FEED THE FUTURE INOVATION LABORATORY FOR SMALL SCALE IRRIGATION

Semiannual Report

October 1, 2015 – March 31, 2016

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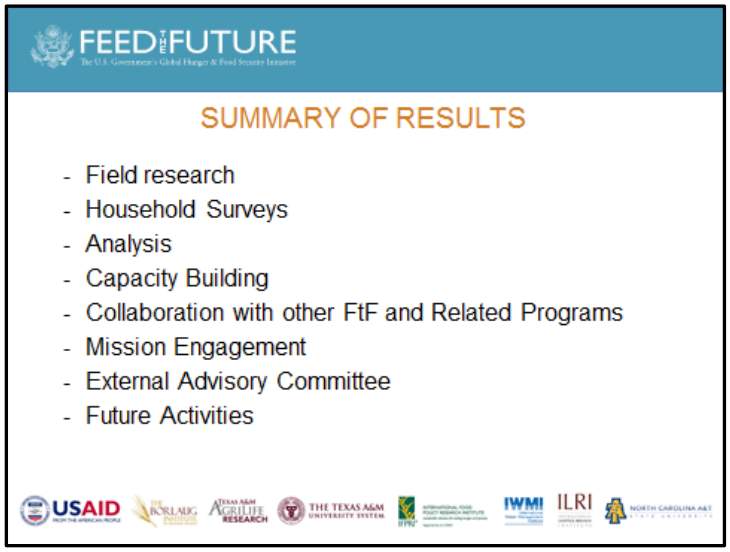
I. Feed the Future Innovation Lab on Small Scale Irrigation in Ethiopia, Tanzania and Ghana

II. Forward

This report covers the first half of project year three of the five-year cooperative agreement for the laboratory. The first year focused on stakeholder engagement and planning for research in Ethiopia, Tanzania, and Ghana. Small scale irrigation interventions were defined and regional and local engagements were initiated in year two. Research began with field studies; household surveys; and ex ante analyses of the consequences of small scale irrigation interventions using the Integrated Decision Support System (IDSS) and continues into year three.

This cooperative agreement is 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 the interventions to be 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. The Borlaug Institute for International Agricultural/Texas A&M University System (BI/TAMUS) is the lead institution. Partners in the 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).

III. Summary of Results



Field Research: Research in farmer's fields is underway in all three target countries. In Ethiopia, the second cropping season is underway; in Tanzania and Ghana, first year studies have been initiated. Multiple water delivery and distribution systems are being evaluated in collaboration with national university partners. Initial data on small scale irrigation systems have been acquired and are being used in modeling results at multiple levels of scale.

Household Surveys: Baseline household surveys involving cohorts of farm families surrounding the areas of field research have been completed, providing data on status of family nutrition, economic status of the farming enterprise and factors relating small scale irrigation to gender. Results of the latter initial studies have been presented in multiple

international meetings. These studies will be followed by a second round of surveys to evaluate the impact of small scale irrigation at the household level.

Analysis: The integrated decision support system (IDSS) is being used to assess the consequences of small scale irrigation interventions on production, environmental and economic outcomes. Initial model results have forecasted the availability of water and other natural resource inputs for citing small scale irrigation studies. Ex ante (before field research) studies of the impact of alternative SSI technologies were completed in the first quarter of year three for the regions of all three countries where field research and household surveys are being done. National summaries have been completed for all three countries. These studies provide a quantitative and stochastic estimate of the consequences of introduction of a variety of small scale irrigation interventions. Ex post (using field and survey research results) analyses of the impact of SSI based on emerging field and survey data have been initiated and will be used in the second half of year three to provide quantitative estimates of the impact of constraints to adoption and options for mitigating these constraints.

Capacity Building: Capacity building includes active training of farmers participating in field studies and the residents in surrounding areas. This training considers these audiences as practitioners of the ILSSI methods and includes development of supporting infrastructure such as microfinance and maintenance of irrigation and related equipment. Collaborators in partner universities have been trained in the use of household survey instruments. Training workshops for the IDSS were held in Ghana and Ethiopia in February 2016. Seventy one trainees were involved in the Ghana and 104 in the Ethiopia workshops (15 females total). In Ethiopia, there was a follow on advanced IDSS training workshop and individual consultations with previous trainees who are now using the IDSS in their research. Graduate students and faculty who are involved in field studies under their parent universities are being mentored in biophysical and economic research methods and in the use of the IDSS for analyzing the results of their field studies. ---- masters theses were produced in the last year that are directly related to these studies.

Collaboration with other FtF and related Programs: In Ethiopia, there is co-location at several sites and active collaboration with Africa RISING field studies and plans for applying the IDSS to AR results. ILSSI and the FtF Nutrition Innovation Laboratory, along with Bahir Dar University in Ethiopia were awarded a contract by the FtF Sustainable Intensification Laboratory to study the impact of sustainably intensified production systems on household nutrition. A pilot study was initiated with the FtF Horticulture Innovation Laboratory to apply the IDSS to the analysis of results from farm level studies in Uganda. ILSSI is collaborating with the ILRI's Canadian funded study on Livestock and Irrigation Value Chains for Ethiopian Smallholders (LIVES) in the application of the IDSS to field and survey results. Initial discussions are underway with the FtF Soybean Innovation Lab for collaboration to evaluate the IDSS in assessing the impact of their genetic research in Ghana.

Mission Engagements: Meeting with staff of the Ghana Mission in February 2016 resulted in follow up to determine if ILSSI or its partner IWMI could assist/advise on irrigation for dry season production of seed – IWMI has an ongoing effort for the Mission and will continue to support this need. The Ethiopia Mission has an active program as part of their Productive Safety Net Program (PNSP) that involves evaluating several techniques for control soil erosion. To evaluate the possibility of improving the assessment methods, a preliminary pilot study was done to compare SWAT as an analytic tool to the currently used universal soil loss equation. Results suggested SWAT would provide more detailed and dynamic assessment of these options. Mission staff are investigating the actions needed to further evaluate and incorporate the SWAT method into their ongoing program.

External Advisory Committee: ILSSI's External Advisory Committee met jointly with its Program Management Committee in Accra, Ghana in February 2016. Status reports and plans for ongoing ILSSI projects were presented and discussed and faculty from the University of Development Studies in Tamale briefed the committee on field studies underway in that region of Ghana. The committee provided substantive feedback and advice on current and future programs and committed themselves to active participation in the upcoming preparations for the USAID External Review.

Future Activities: As ILSSI approaches the mid-term of its current cooperative agreement, field research in all three countries will be continued with collaboration on the new SIIL award on SIPSIN in Ethiopia. Second generation household surveys will be initiated in year 4. Application of the IDSS to the ex post studies of constraints and mitigation analyses will be continued. The integrated product of ILSSI component studies will be developed and enunciated in multiple publications. Scaling up small scale irrigation interventions will be undertaken in collaboration between Texas A&M and IFPRI to regional and then national levels. Stakeholder engagements will be formally continued in all three countries with focus on mitigation of constraints and uptake of SSI interventions. Extensive preparations are being made for the upcoming USAID External Review of the agreement in year four. ILSSI will begin to develop its exit strategy for the current effort and develop the initial strategy for continuation of the effort in a second phase. An international workshop on ILSSI will be planned for year five and conducted in conjunction with another major international water meeting.

IV. Small Scale Irrigation Interventions

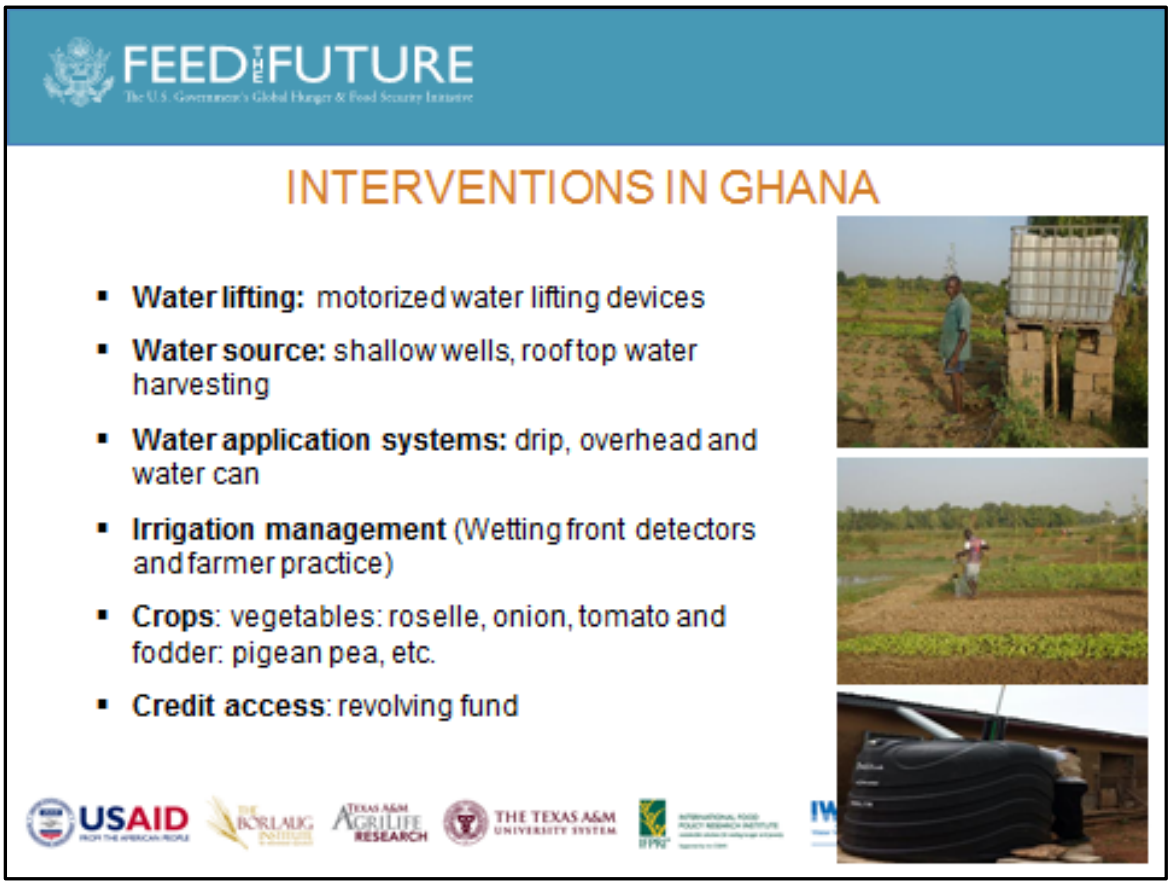
Interventions selected and used in these "research for development" studies involve active planning and selection by stakeholders down to the farm level. Farmers wishing to participate in the studies are given options from which they select the actual intervention used. Farmers receive training on the use of the system and advice on other parts of their farming system such as crop varieties to use in making best use of irrigation. ILSSI does not purchase pesticides or fertilizer as part of these studies but advise farmers on safety and environmental concerns where they are used. Both farmers and national partners, usually graduate students from national universities are trained in collection of data and ongoing engagement is maintained throughout the growing season. The following are illustrations of the interventions currently being evaluated in the three countries.

In year 2, farmers showed preference of some lifting technologies over others in some sites. So year 3 in Ethiopia began with trying to meet farmers' preferences which saw some technology transfers between sites. Specifically, Robit farmers preferred pulley/tank system to Rope & Washer (R&W) pumps, thus they gave up all the R&W pumps for pulley/tanks systems. These R&W pumps were transferred to Dangishta, where new farmers were selected to take these pumps. The farmers in the various sites agreed to grow crops indicated in the table below. Field books were adjusted, made simpler to fill and also shorter from the ones that were used in the previous year. New students were selected to undertake research activities for this season in Robit and Dangishta, as the ones for last year had completed their studies. The Ph.D. students are

ongoing. In addition, measuring/monitoring equipment was installed in the various sites to gather data on crop performance.

Table 1: Intervention sites and interventions for households

Technology	No. of target households being monitored in year 3 dry season				No. of target households in original research design			
	Robit	Dangishita	Bochesa	Upper-Gana	Robit	Dangishita	Bochesa	Upper-Gana
Rope and Washer	0	22	1	11	13	12	6	11
Pulley	24	11	0	0	9	12	0	1
Drip	0	0	0	3	0	0	0	0
Solar pump	0	0	0	3	0	0	0	2
Diesel pump	0	0	12		0	0	20	0
Crops	Tomato (1^{st} dry season Year 3) Green pepper (2^{nd} dry season Year 3)	Onion (1^{st} dry season Year 3) Green pepper (2^{nd} dry season Year 3)	Mix of cabbage, tomato, onion, green bean, maize, etc.	Avocado, fodder, carrot, cabbage (only one season in Year 3)	Tomato	Onion	Tomato	Avocado, fodder,



The dry season irrigation technologies including pumps, drip kits and tanks and hoses were installed in all the research sites for onion, tomato and corchrus production. All measurement equipment has been installed and farmer field books distributed for continuous data collection. In addition wetting front detectors (WFDs) for irrigation scheduling were installed in January 2016, but farmers have faced difficulty in understanding how to use the WFDs. Trainings on WFDs are scheduled for April on irrigation scheduling, irrigation management, irrigation as a business, and gender considerations. The project continued to work closely with the local Ministry of Food and Agriculture (MoFA) officers and engaged regular with farmers participating in the field pilots. IWMI and UDS as the national partner also engaged at policy and planning level with the Savannah Accelerated Development Authority and met with the Ghana Irrigation Development Authority.

Activities in Zanlerigu, Nabdam District, Upper East Region - General activities for both interventions in site:

1. UDS organized a Farmer Forum at Zanlerigu, with 15 men and 12 women attending (23 October, 2015)
2. UDS team visited to meet with women farmers (11 attended), explore gender-based challenges and lessons so far, and encourage the women participants to continue on the project (6 January)
3. UDS team monitoring visit (4 to 5 March)
4. UDS visit to assess rain damage to fields (8 to 9 March)
5. Two weeks after transplanting, agronomic data collection started. In cases of farmers who transplanted late, the crops were not ready for data collection. Data was then collected every two weeks. Data also taken on use of pesticides and fertilizers. Note was also taken with regards to the amount of water applied per unit area.

Zanlerigu Project Site: Farmers using shallow wells

Technology	Treatment Group	No. of farmers	Control Group	No. of farmers
Type of irrigation system	1. Overhead irrigation with tank and hose + irrigation scheduling tool (4 farmers) 2. Overhead irrigation with tank and hose without irrigation scheduling tool (4 farmers)	4 4	1. Watering can + Irrigation scheduling tool (4 farmers) 2.Watering can without irrigation scheduling tool (4 farmers)	4 4
Total		**8**		**8**
Items free of charge	8 Water tanks (one for each farmer)		2 watering cans to each farmer (motivation)	
Items on loan or credit	2 water pumps on loan to each group of 4 farmers		-	
Selected crops	Onions		Onions	

Zanlerigu Home Gardens

Technology	Treatment Group	No. of famers	Control Group	No. of farmers
Type of irrigation system	1.UDS drip irrigation system (2 farmers) 2. Bucket-drip (iDE) irrigation (2 farmers)	2 2	Tank with water hose	1 -
Total		**4**		**1**
Items free of charge	Irrigation kits		2 watering cans and water hose (motivation)	
Items on loan	4 Water tanks		1 Water tank	

Selected crops	Local leafy vegetable: Cow pea or black-eyed pea		Local leafy vegetable: Cow pea or black-eyed pea	

SUA conducted preliminary economic study on the 5 pump groups in the 2 sites Mkindo and Rudewa on the profitability of motor pump irrigation for just one crop season during the dry season. Each pump group has 7 or 8 members and each pump group is assumed to irrigating 4 acres in total. The analysis showed that the preferred crops for irrigation including African eggplant, maize and tomato would be profitable per group with the African eggplant giving a profit of 1.7 million Tshs, maize about 340,000 Tshs, and tomato giving a profit of about 4.6 million Tshs. This kind of analysis will be done for each irrigation season for all the groups, and will also include revenue that will be generated from renting the motor pump among both members and non-members of the group as some of the groups have suggested doing.

SUA recruited a research assistant in December 2015 to assist with project implementation in the field. SUA also works with village extension agents (one in Rudewa village and two in Mkindo village).

Tomato seedbeds for seedlings were prepared in mid-December 2015 and transplanting was expected to be done mid-January 2016. The seedlings were stolen just before transplanting. Another seedbed was prepared immediately. This time seedlings were affected by bacteria spot disease and only 6% of the seedlings

survived. The seedlings were given to the youth group instead of starting the experiments. The plan is to start the experiment in May, which is the end of the rainy season.

SUA team purchased six motor pumps in December 2015 and distributed five pumps to two groups in Mkindo and three groups in Rudewa. Pumps were provided to farmers' groups on credit basis loans, and farmers are expected to pay back. This contributes to the study on willingness and ability to pay loans for irrigation technology by farmers.

SUA team trained farmers on data collection and record keeping. Notebooks for recording data and information were distributed to individual farmers and farmer groups. The following were the type of data that farmers were trained to collect: Irrigation water: Record start and finish time (duration of irrigation), date of irrigation, and crop type; Cost-benefit analysis: Production costs - Amount of fuel used, purchase price, labor, amount and price of inputs (seeds, fertilizer and herbicides), and dates. If farm rented (if any) and rent duration; Income: Crop sold, amount and price, crop type, date; Nutrition impact: Vegetables being sold within the village; Shared motor pumps: Records: Group members, borrowing, borrowing duration, renting, payments, crops grown by each member, field sizes, preferred schedules, minutes of meetings, records of the group bank account or other financial record; Loan payment: agreement between project and group on mode of payment, deposits records, challenges.

SUA is recording economic information on one youth group that grew tomatoes using the pump. The group is now selling vegetables and individual members have managed to grow eggplants they are now harvesting and selling. Analysis will be done at the end of the season. IWMI provided four additional pressure based flowmeters in February 2016. SUA will install soon.

SUA started a pocket garden project at Rudewa village under ILSSI, toward understanding nutrition and gender under the project. Training was conducted between February 15 – 19, 2016 to 10 women farmers, one ward agricultural extension agent and three field practical students from CANRE College. The training was conducted with a champion farmer, Ms. Walter, from Mwembe Village in Same District. SUA also plans another training in Mkindo Village.

V. Fodder Livestock Systems

This farmer, in Southern Ethiopia, is using a rope and washer irrigation system to irrigate fodder which he harvests continually to feed two hybrid dairy cows. His family consumes milk and he sells the remainder either fresh or as butter and cheese. He would like to have a second well and expand his dairy operation.

This is the field irrigated by the rope and washer system.

Small scale irrigation is used in

farmer's fields where several varieties of fodder are being evaluated in for on-farm use in livestock and for sale with income enhancing family nutrition. Studies are moving towards a market chain approach with concurrent evaluation of sources of inputs and markets for fodder.

In Ethiopia, 24 and 26 new farmers' new farmers were selected in Angacha and Lemo woreda, respectively. In Angacha interventions centered on intercropping of forage grass options such as Napier and Desho with food-feed legumes such as pigeon pea and desmodium to: 1) increase overall biomass productivity per unit area, 2) increase overall biomass quality through protein richer legume biomass; and 3) improve soil fertility though nitrogen fixation. In Lemo interventions focused on intercropping of oats and vetches, as in the previous reporting period i.e. no new crop and/or forage combinations were tried, but new management options were investigated in that half of the participating farmers will use oat-vetch mixtures as multi cut forages. Previously oat-vetch mixes were cut only once which had several disadvantages. First biomass yield was limited. Second, all biomass was produced at once resulting in need of preservation. Third, the time window for using the biomass either as home produced feed or as a cash crop was short. In Robit Bata Napier grass was planted by 12 new farmers on about a quarter of a ha. A total of 21 farmers (9 new and 12 farmer previously participating) intercropped Napier with Desmodium (7 farmer), Sesbania (7 farmer) and pigeon pea (9 farmer).

In Ghana, following the rainfed production of 4 forage species Sorghum almum, Brachiaria ruziziensis, Lablab purpureus and Cajanus cajan by 12 farmers in Bihinayili, farmers pooled the fodder produced to fatten ten young rams for about 2 months with average initial weight of 14.11±3.50 kg. The fodder produced was offered ad libitum. Average final weight of the fattened rams was 15.64±2.82 kg. According to the farmers, Cajanus cajan and lablab (the legumes) were the most preferred by rams while Sorghum almum was preferred to Brachiaria. It took a day or two for the rams to get accustomed to Brachiaria. No data was collected on the sales price of the rams as the animals were not sold immediately after the feed trial.
In Tanzania, based on feed assessment studies (FEAST) potential feed and forages options in irrigated areas of Kilosa (Rudewa village), and Mvomero (Mkindo village) in Morogoro region and also in Babati district (Gichameda and Mawemairo villages) of Manyara region were assessed. These assessments were followed up with feedback meetings with farmers. While feed resources in form of natural pastures were abundant in the wet season there were severe pasture shortages in the dry season. This is mainly due to due to insufficient feed conservation, storage, processing and utilization of livestock feeds. Consequently the following activities were conducted between October 2015 and March 2016 in four selected villages of Morogoro and Manyara regions by the project team. After lengthy discussion the project team and farms agreed on testing interventions on improved planted forages and enhanced use of crop residues. A total of 15 farmers were selected who volunteered their land for establishing irrigated fodder and kept improved dairy cattle. Planting of forages is currently ongoing.

VI. Commercial Vegetable Home Gardens

In the second cropping season in Ethiopia, tomato and garlic were grown in Robit Bata and Dangila in 100 square meter plots where conservation agriculture was compared to conventional tillage with drip irrigation. Significantly lower amounts of water were required and yields were higher using conservation tillage. A pail lifting system, designed by Bahir Dar University partners reduced time and effort of women farmers in acquiring water. Improved protocols for data collection were made to provide input to the APEX model for further analysis and a graduate student from NCA&T will spend a major part of year three at BDU in monitoring and data collection

A framer in Ethiopia is using the pail lifting system is shown here with a commercial garden using conservation agriculture and drip irrigation.

In the Mvomero district of Tanzania in collaboration with Sokoine University of Agriculture, 10 commercial vegetable home gardens with women farmers have been established with vegetable grown in 100 square meter plots, with half of the area using conservation agriculture and the other half conventional practices. The mulch used in conservation agriculture protected plots against runoff and loss of seedlings and poor root systems encountered with conventional tillage. Data collection protocols are being employed to enable use of results in APEX analyses. The NCA&T graduate student will also monitor field studies in Tanzania.

In Ghana, in partnership with iDE, first year studies are also underway in the Binduri District in the upper east region of the country. Conservation and conventional production systems are being compared growing cucumbers. Farmers are using water from the White Volta River delivered using fuel pumps. Early observations note that fewer weeds are encountered in the conservation agriculture plots with reduced labor. A contractual agreement will be signed between iDE Ghana and the women farmers on cost of technology and assurance of market facilitation from iDE Ghana for their commercial vegetable gardens.

VII. Household Surveys

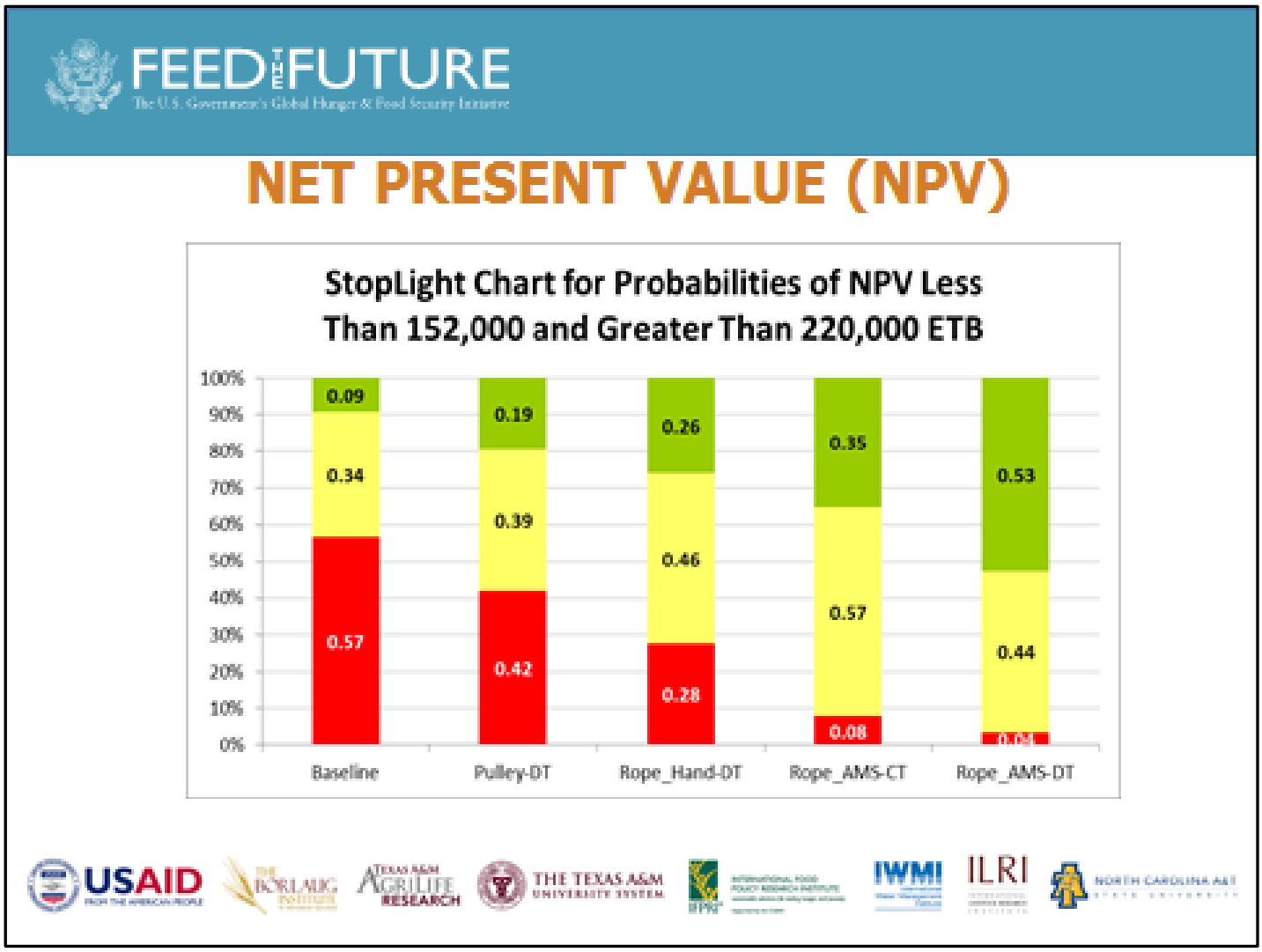
Fieldwork on the household level baseline survey and the gender disaggregated survey has been completed in Ghana. The baseline survey includes direct ILSSI beneficiaries (120 farmers), as well as additional farmers in nine villages of the Upper East region (800 farmers). The University of Development Studies in Ghana served as the survey implementer. Leveraging additional funding from the CGIAR Research Program on Water, Land, and Ecosystems (WLE), IFPRI has managed to cooperate with iDE-Ghana in the Upper East region of Ghana to (i) increase the sample size of the baseline survey to 920, which is more than double the sample size in Ethiopia and Tanzania, and (ii) to do a randomized control trial to explore the impact of irrigation on agricultural productivity, nutrition, health and women's empowerment in Northern Ghana. In mid-December Dawit Mekonnen travelled a second time to Ghana to help ensure successful completion of data collection. IFPRI has finalized cleaning of the data collected from Ghana.

IFPRI is currently analyzing the data and has prepared preliminary drafts of research papers. A draft paper entitled "Irrigation's Potential to Address Food and Nutrition Security in Sub-Saharan Africa: Evidence from Ethiopia" was presented by Simone Passarelli at the annual IFPRI Research Day in Washington D.C. on March 16th, 2016. IFPRI has also joined Africa Rising and USDA Economic Research Service (ERS) in proposing a track session for the 2016 Agricultural and Applied Economics Association (AAEA) Annual Meeting to be held in Boston, MA, in July 2016. The session that includes one paper each from ILSSI, Africa Rising, and ERS under the theme "Food and Nutrition Issues in Sub-Saharan Africa" has been accepted for presentation at the 2016 AAEA Annual Meeting. Dawit Mekonnen will be presenting the results from Ethiopia and Tanzania at the Meeting. By the end of May 2016, a working paper version of this work will be public accessible through AgEcon Search in preparation for the presentation at the Annual Meeting. In addition, another research paper that explores the linkages between irrigation and gender empowerment is currently under preparation. Further outreach events were secured for Stockholm World Water Week (SWWW), both on small-scale irrigation and on water-nutrition linkages. SWWW takes place at the end of August/early September.

VIII. Ex Ante Analysis of Small Scale Interventions in Tanzania and Ghana

The Integrated Decision Support System (IDSS) was used to conduct ex ante analyses of SSI intervention candidates in Tanzania and Ghana, completing the studies begun in year two in Ethiopia. Upon completion of these studies and with field and survey data being generated, the next steps are to conduct ex post studies in the three countries, incorporating these results and to use this analysis as input to the analysis of opportunities and constraints for the most promising of the new interventions evaluated. This chart shows

results of FARMSIM analysis in Ethiopia comparing the net present value at five years after adoption of alternative water lifting systems. The probability of exceeding a NPV of $220,000 ETB ranges from 0.09 to 0.53 with various methods.



Analyses of proposed SSI interventions in Tanzania

During the first quarter of year three, TAMAR used the IDSS to complete ex ante analyses of SSI interventions proposed by ILSSI in three different districts in Tanzania: the Mvomero and Kilosa districts, both in the Morogoro region; and the Babati district in the Manyara region. In each of the three target sites, ILSSI proposed implementing SSI, using diverted river water, to maximize cultivation of high-value vegetable and fodder crops in the dry season and productivity of the rice crop.

Simulations indicated that there is ample water available for the proposed SSI interventions in Mvomero and Babati and that the proposed SSI interventions are sustainable and would not compromise the environmental health of their respective watersheds. In Kilosa, low flows were significantly affected by the withdrawal of irrigation water from rivers (though peak flows were not affected). This suggests that the proposed SSI interventions in Kilosa may not compromise the overall water balance significantly; however, ecosystems that depend on low flows may be affected, and some alternative, surface-water storage or groundwater

extraction may be needed to supply human and livestock drinking water during periods of extreme low flows.

At all three of the target sites, suitable fields far from rivers receive less irrigation water than those close to rivers; accordingly, the proposed SSI interventions will require development of advanced surface water diversion and transfer technologies and/or wells to sufficiently irrigate fields located far from the rivers.

Simulations of flow, sediment, and crop yields at each of the sites showed that the application of additional fertilizer would increase crop yields substantially and, at the Mvomero and Babati sites, would also decrease the soil loss from erosion. The implementation of multiple cropping systems also affected simulated crop yields and sediment losses, though results varied from site to site. Simulations also showed SRI rice production would result in higher crop water productivity compared to traditional rain-fed rice. These results suggest that the SRI method of rice cultivation is preferable for the three ILSSI sites in Tanzania. Simulations also indicated the sensitivity of SRI rice yields to drying and wetting periods.

Economic analyses were conducted to estimate the effects of the proposed SSI interventions (in conjunction with the simulated, improved cropping systems) on farm family economics. Results of the economic analyses varied from site to site. In Mvomero, implementation of the SRI method of rice cultivation and multiple cropping of fertilized maize with irrigated vegetables only (not fodder) produced the highest net present value, net cash farm income, and ending cash reserves of the alternative scenarios simulated (including the baseline, non-irrigated scenarios). In Kilosa and Babati, cash income increased as the irrigated area increased. The most preferred scenario in terms of income generation was the one that allocated the largest area of irrigable cropland to vegetables, fodder and SRI rice.

Despite improvements in farm family economics resulting from the proposed SSI interventions, some nutritional deficiencies persisted under the improved cropping systems in each of the three sites. TAMAR also, therefore, proposed expanding the types of crops irrigated in the dry season to increase family nutrition and net cash farm income, but only if such crops can be irrigated without causing excessive soil erosion or reduction in environmental benefits. The relatively modest percentages of cropland in each of the three districts also limit the expansion of SSI and cultivation of additional crops at the target sites.

The IDSS analysis raised a number of issues to be resolved in future modeling and field research in Tanzania. These include the need to identify:

- the potential for shallow-groundwater irrigation in areas too distant for use of surface water;
- appropriate fertilizer amounts for more intensive cropping systems involving production of irrigated vegetable, fodder, and grain crops in the dry season; and
- appropriate management of fertilizer and harvest practices for irrigated fodder production.

The evaluation and comparison of alternative farming systems, including the types of crops grown, recommended management practices, and associated impacts on soil erosion and environmental benefits, are also subjects for proposed future simulation and field research in Tanzania.

Analyses of proposed SSI interventions in Ghana

During the second quarter of year three, TAMAR used the IDSS to complete ex ante analyses of SSI interventions proposed by ILSSI at three different sites in the Republic of Ghana: the Bihinaayili watershed, located in the Savelugu-Nanton District in the Northern Region; the Dimbasinia (or

Dambiasinia/Dimbasinia) watershed, located in the Kassena Nankana District in the Upper East Region; and the Zanlerigu watershed, located in the Nabdam District, also in the Upper East Region. At each of the three target sites, ILSSI proposed maximizing cultivation of high-value vegetable and fodder crops in the dry season by implementing SSI using irrigation water from either shallow groundwater or water-harvesting ponds, depending on the site.

In the Bihinaayili watershed, water-harvesting ponds along the stream networks (used to collect and store overflow from the nearby Ligba dam) served as the proposed source of irrigation water. Simulations indicated that there would be ample water available in the watershed for the proposed SSI interventions; however, the proposed SSI interventions would reduce average monthly stream flow by 32.7%, reduce peak flows, and increase low flows. A decrease in peak flows (and a related reduction in sediment influxes) and an increase in low flows could have positive implications for upstream and downstream social and ecological systems; however, a decrease in average monthly stream flows could have negative impacts on downstream social-ecological systems. Moreover, the dugouts will be susceptible to siltation, and dredging sediment loads from the dugouts to the fields will be a challenging task. The exact upstream and downstream costs and benefits, both social and environmental, of the proposed SSI interventions in Bihinaayili, as well as potential methods of addressing sedimentation of dugouts, could be addressed in future research.

The proposed SSI interventions in the Dimbasinia and Zanlerigu watersheds relied on shallow groundwater as the source of irrigation water. There are large water resources potential in both watersheds; however, at both of these sites, the annual irrigation water requirements for cultivation of selected dry-season crops exceeded the average annual shallow groundwater recharge. Implementation of the proposed SSI interventions also caused modest reductions in the monthly stream flows in the two watersheds, and reductions in peak and low flows. Accordingly, in the Dimbasinia and Zanlerigu watersheds, TAMAR recommended combining irrigation from the shallow groundwater aquifers with irrigation from other water sources. For example, water-harvesting ponds such as those used in Bihinaayili could be used to store and capture surface runoff for SSI. TAMAR also recommended selecting water-efficient crops for dry-season cultivation in order to minimize reductions in stream flows. Analyses of potential dugout sites and scale, likely costs and benefits of irrigating from dugouts, and recommendations as to specific water-efficient crops for cultivation, were beyond the scope of the study but could be addressed in future research.

Simulations of crop yields showed that the application of additional fertilizers would increase crop yields substantially at each of the three sites. The implementation of multiple-cropping systems also affected simulated crop yields at each of the three sites. At all three sites, multiple cropping of the rainy-season grain crops with fodder significantly increased simulated grain yields by increasing residual nitrogen, without adversely affecting fodder yields. At all three sites, multiple cropping of the rainy-season grain crops with tomato also increased simulated grain yields (although by lesser amounts), but significantly reduced tomato yields. In Bihinaayili, multiple cropping of soybean with dry-season crops did not significantly affect simulated yields of soybean or the dry-season crops. In Zanlerigu, high temperature stress was also a major factor limiting yields of certain crops. For example, the yield of pepper, planted as a rain-fed crop in the cooler season, was double that of irrigated, dry-season pepper. Planting temperature-sensitive crops (like pepper and oats) in the cooler season would therefore also optimize yields.

Plot-scale simulations of flow and sediment indicated that the proposed SSI interventions in Dimbasinia and Zanlerigu would not significantly affect runoff and sediment yields. In Bihinaayili, however, multiple

cropping of sorghum (at both current and improved fertilization rates) with fodder and pepper increased sediment yields by between 20% and 26%.

Economic analyses were conducted to estimate the effects of the proposed SSI interventions (in conjunction with the simulated, improved cropping systems) on farm-family economics in communities in each of the three watersheds. In the Bihinaayili community, simulation results indicated that multiple cropping of dry-season crops with soybean was far more profitable than multiple-cropping of dry-season crops with maize. Similarly, in the Dimbasinia community, the scenarios that implemented multiple cropping of the dry-season crops with sorghum (rather than maize) were preferable. Multiple-cropping with maize and millet were found to be equally profitable in the Zanlerigu community.

The simulations also compared the costs and benefits of three alternative water-lifting technologies: pulley-and-bucket irrigation; diesel-pump (both rented and owned) irrigation; and solar-pump irrigation. At all three sites, the scenarios that implemented multiple cropping of the preferred rainy-season crop(s) with diesel- and solar-pump-irrigated dry-season crops produced by far the highest net present value, net cash farm income, and ending cash reserves of the scenarios simulated (including the non-irrigated and pulley-irrigated scenarios). Additionally, in light of the lower maintenance and environmental costs of solar pumps, simulations at all three sites suggested that investments in solar water-lifting technologies would pay dividends in the long run.

Despite substantial improvements in farm family economics resulting from the proposed SSI interventions, at all three sites, the levels of certain nutrients remained at merely adequate levels, and a nutritional deficiency in iron persisted under the simulated, improved cropping system in Bihinaayili. TAMAR therefore proposed expanding the types of irrigated, dry-season crops at all three sites to further increase family nutrition and net cash income, but only if such crops could be irrigated without causing excessive soil erosion or reduction in environmental benefits.

As in Tanzania, TAMAR's analyses of the Ghana sites raised a number of issues to be resolved in future modeling and field research, including the need to identify:

- exact upstream and downstream costs and benefits (both social and environmental) of decreases in average stream flows and peak flows, as well as increases in low flows;
- potential methods of addressing sedimentation of water-harvesting ponds where utilized;
- the potential scale and locations, as well as the costs and benefits, of water-harvesting ponds or structures to supplement shallow-groundwater irrigation in Dimbasinia and Zanlerigu; and
- recommendations as to specific water-efficient crops for cultivation.

The evaluation and comparison of these and other issues, including the types of crops grown, recommended management practices, and associated impacts on soil erosion and environmental benefits, are subjects for proposed future simulation and field research.

<u>Analyses of proposed SSI interventions in Ethiopia, for the purpose of cultivating Napier, alfalfa and fodder:</u>
In 2015, ILSSI and LIVES entered into a memorandum of understanding in which ILSSI committed to complete ex ante analyses of five LIVES sites in Ethiopia: Dembia, Mecha, Meki, Mirab Abay and Kilte Awlola. It was later determined that only three of these five sites would be analyzed using IDSS, due to a lack of biophysical data. Accordingly, during the second quarter of year three, TAMAR used the APEX model to analyze the effects on crop yield of cultivating Napier, alfalfa and fodder (vetch + oats), using

current agricultural management practices (fertilizer, crop rotation, and irrigation), at Dembiya, Mecha, and Meki, in the North Gonder, West Gojam and East Shewa Zones of Amhara and Oromia regions. At each of the three sites, Napier and fodder (oats + vetch) yields were limited by nitrogen and temperature stress, though the stress levels varied from site to site. With improved fertilizer application, Napier and fodder (oats + vetch) yield could be further optimized. Alfalfa yield was limited by water stress and temperature stress. One of the limitations of this study was the limited availability of yield data (used to calibrate the APEX model parameters, to see the effects of management practices on the environment and crop yield). The analysis could be improved with observed forage yields in those areas. Economic analyses using the FARMSIM model are currently underway.

Upscaling SSI in Ethiopia

The TAMAR team is modifying the SWAT model for upscaling of SSI in Ethiopia. The upscaling activity started in the Lake Tana basin and Omo-Ghiba basin where three of the ILSSI interventions sites (Robit, Dangeshta, and Lemo) are located. The upscaling work will continue in modeling the basins for the entirety of Ethiopia. Results from the upscaling activity in Ethiopia will help the IFPRI team in identifying the Food Production Units (FPUs). In line with the upscaling activity, the TAMAR team has been working to identify the different cropping systems that exist around Lake Tana, as a start, using several household surveys data collected by partners (IFPRI, LIVES/ILRI, Africa Rising and IWMI). This information will be used by IFPRI as well in determining the FPUs in Lake Tana basin with a goal later of covering all of Ethiopia. The TAMAR team has also been working on mapping the areas of irrigation-suitable land in Ethiopia; the input data preparation for the multi-criteria evaluation model has been completed. Upscaling to the national level in Ethiopia and later in Ghana and Tanzania are scheduled.

IX. Capacity Development and Stakeholder Engagement and Dialogue

TAMAR

TAMAR is supporting two postdoctoral fellows and one M.S. student at TAMAR laboratories, all of whom are male and are African nationals. See the attached chart entitled “Long-Term Training” for additional details regarding those students currently enrolled in a degree program funded in full or part by USAID.

TAMAR is supporting multiple students in the use of the IDSS and its component models: the Soil and Water Assessment Tool (or SWAT, at http://swat.tamu.edu), the Agricultural Policy/Environmental eXtender (or APEX, at http://epicapex.tamu.edu) and the Farm Income and Nutrition Simulator (or FARMSIM, at https://www.afpc.tamu.edu/models/farmsim/).

In Tanzania, TAMAR is supporting: three male students in the use of APEX, two of which are faculty at Sokoine Agricultural University (SUA); one faculty member and one Ph.D. student (both are male) at the University of Dar es Salaam (UDS) in the use of SWAT; and two male Ph.D. students at SUA in the use of SWAT.

In Ethiopia, TAMAR is supporting two male students at Bahir Dar University in use of APEX. TAMAR is also supervising two Ph.D. students at Addis Ababa University (AAU). Gebrekidan Worku Tefera, a Ph.D. student from AAU’s College of Development Studies, is preparing a Ph.D. thesis on “Watershed Management Scenarios under Changing Climate in Jemma Sub Basin, Blue Nile Basin” using the SWAT model. Temesgen Gashaw, a Ph.D. at AAU’s Center for Environmental Science, is preparing a thesis on

"Valuation of land use/land cover change effects on stream flow patterns in the Upper Blue Nile Basin, Northwestern Ethiopia."

In Ghana, TAMAR is supporting one female Ph.D. student, Fati Aziz, in the use of SWAT in her Ph.D. thesis. Ms. Aziz was a guest scientist at College Station from June-November, 2015. TAMAR is also supporting Dinko Hanaan Dinko, who is pursuing his Mphil in the Department of Geography and Resource Development Department, at University of Ghana. Mr. Dinko's thesis is on "Climate change/Variability and water security in the Sudan Savannah zone of Ghana."

TAMAR also trained a female Vietnamese Ph.D. student from N.C. A&T in EPIC, a predecessor of SWAT and APEX; and TAMAR also trained another male Ethiopian student from N.C.

IWMI

The list of graduate students whose field work is supported under ILSSI is found in Annex 1.

Student theses completed:

1. 2015 Bahir Dar University, Tesfaye Ewnetie - Assessing the performance of manual water lifting technologies and irrigation scheduling based on measured soil moisture and farmers practice on irrigated tomato production, and comparing soil moisture monitoring and estimation methods: the case of Western Amhara sub- region
2. 2015 Bahir Dar University, Melaku Tesema - Evaluating Simple Irrigation Technologies to Improve Crop and Water Productivity of Onion in Dangishta Watershed
3. 2015 Bahir Dar University, Hannibal Mulugeta - Production, water use and crop coefficient development for Napier grass under small scale irrigation: the case of Robit Kebele
4. 2015 Arba Minch University, Desalegn Tegegne – Assessment of Water Demand, water and crop productivity of selected fodder varieties under small holder irrigated farming practices using wetting front detector
5. 2015 Bahir Dar University, Teshager Assefa Sisha-Analysis of Technical Efficiency of Small Scale Irrigation Technologies: The case of Robit and Dangeshita
6. 2015 Bahir-Dar University, Mihret Dessie-Cost-Benefit Analysis of smallholder irrigation technologies: The case of Robit and Dangeshita
7. 2015 Arba Minch University, MENEYAHEL ZEGEYE TESFAYE-FARMERS WILLINGNESS TO PAY AND CHOICE OF SMALLHOLDER WATER LIFTING TECHNOLOGIES: EVIDENCE FROM ADAMI TULU, LEMO, DANGELA AND BAHIR DAR ZURIA WEREDAS, ETHIOPIA

Student theses on-going:

1. Muluye Gedfew –Comparing the effect of soil moisture and climate based irrigation scheduling strategies on tomato production and partial nutrient balances: Case study in Robit watershed - Bahir Dar University
2. Abdu Yimer –Rainfall-Runoff processes in the upper Blue Nile Basin. The case study of Dangishta watershed - Bahir Dar University
3. Talake Asnekew – Optimizing irrigation scheduling to improve onion production in Danghista, Ethiopia - Bahir Dar University

4. Addisu Wondimnew – Assessment of pesticide residue contamination and transportation in soil and water - Bahir Dar University
5. Misba Hussen - Improving Subsurface Recharge By Breaking Hardpans Through Mechanical Means - Bahir Dar University
6. Belainew Belete-Impact of Small Scale Irrigation Technology on Farm Household Welfare: Micro Econometrics Approach-Bahir Dar University
7. Tariku Yadeta Fufa- The impact of small scale irrigation on farm production and productivity-Arba minch University.

Student theses beginning:

1. Raymond Tetteh has been recruited to pursue MPhil in Soil and Water Conservation and Management in the Faculty of Agriculture on topic 'A study on improved irrigation practices among smallholder dry season vegetable farmers in Northern Ghana'. His supervisor is Bizoola Gandaa and is expected to complete his program in 2016.
2. Mamaru Moges, a Ph.D. student from Ethiopia, supported by the ILSSI project visited the Ghana office and was trained on watershed mapping and isotope hydrological technology (in collaboration with Nuclear Chemistry and Environmental Research Centre) for the three catchments the project is working in northern Ghana. From the training, he will develop a revised protocol and the research work is planned for the rainy and dry seasons.

IFPRI

In December of 2015, IFPRI trained a team of researchers from Sokoine University to conduct focus group discussions to collect qualitative data for ILSSI on gender-based differences in access to irrigation technologies. IFPRI also met with key government stakeholders in Tanzania to start planning for a gender-irrigation technical capacity building activity, scheduled for March 2016.

On December 4, 2015, Claudia Ringler managed, with IWMI, a session on Agricultural Water Management at the Washington DC Dupont Summit Event, which included a presentation on Irrigation, Gender and Nutrition linkages based on ILSSI research (presentation by Simone Passarelli): http://www.ipsonet.org/images/DS2015/P_-_Agricultural_Water_Management.pdf. A blog piece was produced based on the event (The Goldilocks Dilemma of Balancing Irrigation Technologies, Policies and Institutions. https://wle.cgiar.org/thrive/2016/02/03/goldilocks-dilemma-irrigation)

In March 2016, IFPRI in partnership with IWMI and the Ministry of Agriculture and Natural Resources led a Gender and Irrigation Technical Workshop on the ILRI campus that convened nearly 50 stakeholders from government, NGOs, research, and donor communities in Ethiopia. The workshop included 20 speakers from different sectors and interactive discussions on approaches to effectively integrate and address gender in irrigation interventions and research. A checklist for integrating gender into irrigation projects was developed and is being refined through the workshop series. Ethiopia participants expressed interest in using the checklist to inform a new process of gender mainstreaming guidelines in the Ministry of Agriculture.

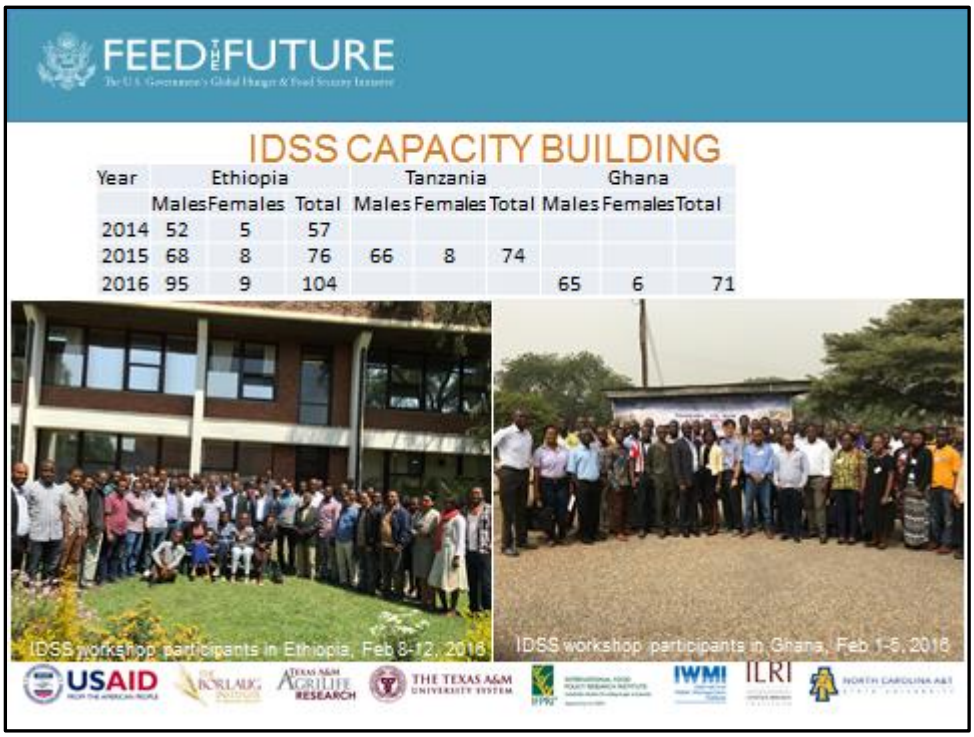
Sophie Theis and Elizabeth Bryan traveled to Ethiopia and facilitated the workshop. A news article was produced for the ILSSI blog: http://ilssi.tamu.edu/news/all/ilssi-technical-workshops/.

Workshops in Ghana and Tanzania are being organized in April 2016 in partnership with IWMI and the Ghana Irrigation Development Authority in Ghana (April 13-14) and with Sokoine University of Agriculture and the Ministry of Agriculture, Livestock, and Fisheries in Tanzania (April 20-21).

X. Prepare and Conduct Short Courses on Use of the IDSS

TAMAR

During the reporting period, TAMAR conducted workshops in Accra, Ghana and Addis Ababa, Ethiopia, for the purpose of training participants in the IDSS and its three component models: SWAT, APEX, and FARMSIM.



The Accra workshop was sponsored by the Council for Scientific and Industrial Research/Water Research Institute, and was held on February 1-5, 2016. The Addis Ababa workshop was held on February 8-12, 2016; in addition, an advanced SWAT workshop and separate FarmSIM clinic were conducted in Addis Ababa on February 15-17, 2016, and a SWAT clinic was held on February 18-19, 2016. The Addis Ababa workshops and clinics were to be sponsored by Jimma University; however, due to security concerns in the Oromia region, the events were relocated to the Addis Ababa offices of ILRI. IWMI helped in arranging workshop facilities and accommodations for the trainers.

At both the Accra and Addis Ababa workshops, the first half-day of training consisted of an overview of the IDSS, with examples drawn from the ILSSI projects in Ghana and Ethiopia, respectively. Participants were also provided a detailed description of the capabilities of each of the three component models. From the afternoon of the first day through the fourth day, the participants attended individual model training in either SWAT, APEX or FarmSIM. On the fifth day of the seminars, the participants came back together as a group for an in-depth case study of the integrated capabilities of the IDSS, drawn from watershed analyses in Ghana and Ethiopia, respectively. The three model trainers presented a demonstration of the hands-on integration exercise. Finally, the participants were divided into groups (each consisting of at least one trainee for each of the three models) to work together on the integration of their individual modeling result. At the Advanced SWAT workshop in Addis Ababa, participants received general overviews of model calibration, sensitivity analysis and uncertainty analysis, and learned strategies for manually calibrating the SWAT model. Then, participants received training in the automatic SWAT Calibration and Uncertainty Program (or SWAT-CUP, at http://swat.tamu.edu/software/swat-cup/), using a case study from the Gumera watershed in the Lake Tana basin, where observed stream flow is available. At the subsequent SWAT and FARMSIM clinics in Addis Ababa, issues of general interest were raised by the participants and discussed in the clinics,

with one-on-one support provided thereafter. Specifically for the FARMSIM clinics, 2 prospect Ph.D. students and 1 current Ph.D. student at Bonn University discussed possibilities of using the FARMSIM model in their Ph.D. research work.
A total of 50 participants attended the Accra workshop. 30 participants were trained in SWAT, of which 12 were affiliated with universities in some capacity and 18 with research institutes. 11 participants were trained in APEX, of which 9 were affiliated with universities, 1 with a governmental ministry, and 1 with a research institute. 9 participants were trained in FarmSIM, of which 7 were affiliated with a university and 2 with various research institutes. Of the 50 participants, 10 were women, with 5 attending the SWAT workshop, 2 attending the APEX workshop, and 3 attending the FARMSIM workshop.

A total of 65 participants (including 7 women) attended the IDSS workshops in Addis Ababa. 48 of the 65 participants (6 of whom were women) were trained in introductory SWAT, with 27 representing various universities, 7 representing governmental entities, 5 representing private industry, and 9 representing various research institutes. 8 of the 65 participants (all men) were trained in APEX, with 6 representing universities, 1 representing a private company, and 1 representing a governmental ministry. 9 of the 65 participants (including 1 woman) were trained in FarmSIM, with 6 representing universities, 2 research institutes, and one a governmental ministry.

A total of 30 people attended the Advanced SWAT workshop in Addis Ababa, of which 2 were women. 16 of the Advanced SWAT participants represented a university in some capacity, 6 a governmental ministry, and 8 a research institute. A total of 14 participants (all men) attended the SWAT clinic, of which 8 represented a university, 5 a research institute, and 1 a government ministry. A total of 3 participants (all men) attended the FarmSIM clinic, of which 2 represented a university and 1 a research institute.

ILRI

Ethiopia: In Robit Bata training was delivered for both the new comers and the previous year irrigated fodder participant farmers. The training was prepared for two days. On the first day, training was prepared for new participant farmers including woreda and kebele agriculture experts while on the second day, training was for both new and previous year participant farmers. The first day of training focused largely on forage, particularly Napier grass development which is provided by Misganaw Walle which lasted more than 2 hours. The second day of training consisted of three components, i.e., intercropping (by Misganaw Walle), water requirement (by Melaku Tessema guest trainer from IWMI - BBU) and improved dairy cow management and breeding (by Tewdrose Bimirew).

Kudimi kebele was selected for experience sharing purpose. This kebele is found at Merawi district which is 60 km away from Robit Bata and is selected since there are farmers who have good experience on irrigated fodder development. Prior to experience sharing, role model farmers (Ato Tena Kebede) were selected in terms of Napier development, legume intercropping and dairy cow husbandry practice. About 11 new participant farmers, 5 kebele agricultural experts and 4 agricultural experts from woreda agriculture office were shared experience from Ato Tena Kebede on forage (Napier grass development and feeding, Rhodes grass production and feeding, Sesebania production and utilization, intercropping of Desmodium and utilization), improved dairy cow management like construction of crash and feeding trough, and feed storage construction that can protect the feed from sunlight, rainfall and termite. Participants understand the following two main points from the experience sharing: 1) the importance of land allocation for Napier grass, and 2) the value of integrated forage development and intercropping of legume forages.

Ghana: In Ghana farmers were trained on irrigated fodder at Bihinayili in Savelugu district on 28 February 2016. The objective of the irrigated fodder production in Northern Ghana is to demonstrate potential of irrigated fodder in the area. Training of partners, namely Animal Research Institute (ARI), agricultural extension officers and farmers, was conducted on 28th of February 2016 at Bihinayili in the Savelugu district based on guidance provided from earlier training by ILRI. The objective of the training was to introduce the participants to small scale irrigation of fodder crops and to train the agricultural extension officers in fodder planting techniques and data collection. The training focused on layout of plots, planting methods and seed rates. Twelve farmers were involved in the training and were selected for dry season fodder production. Eight of the farmers agreed to participate in the irrigated fodder production. These farmers are also involved in IWMI's small scale dry season vegetable production using overhead water storage tank for irrigation.

Tanzania: Conducted training to farmers on the importance of establishing irrigated forage in alleviating feed shortages, forage production, management, harvesting, conservation and or storage, processing and utilization. The training was conducted by the subject matter specialist from TALIRI, ILRI and the extension service. A total of 57 were trained ahead of implementing the intervention.

IWMI

Training and capacity development in Robit:

- Frequent follow up trainings for farmers in the field of agriculture and water management, as BDU had observed a significant capacity gap within the first dry season of year 3. (As listed in table below)
- Farmers were (again) trained this season on nursery preparation and tomato seedling management by an agronomist (Habtamu, from ARARI).
- Field visit: Farmers, students, woreda focal persons and project coordinators went on a field visit to learn from another ILSSI site (Dangishta watershed).
- Training held in Adami Tulu on water management (WFD) for all farmers.

Trainings and capacity development in Dangeshita:

1. New farmers were trained on the project and expectations.
2. Training on WFD for the new ILSSI farmers
3. All farmers trained on about nursery preparation, transplantation and irrigation (Addisu and Melaku), maintenance and installation of Rope & washer (Melaku and Girma, ILSSI farmer from previous year)
4. Field visit: Farmers, students, woreda focal persons and project coordinators went on a field visit to learn from another ILSSI site (Robit watershed).

Trainings: Farmers, local government subject matter specialists, private sector

Date	Purpose of training	Number of trainees	Location/Site
14/10/2015	Project objective awareness (new farmers), crop selection and refreshment training	29	BDU

25/10/2015	Training to farmers about nursery preparation and tomato seedling management by an agronomist	19	Robit Bata
29/11/2015	Field and learning visit - Dangishta watershed	32	Dangishita
8/10/2015	Project information (new farmers)	9	Dangishita
4/10/2015	Nursery preparation, transplantation and irrigation (old and new farmers)	29	Dangishita
20/10/2015	Maintenance and installation of Rope & Washer	19	Dangishita
07/02/2015	Field and learning visit	31	Robit
	MoFA staff (3) and students were trained on biophysical and socioeconomic data collection	5	Upper East Region, Ghana
	Trained on fabrication of UDS drip kits	2 (private plumbers)	Upper East Region, Ghana
23 Dec 2015	Use and maintenance of water pumping machines.		
12 January 2016	Assembling and disassembling of iDE and UDS drip kits		
	Techniques in land preparations-raising of beds, measuring plot sizes, land levelling for installation of drip kits		
	Testing and maintenance of the drip kits system		
	WFD use		
	General agronomic practices-water and soil management		

XI. Publications and Knowledge Products

IWMI

Compiled a zero draft of the paper reviewing trends, constraints and opportunities of small scale irrigation in four East African countries: Ethiopia, Kenya, Tanzania and Uganda.

Draft report on the microfinance trainings and lessons learned across multiple sites in Ethiopia.

Mini workshop with students at BDU in February, at which 10 presentations based on ILSSI research were shared across students of ILSSI and LIVES.

Poster was presented at the 'Sustainable Agricultural Water Management Theme Meeting' in Addis Ababa, Ethiopia from 26 to 29 January 2016.

IWMI prepared a flyer on ILSSI activities in Ghana. This has been shared with the USAID mission in Ghana, the Savanna Accelerated Development Authority and the Ghana Irrigation Development Authority, among other development partners.

In March, a research report has been drafted for biophysical characterization of watersheds in Ghana, Ethiopia and Tanzania.

ILSSI was presented on the EAIR 50th year Anniversary and shared posters with Africa Rising and LIVES on solar pumps and wetting front detectors.

Poster presented in Leuven Belgium: "The importance of Ethiopian soils in irrigation and overall watershed management" in the Africa in Soil conference (4 December 2015).

TAMAR

During the first quarter of year three, TAMAR prepared and submitted a paper highlighting the IDSS integrated models to the Agriculture Water Management journal, based on the results of site studies in Ethiopia.

ILRI

Reports of FEAST studies conducted in Ethiopia, Ghana and Tanzania are available at the ILSSI WiKi Spaces page.

XII. Institutional capacity development

TAMAR

During the reporting period, IDSS workshops were conducted in Ghana and Ethiopia, as discussed in detail in section II.A—Component 4, above. This training involved capacity building for both students and faculty at the host and other universities, as well as government agencies. TAMAR is also supporting students and faculty in Ethiopia, Tanzania, and Ghana; see section II.A—Component 4 [Activity 4.1.3] for a detailed description. TAMAR has also provided SIMETAR to 6 cooperating scientists, in addition to all FARMSIM short course participants. TAMAR also shared all the SWAT models developed for all the four sites in Ethiopia with IWMI.

NCA&T

Both SUA and BDU's capacities in commercial vegetable home garden production systems under CA and drip irrigation is being built up. Students, staff and faculty are being built up through interactions with N.C. A&T team. Team also translated in Swahili learning materials for conservation agriculture vegetable production. Dr. Idassi and Mr. Festo finished Swahili translation of first sheet titled: "Hatua 14 za kulima mbogambogakwa njia ya kilimo hifadhi (Conservation Agriculture) na umwagiliaji wa matone (drip irrigation) ya maji." The fact sheet was a translation of the 14 steps to growing vegetables with conservation agriculture and drip irrigation from blog at: http://blog.horticulture.ucdavis.edu/2015/03/14-steps-grow-vegetables-with-conservation-ag-drip-irrigation/. It will be used at the summer vegetable training workshop targeting commercial vegetable home gardeners in Mkindo Village, Morogoro. Efforts will be made also, to train participants on how to establish a strong drainage system around their gardens for flood protection.

These commercial vegetable home garden systems are also being evaluated using the APEX model.

XIII. Technology Transfer and Scaling Partnerships

National partner institutions such as Bahir Dar University, University of Dar es Salaam, and Sokoine University of Agriculture are actively engaging in the project. TAMAR is supporting graduate students and staff at these institutions in their research. See section II.A. Component 4 [Activity 4.1.3] for a detailed description.

TAMAR has provided IDSS software (SWAT, APEX, and FARMSIM/SIMETAR) to course participants. This software has also been provided to several cooperating scientists at each cooperating ILSSI institution.

ILRI

In all sites in Ethiopia, where activities started earlier than in Tanzania and Ghana, numbers of participating farmers and land allocation to early forage options of Napier, Desho and Oats and Vetch have increased.

XIV. Issues and Concerns

As the project has moved to the generation of substantial new data from all components, the matter of ensuring overall integration of product into a coherent and integrated analysis is both exciting and challenging. Quality of data from field studies continues to be an ultimate limitation on the application of the IDSS. Reality checks on the IDSS product with stakeholders are also important to ensuring the quality and utility of the final product. Working with farmers in their fields has the ongoing challenge of consistency of data acquisition as adjustments to markets, weather and experiences and adjustments to individual social/cultural issues occur. Availability and affordability of useful interventions and access to credit are ongoing challenges.

XV. Future Work

IFPRI

The key activity in the next reporting period for the up-scaling activity will be to finalize the analysis for Ethiopia at the national level. This includes merging SWAT, DREAM and crop mix optimization.

For the survey work, analysis of the baseline data collected from Ethiopia, Ghana, and Tanzania, is the main activity planned for the next reporting period. A paper on irrigation-nutrition linkages is expected to be finalized and presented at the 2016 AAEA annual meeting. Another research output on the linkages between irrigation and gender empowerment is expected to be finalized during the summer. A final report on the Tanzania FGDs will also be available over the summer.

Three dissemination activities will take place during the summer: 1) AAEA conference in the US; 2) Stockholm World Water Week in Sweden; and 3) Africa World Water Week in Tanzania.

TAMAR

Ex post analyses using the IDSS: Evaluation of research sites in the Africa RISING and LIVES projects will continue in the third and fourth quarters of Year 3, with Africa RISING collaboration extending from Ethiopia to Tanzania and Ghana. Collaboration with other Innovation Labs will move from planning to implementation. Preparations for a subsequent round of ex ante analyses will continue. These analyses will use improved input data from field and survey studies to re-evaluate the effects and constraints of irrigation technologies, and means of mitigating these constraints. TAMAR and IFPRI will continue working jointly to scale up results from the farm and local watershed levels to larger levels of scale, as described in greater detail in Section II- Component 3 above ("Upscaling SSI in Ethiopia").
Training and education. TAMAR will provide IDSS workshop in June of 2016 in Arusha, Tanzania. ILSSI will continue to support students from partner universities, as well as other stakeholders and partner institutions, in applying the IDSS. Postdoctoral fellows will continue to gain experience in the IDSS through direct participation in research at IWMI, ILRI, IFPRI, TAMAR and NCAT. Training of graduate students will continue at TAMAR and NCAT.

IWMI

General:

Organization of stakeholder engagement (June-July) and collaboration on scenario development. Finalize reports, papers and publications:

- micro-finance trainings in Ethiopia
- Literature review on micro-finance context in Ethiopia for SSI credit opportunities
- gender and irrigation focus group discussions and interviews for Ethiopia and Ghana
- Participation with IFRPI IDE etc. for Stockholm World Water Week side event 28 August from 16:00-17:30. ""Enabling investment in irrigation in sub-Saharan Africa" (ref ID: 6048)
- Exploring engagement at 6th Africa Water week to be held in July 2016 in Tanzania
- Preparation of various knowledge products as follows:

Table 2: IWMI Knowledge products planned for completion before September 30, 2016

Type of product (report, publication, brief, poster, etc.)	Subject or proposed title	Authors
Publication	Analysis of technical efficiency of smallholder irrigation technologies	Gebrehaweria, Teshager, Surafel,
Report	Socio-economic impact of SSI interventions in Ethiopia	Gebrehaweria, Nicole, Fitsum
Theses in fulfillment of	Impact of Small Scale Irrigation Technology on Farm Household	M.S. students

degree requirements	Welfare, and The impact of small scale irrigation on farm production and productivity, and	
Publication	Review of SSI in Ethiopia, Kenya, Tanzania and Uganda	Prossie, Simon
Working report	Small scale irrigation activities for Ethiopia in the first year of implementation	Prossie, Petra, BDU, AMU
Reports	Constraints and opportunities related to gender in the adoption of SSI: Ghana and Ethiopia	
IWMI Working Paper	Agro hydrological landscape description….	Davie Kadyampakeni
Brief on field studies	Innovation Lab for SSI Briefs for Ghana, Ethiopia and Tanzania	Nicole Lefore, Petra Schmitter, Davie Kadyampakeni with support from consultant

Long-Term Degree Training[1]

Name of Innovation Lab: Feed the Future Innovation Lab on Small Scale Irrigation in Ethiopia, Tanzania and Ghana

Name of Student	Gender	University of Study	Degree[2]	Major	Graduation Date	Home Country	Home Institution[3]
Tewodros Assefa	M	NCA&T State University	Ph.D.	Energy and Environmental Systems	December 31, 2017	Ethiopia	Bahir Dar University
Tsehay Azeref Wondmeneh	M	Bahir Dar University	M.S.	Agronomy	June 2017	Ethiopia	Bahir Dar University
Hailie	F	Bahir Dar	M.S.	Horticulture	June	Ethiopi	Bahir Dar

[1] Include all students (both foreign and U.S. based) who are *currently* enrolled in a degree program funded in full or part by USAID regardless of when they started their program. Include those studying in the U.S., their home country or a third country.

[2] B.S., M.S., Ph.D., other (specify)

[3] Fill out for foreign students only. Specify if the student is from a NARS, an educational institution, the private sector, etc.

Alebachew		University			2017	a	University
Mariana McKim	F	NCA&T State University	M.S.	Agricultural Education	August 2016	USA	N.C. A&T
Sintayehu Alemayehu Teshome	M	Texas A&M College of Agriculture and Life Sciences	M.S.	Ecosystem Science and Management (Range Mgmt)	June 2017	Ethiopia	TAMAR
Belainew Belete	M	Bahir Dar University	M.S.	Economics	October 2016	Ethiopia	Bahir Dar University
Talakie Asnake	F	Bahir Dar University	M.S.	Water resources Engineering	June 2016	Ethiopia	Bahir Dar University
Muluye Gedife	M	Bahir Dar University	M.S.	Water resources Engineering	December 2016	Ethiopia	Bahir Dar University
Adisu Wondimu	M	Bahir Dar University	M.S.	Chemical Engineering	June 2017	Ethiopia	Bahir Dar University
Debebe Lijalem	M	Bahir Dar University	Ph.D.	Water resources Engineering	June 2018	Ethiopia	Bahir Dar University
Misba Abdela	M	Bahir Dar University	M.S.	Water resources Engineering	June 2016	Ethiopia	Bahir Dar University
Abdu Yimer	M	Bahir Dar University	M.S.	Water resources Engineering	June 2016	Ethiopia	Bahir Dar University
Kassaw Beshaw	M	Arba Minch University	Ph.D.	Water resources Engineering	June 2019	Ethiopia	Arba Minch University
Demelash Wendemench	M	Arba Minch University	Ph.D.	Water resources	June 2019	Ethiopia	Arba Minch

				Engineering			University
Tariku Yadeta Fufa	M	Arba Minch University	M.S.	Economics	December 2016	Ethiopia	Arba Minch University
Raymond Tetteh	M	UDS	M.S.				

XVI. Publications

Tewodros T. Assefa, Manoj K. Jha, Seifu A Tilahun, Ephrem Yetbarek, Anwar A Adem and Abeyou Wale. 2015. Identification of Erosion Hotspot Area using GIS and MCE Technique for Koga Watershed in the Upper Blue Nile Basin, Ethiopia. *American Journal of Environmental Sciences. Volume 11, Issue 4. Pages 245-255*

Tewodros Assefa, Manoj Jha, Sushama Pradhan. 2015. Modeling Onsite Wastewater Treatment Systems (OWTS) for Nutrient Fate and Transport for Lick Creek Watershed. *SWAT 2015. International soil & water assessment tool conference. October 14-16, Purdue University, West Lafayette, IN, USA.*

Tewodros T. Assefa, Seifu A Tilahun, Demesew A Mihret, Essayas K Ayana, Michael Mahri, Petra Schmitter, Manoj K. Jha, Simon Langan. 2015. Reservoir sedimentation and hotspot areas in Koga Watershed of the Upper Blue Nile Basin, Ethiopia. TropiLakes 2015. Tropical Lakes in changing environment: water, land, biology, climate and humans.

Adugnaw Tadesse, Mamaru A.Moges, Debebe Lijalem, ,Dessalegn C. Dagnew, Tewoderos Taffese, Mulugeta A.Belete, Seifu A. Tilahun, and Tammo S. Steenhuis. Assessment of nitrate concentration in drinking water sources in rural areas of Ethiopia. 2015. ICAST-2015 Conference, Volume 3, Bahir Dar, Ethiopia.

Assefa, Tewodros; Jha, Manoj; Reyes, Manuel; Srinivasan, Raghavan; Worklul, Abeyou. 2015. Evaluation of Land Suitability for Irrigation and Potential of Water Sources Using GIS and MCE Technique for Lake Tana Basin. *Submitted to ASABE international meeting, Dec 2015*

Reyes, M.R., Enku, T., and Azeref, T. 2016. Success story of an Ethiopian Commercial Vegetable Home Gardener (submitted hopefully chosen to be included in the FtF newsletter April 2016.

Annex 1. IWMI - List of graduate students for current fiscal year

Name	M/F	Univ	Dept	Degree	Research topic	Site	Data to collect	Expected graduation date	IWMI supervisor
Belainew Belete	M	BDU	Economics	M.S.	impact of small scale irrigation technology on farm household welfare	All sites in Ethiopia	Socio-economics survey	October, 2016	Dr. Gebrehaweria Gebregziabher
Talakie Asnake	F	BDU	Hydrology	M.S.	Optimizing irrigation scheduling to improve onion production	Dangishta	Baseline surveys, soil physio-chemical properties, soil moisture, discharge rates of lifting technologies, periodic onion performance including plant height and ground cover, irrigation amounts and intervals, onion yield	Jun-17	Dr. Petra Schmitter/ Dr. Prossie Nakawuka
Muluye Gedife	M	BDU	Hydrology	M.S.	Effect of Irrigation scheduling on partial nutrient balances for tomato	Robit	Baseline surveys, soil physio-chemical properties, soil moisture, discharge rates of lifting technologies, periodic onion performance including plant height and ground cover, irrigation amounts and intervals, onion yield	October, 2016	Dr. Petra Schmitter/ Dr. Prossie Nakawuka

Adisu Wondimu	M	BDU	Environmental Engineering	M.S.	Assessment of Pesticide residual contamination of soil and water resources: Case of Robit Bata	Robit	data on pesticide residual from soil, ground water and surface water	Jan-17	Dr. Petra Schmitter
Debebe Lijalem	M	BDU*	School of Civil and Water Resources Engineering	Ph.D.	Optimizing use of groundwater for irrigation in the dry season in the Robit-Bata watershed located in the Lake Tana basin	Robit	Climatic data, groundwater fluctuations, well yield, soil physical properties, streamflow, sediment concentration, sediment physio-chemical properties, DEM, land use/land cover map, soil map	June 2017	Dr. Petra Schmitter/ Dr. Prossie Nakawuka
Misba Abdela	M	BDU	School of Civil and Water Resources Engineering	M.S.	Improving subsurface recharge by breaking hardpan through deep tillage	Robit	Baseline survey, soil physio-chemical properties, soil penetration resistance, soil infiltration rates, rainfall data, groundwater fluctuations, soil moisture, plot runoff, sediment concentration from treatment plots, sediment physio-chemical properties, periodic crop performance, crop yield	July, 2016	Dr. Prossie Nakawuka/ Dr. Petra Schmitter

Abdu Yimer	M	BDU	School of Civil and Water Resources Engineering	M.S.	Rainfall-Runoff process in the Upper Blue Nile basin: the case study of Dangishta watershed	Dangishta	Climatic data, stream flow, sediment concentration, sediment physio-chemical properties, soil infiltrability, groundwater fluctuations, soil moisture, soil physio-chemical properties, DEM, land use/land cover map, and soil map	July, 2016	Dr. Prossie Nakawuka/ Dr. Petra Schmitter
Kassaw Beshaw	M	AMU	Department of Water Resources and Irrigation Engineering	Ph.D.	TBD***	Upper-Gana and Bochesa	Climatic data, stream flow, soil physio-chemical properties, water (from wells and river) chemical properties, sediment concentration, sediment physio-chemical properties, DEMs, soil maps, land use/land cover maps, groundwater fluctuations, well yield	June 2018	Dr. Petra Schmitter/ Dr. Prossie Nakawuka
Demelash Wendemench	M	AMU	Department of Water Resources and Irrigation Engineering	Ph.D.	TBD	Upper-Gana and Bochesa	Soil physio-chemical properties, soil moisture, water chemical properties, lifting technologies' discharge rates, well yield, irrigation amounts and intervals, crop periodic performances, crop yield	June 2018	Dr. Petra Schmitter/ Dr. Prossie Nakawuka

Tariku Yadeta Fufa	M	AMU	Economics	M.S.	The impact of small scale irrigation on farm production and productivity	All sites in Ethiopia	Socio-economics survey	October, 2016	Dr. Gebrehaweria Gebregziabher
Ghana									
Raymond Tetteh	M	UDS	Agric. Mechanisation and Irrigation Technology	MPhil		Bihinaayilli, Zanlerigu and Dimbasinia	Improved irrigation practices among smallholder dry season vegetable farmers in Northern Ghana. Identify and assess the types of improved irrigation practices available; analyze water use productivity; analyze and predict the sustainability of improved practices and impacts on the ecosystem using APEX	December, 2017	Dr. Davie Kadyampakeni