



FEED THE FUTURE

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

Feed the Future Innovation Laboratory for Small Scale Irrigation (ILSSI)

Year 5 (FY 2018) Semi Annual Report

October 1, 2017 – March 31st, 2018

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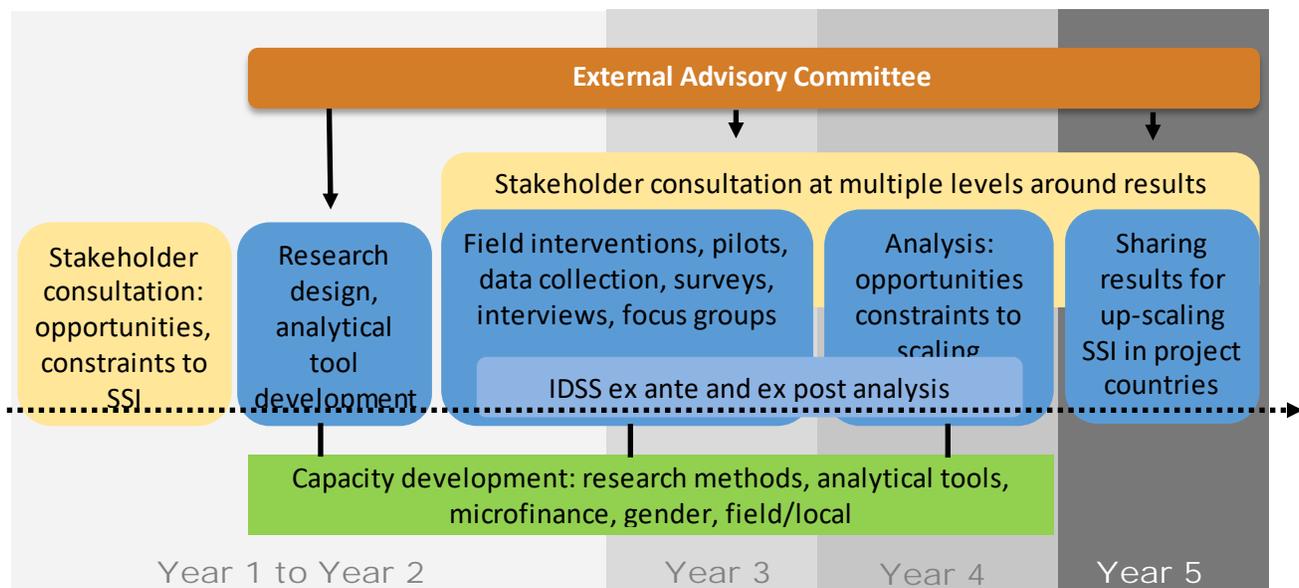
I. Forward

The Feed the Future Innovation Laboratory for Small Scale Irrigation (ILSSI) is led by the Borlaug Institute for International Agriculture of the Texas A&M University System (BI/TAMUS). Partners in the five year cooperative agreement include the International Water Management Institute (IWMI), the International Food Policy Research Institute (IFPRI), the International Livestock Research Institute (ILRI), North Carolina A&T State University (NCA&T) and Texas A&M AgriLife Research (TAMAR). National universities and other institutions, participating actively in field and household survey research, are sub-contractors to international center partners.

The collaborators of this cooperative agreement are conducting research aimed at increasing food production, improving nutrition, accelerating economic development and contributing to the protection of the environment. The major components of this cooperative agreement are: (1) the assessment of promising small scale irrigation (SSI) technologies; (2) stakeholder consultation at multiple levels of scale to define and evaluate the interventions used in field studies; (3) engagement with national partners and farmers for conducting field studies; (4) surveys of farm families in the region surrounding field test sites; and (5) integrated analysis using the Integrated Decision Support System (IDSS) of the production, environmental and economic consequences of small scale irrigation options, including but not limited to interventions actually studied in farmers' fields. Capacity building and training at multiple levels of scale are also substantive elements of the agreement.

This report covers the first two quarters of the fifth year (October, 2017 to April, 2018) of the cooperative agreement. In the first half of the fifth year, field studies and household surveys were mostly completed and constraints analysis and scaling studies taking results from local to national levels were well advanced. The USAID external review was completed, and the ILSSI International Symposium was held in Washington, D.C on January 30-31, 2018. Figure 1 below summarizes the major components of the ILSSI project.

Figure 1. Summary of the Major Elements of ILSSI



II. Executive Summary

The ILSSI project has completed 4.5 years of the cooperative agreement. The following highlights key activities thus far from year five.

- A successful [ILSSI International Symposium on Irrigation in African Small Holder Farming Systems](#) was held during January 2018 following a World Bank Forum ([Water for Food International Forum \(Farmer Led Irrigated Agriculture: Seeds of Opportunity\)](#)); ILSSI staff and external advisory committee members participated in the session focusing on converting and scaling up potential technologies from trial phase to larger scale application of small scale irrigation in developing countries. There were 85 participants; including several USAID staff and important stakeholders from the World Bank and other key institutional partners. The meeting was also live streamed with online attendance of 110 viewers.
- [The USAID External Review of ILSSI](#) was reported in November 2017. The report was favorable in terms of leadership and accomplishments with a recommendation for continuation of ILSSI beyond the initial five year cooperative agreement. Specific recommendations were made with emphasis on research to take promising results to practice with several stakeholder communities.
- A webinar on irrigation and gender on Agrilinks (*Can small-scale irrigation empower women? Insights from the Feed the Future Innovation Lab for Small-Scale Irrigation*) was conducted in October 2017. Some of the key messages from the webinar included: a) SSI diffusion approaches and technologies can be designed to better meet women's preferences and fit their needs, b) SSI has potential to reduce both men and women's workload and increase income, and c) By meeting multiple needs and reducing labor intensity of technologies, SSI can reduce women's time burden. For more detail, see link [here](#).
- Research findings during this time period indicate that small scale irrigation interventions can increase yields and incomes and ensure the sustainable use of water resources. During this semiannual period, the ILSSI project has provided small scale irrigation suitability assessments that could potentially benefit around 2.6 million beneficiaries (0.6 million in Ghana and 2 million in Tanzania), with a potential to generate profits up to \$1.5 billion per year (\$0.2 billion in Ghana and \$1.3 billion in Tanzania).
- In Ethiopia, conservation agriculture practices provided higher yields – which is 35% and 83% higher compared to conventional tillage practices, respectively. Moreover, the application of mulch helped to improve the water productivity in the conservation agriculture practice.

III. Research Progress Summary

This year five semiannual report is organized according to the ILSSI work plan and objectives for years four and five and the newly mandated USAID guidelines for reports. A detailed overview of the ILSSI research progress can be found [here](#).

Field Research

Research in farmers' fields, including crop harvesting for final trials, was scheduled for completion in March 2018 but was slightly extended into May 2018. Clean up and analysis of data by national and

international partners is currently underway. These data and initial analysis are being delivered for more detailed analysis to the IDSS team. Reports are being drafted on infrastructure development, including microfinance and sale/maintenance of irrigation equipment. The development of a fodder value chain in Ghana is being completed and results on sale of fodder as a cash crop continue to be very positive. Results on commercial kitchen garden studies indicate increased income, reduced soil loss, and reduction of irrigation water required for optimal production using this system compared to conventional tillage. Improved water management methods at the farm level, using an integrated systems approach is creating both increased income and enhanced dietary diversity at the household level. Use of the wetting front detector provides a simple means of applying the proper quantity of water, when needed.

Household Surveys

During this reporting period, IFPRI implemented the endline household survey in Ghana, which concludes all six survey rounds planned under ILSSI. The IFPRI team also spent time on cleaning the endline household survey data for Ethiopia and Tanzania. The IFPRI team made substantial progress on a first paper for northern Ghana irrigation-nutrition linkages over the reporting period. Moreover, IFPRI 1) resubmitted the first irrigation-nutrition paper, following comments from external partners; 2) submitted the qualitative gender-irrigation study with IWMI to the journal of [Agriculture and Human Values](#); and 3) published a second [ILSSI policy note on irrigation](#), also with IWMI. A series of results from the household surveys were presented at an AGRILINKS webinar on October 31 with the title “Can small-scale irrigation empower women? Insights from the Feed the Future Innovation Lab for Small-Scale Irrigation” and again during the ILSSI final symposium in January 2018.

Key messages from the AGRILINKS seminar focused on irrigation-gender linkages include:

- SSI diffusion approaches and technologies can be designed to better meet women’s preferences and needs and to potentially avoid increasing inequalities.
- SSI has the potential to reduce men’s and women’s workload and increase income. By meeting multiple needs and reducing labor intensity of technologies, SSI can reduce women’s time burden as well.
- Concerted efforts must be made to ensure that access to necessary and relevant information, credit, and other resources adequately reach women.

IDSS

The IDSS results of field and analysis studies provides an integrated ILSSI result across all components of the project.

Ethiopia- The effect of Conservation Agriculture (CA), together with different irrigation management practices, was studied to understand the impact on onion production, household income, and nutrition in the Dangesheta watershed, Ethiopia. The study explores water use efficiency of the different scenarios and impact on environmental sustainability at the watershed level. The biophysical analysis considered field-collected data from 51 field plots (i.e. 10 m by 10 m) of small-holder farmers in the Dangesheta watershed. Watershed level analysis in Dangesheta indicated that the average annual surface runoff was between 195 mm to 300 mm, while the average annual groundwater recharge ranged from 285 mm to 456 mm. The significant amount of shallow groundwater recharge at the watershed scale suggests that small-scale irrigation can be possible using shallow groundwater to cultivate vegetables during the dry season. The field data indicated that Conservation Agriculture-Crop Water Requirement (CA-CWR) practice had a higher yield compared to other practices. The CA-CWR had a 35% and 83% higher yield compared to Conservation Tillage-Crop Water Requirement (CT-CWR) and Conservation Agriculture-Farmer Irrigation Practice (CA-FTP) practices, respectively

Ghana- IDSS analysis was conducted at the national level in Ghana to assess the biophysical and socio-economic potential of small-scale irrigation. Potential suitable land for small scale irrigation was estimated with multicriteria evaluation in GIS using physical land features (land use, soil, and slope), climate characteristics, and access to market. The SWAT model was also developed to estimate the water resources potential, irrigation water requirement, crop production and soil loss at a 10 km by 10 km grid for the entire Ghana. The best available data, e.g. 250 m resolution AFSIS soil, disaggregated land use data based on the Spatial Production Allocation Model (SPAM), climate and household survey crop information, was used for the upscaling analysis. The SWAT analysis considered cultivation of vegetable crop and fodder during the dry season. Agent Based Model (ABM), which takes output data from SWAT model, potential land suitability map and household survey data, was also developed to estimate the socio-economic development potential of small-scale irrigation across Ghana and geographic locations where such development is most likely to occur. The land suitability for small scale irrigation analysis showed that slope and rainfall deficits were the most important factors, followed by population density and soil characteristics. The value of suitability ranges between 26% (least suitable) and 94% (most suitable). Taking 80% as the suitability threshold, there is about 21,000 km² suitable area for small scale irrigation in Ghana. More than \$285 million USD per year can be generated from small-scale irrigation implementation in Ghana benefiting more than 690,000 people. The most productive areas for small-scale irrigation during the dry season are in the northeastern part of the country.

Tanzania – in collaboration with IFPRI the upscaling analysis was completed and that the preliminary result from this study were presented at the international conference in January. Further during this quarter the preliminary suitability analysis was started, with expected completion in the 4th quarter.

Collaboration with other Feed the Future activities and Related Programs

Collaboration on field studies with [Africa RISING](#) was completed and reports are being shared with collaborators. The Sustainably Intensified Production Systems Impact on Nutrition (SIPSIN) study continued in this reporting period with active collaboration among three FtF Innovation Labs (ILSSI, Sustainable Intensification Innovation Laboratory <SIIL> and Nutrition Innovation Laboratory <NIL>). SIPSIN is a contract between Texas A&M AgriLife Research and SIIL that provides one million dollars over four years for a highly integrated collaboration with ILSSI.

Field studies and household surveys are generating data for further analysis using the IDSS. The ILSSI team is exploring with SIIL the application of the IDSS as one of the tools in the SIIL sustainable intensification assessment framework. Field data collection on the joint pilot study in Uganda with the [Horticulture Innovation Laboratory](#) (HIL) has progressed to the point where initial analysis using the IDSS is underway to assess the utility of the analytic method for the broader HIL portfolio.

As part of the SIPSIN collaboration the data generated by evaluation of Commercial Kitchen Gardens in two separate studies in Ethiopia has been integrated and analyses completed using primarily APEX and FARMSIM. This report compares the biophysical and socio-economic impacts of 1) Conservation Agriculture which includes use of mulch and irrigation based on crop water requirement (CA-CRW), 2) Conventional Tillage with irrigation based on crop water requirement (CT-CRW), and 3) Conservation Agriculture with irrigation based on farmers irrigation practice (CA-FTP) in the Dangeshita watershed in Ethiopia. The CA-CWR practice provided higher yield – which is 35% and 83% higher compared to CT-CWR and CA-FTP practices, respectively. Moreover, the application of mulch helped to improve the water productivity in the CA-CWR practice, which suggests that mulch application integrated with appropriate irrigation management system can enhance production in a sustainable manner. The three irrigation practices provided a positive economic return compared to baseline condition over the five-year planning horizon; however, superior results were obtained for the CA-CWR practice. The impact on

family nutrition awaits further studies by IFPRI, but FARMSIM predictions are that it is enhanced with conservation agriculture.

Progress towards benchmarks and indicators

Progress towards benchmarks and indicators for this reporting period are characterized by the following activities:

Ethiopia--The ILSSI IDSS team conducted a training workshop from 18-29 December, 2017 in Adama, Ethiopia, at the request of the Ethiopian Ministry of Agriculture and Natural Resources (MoANR) and Ethiopian Agricultural Transformation Agency (ATA).

The participants, both female and male, for the training were invited from different institutions engaged in agriculture, natural resources, forestry, water, energy sectors, and higher education institutions.

Table 1. Gender disaggregated participants of the ATA and MoANR tailored IDSS training at Adama from December 18-29, 2017.

Model	Female	Male	No. of Participants
GIS	3	52	55
SWAT	1	30	31
APEX	1	17	18
FARMSIM	1	5	6
AutoCAD	0	18	18
Advanced SWAT	1	8	9

Ghana- IWMI conducted two training sessions for farmers, data collectors, and other local stakeholders (extension, local government and agriculture departments, and community authorities) for each field site area. The training topics included:

1. Training sessions for farmers on the wetting front detector and irrigation scheduling in Ghana (10th and 13th January 2017), totaling 32 farmers (16 men and 16 women)
2. Training on data collection related to field water calibration and experimental data collection

Table 2: Short-term training summary

Country	Subject	Number of Males	Number of females	Organization/Affiliation	Date of training	Location
Ghana	Data collection	2		Private sector	10-13 Jan 2018	Bolgatanga; Tamale
Ghana	Irrigation scheduling and tools	16	16	Farmer producers	10-13 Jan 2018	Bihinaayili; Zanlerigu

Tanzania-Stakeholder meetings to develop fodder markets in Babati district in Manyara regions were held. These meetings targeted actors in the fodder value chains including producers (the farmers), fodder traders, transporters, consumers, research and extension officers. Meetings explored issues that could trigger and or deter them to produce and engage in fodder marketing:

Stakeholder assessments of opportunities to develop fodder markets:

- The current government policy of Tanzania restricts cattle movement to reduce conflict between crop and livestock farmers, which stimulates and catalyze production of irrigated fodder in irrigation schemes
- Improved animals require higher quality fodder
- Climate change results in longer dry periods and fodder scarcity
- Fodder traders attended the meeting ascertained that fodder demand fodder is high and fodder trading infrastructure exists in bigger cities like Arusha but also in the peri-urban areas and within villages.

Stakeholder assessment of key challenges to developing fodder markets:

- Inadequate water for irrigation and under water scarcity farmers tend to give priority to crops irrigation
- The perishable nature of green fodder after harvest favors traders
- The fodder prices are highly seasonal and erratic
- Farmers identified a lack of clear pricing guidelines of fodder with traders setting the prices but not the producers
- Farmers discussed this at length during the meetings and concluded to form a fodder producers' association
- Transport of the fodder product to the markets can be a problem and farmers decided to establish joint fodder markets closer to the production areas.

IV. Human and Institutional Capacity Development

A. Short Term Training on IDSS (Institutional Capacity Development)

The ILSSI IDSS team conducted a training workshop from 18-29 December, 2017 in Adama, Ethiopia, at the request of the Ethiopian Ministry of Agriculture and Natural Resources (MoANR) and Ethiopian Agricultural Transformation Agency (ATA).

The participants, both female and male, for the training were invited from different institutions engaged in agriculture, natural resources, forestry, water, energy sectors, and higher education institutions.

The IDSS training was conducted over a two week period. From December 18-20, GIS Application to Water Resources Management was conducted. A total of 55 participants were trained in this component of the training session (Table 1 and Appendix II). From December 21-27, training was conducted on three IDSS models, including SWAT, APEX, and FARMSIM. From December 28-29, AutoCAD Application for Engineering Design, and Advanced Soil and Water Assessment Tool (ASWAT) training were provided independently. There were 18 and 9 participants for the AutoCAD Application for Engineering Design and Advanced SWAT training, respectively (Table 1, Appendix II).

Over the two week period, participants engaged in different components of the IDSS training, namely SWAT, APEX, FarmSIM, GIS Application to Water Resources Management, AutoCAD Application to Engineering Design, and Advanced SWAT. Most of the participants attended training at least for two models and more than half attended training for all three models. Participants expressed their satisfaction with the content of the training and their confidence that the training will be beneficial when put into practice at their respective institutions.

Note: See Table 1 in the previous section for participant information.

B. Farm-Based Training (Human Capacity Development)

IWMI conducted two training sessions for farmers, data collectors, and other local stakeholders (extension, local government and agriculture departments, and community authorities) for each field site area. The training topics included:

1. Training sessions for farmers on the wetting front detector and irrigation scheduling in Ghana (10th and 13th January 2017), totaling 32 farmers (16 men and 16 women)
2. Training on data collection related to field water calibration and experimental data collection

Note: See Table 2 in the previous section for the short term training summary

C. U.S. Congressional staff visited Feed the Future programs in Ghana

U.S. Congressional staff visited Feed the Future programs in Ghana in February 2018 to assess progress, meet partners, and discuss US government strategy for engagement in the region. As part of this initiative, participants visited the ILSSI project site in Bihinaayili. The delegation interacted with farmers, in a discussion facilitated by Prof Saa Dittoh of University for Development Studies, a national partner in the project. The farmers showed the delegation the rapid uptake of small scale irrigation technologies and practices in the site since the project inception. Women farmers from the project also described the benefits from small scale irrigation, as they previously foraged for firewood during the dry season which required more labor with less certain and lower income.



Participants in the U. S. Congressional Staff Visit to Feed the Future projects at ILSSI site in Bihinaayili, Ghana

D. Innovation Transfer

ILSSI co-sponsored the 2nd Annual Amhara Agricultural Forum in Bahir Dar on 16 January. The theme was “Small Scale Irrigation and Agricultural Technologies for Sustainable Development in Amhara Region.” The forum brought together research institutions, government agencies and other agriculture related projects, including the Small Scale and Micro Irrigation Support project.

ILSSI research results were shared with farmers and other stakeholders (including extension and subject matter specialists) at an exhibition supported by Feed the Future in Fenote Selame in the Amhara region of Ethiopia on 27 January 2018. Graduate students prepared posters in Amharic and explained the potential for use of the Wetting Front Detector and Berken plow.

Further, ILSSI co-sponsored the first annual International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS) in Tamale, Ghana, from 30-31 October 2017. [ILSSI results](#) were shared at a special symposium organized by IWMI on “Small scale irrigation: A Colloquium on improving livelihoods through enhanced land and water productivity in Ghana.”

V. Scaling Partnerships

In addition to collaborations with other Feed the Future Innovation Labs, ILSSI also collaborates with many stakeholders to scale SSI approaches and technologies. Examples include: LIVES project which is funded by the Canadian Department of Foreign Affairs, Trade and Development (DFATD), Agricultural Transformation Agency (ATA), and Ethiopian Institute of Agricultural Research (EIAR) in Ethiopia. In Ghana stakeholders include International Development Enterprises (iDE) and The Animal Research Institute (ARI) while in Tanzania ILSSI partners with the Tanzania Animal Research Institute (TARI).

VI. Success Stories

Application of the Integrated Decision Support System (IDSS) by Government of Ethiopia

ILSSI has engaged the Ethiopian Agricultural Transformation Agency and the Ministry of Agriculture and Natural Resources in the application of the IDSS for planning and evaluating new national initiatives related to irrigation. At the request of these government agencies, a tailored two-week workshop was provided to their staff in December 2017 on the use of the IDSS models. ILSSI remains engaged and supportive of these agencies as they take up the use of the system internally. Similar engagements with government and private sector players are at an earlier stage of development in Tanzania and Ghana.

ILSSI International Symposium

The ILSSI International Symposium—*The Role of Irrigation in African Smallholder Farming Systems* was held at the Ronald Reagan Building in Washington, DC from January 30-31, immediately following the World Bank Water for Food International Forum. Senior ILSSI scientists and members of its External Advisory Committee were active participants in the World Bank Forum; the organizer of the World Bank Forum summarized results of the meeting to the ILSSI symposium. In addition to a review of ILSSI, panels of experts addressed adoption of technology by the private sector and other sponsors. A panel of African leaders and experts in water use discussed the factors affecting successful application of irrigation technology in Africa. There were 85 participants, including multiple USAID staff and administrators. The Symposium was live streamed and can be accessed [here](#).

BDU Incorporation of IDSS into Curriculum

Following their participation in multiple ILSSI training programs and research activities, the faculty and researchers of Bahir Dar University (BDU) voted to incorporate IDSS training into their curriculum repertoire. This represents a major success for ILSSI, as it supports long-term implementation (well beyond the scope of the ILSSI project) of IDSS modeling which will continue to have positive impacts at multiple levels in Ethiopia. Furthermore, this training will further strengthen the relationship between researchers and farmers. Further Information on the IDSS training can be found [here](#).

VII. Programmatic Issues Encountered During Time Period

ILSSI's international partners have offices with scientific and support staff in Ethiopia and Ghana but lack this level of in-country representation in Tanzania. This lack of personnel has made monitoring and evaluation and mentoring to national partners in Tanzania more challenging. Consequently, the quality and quantity of product and the timing of delivery from irrigation field studies in Tanzania is lower.

Additionally, Delayed budget disbursement led to postponement of sub-sub-contracting and implementation of activities in the three focus countries. This required resetting the dates for some activities and therefore anticipated completion dates for deliverables.

VIII. Future Work

The ILSSI team will continue to make progress in each of the programmatic areas. The following activities are planned for the remainder of year 5:

IWMI--Data collection from field studies is nearly complete; it is in the process of being cleaned and aggregated. Individual reports from each country are being completed and incorporated into the overall synthesis in annual and final reports. In the final months of the project, capacity development efforts will emphasize supporting and mentoring the students engaged in fieldwork to ensure theses completion. Also, IWMI will close out the project and share results following the finalization of interventions in the dry season in each country. Farmer forums and farmer learning exchanges will be carried out with farmers and local authorities (e.g. extension and/or agriculture department) at the subnational level. In addition, IWMI plans to interview farmers to gather information on what farmers learned, particularly toward understanding how knowledge and practices about SSI spread beyond the initial intervention plots. Field and local level engagement activities will be conducted in collaboration with ILRI and NCA&T to ensure synergies and comprehensive knowledge sharing. Capacity development materials related to the key technologies will also be completed and shared more broadly to support scaling efforts.

IFPRI--Household surveys have been completed and analyses are currently underway. A number of publications will be produced and an overall synthesis of results across countries will address nutrition, gender and economic consequences of small scale irrigation. Results will be integrated into the overall final report.

IDSS--For the remainder of year 5, the IDSS team will focus on integrating and organizing the results of ILSSI research. The ex post and constraints analyses for all three countries will be completed in year five. The socio-economic analysis for scaling up of small-scale irrigation for Ghana will be completed. Analysis for national level natural resources and socio-economic analysis will be completed for Tanzania. With funding provided by Texas A&M AgriLife Research, the previously developed demonstration model of a dashboard for the IDSS is being developed as an operational model. The national level dashboard is scheduled to be completed and evaluated this fiscal year. The national level dashboard will provide end-users with ready access to the power of the IDSS in a simplified yet powerful format. A second version of the dashboard for use at smaller levels of scale is planned as a separate future project.

Reporting--Preparation of the final and annual reports for ILSSI will be the major remaining activity to be completed in the second half of year 5. These longer reports will be supported by a number of individual specific reports that will be referenced in the full report. In addition, a large number of

manuscripts for peer-reviewed journal are in preparation and will be submitted before the end of ILSSI cooperative agreement. Manuscripts that are in active preparation are:

- Gap and constraints analysis on small-scale irrigation: investigation through integrated decision support system in a case in Robit watershed, Ethiopia
- Exploring potential to expand small-scale irrigation: a national assessment in Ethiopia
- Fodder nutrient and gaps and constraint analysis of production system in Ethiopia
- Water Resource Assessment, Gaps, and Constraints of Vegetable Production in Ethiopia
- Assessment of irrigation potential of Ghana using groundwater

Also, it is recognized that as compared Ethiopia and Ghana, the level of reporting in Tanzania is less. In response to the constraints on data collection in Tanzania, (low capacity in data collection methods, complex templates), ILSSI has developed an open access, online tool that enables detailed data collection for small scale irrigation trials. The tool captures geo-spatial information of the plot, general field conditions, labor, crop performance, amount irrigated and soil moisture. It additionally captures inputs used during the production cycle (fertilizer, seed type). The tool is adaptive for various modes of water lifting (rope and washer, motorized pump, solar) and application methods (bucket, furrow, drip). In Tanzania the following activities are being completed and prepared for reporting:

1. Field activities completed in March 2018 to assess feasibility of small motorized pumps for dry season irrigation
2. Field activities completed in January 2018 to assess feasibility of pocket garden for improving water use efficiency and household nutrition
3. Data collection is continuing for the hydrological and water resources assessment, measuring run off for the current rainy season (March – May 2018), including:
 - Times series of water levels in sites in both the downstream and upstream areas as well as meteorological data for the period up to March have been compiled ready and updated in the existing database
 - Water quality data for the sites within the study area were collected and are in the laboratory for analysis
 - Cross-sections for a river stretch between the upstream and downstream sites of Rudewa watershed were measured and analysed for flood risk analyses
 - Land use and land cover data analyses have been updated
 - Draft paper manuscript for mapping of surface water irrigation potential for the Rudewa watershed has been prepared by the national partner.
4. Social economic survey has been conducted and data is being analyzed

National Stakeholder Workshops--Capstone national stakeholder workshops (one day sessions) will be held in all three countries in the last half of May 2018. The product of these workshops will be a review of what has been accomplished and solicitation of advice from stakeholders on future applications of ILSSI products, especially those aimed at the private and government sector. Results of constraints analyses that follow the last set of stakeholder workshops will be summarized.

Stakeholder Engagements and Transition of Results-- Training at the farm and community level will be completed prior to the end of the cooperative agreement for farmers and local providers of supporting infrastructure. Engagements at the national level with staff of the ministries and with private organizations will be completed. These meetings will provide key insights for the ILSSI Exit Strategy.

Annex 1. Publications

Publications:

1. Watershed, Upper Blue Nile Basin *Land Degradation & Development*. 28; 4: 1386–1397. Moges, M.A., Schmitter, P., Tilahun, S.A. et al. Watershed modeling for reducing future non-point source sediment and phosphorus load in the Lake Tana Basin, Ethiopia. *J Soils Sediments* (2018) 18: 309. <https://doi.org/10.1007/s11368-017-1824-z>
2. Prossie Nakawuka, Simon Langan, Petra Schmitter, Jennie Barron (2017) A review of trends, constraints and opportunities of smallholder irrigation in East Africa *Global Food Security*. <https://doi.org/10.1016/j.gfs.2017.10.003>

Publications under review:

1. Bedru Balana, Jean-Claude Bizimana, James W. Richardson, Nicole Lefore, Zenebe Adimassu and Brian K. Herbst (2018). Economic Analysis of Small Scale Irrigation Technologies in northern Ghana. (*Journal of Agricultural Economics*; final draft and under internal review). [Note: This paper is prepared using FARMSIM modelling with TAMU]
2. Gebregziabher, G., Hagos, F., Lefore, N., Hailelassie, A., Barron, J. (2018). Analysis of impacts of household level water lifting irrigation technologies on poverty: An example from Ethiopia (Under IWMI review)
3. Teshager Assefa Sisha, Surafel Melak Dile, Gebrehaweria Gebregizabher (2017). Analysis of Technical Efficiency of Small Scale Irrigation Technologies in Two Selected Areas of Amhara Region, Ethiopia (*Journal of Development Economics*. submitted and under review)
4. Gebrehaweria Gebregziabher, Fitsum Hagos, Nicole Lefore, Amare Hailelassie (2018). A Multivariate analysis of factors influencing adoption of smallholder irrigation technologies (Draft under IWMI review)
5. Petra Schmitter, Nicole Lefore, Jennie Barron and Meredith Giordano. Improving on-farm water management through irrigation information for climate-smart agriculture in Sub-Saharan Africa (under review, *FAO Compendium on Climate Smart Agriculture*)
6. Walker, David; Parkin, Geoff; Schmitter, Petra; Gowing, John; Tilahun, Seifu; Haile, Alemseged; Yimam, Abdu. Understanding and improving confidence in recharge estimation: insights from a multi-method comparison study. *Hydrogeology Journal* Submitted and Under Review.

Conference presentations:

1. Adimassu, Z., Balana, B., Gebregzabher, S., Appoh, R., Cofie, O.O., Mul, M., Abdulai, A., Barron, J., Kadyampakeni, D., Ayambila, S., Gandaa, B. Z., Boakye-Acheampong, E. and Lefore, N. 2017. Small scale irrigation: Improving livelihoods through enhanced land and water productivity in Northern Ghana. International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
2. Kadyampakeni, D., Appoh, R., Barron, J., and Boakye-Acheampong, E. 2017. Analysis of Water Quality of Selected Irrigation Water Sources in Northern Ghana. International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
3. Balana, B., Appoh, R., Adimassu, Z. and Lefore, N. 2017. Economic Analysis of Small Scale Irrigation Technologies in northern Ghana. International Conference on Irrigation and

- Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
4. Adimassu, Z., Appoh, R., Balana, B., Lefore, N., Ayambila, S. and Cofie, O. O. 2017. Land and Water Productivity of Small-Scale Irrigation System in the Northern and Upper East Regions of Ghana. International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
 5. Adimassu, Z., Appoh, R., Cofie, O.O., Gandaa, B. Z. and Lefore, N. 2017. Improving on-farm water management with wetting front detectors in Northern Ghana. International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
 6. Balana, B., Abdulai, A. and Lefore, N. 2017. Micro and Rural Finance for Small Scale Irrigation Technologies and Tools: Evidence from Northern Ghana. International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
 7. Tetteh, R. 2017. Smallholder Irrigation Under Limited Water Supply in selected Communities of Northern Ghana. International Conference on Irrigation and Agricultural Development (IRAD) at the University for Development Studies (UDS). Tamale, Ghana, 30-31 October 2017.
 8. Balana B., Bizimana JC., Richardson JW., Lefore L., Adimassu Z., Herbst BK. (2018). Profitability and Economic Feasibility Analysis of Small Scale Irrigation Technologies in northern Ghana. Conference paper presented at the ‘Southern Agricultural Economics Association (SAEA)’ 2018 conference Jacksonville, Florida (USA), February 2-6, 2018.
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2. Adie A., Bezabih M., Yitayew A., Demeke B., Yeheyis L., and Blümmel M. 2018. Lessons from small scale irrigation forage production trials in the Amhara region: potential of integrating the perennial forage Napier grass with Desmodium and Pigeon Pea in cropping systems. Books of Abstracts p. 14
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