing its first five-year phase in

September 2019, the evaluation team makes recommendations for sustainable intensification and farming systems research on continuing or new investments.

The evaluation approach for the research project reviews from the external Evaluation Team (ET) are primarily:

- *Document Reviews*: Project proposals, annual operational plans (AOPs), annual and semi-annual reports, travel reports, baseline data, research protocols, data analysis documents, project publications including success stories, research publications, indicator outputs, and data management plans and associated documents, etc.;
- *Key Informant Interviews*: SILL researchers, SILL management team, country and regional coordinators;
- *Focus Group Discussions*: Evaluator dialog with farmers engaged in the project and others at project sites, development agents and other change agents operating at site, and innovation platform actors;
- *Field visits*: Evaluator visit to project sites in the participating regions, as necessary.
- *Survey on Management*: The ET contributed a few questions and took into consideration the outputs of the formal survey conducted on management performance by KSU itself. The survey provided a cross-reference triangulation on information derived from Key Informant Interviews.

A list of key topics/questions were created that provided a common framework/matrix for interviews with persons and institutions, including SILL's Consortia, directly involved in SILL's planning and implementation (see Annex 7.15).

The five-person ET conducted near weekly Skype consultations to jointly shape the reviews' comments and recommendations.

3. Findings

3.1 Overall progress

3.1.1 Overall Results from implementing Sustainable Intensification

SIIL Phase I has demonstrated effective innovative approaches to the implementation of sustainable intensification (SI) in six core countries working through six country Awards and two Consortia, and in this way contributed to FtF. The concept of SI is now well recognized (“Sustainable intensification (SI) comprises agricultural processes or systems in which production is maintained or increased while progressing toward substantial enhancement of environmental outcomes. It incorporates these principles without the cultivation of more land and loss of unfarmed habitats and with increases in system performance that incur no net environmental cost. (Pretty, Nov 2018, Science)). The need has never been greater for SI. World agriculture has witnessed massive growth in productivity since 1950, alongside massive depletion of water resources, degradation of land and weakening of social capital – resulting in unsustainable intensification. The SI concept offers a way to re-inject sustainability into food and nutrition security and agricultural intensification programs.

However, the implementation of SI in the practical World of under-development has faced challenges, which is the major contribution of SIIL. The six selected core countries represent a spectrum of local and regional maize, sorghum and rice-based food bowls in semi-arid, rainfed, highland and irrigated farming systems, with the integration of ruminants, poultry and fish – and thus SIIL results are potentially relevant to wider geographies than the research hubs or countries alone. In these farming systems large yield gaps exist between current smallholder productivity and potential productivity, and thus there is great scope for the implementation of SI which brings new technologies, improves institutional and social capital to empower women and reduce risk, and ultimately to strengthen enabling policies.

Clearly SI cannot be implemented through commodity or disciplinary programs alone, and so the SIIL architecture deployed complementary research expertise from different partnerships into the six core countries to encourage multi-disciplinary research for development. The ET endorses the farming systems approach adopted by SIIL, noting that this farming systems approach includes resource management, production, marketing and community action; and requires joint integrated investigations by bio-physical and socioeconomic researchers. Cross-fertilization occurred at local level in countries, and especially at the annual SIIL workshops. Despite the farming systems approach, the local SIIL teams were unable to articulate an integrated vision of SI success in the research hubs. In this connection, it is important for all local research hub teams in Phase I to be able to articulate an integrated vision of SI success, the interactions between research partners, the pathways to impact and institutional and policy implications. In practical terms, this would be facilitated by a joint participatory farming systems evaluation of research results in each research hub, in order to map pathways to impact and wider effects on gender equity, nutrition and resilience.

The ET proposes that a roadmap be developed for this re-inception process (to jointly designing the Impact Pathway and plan lightweight Farming Systems appraisals and the use of SIAF). The roadmap document should include a budget, and be articulated in the last year of Phase I to jump-start field participation should an extension follow Phase I. We trust USAID will support this process as it is fully mindful that development is rarely linear —most often it has feedback loops and requires subsequent adjustment.

While the core of SIIL implementation is focused in six selected countries supported by six country-linked Awards and two Consortia, SIIL has successfully attracted additional USAID resources for complementary research in African soil fertility, technology assessment, soils and economic policy research. These components actually fill gaps in the original SI research portfolio system, from soils to production and policies. Equally impressive has been the buy-in of USAID Missions to the SIIL concept, both in SIIL core countries and unrelated countries. The Mission investments in Cambodia into the CE SAIN, the CASF and the CA Alliance are strongly complementary to core SIIL activities,

high value for money, and unquestionably add to the impact of SIIL with modest additional management, monitoring and reporting input. The second type of Mission investments to supplement SIIL occurs in non-SIIL core countries and is more difficult to integrate into the overall wider SI system – and need to be considered carefully, on a case-by-case basis. Remarkably, SIIL has also attracted non-USAID resources for aligned research, e.g., USDA (funding feed conversion trials on the Technology Parks), CIRAD (managing the Conservation Agriculture Service for e Fee), USF (funding internships at RUA), SEARCA (locating graduate student research from the Philippines with SIIL in Cambodia) and Swiss-Contact (assisting with the business design for the CA Alliance) in Cambodia, which is testimony to the power of the SI implementation research.

In relation of SIIL achievements, four institutional models/practices and four technologies are particularly noteworthy and have evidence and resonance across many countries. Of the institutional models and practices, CE SAIN and the SIAF will be discussed in this section, and the Peace Corps collaboration and CA Alliance will be discussed in the following sections. The four leading technologies – CA-vegetables, conservation agriculture based sustainable intensification (CASI), crop-livestock and mechanization (which also embeds innovation systems platforms into the research), are discussed in the next section 3.1.2 Farming Systems. In addition, nutrient enriched varieties are being deployed in West Africa, and high Zn rice in Asia. Even more importantly, diversification of farming systems leads to dietary diversity and reduced malnutrition. SIIL has generated many more significant technical and institutional innovations, although sometimes with a narrower evidence from one or two countries, which are referred to in the following sections.

The **Center of Excellence (CE SAIN)** in the Royal University of Agriculture (RUA) in Cambodia is a clearly successful model, although at a relatively early stage of operation. It is addressing two critical inter-related SI needs in Cambodia and the wider region, viz, capacity building and knowledge repository and sharing. The USAID Mission which funds the Center is clearly committed to its continuation, and also asked the Center to track and monitor the status of all USAID-funded SI related projects in Cambodia. This is updated on a quarterly basis and provides an excellent overview of many SI activities in Cambodia, in effect elevating the role of SIIL in Cambodia. The Rector and staff of the RUA assured the ET of their full commitment to the Center and plans for its continuation in the long term. The Center has a small staff, led by Dr. Lyda Hok, which manages a large number of internships (for RUA and some in UBB) as well as research grants for Faculty.

The Center has also established and manages five Technology Parks strategically located around Cambodia in order to demonstrate SI technologies to farmers, students, business persons and the general public – but also host some trials (e.g., cover crops, and poultry and pig feeding). Various local management arrangement arrangements have been developed; for example, the Battambang Park is hosted on the University of Battambang research farm.

Interestingly, the RUA is establishing an agribusiness incubation center immediately adjacent to the RUA Technology Park, which offers great potential to develop business models around SI technologies. In terms of innovation, the Center established relationships with some regional high schools and succeeded in interesting students in agricultural studies, with a consequence that now 9 first year agricultural students enrolled in agriculture at RUA (without the intervention, it was expected to be zero from that school). The Kampong Chhnang Technology Park/CAS demonstration farm is a superbly managed impressive 15 ha farm with a wide variety of cropping systems with work commencing on livestock fattening. With its associated training facilities, this hub has great potential to become a regional training center for CA in the Mekong and wider Asian region.

Several aspects of CE SAIN merit further consideration. First, it is essential to incorporate systems thinking for SI into the RUA curriculum upgrade, to avoid leaving RUA with teaching methods more fitted to the previous Century. Relatedly, the demonstrations and explanations in the Technology Parks must include some common interactions, for example, crop-livestock, cover crops, soil

management and disease pressure. Second, the Technology Parks are just being established and their use, and user feedback, needs to be monitored – to avoid the historical experience with such parks of becoming white elephants. Third, there is a opportunity for regional training for Mekong and wider Asia in CA based on the Kampong Chhnang Technology Park/CAS farm which would have huge regional pay-off in SI capacity and is already supported, in principle, by FAO and GIZ.

The fourth aspect relates to wider benefits from CE SAIN among the 5-6 leading agricultural Universities in Cambodia (including UBB, UM, and others). A recently approved World Bank (WB) loan (\$90m) for strengthening agricultural education in Cambodia would be implemented by RUA, but include another 5-6 regional agricultural universities. The ET recommends, CE SAIN explore opportunities for integration for implementation of the new WB loan to Cambodia.

The fifth and final opportunity is the replication of CE SAIN in other major food bowls of Africa and Asia. The most immediate and obvious opportunity would be a semi-arid Agropastoral Farming system CE SAIN in Senegal, covering the sorghum/millet/legume/livestock farming system of West Africa with some relevance to parts of East Africa. A second opportunity, potentially with even greater impact on food production, would be a CE SAIN for high potential maize legume livestock farming systems in East Africa and also applies to the large, favorable, moist savanna biome running across West Africa.

The second major product of SIIL is the **Sustainable Intensification Assessment Framework (SIAF)**. Its development was contracted by SIIL in order to have metrics on the degree of achievement of SI, and a basis for the assessment of trade-offs between parameters. The SIAF has been peer reviewed and tested on most SIIL Awards, has been launched on the web, and is widely recognized as a useful public tool for SI implementation. Without doubt this is a major public good from SIIL. *It would be appropriate to deepen its use through SIIL Awards and to require, when practical, all final reports provide empirical assessments using SIAF of the Award research portfolio (in contrast to one or another component thereof).*

The following section evaluates the farming systems aspects of Technology Development, followed by sections on Stakeholder Collaboration, Gender, Nutrition, Policy engagement and Program Management. This provides the basis for a discussion of foresight and ways forward.

Sustainable Intensification Assessment Framework (SIAF) in a major output of SIIL and is considered a significant “public good.” Evidence from field-testing indicates it is truly valuable for appraising relative merit of innovation options during planning and the relevant merit of innovations under development or those being scaled up. SIAF application helps guide both research and development.

3.1.2 Farming Systems Agronomy

At the center of SIIL, is its intended contribution towards enhancement of systems-specific agronomic and livestock research, addressing productivity needs and opportunities of small-and medium-holder family farmers in FtF-targeted developing countries. Gender, nutrition and opportunities for rural youth are main issues woven into SIIL’s tactics from the onset of planning. Then too, concern about scaling up adoption is increasingly seen as a necessary, early component in SIIL’s “Impact Pathways.”

The ET recommends that considerations of methods/processes for scaling up, for each major innovation domain, be part and parcel of the planning and prioritization process—from the “on set”—within SILL’s modus operandi. An “Innovation Pathway” should be articulated by principal stakeholders, mapping actions along the development pathway from defining the first concept through to scaling up and out adoption.

SILL’s research is less about discovery research (cutting edge science/agronomy) and more about harnessing best-bet components of crop/livestock systems research. Environmental and health concerns are prioritized, as are efficient development and use of physical (e.g. soils, water, air, etc.) and social capital (e.g. people and formal/informal institutions, etc.). Systems resilience, including systems diversification, and climate change adaptation are prioritized as well.

Examples of main components in the SILL toolbox, include:

- embedding gender and youth empowerment;
- tuning crop mixes (intercropping, relay cropping and rotations, crop/pasture sequencing/cycling);
- water and soil management, including plant nutrition, soil husbandry, etc.
- dry-season horticulture under irrigation;
- appropriate agriculture mechanization for efficiency, reduced drudgery, soil health, enabling women, encouraging young farmers, etc.;
- geospatial technologies to prioritize and tune decision making toward SI;
- agro-forestry, including for lumber, energy, living fence, feed, fruits, nutrient cycling, etc.;
- aquaculture (fish, shrimp, crabs, crustacean), especially in rice-based systems;
- integrated pest management, including weed control;
- post-harvest management;
- market access;
- capacity building (training—formal and informal); and
- policy for enabling.

Most of the specificity and details of SILL’s research for development story, albeit incipient, are articulated in the country and regional reports of the annexes below, and further are detailed in SILL’s Annual Reports for 2017 and 2018. We intend this review to be read in conjunction with those reports.

Herein, we provide a broad-brush narrative highlighting examples of evolving synergies from: convergence of agronomic and livestock components, the enabling of dry-season vegetable production (through appropriate tube-well based irrigation, with and without drip-irrigation) and more. The ET visited all six major hub countries and we reviewed the main concepts, the lessons learned, the partnerships extant and those needing further attention. Fact checking of individual innovations at “ground level,” while important, was, and is, considered less important than appraising the direction and competency of the SILL program at strategic, holistic level, as well as at its own management level.

Innovation Focus and Blur:

SI relies on optimization of the broader production systems at farm, state, national, watershed and regional levels. The very premise for this optimization/intensification is founded on effective “systems” management at those same levels. For country-level, pilot, hub research SILL, has correctly looked to local, USA national, and international partners to engage in the same geographical and temporal space, toward coherent “systems research” planning and implementation. This complexity is additionally expanded by harnessing a wide array of technical disciplines such as: agronomy, soil

health management, weed and pest management (IPM), animal sciences, mechanization optimization, smallholder irrigation, geospatial, gender, capacity building, human and livestock nutrition, youth, marketing, economics, policy, institutional innovation, etc.

At the country hub level, SIIL correctly addresses both vertical integration (crop value chain orientation, e.g., vegetable value chain) and horizontal integration (optimization of multiple commodities, e.g., maize and soybean) across farm and/or watershed levels. In both of these integration approaches, which are not mutually exclusive, consideration of environmental stewardship and resilience are emphasized. The major challenge of SI optimization, and its scaling, lies in the need to have all key elements operational at the same place and time. Managing complexities is vital.

Then too, farmer adoptions of many SI innovations are “knowledge-intensive” in themselves, for example, conservation agriculture or IPM, and are even far more demanding when coupled. Farmers can be mentored to understand the choices, and the implications of the choices, as they manage this complex biology. But the processes of discovery-learning are not accomplished by simple demonstration plots, which generally do work for less complex innovations, such as change of varieties, fertilizer doses, etc. There is an overlooked research domain around the adult education/extension practices for different levels of innovation complexity. Extension research for scaling adoption of more complex innovations is especially relevant for the multidimensional SIIL program, and merits future considerations. Public sector (Land Grant University) engagement and capacity in rural education/extension, as it relates to needs in developing countries, is not what it once was. Wageningen University in Holland has shown recent leadership in this area and could perhaps be a future partner.

The SIIL would be a logical focal point institution to inform FtF's efforts to scale up adoption of innovations based on the most efficient approaches to knowledge transfer in the context of its development goals. One size does not fit all. Research on what works best, where, with whom, and associated costs of scaling up and out, is needed, and relevant knowledge needs to be archived and shared.

Thematic Consortia as organizational technical sub-units:

The foci of the two SIIL Consortia are intended as important elements of SI's development strategy, including for country pilot hubs. ASMC, created one year later after establishment of SIIL's field programs and its GFC, has, for the most part, inserted its programmatic into four pilot hubs' programs of work. But, as of yet, the GFC has not incorporated itself, to the same degree, into SIIL's field programs. Without question, many of the actions of the GFC, through

The ET recommends that both GFC management and SIIL management host a consultation(s) with stakeholders and experts to explore how best to focus GFC's contribution to more directly contribute to the prioritization and decision making around the tangible programatics of targeted pilot hubs.

creative sub-awards, can eventually contribute to impact; the degree of dispersion of funded activities fosters concern about failure to show tangible contributions to SIIL's field activities. (See Section on the GeoSpatial Consortium for further detail.)

The ET sees similar merit for ASMC to consult more widely with the “mechanization community of practice” in order to be more mindful of historical efforts, their successes and failures, and to create a broader consortia partnership now and in the future.

Similarly, the ET is aware that in January 2019 two additional thematic Consortia will be strategically inserted into SIIL. One will be on Soil Health and its many components, while the other will be Enabling Policies that are required to remove barriers to wide-scale adoption. The ET fully endorses these components being fostered under SIIL and would strongly recommend there are wide consultations across the R&D community to better focus what the Consortia will do, where, with whom, how, and when—in the most specific way practical. **We argue that these new Consortia be designed to focus primarily on issues key to the Hubs’ central goals and objectives. They should serve the production systems innovations (agronomy, institutional and social capital). They should not be ends in themselves.**

SI Horticulture as a prizewinner:

Currently, SIIL has incorporated dry-season horticulture in both Asia (Cambodia) and Africa (Ethiopia) with encouraging outcomes. Farmer Groups are replicating with support of local institutions. There are a variety of reasons for this emphasis, but in addition to having the potential to bring in revenue (a farm family priority), horticulture addresses the gender and nutritional benefits of the Innovation Labs' and FtF's overarching goals. Hand tool development is prioritized by the ASMC for women in horticulture from Cambodia to Burkina Faso. Nutritional impact is considered by experts (FAO, personal communications) to be significant, or potentially significant, wherever there is expanded and diversified horticulture. In Ethiopia, a partnership project—SIPSIN, documents impact on incidence of anemia in rural populations. In Cambodia, under guidance of SIIL/KSU staff, a CA system, coupling drip-irrigation-based dry season vegetable production on permanent raised beds with constant mulching for soil protection, is gaining awareness and adoption. Similar CA vegetable production is also showcased, with promise, by the Horticulture Lab's field program in Guatemala and Honduras. The ET sees such cross-lab partnerships to be a very positive development for the Innovation Laboratory concept. Similarly, the use of grafting of tomato scions with desired organoleptic/market characteristics onto root-rot resistant eggplant rootstalks is a very promising technology linked to dry-season horticulture. Again, this innovation is finding

The ET recommends scaling up and out adoption of dry-season, irrigated horticulture be a “centerpiece” of SIIL’s work in Phase II. This should be addressed as a full systems development approach, involving the Policy and the Geospatial Consortia within SIIL, and also other relevant Labs, such as HIL, IPM, Market Access, etc., plus inclusion of CGIAR (World Veg, IWMI, IFPRI etc.), the private sector, and especially with key NARES. Capacity building should be well beyond university-to-university empowerment.

stakeholder interest both in Cambodia (SIIL) and in Central America (Hort Lab). The grafting innovation also links to the IPM Innovation Lab, and is very relevant as a focus for women in agriculture. Women are taught to be the grafters and to run small-scale enterprises, selling grafted tomato seedlings to farmers in zones where tomato root rot is one of the limiting production factors. The CA dry-season horticulture is correctly viewed, in most cases, as a co-enterprise with rainfed crops' value chains. Together they are a system—they complement each other. In many cases the crop residue required for mulching of permanent raised beds for horticulture comes from the rainfed crop. Inputs, including labor, are managed as a system as well. Reliable, clean water availability is key for horticulture intensification. **Consequently, the Geospatial Consortia could (and should) help inform on the geographic hotspots/expansion-domain for this opportunity.**

Cereal/Legume production systems:

In the three semi-arid hubs of Ethiopia, Burkina Faso and Senegal, innovations around optimization of cereal legume rotation are under field study with the perspective of optimizing food security, systems resilience with lowering of risks, and optimization of external inputs usage (see Annual Reports for 2017 and 2018). Dual-purpose (grain and fodder) cereals and cowpeas and/or groundnuts are being tested in intercroops and rotations. In Ethiopia and Burkina Faso, fodder choppers are being promoted as an adjunct toward feed improvement. Maize shellers and strip-till seed drills with fertilizer placement are also part of ASMC's contribution to the system enhancement. Improved feed for sheep and cows contributes to livestock and local dairy production, and consequently, to increased incomes—so badly needed to diversify food and for so many other necessities. In Senegal, the cereal of focus is dual-purpose millet, instead of sorghum. Combining inorganic fertilizers with manure helps increase biomass production,

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but the economics of the investment on inputs is often marginal due to the uncertainty of rainfall and its distribution. The carrying capacity of this agro-ecology, in terms of humans and livestock in these semi-arid zones with 300 to 600 mm of annual rainfall, is limited and needs to be respected to avoid degrading the natural resource base. “Systems thinking” is necessary to determine future opportunities for youth, outside of subsistence agriculture in these areas. Although still very challenging, the scope for SI in zones with adequate rainfall is exponentially higher.

The maize/bean production system, found at the Tanzania hub, and throughout the mid and high elevation zones in Eastern Africa, is of major importance. The hub in Tanzania has focused on maize/bean systems and on testing analytical tools to characterize opportunities and constraints on SI components through the SIAF.

The ET recommends better balance between production systems research and socio-economic parameters should be sought. SIIL management should explore creating a Center of Excellence (similar to CE SAIN in Cambodia) to address the opportunity to help foster SI in the context of maize/beans based production systems in Eastern and Southern Africa. Western Kenya or Central Uganda could be among candidate host countries considered for this facility. NARES are relatively strong providing a foundation for applied research and capacity building, including on extension processes.

- The ET recommends: In Phase II, when appropriate, SIIL strengthen research on conservation agriculture based sustainable intensification (CA SI) for SI in farmers' main-season crops. There should be inclusion of complementary SI practices that support the basic CA principles. Such research should build on the Phase I's CA Horticulture results conducted in a majority of countries. In this context, SIIL partners should investigate issues of soil health, crop rotations, cover crops and climate adaptation, including labor use

efficiency, 'zero tillage' mechanization service provision and efficient crop-livestock integration.

SIIL partners in Cambodia are conducting SI research on soil health and good crop/soil management. For example for lowland rice and upland rainfed farmers, nearly 280 famers, backed by more than 30 Service Providers, have trialed and adopted CASI practices. In other studies when comparing soil organic content found SOC increases under 4 years of reduced tillage to have increased about 25%.

3.1.3 Data Management

The SIIL ME has made concerted efforts to establish robust data management systems and procedures that are compliant with USAID's open data specifications. They have effectively and, where necessary, repeatedly communicated to award holders the benefits of proper data custodianship as well as the fact that compliance with donor standards is mandatory (the carrot and the stick).

Project data come in two main forms, i) the project monitoring data that are generated by routine project management activities ii) the research datasets that are generated by the field and other activities (surveys and trials, principally). SIIL management contracted a local IT company, with relevant experience (PieStar Inc) to design and support an "Online Reporting Hub". This hub integrates these main data functions across the ME, the subawards and the consortia and supports the collation of indicator data for the annual FtF monitoring exercise. The design of the system is well executed online and the level of support offered to the ME and individual users by PieStar would put many global IT companies to shame!

If there is an issue with SIIL's data management, it is a manifestation, in some cases, of the RIRO ("rubbish in, rubbish out") paradigm. Awardees show varying degree of commitment to informative reporting and it is clear that some of them regard it as a chore. It is difficult to see how the system could be redesigned to counter this attitude so, going forward, the ME should seek to identify more effective means of coercion and / or censure for non-compliance.

3.1.4 Gender

Effective gender mainstreaming is a challenge in most research and development projects and programs. In general, SIIL has been very successful in mainstreaming gender concerns throughout the majority of project components. However, due to the lag in obtaining baseline surveys for analysis and integration into project design and implementation sometimes SIIL projects are unable to properly document women's roles and their time constraints. And in some cases, surveys are included in work plans, but results have not been reported. Gender division of labor and time demands, by season, are critical in planning scaling pathways and insuring women and men benefit from multiple research and outreach efforts of SIIL through local collaborators.

There is a tendency to equate "number of women trained" and an impact based on hypothesized economic, social nutritional and environmental benefits. Training is process. It is important to be able to provide evidence for changing gender roles and benefits through the impact of SIIL's innovations and interventions. SIAF provides creative methodology to appraise the impact on socio-economic changes.

The ASMC is doing an excellent job of assessing technologies for gender sensitivity by collaborating with AgReach's Integrating Gender and Nutrition within Agricultural Extension Services (INGENAES) project. The partnership is analyzing gender sensitivity of ASMC's Planter technology design, use and dissemination by interviewing farmers to understand effects of planter innovation on women's time, labor, income, assets and food availability. Then they utilize findings to implement feasible recommendations, enabling better adoption of technologies by women and men farmers.

However, other Consortia and research projects have often not attended to gender mainstreaming. The Geospatial project published a paper articulating how women-oriented data sets could be used in program planning and evaluation in Nigeria. Unfortunately, SIIL target countries do not have long-term socio-economic data available for such geospatial analysis. ASMC focus groups identified women's access to credit, markets, adequate training and knowledge and access to the use of equipment for both production and post-harvest efficiencies. SI interventions are also directed at removing agriculture drudgery, especially for women and youth.

A household survey was completed and partially analyzed by SIPSIN in northern Ethiopia. Based on that survey, gender-related issues will be identified with recommendations for research. A goal in Ethiopia is to empower women to increase household food security. SIPSIN found irrigation pumps reduce the labor required to irrigate a hectare of land from 108 and 80-person-days per year to 48 and 14 person-days per year for men and women, respectively. This translates into a reduction of 56% and 137% for men and women, respectively. Men and women work collaboratively on agricultural production, including irrigation. There is some gender division of labor where women are primarily cultivating vegetables and gesho (an aromatic herb with an international demand, particularly for beer making).

In Burkina Faso, women are key players in nutrition interventions using SIIL's more diverse and nutritionally enhanced grains, pulses and moringa leaves for infants and children, but systematic monitoring of the impact on child and maternal health is not in place. ***The ET recommends that SIIL stakeholders appraise how to best facilitate controlled studies on innovation impact for gender, youth and nutrition.***

In Ethiopia SIPSIN found irrigation pumps reduce the labor required to irrigate a hectare of land from 108 and 80 person-days per year to 48 and 14 person-days per year for men and women, respectively. This translates into a reduction of 56% and 137% for men and women, respectively. Men and women work collaboratively on agricultural production, including irrigation. They found gender division of labor by crop. Women take responsibility for vegetables and herbs, which require irrigation. Irrigation techniques are gendered. Pump technologies are used for different purposes by men and women: men use pumps for irrigation, while women use them for domestic purposes, dry season vegetables and watering livestock.

Phase II recommendations.

- ***The ET recommends the ME, in concert with INGENAES should facilitate in-country participatory trainings for technology developers, faculty and students, targeting gender integration in research and development.***
- ***The ET recommends SIIL stakeholders should work with local institutions to overcome barriers to women's initiating enterprises that facilitate scaling out and pathway implementation. Working with extension and NGOs, women groups could identify local sources of credit, share the potential investments with those sources, and work to harmonize loan requirements (often requiring collateral), investment risk, and potential collective ways guaranteeing loans. Women's groups could analyze marketing issues, such as prices and costs of production, to evaluate which efforts should first be attempted to market what is processed and produced, as well as ways of warehousing to hold crops until the market price increases.***

3.1.5 Nutrition

SIIL has contributed significantly to improved rural household nutrition in the research communities in the six core countries during Phase I. Through increased productivity, both household food and nutrition security have been directly improved. The increased diversification of farming systems is a second direct effect on nutrition. It is well established that rural malnutrition is reduced by diverse diets, which are strongly correlated with diversity of farming enterprise patterns (cereals, legumes, wild gardens, vegetables, livestock, poultry and fish). Naturally, poverty reduction and increased household income have direct affects, as well, on nutritional security.

For the longer term, SIIL is supporting the integration of human and animal nutrition traits into plant breeding. In Bangladesh the Polder project is promoting high-Zn rice. In Senegal, the dual-purpose sorghum and millet, in combination of grain and fodder, are producing high quality feed for small ruminants.

Some Awards have collected nutritional status data. For example, the WAgN Award in Cambodia included nutritional status parameters in their baseline survey. This was complemented by nutritional assessments of selected wild garden species, and detailed market prices data collection for 70 underutilized species for one season in Battambang. In Ethiopia SIIL, through its cooperative program Sustainably Intensified Production Systems Impact on Nutrition (**SIPSIN**) is engaging in community nutritional status monitoring, attempting to provide evidence concerning nutritional benefit of off-season vegetable SI under irrigation. The SI Assessment Framework (SI AF) also includes nutritional parameters in innovation evaluation.

In Phase II, the use of the foods generated by the project, including more diverse and nutrient-rich food, and the milk produced by healthier animals, should be monitored and their collective impact assessed. The use of focus groups of mothers connected with the project in the various sites could prove a good source of data. In such discussions, concrete indicators will emerge that are relevant to the individuals in the household who prepare and serve food. There should also be follow up, in terms of the impacts of school nutrition provided by school crop and livestock projects, perhaps as assessed by the teachers or parents. More rigorous evaluation of livestock gain, based on diets, including diverse sources of feed and fodder.

3.1.6 Enabling Youth in SI Enterprises, Capacity Building and Entrepreneurship

Many of the SIIL countries have high rates of youth unemployment, which leads to out-migration and social unrest. Sustainable Intensification offers opportunities for youth who are knowledgeable about the SI process to develop enterprises to provide key services to enhance pathways to scaling. All the host countries have rapid population growth, out-migration and potential unrest. Emphasis on even more inclusion of youth and fostering them in enterprises that enhance scaling out pathways in terms of production technology and product transformation and marketing, including access to credit and introduction to value chain concepts and local and national enterprises.

Cambodia and Senegal have been effective in including youth through SI projects in the schools. SIIL has supported youth clubs where SI is a key component of agricultural endeavors. Providing viable opportunities for youth not only in agricultural production but in service enterprises that support SI and provide markets for the diversified products in critical. AMSM is working to involve male and female young people in enterprises that add value to local crops, including producing silage from crop residue.

In Phase II, each project/Consortium should work with local youth to identify opportunities for youth to move their knowledge of SI into income generation through providing inputs (seed production, machinery production, custom field work), processing the animal/fish, fruit/vegetable,

and seedlings, and marketing the products. At the same time, Scaling Out Pathways can be integrated to see where the optimum opportunities lie for SIIL and the young entrepreneur.

As local collaborators identify emerging enterprise opportunities, banks and other credit institutions should be involved in the planning to facilitate the capital investment needed to start the business.

3.1.7 Partnerships, Process and Institutional Research.

SIIL has been diligent, overall, in establishing partnerships at the country- Consortia- and Center of Excellence-levels. Details of these alliances and the strong inter-university partnerships, both in the USA and abroad, are described in detail in the 2018 Annual Report (see Annex 10, Addendum 1). However, SIIL, including its ASMC, enabled establishment of functional linkages among most national institutions (NARES) by building a shared vision for action research (Cambodia is one exception, which is now being rectified). This was based primarily on explicit, participatory, problem and opportunity identification through national SWOTs, although participatory farming systems appraisals in the hubs were not routine. In contrast, the GFC's institutional linkages were primarily with other advanced US educational institutions or the CGIAR. Many more field-directed geospatial inputs are needed in the future.

SIIL's primary charge is to conduct, in partnerships, applied research that enables identification, adaptation (where necessary), testing and adoption of SI practices that will contribute to FtF goals. For the most part, too little attention was focused in Phase I on those linkages (institutional innovations and platforms, (see Makati et al. 2013¹) that need to be optimized to enable adoption in any defined "expansion domain," beyond the hub research areas. Such linkages bring together community groups and input providers, foster farmer-to-farmer-learning and research-extension interactions. Within SIIL, one good example is the CA-vegetable women's groups in Battambang Province in Cambodia. Often, those linkages appeared to be rather opportunistically created and, less often, created by design. Similarly, limited attention was paid in Phase I to agricultural policy engagement and the improvement of agricultural institutions, which would foster adoption and scaling of SIIL technologies. For this purpose, alliances need to extend beyond the NARS to include engagement with Ministry of Agriculture policy makers.

SIIL has demonstrated the clear value of an alliance with Peace Corps workers in Senegal for the demonstration of SIIL technologies and the training of farmers in those technologies. Early performance should be assessed, in order to understand the preconditions for replication in other SIIL countries.

Progress on gender mainstreaming is positive in most country activities. In a few cases, involving SI vegetable production under dry-season irrigation, SIIL stakeholders gave explicit attention to nutritional enhancements. In most cases, nutritional improvement was more implicit—a reasonable impact pathway envisions increased productivity, and lower production costs will result in both more food availability and increased rural incomes, which can both result in nutritional benefits. Future research, directed at mainstreaming of impact pathways, should aim to identify explicit relationships of SI to nutritional, and other human and social, outcomes / impacts.

The ET noted that no research to date has been oriented to guide effective and efficient extension toward scaling adoption of knowledge intensive SI innovations. Most are, in fact, knowledge intensive. SI application is essential, but it is also challenging. Well-designed extension research

¹ Makini FW, Kamau GK, Makelo MN, Adekunle W, Mburathi GK, Misiko M, Pali P, Dixon J. 2013. *Operational Field Guide for Developing and Managing Local Agricultural Innovation Platforms*. KARI-ACIAR-AusAID, Nairobi, Kenya, 79 pp.

merits attention. There are examples of ways forward, such as the effective use of Farmer Field Schools (FFS) for capacity building in IPM adoption (Settle et. al., 2017²).

3.1.8 Policy Research and Engagement

It is clear that successful SI depends on technologies, social and institutional capitals, human and organizational capacity and enabling policies. Naturally, policies take many forms, e.g., research, economic, resource management and trade, and are implemented at regional, national and local, e.g., district, levels. In case regional policy requires explanation, Africa has continental-wide and sub-regional agricultural research organizations, which influence national research resource allocations, e.g., CORAF in West Africa and ASARECA in East Africa. Similarly, FARA and NEPAD-AU (CAADP) have had substantial influence on agricultural research and development expenditures. Thus, policy engagement with national and regional research organizations is relevant to SI.

SIIL Phase I did not envisage specific policy research, outputs or outcomes, but the relevance of policy research and engagement grows as SIIL develops technology results and builds human and organizational capacities for SI. Thus the prospect of SIIL the Policy Research Consortium, commencing in 2019, is welcome and timely.

However, most Consortia and Awards have now developed sufficient initial results to underpin dialogues with relevant policy makers in NARS and Ministries of Agriculture. Certainly Senegal, Bangladesh and Cambodia have SI narratives of potential interest to policy makers in Phase I. Such dialogues might be supported by SI technology briefs summarizing initial results. Such dialogues would also foster the links, often weak or missing in SIIL Phase I, with Ministries of Agriculture during Phase 2.

Based on the experience of SIIL, one of the critical constraints to the adoption and scaling of SI is credit. Effective SI requires a variety of equipment (e.g., no-till planting, storage) and inclusiveness of women and youth in the mainstream of credit availability for SI processes. The ET encourages SIIL to initiate local policy dialogues with credit providers, including but not limited to national banks. The purpose would be to explore policy adjustments by banks and credit providers that would improve credit availability to women and local entrepreneurs who lack land, as well as collateral for loans. It is considered that local universities would be able to convene such dialogues. The SIIL experience provides many other examples of useful policy dialogues, which could be initiated at this stage. It should be noted that such local dialogues about local policy adjustments are different to the economic policy research envisaged under the forthcoming consortium.

3.1.9 Towards Scaling — Impact Pathways

The mandate of SIIL, in common with other USAID innovation laboratories, revolves around the generation of research outputs based on local and expert consultations on constraints and opportunities. The intention is that the research generates evidence that these outputs could be used to underpin improvements in human wellbeing in FtF target countries. It is accepted that actually achieving this at scale requires investment from other actors with the capacity / infrastructure to reach the “big numbers” of beneficiaries. SIIL is a research project. However, this scenario does not absolve SIIL from a responsibility to ensure that its research products have the best possible chance of entering the pipelines that are managed by development actors such as USAID bilateral investments at the country or regional scales or via partner governments own development efforts. ***SIIL partners should ensure that scaling considerations are noted in Impact Pathways and that scaling must be part of the development vision for every***

² [Settle, W., Soumaré, M., Sarr, M., Garba, M. H., Poisot, A. S. \(2014\) Reducing pesticide risks to farming communities: cotton farmer field school in Mali, FAO, The Royal Society Publishing. <http://rstb.royalsocietypublishing.org/content/369/1639/20120277.short> - abstract-1](http://rstb.royalsocietypublishing.org/content/369/1639/20120277.short)

innovation to be researched. The ET identifies a number of generic impact pathways (IPs) that SIIL could mobilise in order to fulfil these responsibilities:

IP1: Co-investment with USAID mission-funded activities in countries or regions. This is the impact pathway that would appear to offer the most immediate traction with the idea that one USAID funded activity leverages off another appearing attractive. SIIL have already managed to establish examples of this kind of engagement with CE-SAIN in Cambodia and there is likely mission interest in similar activities in Ethiopia. In Senegal a partnership with the USA Peace Corp is emerging as one model for scaling of farmer learning/discovery. The cautionary note is that mission investments are often earmarked some years in advance, sometimes driven by individuals who have been reposted! This situation makes planning difficult and generally this IP is likely to be highly opportunistic.

IP2: Co-investment with other development partners. In terms of implementation this is likely to be a similar model to IP1. Partners may be drawn from the public or private sector. Attention needs to be given to identification of partners and it is desirable for these engagements to be made at an early stage of the research process. Under phase I, the partnership with Peace Corps in Senegal provides a good example of this type of impact pathway. Linkages to the NARES who intern have alliances with donors such as IFAD, AfDB, ADB, WB, BMGF, iDE, etc., are opportunities for the broad IP2 approach.

IP3: Private sector business models to enhance enabling environments. For some SI technologies there are aspects of the enabling environment that require a long-term engagement. It is rarely feasible for this to be delivered by donors, governments or NGOs. A key example of this that is relevant to SIIL might be the supply and maintenance of equipment for mechanisation. There are also opportunities for the development of service provider models around cultivation operations and water delivery. Of course IP3 can be blended with IP1 and IP2. Overall these business oriented strategic alliances with the private sector have not been fully harnessed in Phase I. Perhaps a partnership with iDE, or similar, could be explored for Phase II for augmenting business linkages.

IP4: Adult education and knowledge scaling. Knowledge scaling to create wider, detailed awareness of the opportunities generated by research projects and programmes such as SIIL are always likely to deliver engagement although this may need a long-term view. Such awareness can be supported with target education and capacity development that creates a favourable environment for implementation. There are associated research questions to be addressed for IP4, such as, determining which adult education approaches are most efficient for wide adoption of specific innovations. This is especially critical for more knowledge intensive technologies, such as IPM or CA-based production systems or crop/pasture/livestock integration.

These IPs are not intended to be applied on an either / or basis. All have the potential to be mutually reinforcing and we could envisage situation where all five might be used in a coordinated fashion. We should also stress that these pathways, although progressive, are not entirely linear. Opportunities for feedback into research design and re-design should be implicit in each of them.

Our **blanket recommendation in respect of IPs and Scaling is that the SIIL ME, in Phase II, takes a more strategic view of establishing and nurturing appropriate IPs for the lab's products.** This might build on some of the lessons learned from the current RODs review, which is coordinated through SIIL and housed at UC Davis for IL products as a whole. SIIL already has good links with USAID missions in at least some of its target countries and is aware of the need to follow the mission money when designing phase II. We **also recommend that the ME continues and enhances its efforts to engage a wider network of development partners who can contribute to the "demand-drive" for its future research products and be primed to move these through their own scaling pipelines.**

Finally, as mentioned in other Sections, **there is a research area on best extension approaches for innovations that are knowledge intensive**, as is the case for a number of SIIL's. This area should be considered for Phase II.

3.2 SIIL Consortia for Research and Development

SIIL, from the onset, acknowledged the need and opportunity to harness the wide-ranging research and development power of multi-institutional partnerships. GFC, housed at UC Davis was created in 2015 to address Geospatial science and its applications toward SI. (See 3.2.1 below). A year later the second consortia, Appropriate-scale Mechanization Consortium (ASMC) was launched and housed at the U of Illinois at Urbana Champaign (See 3.2.2). Through Phase I it became clear that these multi-institutional alliances have potential for impact, when well-focused. Consequently, there are current plans for two, new SIIL consortia to be launched in 2019, one on Policy Research for SI and the other on Soil Health from SI. **These temporal “institutions” will be most effective if their longevity is planned and then enabled by broadening the base of support along with creation of lightweight coordination units for each.**

3.2.1 Geospatial and Farming Systems Consortium (GFC)

The GFC, hosted at the University of California Davis (UCD), was established October 2014 upon funding of SIIL, with a current completion date of September 15, 2019 and a projected budget of \$5,000,000 (initially 4.3 \$M). GFC is SIIL's largest sub-award, but only slightly more than the sub-award to ASMC, the other SIIL consortium established at the start of the first phase. GFC is intended to contribute to regional, and especially, national-level field activities in targeted countries. GFC also creates global public goods—technologies for coupling data and knowledge archiving and sharing – to enhance SI goals. The Consortium includes collaborators from CGIAR centers (CIAT, CIMMYT, ICRAF, IFPRI & ILRI), regional institutes and universities (CNRA-ISRA Senegal, ITC-Netherlands, IIASA-Austria & RUA-Cambodia), U.S. Universities (e.g. Stanford University, KSU, Univ. of Arkansas) and private companies (e.g., QED).

Raison d'être, Goal statement, and Strategic Objectives

GFC's purpose statement: In sum, GFC is to enable developing countries to collect and analyze data, using modern geospatial tools, to guide investments toward SI. This capacity building intends to help shape critical strategies and policies, cutting across food security, soil- water- and air-management, and across a very broad array of SI-oriented services for the rural populations, all needed for SI and development. GFC "...envisages 'big data' can revolutionize agriculture. Our (GFC's) specific objectives are: i) identifying current patterns of intensification and opportunities for sustainable intensification, ii) improving the resource-use efficiency in crop production, iii) designing crop growth monitoring tools, iv) estimating current and potential yield in the region of interests and v) understanding the impact of market socio-economic and environmental conditions on opportunities for intensification. GFC is also committed to i) organizing regional training workshop/courses and prepare online course material on spatial data analysis for agricultural development and ii) promoting and supporting the use of open data within SIIL and the larger agricultural development community.”³ The ET notes that attention to environmental geospatial information is not highly prioritized in stated priorities.

Its overarching strategy/tactics are:

- building capacity in spatial data analysis for agricultural development, and
- promoting and supporting the use of open data within SIIL and the larger agricultural development community.

³ 2018 SIIL Annual Report—Annex 10

As indicated in the 2018 Annual Report, GFC's research encompasses five thematic domains, namely:

- 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.

From field visits and discussions with diverse stakeholders, it is apparent that while goals are lofty, there are, in fact, too few activities at the country hub level resulting in a general disconnect of the Consortia to the coherence of the SIIL strategy.

The ET recommends that the ME and the GFS stakeholders organize workshops (perhaps virtual) to review and re-think Geospatial science inputs in the context of "Impact Pathways" elaborated at the country levels to ensure more relevant outputs for SIIL's overall goals.

GFC's design strategy—through partnerships

The Consortium has a significant number of partners, many of who received sub-grants (see GFC Annex 1) to work on agreed programs with the goal of convergence and creating coordinated outputs greater than the sum of its parts. Much of this work is moving in the right direction, but the time required has been, in some cases, underestimated. This is particularly evident in the delays of obtaining regulatory clearances from the host country to import high-tech equipment, such as the drones for geospatial data harvesting. The time for creating specific software prior to hub-level trainings was also underestimated. The ET acknowledges that the consortium's management has appreciated this design shortfall, and the timing reality-check is considered by all a "lesson learned."

GFC management hopes for consideration toward a geographic consolidation, principally into one region for the next three to five years, for example East Africa, namely Kenya, Tanzania and Rwanda. GFC leadership reasons this would enable more efficiency for tangible outputs, including capacity building. Travel time and costs by the few staff would, as well, be more efficiently spent. This strategy, however, would create concerns about the level and breadth of support the Consortium can provide to SIIL's country efforts and to FtF. The SIIL ME needs to appraise this carefully with guidance from USAID.

A critical management decision must be framed: Should the GFC be expanded to better enable broader engagement and impact in most all country programs, or should the consortium increase its focus (fewer countries for pilot research), so that program efficiencies can be realized and lessons consolidated before future expansion? Perhaps field action in other regions should be open to a new bidding process.

In general, the design correctly incorporates a wide array (10) of foci "observation domains," namely: Household Surveys, Market Access, Inputs & Infrastructure, Management Activities & Policy, Land Cover/Crops, Production Estimations, Climate & Weather, Soil Properties, Water Availability, and Biodiversity, which demonstrate the scope of potential decision-making impact for SI through geospatial observations and analysis.

Major highlights of GFC outputs from SIIL 2018 Annual Report are found in Annex 7.3

GFC Relevance to national and regional needs

GFC and its diverse stakeholders are contributing to demonstrating and creating awareness of the rapidly expanding power of geospatial technologies in sustainable development, in general—

(alongside many other actors, including FAO and the CGIAR, e.g., IFPRI), and to some degree in the characterization and planning of SI, in particular. This is most clear at the state/province and national levels. But, as most geospatial observation domains are not geo-politically delineated, they generally cut across political boundaries. Neighboring countries will need to jointly appraise constraints and opportunities. If understood and harnessed positively, the opportunities for joint planning of similar agro-ecologies and farming systems will greatly contribute to SI, regional prosperity and broader, more coherent, environmental stewardship. However, a re-appraisal of relevance and positioning would be useful before further major investment, taking into consideration the nature and timing of the local, national and global scale products from Geospatial.

Research effectiveness on cropping systems agronomy & improvement

The GFC does not research cropping systems or agronomy. There are many areas of geospatial analyses that could shape intervention choices and the needed supporting policies. For example: Where are the best areas to target enhancement/adoption of any given farming systems innovation? When, for a given farming system, are the inputs needed, and when are production outputs reaching key markets? How many women, in a farming systems domain, have access to credit, and under what conditions? The tools for data collection and analysis are under development and refinement.

Overall GFC effects on systems-level sustainability, productivity and resilience

The potential of geospatial data and analysis to shape SI interventions and investments, and thus farming system level performance, is enormous. However, to date the databases and analytical results of GFC have had little effect on the overall work of other SIIL partners, largely because of lack of focus on partners' subject matter areas and geographies. Tangible examples of Geospatial's contribution to local systems-level sustainability, productivity and resilience may emerge in the coming two to three years, if Geospatial focuses on direct support to the local priority needs of the other SIIL partners in the SIIL countries.

The ET does not question the potential contribution of Geospatial applications, but see the need for strategic engagement in country hubs, contributing insights for innovation targeting and for definition of application domains.

Goodness of fit for US Universities' value propositions vs. the CGIAR and/or NGOs

Given geospatial technologies and their applications are coming into existence (and on to markets) at exponential growth rates, the engagement of US universities is a very good institutional fit, enabling development of cutting edge software and access to cutting edge hardware. Most of SIILs affiliated US universities have important capacities and the partner country universities could benefit from capacity building. In sum, USA universities' fit is good.

Impacts of GFC on social equity and animal and human nutrition

The role of GFC should be to assist SIIL partners to boost their impact on social equity and human nutrition. Companion geospatial studies on equity for women in Nigeria, exemplifies the power of geospatial analysis in characterization of female empowerment, and abuse, over time and across geographies. Joint planning of labs in Ethiopia has enabled nutrition impacts to be mapped, along with groundwater availability for winter production of fruits and vegetables, though this work was not done by SIIL's GFC. ***In general, we conclude little contribution has been realized by GFC toward SI, in general, and to social equity and nutrition, in particular.***

Effectiveness for water optimization (irrigation, water harvesting, green & blue)

While smallholder controlled irrigation can provide supplemental water, resulting in 2nd and sometime 3rd crops in a calendar year, use of such tube wells are only sustainable where adequate recharge of the water table is frequent and reliable. Studies of water availability at the Ethiopian hub

is a very good example, though in this case, the geospatial research team was provided by the Smallholder Irrigation Lab hosted at Texas A&M.

Effectiveness of social capital activities (FFS, IPs, community/farmer groups)

We did not read about or witness creation or utilization of community organizations to harness engagement and adult learning of innovations derived through the Consortium. The training and empowerment was primarily at university-to- university levels. Moreover, few spatial analysis teams have assembled databases related to social capital.

Capacity building, design, and accomplishments

Capacity building under GSC has multiple dimensions. Getting adequate data collection hardware into the hubs has been a challenge, as has been the hands-on training needed to fully benefit from the expanded data-collection capacity. Nevertheless, GFC has contributed to short and long-term capacity building. Training in mega data management, analysis, and interpretation is required regardless of source, whether from surveys or from satellites. GFC has and had 21, 3, and 15 students, respectively, for BS, MS and PhD degrees. Group, non-degree, training involving 208 students is also significant, given the technical intensity of geospatial science.

Appropriateness of current research design and engagement in foresight

Compared to the Mechanization Consortium (ASMC), the GFC activity profile was more top-down designed. Less process time and expense was given to identifying farm-level or district/province-level local priorities in the FtF zones of influence in the partner countries. GFC, and indeed other labs using geospatial technologies, have demonstrated the significant potential of characterizing agro-ecological—physical and social—environments, and livelihood patterns/farming systems and showed how strategy and policy can change in response to the analysis when presented effectively. The potential is not realized to any significant extent in SIIL.

The ET believes that greater management experience in foreseeing and mitigating (or bypassing) logistic hurdles of getting sophisticated observational equipment into developing countries would have resulted in earlier data collection and analysis for shaping policy.

In regard to foresight, there needs to be clarity as to expectations on the geographic areas of focus for the new phase. The GFC has the notion of “Farming Systems orientation,” yet to date, actual addressing geospatial application is for the most part, non-existent.

The GFC should place greater focus on delineating and facilitating in optimization of SIIL's farming systems. Its name reflects this very intention.

In the process of prioritization, the ET recommends an analysis/characterization of high potential production areas and their promising farming systems. One example may be the maize/legume farming system in Africa's moist savannah biome that extends across West Africa and is prevalent in a number of countries in South-eastern Africa. The identification of “hot spots” for expansion of horticulture systems could be extremely valuable for empowering women and addressing nutritional needs.

3.2.2 Appropriate-Scale Mechanization Consortium (ASMC)

As summarized in SIIL's 2018 Annual Report, “ASMC aims to introduce multifunctional and modular mechanized technologies that are technically, environmentally, economically and socially appropriate for use by smallholder farmers (including women) with the flexibility to accommodate different power sources. ASMC is currently active in four countries.” 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.

The ASMC, was established October 2015 upon funding from SIIL, with current completion date of September 15, 2019, and a projected budget of \$4.7M. Partnership building has been generally effective at the hub and target country levels. There are currently 13 principal direct stakeholders from four US universities and dozens of indirect, but still very important, partnerships across the four country Hubs. Scope for broader research partnerships to harness global experience is evident from both public, international organizations (e.g., IARCs and FAO), and from the private sector (e.g., companies in India, Bangladesh, Brazil, and China).

ASMC Collaboration

Hub sites (and hence the agro-ecologies) for the Consortium's action were determined by a SIIL process prior to creation the Consortium. Country level consultations were conducted early on to identify felt needs of the targeted farm communities (Hubs) and capture insights from other local stakeholders, including national universities, blacksmith guilds, farmer organizations, private sector, etc. In most countries this Consortium, and SIIL in general, engage *rather* minimally with the Ministries of Agriculture (MoAs), which are principal institutions for research, extension and scaling up. Rather, engagement is mostly university-to-university with only modest engagement with NGOs and SMEs, and sometimes even minimal linkages with other SIIL awards, for example in Bangladesh.

While the hub site level partnerships are generally strong, the ET sees a need to create even broader alliances of partners/institutions to leverage research resources, build on past achievements and to pool resources for scaling.

ASMC's Goal Statement and Strategy Formulation:

Assess/develop/adapt/implement/promote appropriate-scale agricultural mechanization for sustainable intensification, focusing on smallholder farming systems and enhancing the participation and experience of women in the adaptation/adoption of technologies for agricultural development

Strategy Formulation—

Overall Objectives **include:**

- develop an actionable strategy that identifies high priority Appropriate Scale Mechanization subject areas;
- gain insights into country stakeholders' perspectives on how agricultural mechanization might significantly improve quality of life and livelihood of smallholder farmers in a sustainable way;
- explore and build synergy and partnerships among stakeholders and practitioners in systems predominately involving smallholder farmers; and
- identify and assemble resources for advancing the goals of ASMC in a timely fashion.

The need for the ASMC to participate strongly in the field program of four focus countries (Cambodia, Bangladesh, Ethiopia and Burkina Faso) is becoming increasingly clear to SIIL's stakeholders. Attention to field activities in Tanzania and Senegal is required soon. Human and financial resources are part of the limitation. This raises an issue, not only for the ASMC, but even beyond: can USAID's FtF Labs create enduring "institutions/facilities" that welcome and entice resources from the broader development community. Perhaps Consortia funds could be empowered to create broader partner funding facilities.

Observing the kinds of tools currently under design and test, we suspect that for Africa there was only a limited stocktaking of previous mechanization innovations tested. *The ET believes the priority needs for each principal targeted farming systems merits further consultation, especially in the complex agro-ecologies of Africa.* A policy brief as well as a technical publication would be valuable outputs. Considerable mechanization expertise and experience can be found, for example in Kenya, India, Bangladesh, Brazil, Zambia, and at CIMMYT and IITA. There are a number of other significant mechanization R&D initiatives in Africa and Asia, including the FAO sustainable mechanization activities, CIRAD CA mechanization in Senegal, CIMMYT FACASI program in East and Southern Africa and the CIMMYT CSISA mechanization project in Bangladesh and India.

Care must be taken to consider the full systems needs related to mechanization innovations. As

ASMC should invest in regular knowledge exchange and harmonization of messages to policy makers with other appropriate small-scale mechanization R&D programs, and ensure effective working linkages with other SILL awards.

an example, for CA —requiring permanent soil cover— grazing of livestock during the dry season will need to be controlled in zones with open grazing. Living fence establishment as part of the solution could be required. Access to no-till planters may not, by itself, be enough to scale adoption of reduced tillage agriculture. *In sum, optimization of SI generally demands systems approaches.*

The private sector, especially micro-entrepreneurs and small businesses are essential for mechanization service delivery, equipment manufacturers, imports and repairs. ASIH Cambodia has actively engaged in the supplementary research on fee-based CA services and the establishment of a public-private Consortium to promote CA. ***The ET recommends that ASMC appraise and promote similar public/private consortia in other countries.***

For example, there is a strong ASMC focus in West Africa on improvement of animal traction implements, while in East Africa, more attention is on post-harvest and irrigation. In Africa, significant adoption of animal traction cultivation and planting over the last four decades has been largely restricted to where it was introduced, promoted, and subsidized by both French and British colonial interests for cotton-based production systems in the Cereal Root Crop Mixed Farming System in the mono-modal Guinea Savanna (cotton/sorghum) biome. Across West Africa, animal traction did not extend into the southern, more humid savannas, originally because of higher incidence of tsetse fly, and because there was commonly higher incidence of river blindness disease in these moist transition zones. Recently, the demand for tractor-based mechanization services has increased as cropping expanded since the disease pressure has diminished. River blindness is now easily prevented with medicinal eye drops applied annually, and tsetse populations have dropped too, responding to disruption of habitat and massive annual airplane drop release of male-sterile flies, breaking the breeding fecundity. It is, however, *highly unlikely* that, at this time, there will be a major expansion of demand for animal traction for land preparation, except where it has had previous history. This situation raises the strategic issue of priority mechanization research for production systems. What percent of the investment in mechanization for Africa should be focused on animal traction systems compared with 2WT or 4WT. Large and sophisticated machinery is, in most cases, a very low priority. ASMC has correctly appraised the latter option as low priority.

For-hire tractor plowing is increasingly common, including in many parts of Africa. No-till based conservation agriculture has promise in several farming systems in African savannas, but planting equipment must be coupled to weed control, fertilizer application, ground cover management and other operations that will mostly be realized by fossil fuel power in these zones. In South Asia the single axle tractor is making major inroads into smallholder family farming, including for conservation

agriculture, and showing promise in pockets in East Africa. The single axle tractor is often also used for rural hauling of goods to market and then transporting of inputs back to the farm in periods when they are not needed for crop establishment or other farm operations, such as crop reaping, threshing, water pumping, etc.



Cambodia No till planting into crop residue

Because CA, when combined with complementary SI technologies related to water, livestock, markets, etc., is one of the few proven sustainable agriculture technology clusters, ASMC should prioritize CA related interventions when appropriate.

We conclude, a major stocktaking of technologies and expert appraisal of opportunities and needs for each major farming system 10 and 20 years from now, should be a major output of ASMC.

A mechanization-oriented information portal should be an AMSC/SIIL output, if the longevity of the resource and a global host can be secured, perhaps at FAO.

The ASMC is giving strong attention to program design with women in mind, especially for hand tools, but also the strip tillage approach enables women farmers to be less dependent on muscle-contingent land preparation. In each hub, in-country gender specialists led Focus Group Discussions. ASMC organized Training-of-Trainers workshops in four Hubs. Field visits have also confirmed the ASMC is making gender empowerment a priority

Currently, in Burkina Faso a substantial effort is underway to empower local blacksmiths for the construction and maintenance of the animal traction-based strip tiller and the associated no-till planter. Women are not historically involved in metal craft, but could be. Women could become managers of small implement production companies, as could youth. Policies to enable expansion of equity-centered agro-industries could be researched under the SIIL platform, perhaps in cooperation with the Food Security Policy Lab, housed at MSU. ***Management-level Capacity building for women and youth in these agro-industries is recommended.***

Policies to enable expansion of equity-centered agro-industries could be researched under the SIIL platform. Management-level Capacity building for women and youth in these agro-industries is also recommended.

ASMC includes mechanization for water management, including developing and promoting solar pumps, axial flow pumps, and lay-flat plastic pipe for distribution of water to and inside of fields. While these innovations are extremely important for SIIL's goals, **the ET recommends the research dimension of irrigation should be realized primarily by the Small Scale Irrigation Lab, thus increasing strategic partnerships across labs.** Examples of that very partnership are seen in Ethiopia and Cambodia. SIIL's role in fostering adoption of innovative irrigation within production systems should be strong; here ASMC's leadership is obvious.

Capacity Building

Investment in capacity building is substantial. ASMC initiated training programs for 11 long-term trainees. More than 40 field days and training events were reported for 2017 alone. This included a 5-day field trip in Cambodia to experience successful CA examples. All four hubs have been equipped with machine shops with fabrication facilities that presumably will enable ongoing local innovations. Whether local/national support will be available in the future is uncertain, but ASMC and partners are nurturing private entrepreneurship. Other points considered relevant to the evaluation on ASMC are included in Annex 7.3.

3.3 West Africa

3.3.1 West Africa Overview

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); 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 Développement (IRD) (France), CIRAD

Sustainable Intensification of Millet-Based Agrosystems Using Cowpea in the Groundnut Basin of Senegal (Laure Tall, LNRPV/ISRA); Louga, Fatick, and Kaolack, Senegal; CNRA/ISRA, LNERV/ISRA, IRD, CIRAD;

Sustainable intensification through better integration of crop and livestock production systems for improved food security and environmental benefits in Sahelian zone of Burkina Faso ILRI, INERA, University of Wisconsin, IUCN

SIIL is active in two West African countries, Senegal and Burkina Faso. There are three sub-awards, two in Senegal and one in Burkina Faso. All three of these projects has well-respected national scholars as PIs, with support from US universities, particularly Kansas State University in Senegal and University of Wisconsin in Burkina Faso. Both of the country projects involving livestock have benefitted from ASMC, based at the University of Illinois, although the major activities are in BF, the Senegal project is informed by those activities in developing appropriate animal traction technologies. GFC has delivered some equipment – drones and weather stations – to both countries.

West African is the most densely populated area of Africa. Both Senegal and Burkina Faso are ex-French colonies, with some serious political disruptions in the past, but now each are democracies with peaceful elections allowing for relatively easy power shifts, but with potential for unrest due to very young populations and high youth unemployment. Senegal is more central and more developed. The capital city, Dakar, is on the Atlantic Ocean, which gave it centrality in trade, which continues based on a relatively good internal transportation system and its international airports. BF is a poor, landlocked country, with less robust infrastructure.

In both countries, SIIL is working in relative arid areas with mixed crop and livestock systems, where many Fulani households are settling out of their season migration with their herds and engaging in agriculture while maintaining large and small ruminants and donkeys.

Research Activities

Senegal and BK SIIL research is to develop sustainable intensification through better integration of crops and livestock. Dual-purpose grains and pulses are designed to aid in both human and animal nutrition, producing healthier people, animals, and soils. There is good communication between the BF and Senegalese SIIL activities, which speeds the development and implementation of agronomic and technology innovation, as is evidenced in the development of SI appropriate animal drawn ripper-seeders and forage choppers. In both countries, many field trials are underway with improved seeds, with the results mainly measured in plot stands and grain/pulse yields. Both sites need to address systematic ways to measure soil quality beyond fertilizer recommendations. US universities could collaborate in these studies, and train students in both colleges and high schools to understand systems approaches and soil microbiology enough to make such data gathering a part of on-going field trials on experiment stations and on farmers' fields. The nutrient-rich grain-legume mixes sown with little soil disturbance showed substantial improvement over traditional varieties and methods in farmers' fields and on experiment station plots. Farmers were quickly applying them to their fields when introduced.

These systems are much more resilient in response to weather and rain variation and volatility, as demonstrated in side by side field trials with other varieties and other farming technologies in both countries. Thus, productivity was consistently higher in both settings. Milk productivity is systematically monitored in Senegal and was found to be higher in goats fed the dual-purpose grain and legume residue. In both sites, the improved farming system offers opportunities for local entrepreneurship, particularly of women and youth. Credit access was found to be a major barrier to launching small businesses.

In both countries, there is close collaboration with other FtF projects and international research centers, as well with national research and extension and appropriate NGOs, particularly in Senegal with farmer cooperative and in BF with private sector organizations such as the local blacksmiths' association. In Senegal, collaboration with the Peace Corps was impressive. SIIL train male and female PCVs, who then worked with Master Farmers and the group of farmers around them in both the theory and practice of SI. While some women's groups are involved in child health interventions, there is no systematic monitoring of the exact content of the interventions or, more importantly, the health outcomes.

Capacity Building

In both countries, university students, only a few of whom are supported directly by SIIL work with farmers in on-farm trials and participate in activities of increase the quality of the residues of the improved grain and pulses through chopping and silage. Both countries have post graduate students enrolled in African universities who are doing their theses or dissertations on SI topics. Their professors as well as the students could benefit from training in farming systems, as it is easy to get focused only on the component research. In Senegal, SIIL-sponsored whole school projects, modeled after those the PI saw in Cambodia, are expanding the understanding of SI and how to implement it not only with the students, but their parents and teachers.

Stakeholder Engagement

There is a lot of collaboration with appropriate national and international research institutions in both countries. Youth and women are involved, but there has been no measurement of the impact of their participation on the SAIF variables. In terms of scaling out, the involvement of blacksmith organizations in the development of appropriate machinery has been very effective. Training in impact assessment for both researchers and students would be very helpful in Phase II.

Policy makers, beyond the Ministries of Agriculture, have not been systematically involved. With scaling out, it will be important to identify key places where scaling out is either helped or hindered, and work on the kind of actions that enhance the scaling out pathway.

Phase II Recommendations:

Regionalization

Researchers and research and extension directors in each country were enthusiastic about a Center of Excellence for West Africa, based in an existing research for development institution. There was also general agreement that it should be based in Senegal, as well as recognition of West Africa, particular the Sahelian areas, have a great deal in common. However, the country-based projects are critical if the kinds of supporting institutions – market, state, and civil society – are to be developed to support SI in the future.

Publication

One area where US institutions could be more involved is moving the research findings to publication. While there are excellent presentations at national and international meetings, the research should be subjected to peer review. Perhaps some scientists from CIRAD could be involved in helping get the research findings into French.

Analyzing Farming Systems

There is a general assumption in the research that the target farmers have access to land, draught and milk animals, and grow grains and legumes. More specific analysis of the different farming systems and the contexts in which specific SI technologies work best is needed and should be carried out as the projects move to the second phase. This was originally thought to lie with the Geospatial consortium, but so far, no such analysis has been made available.

Expanding Stakeholder Engagement

There is a need to involve more local institutions in the research to understand their potential role in scaling out SI. Schools are a good place to start, but local and regional businesses and their organizations should be involved as well. Social scientists could work with local farmer and women's groups to identify keep organizations and enterprises to inform about the research, get their input as to how they see it related to what they do, and discuss new ways of enabling service businesses and new marketing structure to be put into place.

Documenting Impacts

In both sites, there is a need to begin to get comparative baseline data from farm household on gender, health status, diets, soil quality, and participation in organizations such as churches, women's groups, youth groups, and school activities, including sports and the participation of women and men in informal savings/credit activities. Then the participants could analyze 1) if other groups should become involved, 2) which parts of the SI work is working well for the SAIF outcomes, and 3) ways to make SI work even better. Of particular interest is the participation of women and men in informal savings/credit activities. Impacts on human health should be measured. Such measurement does not necessarily intrusive measures, but could come from focus group discussion with women who use and women who do not use products from the improved crop and livestock production.

Availability of Data

The BK baseline survey to characterize the crop-livestock systems in 8 project communities with focus on constraints and intensification practice by small holder farmers was added to Dataverse on 2/8/18 and is accessible on that site. Thus far it does not seem to have been analyzed and related to on the ground research and outreach.

Policy Articulation

Although concrete policy blocks to SI expansion in BF have been identified, as of our visit there was no concrete plan for which entity needed to change a policy, who to talk to, etc. This would be a good place to involve university students in BF, perhaps using an Advocacy Coalition approach.

Efforts in both countries, with a focus on scaling out pathways, should continue, with an emphasis on documentation not only of changes in yields, but in all the SAIF areas.

3.3.2 Burkina Faso Country Report

Sustainable intensification through better integration of crop and livestock production systems for improved food security and environmental benefits in Sahelian zone of Burkina Faso.

ILRI, INERA, University of Wisconsin, IUCN

Burkina Faso (BF) is a poor, landlocked country that depends on adequate rainfall. Increasing irregular patterns of rainfall, poor soil, and the lack of adequate communications and other infrastructure contribute to the economy's vulnerability to external shocks.

BF went through a political transition supported by the U.S. government in 2014-2015. Its democratically elected government seeks to maintain peace in the region and to contain terrorism. SIIL's work with youth enhances that strategy.

Traditionally pastoralists, BF's Fulani herders have settled out of seasonal migration as land has been enclosed. They maintain livestock, a traditional measure of wealth, and adapted to agriculture utilizing the fertility of endogenous bushes and trees and some manure. Previous USAID assistance to BF has focused on increasing production of high-potential agricultural zones, enhance access to markets, and increased investment in land and rural productivity. BF still contains food-deficit areas, and SIIL is engaging in them as well. SIIL is implementing a systems approach for research and scaling out with national and international partners.

SIIL in BF has a well-connected, well-respected scientist based at ILRI as the Country PI addressing sustainable intensification through better integration of crop and livestock production systems for improved food security and environmental benefits in the Sahelian zone of BF, addressing a felt national and regional need for improved, resilient farming systems. This is very relevant to the SIIL system approach. Many institutions – local, national, regional and international – make up the research effort.

There are an impressive number of participatory on-farm testing and evaluation of sustain crop and livestock innovations, focused on nutrient-enhanced dual-purpose crops, including millet and cowpeas. Cowpeas is new to many in the farming system, and they are very well-received by farmers. The transformation of the stover into fodder and silage has a positive impact on animal nutrition, providing milk for more the year and increasing animal strength when plowing at the end of the hungry season. Experiment station fields are used to determine the impact of different management practices on soil quality. Gender analysis was included in the mechanization part of the program, which led to mechanization that enhanced the work load of both women and men, attending to the gendered division of crops and animals. The new systems involve monitoring the effects of new foods on child and maternal health, with the implementation of nurseries of trees with

high nutrient leaves prescribed for children and women with health problems. The leaves from those trees are now marketed, mainly to Japan.

The groups around mechanization, students, black smiths, and farmers, are a good start at forming the linkages necessary for scaling out mechanical innovations found to be effective. Entrepreneurial farmers are already multiplying and selling the improved seed. Introducing vegetables for different seasons provided healthier household diets and market opportunities for women. We visited a guinea fowl project with ILRI and INERA, but it was not clear if this was related to a women's group as a potential source of protein for the home and local markets.

Productivity has improved in terms of both grain and biomass with the new varieties and planting methods. The newly adopted varieties and improvements in animal health makes the new systems sustainable under current volatile climate conditions, and the methodology of encouraging farmers to constantly experiment to improve their systems help make it more resilient. Resiliency is aided by attention to food availability for humans and animals throughout the seasons, as well as the regular monitoring in some areas of child and maternal health so that appropriate interventions can be made.

In Phase II, more attention should be given to regular meeting of the research institutions and the universities where students are trained with the project PIs to help better integrate SILL's systems perspective. The socio-economic data should be more consistently gathered and shared, including the bio-metric data used in the innovative nutrition work. In Phase II, moving experiments to schools that are integrated into class work and school meals could enhance child nutrient and build competence in systems thinking.

On-going activities could be improved through even more engagement of students at all levels, particularly university students. SILL faculty could serve on student committees at West African universities, although low French language ability among North American scientists could make that problematic.

The impact of the nutritionally improved millet and cowpeas were evaluated at one site through monitoring maternal and child health, generally through BMI. As a result, nutritional leaves previously fed only to animals were added to their diets with good results. There were also experiments to measure increased milk productivity associated with nutritionally improved forage. However, the data have not been systematically analyzed and shared. Results mainly influenced on the ground interventions. Phase II should increase record keeping of these interventions and the perceived impacts at the local level.

A regional center of excellence in sustainable intensification based in Senegal for the semi-arid lands could help Burkina Faso and other areas in West Africa and later allow for expansion into other ecosystems in the region.

In discussions with the mechanization team, we discovered that policy will be important in scaling out the work with blacksmiths. 1) Iron needs to be available to the blacksmiths for this purpose (apparently a national rationing decision) and 2) a system of standards to ensure the quality of the work remains exact. In Phase II, policy work in Burkina Faso should be based on concrete policies – often small and sometimes at a local level – that can hasten the pathway to scaling out.

3.3.3 Senegal Summary Report

Dual-Purpose Millet - Leguminous Crops - Livestock Systems in Senegal 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); 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 Développement (IRD) (France), CIRAD.

Sustainable Intensification of Millet-Based Agrosystems Using Cowpea in the Groundnut Basin of Senegal (Laure Tall, LNRPV/ISRA); Louga, Fatick, and Kaolack, Senegal; CNRA/ISRA, LNERV/ISRA, IRD, CIRAD;

The French colonies of Senegal and French Sudan were merged in 1959 and granted independence in 1960 as the Mali Federation. The union broke up after only a few months. Senegal joined with The Gambia to form the nominal confederation of Senegambia in 1982. The envisaged integration of the two countries was never implemented, and the union was dissolved

in 1989. The Movement of Democratic Forces in the Casamance has led a low-level separatist insurgency in southern Senegal since the 1980s. Several peace deals have failed to resolve the conflict, but an unofficial cease-fire has remained largely in effect since 2012. Senegal remains one of the most stable democracies in Africa and has a long history of participating in international peacekeeping and regional mediation. Senegal's military expenditures in 2017 were 89% of GDP, a percentage that has been increasing substantially each year.

Senegal was ruled by a Socialist Party for 40 years until Abdoulaye WADE was elected president in 2000. He was reelected in 2007 and during his two terms amended Senegal's constitution over a dozen times to increase executive power and weaken the opposition. His decision to run for a third presidential term sparked a large public backlash that led to his defeat in a March 2012 runoff with Macky Sall, whose term runs until 2019. A 2016 constitutional referendum reduced the term to five years with a maximum of two consecutive terms for future presidents. (Elections will take place February 24, 2019, with a run-off, if necessary, will take place in March. While French is the official language, many of diverse ethnic groups, including Wolof, Pular, Serer, Mandinka and others maintain traditional languages and knowledge. The fertility rate is very high, and many men have or aspire to have multiple wives. Illiteracy is high, as is unemployment, even among university graduates, and poverty is widespread. Bordering on countries with high levels of unrest, providing hope and viable alternatives for youth is critical. Outmigration was high during the economic crisis of the 1970s, and the rate of out-migration has increased. The more than 30 years of fighting between government forces and rebel separatists in southern Senegal.

Ecosystems in Senegal are fragile, as the country suffers from deforestation; overgrazing; soil erosion; desertification; periodic droughts; seasonal flooding; overfishing; and weak environmental protective laws.

Much is being done in Senegal to integrate the many pieces of SIIL research and to scale it out due to the energy, scientific vision, and embeddedness of the Dr. Aliou Faye, who was appointed PI in Senegal in 2017. Under his leadership and coordination, SIIL has greatly increased the systems reach of SIIL in Senegal and across the region. Most of the collaborating scientists we talked to emphasized systems and the need to involve farmers in the discovery process in ways farmers could make choices and determine the outcomes. The Consortia Projects are well integrated. AMSC is involved in the mechanization work adapted in Senegal for their soils and systems. GFC provided fertilizer recommendation for dual purpose millet, SI recommendations in millet-cowpea intercropped system, a fertilizer price survey, and 7 weather stations for crop trials.

The project documents talked of a baseline survey, but we saw no evidence of it, nor was it mentioned during any of our conversations. There was great interest among the various Centers we visited to work with other Centers not only within Senegal but across the region. Dr. Faye had good relations with regional, national, and international private and public agricultural research and outreach institutions. Yet there were problems getting aspects of the project launched due to inter-agency tensions within Senegal. Knowing the local institutional cultural and patience has helped overcome these structural issues. More explicit attention to policy in Phase II should help identify both barriers and opportunities in putting in place the policies that can enhance the scaling out of SIIL.

The involvement of youth in the schools, an innovation based on the SIIL meeting in Cambodia, has been enthusiastically accepted in some local school systems, as it is integrated into the

curriculum and the meals of the participating schools. The whole school approach differs from club-based models that other entities are implementing with SILL's collaboration.

Those with whom we talked found that the SILL work is exceedingly relevant, as SILL considers crop/livestock interactions with dual purpose crops that increased the supply of nutritious food for humans and animals. Farmers met with us in several cases, explaining what was going on in their fields. The impact was enhanced by SILL's recognition of the importance in field of trees and bushes – a kind of agro-forestry -- that provide nutrients to the soil, humans, and animals and that could increase productivity of new varieties and remain in the fields. The use of animal traction made it easier to plant without ripping out these natural sources of soil nutrients.

Plans for scaling are based on a Master Farmer organizational approach, which often involves West African University students as well as Peace Corps volunteers. Women and men work with the Master Farmers. Introducing sustainable intensification practices for a variety of crops, including grains, legumes, and vegetables with chicken in schools as an integrated part of the curriculum as well as the school menu is another way of beginning to scale out both the approach and the practices. The program seems sustainable due to the large number of local, regional, national, and international partners. It was clear in the experimental fields, which we visited when the rains were nearly 30 days late, that the new varieties and the new practices fared better during low moisture than traditional varieties sown in traditional ways. Because of the method of working with farmers to make choices based on their own contexts, the system is more resilient to climate change both due to the genotypes introduced and the way farmers are empowered to make choices to change their cropping mix. Nutritionally enriched dual-purpose crops combined with increased use of silage (increasing the nutrient content that is already higher than normal due to plant breeding) that improved animal nutrition for milk and for traction. The appropriate scale mechanization, developed in Senegal but with coordination with the work in Burkina Faso, released women from much difficult field work, which could allow them to develop simple business models, such as peanut butter production.

The gender component needs substantial attention. The gender specialist has been working with local female farmers, training them about millet flour enrichment and silage making. The project appears to be well-managed at the national level, but the feedback from the subprojects, such as the baseline survey, could be better managed by the US-based PI. Many African university students are engaged with SILL at the graduate and undergraduate level, which help expand further adaptation of the basic principles to other settings. It is not clear yet how the drone training is being utilized in identifying actual and potential SI sites or characterizing farming systems..

In Senegal, Dr. Aliou Faye and Dr. Laure Tall have agreed to share the equipment purchased for their projects. While Dr. Faye will conduct sUAS-based monitoring of the experimental plots managed by Dr. Tall, he will also have access to the Li-COR leaf area meter and other instruments from Dr. Tall's project.

There are still coordination problems in Senegal. Miscommunication and friction between departments caused delay in fertilizer survey in Senegal. The funding to conduct the survey was transferred in July 2017 but the survey has not been completed yet. Friction between departments within the same agency can often delay or disrupt the progress of the project. E.g. sUAS-training in Senegal was postponed at the last minute due to this reason.

In Phase II, expansion of the farming systems covered, building women's organizations, and expansion of involvement with youth could enhance national food security and the well-being of rural households. Building a regional SILL-oriented Center would enhance scaling out of the system approach to sustainable intensification that stresses ecosystem health, economic security and social inclusion.

3.4 East Africa

3.4.1 East Africa Overview

SILL is currently operating in two East African countries, Ethiopia and Tanzania. Activities are implemented under two research sub-Awards, one in each country, with a cluster of ASMC activities in Ethiopia as well as some more *ad hoc* engagements of the GFC across the two countries.

Many East African countries are currently experiencing, some of the highest economic growth rates on the planet. These are accompanied by population growth that remains equally rampant. Embedded in these growth profiles are demographic changes - most notably urbanization and changing age distribution within populations – as well as the increased aspirations of burgeoning middle classes. These factors are driving new patterns of demand for agricultural products. The implications of all of these changes for the managers of the small, family farms that account for most of the production in the region (FAO, 2014) are not always obvious. What is clear is that there will be a need, in the short to medium term at least, for smallholder farmers to respond through the implementation of viable and validated SI trajectories. SILL's activities in Ethiopia and Tanzania cover a range of agro-ecologies but operate across a common landscape of mixed (crop, livestock, tree) farming systems. In their current forms, these systems exhibit significant yield and efficiency gaps (the core opportunity for SI) and are often posing some complex risks to the environment (the core challenge). They probably do not possess the innate adaptive capacity to respond to likely upcoming challenges such as environmental change (in its multiple forms), increased demand and youth disengagement from agriculture. SILL's research in the region, if guided by effective foresight, has great potential to deliver some of this capacity.

The activities supported by the SILL investments in East Africa have been well focused on some of the key issues emerging from the changes outlined above; more efficient and integrated production, enhancing the nutritive value of food produced as well as food security, quantifying some of the environmental downsides of increasing production and a growing focus on the human dimensions of sustainability (e.g. equity, drudgery). The following country reports identify some of the highlights of the research, some areas that require improvement and some direction shifts that might enhance the potential impacts of the research conducted during a second phase of SILL.

3.4.2 Ethiopia Country Report

Background

SILL investments in Ethiopia are being implemented via two primary mechanisms:

- The sub-award to Texas A & M University entitled “*Sustainably Intensified Production Systems Impact on Nutrition – SIPSIN*”. The principal, named partners are the International Food Policy Research Institute (IFPRI), Tufts University, International Water Management Institute (IWMI), International Livestock Research Institute (ILRI), North Carolina Agricultural and Technical State University (NCA&T but now moved to Kansas

State University; KSU) and Bahir Dar University (BDU). This project was designed around linkages to other USAID innovation laboratories already operating in-country; namely the Innovation Laboratory for Small Scale Irrigation (ILSSI) and the Nutrition Innovation Laboratory (NIL).

- Activities of the Appropriate Scale Mechanization Consortium (ASMC) managed by the University of Illinois at Urbana-Champaign and coordinated by BDU in Ethiopia.

Co-location of activities under these two mechanisms at BDU and effective joint working of BDU staff and other partners has led to some integration of activities that could be strengthened with greater support during a second phase.

In addition, the Geospatial Consortium has supported the production of crop-extent maps for the country based on high resolution satellite imagery.

Research Activities

Research results are, in some cases, still emerging from both sets of activities (TAMU and ASMC). Highlights to date include:

- Application of solar water pumps (Magipump) and drip irrigation systems for the production of high value vegetable crops under conservation agriculture (SIPSIN & ASMC). This nice example of collaboration between the two implementation mechanisms appears to be addressing a number of dimensions of SI within the target system;
- A new activity on the integration of forage (lablab and vetch) into maize under conservation agriculture shows a strong awareness of potential adoption barriers in the target system (SIPSIN);
- Ergonomics of tool use and the role of appropriate scale mechanization in alleviating drudgery (ASMC). This is an excellent example of an activity that focuses on one of the SI domains that often receives less explicit attention, namely the human well-being domain;
- Monitoring of pesticide and nutrient contamination of groundwater again shows a strong awareness of what SI is really about (SIPSIN). The research team's findings are of significant concern. They are currently working on policy briefs to outline their initial findings. The ET recommends future prioritization of follow-up research on the extent of the nutrition and income problems, and SIIL's potential mitigation measures.

Delivery around the following objectives is either still pending or needs to be clarified or strengthened

- There is relatively little evidence to date of the modeling work driving the prioritization of on-the-ground adaptive research that can be directly attributable to SIPSIN;
- The end-line nutrition survey is currently ongoing (SIPSIN). This could potentially deliver significant insights into the benefits of the SIPSIN SI technologies for human well-being. However, it was not clear to this reviewer to what extent SIPSIN (as opposed to ILSSI beneficiaries) have been embedded in the survey's sampling frame;
- ASMC has implemented specific, gender disaggregated studies of the implications of small-scale mechanization. These are, of course, very worthwhile and should be embedded more strongly in the other lines of ASMC / ASMC-SIPSIN research;
- Under the aegis of ASMC, BDU collaborators have devoted considerable effort to the development and testing of equipment for small-scale mechanization (ASMC. These

include maize shellers, forage choppers and other equipment that appear to address several relevant entry points within the system. There is a concern, partly addressed during in- country discussions, that some of these activities might have re-invented a number of wheels. ASMC should consider how to support their in-country collaborators to broaden their horizons and what sort of strategic role they might take in brokering knowledge of existing equipment and designs.

Catalyzing Change

Consideration of impact pathways and the crystallization of actual scaling partnerships has not, apparently, received great attention during this stage of the project. There is some awareness of the technologies being tested amongst government extension services. In relation to the mechanization work, there has been some consideration of how production of equipment might be out-sourced to local artisans but appropriate business models are still theoretical and probably not diverse enough to cover the range of equipment being considered.

The SIPSIN project sought to leverage existing activities under ILSSI and NIL. This has clearly been beneficial in terms of using existing collaborative linkages and being able to locate the project's on-the-ground research amongst a wider portfolio of complementary research activities. At the project planning stage, there appears to have been a clear appreciation of the need to identify acknowledge the contributions of all projects:

“... we will carefully construct the work plans and budgets to assure [sic] that there is clear separation of the objectives and funding to provide a clear and transparent approach to tracking this project.”

Unfortunately, it is far from apparent, from the available reporting, that this aspiration has been realized. SIPSIN activities, particularly in terms of the modeling studies, are not clearly disentangled from those of ILSSI. A statement of joint outputs has been prepared by the project management, but none of these appear to have been formally reported as SIPSIN deliverables so, as it stands, SIPSIN appears to have no specific deliverables at all! This impression is not consistent with the situation revealed by the site visit and needs to be addressed urgently by project management.

Project Future

There is a number of opportunities and needs that this project should aim to build on in any proposal for future funding under the second phase of SIIL:

- The on-the-ground partnerships (primarily BDU-IWMI-ILRI-NCA&T/KSU) have impressive traction in the communities in which they are working. They are pursuing a number of promising research lines which could be continued and further developed in future;
- The modeling work has considerable potential to define relevant directions for such activities. However, it needs to be driven by local priorities. Currently, data flows appear to have been largely out of Ethiopia. Constraints upon and opportunities for strengthening SI that have been identified in the target systems have not been strongly accounted for.

- As stated above, the impact pathways for these activities need work. Ethiopian universities in general and BDU in particular, have strong commitments to outreach activities that aim to ensure their research leads to long-term scaleable benefits in the communities that they serve. It would be highly desirable, in future, to see this, with the collaboration of government and NGO partners, being used as a platform for generating impacts at scale.

3.4.3 Tanzania Country Report⁴

Background

SIIL investments in Tanzania comprise the sub-award entitled “Raising Crop Response: Bidirectional learning to catalyze sustainable intensification at multiple scales”. The project is led by Michigan State University with a broad and somewhat fluid cohort of partners that includes the Centro Internacional de Agricultura Tropical (CIAT), Wageningen University Research (WUR), the International Institute for Tropical Agriculture (IITA), Nelson Mandela University and Sokoine University. In addition, there is a wide network of national partners contributing to the different research activities.

Research Activities

Research activities are clustered around four objectives that, from the information available, appear to operate somewhat in the manner of sub-projects:

1. To generate improved agronomic knowledge of practices that sustainably raise maize & bean yields and crop response to inorganic fertilizer;
2. To evaluate effects of bidirectional learning about OMTs and other SI technologies among researchers, extension, agro-dealers, NGOs, and farmers;
3. To generate improved knowledge of the nutrition impacts of adoption of SI technologies and of bidirectional learning about those technologies;
4. To provide practical guidance to governments on staple food marketing, trade, and extension policies that support adoption of OM/SI technologies to support broader diffusion and scaling, and to work synergistically with activities under objectives 1-3.

Activities across some of these objectives appear to be quite well integrated but, in other cases, teams appear to be operating almost as sub-projects. There are significant highlights to report from the project:

- The project management has been effective in managing a number of on-the-ground difficulties. Some of the original partnerships around objective 1 failed to materialize so, new linkages were formed with, for example, the TAMASA (Taking Mazie Agronomy to Scale) project managed by CIMMYT in order to complete the objective 1 surveys;
- The project has generated evidence that SI does contribute to enhancement of child nutrition that has now been subject to peer review (Agricultural Economics, in press). As well as being an extremely positive tick for SI in terms of its potential to contribute to the SDGs, this is great supporting evidence to justify the decision that was taken to

⁴ Note. The observations regarding the Tanzania project are based largely on document review and key informant discussions with only a limited engagement in the field during a previous, unrelated visit by the reviewer. The implications of this for the level of detail that it has been possible to extract are acknowledged

broaden the sustainability domains of the SIAF beyond environmental considerations only.

- Interesting insights in to farmers existing practices around soil conservation and fertility management have been gained from survey findings. These could offer great potential for defining baselines that could be enhanced by future intervention.
- The projects soil analysis activities feeding into wider efforts to support global standardization of methods and procedures. Interfacing these efforts with those of the new Soil Health consortium should be explored during Phase II.

It is possible that there are other significant achievements attributable to the project but the lack of a field visit, due to time constraints, and project reporting that is, at best, rather cryptic, has obscured these.

Catalyzing Change

The project and the team implementing it, have a strong partner network, with potential to move its research outputs into effective scaling pathways. However, like several of the SIIIL projects, the impact pathways have not been particularly clearly articulated. This would be a useful exercise for the team to undertake formally during the remainder of phase I. The impact pathway should consider potential resource mobilization efforts given that the USAID mission in Tanzania is likely to commit significant fund beyond the very short term.

The team is also well-networked globally in the soil health community. It is to their credit that they have sought to contribute to some of the global public goods that are ongoing around soil analysis and data use. It is to be hoped that these experiences and contacts can be used as the Soil Health consortium is established.

Project Future

The future of the project is likely to be dependent on two factors:

- A clarification of the project outputs to date. On reviewing the documentation, these appear somewhat limited. However, there are indications that this is due to fragmented reporting. A more complete overview of the outputs would allow the most promising lines of research to be identified;
- Whilst not implying a criticism of the project team, the fact remains that there has been no significant leveraging of wider investment by the Tanzania project. This weakens any attempt to make the kind of case that might be made for continuation in Cambodia based on the joint support achieved for CE-SAIN and the USDA investments in soybean production. In the likely event that future activities in the region are located elsewhere than in Tanzania, the main challenge will be to ensure that these build on the progress already made by the current project. It is suggested that the most promising research should, with the collaboration of the project management team, but embedded in the future research.

3.4.4 Towards a Phase II for East Africa

Planning a second phase of SIIIL will, at the risk of stating the obvious, be a complex task for the ME. This section of the report is not an exhaustive analysis by any means. However, it does attempts to highlight what this reviewer sees as some of the key issues for future activities in the region by considering three questions:

- Is the thematic focus of the research appropriate to the targeted households?
- Is the current country focus appropriate for the continuing, wider aims of SIIL?
- Is there scope for increased regionalization of SIIL's activities during Phase II?

Thematic focus: In judging the thematic focus it is useful to consider to what extent the activities have addressed aspects of the SIAF domains (productivity, environment, human, social and financial), and at what scales. The SIAF itself is one of the most striking Global Public Good outputs of SIIL and it is encouraging to see that the principles underlying it are well reflected by both projects and the consortia activities. All domains are covered and it is encouraging to see robust attempts to address issues in those domains that are relatively new in our considerations of sustainability; namely the human with the emphasis on nutrition and well-being and social domains (e.g. business models for mechanization). The SIPSIN project, in particular has tried to address SI at multiple scales. This is demanding for a project with this level of funding and would probably not have been possible without the synergies with ILSSI. Whilst acknowledging that no project can do everything, there is scope to strengthen consideration of some key trade-offs at the system level. Given the predominance of crop-livestock systems in the two countries, it would be good to see these considered more explicitly, beyond the very limited investment in feed and forage work made by SIPSIN, during a second phase.

Country focus: As far as any sub-sample can be representative of an extremely heterogeneous population, we can be confident that Ethiopia and Tanzania could be regarded as representative of East Africa. The systems targeted embrace a number of staple crops, soil types, levels of market orientation, social systems and the existing activities offer an opportunity to compare across countries that has yet to be taken. Having said that, donor priorities are changing and, whilst it is clear that Ethiopia is likely to remain a priority country for USAID for some time, this does not appear to be the case for Tanzania (see above). Engagement in a second East African country during Phase II is a decision that rests with the ME and is likely to be driven, in the first instance, by the USAID criteria that they are very familiar with. Kenya would be an obvious candidate due to the relative continuity of farming systems that would allow the greatest benefit to be derived from the phase I research in Tanzania.

Regionalization: The component activities of the SIIL investments in the region were not strongly integrated during Phase I; some exceptions are noted in the country reports above. A regional coordinator was appointed for phase I but his role appeared to be more about supporting the country projects individually than bringing about integration or harmonization. The ME obviously recognizes that there is clear steering from USAID, indeed it is mandated, that centrally-funded investments such as the innovation laboratories should be able to, at least, demonstrate regional relevance. The current activities have certainly been generating outputs that have regional and even global relevance, but the project teams have not been strongly minded or encouraged to report them as such. A case could be made for a regional synthesis of relevant outputs that might form a basis for a more regionally focused implementation during any phase II. The need to validate and / or ground-truth SI technologies at multiple, representative but specific locations is unavoidable for SIIL to deliver its aims. Ensuring relevance at regional levels and beyond can be factored in by i) using standardized approaches (e.g. SIAF) within systems that are widely represented across the region ii) ensuring that the priorities of regional organizations are embedded in SIIL's own regional priorities; and being able to demonstrate that this is the case iii) forging wider partnerships for multi-locational activities that share common objectives iv) engaging with regional development/scaling partners around regionally relevant innovations. The question of designing potential regional functionality into Phase II for East Africa remains an open one for this reviewer.

3.5 Asia

3.5.1 Asia Overview

At the time of writing, the Feed-the-Future Program targets three countries in the Asia region, viz, Bangladesh, Cambodia and Nepal. The region as a whole has benefited from high national economic growth rates (Bangladesh and Cambodia growth rates are of the order of 10% pa over the past decade), which has underpinned solid agriculture sector growth rates. Nevertheless, poverty and household food insecurity is prevalent in all three countries, especially in rural areas.

The Sustainable Intensification Innovation Lab (SIIL) engages with national and local partners in Bangladesh and Cambodia. Field research is concentrated in two broad farming systems which are common to these countries. A substantial part of the SIIL research tackles productivity and livelihood issues in the lowland rice-based farming system in Bangladesh and Cambodia which is the most populous farming system in Asia (supporting approximately 40% of the East Asian agricultural population and 50% of the South Asian agricultural population, if combined with the similar rice-wheat farming system). It should be noted that lowland rice systems contain a wide range of other crops including maize (the fastest expanding crop in Asian rice areas), pulses, oil seeds, vegetables and sugarcane and manage large and small ruminants, poultry and aquaculture and maintain, in many places, farm forestry – and support livestock and fish production. SIIL also addresses issues of the rainfed upland intensive mixed (crop-livestock-tree) farming system in Cambodia – this farming system supports more than one-quarter of the agricultural households in East Asia and about 7% of the agricultural population in South Asia. Obviously, the smallholder technologies and institutional innovations developed by SIIL in Bangladesh and Cambodia are of direct relevance to other rice based and hill farming systems in many other Asian countries.

3.5.2 Bangladesh Country Report

Two major SIIL activities are underway in Southern Bangladesh, in the area of influence identified by the USAID Mission. The country Award, Unlocking the production potential of polder communities in coastal Bangladesh, is making excellent progress in Polder 30 in Kulna District under the leadership of KSU and IRRI, working closely with local partners including BRAC, Kulna University and a number of local businesses. The project is focused on national priorities, incorporates SIIL SI principles and is of direct relevance to other countries in Asia – and results have already been shared with Myanmar and Vietnam. The target rice-based farming system is low yielding, poor smallholders with limited adaptive capacity under intense pressure from salinity and climate change. The multi-disciplinary research has introduced high yielding, high-Zn, stress tolerant rice varieties, improved practices for rice and fish cultivation and high value rabi (post-monsoon rice) crops – and reapers introduced for rice harvesting. Both the research design and operation shows integration between water management, cropping, fish, household management, social capital and entrepreneurship. Yields of rice and fish have increased, household consumption of fish has increased, water users groups have been strengthened, an innovation system Learning Hub established, linkages established with local business and women entrepreneurs identified. Extensive capacity building of farmers (40% women) and landless households in practices, entrepreneurship and human nutrition, local officials, school teachers and students in nutrition, and University students is ongoing and has been very effective. Communications with stakeholders have been outstanding, notably the regular Polder tidings; and the project has convened knowledge sharing events with other projects in the area. Local governance arrangements are functioning and have the potential to

support policy engagement. There are, of course, aspects which could be improved, including *better documentation and publication of the integrated participatory research methods, and publication of systems research results alongside component research results*. Nevertheless, the Polder project may well be the highest performing SIIL Award.

At another polder in southern Bangladesh the ASMC mechanization research hub established another rice farming systems intensification project. The choice of a different polder than the country Award is inexplicable, given the importance of integrated multidisciplinary systems research for effective implementation of sustainable intensification. The ASMC has a different set of national partners, with the University in the lead and good business partners, but only weak connections to the NARS. The two SIIL projects confirm there has been little interaction or cross-learning to date, despite the similarity of activities. The ASMC project has made some headway on labor saving devices, especially for rice harvesting, and potentially for rice transplanting – with prospects for the establishment of local entrepreneurs for reaping. Capacity building has been strong, especially of extension agents and BAU students. All theses to date have been disciplinary, with little relation to the rice farming system as a whole or to the SIAF context. As with the Polder project, there is an urgent need for data analysis and publication rather than leaving these activities to the end of the project.

For Bangladesh, it is recommended that the two SIIL projects launch a series of knowledge sharing cross-learning experiences during Phase I, and to prepare a joint SIIL brief for national policy makers articulating the complementary roles of the two SIIL projects. It is also recommended that both projects immediately accelerate research data analysis and publication in advance of the end of Phase I.

3.5.3 Cambodia Country Report

Cambodia is a small country surrounded sandwiched between the vibrant economies and agricultural markets of Thailand and Vietnam. The USAID influence area surrounds the central Tonle Sap containing a majority of the rural poor and food insecure of Cambodia and includes smallholder producers in the lowland rice farming system which is linked ecologically and economically to the surrounding rainfed upland/hill farming system where smallholder maize, cassava and livestock are common, as well as concessions for plantation rubber. SIIL has three major activities in Cambodia, viz: Women in Agriculture Network Cambodia: Gendered- and Ecologically-Sensitive Agriculture (WAgN) led by Penn State University with the support of University of Tennessee Institute of Agriculture; Appropriate Scale Mechanization Innovation Hub (ASMIH) led by Illinois State University; and the USAID Mission supported Center of Excellence on Sustainable Agricultural Intensification and Nutrition (CE SAIN) managed by the SIIL ME in Kansas State University. In addition, the Global Food Security and Farming Systems Consortium (GFC) conducts some modest research activities. Major local partners are the Royal University of Agriculture – Phnom Penh, the University of Battambang and CIRAD. Other local partners are also involved in implementation including the Ministry of Agriculture, Forest and Fisheries (MAFF), Ministry of Education and Youth (MoEY), Agricultural Development Denmark Asia, Conservation Agriculture Service Center (CASC) and Institute of Technology of Cambodia (ICT). Four regional and international organizations also assist, viz, the World Vegetable Center (AVRDC), CIRAD, Asia Impact Center (ECHO Asia) and the Kasetsart University, Thailand. SIIL-Cambodia has built on, and continue to collaborate with, the work with several other Innovations Labs, notably the Horticulture IL and the Livestock IL. Of course, SIIL benefited from the research results and partnerships of SAMREM in Cambodia, which have all contributed to the excellent current performance of SIIL-Cambodia. In addition, Cambodia-

SIIL has attracted resources for research grants and capacity building from USF, USIS and SEARCA, and Swiss-Contact. The combination of the sound research foundations, good partners and excellent leadership has contributed to what may well be the best-performing of the six SIIL core countries.

A noteworthy characteristic of the SIIL activities in Cambodia is the co-location of the core field research of the Awards and the CE SAIN in three districts: Banan District (Battambang Province), Puok District (Siem Reap Province) and Stung Chinit District (Kampong Thom Province). Special approval was granted for the inclusion of Stung Chinit District even though Kampong Thom Province falls outside the FtF zone of influence in Cambodia. Although co-located, often with inter-twined funding and operations, from a science perspective the degree of systematic functional integration of research is surprisingly low – *although the potential is high*.

A second characteristic is the sound development of SIIL research based on previous USAID activities in Cambodia, notably SANREM Phase 4, Horticulture IL and Harvest 1 and 2. This feature combined with the excellent understanding of local smallholder farming systems of local Universities and CIRAD, complemented by the inception SWOT, led to acceptable positioning of the SIIL activities on researchable farming systems issues. Nevertheless, it is judged that a specific participatory multi-disciplinary multi-award farming system evaluations in the three districts (with due focus on gender, nutrition, sustainability and resilience) would be useful at the end of Phase 1 to formalize the feedback from technology users, map pathways to impact and identify scaling opportunities, and provide a benchmark for subsequent research design for Phase 2.

Turning to the country Award, WAgN 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, i.e., to understand the nexus of gender and SI. The unique and novel focus on plant diversity and utilization in under-utilized spaces near homesteads and between farm fields (so-called 'wild gardens') is particularly noteworthy and aligns with international (e.g., FAO) interest in neglected and underutilized species (NUS). WAgN has contributed significantly to knowledge of CA based SI (hereafter referred to as CASI) on grain crops (notably soil improvement) and vegetable production (a major global contribution of SIIL in Cambodia and the Hort IL in Honduras). The CASI vegetable gardens appear very promising, reportedly significantly augmenting the incomes of 43 women farmers. Another major breakthrough has been the successful production of tomatoes grafted on eggplant rootstocks for high-priced wet season markets. One wonders if the research should be extended to community lands. These two themes contribute to the critical national need for diversification of lowland rice (and upland) farming systems. The prevalence and prices of 70 local vegetables and fruits in Siem Reap markets was surveyed during one wet and one dry season; and nutritional profiles of the more important products have been locally determined. Because of the foci on cultivated (CASI) vegetables and wild gardens, the project works entirely with women which has led to some gender research on division of labor (for the most part, already well known) and leadership (a critical new area of investigation). Two other intra-SIIL collaborations are the support to the technology demonstrations in the CE SAIN Technology Parks; and the development, in Thailand, of a framework for demonstrating and extending promising SI technologies and practices by CE SAIN. Clearly, the project contributes to two SIIL priority themes, viz, improved family nutrition and empowerment/improved income of farm women. Two additional research themes should be considered, namely returns to women's

labor (compared with alternative employment such as local trading or garment factories) and the vegetable production/NUS collection and market risk faced by women. The GFC has been requested to use the recently-imported drones to survey the area, density and species composition of the wild gardens – an important area of research, but not yet agreed. Capacity building has been significant, including farmers, businesspersons, University staff and postgraduate students. Despite the novel foci and substantial progress, the project lacks a *detailed baseline survey report and lacks journal articles – definitely areas meriting immediate attention.*

The Appropriate Scale Mechanization Innovation Hub (ASMIH), Cambodia is located at the Royal University of Agriculture, Phnom Penh. The activity is fully appropriate to SIIL and to the Cambodian and Asian regional priorities. Its objectives are: to design and assess conventional and direct seeding mulch-based cropping systems; to assess the performance of appropriate scale machinery while preserving soil capital; to adapt and train smallholder farmers, service operators, field technicians, and students on the use of ASM and conservation agriculture (CA)-based cropping systems; to support multi-stakeholder initiatives; and to initiate a negotiation process between farmers for the individual or collective management of fodder sources or crop diversification after wet season rice. The project has worked collaboratively with WAgN and CE SAIN with sharing of resources and technicians and has drawn upon the results of earlier projects, e.g., a zero till planter developed by an earlier Australian ACIAR project. It has explored ecosystem services, investigated microbial and nematode communities under no-till, field tested prototype 2- and 4WT equipment for CA and conducted substantial training at University and with farmers. There are several noteworthy initiatives: the Hub Advisory Committee for sharing knowledge and co-learning, and ultimately policy engagement; simulation game and participatory analyses and the interactions with gender assessment; and the contributions with CE SAIN to the institutional innovations on Conservation Agriculture Services on Fee (CASF) and the Conservation Agriculture public-private Alliance.

The **Center of Excellence (CE SAIN)** in the Royal University of Agriculture (RUA) in Cambodia addresses two critical inter-related SI needs in Cambodia and the wider region, viz, capacity building and knowledge repository and sharing. The USAID Mission which funds the Center also asked the Center to track and monitor the status of all USAID-funded SI related projects in Cambodia. This is updated on a quarterly basis and provides an excellent overview of many SI activities in Cambodia, in effect elevating the role of SIIL in Cambodia. The Rector and staff of the RUA assured the ET of their full commitment to the Center and plans for its continuation in the long term. The Center has a small staff led by Dr. Lyda Hok which manages a large number of internships (for RUA and some in UBB) as well as research grants for Faculty. The Center has also established and manages five Technology Parks strategically located around Cambodia in order to demonstrate SI technologies to farmers, students, business persons and the general public – but also host some trials (e.g., cover crops, and poultry and pig feeding). The Technology Parks are an excellent platform for potential engagement with youth. Various local management arrangement arrangements have been developed; for example, the Battambang Park is hosted on the University of Battambang research farm. Interestingly, the RUA is establishing an agribusiness incubation center immediately adjacent to the RUA Technology Park which offers great potential to develop business models around SI technologies. In terms of innovation, the Center established relationships with some regional high schools and succeeded in interesting students in agricultural studies, with a consequence that now 9 first year agricultural students enrolled in agriculture at RUA (without the intervention, it was expected to be zero from that school). The Kampong Chan Technology Park/CAS demonstration farm is a superbly managed impressive 15 ha farm with a wide variety

of cropping systems with work commencing on livestock fattening. With its associated training facilities, this hub has great potential to become a regional training center for CA in the Mekong and wider Asian region.

CE SAIN co-hosted the First International Sustainable Agricultural Intensification and Nutrition Conference and Field Trips in January 2018. One hundred sixty-five individuals from 16 countries attended the conference, and over 60 individuals participated in the field trips. The CE SAIN also continues to build human and institutional capacity at the Royal University of Agriculture in Cambodia. The Center, through its five Technology Parks (see above), has also played a key role in linking RUA faculty and students and the private sector, NGOs, Innovation Labs, and other networks. These partnerships support the promotion of information dissemination and serve as a catalyst for new innovations.

Several aspects of CE SAIN merit further consideration. First, it is essential to incorporate systems thinking for SI into the RUA curriculum upgrade (in conjunction with ASMC), to avoid leaving RUA with teaching methods more fitted to the previous Century. Relatedly, the demonstrations and explanations in the Technology Parks must include some common interactions, for example, crop-livestock, cover crops, soil management and disease pressure. Second, the Technology Parks are just being established and their use, and user feedback, needs to be monitored – to avoid the historical experience with such parks of becoming white elephants. Third, there is an opportunity for regional training for Mekong and wider Asia in CA based on the Kampong Chan Technology Park/CAS farm which would have huge regional pay-off in SI capacity and is already supported in principle by FAO and GIZ. The fourth aspect relates to wider benefits from CE SAIN among the 5-6 leading agricultural Universities in Cambodia (including UBB, UM, and others). A recently approved World bank loan (\$90m) for strengthening agricultural education in Cambodia would be implemented by RUA but include another 5-6 regional agricultural universities. Thus, CE SAIN should explore opportunities for integration with the loan implementation.

In relation to SIIL Cambodia as a whole, there are opportunities to deepen the integration of SIIL research and its reporting, and to build capacity in the Universities and in research grants for systems research approaches. Attention is needed for research data management. There would be great value in developing an integrated systems SI vision for each of the research districts/hubs, backed up by a participatory farming systems evaluation of SIIL technologies, and feeding into a map of pathways to impact and scaling opportunities.

Asia Regional. The SIIL results of Bangladesh and Cambodia have direct relevance to other Asian countries including Nepal, and SIIL reporting of Phase I should be suitable for sharing across Asia. During Phase 2, it is **recommended that a SIIL regional platform be established for SI knowledge sharing and capacity building, supported by CE SAIN in Cambodia.** As a prelude to the regional platform, **during Phase I it is recommended that the a CASI Asia regional training center be established at Kampong Chan in Cambodia with the support of donors such as CIRAD, FAO and GIZ.**

4. Program Management

Overall program effectiveness depends upon adequate management at all levels. This section evaluates overall SIIL program governance and management, the management of Consortia and Awards, and the coordination of SIIL activities at country level – in essence four levels of management and coordination. The section also considers reporting processes, data management and monitoring procedures. It is noteworthy that the SIIL ‘sustainable intensification’ approach and activities has generated confidence in many USAID Missions who have invested supplementary resources in SIIL-related activities, e.g., CE SAIN in Cambodia, and precision agriculture research in Malawi, which are reported in the SIIL Annual Report 2018.⁵ Further, USAID has augmented SIIL resources for specific tasks aligned with the SIIL mandate, e.g., African soil research priorities, and agricultural policy. The partnership approach of SIIL has also attracted other partners with aligned objectives, e.g., USDA soybean-based fish feed industry development in Cambodia, and the French CIRAD long term conservation agriculture investment, both in Cambodia. The attraction of like-minded research and development partners has clearly increased the impact of SIIL as a program but has also required additional management and reporting effort.

Kansas State University (KSU) has provided high-level leadership and support to SIIL governance, strategic directions, administration and management. KSU oversight of SIIL was exercised by the Dean and Director of KSRE, Dr. John Floros -- until he recently was promoted to the Presidency of another University. The responsibility for KSU oversight now lies with another exceptionally-well experienced person, Associate Dean of International Agriculture Research, Dr Nina Lilja. University leadership has been actively involved in SIIL events at KSU, and other senior technical staff from relevant fields supported SIIL annual meetings. SIIL has also benefited substantially from the strategic advice of the six-member International Advisory Board which participates in SIIL annual learning workshops and field visits, and provides intermediate guidance as required. The Board brings a wealth of experience on the positioning and implementation of sustainable intensification research in Asia, Africa and other regions.

The SIIL Management Entity (ME) staff are recruited and employed under KSU conditions, as with other KSU staff, with HR services provided by KSU. A number of positions are cost-shared on the Grant, e.g., Business Manager. KSU handles administration, contracting and payments. KSU also provides financial reporting and auditing requirements. The SIIL Grant benefits from a particularly low overhead rate (35%), significantly less than the standard university rate on Federal grants and contracts in 2014 (48%) when SIIL was awarded.

The ME staff are well qualified and experienced, highly motivated and have established excellent working relations with PIs, Missions and other stakeholders. The ME also appears to be responsive to the needs and opportunities of USAID HQ. The ME management style is inclusive and thus most awardees appreciate the role and contributions of their activities in the broader aims and objectives of SIIL. Of great practical significance, the ME arranged tools to ease reporting, notably the PieStar Report Hub. The Report Hub offer ‘state-of-the-art’ processes for USAID report loading and is being considered by other Labs. If a further development of Piestar were to be contemplated, means to facilitate the displays of whole-reports would be useful. SIIL annual reports are accessible, informative and easy-to-read – and could be complemented by a brief introductory statement of ‘what is sustainable intensification’ for the uninitiated.

⁵ <https://www.dropbox.com/s/gvz5ga5ps34ct40/FY2018-SIIL-Annual-Performance-Report-Submitted-15-Nov.docx?dl=0>

Internal and external SIIL communications have been, on the whole, effective. The website and blog are accessible and provide access to some key resources, not least the Sustainable Intensification Assessment Framework (SIAF). After several years of field operations, it is time to populate each of the website resource areas with SIIL achievements and stories, and papers and presentations as appropriate. As the body of results from SIIL begins to grow, an additional Communications position should be considered for the end of Phase 1 and certainly for Phase 2. There is a double communications challenge, not only to demonstrate progress and results across all Consortia and Awards, but also to explain and promote the concept of SI and its implications for research and policy which are not understood in depth by many SIIL stakeholders. The ME has regular communications with Consortia and Awards and is abreast of key plans and activities. The ME has organized a number of major events at USA, e.g., Baltimore agronomy, and international conferences, e.g., TropAg in Brisbane, Australia.

The Achilles Heel of many research programs is research data management. The ME has made concerted efforts to establish robust data management systems and procedures that are compliant with USAID's open data specifications and worked with award holders on the benefits of proper data custodianship as well as the fact that compliance with donor standards is mandatory. However, there have been delays in Consortia and Awards in the finalization and posting on-line of research data sets (baseline surveys, field research, simulation results, lab research etc.) which should be addressed – depending on the commitment of PIs and the quality of the raw data from research. The delays in the posting of research data represents a missed opportunity in terms of further research on expensive, and sometimes unique, data sets. Clearly, research data, capture, entry and meta-documentation merits attention from the ME and the PIs of Consortia and Awards.

Conversely, the ME has led monitoring indicator development and reporting from local partners very successfully. It has made frequent monitoring and stakeholder engagement visits to the field, which involved developing local capacity in monitoring, indicator identification, collection and reporting which has been appreciated by local partners. SIIL and its Consortia and Awards are focused on four formal indicators that are found in the Feed the Future Monitoring System (FTFMS) report⁶. They are the following: EG.3.1-12: Number of agricultural and nutritional enabling environment policies analyzed, consulted on, drafted or revised, approved and implemented with USG assistance; EG.3.2-1: Number of individuals who have received USG-supported short-term agricultural sector productivity or food security training; EG.3.2-2: Number of individuals who have received USG-supported degree-granting non-nutrition-related food security training; and EG.3.2-7: Number of technologies, practices, and approaches under various phases of research, development, and uptake as a result of USG assistance. The contributions to FTFMS are proceeding smoothly. SIIL has added a number of additional indicators, viz, publications, and presentations, project progress, collaborators, lessons learned and future directions. As program implementation proceeds, it would be advisable for the ME and Consortia to ground truth activities and results on the ground, in order to ensure accuracy of results, to fill SIIL-specific gaps in reporting (e.g., gender, nutrition) and to identify opportunities for stronger inter-Award linkages and integration, e.g., in Ethiopia.

Overall, the ME under KSU oversight and support is now well-established and high-performing, has gained the trust of the PIs and is leading an effective program. It has creatively responded to unplanned challenges coming from field programs and changes in the FtF program, and attracted additional resources to important activities aligned with, and integral to, SIIL, notably related to

⁶ <https://www.agrilinks.org/post/feed-future-monitoring-system-ftfms-resources-page-2018>

the knowledge and training in Cambodia (CESAIN), African soil research priorities and SI policy research. Any major structural change in governance or management would inevitably lead to inefficiencies and delays in program impact.

The two Consortia are key structural components of SIIL operations. While the start-up of GFC was, perforce, somewhat rushed, the converse is the case with ASMC. Neither Consortia management appears to have insisted in all cases on close working linkages with country Awards, with a view to supporting the country Awards (as opposed to separate local operations). Through in-country co-design and cross-fertilization greater coherence and impact could be achieved. The implementation of country Awards also appears to have proceeded at different paces. Notwithstanding the normal institutional challenges of international research partnerships, there might be opportunities to accelerate the implementation, analysis and reporting of some of the lagging awards in Phase I.

The ET has observed that local SIIL profile, results and impacts are clearly stronger where country activities are facilitated. Two examples stand out: Senegal, with a local coordinator, and Cambodia, with an international (unofficial) coordinator. The required role is facilitation of coherence and integration rather than coordination per se, since responsibilities for management lie with the PIs.

5. Opportunities for Program Future

5.1 Foresight

One of the great inefficiencies in agricultural research is solving ‘old’ problems for which the solutions are not adoptable because of changing climate, population density, markets and agricultural policies. In the five years since the design of the SIIL Grant, there have been significant changes in rural population density, infrastructure, food and input markets, policies, and above all technologies. By way of illustration, the technologies and capacities for geospatial analysis have advanced massively, calling into question the optimality of the Consortium design. A similar analysis applies to mechanization, the adoption of which is being driven by the rapidly rising opportunity cost of labor and wider availability of power sources. As a consequence, the ET has discussed in depth the optimal organization and priorities for ASMC research.

In relation to Phase 2, ***the ET recommends that the ME arrange a series of foresight studies at (a) major theme/consortium level and (b) the three regions to develop scenarios for 2030, representing both a suitable technology target for Phase 2 and also the target year for the SDGs. There are a variety of low cost foresight techniques, which could be developed, such production systems scenarios for 2030, informed by known analyses (e.g., IFPRI, and USDA) and syntheses of SIIL Phase 1 results. Particular attention would be paid to poverty, food and nutrition security, gender equality, and plausible rates of technology adoption and infrastructural development in each region.***

5.2 Systems, Sustainability, and Scalability Systems

Systems:

As highlighted throughout this review, USAID’s strategic development in the SIIL is premised on addressing: productivity with resilience, economics with enhanced livelihoods, environmental stewardship, human/social capital including food security and nutrition, social with attention to equity and opportunities for women and youth.⁷

Impact from SI very rarely evolves from adoption of any simple change, e.g., adoption of a new variety, or adoption of a fertilizer recommendation. Convergence and integration of components are highly desirable, if not essential. In many cases, this can be enhanced by a combination of innovations that bring about productivity improvement and systems resilience with environmental stewardship. Farmers in their own environments, building on their own vast experience, can learn, integrate, and adopt critical novel SI components. The reality is the SI research is primarily systems research. Systems research requires effective coordination.

The ET is mindful that the ME is performing effectively by enabling and empowering the sub-award holders to deliver their stated outputs, reports and financials. ET also notes that the ME is very active and effective in advocacy of SIIL, highlighting the needs and opportunities for SI systems coherence and its applications. ***However, there is need for additional oversight, especially on country-level coordination, through joint planning by PIs. The ET recommends that the ME step up its oversight and enable better country-level coordination.*** One caveat is: the ME should take care that SIIL PI stakeholders and other

⁷ http://www.k-state.edu/siil/documents/docs_siframework/Guide%20for%20SI%20Assessment%20Framework%20-%2010.24.17.pdf.

participating labs do not feel over-managed. This will require both sensitive management skills and diplomacy. The ET has observed these skills in the current ME staff. Workshops for PIs on systems research that create synergies through convergence of stakeholders and integration of research components will likely be helpful, by jointly creating a shared vision of this impact pathway. Coordination and integration of components needs leadership at the country level.

ET recommends: the ME, in collaboration with relevant PIs, including Consortia Leaders, establish a country-level coordinator/facilitator to guide joint planning and implementation through convergence and integration of SI components. In general, this selected leader would be from a central relevant NARES institution.

Sustainability and Scalability:

SIIL ME must be diligent in establishing country-level leadership, and then should be more directive that process (e.g. workshops) takes place where the shared vision is created of what, where, when, how and by whom, under an explicit impact pathway. **The ME and PIs (including the country-level facilitator) must look at each node in the impact pathway, and reflect on the choices and their implications for sustainability and their eventual scalability of adoption.** When possible, these early stakeholder discussions should involve, or be shared with, institutions that are principals in designing and implementing major development projects in the country. This engagement will be a manifestation of foresight.

The ET Recommends: Participatory stakeholder process to design “Impact Pathways” (IPs) for a SI program should ensure that both sustainability and scalability are significant considerations in the choice of major innovations in the IP.

6. Compiled Recommendations and Opportunities

6.1 Phase I Recommendations and Opportunities

6.1.1 Technology Development

1. The ET recommends: ASMC can and should expand its efforts toward creating a digitized knowledge-archiving and sharing facility—functioning in-perpetuity—on specific technologies and their implementation for Appropriate Scale Mechanization (ASM) covering global innovations to reduce “re-invention of the wheel.”
2. The ET recommends: ASMC, beginning in Phase I, should include more analysis of future needs and opportunities concerning appropriate implements for SI innovation adoption.
3. The ET recommends: While there is no question about the potential contribution of Geospatial applications to SI, increased strategic engagement of SIIL’s geospatial activities in country hubs is strongly recommended for innovation targeting. For example the identification of “hot spots” for expansion of irrigated horticulture systems, including water table resilience/recharge, could be extremely valuable for empowering women and addressing nutritional needs.
4. The ET recommends: Before further major investment in geospatial research, the ME should organize an appraisal of GFC’s actual relevance and what future positioning should be made, taking into consideration the current national and regional level of capacities in this domain. This should include an assessment of where foresight activities might be located (in a repositioned GFC or elsewhere).
5. The ET recommends that GFC make explicit the databases it requires to create helpful information for the SIIL projects on the ground.
6. The ET recommends: Because CA—especially when combined with complementary SI technologies related to water, input-use efficiency, IPM, livestock, markets, etc., as Conservation Agriculture based Sustainable Intensification (CASI)—is one of the few proven sustainable agriculture technology clusters, and CASI is a significant part of the research in all three regions, SIIL should arrange a cross-cutting synthesis of Phase I results, including CA-based Horticulture, and their regional significance on this theme. A background paper should be presented in an Annual Workshop for discussions on Impact Pathways for scaling up.
7. The ET recommends: As a sub-set of the CASI initiatives, SIIL should arrange a crosscutting synthesis of Phase I CA Horticulture results and their regional significance—background paper to be presented in Annual Workshop.
8. The ET recommends: At country-level, stakeholders—where this has not already been done—characterize the socio-economic and nutritional status of target populations at the onset of interventions, and then review periodically, including with control groups.
9. The ET recommends: SIIL ME explore, across institutions, the best way to support broad adoption of SIAF SI-guidance tool and determine a process for continuous updating, based on lessons learned during applications.

10. The ET recommends in Phase I a participatory appraisal of farm- women, men and youth's evaluation of SI technologies in order to inform priorities for Phase 2.
11. ET recommends: In each continuing research location, stakeholders conduct participatory farming systems/rural appraisals that, while considering SIIL technologies, diagnose future system and research priorities to avoid un-needed, unwanted innovations.

6.1.2 Stakeholder Collaboration/Communication for Enabling Environments

1. The ET recommends: ASMC invest in regular knowledge exchange and harmonization of messages to policy makers along with other appropriate small-scale mechanization R&D programs, and ensure effective working linkages with other SIIL awards.
2. The ET recommends: SIIL management should foster and document key pilot examples of innovations in SI, focused on public/private sector/microbusiness enterprise, articulating public/private sector alliances, such as those emerging at the CA Consortium in Cambodia.
3. The ET recommends: The ME and regional leaders should routinely brief mainstream Government agencies, including Ministries of Agriculture and also nutritional groups, on SIIL's program and research results. This could be a good investment with minimal costs. The IAB could provide leadership for this.
4. The ET recommends: SIIL ME should foster joint integrated research plans by linking different SIIL partners/awards, when practical, based on a shared vision of development pathways in each research hub location. This will catalyze systems/deep integration across SIIL awards/partners. It will be especially beneficial for students to learn to work as researchers in teams. Co-location planning and implementation of field research has been mostly positive at hub sites. But there is opportunity to take cooperative research to a higher level.
5. The ET Recommends: Crosscutting assessments of the effectiveness of conventional and innovative social capital mechanisms operating in Phase I to guide investments in Phase 2.
6. The ET recommends: The ME further facilitates publication of SIIL results in agricultural systems-oriented journals to complement the disciplinary and commodity journal publications.
7. The ET recommends, CE SAIN explore opportunities for integration for implementation of the new WB loan to Cambodia

6.1.3 Scaling and Impact Pathways

1. The ET recommends: a) future research efforts be required to consider scaling challenges from the beginning of the design process; and b) ME should consider launching a new research theme to identify the optimal approaches to farmer-level

knowledge acquisition (extension methods), with particular emphasis on knowledge intensive innovations, such as IPM or CA-based SI and/or multicomponent innovations, such as the CA-based, dry-season, irrigated horticulture production.

2. The ET recommends: Each Consortium and Award of SIIL should draft a scaling strategy and exit plan, which would incorporate the effective repositories of the knowledge generated during Phase I. All new innovation proposals should include an Impact Pathway concept-note on scaling of adoption, comprising notations of key partners in the process. These should primarily indicate where Phase I knowledge is embedded to support effective implementation during Phase II.

6.1.4 Management Specific

1. The ET recommends: SIIL ME should, in partnership with relevant PIs, organize expert consultations (these could be virtual) to explore SIIL's balance between bottom-up and top-down innovation discovery and implementation approaches, discerning between demand-driven versus supply-driven innovation prioritization.
2. *ET recommends: ME should seek to identify more effective means to reward those who, in a timely manner, submit reports and insert data into SIIL databases and coerce laggards as Phase I approaches completion.*
3. *The ET Recommends: the ME engage with Consortia and Awards, starting in Phase I, in closer site assessment of, and possible adjustments to, field programs in order to foster integration on the ground and focus documentation and reporting on core SIIL themes.*

6.2 Phase II Key Recommendations and Opportunities

Note: Some of these recommendations can be initiated in Phase I as a basis for major implementation in Phase II.

6.2.1 Technology Development

1. The ET recommends that the ME arrange a series of foresight studies at (a) major theme/consortium level and (b) the three regions to develop scenarios for 2030, representing both a suitable technology target for Phase 2 and also the target year for the SDGs.
2. ET recommends: farming systems analysis and stocktaking be conducted to help focus research on most important and promising innovations and target domains.
3. ET recommends: A permanent mechanization-oriented information portal should be an ASMC/SIIL output, if the continuity of maintenance resources and a global long-term host institution with a portal manager can be secured, perhaps at FAO.
4. ET recommends: The research dimension of smallholder irrigation should primarily be realized by the Small Scale Irrigation Lab (ILSSI), thus increasing strategic partnerships between labs. ASMC should continue its critical role in piloting appropriate application of water-use innovations (e.g., solar pumps, axial flow pumps, lay-flat plastic pipe, drip irrigation, etc.) in the context of selected production-systems optimization at hubs and

for scaling adoption.

5. ET recommends: broadening of focus on non-animal traction mechanization in African farming system zones where animal traction is not already predominant, which is most of the developing country biomes where SIIL will focus. When appropriate this should be combined farmer-based supplemental irrigation (including possible use of solar pumps and of lay flat plastic pipe) to expand production cycles for SI. The Brazilian Cerrados provides an example though the farm scale in Africa and Asia will be much smaller.
6. The ET recommends: GFC place greater focus on delineating and facilitating in optimization of SIIL's farming systems in the six SIIL core countries. Its name reflects this very intention, but there is only superficial reporting of farming systems analyses for the six core field programs in Phase I.
7. The ET recommends: In Phase II, when appropriate, SIIL strengthen research on conservation agriculture based sustainable intensification (CASI) for SI in farmers' main-season crops. There should be inclusion of complementary SI practices that support the basic CA principles. Such research should build on the Phase I's CA Horticulture results conducted in a majority of countries. In this context, SIIL partners should investigate issues of soil health, crop rotations, cover crops and climate adaptation, including labor use efficiency, 'zero tillage' mechanization service provision and efficient crop-livestock integration.
8. The ET recommends: ME build on/deepen results/networks in existing geographies where there are high pay-offs from continued research and innovation scaling. Specifically, as an example, SIIL management should explore creating a Center of Excellence (similar to CE SAIN in Cambodia) to address, for example, the opportunity to help foster SI in the context of agropastoral sorghum/millet/livestock farming system in West Africa. Senegal. Another attractive option is SI optimization of maize/beans mixed farming system in Eastern and Southern Africa, —here Western Kenya or Central Uganda could be among candidate host country sites considered for this facility. Many universities and the NARES are relatively strong, providing a foundation for applied research and capacity building, including public and private sector scaling processes. Regional capacity building and knowledge repository would be major goals.
9. The ET recommends: increased attention be given to optimum total SI biomass production, due to multiplicity of demands—food, feed, fiber, soil organic matter/soil health. Action plans should be designed and studied in local context within major agro-ecologies.
10. The ET recommends: research into use of living fence and solar electric fence, as fences are needed to optimize feed production by managing grazing in many Systems. They will also often help insure enough soil cover can be maintained for critical mulching in CA systems.
11. The ET recommends: SIIL expand research on the systems constraints/opportunities and on scaling up and out adoption of dry-season, drip-irrigated CA-horticulture. This should likely become one "centerpiece" of SIIL's work in Phase II. This CA-horticulture approach is a major output of the current Phase I, and future research is a logical extension/continuation of Phase I. This research should be addressed as a full systems

- development approach, involving farming systems at hubs with engagement of SIIL's two existing Consortia, plus field level contribution from the new Policy and Soil Health initiatives within SIIL. The systems work should seek convergence with relevant Labs, such as HIL, ILSSI, IPM, Market Access, etc., and also inclusion of CGIAR (World Veg, IWMI, IFPRI etc.), the private sector, and especially with key NARES. Capacity building should be well beyond university-to-university empowerment. Agribusiness for women should be prioritized. The way forward may include co-hosting of joint workshops for science and development partners.
12. ET recommends: ME should explore research opportunities to enable farm and community levels decentralized small animals/poultry and fish companion enterprises, with and without feed milling capabilities, as an SI research component, and especially as high-income potential women's' activity
 13. ET recommends: as a foresight option attention be given, at selected hubs, to smallholder (or village-level) feed production and processing to meet local and regional demands for poultry and fish feed within decentralized value chains.
 14. The ET recommends: UC Davis continue its geospatial field engagement at field locations in East Africa to build on work during Phase I, but there be a re-bidding for delivery of other priority geospatial project outcomes to be determined by ME, with guidance from a small steering committee. UC Davis can, of course, be one of the bidding candidates for any/all future work. This broadening—inclusion of other US university partners—will strengthen output delivery, including formal and informal capacity building.
 15. ET recommends: In each continuing research location, stakeholders conduct participatory farming systems/rural appraisals that, while considering SIIL technologies, diagnose future system and research priorities to avoid un-needed, unwanted innovations.
 16. ET recommends: For each major prioritized farming system, ME foster the conducting of a major stocktaking of technologies and institutional innovations along with an “expert” appraisal of opportunities and needs with a 10- and 20-year future perspective (based on the results of the “Foresight” dialogues). The reports and proceedings should be a major output of SIIL and guide its program of work, especially for ASMC and GFC. These outputs, if done well, will be highly valued by the broader development community.
 17. ET recommends: increased attention of ASMC to Africa's key maize-mixed and root crop-based farming systems. Currently no ASMC attention is given to reduced-tillage mechanization in vital maize/legume systems for Africa. This also should be rectified. For example, in African savannah zones, where no-till maize and soybean are just beginning to replace sorghum- or cassava-based systems, the needed implements and capacity building requirements for this future scenario should be considered now. SIIL needs to be foresight oriented. A companion recommendation for USAID is to encourage SIIL to invest in research of systems scenarios and their implications. As a corollary, future farming systems are likely to include a greater proportion of perennials, which also require the selection and testing of appropriate equipment and mechanization options.

18. The ET recommends: a better balance between the biophysical and socio-economic domains of production systems research should be sought.

6.2.2 Stakeholder Collaboration for Enabling Environments

1. The ET recommends: Co-location planning and implementation of field research has been mostly positive at country field sites. However, there is opportunity to take cooperative research to a higher level. SIIL management should foster joint integrated research designs by inter-connecting different SIIL partners/awards, based on a shared vision of development pathways in each research hub location. Where appropriate, this will catalyze systems deep integration across SIIL awards/partners. It will be especially beneficial for students to learn to work as researchers in teams.
2. The ET recommends: recognizing the country programs and the ASMC have set high marks for partnership development, yet acknowledging the need to create even broader alliances of partners/institutions, especially with private sector and Ministries of Agriculture, ME and ASMC should leverage research resources, building on past achievements, and foster a shared vision among stakeholder for scaling.
3. ET recommends: that regional mechanisms/platforms be established to facilitate SI lesson learning and knowledge sharing among researchers, policy makers, business and civil society, as well as capacity building for key development agencies. Such mechanisms would be implemented in consultation with relevant existing regional alliances, and with development banks and other investors to support scaling.
4. ET recommends: Considering the rapid evolution of farming systems and the critical need for foresight and minimizing duplication, SIIL should budget for and implement expert and stakeholder reviews of future scenarios and issues and current knowledge, globally, on key topics/thematics central to SIIL's programs, such as on: small-holder oriented mechanization, CASI, crop/livestock systems, smallholder-based irrigated systems for SI, living fence to manage grazing, Peri-urban Horticulture, etc.
5. ET recommends: ME prioritize actions to pilot agribusiness focusing on farm and non-farm growth multipliers, with emphasis on women and youth. Examples include:
 - drip and solar irrigation systems for horticulture;
 - sales, rental, and maintenance of 2-wheel tractors and their implements;
 - service provider business for SI crop establishment (e.g. conservation agriculture), crop protection, reaping/harvesting, and post-harvest processing.
6. ET recommends: Stakeholders tap new knowledge sources while maintaining core/minimum continuity. ASMC should especially broaden these partnerships and capitalize on promising innovations from Asia and Brazil, with relevance to Africa, where both public investments and involvement of the private sector has been limited.

6.2.3 Capacity Building

1. The ET recommends: Phase II should include specific training in systems approaches for faculty in African, Asian and US universities working with SIIL students, with regular virtual meeting of the committees overseeing the research, ideally supported by a

systems research mentoring service for supervisors and students.

2. ET recommends: ME explore piloting capacity building to enable private enterprise, with emphasis on women, to actively engage in monitoring and certifications regarding farm-level application of government and private sector standards concerning food safety and environmental stewardship.
3. ET recommends: ME foster management-level agribusiness capacity-building for women and youth in Mechanization, Service Provider Provision, and Postharvest agro-industries for each region of SIIL engagement.
4. ET recommends: That, while there is general merit in distribution of field programs across countries, there are compelling reasons, in specific cases, to have relevant labs work together in an integrated fashion, in the same hub space at the same time to optimize impact on nutrition and livelihood goals. These opportunities should be identified and addressed through cooperative planning.

6.2.4 Scaling and Impact Pathways

1. The ET recommends: Each Consortium and Award of SIIL should draft a scaling strategy and exit plan, which would incorporate the effective repositories of the knowledge generated during Phase I. All new innovation proposals should include an Impact Pathway concept-note on scaling of adoption, comprising notations of key partners in the process, when possible. These should primarily indicate where Phase I knowledge is (or will be) embedded to support effective implementation during Phase II.
2. ET recommends: Policies to enable expansion of equity-centered agro-industries should be researched under the SIIL platform in the context of regional, country and farming systems specificities.
3. The ET recommends: SIIL ME budget for and organize workshops to develop Impact Pathways for the above innovations toward targeted country scaling up in alliances with other development partners, both national and international.
4. The ET recommends: a) future research efforts be required to consider scaling challenges from the beginning of the design process; and b) ME should consider launching a new research theme to identify the optimal approaches to farmer-level knowledge acquisition (extension methods), with particular emphasis on knowledge intensive innovations, such as IPM or CA-based SI and/or multicomponent innovations, such as the CA-based, dry-season, irrigated horticulture production.
5. ET recommends: “Beyond project” strategy for continuity be prioritized before further investments, especially including for CEs.

6.2.5 Management Specific

1. The ET recommends that no change be made with regards to KSU as SIIL’s host institution in Phase 2. Similarly, the current management staff have shown competence, diligence, creativity and energy; and no changes in the ME team positions is suggested.

2. The ET recommends: the ME engage in closer site assessment of, and possible adjustments to, field programs, in order to verify that the descriptions of the field activities are properly documented and accurately reflected in the sub award report submissions.
3. ET recommends: Both GFC management and SIIL management host a consultation(s) with stakeholders and experts to explore how best to focus research to more directly contribute to the prioritization and decision-making around the tangible programmatic of targeted pilot hubs. Consortia should be designed to focus primarily on issues key to the Hubs' central goals and objectives. That is, Consortia should primarily serve the production systems innovation efforts (agronomy, institutional and social capital).
4. ET recommends: ME should reinforce and re-orient research supervisors/mentors of SIIL graduate student on systems oriented research approaches. Closer guidance for SIIL students will be required. Briefs should be developed for supervisors on SIIL systems/multi-disciplinary approach. Workshops should be conducted involving supervisors and students to optimize guidance toward systems-oriented research for development targeting SI.
5. The ET recommends: SIIL ME foster consultations to scope out action areas for SIIL and/or it's partners to more coherently strengthen the social capital associated with hubs' needs, while at the same time, looking for the relevant overarching lessons that can be shared more widely.
6. The ET recommends: USAID considers SIIL to become among empowered focal point institutions to inform FtF's efforts to scale up adoption of innovations, based on the most efficient approaches to knowledge transfer, in the context of its development goals within the three target regions. One size does not fit all. Research on which knowledge transfer processes works best, where, with whom, and including associated costs of scaling up and out, is needed. Also, relevant knowledge needs to be archived and shared.
7. *The ET recommends that the ME arrange a series of foresight studies at (a) major theme/consortium level and (b) the three regions to develop scenarios for 2030, representing both a suitable technology target for Phase 2 and also the target year for the SDGs. There are a variety of low cost foresight techniques, which could be developed, such production systems scenarios for 2030, informed by known analyses (e.g., IFPRI, and USDA) and syntheses of SIIL Phase I results. Particular attention would be paid to poverty, food and nutrition security, gender equality, and plausible rates of technology adoption and infrastructural development in each region.*

7. Annexes

7.1 Evaluation Questions, Scope of Work, Evaluation Plan

(In-Progress)

7.2 Methods and Tools

(In-Progress)

7.3 Consortia Details and Graphics

Major highlights of outputs in 2018 as prepared by the GFC management

i) The project on generating cropland extent of Ethiopia by capturing field boundaries from high-resolution imagery is now complete. This study used high spatial resolution imagery within an online digitizing tool and trained users to manually digitize field boundaries from those images. This resulted in a unique crowd-sourced database of over 7,000 field boundaries in the Amhara highlands and Oromia region of Ethiopia. Two semi-automated field boundary mapping techniques, gPb and eCog, were applied to the same imagery and the resulting boundaries were compared against the manually digitized boundaries. Overall, eCog is recommended over gPb for field mapping since it captures boundaries that represent objects at the field level whereas gPb seems better at capturing boundaries for larger agglomerations of fields and may be suitable for cropland extent mapping. The study demonstrates the challenge of applying semi-automated techniques to highly variable, smallholder farming systems in Africa where field sizes are small, prior information is poor and where boundaries are unclear. This study is a first attempt to develop a large “high quality” dataset on field boundaries in Ethiopia using crowd-sourced methods. It is also a first attempt to compare the ability of two semi-automated methods for field boundary detection against an independent dataset.

ii) The project lead by Stanford University (PI Dr. David Lobell) on developing and testing procedures to map the location of maize fields and estimate their productivity in eastern Africa is now complete. This information is central to better understanding the current level of intensification in maize systems and the constraints to raising the system’s productivity. The approach leveraged newly available imagery from the European Space Agency’s Sentinel-1 and Sentinel-2 satellites, ground data on crop locations and yields, and a new simulation-based approach to estimating maize yields anywhere in the world. Results showed considerable success in mapping both where maize is growing and how productive it is. The results of this study indicate great promise for using new satellite data, in particular from the Sentinel constellations, to map smallholder agriculture in Eastern Africa. Continued investment was recommended to realize the full potential of applying these data to sustainable intensification in the region. Future work will focus on applying these datasets to understand drivers of maize productivity in the region.

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

iv) Two new projects have been identified for suba wards:

1. CIMMYT-Ethiopia is leading a study on spatial profitability of alternative production strategies in maize-based smallholder farming systems in sub-Saharan Africa;
2. GFC will analyze different properties (N, P, K, pH, SOM, CEC) of 2000 soil samples (1000 locations at two depths) to be collected across the crop-growing regions in Senegal. This datasets will be used to create a high-resolution map of the key soil properties in Senegal.

v) GFC supported two Cambodian research groups' application for grants under the Partnerships for Enhanced Engagement in Research (PEER) Program of the USAID. Both applications were recently selected. The research project led by Dr. Sok Serey from Royal University of Phnom Penh focuses on assessing impacts of climate change on rice yield leading to food insecurity in Cambodia. The research project led by Dr. Sanara Hor from Royal University of Agriculture focuses on developing remote-sensing based tools to create nationwide cropland database to support sustainable intensification and land resource management in Cambodia.

vi) GFC partnered with the CGIAR to organize series of events at the Free and Open Source Software for Geospatial Research Conference, (FOSS4G) 2018, in Dar es Salaam (27-31 August 2018). <http://2018.foss4g.org>

GFC conducted a daylong workshop on spatial data handling with R with more than 70 participants on August 28. We also organized a workshop on 'Open spatial data and software for Sustainable Intensification of Agriculture in Africa' which included more than 25 presentations on the following broad topics: i) free and open source software and data for agricultural development, ii) FOSS4G tools for natural resource and livestock resource management, understanding spatial variation in market access and prices, and soil and nutrient management, iii) Remote sensing applications in agriculture. The complete list of presentations can be found: <https://foss4g4ag2018.sched.com/>. This event was a result of the ongoing partnership and collaboration between CGIAR Institutes and SIIL.

vii) In a recent blog post, we highlighted the importance of dense weather station networks for agricultural applications GFC has been working on, with in-country partners, to install weather stations. (<https://blogs.k-state.edu/siil/2017/11/20/worldclim2/>) During this reporting period, we have supported purchase of 2 stations in Senegal (managed by LNPRV/CNRA, in addition to existing 5 stations managed by ISRA/CNRA), 2 stations in Burkina Faso (managed by ASMC), and 3 stations in Tanzania (managed by CIMMYT). GFC also supported installation of 5 weather stations in Cambodia (managed by CE SAIN and RUA).

viii) In at least two occasions, multiple GFC sub-awardees have collaborated on their research projects. In Cambodia, working with Dr. van Wijk and Dr. Hammond from ILRI, Dr. Sanara and his team in RUA have implemented RHoMIS framework for the household survey with mobile devices. In Senegal, Dr. Aliou Faye and Dr. Laure Tall have agreed to share the equipment purchased for their projects.

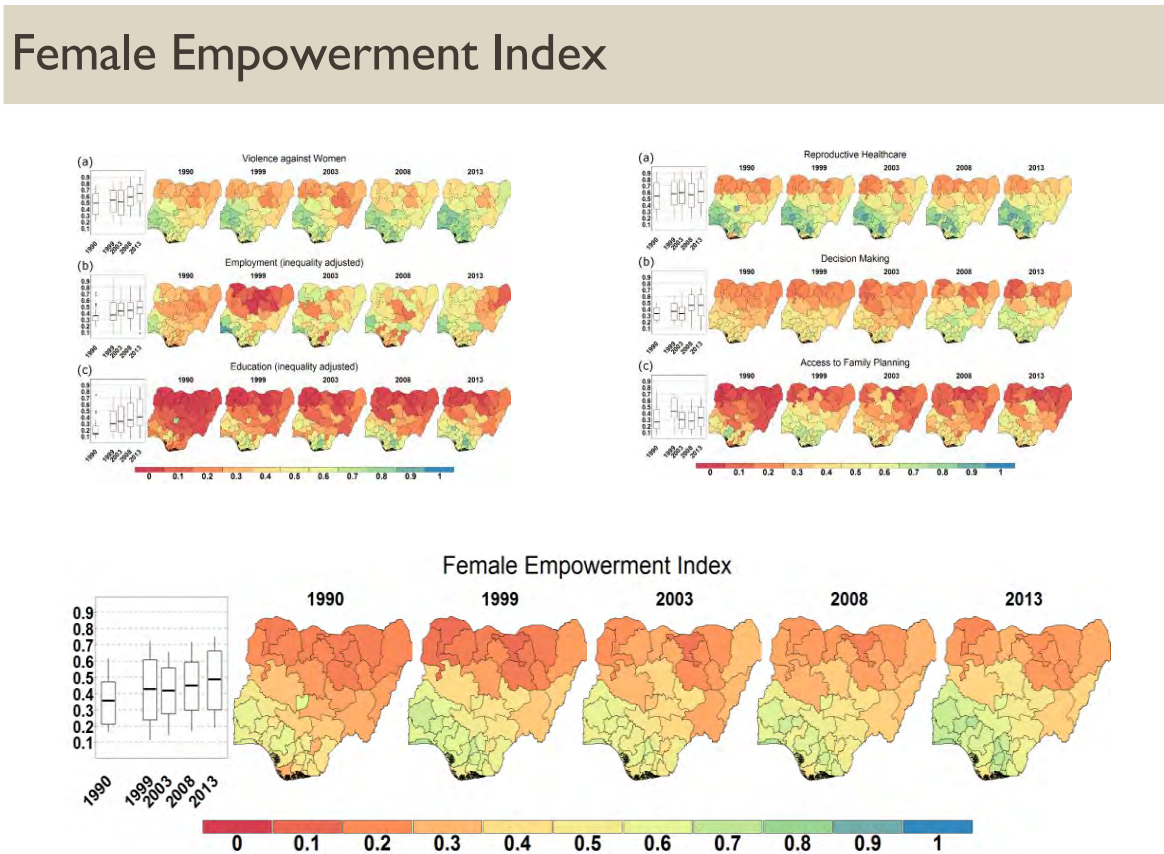
ix) GFC recently started a collaboration with USAID Feed the Future Innovation Lab for Assets and Market Access to develop high-quality spatial database (map) of maize fields, as well as for time series of relevant indices such as NDVI that can be used to estimate yield. This project is supporting ongoing research on maize insurance contracts in Tanzania."

The lessons learned reported in the 2018 GFC report with a link provided in Annex 10.

GFC Gender and Youth Outputs

Gender factors are beginning to be integrated. For example, GFC has applied detailed survey data on gender conditions, from violence to empowerment, for women across Nigeria from 1990 to 2013. They compiled data into geospatial distributions across the country (see GFC 3.2.1) to demonstrate the potential for identifying trends in gender equity in order to shape strategy and policy. GFC also appreciates the need and opportunities to involve young adults in this powerful and exciting scientific development and its application, as geospatial science will impact future SI development. While this study is not widely scalable (Nigeria has much more data over a much longer period of time compared with most SIIL target countries) but it demonstrates the kind of GeoSpatial analysis that can be applied to social data.

Figure GFC 3.2.1 Geospatial analysis of gender empowerment over time in Nigeria



Additional evaluation criteria for ASMC Appraisal

The ET's appraisal of important criteria concerning merit and potential impact are highlighted below:

Relevance to national and regional needs — Without question, well-designed research and partnership development toward expansion of appropriate mechanization is fundamental to SI and SIIL's potential impact in line with national development goals. The initial work of three years in four counties is especially strong in partnership development, with the exception of SIIL still needing stronger linkages to Ministries of Agriculture.

Research effectiveness on cropping systems agronomy & improvement — The outputs of the ASMC will soon be significant core components of SIIL's current county-level Hubs. This is beginning to happen now, following two years of pre-development needs identification and testing under local conditions. However, broadening of focus on non-animal traction mechanization is critical in Africa's key maize-based and root crop-based cropping systems. No current attention is on reduced tillage in vital maize/legume systems for Africa and Asia.

Overall effects on systems-level sustainability, productivity and resilience — ASMC's contributions to soil health (reduced tillage innovations), water and pest management (including weed control) and to resilience are all potentially very significant. Soil organic matter increased from reduced tillage, combined with continual ground cover plus water use efficiency, will contribute to increased cropping intensity, reliable productivity and improved resilience, in the face of climate and market stresses. Widespread productivity, environmental and economic benefits will emerge where CA-systems adoption is scaled up. This should be more evident in 2020 when field programs are more mature and farmers are adopting selected innovations.

Goodness of fit for US Universities' value propositions vs. the CGIAR and/or NGOs — While most US universities no longer have major research for development capacity with respect to smallholder mechanization, clearly, the University of Illinois has stepped directly into this lacuna. However, the some appropriate manpower experience, especially with CA mechanization experience, exists in selected developing countries, such as: Brazil, Bangladesh, India, China, and the ASMC has linkages with some of these. As a Consortium, it would behoove ASMC to broaden these partnerships and capitalize on promising innovations from Asia and Brazil, with relevance to Africa, where both public investments and involvement of the private sector has been limited.

Impacts of ASMC on social equity and animal and human nutrition — The attention of the Consortium to needs and opportunities for rural women is impressive. Tool designs take needs of women into major consideration, as do training programs in tool use. Any impact on human nutrition will likely be primarily derived from increased availability of nutritious low-cost food from increased diversification (occasionally supplemented by biofortified varieties, e.g., Zn levels of new rice in Bangladesh). Livestock nutrition, on the other hand, will likely be improved by the increase in biomass production through crop/pasture rotations, selected and managed to optimize soil protection and grazing capacities and better management of the feed resource base generally to reduce unnecessary wastage. The partnership with ILRI, primarily for promotion of "fodder choppers (FCs)," is noteworthy. Crop residues (especially sorghum and millet stalks and groundnut haulms) when chopped and mixed, provide a more nutritious animal feed ingredient. This is not, however, a research topic, as FCs have been known and used for years in many places. Their use does make good sense as a component of the SI systems applications of SIIL,

especially, but not exclusively, where livestock are used for power, and their strength at the onset of land preparation and planting is so critical. However, the incorporation of multi-purpose cover crops into staple crops (rice or maize) production systems, such as in Cambodia, requires research.

Effectiveness for water optimization (irrigation, water harvesting, green & blue) — ASMC correctly has a research/demonstration component on water management with emphasis on solar pumps, axial flow pumps, lay-flat plastic piping, drip systems, etc. This makes sense, on one hand, as this bundle of technologies is critical for systems enhancement for SI in the Hubs. On the other hand, in terms of research in this domain, the Lab for appropriate Innovation Laboratory on Small Scale Irrigation (ILSSI), hosted at Texas A&M, focuses on similar innovation options. **When practical, the ASMC should partner with ILSSI at the country level.** The ET is mindful that opportunities for country-level convergence are sometimes limited, as USAID has other prioritizations for country engagements by labs.

*Getting all relevant labs to work in, **an integrated fashion**, in the same Hub space at the same time, is an important challenge, but often critical to optimizing impact on nutrition and livelihood goals.*

Effectiveness of social capital activities (FFS, IPs, community/farmer groups) — ASMC has been effective in identifying and fostering farmer- and blacksmith- groups to participate in the technology tuning to meet local conditions of the Hubs. It has also build alliances with NGOs, such as Tillers International, and with co-funders for planters, such as the National Research Funds for Development (FONRID). Gender training was often a cooperative effort involving faculty and students of universities such, as Nazi Boni, where creative applications of adult education methods, such as from Integrating Gender and Nutrition within Agriculture Extension Services (INGENAES), were incorporated in training-of-trainers.

Appropriateness of current research design and engagement in foresight — Overall the process of engaging local stakeholders in the choice to constraints and opportunities served ASMC well. However, there is evidence that suggests the bottom-up design inputs would best be combined with information and knowledge from outside the specific hubs. For example, while enhancement of animal traction is very relevant in the “cotton triangle” zone of the Guinea Savannah biome of West Africa, e.g., in South-western Burkina Faso. Animal traction will be less relevant in most of Africa, and there are important needs, at the same time, to investigate the merits of broader use of the single axle tractor power for the innovative reduced tillage farming systems and smallholder-based irrigation under test and promotion. In much of the high potential savannah zones in Africa, managing grazing in the dry season is a challenge, due to customary open grazing after crop harvest. Land is overgrazed and barren. Research into use of living fence and solar electric fence will be needed to manage grazing, so enough soil cover can be maintained for critical mulching. Then too, the choice of innovations for ASMC to explore is also strongly influenced by SI farming systems that, in the near future, are expected to provide improved livelihoods, especially for women and also youth. For example, in zones where no-till maize and soybean are replacing sorghum- or cassava-based systems, the needed implements and capacity building requirements for this future probability should be considered now.

A number of mechanization implements developed for smallholders in Africa can be found in South Asia, Brazil and China. A serious stocktaking of these opportunities for each farming system should be explored.

7.4 SIIL Country Synthesis for Bangladesh

SIIL evaluation supporting matrix: Unlocking the production potential of “polder communities” in coastal Bangladesh (PI: Krishna Jagadish, Kansas State University; and Sudhir Yadav, IRRI; high yielding and stress tolerant rice varieties, improve productivity of rice and fish cultivation, and introduce high value rabi crops.

(please see composite matrix Annex for scores)

SIIL evaluation supporting matrix

Overarching Central SI Themes		
Relevance to National and Regional (Asian) Needs		- Coastal zone is a high priority area for Bangladesh government¹ for sustaining food security, with the northern parts having little flexibility for further increase in cropping intensity and production. - The government of Bangladesh suggested IRRI to focus on unlocking the production potential of polders as part of Govt of Bangladesh-IRRI work plan². - Some of the findings from the SIIL polder project have been extended to the Delta regions of B'desh, Myanmar, Vietnam, Indonesia etc., which are characterized by a similar tidal environment and challenges. Recently the project shared the learning of community Rice+Fish system with Myanmar³.
Relevance to SIIL		- The project has focus on key areas of Innovation Lab including improving the system resilience with a framework on system level intervention including technological options, enabling environment, change agents, policy engagement and capacity building. - For farming system designing, the project emphasized on understanding the trade-off with productivity gain, engaging and empowering women and youth and capacity building of stakeholders including next generation scientists, reforming the cropping system by exploring and devising strategies to be able to have year round cropping utilizing available water resources, enhance the nutritional intake of the community through diversified dry season crops including increased pulse production and different breeds of fish in the Rice+Fish system

Research effectiveness on Crop systems agronomy & Improvement	Research on System designing including planting time, choice of crops, choice of varieties, planting methods, fertilizer management, water management, harvesting and grain storage methods, best practices of rice-based farming including fish for higher productivity, nutrition, and income: • The rice equivalent yield (REY) of the traditional rice-sunflower pattern (4313 kg/ha/yr) was higher than that of traditional rice-sesame (2593 kg/ha/yr) and the rice equivalent yield of HYV rice-sunflower pattern (6762 kg/ha/yr) was 160% higher than traditional rice-sesame (farmers' practice)¹ • Results of choice experiment of different crops indicated high preference for sunflower and maize over the traditional sesame² • The mean yield of the HYVs (BRRI dhan 52 and BRRI dhan 72) (3.0-7.4 t/ha) was ~2.1 t/ha higher than the traditional varieties. The mean yield of climate-resilient HYVs ranged from 3.0 to 7.4 t/ha, and the yield of the nutritious HYVs ranged from 3.3 to 5.9 t/ha. The yield of the traditional rice varieties ranged from 1.1 to 4.4 t/ha³ • Sunflower variety Hysun 33 and 36 gave similar yield (0.8-1.2 t/ha) under different tillage practices including dibbling, strip and conventional tillage⁴ • The time required to transplant rice by machine varied from 13 to 22 hr/ha (with an average of 16.6 hr/ha), and for manual transplanting, it varied from 123 to 191 hr/ha³. • 50% of the dose of recommended fertilizer can give a similar yield for HYV in the polders and hence minimizes negative trade-offs⁵. For submergence tolerant variety N-use efficiency (kg of grain/kg of N) was increased by 186% with 50% N application than conventional rate (61 kg of grain/kg of N) • The net income of the top 10 percentile farmers from traditional rice, HYV rice and sunflower was Tk. 56744, Tk. 68880 and Tk. 25000 per ha, respectively¹. • Two women from Fultala (Madhuri Mollik) and Hetalbunia (Shipra Biswas) villages borrowed the reaper from the SIIL-Polder project and harvested 3.14 ha rice in aman season 2017 and 17.52 ha in boro season 2017-18, earning 27000 and 5600 taka⁶
Overall effect on systems resilience	The high risks to agricultural production in the coastal zone includes excess water in the wet season, salinity and terminal storm in the dry season • The project has analyzed 36 years (1970-2016) of past weather data to understand the climatic variability and design the system to improve resilience¹. • The major reason for the current precarious scenario of the polder communities is over reliant on single traditional rice crop but with SIIL intervention introduction of

		climate resilient HYV of rice has allowed to adapt to risk of flooding in <i>aman</i> season and identify opportunities to accommodate rabi crops. - The traditional practice of growing sesame in dry season which often failed due to terminal rainfall has been supplemented with other rabi season crop options including pulses (mungbean), maize and sunflower which aims at overall system resilience by supporting human economic condition, fodder for livestock and year-long nutrition for the farming communities². - Along with technical interventions, the project has also worked on institutional aspects and capacity building to improve the resilience. The project is working closely with BWDB and DAE to introduce the lesson learned from different water governance model and extension model. DAE has highlighted their learnings to use WMG platform for extension service. BWDB Director General and DAE's Additional Director are part of SIIL-Polder advisory committee and leverage the learnings to and from SIIL-project³. - Achieving early harvest of HYVs and introduction of short duration maize and sunflower, with earlier rabi planting allowed farmers to harvest rabi crops in 2018, while in the past four years even the routinely planted sesame (late planting due to long duration traditional rice during aman season) was completely destroyed due to late season storms. The cropping system ie HYVs-early planting of short duration maize/sunflower in rabi provides system resilience to storms and cyclones predicted to increase in the future due to climate change									
Overall effect on systems productivity		Studies and demonstration of the different farming systems¹ including - Traditional/HYV rice followed by Maize - Traditional/HYV rice followed by Sunflower - Traditional/HYV rice followed by Sesame - Traditional/HYV rice followed by Mungbean - Traditional Rice+Fish System - HYV Rice+Fish System <table border="1"> <thead> <tr> <th>Cropping system</th><th>Productivity (t/ha/yr) in rice yield equivalents</th><th>Profitability (USD/ha/yr)</th></tr> </thead> <tbody> <tr> <td>HYV rice-Maize</td><td>14.6</td><td>2866</td></tr> <tr> <td>HYV rice-Sunflower</td><td>9.0</td><td>1164</td></tr> </tbody> </table>	Cropping system	Productivity (t/ha/yr) in rice yield equivalents	Profitability (USD/ha/yr)	HYV rice-Maize	14.6	2866	HYV rice-Sunflower	9.0	1164
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HYV rice-Sunflower	9.0	1164									

		HYV rice-Mungbean	5.9	979
		Traditional rice-Sesame (Farmer practice)	2.6	346
		- Among different systems, the productivity and profitability gain was significantly higher with HYV rice followed by Maize and is a system that is high on our list for up and out scaling as we look to other adjoining polders - With Rice+Fish system the participating farmers were able to sell fish worth Tk 23370 and consumed 120 kg in 21 household in 2016-17 while in the second year they consumed 333 kg in 44 household (moving towards a more balanced protein- carbohydrate diet)²		
Number and quality of journal and other publications		<u>Published Journal papers</u> - Bhattacharya et al. (2018) The feasibility of high yielding aus-aman-rabi cropping systems in the polders of the low salinity coastal zone of Bangladesh. Field Crops Research (Accepted) - Shew and Ghosh (2017) Using multi-temporal remote sensing data to analyze the spatio-temporal patterns of dry season rice production in Bangladesh. Remote Sensing and Spatial Information Sciences, Volume IV-4/W2*. <u>Strategic communication</u> - Five volumes of polder tidings newsletter (35 articles), - Mondal and Yadav, 2018. The food-water-energy nexus: Using gravity drainage to intensify production systems in the coastal zone of Bangladesh. Rice Today. International Rice Research Institute, Los Baños, Philippines, pp. 28-29. <u>Conference proceedings/abstracts</u>= 12 <u>Manuscripts in pipeline</u> - Sudhir-Yadav et al. Making inroads to intensify agricultural system productivity in the polders of the coastal zone of Bangladesh. Ready to be submitted to "Water resources." - Mondal et al. Is gravity drainage viable option for sustainable cropping intensification in polders of the coastal zone of Bangladesh? Target Journal: Water Resources. Submission timeline: By December 2018 - Ali et al. What agriculture means to youth- a case study from coastal zone of Bangladesh. Target Journal: Agriculture and Human Values. Submission Timeline: March, 2019		

		• Yadav et al., Learning hub model - an effective and pragmatic route to disseminating system level technological innovations to the farming communities in coastal zone of Bangladesh. Target Journal: Organizational dynamics and timeline: June, 2019 • Saha et al. Trade-off analysis for system intensification in polders. Target journal: Field Crops Journal. Submission timeline: By April 2019 • Roy et al. Market response to improved rice varieties in the coastal Bangladesh. Target Journal: Agricultural System, Submission target: April, 2019. • Nath et al. Water governance assessment to improve the system production potential in polders. Target Journal: Water resources. Submission Timeline: July, 2019 • Aktar, N (2018) Gender and socio-cultural dimensions affecting adoption of improved agricultural technologies in coastal Bangladesh. Target Journal: Climate and development; Submission target: July, 2019
Goodness of fit for US Universities' value propositions vs NGOs		• Kansas State University brings a huge amount of experience in formal mentoring approaches, skills to develop the next generation of local students, incorporate the mindset of free thinking among students and professors, and encourage ideas which are out of the box, emphasize on the need for interdisciplinary system-based research to deal with complex problems such as those faced in the polders. • On the other hand, projects such as ours funded by SIIL makes it possible to provide opportunities to introduce US students to the complex challenges in international agriculture and to be able to train/mentor more students from these universities to take on international agri as their careers. For example, a joint PhD student Aaron Shew from KSU and University of Arkansas had his entire dissertation on coastal polders and is now selected as the INAUGURAL HOLDER OF R.E. LEE WILSON CHAIR OF AGRICULTURAL BUSINESS at Arkansas State University, https://www.astate.edu/news/shew-is-inaugural-holder-of-r-e-lee-wilson-chair-of-agricultural-business • In addition, specifically related to the SIIL polder project, KSU brings in expertise on the crop-climate modelling which would allow ascertaining the sustainability of the proposed productive cropping systems into the future. HYV rice + Maize coming out as a winner in the different systems we have tested would allow KSU faculty to contribute extensively on system-level best management practices which are not a strength of commodity specific centers.

Data quality, analysis and open access sharing	- Standard protocol for all research studies - Raw data including questionnaire uploaded on dataverse Examples: The baseline data of 1025 household has been shared using dataverse (https://doi.org/10.7910/DVN/H82HES). Other than project team, we have already received 5 requests for this dataset (see snapshot). The data has been successfully used by Dr. Patrick Kilby, a Fullbright scholar working with SILL and Aaron Shew, Uni of Arkansas as part of his PhD thesis. The data will also be shared with the public by end of this year. We are also sharing the raw data of all research scholars on dataverse soon after submission of their thesis e.g. - Bhattacharya, Jayanta, 2018, "Raw data-PhD research" https://doi.org/10.7910/DVN/KN56TV - Saha, Nibir, 2018, "Raw data Ph.D. research" https://doi.org/10.7910/DVN/3QNYXH, - Shakhawat H, 2016,"Raw data MS research" https://doi.org/10.7910/DVN/ZIKOOA
Impacts on human nutrition (quantity, quality, safety)	The project has worked out theory of change to improve human nutrition. The focus has been - Understanding the food consumption pattern of polder community, to identify the peak and lean phases of food availability - Awareness and training of polder community to reduce malnutrition - Nutrition productivity as part of system design, through different rabi crops such as mungbean, sunflower and maize MS research studies on Human nutrition (quantity) was conducted with 156 households¹. The project has provided training to 287 primary school teachers, mothers of school kids and other household members on importance of Zn and protein in the diet². Introduction of sunflower and maize in the learning hubs received a positive response with sunflower oil used for household consumption³, At the community level the rice + fish was partially successful (social differences) and the different varieties of fish introduced allowed improved diet in participating farming households⁴. Introduction of maize brought opportunities to improve feeding of livestock and poultry⁵
Livelihoods impact (current and expected) from scaling	The project has used "farm-business concept" to explore new opportunities of income for women and youth. - Women are engaged in service provision of mechanical harvesting using reaper. One service provider was able to earn ~27000 tk in boro season and used 23% of the income for educating her children ^{1,2} - Community seed bank model provided additional income opportunities to the distressed women member of WMG³

		Women explored opportunities for additional income generation by engaging in mat nursery for machine transplanting⁴ Youth are involved in service provision of machine transplanter and seed drill.⁴ Significant area of land which used to remain fallow has slowly started to come under double cropping bringing about a system change and some of the key aspects have huge potential for scaling such as - nutritious and climate resilient rice, early duration maize and sunflower for dry season, reaper for timely harvest of rice to get the dry season crop in the ground - are high on the scaling side of things and put together have the potential for having a sustainable impact on improving the system productivity and livelihoods of the rural farming households of the coastal zone The diversified system is opening the opportunities of agribusiness for women and youth to engage at different entry points along the value chain. The incorporation of maize into the production system is opening up opportunities for new small-scale entrepreneurship through poultry												
Effectiveness of SI application		We have assessed different system design options for trade-offs using sustainable intensification assessment framework. We have analyzed productivity, profitability, spatial variability, environmental indicators and social cohesion¹. <table border="1"> <thead> <tr> <th>Cropping system</th><th>Productivity (t/ha/yr) in rice yield equivalents</th><th>Profitability (USD/ha/yr)</th></tr> </thead> <tbody> <tr> <td>HYV rice-Maize²</td><td>14.6</td><td>2866</td></tr> <tr> <td>HYV rice-Sunflower</td><td>9.0</td><td>1164</td></tr> <tr> <td>Trad rice-Sesame (Farmer practice)</td><td>2.6</td><td>346</td></tr> </tbody> </table>	Cropping system	Productivity (t/ha/yr) in rice yield equivalents	Profitability (USD/ha/yr)	HYV rice-Maize ²	14.6	2866	HYV rice-Sunflower	9.0	1164	Trad rice-Sesame (Farmer practice)	2.6	346
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Overall effectiveness of systems research /linkages		Right from the get-go, our approach has targeted whole system-based approach involving farming community, NARES, NGOs, local leaders, local water management bodies, other government agencies, and private companies to be able to make a change at the system level. In addition, through the knowledge sharing platform, we have developed strong linkages with the local and national government organizations including BARC, BINA, BRRI, BARI, DAE, BWDB, etc.												

		There is knowledge spillover to other research and development initiatives. The Blue-Gold project funded by the Dutch Government has worked closely with the SIIL project team towards making a quantifiable change in the polders. They have acknowledged the learnings on community-led approach for water management from the SIIL project team in one of the articles published in Polder Tidings Vol 2 (1). They are using these learning on crop and water management to outscale it in 20 polders
Farming systems characterization and design		Large baseline survey with 1020 households in two polders for household profiling, Farm income and livelihood, current production systems, off-farm income source, farmers' perceptions on different technologies, Food security, Gender, water governance, migration, assets have been collected to help characterize and design our approaches1 PhD research on intra-household decision making dynamics2 PhD research on understanding the role of community in water governance3 Understanding role of different stakeholder and value chain for marketing of rice and rabi crops4 Farming system design including rice+fish, rice+maize, rice+sunflower5
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ..)		• We have introduced the Learning Hub (LH) model to engage and leverage the learnings from and to the community. These LHs provide opportunities for 4 dimensional learnings including engagement of farmers/community, development partners, private sectors and scholars¹. • Engagement with DAE to consider Learning hubs model which are based on WMGs for training and upscaling² • Significant emphasis on community-led approach for a system approach³ using existing social cohesion units (water management groups-WMGs) - Synchronizing planting time within a command area - Rice+Fish system - Water management - Community seed bank
Technology Development		
Research effectiveness on crop systems agronomy & Improvement		Research and technology development was focused on improving year-round system productivity utilizing available land and water resources in the polder ecosystems including planting time, choice of crops, choice of varieties, planting methods, fertilizer management, water management, best practices of rice-based farming including fish for higher productivity, nutrition, and income. The following technologies were developed

		- Developed two improved cropping patterns (HYV rice-maize and HYV rice-sunflower) having 2-3 times higher productivity and profitable than the existing cropping pattern (traditional rice-sesame) ¹. - The yield can be increased by optimizing planting time for both HYV and traditional rice (by the first week of August), Maize (by last week of Jan) ^{2, 3} - The mean yield of the HYVs (BRR dhan 52 and BRR dhan 72) (3.0-7.4 t/ha) was ~2.1 t/ha higher than the traditional varieties. The mean yield of climate-resilient HYVs ranged from 3.0 to 7.4 t/ha, and the yield of the nutritious HYVs ranged from 3.3 to 5.9 t/ha. The yield of the traditional rice varieties ranged from 1.1 to 4.4 t/ha ⁴ - The time required to transplant rice by machine varied from 13 to 22 hr/ha (with an average of 16.6 hr/ha), and for manual transplanting, it varied from 123 to 191 hr/ha ⁴.
Effectiveness for soil health		Studies on different tillage methods, inclusion of mulch, and salinity dynamics - Temporal and spatial soil salinity assessment - Sunflower variety Hysun 33 and 36 gave similar yield (0.8-1.2 t/ha) under different tillage practices including dibbling, strip and conventional tillage ¹ - Maize yield was highest under conventional as the tilled soil worked as mulch and avoided soil cracking ¹
Effectiveness for plant nutrient-optimization		Plant nutrient optimization for rice under tidal river water management 50% of the recommended dose of recommended fertilizer can give a similar yield for HYV in the polders and hence minimizes negative trade-offs ¹. For submergence tolerant variety N-use efficiency (kg of grain/kg of N) was increased by 186% with 50% N application than conventional rate (61 kg of grain/kg of N)
Effectiveness for water optimization (irrigation, waterharvesting, green & blue)		Improved water governance model on managing tidal water both for irrigation and drainage, micro drainage within catchment area where double cropping of improved rice and rabi season crops can be made feasible and sustainable ¹
Research effectiveness on farming systems integration— crop/livestock-trees-fish etc.		Significant focus on the farming systems integration including; - Rice+Fish system where the farmers were able to sell fish worth Tk 23370 and consumed 120 kg in 21 household in 2016-17 while in the second year they consumed 333 kg in 44 households ¹ - Although not a direct objective of the SIIL polder project but the success achieved with the dry season maize has provided a route for fodder during the really challenging dry season for the livestock in the polders

		and is also helping support a budding poultry enterprise) ²
Capacity Building & Scaling		
Quality of Scaling concepts and design		• Highly integrated approach having all the related government agencies on our Knowledge Sharing Platform¹ including NARES, major NGOs, international organizations, development partners and Private companies, allows for an excellent platform for up and out scaling of effective technologies. In addition, our presence over the years has allowed us to look for additional partners for effective scaling and will be accommodated into our planning for Phase II. • The learning hub approach is an effective approach to out scale the technologies² • Non-binding agreement with four local universities to research for innovation and catalyzing the technologies in polders and for developing next generation of scientists with inter and trans disciplinary research training • 13 MS and PhD scholars are engaged with the project and out of them four are already started to serve their country after finishing their degree program³.
Effectiveness of scaling and dissemination activities		Hands-on training (reaper for harvesting, mechanical transplanting, mat seed-bed nursery preparation, community fingerlings rearing) and participatory demos (varietal trials, sunflower and maize comparison to sesame in rabi), nutritional awareness which involved TARGET groups such as high school teachers and mothers of school children; a good mix of male, female and youth were involved in our training and dissemination activities. So far directly reached 4048 men and women (47% women) on the above topics. <u>Effectiveness</u> • Three women are now providing mechanical harvesting service in the polder. One of them was able to earn ~27000 tk in the last dry season 2017-18¹ • Along with technical interventions, the project has also worked on institutional capacity building to improve the resilience. The project is working closely with BWDB and DAE to introduce the lesson learned from different water governance model and extension model. DAE has highlighted their learnings to use WMG platform for extension service². • The training/knowledge shared with Dutch Govt funded Blue Gold program resulted in out scaling of production system design consideration (including diversification) in 20 polders

Effectiveness Formal Training (degree or certificate)	8-9	- We have had tremendous success in recruiting some of the best talent among the local educational institutes by advertising scholarships formally through IRRI SIIL adaptive research scholarships through which we have 9 MS and 5 Ph.D. participating in the project and working across a range of disciplines such as social sciences, market analysis, agronomy, water management, gender, and nutrition; 3 students participated in the international nutrition conference in Cambodia, and 6 students awarded travel grant to present their work at the International Rice Congress in Singapore this month. - Faculty from KSU and IRRI along with the local institute professors designed the thesis objectives of the students, and at least one of the faculty/scientist from the SIIL polder project was a part of the advisory committee member for the students
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)		- Major tie-up with BRAC¹, world largest NGO where in their staff are the core people operating the activities on the ground for SIIL polder project, they are extensively trained and have demonstrated the potential to take on different roles and responsibilities within the project, a local resource available for Phase II and beyond; - Through learning hubs approach, farmers are engaged in different training programs to build their skills for improving system productivity. - DAE and BWDB are the key government bodies with the responsibility of extension and water management, and the project has worked very closely with them to build the awareness and capacity on appropriate water management for making it possible to have double cropping in the moderate saline regions of the polders. One BWDB senior engineer is working with the project (as a PhD scholar) to gain knowledge on food provisioning and water management. - Using the approach of engaging school teachers and mothers (287) of school kids, the project is providing training on nutrition. - Hands-on trainings and travelling seminar to create awareness on system level sustainable solutions for polders among local and regional stakeholders - Engaging local government institution (8) and water management units (43) in training for improved water management².
Stakeholder Engagement		
Internal partners engagement, including USG		Knowledge sharing platform - local partners, institutes and also other projects and programs operating in the region engaged;

Effectiveness of policy engagement (local and national)	The SIIL-Polder project has engaged in policy dialogue at different level - Ministry level¹: Dialogues with Ministry of Agriculture for priority area of research and development in the country ¹ Dr. Yadav presentation about the SIIL polder project progress and future plan to improve the system productivity of the polders during the Ministry of Agriculture visit to IRRI, Philippines, was well received and played a role in the development of the 2018-22 work plan which has a focus on the coastal zone. - Middle level²: Establishment of "Knowledge Sharing Platform" for engagement with Heads of NARES, development partners including USIAD, ACIAR, Dutch Govt, ADB, CGIAR centers, NGOs for leveraging knowledge, system level designing and developing framework to achieve impact. - Local level: The SIIL-Polder advisory board³ is represented by the heads of the key govt and policy making bodies including director general of BWDB, Additional Director of DAE, Director, IWM; Director, BRAC and member director BARC. *For polders, DAE has recognized to consider water management group (instead of Farmer Field School) as more appropriate model to provide training. **The WMG has started to synchronized sluice gate operation to support to cropping system design at landscape scale
Effectiveness of youth activities	- Detailed understanding on youth perception and desire to participation in agriculture¹ Engaged male and female youth in service provision including mechanical transplanting (transplanter), harvesting of rice (reaper), and sowing the seeds of rabi crops by power tiller operated seeders (PTOS) for alternating income generation and to attract them in agriculture. - Three youth engaged in service provision for mechanical harvesting of rice (see next section in details)^{2,3}
Effectiveness of gender activities	The project has used different entry points to engage with women in context of system design, improving resilience and livelihood, - Research studies on gender time-use pattern indicated high degree of work-load on women especially for household which so often is not considered as “work” in the society.¹ - Understanding intra-household decision negotiation to design the farming system²

		• Young women were trained and engaged in mat nursery preparation required for machine transplanting of rice, harvesting paddy by reaper, seed storage in cocoon. Women are engaged in service provision of mechanical harvesting using reaper. One service provider was able to earn ~27000 tk in boro season and mainly (23%) used the income for educating her children ^{3,4} A distressed women in the society was able to earn Tk 1852 for coordination and maintenance work of community seed storage mode⁵ • Awareness training for mothers of elementary school students and women school teachers on nutritional awareness for improved household nutrition⁶
Agribusiness engagement (corporate and MSMEs)		• ACI Ltd has been involved in providing training to different stakeholder on mechanized operations (rice transplanter, reaper, seed sowing of dry season crops by PTOS)¹. • Brainstorming with local traders to start contract farming for sunflower². • ACI Ltd, Metal and other private companies expressed their willingness to engage to assist women and youth male to be service providers in harvesting paddy by reaper, and sowing seeds of dry season crops by PTOS³. • Metal has been involved in providing training to different stakeholder on the operation and troubleshooting of axial flow pump. • The private companies are open for student internships as a means to develop small scale machines for the polders based on the market size, as discussed in the recently concluded Knowledge Sharing Platform³
Stakeholders engagement regional (public, banks, civil society)		• Engagement with Dutch embassy, ADB, USAID, ACIAR and KGF for investment in polders¹. • Engagement with WorldVeg, WorldFish, ICRISAT and CIMMYT for system design framework¹ • Interaction with different CG CRPs¹ • Strategic communication using Polder Tidings (reached to 200 stakeholders)
Stakeholders engagement national (public, banks, civil society)		• Engagement with key research and development agencies including DAE, BWDB, BRRI, BARI, IWM, BINA, BFRI for sharing research results in the Knowledge Sharing Platform. • The project has signed non-binding agreement with four local Universities for MS and PhD thesis focused on inter disciplinary adaptive research in the polders • Approached by the chairman of KGF for a commissioned proposal to support effective implementation of system

		level technology being developed by the SIIL polder project for the improvement of the polders. • Coordination and engagement with private companies including ACI, Metal Ltd. • Knowledge Sharing Platform; Advisory committee, Participating in regular meetings with key government agencies • Project webpage, Project Facebook page
Stakeholders engagement local (public and civil society)		• Engagement with Water management associations, LGIs, local trader for contract farming • Coordinated with farmer community to make a cooperative for Rice+Fish system
Linkages to Mechanization (non-ASMC projects)		The SIIL-Polder team has coordinated with ASMC on training and troubleshooting of machinery mainly- reaper and PTOS. Both project and consortia team has regularly attended meetings to leverage knowledge from these initiatives.
Linkages to Geospatial Consortium (for non-GeoSpatial projects)		The linkages with Geospatial Consortium has been mainly through our PhD student Aaron Shew who worked on crop suitability assessment for the dry season. There was no effect/involvement in the designing or implementation of the research activities of the polder project

7.5 SIIL Country Synthesis for Cambodia

SIIL evaluation supporting matrix WAgN Cambodia

Overarching Central SI Themes	I-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional (Asian) Needs	7	Government of Cambodia seeks to increase vegetable production nationally, in more environmentally friendly ways. WAgN addresses vegetable rice systems with an ecological approach, using Sustainable Intensification as a suite of practices to enhance agricultural systems, including soil health. This is relevant to the region as communities across similar latitudes and altitudes face similar constraints and challenges. MAFF has policy about increasing women's empowerment in agriculture. WAgN address women's empowerment, identifying and fostering enabling conditions and social networks for women to fully participate in the local, regional and value chains for horticulture and rice-based foods produced via SI. We work with multiple cooperatives to enhance women's' engagement. Regional needs of addressing gender inequality and also regional needs to sustainable intensify systems. Enhancing capacity of students and technicians. Enhancing capacity through the translation of materials into Khmer and distributing at workshops.
Relevance to SIIL	8	WAgN addresses the goals of SIIL by testing SI techniques, including research on best practices for: tomato grafting for the wet season, wild (or perennial) gardens and the marketability of underutilized species, as well as conservation agriculture across vegetable-rice systems. WAgN works with women farmers to improve nutrition by promoting women's participation in the value chains for horticultural crops and rice produced via sustainable intensification (SI) practices. WAgN directly addresses empowerment of women, a cross cutting focus of USAID programs, and of SIIL.

Research effectiveness on Crop systems agronomy & Improvement	6.5	CIRAD and CASC collaboration – we work with these partners to document soil health improvement via cover cropping following rice, and we support conservation and promotion of underutilized agronomic species. Conservation Agriculture for women- we continue the work of the HortIL on conservation agriculture by promoting SI of rice via integration of commercial vegetable home gardens. We work to diversify smallholder paddy rice using CA approach (no tillage, mulch, rotations); originated with Hort IL and SANREM (Dr. Manny Reyes). In partnership with Univ. of Battambang and ASMC (designing and testing ergonomic tools for women), we test numerous SI rice – vegetable – cover crop combinations and try to promote microenterprise development for women's groups.
Overall effect on systems resilience	7.5	WAgN support the increase in biodiversity which can increase resilience in the vegetable rice system. WAgN supports the increase use of underutilized spaces and species, also linked to increased resilience in the system.
Overall effect on systems productivity	6.5	Wild gardens (SI of the messy fringe) Cambodian homes and villages have underutilized land (fencerows, weedy patches, open areas, etc.). There exist opportunities to transition this land to achieve gains in household nutrition, market income, livestock fodder. It can be achieved at field, farm or landscape scale. The increased production of useful and valuable biomass in the system increases overall effectiveness of the system.
Number and quality of journal and other publications	5	This is difficult to assess, with a variety of partners and joint reports Recommendation. Report preliminary results of surveys and research in reports, briefs and papers.
Goodness of fit for US Universities' value propositions vs NGOs	7	WAgN is able to mobilize and leverage work from multiple partnerships including US universities and local universities. They are able to access expertise that NGOs cannot. So in that sense, it is useful for SIIL to work with and invest in US university engagement in Cambodia. However, some MOST? aspects of farmer engagement are more difficult for foreign researchers than for local NGO and civil society who are based permanently on the ground.

Data quality, analysis and open access sharing	6.5	Datasets have been gathered and are being submitted to Piestar and Dataverse for open access sharing. WAgN/ASMC dataset: Medium Quality. This dataset has lower quality data because of cleaning issues and survey instrument design. It could be improved by working with more households/villages across more provinces. Youth Migration Dataset: Good quality data, both quantitative and qualitative. Could be expanded to include more students and universities students in other cities. It could also be linked to Kampong Thom Technology park school and the youth there. Nutritional Analysis dataset: Good quality but could be more expansive across more species and elements/minerals. Wet/Dry market data: Good quality dataset to analyze the market demand of underutilized species. Could be improved by building on what has been done and replicating it in other markets across Cambodia. Soil Health Dataset: Good quality dataset. Could be replicated across more plots with more women farmers. Tomato grafting data: Good quality data. This experiment could be replicated across other soil types, moisture levels, and in other seasons. Wild Garden dataset: Good quality data. Could be improved by increasing the questions and number of households involved.
Impacts on human nutrition (quantity, quality, safety)	7	WAgN has been able to work with farmers in the vegetable-rice system. We have been able to increase production of vegetables with SI techniques. This increases the quantity and quality of food for household as well as increased income for households. High potential, needs to be documented
Livelihoods impact (current and expected) from scaling	6.5	WAgN has been able to increase the incomes of farmers involved in conservation ag across Siem Reap and Battambang, for vegetables and grain. As well as increased soil fertility for increased agricultural livelihoods. Recommendation. document

Effectiveness of SI application	6.5	The SI techniques trial/tested/demonstrated with WAgN have been shown to be effective in increasing livelihoods and women's empowerment. Recommendation. Document SIAF assessment
Overall effectiveness of systems research /linkages	6	We link across many projects and partners. They are not always helpful. But the synergy between groups is useful in leveraging results.
Farming systems characterization and design	6	WAgN supports the characterization of underutilized spaces and crops, the messy fringe. WAgN supports the design of conservation agriculture approaches
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ...)	6	WAgN supports Cooperative in SR Wild garden FFS planned
Technology Development	na	Grafting Wild gardens HOW? Cover cropping Conservation ag
Research effectiveness on crop systems agronomy & Improvement	6.5	Effective
Effectiveness for soil health	6	Soil health assessment?
Effectiveness for plant nutrient-optimization	na	
Effectiveness for water optimization (irrigation, waterharvesting, green & blue)	6	Conservation ag support drip irrigation but farmers often opt out with electric pumps.
Research effectiveness on farming systems integration—crop/livestock-trees-fish etc	7.5	WAgN focuses on integrating rice-vegetable farming systems with additional focus on perennial species including trees. RESULTS?
Capacity Building & Scaling	na	WAgN build capacity in local agricultural institutions, NGOs, and international universities and research institutes, to scale up and out innovations in gender and ecologically sensitive SI. Research dissemination via ECHO, workshops, training at CESAIN, lectures/training at universities. Capacity training of CESAIN WAgN supports conservation agriculture with a fee to scale up cover cropping technology with CIRAD.

Quality of Scaling concepts and design	6	The concepts of scaling are interesting but the quality cannot really be determined until we see if they are successful.
Effectiveness of scaling and dissemination activities	6.5	WAgN workshops, and trainings
Effectiveness Formal Training (degree or certificate)	8	Formal student training: Sovanneary Huot who is pursuing an MS and PhD in Rural Sociology at Penn State. Neary began her studies in Fall, 2017. She is keenly interested in gender dimensions of SI, as well as the nexus of agriculture and climate change. Effective education. Ry Saren (Ren) – B.S., University of Battambang Ngang Channaty – Master of Sustainable Agric. (MSA), University of Battambang Rechane Sel – M.S., Community Development, University of the Philippines Los Baños; SEARCA Soborn Meas – M.S., Int. Research and Development, Kasetsart University; SEARCA Sregnyet Lo – M.S., Community Development, University of Battambang Sarah Eissler- PhD. Rural Sociology, Penn State University.
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	7	Workshops and trainings can be effective means to address capacity building.
Stakeholder Engagement	6	Good stakeholder engagement.
Internal partners engagement, including USG	7	Links with other USAID projects
Effectiveness of policy engagement (local and national)	4	Project engages with policy makers.
Effectiveness of youth activities	7	Support to CESAIN work with youth, and students.
Effectiveness of gender activities	7	Quantitative survey data, and qualitative interview and focus group data to identify barriers for women in agriculture. But evidence of effectiveness needed.
Agribusiness engagement (corporate and MSMEs)	5	Conservation agriculture service with a fee.
Stakeholders engagement regional (public, banks, civil society)	6	NGOs

Stakeholders engagement national (public, banks, civil society)	7	National organizations
Stakeholders engagement local (public and civil society)	7.5	Local NGOs
Linkages to Mechanization (non-ASMC projects)	7	Links to ASMC, sharing data, sharing farmers.
Linkages to Geospatial Consortium (for non-GeoSpatial projects)	5	But potential exists, and a request has been made.

**SIIL evaluation supporting matrix
CE SAIN Cambodia**

Overarching Central SI Themes	I-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional (Asian) Needs	8	Excellent <u>national alignment</u> with current (a) national 'rectangular' strategy on <u>growth, employment, efficiency and equity</u>, (b) national strategy on <u>food security and nutrition</u> and (c) the <u>capacity building</u> pillar of the Ministry of Agriculture, Fisheries and Forestry MAFF strategic plan (one of four pillars). According to the Rector, the Lab is also well aligned to the strategic plan of the Royal University of Agriculture RUA strategic plan, especially the strengthening of teaching staff and transition to a research lab (and ultimately teaching-research-extension university, mimicking the land grant universities of the USA. Led by the RUA, the focus lies on 6-10 universities with agricultural departments including Battambang which is involved in the Lab. The country has also attracted a \$ 90 M World Bank loan for development of agricultural universities which will reinforce the CE SAIN outputs. Essentially, CE SAIN strongly buttresses Cambodia's agricultural transformation, from the natural resources poor extractive and degrading farming systems to the natural resources enhancing and agroecological friendly conservation agriculture based sustainable intensification and diversification farming systems for the future, to boost rural incomes and rural economies There is also wider <u>relevance to the Asia region</u>, both rice based lowland farming systems (especially CASI and diversification) and upland/hill farming systems (especially sustainable natural resource management). CESAIN is working with themes and technologies which are relevant to the both systems in many countries in the S E Asian and South Asian regions, including Bangladesh and Nepal. These systems have inadequate professional research, scaling and policy capacity to confront population pressure, massive degradation, weak market linkages and weak institutions and policy settings. There is a great opportunity to establish a center of excellence on conservation agriculture based sustainable intensification (CASI) in Cambodia to (a) train Cambodians and others in the region on CASI and (b) share knowledge on successful approaches to CASI.

Relevance to SIIL	8	CESAIN is fully relevant to SIIL (albeit with a capacity building focus) because it will create a CE that will foster private sector innovation, agricultural research, education and training, and public-sector capacity building through improved collaboration and knowledge sharing that is focused on improving food and nutritional security while enhancing quality of soil, water and biodiversity (progress is being made on all fronts). CE SAIN is also integrating the SI assessment framework (SIAF) mainly targeting smallholder and/or home garden farmers. Following CESAIN objectives (and bearing in mind that CESAIN is co-funded by the USAID Mission), CESAIN is tracking (the 'tracker database) and fostering links across of several USAID innovation labs (Hort, Livestock) and other projects.
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Research effectiveness on Crop systems agronomy & Improvement	7	CESAIN main function is capacity building, but in the process is demonstrating improved technologies in the Technology Parks and supporting some limited adaptive research. For example, screening for heat tolerance in tomatoes (Vara is a supervisor) and value-added processing of tomatoes. Agronomy research is conducted through the 8 Ph.D. and 8 M.S. scholarships, largely concentrated in RUA (some supplementary funds were identified for M Sc in UBB). Although many of these are at an early stage, the Mission noted adequate quality of the research designs, field work, analysis and presentation (several Ph Ds are supervised by US staff). Importantly, there are a set of faculty research grants as well as undergraduate internships which could not be appraised. These are largely disciplinary, and certainly build capacity, but CE SAIN and RUA have not so far articulated an overall SI research strategy to which these grants would contribute. CE SAIN does archive the results of research grants which will ultimately contribute to the effectiveness of the agronomy research. The five Technology Parts are conceived as extension/technology transfer rather than agronomy, horticulture or livestock research. They are referred to below. Complementary agronomy/forage field research has been supported from the final call by the Livestock Innovation Lab. These trials in two locations (one the Battambang UBB Technology Park) were relatively complex short-duration experiments, presumably for analysis in Kansas State University, It would be important for the results to be made available in Cambodia.
Overall effect on systems resilience	6.5	The modest CE SAIN research and demonstration efforts cover a wide spectrum of issues related to systems resilience and could ultimately have an effect on systems resilience when incorporated into broader knowledge of farming systems. Examples include demonstrating water efficiency of CA systems, soil carbon of CA systems, cover crops, etc. Recommendation. Policy briefs or other public documents on importance and contributions to resilience.

Overall effect on systems productivity	6.5	Contributing to the demonstration of productive technologies and systems in Tech Parks, and supporting some adaptive research.
Number and quality of journal and other publications	7.5	Seven good articles in 2018 (see list) and some earlier pubs and an edited book (John, let us discuss so I can clarify). A significant portion from Ph Ds.
Goodness of fit for US Universities' value propositions vs NGOs	8.5	Good fit in respect of education, research and extension, and teaching and lab hardware capacity building of the RUA and UBB.
Data quality, analysis and open access sharing	6	Limited data posted to Dataverse. Dissertation and thesis data pending. Recommendation: Accelerate the posting of data to Dataverse
Impacts on human nutrition (quantity, quality, safety)	6	Good potential from the impact, but limited documentation – despite improved nutrition being one of the targeted outcomes of Objective 1. The SIIL experience Recommendation: Policy briefs on agriculture and nutrition
Livelihoods impact (current and expected) from scaling	7	Contributing to the demonstration of livelihood technology systems in Tech Parks. Long term indirect impact through the ATP. Recommendation: establish integrated 'agriculture of a little bit of everything' demos in each of the ATP and monitor the economics.
Effectiveness of SI application	6.5	Demonstrates multiples of relevant technology an integrated SI system in the ATP and provides education and extension materials for smallholders.

Overall effectiveness of systems research /linkages	7.5	Good working linkages across a variety of organisations, including several innovation lab projects, non-innovation lab FtF projects (i.e. NOURISH, World Veggie home gardens, IRRI's seedling project), non-US government funded research agencies (i.e. CIRAD, ACIAR, Kyoto university), NGO's (i.e. Green Shoots, ADDA), private (i.e. ATEC, Swiss contact, ASA), and government (i.e. RUA, UBB, high school, MOEYS, and MAFF) on integrated research on conservation agriculture for sustainable intensification. On-going establishment of an 'integrated agriculture of a little bit of everything' In farm household sites although ATPs promote multiple disciplinary technologies. However, limited measurement and data to prove effectiveness of systems research; and no attention to systems research and development in RUA curriculum development (see recommendation below).
Farming systems characterization and design	6	No documented SIIL farming systems characterization, although there could be some relevant farming systems characterization from the previous SANREM Phase 4. Nevertheless, demonstration at farm level of an 'integrated agriculture of a little bit of everything' farming system' Recommendation: Monitoring and evaluation of integrated farms; Brief on productivity, resilience and sustainability of integrated farming systems.
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ..)	6	Conducts training for community/farmer groups in CA=veggie, with monthly meetings of the 22 CA=veggie farm women. No attention in RUA curricula. Recommendation: Initiate series of lectures on social capital, farmer groups and innovation platforms in RUA and UBB, to provide foundation for the future teaching of social capital at RUA and UBB.
Technology Development	N/A	CE SAIN demonstrates multiple technologies in the ATPs. Also some adaptive research, directly and through partners such as CIRAD and other ILs. RUA strategy aspires to become a research university though improved culture and capacity of staff.

Research effectiveness on crop systems agronomy & Improvement	7	Several research grants, Ph.D. and M.S. funded researches that are on-going. CE SAIN facilitated six Cambodian SEARCA scholars (two already completed their degrees) to conduct CA research thesis in Cambodia. CE SAIN facilitated CA nematode research of a Thai M.S. student from Kasetsart University See also above discussion.
Effectiveness for soil health	6.5	Limited. Demonstration of CA technologies that enhance soil health, that include legume based living tree fences, composting and manure biodigesters. All of these contribute to enhancement of soil health. Education on crop biodiversity is scaled-up to youth in high schools and universities.
Effectiveness for plant nutrient-optimization	N/A	N/A
Effectiveness for water optimization (irrigation, waterharvesting, green & blue)	6.5	Demonstration of CA which is a water optimization technology that replenishes groundwater (increased infiltration) and reduces soil evaporation (mulch). It also reduces flooding due to increase in infiltration. Drip irrigation and micro-sprinklers demonstrated in the ATPs. It should be noted that CARDI requested the data on CA performance in lowland irrigated rice systems.
Research effectiveness on farming systems integration—crop/livestock-trees-fish etc	7	CE SAIN is moving towards, but has not yet evaluated or documented farming systems integration. Progress can be observed on Integrated 'Agriculture of a little bit of Everything' farming system; livestock feeding introduced in four ATP (only Kampong Thom does not have a livestock). Siem Reap Tech Park (chicken and pigs, with a biodigester, American Soybean Association); Battambang (chicken and pigs, with a biodigester, American Soybean Association); Kampong Cham (electric fenced cattle to demonstrate cover crop as forage feed); RUA (goats and several others). Coming soon are modernization of aquaculture ponds of ATP (in Battambang, and Kampong Thom and likely in Siem Reap and RUA), from the new grant from the American Soybean Association.

Capacity Building & Scaling	9	Human (from K-12, (i.e. green shoots an NGO who brought 46 teachers from Ode Meanchay who got training in CA and are applying it in their school gardens; Kampong Thom Tech Park, CE SAIN recruited nine high school students now studying in RUA and continuous to demonstrate SI Technologies in the Park); to undergraduate, and graduate (several CE SAIN scholars); faculty and staff (several research grants), machine operators and field staff (i.e. CASC training in Kampong Thom and Battambang on CA systems including machinery) and farmers (i.e. several CA vegetable and CA crop production trainings). Also will be the more than 30 CE SAIN Lectures from the CE SAIN lectures series provided from US universities and also from non-US universities.
Quality of Scaling concepts and design	7	CE SAIN is young and was able to establish five ATPs in less than a year and now ready to add documentation and demonstration of integrated technologies in the ATPs. Simple reliance on the ATPs is necessary but not sufficient as an effective pathway to smallholder impact; the subsequent steps and actors need to defined and engaged – and the concept and design of the impact pathway fully documented and described.
Effectiveness of scaling and dissemination activities	8	CE SAIN has been demonstrating CA in her ATPs and materials. Most ATPs appear well managed. Many stakeholders have benefitted from visiting the parks. Three ATPs have regular student visitors. From the farmers trained on CA for grain production in Kampong Cham to farmers and K-12 teachers trained on CA for veggie production in Siem Reap. There are the high school faculty and students in the Kampong Thom Tech Park. And the Tech Parks located in two key agriculture universities (RUA and UBB) have been training students and technicians to do extension. In addition there are the five farm managers trained to extend and tour visitors at Tech Park and scale up SI technologies. Perhaps the partnerships of CE SAIN have been even more effective than the ATPs in scaling and dissemination beyond the ATP fences. CIRAD is actively engaging and training lowland and upland farmers on CA rice, cover crop and diversification practices. The NGO Green Shoots also contributes. There is great potential to reach large numbers of farmers with the fee based CA services (CASF) funded by USAID; and through the public-private CA Consortium to be launched in January 2019

Effectiveness Formal Training (degree or certificate)	9	CE SAIN has 30 RUA interns (about 20 completed undergraduate degrees), 9 undergraduate, 8 MS, 8 PhD scholars (all getting degrees at RUA), trained about 80 farmers (I think they were given certificates will check with CASC team), three undergraduate scholars (degree at UBB) and facilitated the SEARCA scholars to conduct thesis in Cambodia (six of them).
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	7.5	From the above CE SAIN has been focused on CA for sustainable intensification building human capacity from K-12 to University and government and NGO; and 'hardware' or 'infrastructure' renovation.
Stakeholder Engagement	8	From the above CE SAIN has been engaged with a diversity of stakeholders. Surprisingly, CE SAIN has not met or communicated with national research (CARDI) or Agricultural Universities apart from those directly implementing the Lab, i.e., RUA and to a lesser degree UBB or with the Ministry of Education in relation to the potential enrichment of school and University curricula.
Internal partners engagement, including USG	7	CE SAIN has engaged with other SIIL partners. Many field activities are co-located, and the activities are blended. This has facilitated the funding of technicians and inputs, but the line of sight to Award objectives is not always clear. There tends to be a strong technology push in the field locations which overlooks socioeconomic dimensions including livelihood evaluation, social capital and market linkages. Many opportunities for effective scientific integration between CE SAIN, WAgN and ASMIH, as well as other ILs, have been missed.
Effectiveness of policy engagement (local and national)	3	Limited. CE SAIN has partnered with the General Directorate of Agriculture (GDA) but has not attempted to influence agricultural education policy in Min Ag or Min Education. However, CE SAIN is fully aligned with relevant policies, clearly evident in the CASC headquarters in Kampong Cham and in the five ATPs. The government provided those sites for CE SAIN to disseminate CA-related technologies for Sustainable Intensification Integrated Farming System. Recommendation: prepare policy briefs for Ministries of Agriculture (which supervises RUA) and Education on incorporating sustainable integrated farming systems approaches into schools and Universities.

Effectiveness of youth activities	9	Youth from K-12 to Universities is clearly reached by CE SAIN as described above. Partnership with Green Shoots extended CE SAIN's reach to K-7 students Meanchay and the Aggie Tech Park in Kampong Thom to a high school. Scholarships for high school students in Battambang provided by the ESP (an US retired national agricultural extension organization) will reach these students with UBB reaching out to these high schools to recruit qualified scholars.
Effectiveness of gender activities		Students, staff, faculty, gender ratios 'on the surface' are 'acceptable.'
Agribusiness engagement (corporate and MSMEs)	8	ASA (swine, poultry, fish), ATEC biodigester, Swiss contact has been preparing CE SAIN to get connected to many other private business stakeholders.
Stakeholders engagement regional (public, banks, civil society)	7	Provincial Department of Agriculture, and a lot of expected engagements will be done with farmer cooperatives, banks, service providers, dealers, manufacturers, NGO's engaged in the CA production value chain will be done through the CASF project. Recommendation: broaden the potential membership of the Consortium, to include Banks
Stakeholders engagement national (public, banks, civil society)	6.5	MAFF and MoEYS, and a lot of expected engagements will be done with farmer cooperatives, banks, service providers, dealers, manufacturers, NGO's engaged in the CA production value chain will be done through the CASF project.
Stakeholders engagement local (public and civil society)	7	
Linkages to Mechanization (non-ASMC projects)	7	Partly through the efforts of the active SIIL country coordinator, CE SAIN has been linked beyond ASMC to include the mechanization efforts of CIRAD which resulted in the supplementary funding from USAID for the 2-year fee-based CA services project. Recommendation. Link with CARDI on 2WT NTD mechanization

Linkages to Geospatial Consortium (for non-GeoSpatial projects)	6	GFC has been late and modest in Cambodian activities, including weather stations and drones for local sensing, which are implemented by RUA. GFC has monitored ASMIH machine use in the field, and intends analyzing land use changes across a transect in newly developed lands. WAgN has requested supported on the prevalence of wild gardens which to date has not commenced
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For incorporation:

Positioned Cambodia to be the Center of CA/SI in Southeast Asia; Cambodia is strategically located and is the leader in CA research and extension in the Southeast Asia region. Cambodia has the longest no-till CA farms for upland crops, lowland rice and vegetables in the region. It also has been doing extensive CA research in the region and several CA trained scientist and field staff. CE SAIN is strong in building this capacity.

Annex: Cambodia evaluation matrices

SIIL evaluation supporting matrix: **Women in Agriculture Network Cambodia: Gendered- and Ecologically-Sensitive Agriculture (WAgN)**

(please see composite matrix Annex for scores)

Overarching Central SI Themes	I-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional (Asian) Needs		Government of Cambodia seeks to increase vegetable production nationally, in more environmentally friendly ways. WAgN addresses vegetable rice systems with an ecological approach, using Sustainable Intensification as a suite of practices to enhance agricultural systems, including soil health. This is relevant to the region as communities across similar latitudes and altitudes face similar constraints and challenges. MAFF has policy about increasing women's empowerment in agriculture. WAgN address women's empowerment, identifying and fostering enabling conditions and social networks for women to fully participate in the local, regional and value chains for horticulture and rice-based foods produced via SI. We work with multiple cooperatives to enhance women's engagement. Regional needs of addressing gender inequality and also regional needs to sustainable intensify systems. Enhancing capacity of students and technicians. Enhancing capacity through the translation of materials into Khmer and distributing at workshops.
Relevance to SIIL		WAgN addresses the goals of SIIL by testing SI techniques, including research on best practices for: tomato grafting for the wet season, wild (or perennial) gardens and the marketability of underutilized species, as well as conservation agriculture across vegetable-rice systems and field systems. WAgN works with women farmers to improve nutrition by promoting women's participation in the value chains for horticultural crops and rice produced via sustainable intensification (SI) practices. WAgN directly addresses empowerment of women, a cross cutting focus of USAID programs, and of SIIL.

Research effectiveness on Crop systems agronomy & Improvement	CIRAD and CASC collaboration –to document soil health improvement via cover cropping following rice, and we support conservation and promotion of underutilized agronomic species. Conservation Agriculture for women - continue the work of the Hort IL on conservation agriculture by promoting SI of rice via integration of commercial vegetable home gardens. Diversify smallholder paddy rice using CA approach (no tillage, mulch, rotations); originated with Hort IL and SANREM (Dr. Manny Reyes). In partnership with Univ. of Battambang and ASMC (designing and testing ergonomic tools for women), we test numerous SI rice – vegetable – cover crop combinations and try to promote microenterprise development for women’s groups.
Overall effect on systems resilience	WAgN support the increase in biodiversity which can increase resilience in the vegetable rice system. WAgN supports the increase use of underutilized spaces and species, also linked to increased resilience in the system.
Overall effect on systems productivity	Wild gardens (SI of the messy fringe) - Cambodian homes and villages have underutilized land (fencerows, weedy patches, open areas, etc.). There exist opportunities to transition this land to achieve gains in household nutrition, market income, livestock fodder. It can be achieved at field, farm or landscape scale. The increased production of useful and valuable biomass in the system increases overall effectiveness of the system.
Number and quality of journal and other publications	Variety of partners and joint reports Recommendation. Report preliminary results of surveys and research in reports, briefs and papers

Goodness of fit for US Universities' value propositions vs NGOs	WAgN is able to mobilize and leverage work from multiple partnerships including US universities and local universities. They are able to access expertise that NGOs cannot. So in that sense, it is useful for SIIL to work with and invest in US university engagement in Cambodia. However, some MOST? aspects of farmer engagement are more difficult for foreign researchers than for local NGO and civil society who are based permanently on the ground.
Data quality, analysis and open access sharing	Datasets have been gathered and are being submitted to Piestar and Dataverse for open access sharing. WAgN/ASMC dataset: Medium Quality. This dataset has lower quality data because of cleaning issues and survey instrument design. It could be improved by working with more households/villages across more provinces. Youth Migration Dataset: Good quality data, both quantitative and qualitative. Could be expanded to include more students and universities students in other cities. It could also be linked to Kampong Thom Technology park school and the youth there. Nutritional Analysis dataset: Good quality but could be more expansive across more species and elements/minerals. Wet/Dry market data: Good quality dataset to analyze the market demand of underutilized species. Could be improved by building on what has been done and replicating it in other markets across Cambodia. Soil Health Dataset: Good quality dataset. Could be replicated across more plots with more women farmers. Tomato grafting data: Good quality data. This experiment could be replicated across other soil types, moisture levels, and in other seasons. Wild Garden dataset: Good quality data. Could be improved by increasing the questions and number of households involved.

Impacts on human nutrition (quantity, quality, safety)		WAgN has been able to work with farmers in the vegetable-rice system. We have been able to increase production of vegetables with SI techniques. This increases the quantity and quality of food for household as well as increased income for households. High potential, needs to be documented
Livelihoods impact (current and expected) from scaling		WAgN has been able to increase the incomes of farmers involved in conservation ag across Siem Reap and Battambang., for vegetables and grain. As well as increased soil fertility for increased agricultural livelihoods. Recommendation. Document
Effectiveness of SI application		The SI techniques trial/tested/demonstrated with WAgN have been shown to be effective in increasing livelihoods and women's empowerment. Recommendation. Document SIAF assessment
Overall effectiveness of systems research /linkages		Multiple links across many projects and partners (WAgN staff are open and inclusive). In reality, some projects and partners are not always helpful !! But the synergy between groups is important in leveraging results.
Farming systems characterization and design		WAgN supports the characterization of underutilized spaces and crops, the messy fringe. WAgN supports the design of conservation agriculture approaches
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ..)		-WAgN supports Cooperative in SR -Wild garden FFS planned
Technology Development		
Research effectiveness on crop systems agronomy & Improvement		-Grafting; Wild gardens -Cover cropping; Conservation agriculture
Effectiveness for soil health		Soil health assessment
Effectiveness for plant nutrient-optimization		

Effectiveness for water optimization (irrigation, waterharvesting, green & blue)		Conservation ag support drip irrigation but farmers often opt out with electric pumps.
Research effectiveness on farming systems integration—crop/livestock-trees-fish etc		WAgN focuses on integrating rice-vegetable farming systems with additional focus on perennial species including trees.
Capacity Building & Scaling		WAgN build capacity in local agricultural institutions, NGOs, and international universities and research institutes, to scale up and out innovations in gender and ecologically sensitive SI. -Research dissemination via ECHO, workshops, training at CESAIN, lectures/training at universities. Capacity training of CESAIN - WAgN supports conservation agriculture with a fee to scale up cover cropping technology with CIRAD.
Quality of Scaling concepts and design		-Staff are interested in the concepts of scaling, but little planning or application of the ideas
Effectiveness of scaling and dissemination activities		WAgN workshops, and trainings. Just starting.
Effectiveness Formal Training (degree or certificate)		Good formal student training.
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)		Substantial. Workshops and trainings have been effective.
Stakeholder Engagement		
Internal partners engagement, including USG		Good stakeholder engagement. Working links with other USAID projects.

Effectiveness of policy engagement (local and national)		Project engages with policy makers, but as yet no examples of adjustments under consideration.
Effectiveness of youth activities		Support to CESAIN work with youth, and students.
Effectiveness of gender activities		Quantitative survey data, and qualitative interview and focus group data to identify barriers for women in agriculture. But evidence of effectiveness needed.
Agribusiness engagement (corporate and MSMEs)		Conservation agriculture service with a fee.
Stakeholders engagement regional (public, banks, civil society)		NGOs
Stakeholders engagement national (public, banks, civil society)		National organizations
Stakeholders engagement local (public and civil society)		Local NGOs
Linkages to Mechanization (non-ASMC projects)		Links to ASMC, sharing data, sharing farmers.
Linkages to Geospatial Consortium (for non-GeoSpatial projects)		But potential exists, and a request has been made.

SIIL evaluation supporting matrix: **ASMIH mechanization** **Cambodia**

(please see composite matrix Annex for scores)

ASMIH mechanization Cambodia		
Overarching Central SI Themes	1-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional (Asian) Needs		National Relevance Cambodia experienced drastic changes in agricultural machinery in the last decade particularly to offset the scarcity of labor force. The main examples are the increase number of power tillers, tractors and combine harvesters in the country. A common transfer of technologies occurred from the neighboring countries of Thailand and Vietnam. Agricultural implements are relatively common for land preparation with an extensive used of plough, harrow and more recently rotavator. Appropriate-scale machinery should be part of an integrated approach of soil and water management to promote sustainable intensification of the farming systems in the lowlands and uplands of Cambodia. Innovative implements and farming/cropping systems should be introduced and adjusted based on farms diversity and capabilities (i.e., financial capacity, labor force...). Thus, the machinery, should be appropriate to be used in the transitory period of conversion from conventional (plough-based) practices to farming systems which will be based on a sustainable management of soil, biodiversity and water resources. In Cambodia the ASMIH team in partnership with the General Directorate of Agriculture (GDA), Department of Agricultural Engineering (DAEng), Department of Agricultural Land Resources Management (DALRM), the Conservation Agriculture Service Center (CASC), and CIRAD is building upon over a decade of efforts to promote sustainable cropping systems in the lowland and upland systems around the Tonle Sap Region. The combined application of the three CA principles brings a warranty on the agronomic sustainability of farmers' practices and strengthens the economic profitability of the rain-fed crops (rice, maize, pulse crops). However, change in farmers' perceptions, their attitude toward accepting a new rationale for soil fertility management, and the adoption of the innovation could be slow. From an initial 'simple' interest in the no-till crop practice (using a no-till planter) mainly to save seeds, labor, cash inputs, farmers have to move towards a progressive understanding of the efficiency and positive impacts of CA/DMC systems. This move is also related to the farmers' perceived risks (climate variability and high inter-annual volatility of farm gate prices.) and expected benefits. Moreover, access to appropriate-scale mechanization and engagement of service providers to scale these cropping systems is found to be a main challenge. To promote and scale this new cropping system,

	“Appropriate Scale Mechanization Innovation Hub (ASMIH)-Cambodia” funded by University of Illinois via the Sustainable Intensification Innovation Lab intends to conduct systematic studies to find appropriate-scale agricultural mechanization for sustainable intensification focusing on diversified cropping systems. The goal of ASMC is in line with the strategic plan of the MAFF. Regional Relevance This advanced ecological approach pioneered by the Conservation Agriculture Service Center (GDA, DALRM/CASC) is unique for the Southeast Asia region. Activities developed by others SIIL facilities and projects (CE SAIN, WAgN) in combination with national (GDA/DAEng, DALRM) and international partners (CIRAD), and others funding agencies (AFD, Cambodia Climate Change Alliance/UNCCD), give Cambodia the opportunity to be at the forefront of CA-Direct seeded, mulch-based cropping systems and machinery.
Relevance to SIIL	SIIL: Produce measurable impacts on reducing global hunger, poverty, and improving nutrition of smallholder farmers. Activities are focused on four core areas: to sustainably increase the production of nutritious food and encourage dietary diversity of smallholder and women farmers, to increase the involvement and empowerment of women in agricultural production and processing, to increase food production through improved crop-production technologies while minimizing environmental impact, and the prevention of food loss and waste and improving food safety. ASMC-Sustainable Agricultural Mechanization The goal is to improve the resilience of farming systems in the rain-fed lowland areas of Cambodia through the use of appropriate-scale machinery and innovative rice cropping systems. Specific objectives are: • To design and assess CA-based cropping systems preserving soil functionality, increasing profit, and advancing in farm sustainability. • To assess the performances of appropriate-scale machinery (i.e., affordability, practicability, efficiency, labor saving) while preserving the soil capital. • To train smallholder farmers, service operators, field technicians, and students on the use of ASM and CA-based cropping systems.

	To support multi-stakeholder initiatives to initiate a negotiation process between farmers for the individual or collective management of fodder sources or crops diversification after wet season rice. ASMC is focused on identifying appropriate machines and tools that can foster Conservation Agriculture for Sustainable Intensification in Cambodia using as metrics the SI Framework of Social (Gender and equality), Human Condition (nutrition and food security), Economic (income), Environmental (enhancing natural resources while producing food), and Productivity (increase yield) or 'SHEEP.'
Research effectiveness on Crop systems agronomy & Improvement	Despite the design of promising technologies, the implementation and dissemination are limited. There is a need (i) to develop and improve the means of knowledge transfer that includes a higher participation of private sector including service providers, small and medium-sized manufacturers and retailers in the design and assessment processes of the innovations, (ii) to have better access to appropriate-scale machinery and services, and (iii) to improve market access for seeds of cover/relay crops, but also to explore value-chains to sell grains of cover/relay crops (pulse crops, sunflower, sorghum, finger millet, sun hemp...). Overall, improved pathways for adoption need to be researched. In addition, one of the challenges encountered in this R4D dynamic is that production structure and patterns evolve very fast both in the lowlands and uplands. This becomes an issue when the modifications in the farms' environment induce rapid changes in the cropping and production systems, quicker than the minimum required time for evaluating their performances and impacts on natural resources and on the farms production's productivity. This fact strengthens the need to create and maintain experimental fields and/or on-farm demonstrations to assume the role of "technological beacon," where co-designed cropping systems are compared with one another for several years, alongside past and present farming practices (From Kong et al., 2016). Despite this range of constraints, investment in CA/DMC systems and dissemination should be strengthened as these innovations provide the basis for a more autonomous agricultural production, notably less dependent of external inputs. They pair with knowledge development of farmers and farmers' organization and lead to deep, systemic change in the way to consider the agroecosystems in their relations with natural resources. Maintenance and improvement of soil fertility and production of ecosystems services under CA may

	contribute to a higher adaptive capacity and better livelihood of rural communities. Design and assess CA-based cropping systems Direct Seeding Mulch-based Cropping (DMC) systems (Séguy et al. 1998; Séguy et al., 2006; Husson et al., 2013) are based on 3 technical principles with: (i) minimum soil disturbance, (ii) permanent soil protection and (iii) diversification. These principles are translated into ecological processes particularly with a litter system, a continuous flow of fresh organic matter, driving soil biota diversity and functionality (Lienhard et al., 2013), soil structure and soil organic C and N accumulation (Tivet et al., 2013) contributing to the resilience of the system. Biological processes and systems properties are enhanced and extended through the use of multifunctional cover crops and a higher degree of crops diversification (Husson et al., 2013). The primary goal is to build a permanent flow of carbon from above and belowground biomass to improve all compartments (physical, chemical and biological) of the soil's fertility. Thus, DMC systems constitute a biological integrated way to manage soil's fertility when classical approach tends to manage more independently each of these compartments: soil tillage to improve physical conditions (and partially weeds), fertilizers (inorganic and organic) to first improve nutrients' availability, herbicides and fungicides to control weeds and diseases. Thus, the strategy is to restore and build a living soil using a large diversity of plants over time and space at the field and landscape levels, optimizing nutrient availability, minimizing losses of water and nutrients, enhancing soil functional biodiversity, and enhancing beneficial biological interactions and synergies. Besides enhancing biological functions, the use of a large diversity of plants in rice-based and upland cropping systems open ways to diversification (grains, seeds, and intensification of livestock system in the lowlands). Support multi-stakeholder initiatives – Towards a collective management of land after wet season rice Participatory processes are engaged with communities assessing options of diversification after wet season rice. Several technical options are available specifically through the use of cover/relay crops after rice that can fulfil different objectives with: (i) soil fertility improvement, (ii) fodder source for cattle and (iii) seed production of cover crops. Promising results were obtained from on-farm demonstration, in terms of their capacities to adapt to a wide range of soil and water recession dynamics, while effectively restoring soil fertility. No-till planters and cover crops have been used on-farm with overall good results in Banan and Santuk districts. Thus, the next step was to consider which process could support an uptake of these innovations at a larger scale. Participatory process took place in four villages in
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	Banan District (Battambang) and three villages in Santuk district (Kampong Thom). The action aimed to provide support to farmers in (i) understanding the opportunities enabled by a range of practices, (ii) exploring how these innovations could be specifically used given their farming systems and their own priorities, and (iii) assessing the constraints for implementation and how to address them. These villages encompass both rainfed lowlands, floodplains and irrigated areas. In the first phase, a preliminary assessment enabled to understand the farming systems, agricultural dynamics and to build farm typologies. In the second phase, game simulations took place, involving farmers representing the diversity of those existing in each village. In the simulation, farmers managed farms that were similar to the one they own. During the first round, they simulated their current practices. Then, the farmers were introduced to agroecological practices using videos, pictures, exchanges with other farmers, and discussions with technical experts. During the second and third round, participants simulated the proposed agroecological practices. In a third phase, post-game interviews and group meeting were organized to plan the implementation of cover/relay crops and to build the demand for no-till planters for the next rice sowing (2019). Then, several meetings were conducted to discuss the implementation process based on the options selected by the farmers both technically (type of cover crops and for which purpose) and collectively in terms of land management after rice. It is expected to implement over 200 ha of diversification after wet season rice in Battambang and Kampong Thom provinces. Evaluation will be conducted assessing technical constraints and collective land management. This is one of the main issues that has to be addressed to bring this innovation to scale on the agroecosystems around the Tonle Sap lake (> 700,000 ha) where fields are kept bare during the dry season. <i>Assess the performances of appropriate-scale machinery</i> Appropriate-scale mechanization is key to bring this option of diversification to scale specifically for rice sowing operation (use of no-till planter or seed broadcaster). Complementary work on ASM is needed specifically on how to use the fodder sources produced in the dry season after rice and how to store it under smallholder farmers' capacities. At the present stage, the Appropriate Scale Mechanization Innovation Hub-Cambodia through partnership with RUA, DAEng, UBB, and DALRM/CASC is working to develop and scale machinery for CA production systems and identify appropriate tools for CA vegetable production systems.
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Overall effect on systems resilience	Assessing resilience has to pair with different dimensions such as (i) buffer capacity at farm or community level (financial, physical, human, natural and social assets), (ii) vulnerability (crop, livestock, market, flood and drought), and (iii) adaptive capacity (productivity, stability, intensity ...). At this stage of ASMC implementation, few dimensions are addressed focusing on buffer (ASMC and WAgN baseline) and adaptive capacity assessing changes in rice yield, biomass production of cover/relay crops used during the dry season, soil fertility changes, (ecological) intensity of cropping systems. To assess those changes, R4D platforms are implemented embedding most of the time three main scales: (i) experimental fields (cropping system design, assessing agronomic performances), (ii) on-farm demonstrations (performances and abilities of the systems to match the means and goals of the farmers), and (iii) pre-extension network (analysis of farmers' adoption and adaptation of machinery and cropping systems; detailed record of costs, labour requirements and economic performances of a sub-sample of representative farms). Two experiments are established on upper sandy terraces in Stung Chinit (Santuk district, Khampong Thom) and in the flood plains in Veal Kroupeu (Banan district, Battambang) with the main objectives to assess the performances of contrasted rice cropping systems with conventional plough-based management and CA cropping systems. In addition, a range of agricultural implements (i.e., no-till planter, roller crimper and seed/fertilizer broadcaster) are tested. In both locations, the objective is to increase the resilience of the rice production systems through a diversification process with the establishment of cover/relay crops and fodder legumes (<i>Stylosanthes guianensis</i> and <i>Centrosema pascuorum</i>) and grasses (Sorghum and pearl millet mainly). Fodder species are mixed and broadcasted before or just after rice harvesting when water still remains on the field allowing a long-lasting period before the next cropping season. IN 2018, farmer's networks cover in both provinces (Kampong Thom and Battambang) 279 households and 597ha both lowlands and uplands agroecosystems. Changes in soil fertility and main soil functions – Adaptive capacity <i>Upper sandy terrace, irrigation scheme of Stung Chinit (sandy podzolic soil, 80% sand)</i> The depletion of soil organic C (SOC) content has been assessed comparing native vegetation and adjacent paddy fields. On average the depletion rate of SOC stock under paddy soils ranges from 26 to 66%. After 4 years, SOC, labile-C pool (POXC), N stocks, and soil microbial respiration increased under DMC management when compared with CT. SOC and N
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	stocks increased by 23% and 30% under DMC in 0-10 cm depth, respectively, contributing significantly to an increase in nutrients stocks under an organic form (Leng Vira, Msc, 2016). Dynamics of soil organic C & N will be assessed in December 2018 allowing a chronosequence comparison. The study is funded through IFDC bringing together DALRM/CASC, CIRAD and CE SAIN. <i>Flood plains, Veal Kropeu, Banan district, Battambang</i> In Veal Kropeu, a demonstration field has been established since 2012 through first the SANREM CRP funding and CIRAD technical and scientific backstopping. This field is used to design and test alternatives rice-based cropping systems integrating a diversity of cover/relay crops after wet season rice (Pkha Rumdoul). The three first years focused on the testing of appropriate technology to diversify after rice after water receding (early December). A range of species has been tested with <i>S. guianensis</i>, <i>C. pascuorum</i>, sorghum, pearl millet, <i>Crotalaria juncea</i> and <i>C. ochroleuca</i> mainly. All species exhibit a high potential to be used after wet season rice on residual soil moisture contributing to an overall increase of the biomass production (quantity and quality) and to an improvement of the soil fertility. The Biofunctool (Thoumazeau et al., 2018) has been used (Sar Veng, Msc study in partnership between GDA/DALRM, CIRAD and Kasetsart University, January 2018) to assess changes for 3 main soil functions under contrasted soil and crop management with: (i) C transformation, (ii) nutrient cycling and (iii) soil structure. In addition, chemical analysis was conducted to quantify SOC, N and nutrients contents; bulk density was also recorded to assess SOC and N stocks. Trend of SOC stabilization was observed under DMC when compared with conventional management for which a trend of SOC mineralization was emphasized. In addition, SOC and N stocks under DMC systems (19.8 Mg C ha⁻¹, 2.04 Mg N ha⁻¹) are significantly higher than under CT management (13.8 Mg C ha⁻¹, 1.38 Mg N ha⁻¹) in 0-10 cm depth, representing on average + 1.19 Mg C ha⁻¹ yr⁻¹ and + 130 kg N ha⁻¹ yr⁻¹. Beside the improvement of the main soil functions (i.e., C transformation, nutrient cycling and soil structure) provided by these mixes of legumes and grasses, the use of these species allow a better integration and intensification of the rice – livestock farming system, providing potentially high nutritional fodder resources at the onset of the rainy season. The cover/relay crops used grow during the dry season on residual soil moisture and can produce over 15 tons of fresh biomass at the onset of the rainy season that could be used as a fodder source and as a cover crop for the coming rice crop.
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Overall effect on systems productivity	A range of innovative rice-based cropping systems have been designed in the flood plains of the Tonle Sap lake with a threefold objectives: (i) enhancing soil resilience (increasing soil organic C content, soil biota and nutrient cycling), (ii) providing options to smallholder farmers to diversify crop productions, and (iii) improving rice – livestock integration through the use of cover/relay crops as fodder sources in the dry season. Upper sandy terrace, irrigation scheme of Stung Chinit (sandy podzolic soil, 80% sand) For early wet season rice (April – July), based on fertilizer levels and cropping sequence, difference in yields between DMC and plow-based management ranged from +860 kg/ha to +1110 kg/ha. This increase in yields represents a gain of approximately +\$150/ha (\$175/ton of paddy for normal white rice). The increase in yield between fertilization levels was highly contrasted between tillage treatments. On average, yield ranged from 650 to 2100 kg ha⁻¹ under CT. By contrast, the yields under DMC systems showed a higher range from 1530 kg ha⁻¹ to 2650 kg ha⁻¹. The mean yield under the lowest level of mineral fertilizer under DMC (1375 kg.ha⁻¹) is similar with the mean yield recorded under plow-based tillage and under the highest level of mineral fertilizer (1400 kg.ha⁻¹). This emphasizes a better nutrient status (i.e., plant nutrition and use of external inputs), and a higher efficiency of the system to convert mineral fertilizer in grains and cash. For wet season rice, yield under CT and DMC management are not significantly different even if on average yields are higher under DMC management. Thus, main difference is related to the productivity of early wet season rice and the possibility to use cover/relay crops after wet season rice for soil fertility improvement, livestock intensification and eventually producing seed of cover crops. Flood plains, Veal Kropeu, Banan district, Battambang In Veal Kropeu, rice yields of jasmine rice (cv. Phka Rumdoul) increased up to 1 ton ha⁻¹ when using mix of sorghum + legume (stylo or centro) and 0.5 ton ha⁻¹ when shifting from rice seed broadcast (conventional practice, high rate applied) to sowing by planter. A step-by-step process is followed meaning that ‘simple’ elements and tools (use of planter even under plough-based management, use of cover/relay crops) are first proposed to smallholder farmers allowing them to learn collectively, share experiences and move progressively to an integrated management of soil and water resources, crop diversification pattern and livestock intensification In the uplands In addition, in the uplands grain and vegetable production systems, machinery and tools are being tested and identified and recommended for effective no-till CA mulched based highly
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	diversified cropping systems. Positive results in terms of yields, income, labor inputs and labor profitability have been recorded along with improving soil functions such as increase in soil fertility. In the Mollisol of Rattanak Mondoul district (Battambang, SOC contents has dropped from 35 g C kg⁻¹ (native vegetation, forest) to 21 g C kg⁻¹ under cultivated area that has been converted first for subsistence farming and then for intensive cultivation of commodities (maize and cassava). First set of data emphasized higher SOC content under DMC (28 g C kg⁻¹) when compared with intensive cultivation practices but additional soil analysis should be conducted to draw an accurate scenario of soil fertility depletion under CT and potential recovery rate under DMC. Increase in yield between DMC and plough-based management is relatively low. Maize yields under CA increased by more than 0.5–1.0 t/ha with an average of 4.6 t/ha of maize under DMC. Farmers are first motivated by the quality of sowing, higher yield and seed saving. In 2018, services were provided for a total of 114 households covering 386 ha of maize and diversification with pulse crops and seed production of cover crops (mainly <i>C. juncea</i>). Crop diversification is key, both in the lowlands and uplands, to sustain livelihoods. Rice production as well as commodities (i.e., maize, cassava, among others) can't sustain alone livelihoods of smallholder farmers emphasizing the need of a territorial approach (multiscale, multi-stakeholders: from field to markets and consumers). In addition, land restoration should also be an element that have to be considered in coming years moving from an approach that aims at adjusting cropping and farming systems to a range of constraints to an approach focused on restoring degraded land and ecosystem services deficit.
Number and quality of journal and other publications	About 15 papers and presentations have been presented at Conferences and published in Proceedings. Additional Conference Publications arose from the November 2018 Regional Forum on Agroecology Futures in Siem Reap. Importantly, a variety of practical leaflets have been developed, for example: • Service provision of no-till planters to farmers: opportunities and challenges in Tonle Sap Lake Region • Developing appropriate-scale mechanization for CA-based cropping systems in South-East Asia • Diversification of rice-based farming systems in Tonle Sap Lake Region, Cambodia

Goodness of fit for US Universities' value propositions vs NGOs	The Appropriate Scale Mechanization Consortium is comprised of 4 US land-grant colleges as established by the Morrill Acts of 1862 and 1890. The Consortium is led by the University of Illinois, Michigan State University, Kansas State University, and North Carolina A&T Universities. The land grant mission connects teaching-research-extension and promotes economic growth of agriculture. The heart of the model is to breakdown silos that inhibit research from impact. This model ensures the agricultural research is relevant, shared with community, and creates a pipeline of graduates with the skills and knowledge to advance agricultural systems to be able to address future global challenges and demands. Additionally, the US University systems bring a wealth of expertise, research experience, and connections to enable the multidisciplinary systems research needed to promote agricultural research and development projects. The University of Illinois has a rich history of working within the USAID Food Security initiatives and UIUC led projects have a unique and positive position to easily tap into this network of practitioners (at UIUC and partners beyond) to easily extend the interdisciplinary aspects of the research. This network is exemplified by the integration of the INGENAES Technology Assessment Toolkit to assess how agricultural technologies can change gender dynamics and food security outcomes. This tool kits was developed by another USAID funded initiative at the University of Illinois. This close connection at the University allowed the ASMC to easily integrate the toolkit into the ASMC.
Data quality, analysis and open access sharing	The Appropriate Scale Mechanization Innovation Hub is following guidance from Sustainable Intensification Innovation Lab (SIIL) as it relates to open access data sharing. The ASMIH-Cambodia baseline survey is available via dataverse. Subsequent datasets will be added to dataverse accordingly.
Impacts on human nutrition (quantity, quality, safety)	The Appropriate Scale Mechanization Consortium is building off the foundation established by other Feed the Future projects to promote commercial vegetable home gardens with 43 farmers in three villages in Battambang adopting CA. The vegetable yield, soil health, and diversity of produce of the home gardens increased due to CA providing income and a diverse nutritious food source for the households. In addition, the ASMC tools team are testing tools for farmers to have a more ergonomically friendly and labor efficient protocol in CA vegetable production system. Lastly, the team is also observing each task farmers, especially women, and meet with the farmers to identify ways to improve efficiency of each tasks and its sequencing. The goal is to develop extension materials that provides a step-by-step

		guide on efficient CA vegetable production system in Cambodia. Tools will be recommended as part of this guide.
Livelihoods impact (current and expected) from scaling		ASMC targets conservation agriculture for sustainable intensification production systems which research began in 2004, and has been showing to increase yield and reduce cost. Therefore, appropriate machineries and tools that enable CA will and are currently improving livelihoods (yield increase, soil health enhanced, labor saved, income increased) for households producing grains and veggies the CA way. Recent interviews with farmers in Battambang and data from CA grain and CA vegetable researchers attests to the above statement. ASMC in partnership with WAgN are also identifying ways to integrate CA vegetable production and grain production systems to further improve livelihoods. A test is being conducted in a farmer's field in Banan (Dr. Dixon you saw this, our first stop where there were living fences). The farmer who owned the land is a CA vegetable farmer, forage will be sown after the paddy is harvested. Data will be collected on the results of this test. In addition, the living fences (funded by the livestock systems innovation lab) were already planted at the perimeter of the farmers' field.
Effectiveness of SI application		The SI framework (SHEEP) mind-set is being learned by the ASMIH-Cambodia team and actions are being done to apply them. The role playing game, has been conducted with farmers to identify ways that appropriate machineries can be accepted and adopted by the community. The role playing game reveals the farmers' needs and their priorities and challenges through a participatory methodology. The ASMC team adopts and identifies actions that are congruent with the farmer inputs (S or Social of SHEEP). Diversification of crops, veggies, fruits and animals produced (in partnership with WAgN) are being promoted. Tools, machines and tasks are being identified and trainings conducted to enable diversification of the farming systems. Integration of rice and vegetables (machines and tools) and its gender dimensions are being studied by the ASMC gender team in partnership with the WAgN team. There are indications based on interviews that the systems approach of integrating rice and vegetable CA (and enabling the adoption through appropriate machinery and tools) provides a unique role with the men continuing on their roles to do grain production and the women vegetable production and both having increased income due to CA for sustainable adoption approach. The economic (increase income), environmental (enhancement of natural resources, specially soil health, biodiversity and water quality) were also research in partnership with WAgN and shows the promising positive impact of CA on the two 'E's of SHEEP. Lastly, production increased due to CA and further labor efficiency improved due to introduction of CA

	machinery and tools. Moreover, collective cattle management during the dry season (prevent cattle from eating the forage on rice paddies) are being implemented in Banan (Battambang) and Santuk (Kampong Thom). Additional tool such as electric fence was tested in 2017 in Veal Kroupeu and will be extended to Samrong village (Banan) for the coming dry season. Energiser is provided by CASC and all costs related to fencing and management are shared between farmers. Cattle grazing with electric fencing are being demonstrated in Kampong Cham Aggie Tech Park and home of the CASC headquarters. Hence, ASMC-Cambodia is effectively impacting SI in the wholly integrated grain-vegetable-livestock production system in Cambodia.
Overall effectiveness of systems research /linkages	The Innovation Hub approach is to create a framework or linkages of multi-sector stakeholders including farmers, extension agents, universities (researchers and students), entrepreneurs, private sector, governmental agencies, and non-governmental organizations, with the common purpose to support sustainable intensification by identifying, developing, and/or adopting appropriate-scale mechanization technologies for farmers. The Appropriate Scale Mechanization Innovation Hub-Cambodia has made substantial progress to integrate with many of the other relevant stakeholders. The systems research linkages by the SIIL Research teams (ASMC/WaGN/CESAIN) are largely integrated by partnerships with RUA, UBB, and CASC teams. There is an opportunity to further expand on the linkages on the research with other international development research programs. A new player, Swisscontact, further buttressed the strength of the Hub by strengthening engagement of the private sector and realigning the mindset of the team on how to include the private stakeholders in the design, testing and adoption of Appropriate Machine and Tools for CA grain-livestock-veggie production system.
Farming systems characterization and design	The rain-fed lowlands of the Tonle Sap Lake in Kampong Thom and Battambang provinces are the main agro-ecosystems that the action will address. Rice is the principal staple crop of Cambodia and any deterioration of rice production systems through climate change would seriously impair food security of the nation. Drought is a major limiting factor for the production of rain-fed lowland rice representing 2.2 million ha (Tsubo et al. 2009; Michell et al., 2012). Most rice paddies lie in gently sloping lowlands but field water availability varied from upper (coarse-textured soils) to lower positions (clayed soils) of a sloping land in the rain-fed lowland ecosystem of the Tonle Sap region, causing variation in yield within the toposequence. The production of paddy rice has remarkably progressed during the last 10 years from 4.2 million tons in 2004 to 9.4 million tons in 2013. However, this global increase of the rice production

	remains poorly qualified and presents deep disparities between regions (some remaining very sensitive to climate accidents), between type of rice farming system (i.e., receding rice, hydromorphic plains and sandy upper terraces) and type of producers. Rice is commonly grown only once a year as a mono-crop in the wet season with still low input and relatively low output even if the yield has increased from 1.4 to 2.8 t/ha over the last 20 years (Fukai and Ouk, 2012). Animal husbandry is one of the main components of the rice farming system. Cattle and buffalo are in a constant state of undernourishment as they rely on poor-quality roadside grasses and rice straw as their primary source of nutrition in both wet and dry seasons (Pen et al. 2010; Nampanya et al. 2012). <i>Uplands farming – Recent agrarian changes (Battambang)</i> Based on household surveys conducted in 2016 (Kong et al., forthcoming), farm household can be clustered into five main groups with: (1) Orchard-based high resources farm (orchard farm) 1%; (2) Orchard and annual upland crops based on high resources farm (mixed farm) 14%; (3) Annual upland crop medium resources farm (annual crop farm) 15%; (4) Paddy-based medium resources farm (paddy farm) 49%; and (5) Off-farm activities based on low resource farms (Poor farm) 21%. The farming activities have actually been in a rapid transition. From 2005 to 2015, the region underwent a massive land conversion from forest to agriculture, mainly driven by maize expansion (Kong et al., 2019). Agricultural expansion was driven by market demand and high profitability of hybrid maize, vast available forestland with weak land governance and spontaneous in-migration of poor and landless farmers from populated lowlands. These rapid changes were driven by the decisions made by individual farmer and in turn have deeply affected their livelihoods (Kong et al., 2019). Concerned by the negative impacts of the rapid maize expansion on the sustainability of upland farming systems, the Ministry of Agriculture, Forestry and Fisheries (MAFF) with technical support from CIRAD and financial support from the French Agency for Development (AFD) and the United States Agency for International Development (USAID, SANREM CRP) initiated a research for development project on CA and DMC systems. Alternative cropping practices were introduced together with different intervention mechanisms according to two periods, i.e. with subsidy (2010-2012, SANREM CRP) and without subsidy (2013-2016). The first period corresponded to the tip of the maize boom curve, when farmer adopted massively the high-input, monocropping system. During the second period, farmers faced declining yields due to soil fertility depletion land degradation and alternatives to maize emerged in the form of cassava and fruit trees. Therefore, both the contexts of intervention and the intervention mechanisms differed during the two periods. A
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	range of cropping systems were proposed and as emphasized previously a step-by-step process has been implemented after 2013 introducing successive elements and tools with first providing no-till services and then introducing options of diversification with pulse crops and seed production of cover/relay crops. The main reasons to practice CA is the quality of sowing, seed saving, and yield increase. These three factors were related to the use of the no-till planter as it provided better germination and more regular sowing density, allowed to save seeds as compared to other planters or manual sowing, provided more regular sowing density and seedling emergence and ultimately increasing the yield. Services were provided for a total of 114 households covering 386 ha of maize and diversification with pulse crops and seed production of cover crops (mainly <i>C. juncea</i>). However, availability of no-till planter and purchase cost are among the main constraints to foster the dissemination of such implement and to enlarge the cultivated area under CA. Connection is made with the current project <i>Private Sector Engagement in Conservation Agriculture Machinery and Service Provision to Smallholder Farmers</i> that aims at engaging private sectors into the CA dynamic with medium-manufacturers, retailers and service providers. Support is needed to catalyze the growth of this demand and this market. In particular, there is a need to support service providers through a demand-creation process and to have increase access to affordable no-till planters. For vegetable production, tools are being identified for households to efficiently produce vegetables in CA commercial vegetable home garden production system. For example for hole digging to transplant vegetable seedlings, tools for clay are different for sandy soils, an auger in a handle for clay and a sharpened bottom cylinder with a handle for sandy soils. The tools are tested, especially for women and for long term ergonomically friendly posture. Harvesting tools (i.e. manually cutting stems that attaches to a fruit vegetable) are also being tested with the women And also weeding tools Pruning tools and many other tools that will make the household save time/labor. In addition, a task analysis is being conducted and task protocol changes tested and home gardeners are interviewed if the protocol change made them more efficient. A training manual identifying the tasks and ergonomically friendly tools for efficient conservation agriculture with drip home garden vegetable production system will be prepared as a final product of this effort.
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Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ..)	<u>CA-Commercial Vegetable Home Garden Farmer Group:</u> The Appropriate Scale Mechanization Consortium establish a network of ~50 female farmers in Banan District, Battambang to produce commercial vegetables under CA production. These farmer network meets regularly with the ASMC technician Channaty, who is completing her Master's research (WAGN) with the data on this plots. <u>CA Farmers in Battambang:</u> Lowlands: 80 households farmer network (151 ha) from upper sandy terraces to flood plains (clayey hydromorphic soils). Uplands: 144 households and 386 ha (maize cultivation and pulse crops), Mollisol. <u>CA Farmer Network in Kampong Thom:</u> 55 households (60 ha), irrigated scheme (sandy podzolic soil) <u>Service Providers:</u> The team has created a service provider network. The network consists of 31 service providers from two provinces: Battambang (23 Total; 6 Banan District; 10 Ratanak Mondoul District, 7 Samlot District) and Kampong Thom (8 total; 8 Santuk District). The team is assessing this network and three main objectives are targeted: (i) assess current conventional business models among service providers, (ii) understand and detail the potential economic benefits of CA for service providers, and identify potential service providers that would be interested in investing in CA machinery in order to answer the increasing farmer's demand.
Technology Development	A key foundational component for the direct seeded mulch based cropping system (DMC) is improved ecological services outlined below. This system has been tested and validated with over a decade of research by the GDA/DALRM/DAEng, CASC, CIRAD, North Carolina A&T and Kansas State University. Appropriate Scale Mechanization is a key need to enable the scaling of the improved cropping pattern.
Effectiveness for soil health	• Improved soil structure and erosion control • Increased organic matter content • Increased biological activity • Boost species diversification, enhance soil biota activity and nutrient cycling
Effectiveness for plant nutrient-optimization	Nutrient Cycling through various species of shallow and deep-rooted crops and cover crops. Deeply rooted crops acts as

		nutrient pumps recycling nutrients leached deep into the soil profile. Machinery and tools are identified for inclusion of a large diversity of plants in the cropping system hence promoting a complex system of soil nitrogen and mycorrhizae symbiosis, and others nutrient cycling 'strategy'. Organic matter act as 'nitrogen' and nutrients storage and when mineralized become available to plants.
Effectiveness for water optimization (irrigation, water harvesting, green & blue)		Improved water infiltration and retention from no-till CA production system promoted by ASMC-C. Flooding is also reduced due to increased infiltration during the wet season. This infiltrated water is stored in groundwater. Stored groundwater is essential for irrigation from groundwater and maintenance of stream flows during the dry season. Soil evaporation is reduced because of mulch Water is retained, and used by plants through transpiration increasing the 'yield/water use' ratio. ASMC-Cambodia identifies machines that can drill or broadcast cover crops or crops (like mungbean, sweet corn, and others) that can capitalize on moisture left in rice paddies after harvest, and the receding shallow water table. Those cover crops are established when water is still available during the months of October to December. They are drought tolerant offering green fodder during the dry months of January to May.
Research effectiveness on farming systems integration— rice-corn-vegetable-tree/livestock-trees-fish etc production system		The strategy is to increase the resilience of the rice production systems through a diversification process with the establishment of fodder legumes and grasses. Fodder species are mixed and broadcasted before or just after rice harvesting when water still remains on the field allowing a long-lasting period before the next cropping season. Beside the ecosystem services (i.e., N fixation, soil organic C accumulation, and nutrients cycling ...) provided by these legumes, the use of these species might allow a better integration and efficiency of the rice – livestock - vegetable farming system, providing high nutritional fodder resources at the onset of the rainy season and mulch for vegetable production.
Capacity Building & Scaling		

Quality of Scaling concepts and design	The Innovation Hub Framework aims to create an integration between the different stakeholders to facilitate market linkages to encourage adoption of Appropriate Scale Mechanization. The ASMIH-Cambodia is working to develop service provision of no-till planting. In 2018, the no-planting service of CASC was expanded to 386 ha in the uplands and it is expected to establish cover crops on > 200 ha in lowlands areas of Battambang and Kampong Thom Provinces. The project has successfully proven there is a market for no-till services, however, existing service providers may be reluctant to enter the market due to inherent competition and potential diminished returns compared with their current business model. In partnership with the NGO “Agronomists and Vets Without Borders” (AVSF) and Pierre Vernet, MSC Student, and the multi-stakeholder SIIL/CASC/RUA/CIRAD/ASMC/ SwissContact the teams conducted a participatory assessment of 31 services providers in project regions. The objectives of the action were: • To assess the practices of service providers in Battambang and Kampong Thom provinces and to make an economic assessment; • To assess under which scenario the integration of no-till planters in the activities of these services providers would be profitable for them; • To collect service providers’ opinion regarding potential purchase of no-till planters; and, • To identify service providers that may be interested in investing in no-till planters
Effectiveness of scaling and dissemination activities	The Appropriate Scale Mechanization Innovation Hub-Cambodia is utilizing participatory methodology including role playing games to work with farmers and service providers to determine key barriers to scale of CA and Appropriate Scale Machinery. <u>Scaling Conservation Agriculture</u> Social and land management issues have rapidly emerged as barriers to adoption of CA. There is not a common practice of fodder/cover crops during the dry season, and adopting this system cause conflict with common dry season practices of free roaming of cattle, fire to enhance the regrowth of natural grasses or for hunting purposes. Thus, a multi-stakeholder participatory approach (partnership between GDA/DALRM/CASC, CIRAD and AVSFI) has been initiated through the use of role-playing game in Banan (Battambang) and Santuk (Kampong Thom) to explore farms’ trajectories, how farmers perceive and understand the innovations, and to identify new mechanisms of intervention to upscale the innovations. The role-playing game is a powerful tool to explore collective issues at the community level or within a farmer group.

		<u>Service Providers as Scale Agents of CA:</u> Service providers (tractor owners) in the Tonle Sap Lake region currently offer a wide range of services, such as ploughing, building ridges for cassava, cultivation, sowing for maize and mungbean, use of rotavator for rice field preparation, and transportation. In addition, they all tend to their own farms as well. Their business models are highly diverse. The dynamics for service providers to invest in CA equipment are complex. CA competes directly with service providers current business proposition (land preparation). Despite this fact, twenty-five out of the thirty-one interviewed service providers were interested in a no-till planter, not only to offer the service, but also for their own fields. They asked for more information on the machine, and in particular to see it working. However, 15 mentioned that they did not have sufficient funds to purchase a no-till planter. Support is needed to catalyze the growth of this demand and this market.
Effectiveness Formal Training (degree or certificate)		<u>ASMC Internship</u> ASMC coordination team from the faculty of agricultural engineering (RUA) recruited a 4-year student to do his internship from June to September 2018 with CASC in Battambang. Mr. Hok Lyhong joined CASC team since June 7th to be trained on all activities including the follow-up of experiments in the lowland and upland (CA concept, cropping system design and assessment), the use of machineries (roller crimper, small and medium size imported and local made planters, the assessment of performance, maintenance, and operation of each machine), the follow-up of the service provision of rice and maize to lowland and upland farmers. The Internship has transitioned into full time employment with the CASC team. <u>Agricultural Engineering Curriculum Modernization</u> The Appropriate Scale Mechanization Consortium is assisting the Royal University of Agriculture to update and modernize its Agricultural Engineering Curriculum. This effort is led by Dr. KC Ting. Dr. Ting has over 12 years' experience as department head at the Department of Agricultural and Biological Engineering at the University of Illinois.

Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	The Appropriate Scale Mechanization Innovation Hub-Cambodia has held over 40 training events focused on building the capacity of local stakeholders to adopt CA cropping systems and CA machinery. CASC has conducted several training at the Bos Khnor Station. The last training, <i>Seed saving and production, Soil health and Integrated pest management</i>, brought together 80 participants with 50 farmers, 30 academia/researchers and development practitioners. In addition, a range of partners were involved on the training with ECHO Asia, Pennsylvania State University/WAgN, Horticulture Innovation Lab, CE SAIN, the Faculty of Agricultural Engineering, and the Department of Agricultural Engineering. The General Directorate of Agriculture targets to strengthen the training activities, the experimental and demonstration fields establishing a regional training center on Agroecology and Conservation Agriculture.
Stakeholder Engagement	
Internal partners engagement, including USG	Royal University of Agriculture-Faculty of Agricultural Engineering (RUA); General Directorate of Agriculture, Department of Agricultural Engineering (DAEng), Department of Agricultural Land Resources Management (DALRM), Conservation Agriculture Services Center (CASC), University of Battambang (UBB), and CIRAD. The Hub Advisory Committee: CARDI, Mr. Som Bunna; University of Battambang, Dr. Pao, Ms. Channaty; IRRI Cambodia, Mr. Gerald Hitzler; Local manufacturing workshop in Phnom Penh (Reuseykeo), Mr. Loem Bunny; Local manufacturing workshop in Kampong Thom, Mr. Tiv Noeurn; Local manufacturing workshop in Kampong Speu, Mr. Chhun Noeurn; Local manufacturing workshop in Kampot, Mr. Uch Seth; Local manufacturing workshop in Takeo, Mr. Mak Samnang; Department of Agricultural Engineering, Dr. Saruth, Mr. Seng Savath, Mr. Chhun Meng, Ms. Khom Sokha, Mr. Hong Soth, Mr. Sor Santy; Don Bosco Vocational Training School, Mr. Ung Bora; Department of Agricultural Land Resources Management and CASC/CIRAD, Mr. Vira Leng, Mr. Suos Vuthy and Dr. Florent Tivet; Contractor for laser land leveling in Battambang, Mr. Reach Sorin; Sustainable Intensification and Diversification in the Lowland Rice System in Northwest Cambodia (CamSID), Dr. Bob Martin; Center of Excellence for Sustainable Agriculture Intensification and Nutrition (CE SAIN), Dr. Hok Lyda; Royal University of Agriculture, Dr. Ngo Bunthan, Mr. Lor Lytour, Dr. Theng Dyna, Ms. Ong Socheat; Swiss contact, Mr. Rajiv Pradhan, Mr. Premprey Denna Manith

		USAID Mission Cambodia The Appropriate Scale Mechanization Innovation Hub with US leadership meets with the USAID Mission-Cambodia on an approximately annual basis. Our main contact in the mission is Laura Cizmo (previously Sang Lee). The team is regularly updating the USAID Mission team via the monthly mission tracker developed by CESAIN.
Effectiveness of policy engagement (local and national)		The Appropriate Scale Mechanization Innovation Hub-Cambodia is partnered with Dr. Saruth Chan (GDA/DAEng). With this partnership the Appropriate Scale Mechanization Innovation Hub-Cambodia helped establish the Strategic Development Plan of Agricultural Engineering for Cambodia 2016-2020.
Effectiveness of youth activities		Study Tours The Appropriate Scale Mechanization Innovation Hub-Cambodia regularly hosts study tours of the Agricultural Engineering Students to the project sites. The students learn about Conservation Agriculture and the importance of sustainable cropping systems and appropriate scale mechanization. The study tours allow students to interact with the real farming systems and discuss challenges with farmers. The goal is to start to create the linkages between on-farm challenges and agricultural engineering students. ASMC Internship Program The Appropriate Scale Mechanization Innovation Hub-Cambodia has established an internship program to give students a first-hand opportunity to work on research and development of mechanization. ASMC coordination team from the faculty of agricultural engineering (RUA) recruited a 4-year student to do his internship from June to September 2018 with CASC. This internship has transitioned into a fully time employment with the CASC team.
Effectiveness of gender activities		The Appropriate Scale Mechanization Innovation Hub-Cambodia has encouraged the Gender Team to attend the various training events and workshops and host FGD and KII to start to assess gender and mechanization in the region. The Appropriate Scale Mechanization Consortium has realigned gender component of the project to provide additional support related to gender. The Integrating Gender and Nutrition in Agricultural Extension Services (INGENAES) Project funded by USAID developed the Technology Assessment Toolkit to assess

	the change in gender dynamics and food security as an outcome of agricultural technologies. Maria Jones from the INGENAES project has joined as the Gender and Technology Adoption Coordinator of the Appropriate Scale Mechanization Consortium. Maria will be in Cambodia in Jan 2019 to start these assessments to develop technology profiles utilized the Technology Assessment Framework.
Agribusiness engagement (corporate and MSMEs)	The ASMIH-Cambodia Agribusiness Engagement includes partnership with the following companies to help support Small enterprises and micro-entrepreneurs. • Local Manufacturers (Mr. Larano; Mr. Tiv Noeurn; Mr. Sorin; Mr. Seth; Mr. Chhun Neourn, Mr. Seng) ; • The team is establishing partnership with 3I service providers in Kampong Thom and Battambang Provinces to assess their potential for promoting CA service provision. These local manufacturers attend and support ASMIH-Cambodia events, serve on the ASMIH-Hub advisory committee. The Appropriate Scale Mechanization Innovation Hub-Cambodia has met partnered with SwissContact to help build business skills of small medium enterprises to improve markets for CA and machinery.
Stakeholders engagement regional (public, banks, civil society)	UN-ESCAP- Center of Sustainable Agricultural Mechanization Dr. Saruth Chan was instrumental in facilitating a Regional Workshop on the Role of Mechanization in Strengthening Smallholders' Resilience through Conservation Agriculture in Asia and the Pacific hosted by the UN-ESCAP Center of Sustainable Agricultural Mechanization in Phnom Penh, Cambodia. The workshop worked to identify key areas of regional collaboration to promote conservation agriculture and sustainable agricultural mechanization. <u>Press Release</u> https://www.unescap.org/news/escap-cambodia-workshop-advances-sustainable-agriculture-asia-pacific-region ALiSEA/ACTAE The ASMIH-Cambodia team members are integrated into The Towards an Agroecological Transition in Southeast Asia (ACTAE) Project and Agroecology Learning alliance in Southeast Asia projects. These projects hosted the Agroecology Futures Regional Forum, and Dr. Florent Tivet of CASC/CIRAD, and leader of the ASMIH-Cambodia helped integrate the connection between the projects. During this regional forum the ASMIH-Cambodia presented during the parallel session appropriate-scale machinery, agroecology and sustainable intensification. This provides an pathway for continue

		collaboration and research and development for Appropriate Scale Mechanization upscaling in the region.
Stakeholders engagement national (public, banks, civil society)		The Appropriate Scale Mechanization Innovation Hub-Cambodia has many linkages with stakeholders at the national level. The following is a list of organizations that have attended recent workshops or consultative meetings of the ASMIH-Cambodia: Department of Agricultural Land Resources Management, Conservation Agriculture Service Center; Royal University of Agriculture; University of Battambang; Department of Agricultural Engineering; Provincial Department of Agriculture in Kampong Thom; Provincial Department of Agriculture, Forestry and Fisheries in Battambang; Provincial Department of Agriculture, Forestry and Fisheries in Siem Reap; Local manufacturing workshop in Kampong Thom/Battambang/Reuseykeo, Phnom Penh/Kampng Speu province/ Takeo province; Kampot province; Farmer Association in Siem Reap province; Farmer Network in Battambang; Farmer Network in Kampong Thom; Agriculture Association in Siem Reap; Local manufacturing workshop in Siem Reap; Don Bosco Vocational Training School; Meanchey University; IRRI; GIZ; Sustainable Intensification and Diversification in the Lowland Rice System in Northwest Cambodia (CamSID); Agri-Smart; International Rice Research Institute (IRRI) in Cambodia; Cambodia Agricultural Research and Development Institute (CARDI); and Private Contractor in Battambang
Stakeholders engagement local (public and civil society)		The Appropriate Scale Mechanization Innovation Hub has held a total of 40 training sessions within the local communities including: Field days and demonstration to introduce the crop cultivation under CA through the use of mixed cover crops for soil fertility improvement with minimizing soil disturbance, (ii) the use of appropriate scale machineries (seed broadcaster, roller & no-till planter attached with power tiller) under CA.
Linkages to Mechanization (non-ASMC projects)		We are connected to the SwissContact MIGIP Program. The Objectives of the MIGIP are: 1. Increasing efficiency of service providers 2. Introduction of agricultural technology 3. Increase quality of crops 4. Commercial orientation of agricultural technologies SwissContact MIGIP team serves on the ASMC Hub. SwissContact is a partner on the Conservation Agriculture Service for a Fee funded by USAID Missions Cambodia.

Linkages to Geospatial Consortium (for non-GeoSpatial projects)		Recently started a research project connecting with the GeoSpatial Team to utilize drones to assess machinery effectiveness at the plot scale.
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7.6 SIIL Country Synthesis for Ethiopia

SIIL evaluation supporting matrix TAMU Ethiopia

Overarching Central SI Themes	1-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional Needs	7	It likely the original design was rather top-down but subsequent, strong national partner engagement appears to have improved alignment with FGE and Amahara regional priorities.
Relevance to SIIL	8	Covers a number of systemic issues of great relevance to SIIL (water resources, soil health, productivity).
Research effectiveness on Crop systems agronomy & Improvement	7	On-farm trials are well-designed and relevant to the constraints and opportunities that targeted farms are faced with.
Overall effect on systems resilience	6	Significant potential to contribute to resilience in the longer term but scaling pathways are vague.
Overall effect on systems productivity	5	Interim research results indicate that there the technologies under test are likely to close yield gaps in the target systems (notably under CA horticulture and feed and forage production).
Number and quality of journal and other publications	0	No publications explicitly reported and the clarity around shared publications is not there.
Goodness of fit for US Universities' value propositions vs NGOs	N/A	No information available.
Data quality, analysis and open access sharing	N/A	No information available.
Impacts on human nutrition (quantity, quality, safety)	0	No evidence presented as yet.

Livelihoods impact (current and expected) from scaling	7	A wide range of livelihoods impacts have been considered by the project itself and in association with other activities in the Ethiopia cluster (mainly ASMC). The focus on nutrition is desirable although it is difficult to see how this might generate directly scalable outputs.
Effectiveness of SI application	5	Applied within the context of the whole farm models. Less clear how the SIAF has been used in conjunction with the adaptive research activities.
Overall effectiveness of systems research /linkages	4	On the modeling side this is likely to be strong although outputs are blurred with those of other projects. In the adaptive research there are examples (e.g. forage production under CA) but these are patchy.
Farming systems characterization and design	7	Largely built on previous activities but positively so. Might be improved by specific activities (e.g. the nutrition survey) focused on SIPSIN priorities but these are still ongoing and so not likely to contribute much.
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ..)	4	Limited and unsystematic but probably less of a priority at this stage of the R4D continuum.
Technology Development		
Effectiveness for soil health	5	The partial focus on CA has potential to contribute to improvements in soil health.
Effectiveness for plant nutrient-optimization	7	CA practices would appear to contribute strongly but this is an assessment made by a livestock specialist.
Effectiveness for water optimization (irrigation, water harvesting, green & blue)	8	Integration of small-scale irrigation into the targeted production systems is a core focus of the work. The design of interventions has been undertaken systematically and the solutions have the potential to work in the system (although, as ever, potential barriers to adoption are substantial).

Research effectiveness on farming systems integration— crop/livestock-trees-fish etc.	7 5	Integration within the project has something of an ad hoc feel to it but the project team is making efforts to make this more systematic. In this reviewer's opinion, this is something that could be strengthened in Phase II. Some work on forage production addressing feed shortages widely found in production systems of the target areas. Some integration of this work with the CA trials on maize. Rather low budget allocation to this activity.
Capacity Building & Scaling		
Quality of Scaling concepts and design	3	These do not appear to have been convincingly formalized. Better impact pathways needed for any continuation.
Effectiveness of scaling and dissemination activities	2	Limited activities to date.
Effectiveness Formal Training (degree or certificate)	7	Strong engagement of students from within and beyond the region.
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	4	Emergent at best.
Stakeholder Engagement		
Internal partners engagement, including USG	4	This would appear to be functional but there are concerns. Partners appear to have different priorities (TAMU-modeling; BDU, IVMI, ILRI - systems evolution for SI; Tufts - nutrition survey) and there are indications of extractive data collections with limited return of conclusions / messages / recommendations.
Effectiveness of policy engagement (local and national)	3	Limited evidence other than ad hoc contacts.
Effectiveness of youth activities	N/A	The reviewer did not pick out any activities directly aimed at youth.
Effectiveness of gender activities	7	The adaptive research activities are directly focused on benefits for women farmers and the on-the-ground engagements reflect this well.

Agribusiness engagement (corporate and MSMEs)	1	Appears limited at present. This is not necessarily a problem but would need to increase dramatically if the water lifting technologies are to be scaled in any meaningful way.
Stakeholders engagement regional (public, banks, civil society)	5	Likely to be reasonably strong via BDU.
Stakeholders engagement national (public, banks, civil society)	N/A	Not clear at present.
Stakeholders engagement local (public and civil society)	7	Much of the research has been conducted at a community level where participants appear to be well-briefed on objectives and contributing to the elaboration of the technologies.
Linkages to Mechanization (non-ASMC projects)	7	Effective colocation has taken place and there is clearly good collaboration within BDU. It is less clear whether this is mirrored at a more strategic level between TAMU and UIUC (and whether such a dialogue would have strengthened project outputs).
Linkages to Geospatial Consortium (for non-GeoSpatial projects)	N/A	No direct links evident although the sub-award may have benefitted from GFC products.

7.7 SIIL Country Synthesis for Tanzania

SIIL evaluation supporting matrix MSU Tanzania

Overarching Central SI Themes	1-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional Needs	7	The project has good engagement with the on-the-ground national partners and priorities appear to be well harmonized.

Relevance to SIIL	6	A more focused cropping systems project with a strong handle on the core issues around this and attempts to consider the wider systems implications. Perhaps less embedded at the whole farm systems levels which might compromise the scalability of results on the farms that show quite strong integration around crops and livestock that are common in the region.
Research effectiveness on Crop systems agronomy & Improvement	8	A systematic approach to the intensification of the legume components of the system has been taken and both agronomy and germplasm issues have been tackled (although it would appear with relatively little integration).
Overall effect on systems resilience	5	The SI trajectories being promoted have significant potential to promote systems resilience but these have not been explicitly addressed as part of the research.
Overall effect on systems productivity	7	Likely to strongly enhance the productivity of the crop component of the systems.
Number and quality of journal and other publications	6	Good emerging publications over a range of disciplines. This is likely to be something that would score higher if re-evaluated in 12 month's time.
Goodness of fit for US Universities' value propositions vs NGOs	N/A	N/A
Data quality, analysis and open access sharing	N/A	N/A
Impacts on human nutrition (quantity, quality, safety)	7	Publications in press provide evidence of these emerging impacts.
Livelihoods impact (current and expected) from scaling	7	Considerable potential for livelihoods impacts to be made across a range of domains (productivity, economic, environmental and human).
Effectiveness of SI application	5	Some application emerging around project outputs. This is likely to improve in future.
Overall effectiveness of systems research /linkages	4	Good under the cropping systems umbrella but there might need to be an improved consideration of wider systems linkages going forwards.

Farming systems characterization and design	6	Built on strong inputs from national program partners.
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ...)	4	Apparently limited but probably less of a priority at this stage of the R4D continuum.
Technology Development		
Effectiveness for soil health	8	Soil health implications of the interventions have received explicit attention and the project has made noteworthy efforts to contribute to the wider activities of the global community around soil health.
Effectiveness for plant nutrient-optimization	7	Integration of legumes would appear to contribute strongly but this is an assessment made by a livestock specialist.
Effectiveness for water optimization (irrigation, water harvesting, green & blue)	N/A	This has not been a key priority for the project.
Research effectiveness on farming systems integration—crop/livestock-trees-fish etc.	5	As outlined above, the drawing of the boundary might be too limited (for a SILL project at least). No explicit consideration of livestock as part of the project activities.
Capacity Building & Scaling		
Quality of Scaling concepts and design	5	Variety release processes well defined and implemented. Better impact pathways need to be specified for other project outputs.
Effectiveness of scaling and dissemination activities	5	Imminent lab variety releases.
Effectiveness Formal Training (degree or certificate)	6	Strong engagement of students from within and beyond the region.
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	6	In support of varietal releases.
Stakeholder Engagement		
Internal partners engagement, including USG	6	There appears to have been some fragmentation around the project's four key objectives but overall direction and internal communication would appear to be relatively strong.

Effectiveness of policy engagement (local and national)	5	Mostly ad hoc apart from interactions with the national breeding system.
Effectiveness of youth activities	N/A	The reviewer did not pick out any activities directly aimed at youth.
Effectiveness of gender activities	6	Largely a focus on gender positive technologies and evaluation of nutritional outcomes embeds issues that are important to women and children within the SI trajectories that could be promoted.
Agribusiness engagement (corporate and MSMEs)	N/A	Difficult to elaborate from the available information.
Stakeholders engagement regional (public, banks, civil society)	N/A	Difficult to elaborate from the available information.
Stakeholders engagement national (public, banks, civil society)	5	The project is in the process of feeding new germplasm into the national release system.
Stakeholders engagement local (public and civil society)	7	The research approaches employed (e.g. mother-baby trials) are client-friendly and the research team has significant experience in applying these.
Linkages to Mechanization (non-ASMC projects)	N/A	No linkages apparent.
Linkages to Geospatial Consortium (for non-GeoSpatial projects)	7	No direct links evident although the sub-award may have benefitted from GFC products.

7.8 SIIL Country Synthesis for Burkina Faso

SIIL evaluation supporting matrix Burkina Faso

SIFSEB – Burkina Faso

Sustainable Intensification through better integration of crop and livestock production systems for improved Food Security and Environmental Benefits in Sahelian zone of Burkina Faso

Objectives

1. To increase crop and livestock integration in these mixed systems through improved crop production (dual purpose sorghum and cowpea varieties), soil fertility (application of manure and inorganic fertilizer), water harvesting (zai and stone-bunding with vegetation strips) and livestock feed enhancing interventions (forage sorghum, dual purpose cowpea, efficient feeding systems).
2. To assess the economic, social, nutritional and environmental benefits and tradeoffs of the productivity-enhancing interventions, and the potential for cost-efficient out scaling.

3. To build capacity of smallholder farmers and researchers on sustainable intensification and improved nutrition through multi-stakeholders' platforms and to provide platforms for co-learning.

Overarching Central SI Themes	I-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional (West African) Needs	8	Crop and livestock systems are critical to well-being of a majority of households in the Sahel in BF and beyond. Both crops and animals have dual purposes as food for humans. Crops residues are being developed for animal feed, while new legumes are introduced to keep cover on the ground and to improve the health status of people and animals. Increased milk production is important as well.
Relevance to SILL	9	The research is highly relevant to SILL and is enhanced by the interchange among projects.
Research effectiveness on Crop systems agronomy & Improvement	8	By addressing cropping systems that include grain and legumes that can be used for human and animal consumption, and by employing SI, farmers are eager to put trials in their fields and then adapt the innovations to more of their land. Legumes are an important addition, as cowpeas can easily be eaten in the field, reducing hunger.
Overall effect on systems resilience	8	Because of a focus on experimentation and farmer choice, farmers are empowered to adapt their systems in response to climate volatility.
Overall effect on systems productivity	8	The improved crops also yield better under harsh conditions than the traditional varieties, as show on farmer fields and the experiment station. Improved health of animals through consumption of the stover results in increased milk production.
Number and quality of journal and other publications	2	There is a real need to move the research into publication. A lot that is there that needs to be subjected to peer review and shared with other researchers, policy makers, and educators in BF and worldwide.
Goodness of fit for US Universities' value propositions vs NGOs	8	The US universities involved have provided survey data and tools for monitoring climate and perhaps productivity through drones. AMSC and its US LGU partners seem particularly attuned to the work in BK.

Data quality, analysis and open access sharing	6	The BK baseline survey to characterize the crop-livestock systems in 8 project communities with focus on constraints and intensification practice by small holder farmers was added to Dataverse on 2/8/18 and is accessible on that site. Thus far it does not seemed to have been analyzed and related to on the ground research and outreach.
Impacts on human nutrition (quantity, quality, safety)	6	While quantity and quality have increased, we have only anecdotal reports on the impact on human nutrition through programs with mothers and children.
Livelihoods impact (current and expected) from scaling	7	As the new and improved crops have greater resiliency, livelihoods of farm households adopting and adapting them have become more stable. As new enterprise opportunities evolve, livelihoods should become more diverse and thus better able to withstand system shocks. However, some policy changes will be needed for women and youth to get the credit need to initiate such enterprises.
Effectiveness of SI application	8	We did observe nor did we read about impacts of the new SI systems on soil health. Productivity and nutrient efficiency are improved.
Overall effectiveness of systems research /linkages	8	There are good linkages with AMSC and the work in Senegal. However, the relations to the GSP group are not systematic enough to allow the delivery of the equipment and data it delivers to be well used. Linkages are excellent with NIERA and its experiment stations, ILRI (where the PI is based), CNRST and the University in Bobo-Dioulasso. There is limited measurement and data to prove effectiveness of systems research, although BF government agencies are eager to see the impacts of the research.
Farming systems characterization and design	6	No documented SIIL farming systems characterization. The research and outreach are to create crop-livestock farming systems with drought-tolerant enriched grains, legumes (enriched cowpeas and peanuts), small and large ruminants and donkeys. Recommendation: Monitoring and evaluation of integrated farms; Brief on productivity, resilience and sustainability of integrated farming systems.

Effectiveness of social capital activities (FFS, AIPs, community/farmer groups, ..)	7	Uses the Master Farmer organizations and black smith organization very effectively, as well as involving students. Some women's groups are involved in monitoring and improving child and maternal health through innovative uses of the improved grains. Recommendation: Monitoring the impact of the variety of groups in terms of changes in household well-being and the strength of the networks formed and their ability to expand membership or create new groups.
Technology Development		
Research effectiveness on crop systems agronomy & Improvement	8	Several research grants, Ph.D. and M.S. funded researches that are on-going. Importantly, those funded are studying in African institutions, with the
Effectiveness for soil health	6.5	
Effectiveness for plant nutrient-optimization	6	The measures of soil health we were shown was an initial soil test for fertilizer recommendations (currently there is a single fertilizer recommendation for the entire country) and then comparative crop health in field trials and on farmers' fields. There does not seem to be a regular measure for soil health, nor are farmers trained to observe it.
Effectiveness for water optimization (irrigation, waterharvesting, green & blue)	5	The major strategy to optimize water appears to be increasing the capacity of the soil to absorb water through diverse farming systems and constant group cover through new crop rotations.
Research effectiveness on farming systems integration—crop/livestock-trees-fish etc	7	The dual-purpose nature of the improved crops helps heighten the efficiency of the entire farming system. There are some measures of increased goat milk production at experiment stations. Research on appropriate mechanization through ripping rather than plowing considers the health of the animals doing the pulling. The improved stover has nutrients that contribute to animal health, which is mentioned by not monitored beyond milk production.
Capacity Building & Scaling		

Quality of Scaling concepts and design	7	This is primarily a result of AMSC, which has a clear strategy for scaling out mechanization innovations by working with blacksmith organizations to develop and produce the machines. Blacksmith, sometime working with Master Farmers (also organized) working with their clients to put improved machines in the field, hopefully with more human harnesses and yokes.
Effectiveness of scaling and dissemination activities	7	Policy and custom blockages have been identified that make the opportunities for scaling more difficult.
Effectiveness Formal Training (degree or certificate)	8	Several research grants, Ph.D. and M.S. funded researches that are on-going. Importantly, those funded are studying in African institutions, with the
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	7	Capacity building for research is through the graduate students studying aspects of SIIL projects, who then can help involve their professors in systems thinking around SI. Farmers are being trained by the Master Farmer method of farmer groups. Extension is informed and sometimes involved in the research, but it is difficult to tell if they are including SI approaches in their general work with farmers.
Stakeholder Engagement		
Internal partners engagement, including USG	8	BF universities, experiment stations, and NGOs are involved in field trials and nutrition organizing.
Effectiveness of policy engagement (local and national)	2	Although concrete policy blocks to SI expansion have been identified, as of our visit, there was no concrete plan for which entity needed to change a policy, who to talk to, etc. This would be a good place to involve university students in BF, perhaps using an Advocacy Coalition approach.
Effectiveness of youth activities	6	Youth activities are not an explicit part of the project, AMSC has involved youth in machinery testing and application, providing entrepreneurial opportunities for youth as service providers and fodder processors. However, there is no mechanism in place for youth the access the capital necessary for the small investments necessary to start such businesses.

Effectiveness of gender activities	5	Women are involved in a maternal and child health project which monitors health, facilitates feeding the nutrition-enhanced crops and a more diverse diet, and supplements diets with moringa leaves (previously only fed to animals). The women report good results, and are now marketing small quantities of the moringa leave from their own trees to Japan, which it is a well-known diet supplement.
Agribusiness engagement (corporate and MSMEs)	6	While we did not observe corporate engagement, small businesses such as blacksmiths were involved not only in scaling out the new technologies but in developing them. There was no other specific activity to involved MSME that were reported or could observe.
Stakeholders engagement regional (public, banks, civil society)	5	Regional branches of nation research and extension are involved in field trials. Civil society in engaged through blacksmith associations. Banks will be necessary to provide credit for new SI enterprises, particularly for women and youth. Involvement of local bank representatives could help them see the possibilities of success of such loans.
Stakeholders engagement national (public, banks, civil society)	6	National research entities and universities are involved in SI research and outreach, aided by their connections to SIIL. National banks should also be involved, as they must create new lending mechanism to further scaling out of SI-relevant practices.
Stakeholders engagement local (public and civil society)	5	The main involvement of the public at the local level is though observation of the results.
Linkages to Mechanization (non-ASMC projects)	5	It was not clear that there were other mechanization projects in BF.
Linkages to Geospatial Consortium (for non-GeoSpatial projects)	5	The Geospatial projects has purchased 2 weather stations in BF managed by ASMC. Thus far it is not clear how they are being used. Phase II should emphasize training in analyzing system through areal images.

7.9 SIIL Country Synthesis for Senegal

SIIL evaluation supporting matrix

Dual-Purpose Millet - Leguminous Crops - Livestock Systems in Senegal

Dual-Purpose Millet - Leguminous Crops - Livestock Systems in Senegal

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); 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 Développement (IRD) (France), CIRAD

Sustainable Intensification of Millet-Based Agrosystems Using Cowpea in the Groundnut Basin of Senegal (Laure Tall, LNRPV/ISRA); Louga, Fatick, and Kaolack, Senegal; CNRA/ISRA, LNERV/ISRA, IRD, CIRAD;

Overarching Central SI Themes	1-9	Evidence of achievement of the criteria, plus notes
Relevance to National and Regional (West African) Needs	8	The two projects, so interwoven that they are difficult to separate, seem to coordinate their efforts to address major issues around creating and improving resilient agro-ecosystem in arid portions of Senegal. This research is critical for these less favored parts of Senegal and West Africa.
Relevance to SIIL	9	These efforts are very relevant to SIIL.
Research effectiveness on Crop systems agronomy & Improvement	8	The nutrient-rich grain-legume mixes sown with little soil disturbance showed substantial improvement over traditional varieties and methods in farmers' fields and on experiment station plots. Farmers were quickly applying them to their fields when introduced.
Overall effect on systems resilience	8	As we observed the field trials when the rains were nearly 30 days late, the mixed cropping system with improved practices show much better growth. This suggests that the SIIL research is providing greater resilience to weather volatility.
Overall effect on systems productivity	8	Yields were up, as was milk production from animals fed the dual-purpose crop residue.

Number and quality of journal and other publications	2	The only journal article reported is one by the KSU PI on changing weather trends in Kansas from the 1890s to 2015. The PIs in the US and in Senegal should focus on getting their research and outreach results documented and in press in appropriate journals, including those in French, in Phase II.
Goodness of fit for US Universities' value propositions vs NGOs	8	For both the convergent projects, KSU is the only US university involved, although the Consortium projects seem to be involved. Since the Geospatial project has main been involved with technology delivery, we have yet to see how those US university-based researchers work with the Senegalese colleagues on research design, data gathering, data analysis and publications.
Data quality, analysis and open access sharing	6	While data on weather conditions, milk production, and plants yields are gathered, their availability and analysis need serious improvement.
Impacts on human nutrition (quantity, quality, safety)	6	While the food produced through SILL technologies and practices is superior in quantity and quality to farmers current practices, we saw no studies of health impact on humans. Despite the frequent mention of human nutrition in project documents, the inclusion of minerals in the dual-purpose crops and increased milk production were assumed to impact human health positively. In Phase II, impacts of human health should be measured. Such measurement does not necessarily intrude measures, but could come from focus group discussion with women who use and women who do not use products from the improved crop and livestock production.
Livelihoods impact (current and expected) from scaling	7	This could have very positive impacts on livelihood diversification and improvement of the support systems needed for scaling out pathways. A major barrier identified by the project is lack of access to credit by youth and women. Phase II should work with banks and other lenders to address this issue. The coops, with whom they are collaborating, should help in the credit provision strategies developed locally.

Effectiveness of SI application	8	SI seems quite effective, based on farmers' analysis of their fields, and increased production. There have not been measures of soil quality nor water retention due to increase organic matter in the soil (in case that has resulted).
Overall effectiveness of systems research /linkages	8	Senegal is very well integrated to other FtF projects in Senegal and working to include SI knowledge for Coops and youth clubs and projects. Many Senegalese universities are involved, as are Peace Corps volunteers. Links to village leaders and school principals is beginning to move the research to youth through the involvement of middle schools.
Farming systems characterization and design	6	There appears to have been no systematic characterization of farming systems, and the research approach has assumed a crop/livestock mix that could include millet, corn, cowpeas, and peanuts with ruminants for milk and traction, plus donkey for traction. In Phase II more precise characterization of farming systems would help in scaling out.
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups,...)	7	Uses the Master Farmer organizations, aided by Peace Corps Volunteers and university students from a variety of Senegalese institutions, which included students from other parts of West Africa, to spread not just the new technologies, but the rationales for selection crops for each farmer's situation. Involving grade schools on the theory and practice of SIIL shows promise not just for the students but for involving the entire community in the systems logic of SIIL. Some women's groups are involved in monitoring and improving child and maternal health through innovative uses of the improved grains. The inclusion of the major cooperative organization and youth organization helps build sustainable linkages at the local level Recommendation: Monitoring the impact of the variety of groups in terms of changes in household well-being and the strength of the networks formed and their ability to expand membership or create new groups.
Technology Development		

Research effectiveness on crop systems agronomy & Improvement	8	Several research grants, Ph.D. and M.S. funded researches that are on-going. Importantly, those funded are studying in African institutions, with their research integrated into SIIL. The collaborating national and local institutions are quickly engaging in their own experiments with SIIL's agronomic innovations.
Effectiveness for soil health	6.5	Many of the implanted SI practices should contribute to soil health, and crops as showing positive responses, but here are no reported measurements on changes in soil health.
Effectiveness for plant nutrient-optimization	6	The measures of soil health we were shown was an initial soil test for fertilizer recommendations (currently there is a single fertilizer recommendation for the entire country) and then comparative crop health in field trials and on farmers' fields. There does not seem to be a regular measure for soil health, nor are farmers trained to observe it.
Effectiveness for water optimization (irrigation, waterharvesting, green & blue)	5	The major strategy to optimize water appears to be increasing the capacity of the soil to absorb water through diverse farming systems and constant group cover through new crop rotations.
Research effectiveness on farming systems integration—crop/livestock-trees-fish etc	7	The dual-purpose nature of the improved crops helps heighten the efficiency of the entire farming system. There are some measures of increased goat milk production at experiment stations. Research on appropriate mechanization through ripping rather than plowing takes into account the health of the animals doing the pulling. The improved stover has nutrients that contribute to animal health, which is mentioned by not monitored beyond milk production.
Capacity Building & Scaling		
Quality of Scaling concepts and design	5	Scaling does not appear to have been integrated into the project. Phase II should start with the research team and its collaborators discussing scaling out of a system of SI, developing a pathway(s) model, and seeing how their activities could be altered to enhance pathway achievement.

Effectiveness of scaling and dissemination activities	7	Since there are no pathways for scaling presented, scaling out appears to be occurring, but in an opportunistic way, based on the social entrepreneurship of the PIs in finding and involving new collaborators.
Effectiveness Formal Training (degree or certificate)	8	Several research grants, Ph.D. and M.S. funded researches that are on-going. Importantly, those funded are studying in African institutions, with the students involved in SILL research. These efforts could be enhanced through regular webinars (In French) with the students and their professors on a systems approach that optimizes specific disciplinary contribution.
Effectiveness Local and national capacity building (research, extension, NGOs, farmers)	7	Many research and extension professional and institutions are included in the research and field trials, increasing local and national capacity. More explicit consideration of a systems approach could increase that efficiency. A youth-oriented NGO is involved through collaboration with another FtF project. Farmers capacity is increased through the Master Farmer program and cooperatives.
Stakeholder Engagement		
Internal partners engagement, including USG	8	There seems to be relatively good engagement of the internal partners, despite some small conflicts between the two projects on equipment provided by SILL and other outside donors.
Effectiveness of policy engagement (local and national)	2	Policy engagement should be based on reducing the barriers to scaling out. Without pathways laid out, it has been difficult to address what local and national policies – of market, state, or civil society actors – need to be addressed. Personal connections have brought about changes in local school policy to implement SILL practices in an elementary school.
Effectiveness of youth activities	6	There has been no measurement yet of the effectiveness of youth activities, not has a definition of effectiveness been articulated. There is an implicit assumption that if schools and youth clubs can count more young people participating in instruction or projects, such activities are effective.
Effectiveness of gender activities	5	This has been a neglected part of the project. A gender specialist visited the project neither explicit recommendations nor changes were mentioned in any of the reporting.

Agribusiness engagement (corporate and MSMEs)	6	We saw no corporate engagement, and MSMEs participating mainly through purchasing some of the products.
Stakeholders engagement regional (public, banks, civil society)	6	Regional universities are involved, but there is no involvement of banks. Civil society is represented by the cooperative organization and youth clubs. In Phase II, after laying out pathways for scaling, banks need to be brought into the project to help them understand the viability of loans to women and youth to support SI related enterprises.
Stakeholders engagement national (public, banks, civil society)	6	The stakeholders involved at the national level are other research institutions and universities. No civil society groups were involved. To the degree that lending practices are involved in setting the rules for lending, they need meet with project researchers to discuss the to-be-formulated scaling out pathways to understand their potential role and the risks involved.
Stakeholders engagement local (public and civil society)	7	Appropriate local organization, particularly farmer organizations, are engaged, but there are few efforts that could be determined to inform the public and civil society.
Linkages to Mechanization (non-ASMC projects)	7	Some linkage to non-ASMC mechanization is in place, particularly with motorized machinery on experiment stations.
Linkages to Geospatial Consortium (for non-GeoSpatial projects)	4	They are received some equipment, but the nationally-controlled weather stations maintain their old methods of data collection and entry (by hand). There is a need for training in weather station management and in gathering and analyzing data from the drones from the project in order to be more effective. Apparently there was training on how to fly the drones, but not sufficient training on drone-gathered data and how to use them.

7.10 Reports, List of Publications and Presentations

FY2018 SIIL Annual Performance Report:

<https://www.dropbox.com/s/gvz5ga5ps34ct40/FY2018-SIIL-Annual-Performance-Report-Submitted-15-Nov.docx?dl=0>

7.11 Survey Questionnaire

(in-progress)

7.12 Travels Itineraries

Travel Itineraries for External Review by Evaluation Team and Management Entity

Date of Travel	Traveler(s)	Location(s)	Comments
11/4/18	John Dixon	Siem Peap	Evaluation field visit
11/5/18	John Dixon	Siem Peap	Evaluation field visit
11/6/18	John Dixon	Siem Reap	Evaluation field visit
11/7/18	John Dixon	Phnom Penh	Evaluation field visit
11/8/18	John Dixon	Phnom Penh	Evaluation field visit
11/9/18	John Dixon	Battambang	Evaluation field visit
11/10/18	John Dixon	Battambang	Evaluation field visit
11/11/18	John Dixon	Siem Reap	Evaluation field visit
9/24-9/28	Judee Fisher, Eric Kueneman	Purdue U, Lafayette, IN	Scale-up Conference, Innovatons in Agriculture
10/23/18	Peter Thorne, Vara Prasad, Jan Middendorf	Addis Ababa	Evaluation field visit
10/24/18	Peter Thorne, Vara Prasad, Jan Middendorf	Bahir Dar	Evaluation field visit
10/25/18	Peter Thorne, Vara Prasad, Jan Middendorf	Bahir Dar	Evaluation field visit
10/26/18	Peter Thorne, Vara Prasad, Jan Middendorf	Bahir Dar	Evaluation field visit
10/27/18	Peter Thorne, Vara Prasad, Jan Middendorf	Bahir Dar	Evaluation field visit
10/28/18	Peter Thorne, Vara Prasad, Jan Middendorf	Addis Ababa	Evaluation field visit
8/22/18	Cornelia Flora	Bambey, Senegal	Evaluation field visit
8/23/18	Cornelia Flora	Ngekokh, Senegal	Evaluation field visit
8/23/18	Cornelia Flora	Thies, Senegal	Evaluation field visit
8/24/18	Cornelia Flora	Dakar, Senegal	Onsite meeting
8/26-8/27	Cornelia Flora	Ouagadougou, Burkina Faso	Evaluation field visit
8/28/18	Cornelia Flora	Bobo Dioulasso, Burkina Faso	Evaluation field visit
8/30/18	Cornelia Flora	Ouagadougou, Burkina Faso	Onsite meeting

7.13 Chronology of Interviews & ET Meetings

SIIL EXTERNAL EVALUATION INTERVIEWS AND MEETINGS

Meeting/Interview	Date	Participants	Comments
Stakeholder re Bangladesh	7/9/18	John Dixon, Evan Christen, ex ACIAR RPM	Passing familiarity with Polder project; ASMC project n/k
Stakeholder re Bangladesh	7/10/18	John Dixon, Eric Huttner, ACIAR RPM	Detailed notes on multi-project exchange planned by polder and ACIAR projects
Stakeholder re Cambodia	7/16/18	John Dixon, Daniel Tan, PL, ACIAR Sustainable Intensification and Diversification project	Aware of CE SAIN but no awareness of the SIIL field activities
On site meeting, UCD	7/19/18	Judee Fisher, Eric Kueneman, Jan Mittendorf	Exploratory discussions on KC participation in SIIL external evaluation
ET Virtual Meeting	8/16/18	Judee Fisher, Eric Kueneman, Jan Mittendorf	Review scope of work
On site review, Agroforestry system, Biochar trial and other SIIL activities, Bambey, Senegal	8/22/18	Cornelia Flora, Jerry Glover, Vara Prasad, Aliou Faye	
On site review SIIL-PC-ISRA Experiment, Ngekokh, Senegal	8/23/18	Cornelia Flora, Jerry Glover, Aliou Faye, Vara Prasad	
On site review CERAAS Facilities, ANCAR, Thies, Senegal	8/23/18	Cornelia Flora, Jerry Glover, Aliou Faye, Vara Prasad	
On site review Keur Daouda Cisse, SIIL-PC-ISRA Technologies, Thies, Senegal	8/23/18	Cornelia Flora, Jerry Glover, Aliou Faye, Vara Prasad	
On site meeting ISRA Hq: DG Aliou Fall, Dakar, Senegal	8/24/18	Cornelia Flora, Jerry Glover, Aliou Faye, Vara Prasad	
On site meeting USAID Mission, Dakar, Senegal	8/24/18	Cornelia Flora, Jerry Glover, Vara Prasad; Aliou Fayer	
On site meeting PC Hq, Dakar, Senegal	8/24/18	Cornelia Flora, Jerry Glover, Aliou Faye; Vara Prasad	
On site review INERA, SARIA long-term field sites and other experiments, Ouagadougou, Burkina Faso	8/26/18	Cornelia Flora, Jerry Glover, Vara Prasad; Hamidou TRAORE, Aliou Faye	
On site review Farmer field sites, ILRI, INERA, Ouagadougou, Burkina Faso	8/27/18	Cornelia Flora, Jerry Glover, Vara Prasad, Hamidou TRAORE, Aliou Faye	
On site review Univ Bobo, Mechanization Hub, Bobo Dioulasso, Burkina Faso	8/28/18	Cornelia Flora, Jerry Glover, Vara Prasad, Hamidou TRAORE, Aliou Faye	

SIIL EXTERNAL EVALUATION INTERVIEWS AND MEETINGS

Meeting/Interview	Date	Participants	Comments
On site meetings CNRST-INRA-USAID-ILRI, Ouagadougou, Burkina Faso	8/30/18	Cornelia Flora, Jerry Glover, Vara Prasad, Hamidou TRAORE, Aliou Faye	
ET/ME Virtual Meeting	9/13/18	John Dixon, Judee Fisher, Cornelia Flora, Eric Kueneman, Jan Mittendorf, Vara Prasad	Clarification & orientation on scope of work for External Review
Scale-up Conference, Innovatons in Agriculture, Purdue Univ, Lafayette, IN	9/25-27/18	Judee Fisher, Eric Kueneman, Jan Middendorf	International Conference, Purdue Univ & AfDB; key input to understanding potential of scaling in SIIL Phase 2
External Evaluation Side Meeting, Purdue Univ	9/27/18	Judee Fisher, Eric Kueneman, Jan Middendorf	Refine scope of work
Scale-up Conference Side Meetings, Purdue Univ	9/25-27/18	Judee Fisher, Eric Kueneman, Jan Mittendorf with: Robert Bertram, Chief Scientist, USAID Bureau Food Security; Erin McGuire, Assoc Dir Horticulture Innovation Lab, UCD; Anthony Phan, Proj Analyst, Horticulture Innovation Lab; Brigitte Pfluger, Monitor & Eval Specialist, Lab for Livestock Systems, U FL; Peter Goldsmith, Principal Investigator, Soybean Innovation Lab; U IL; Nat Bascom, Asst Dir, Sorghum & Millet Innovation Lab, KSU	As relates to SIIL External Evaluation: central thematic on need to plan for scaling at the very onset of innovation testing; generally essential to build strategic alliances across stakeholders in value chain/impact pathway; research on extension methodologies efficient for SI adoption is urgently required
ET virtual interview with ME	10/9/18	Judee Fisher, Cornelia Flora, Eric Kueneman, Jan Middendorf, Vara Prasad	Scaling innovs, new phase, optimization systems research
Small Scale Irrigation Lab virtual interview	10/9/18	Neville Clarke, Dir SSIL, PI SIIL, TX A&M AgriLife Rsrch; Nicole Lefore, Sr Proj Mgr IWMI, SA	Principal Investigator SIIL field program. Interactions between ILSSI & SIIL ASMC, parrrticularly in Ethiopia
On site interview, UCD	10/10/18	Aliou Faye, SIIL Senegal, Judee Fisher, Eric Kueneman	SIIL Senegal partnerships with Peace Corp, local U's & Public Schools, Extension & Farmer Orgs; need to consider perennials including for living fence for livestock browse and controlled grazing
Remote	10/10/18	John Dixon, Jan Mittendorf	Report structure
ET virtual meeting	10/11/18	John Dixon, Judee Fisher, Eric Kueneman	Interim Report, upcoming interviews,
Sustainable Intensification Assessment Framework (SIAF) virtual interview	10/12/18	Judee Fisher; Eric Kueneman; Mark Msumba, PhD Cand Ag Econ, TX A&M & U FL; Cheryl Palm, Soil & Land Mgt, U FL; Sieglinde Snapp, Soils & Crop Syst Ecol, Dept Plant, Soil & Microb Sci, Cntr Global Change & Earth Observs, MSU	Success (rapid adoption) of SIAF across FtF is encouraging opportunities to apply the SIAF routinely in SIIL innovation planning and implementation

SIIL EXTERNAL EVALUATION INTERVIEWS AND MEETINGS

Meeting/Interview	Date	Participants	Comments
Appropriate Scale Mechanization Consortium	10/16/18	John Dixon, Eric Kueneman, Judee Fisher, Cornelia Flora, Alan Hansen, Leader, PI SIIL, U IL, Urbana-Champaign; Tim Rendall, Proj Mgr, Tech Syst MGT, U IL Ur-Ch,	Mechanization program of work, achievements, constraints & opportunities
SIPSIN partner interview	10/16/18		Role of ILRI in SIPSIN
GeoSpatial & Farming Systems Research Consortium on-site review, UCD	10/17/18	Eric Kueneman; Robert Hijmans, Leader GSP, Prof Environ Sci & Policy, UCD; Aniruddha (Ani) Ghosh, GSP Proj Sci, Asst Proj Sci Environ Sci & Policy Dept, UCD & Sierra Mabanta, GIS Intern UCD	Geospatial program of work, constraints & opportunities
FtF Innovation Labs on-site review, UCD	10/17/18	Nancy Allen, Soc, Indep Consult, Intl Prog UCD & Levy McGarry, Commun Spec, Intl Prog Ofc,	Proj: Review & Report Best Bet Innovs across USAID's FtF Labs (SIIL award); CA selected as 1 of 8 best bet innovs contributed by SIIL; SIIL's potential role in innov converg among Labs & ptrnrsh bldg
ET co-leaders virtual meeting	10/19/18	John Dixon, Eric Kueneman	Review evaluation progress
Channaty Ngang, Grad Student, Battambang U, Cambodia, virtual interview	10/22/18	Eric Kueneman & Channaty Ngang, MS Cand, U Battambang; CA hort w/drip proj SIIL ASMC/Hort Lab; SIIL WAgN, Battambang	CA permanent raised bed horticulture (CIRAD soil analysis support), Cambodia
Polder project interview	10/23/18	John Dixon, Krisha Jagadish, Sudhir Yadav, Manoranjan Mondal	Constructive and detailed interview structured around the evidence of the the matrix; cl with good documentation nearly well organised team
SIPSIN partner interview	10/23/18	Peter Thorne, Vara Prasad, Jan Middendorf	Role of IWMI in SIPSIN
SIPSIN Partner Meeting	10/24/18	Peter Thorne, Vara Prasad, Jan Middendorf	Presentation of SIPSIN by in country teams
Fatou Tine	10/25/18	Eric Kueneman & Fatou, PhD Cand VT	Cropping systems agron millet, cowpea, groundnuts in Senegal
Meeting with BDU president	10/26/18	Peter Thorne, Vara Prasad, Jan Middendorf, Firew Tegegne Amogne	Project briefing and possible future collaboration with BDU
ET co-leaders virtual meeting	10/26/18	John Dixon, Eric Kueneman	Review progress
Polder project interview	10/26/18	John Dixon, Krisha Jagadish, Sudhir Yadav, Manoranjan Mondal	Good gapfilling interview, particularly focused on evidence related to tentative matrix evaluations
Stakeholder Cambodia	11/1/18	John Dixon, Deputy Secretary General, Council of Ministers, Cambodia	Recognition of USAID assistance to Cambodia but critical of lack of engagement with Government
Meeting with Tanzania project leader	11/2/18	Peter Thorne, Seiglide Snapp	Briefing on prokect aims and progress.

SIIL EXTERNAL EVALUATION INTERVIEWS AND MEETINGS

Meeting/Interview	Date	Participants	Comments
Siem Reap -- Project staff and stakeholders, field	11/4/18	John Dixon, Ren Ry, WAgN technician; Tim Tandall, ASMC Program mgr; Stephane Boulakia, CIRAD; Florent Tivot, CIRAD	Stephane started CA in Cambodia in 2004. Ren Ry was formerly HORT IL technician.
Siem Reap - field visits	11/5/18	John Dixon, Dave Ader – Co-PI of WAgN, University of Tennessee; and also Co-PI of the Living Fence project, LIVE IL; Farm women and men; Srey Tha, Field Technician. Jessie Vipham's/Zach Stewart's complex trial in Siem Reap; Siem Reap Aggie Tech Park Farm Manager	Complex cross-funding. Some excellent US and Cambodian staff.
Siem Reap Agroecology Conference: numerous stakeholders and project staff	11/6/18	John Dixon, Numerous project and CGIAR staff; World Vision; Bob Martin, ACIAR; Lytour Lour, Dean RUA, Faculty of Agricultural Engineering; Saruth Chan, Director, Department of Agricultural Engineering, MAFF; Ngang Channaty – Field Technician of ASMC project in Battambang	Well attended conference. Good opportunity for networking and checking with stakeholders
Phnom Penh; Kampong Thom Teck Park	11/7/18	John Dixon, Iain Russell, FAO Policy Adviser; Deputy Secretary General, Council of Ministers; Vira Leng, MAFF/Conservation Agriculture Service Center team; Farm manager of Kampong Thom Tech Park	National commitment to nutrition. Strong donor interest in regional CA training center based in Cambodia
Phnom Penh; RUA; CARDI	11/8/18	John Dixon, RUA Aggie Tech Park, Farm manager Ms. Sopheak Noun; Lyda Hok and CE SAIN staff; numerous CE SAIN scholars and research grant recipients (mostly lecturers, RUA); several SEARCA scholars; 9 undergraduate CE SAIN scholars supported by the USF; H.E. Dr/ Ngo Bunthan, Rector Royal University of Agriculture; Dr. Ouk Makara, Director, CARDI; Jim Hershey, American Soybean Association; Dr. Saruth Chan	Strong RUA commitment; multiple sources of scholarship funding; strong GDA Engineering commitment and link to Asian Engineering Association.

SIIL EXTERNAL EVALUATION INTERVIEWS AND MEETINGS

Meeting/Interview	Date	Participants	Comments
Travel to Battambang	11/9/18	John Dixon, Aggie Tech Park, Battambang; Pao Srean, Dean, College of Agriculture, University of Battambang; Bob Martin, University of Sydney; Farm manager, Battambang Aggie Tech Park; Hor Sanara, Dean RUA, Faculty of Land Management and Land Administration, PI, RUA Geospatial Research Consortium; Nut Nareth, Lecturer Faculty of Agricultural Engineering, Ph.D. CE SAIN Scholar, using the drone for research advised by Sanara. Nareth and Sanara both got National Science Foundation Grant to do SWAT research; H.E. Rector Siem Emtotim, Rector, University of Battambang; Rechaney Sel, Masters, UPLB/SEARCA scholar; Sreyngat Lo, Master's student, UBB; Kit Magellan, UBB.	
Field visits, Battambang	11/10/18	John Dixon, CA vegetable farmers; CA lowland rice farmers; CIMMYT, IRRI and CIRAD scientists; upland CA farmers including Crotalaria juncea cover crops	Excdellent adaptive field research; limited data collection; mixed approaches to farmer evaluation; some CIRAD farm gaming
Travel; departure	11/11/18	John Dixon, Yorn Try, Vice-Rector, University of Meanche	
WAgN virtual interview	11/12/18	David Ader, UTK, Ricky M. Bates, PSU Cornelia Flora, Leif Jensen, PSU	Women in Ag Network, Cambodia
SIIL Lab ET virtual meeting	11/13/18	John Dixon, Judee Fisher, Cornelia Flora, Eric Kueneman, Peter Thorne	Report progress review
SIIL Lab ET virtual meeting	11/19/18	John Dixon, Judee Fisher, Eric Kueneman, Jan Mittendorf, Vara Prasad	Discuss relationship between SIIL and other innovation labs & future SIIL field programs priority changes
SIIL Lab ET virtual meeting	11/20/18	John Dixon, Judee Fisher, Cornelia Flora, Eric Kueneman, Peter Thorne	Report progress review
SIIL Lab ET virtual meeting	11/27/18	John Dixon, Judee Fisher, Cornelia Flora, Eric Kueneman, Peter Thorne	Report progress review
SIIL Lab ET virtual meeting	12/4/18	John Dixon, Judee Fisher, Cornelia Flora, Eric Kueneman, Peter Thorne	Report progress review
SIIL Lab ET virtual meeting	12/11/18	John Dixon, Judee Fisher, Cornelia Flora, Eric Kueneman	Report progress review

7.14 Photographs

7.14.1 Burkina Faso Photographs



Burkina Faso farmer explaining field trials TO women's group



Burkina Faso multi-purpose cow pea innovations demonstrated to village farm families



Burkina Faso Perennial Tree Innovation (Moringa nursery) in SI women's field program, Burkina Faso, targeting improved nutrition and income generation

7.14.2 Cambodia Photographs



John Dixon and Manny Reyes, Cambodia, November 2018



Cambodia: researcher in conservation agriculture cover crop



Cambodia: John Dixon and national scientists at sorghum and cassava research trials



Cambodia John Dixon, Manny Reyes and farmers at Rice+Fish innovation site



Cambodia John Dixon, Manny Reyes and research team



Cambodia Manny Reyes students Center of Excellence



Cambodia No till planting into crop residue



Cambodia: Woman farmer in raised beds conservation agriculture horticulture



Water holding tank for pressurized drip irrigation horticulture



CA Horticulture with heavy mulch on raised beds in Cambodia



Cambodia: Rice+Fish integrated system

7.14.3 Ethiopia Photographs



Dr Seifu, lead researcher BDU, explains the research conducted on CA vegetable production from raised beds under drip irrigation



The storage and delivery system for drip irrigation under experimental CA and non-CA cultivation



This solar panel is used to power the Magipump for water lifting



Water drawn from shallow wells using the Magipump is stored in 500 litre tanks for delivery via the drip irrigation system



Without drip irrigation, women farmers wishing to practice irrigation would have to resort to more labor intensive water lifting by hand and delivery by watering can



Women farmers share their experiences of SI with project leaders and members of the SIIL Management Entity



“Water quality measurements undertaken by the project are generating important findings around nutrient and chemical contamination that could potentially have great significance for human well-being”



“Without drip irrigation, water lifting is a laborious task that is usually undertaken by women (although for this demonstration, the male researcher elected to lead)”

7.1 Matrix

Annex: Compiled Evaluation Matrix

Explanation. In order to support the evaluation of each Consortium and country Award, the Evaluation Team identified a set of 33 criteria in relation to SI themes, technology development, capacity building and scaling, and stakeholder engagement. The criteria were scored from 1 (very weak) to 9 (very excellent) by individual Evaluation team members based on the documentation, interviews and field visits to each Award, and hence are subjective and non-comparable across Awards. Each score was supported by explanatory notes and in many cases by strategies, publications or science reports. The detailed explanatory notes are provided in the country and Consortium annexes. As an indication of the comprehensiveness of the assessment, the full compiled Annex appears in this Annex. It is noteworthy that several PIs commented on the relevance and effectiveness of the scoring matrix for their own Award, and how the evidence and scoring process led the project teams to look in a different way at their research work – after all, one of the important benefits of evaluations.

7.1.1 Compiled Matrix Scoring

SIIL's Compiled Matrix

Scoring 1 to 9 or N/A (color coded)	1.0	2.0	3.0	4.0	5.0	6.0	7	8	9	N/A
Evaluator	JD	JD/EK	EK	JD	JD	JD	PT	PT	CF	CF
Network/Country	WAgN	ASMC	GFC	CeSAIN	Bangladesh	Cambodia	Ethiopia	Tanzania	Burkina Faso	Senegal
Over-Arching Central SI Themes										
Relivance to National and Regional Needs	7.0	8.0	3.0	8.0	8.0	8.0	7.0	7.0	8.0	8.0
Relivance to SIIL	8.0	8.0	7.0	8.0	9.0	8.0	8.0	6.0	9.0	9.0
Overall effect on systems resilience	7.5	7.0	3.0	6.5	6.0	6.5	6.0	5.0	8.0	8.0
Overall effect on systems sustainability	7.0	7.0	3.0	N/A	N/A	N/A	5.0	5.0	N/A	N/A
Overall effect on systems productivity	6.5	8.0	3.0	6.5	8.0	8.0	5.0	7.0	8.0	8.0
Number and quality of journal and other publications	5.0	5.0	5.0	7.5	7.0	6.0	0.0	6.0	2.0	2.0
Goodness of fit for US Universities' value propositions vs NGOs	7.0	6.0	7.0	8.5	8.0	9.0	N/A	N/A	8.0	8.0
Data quality, analysis and open access sharing	6.5	5.0	8.0	6.0	7.0	7.5	N/A	N/A	6.0	6.0
Impacts on human nutrition (quantity, quality, safety)	7.0	5.0	3.0	6.0	5.5	7.0	0.0	7.0	6.0	6.0
Livelihoods impact (current and expected) from scaling	6.5	4.5	3.0	7.0	6.5	7.5	7.0	7.0	N/A	7.0
Effectiveness of SI (SIAF) application	6.5	6.0	4.0	6.5	7.5	7.0	5.0	5.0	8.0	8.0
Overall effectiveness of systems research/linkages	6.0	6.5	4.0	7.5	8.0	8.0	4.0	4.0	8.0	8.0
Farming systems characterization and design	6.0	6.0	5.0	6.0	8.0	6.5	7.0	6.0	6.0	6.0
Effectiveness of social capital activities (FFS, AIPs, community/farmer groups,...)	6.0	7.0	3.0	6.0	6.5	7.0	4.0	4.0	7.0	7.0
Technology Development										
Research effectiveness on crop systems agronomy & Improvement	6.5	7.0	3.0	7.0	8.0	7.5	7.0	8.0	8.0	8.0
Effectiveness for soil health	6.0	7.0	5.0	6.5	N/A	6.5	5.0	8.0	6.5	6.5
Effectiveness for plant nutrient-optimization	N/A	6.0	6.0	N/A	N/A	5.0	7.0	7.0	6.0	6.0
Effectiveness for water optimization (irrigation, waterharvesting, green & blue)	6.0	6.5	3.0	6.5	N/A	6.5	8.0	N/A	5.0	5.0
Research effectiveness on farming systems integration (crop/livestock-trees-fish etc.)	7.5	3.5	3.0	7.0	N/A	6.5	7 & 5	5.0	7.0	7.0
Capacity Building & Scaling										
Quality of Scaling concepts and design	6.0	4.0	N/A	7.0	7.5	7.0	3.0	5.0	7.0	5.0
Effectiveness of scaling and dissemination activities	6.5	3.0	4.0	8.0	N/A	6.5	2.0	6.0	7.0	7.0
Effectiveness Formal Training (degree or certificate)	8.0	6.0	6.0	9.0	8.5	7.5	7.0	6.0	8.0	8.0
Effectiness Local and national capacity building (research, extension, NGOs, farmers)	7.0	7.0	6.0	7.5	7.5	8.0	4.0	6.0	7.0	7.0
Stakeholder Engagement										
Internal partners engagement, including USG	7.0	8.0	7.0	7.0	8.0	7.5	4.0	6.0	8.0	8.0
Effectiveness of policy engagement (local and national)	4.0	4.0	2.0	3.0	5.0	7.0	3.0	5.0	2.0	2.0
Effectiveness of youth activities	7.0	5.0	4.0	9.0	N/A	7.5	N/A	N/A	6.0	6.0
Effectiness of gender activities	7.0	5.0	6.0	N/A	7.0	6.0	7.0	6.0	5.0	5.0
Agribusiness engagement (corporate and MSMEs)	5.0	5.0	3.0	8.0	7.5	7.5	1.0	N/A	6.0	6.0
Stakeholders engagement regional (public, banks, civil society)	6.0	3.0	3.0	7.0	7.5	8.5	5.0	N/A	5.0	6.0
Stakeholders engagement national (public, banks, civil society)	7.0	4.0	2.0	6.5	7.0	7.0	N/A	5.0	6.0	6.0
Stakeholders engagement local (public and civil sociaety)	7.5	6.0	3.0	7.0	7.0	6.5	7.0	7.0	5.0	7.0
Linkages to Mechanization (non-ASMC projects)	7.0	N/A	2.0	6.0	6.0	6.0	7.0	N/A	5.0	7.0
Linkages to Geospatial Consortium (for non-GeoSpatial projects)	5.0	3.0	N/A	4.0	5.0	7.0	N/A	N/A	5.0	4.0