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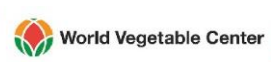
Irrigating farmer in the Volta Region of Ghana harvests carrots, 2023. (Credit: Reel Diaries)

Feed the Future Innovation Laboratory for Small Scale Irrigation

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Submitted by the Norman Borlaug Institute for International Agriculture and Development, The Texas A&M University System & AgriLife Research

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Executive Summary

The Innovation Lab for Small Scale Irrigation (ILSSI) cooperative agreement led by the Borlaug Institute for International Agriculture Development at Texas A & M University, made progress across objectives:

Objective 1, Identify and test approaches to sustainably Scale Small Scale Irrigation through reducing constraints and strengthening opportunities for access. Research and market-based activities with private partners in Ghana, Ethiopia and Mali show high potential for solar irrigation development. Solar suitability mapping, market segmentation analysis, demand-supply linkage workshops and innovation scholar internships have all benefited companies' market growth. Sales targets were met in Mali and Ethiopia in the two quarters of reporting. Multi-stakeholder dialogues have received support from other development partners to ensure continuation after ILSSI exit. Research results have been integrated into initiatives including World Bank's AICCRA, Water and Energy for Food, and SURE-Senegal.

Objective 2, Identify and test approaches to scale Small Scale Irrigation to be sustainable and support resilience. ILSSI climate and water resource analysis in West Africa shows growing limitations for rainfed production and the need for supplemental and dry season irrigation. Analysis on the energy-water-food nexus show increasing feasibility and returns for solar irrigation under climate change scenarios, particularly with increased energy costs; data has been generated for specific regions within Ghana. In Mali, guidance has been drafted on scaling irrigated vegetable production and nutrition-sensitive irrigation investment.

Objective 3, Identifying and testing approaches to maximize inclusivity, effective governance, women's empowerment, and involvement of youth for nutrition-sensitive irrigated production. ILSSI partners published policy and technical notes and peer-reviewed papers on gender empowerment, as well as inclusive, market-based approaches to reach more women and youth. While private partners are achieving between 7-10% sales to women, reaching youth is more challenging; household decisions on credit and investment are largely made by family elders, and companies recognize the need for adapted marketing strategies. Towards inclusive resilience, ILSSI completed fieldwork on community-level water governance; the local partner in Ghana and a South-South knowledge exchange serve to continue activities post-exit.

Objective 4, Achieve impact through uptake of ILSSI research results and methods. ILSSI organized and/or were invited to national and global forums targeted at policy makers and investment planners, including with the UN (World Water Day), African Union, World Bank, UN Working Group on Nutrition, among others. ILSSI continually updates the project website, open access library repository and produces a quarterly newsletter; datasets and publications are being uploaded to the USAID repositories. Trainings targeted private companies, young scientists, extension and farmers. More knowledge products were produced in both French and English, including policy briefs and videos.

1. Introduction

The Feed the Future Innovation Lab for Small Scale Irrigation (ILSSI) is a cooperative agreement led by the Borlaug Institute for International Agriculture Development at Texas A & M University (TAMU) AgriLife Research. ILSSI's vision is to contribute to an increase of profitable, sustainable and gender-sensitive irrigation to support inclusive agricultural growth, resilient food systems, and nutrition and health outcomes, particularly for vulnerable populations. The project works in Ethiopia, Ghana, and Mali; Bureau for Humanitarian Affairs supports buy-in activities in Ethiopia and Mali. Limited analysis of data continues for Tanzania. ILSSI has sub-awards with the International Water Management Institute, International Food Policy Research Institute, International Livestock Research Institute, the World Vegetable Center, Kwame Nkrumah University for Science and Technology, University of Ghana, Prairie View A & M University, and private sector partners Rensys Engineering (Ethiopia), EMICOM and EcoTech in Mali. ILSSI also contracts with Bahir Dar University to support graduate students. This report describes progress toward objectives in fiscal year 2023, the tenth year of the cooperative agreement.

2. Progress toward objectives (Areas of Inquiry)

Objective 0: Effectively plan, coordinate, and organize multi-institutional activities

- The management Entity (ME) maintained 10 sub-agreements, leveraged several funded and unfunded collaborations.
- Budget burn rate improved with stronger monitoring of sub-agreement expenditure rates.
- Convened regular virtual Project Management and External Advisory Committee meetings.
- Engaged with the USAID Missions in Ghana, Ethiopia, and Mali Mission representatives attended ILSSI workshops; engaged Mission supported projects (Mali, Ghana, Rwanda, and Malawi).
- Engaged as a technical partner in the Horticulture Innovation Lab with UC Davis.
- Managed dataset uploads and reports/papers to USAID repositories.

Objective 1: Identify and test approaches to sustainably scale SSI through reducing constraints and strengthening opportunities for access

Activity 1.1: Identify upscaling opportunities for resilient SSI systems

Sub-Activity 1.1.1. Joint research scaling activity with private sector entities

Joint scaling activities (field-level) with several private sector entities in Mali, Ghana, and Ethiopia have been completed. Private companies have benefited through increased market sales of solar pumps. Results on how to scale solar pumps sustainably are being used by World Bank, GIZ, SURE (USAID activity in Senegal), and [AICCRA](#) for scaling.

In March 2023, a new partnership was established with Interplast to joint-scaling irrigation equipment and services to smallholder farmers in Ghana.

IWMI had been collaborating with and providing technical support to ILSSI private sector partners by supporting ILSSI private sector partners (PEG, Rensys, EMICOM, ECOTECH). In addition, IWMI established and facilitated business-research partnerships with the private sector entities in Ghana to develop the co-investment mechanism for scaling irrigation innovation bundles.

In Ghana, co-leveraging with Africa Rising, IWMI has established and facilitated the private sector scaling partnership with Pumptech, TECH2, GIZ, and MOFA. In March 2023, a new partnership was established with Interplast to joint-scaling irrigation equipment and services to smallholder farmers in Ghana. The partnerships are functioning under the co-investment mechanism by which all kinds of resources have been mobilized for the scaling of solar-based irrigation bundles in Ghana. ILSSI and Africa Rising contribute to this partnership with the IWMI's technical support and facilitation, including:

- Conducting market segmentation for the solar-based irrigation bundle in the Upper West, Northern, North-eastern, and Savannah Region,
- Organizing the demand-supply linkage workshops and field demonstrations in these regions, and
- Preparing for the follow-up activities and engagement to enhance the demand-supply linkages in three regions with high market demand and growth: Upper East, Upper West, and Savannah.

In Ethiopia, IWMI facilitated the partnership with Rensys by providing technical support and facilitation. These include:

- the digitalization of client assessment scorecards and inclusive marketing via Hackathon and internship co-organized with BUD
- the establishment of pay-go solar pump supply to Lemo, SNNPR by organizing the demand-supply linkage workshop and field demonstrations, and
- the segmentation of market demands for solar-based irrigation bundles in two new regions of Oromia and Amhara region.

Sub-Activity 1.1.2. Qualitative survey with private and public sectors to assess information requirements and format

IWMI collected and analyzed data from semi-structured interviews (Ghana, Ethiopia) and online survey with 140+ company respondents; the technical report and article on the necessary information to enable private sector investment in small-scale irrigation was submitted.

The analysis highlights that:

- The market information (66% of respondents) including factors like the need for irrigation, the demand for irrigation products and services, clients' financial capacity, farming systems, and farming capacity as well as their cash-flow possibility to get irrigation investment started has the biggest impact on the company's decision on expanding their products and/or services. Hence, the identification of suitable markets for their products and services is the most vital consideration before expansion.
- The second group of factors determining the company's decision on expanding their products and/or services is expanding their products and/or services is farmer-based information such as farm's specifications (e.g., size, location, crop's specific information, and irrigation system) (73%) and the presence of farmer cooperative, unions, and/or other social structures most often (61%).
- Companies most frequently considered the availability and quality of water sources (75%) and the network of renewable and non-renewable energy sources (75%) as important information determining their decision.
- The market for capital-intensive equipment is mostly demand-driven with water lifting and conveyance equipment being the most demanded product on the market with pipes and spares being the least demanded. Private sector entities need farmer-based, geographical, and socioeconomic information to better unpack the real market demands, thereby managing the risks of their investment in expanding the irrigation product and service profile.

- Given the focus on creating new products and services to meet farmers’ needs—and a focus on sustainability—it is recommended that companies in the irrigation business incorporate data-driven tools and technologies in the business management to improve access to client-based, geographical, and socio-economic information.

Sub-Activity 1.1.3 Refining the suitability mapping framework for solar and SSI packages at national scale and sub-national scale; Sub-Activity 1.1.4 Validation of the suitability maps with private sector

IWMI finalized the paper on customizing and validating solar suitability maps with the use of private sector investment into solar irrigation and refining the current solar suitability framework to the needs in Ethiopia, Ghana and Mali. Learning from engagement with the private sector partners and collaborators on the customization of solar suitability mapping focused on the integration of socioeconomic and financial factors. As a result of this engagement IWMI is preparing an article ‘Development of a solar suitability framework for expanding solar pump supply chains across sub-Saharan Africa’.

The suitability maps are presented to stakeholders in the form of an online interactive tool that is available on mobile devices. Key highlights from Solar Irrigation Suitability Mapping in Sub-Saharan Africa include:

- The study revealed that sub-Saharan Africa has approximately 120 million hectares (Mha) of potentially suitable land for solar-based irrigation.
- This area comprises of using groundwater as the source of irrigation (112 Mha), accounting for 85% of the total suitable area, and 18 Mha using surface water irrigation water sources. Further, the East African countries account for 46 Mha, while Southern African countries have the smallest portion, with only 15 Mha. Middle and Western African countries have 34 Mha and 25 Mha solar suitable potential areas, respectively.
- Among the countries assessed, Angola, Zambia, South Africa, Congo, and Nigeria demonstrated the highest suitability for groundwater irrigation, in descending order. On the other hand, Angola, South Africa, Nigeria, Zambia, Congo, and Tanzania were found to have the highest suitability for surface water irrigation, in descending order.

Sub-Activity 1.1.7.a. Land suitability assessment for cocoa cultivation in Ghana using a GIS based Multi-Criteria Evaluation (MCE); Sub-Activity 1.1.7.b. Potential of small-scale irrigation and improved soil management practices on cocoa production, income and nutrition in Ghana

Graduate students at national partner institution Kwame Nkrumah University of Science and Technology, completed household surveys in cocoa-producing areas (Ashanti, Western) to assess the potential of SSI and improved soil management on production and household income/nutrition. A farm simulation model was used to analyze cocoa and farm production at household and village levels.

Activity 1.2: Identify constraints and assess impact of policy through analyses and dialogue

Sub-Activity 1.2.1. Constraints Analysis

The journal article on [“Demand and supply constraints of credit in smallholder farming: Evidence from Ethiopia and Tanzania”](#) was published by *World Development* in November 2022.

Sub-Activity 1.2.5: Micro-economic study of the effect of loans and tax breaks on the demand for different SSI types

IWMI has completed this activity in Year 10 and the dataset was uploaded to Texas Data Repository (Marie-Charlotte Buisson; Soumya Balasubramanya; Fitsum Hagos; Archisman Mitra; David Stifel; Bezabih Tesfaye, 2023, "Micro-economic study on willingness to adopt SSI technologies <https://doi.org/10.18738/T8/ZTH2WF>, Texas Data Repository, DRAFT VERSION).

As a result of this activity a peer-review paper on '[Price, credit, or uncertainty? Increasing small-scale irrigation in Ethiopia](#)' was published by World Development. The paper highlights that farmers' irrigation adoption decisions are most sensitive to the availability of loans, and the removal of uncertainties around well drilling.

Sub-Activity 1.2.6. Assess impact of change in cost of water lifting technologies related to reduction in tariff on producer revenue

IFPRI is drafting a report on duty-free provision for irrigation pumps in Ethiopia.

Sub-Activity 1.2.7. Facilitating dialogue between key stakeholders to strengthen SSI scaling

The final multi-stakeholder dialogues were convened and facilitated by ILSSI to bridge information gaps and strengthen irrigation equipment/input markets in Ethiopia and Ghana.

Since 2019, IWMI together with different co-hosting organizations and partners organized 15 Small Scale Irrigation Multi Stakeholder Dialogue (MSD) meetings in Ghana (08), Ethiopia (06), and Mali (01). These MSD meetings were co-organized with national partners, involving around 600 participants from the government, development, and private sector as well as farmers and other value chain actors. MSDs engage the private sector actors, creating opportunities for cross-sector learning and capitalizing on multi-sector investments in scaling FLID. An overview of the MSD meetings is presented in Table 1.

No.	Title	Source
Ghana (08 MSD meetings)		
1 st	Small Scale Irrigation Dialogue Space: Concept and Kick Start	Small scale irrigation dialogue space: Concept and kick start. Ghana, October 24, 2019
2 nd	Partnerships and financing solutions for sustainable and inclusive farmer-led irrigation scaling in Ghana	Small Scale Irrigation Dialogue Space: Partnerships and financing solutions for sustainable and inclusive farmer-led irrigation scaling in Ghana – 2020
3 rd	Understanding the scalability of solar-powered irrigation in Ghana: market segmentation and mapping pump suitability	Small Scale Irrigation Dialogue Space: Understanding the scalability of solar-powered irrigation in Ghana: market segmentation and mapping pump suitability – 2021
4 th	Sustainability of cocoa systems: Exploring segmentation, water management and small scale irrigation suitability	Small Scale Irrigation Dialogue: Sustainability of cocoa systems: Exploring segmentation, water management and small scale irrigation suitability

5 th	Market and value chain approaches to farmer-led irrigation development	https://ilssi.tamu.edu/files/2022/07/20220625-5th-MSD-Meeting-Report-Ghana_edited-v-for-web-FINAL.pdf
6 th	Innovations for improving irrigation water use efficiency in farmers' field	Remark: this MSD meeting was sponsored by GASIP project
7 th	Bundling innovations for scaling farmer-led irrigation development	20221204-7th-MSD-Meeting-Report-Ghana.pdf (tamu.edu)
8 th	Co-designing sustainable and inclusive irrigation to leverage the climate resilience cocoa initiatives	20230507-2nd-cocoa-dialogue-report-final.pdf (tamu.edu)
Ethiopia (07 MSD meetings)		
1 st	A multi-stakeholder dialogue on farmer-led irrigation development (FLID) in Ethiopia: Engaging with Stakeholders from the Agricultural Water Management Task Force	A multi-stakeholder dialogue on farmer-led irrigation in Ethiopia: Engaging with stakeholders from the Agricultural Water Management Task Force – 2020
2 nd	Financing solutions for scaling sustainable and inclusive farmer-led irrigation in Ethiopia	Farmer-Led Irrigation Multi-Stakeholder Dialogues: Financing solutions for scaling sustainable and inclusive farmer-led irrigation in Ethiopia – 2020
3 rd	Value Chain Approaches to Small Scale Irrigation Development	Farmer-led Irrigation Multi-Stakeholder Dialogues: Value Chain Approaches to Small Scale Irrigation Development – 2021
4 th	The role of offtake markets in unlocking small scale irrigation investments	https://ilssi.tamu.edu/files/2021/12/20211120-4th-MSD-meeting-report-submitted-FINAL.pdf
5 th	Inclusive and Sustainable Scaling of Farmer-Led Irrigation	2022-07-01-5th-MSD-Meeting-Report-FINAL-submitted.pdf (tamu.edu)
6 th	Bundling innovations for scaling farmer-led irrigation development and improving water use in rainfed and irrigated agriculture	https://ilssi.tamu.edu/2023/03/18/a-glimpse-of-hope-in-the-role-of-private-sector-engagement-for-scaling-irrigation-innovation-bundles-in-ethiopia/
7 th	The development of a PPP Strategy for Small Scale Irrigation Development and Management	Remark: This MSD meeting took place in July 2023 and a report is forthcoming.
Mali (01 MSD meeting)		
1 st	Multi-stakeholder dialogues supporting the scaling of ecological inclusive and sustainable agricultural water management (ISAWM) in Mali: A kick start meeting	https://ilssi.tamu.edu/files/2021/08/20210811-MSD-Mali-Report-Submitted-Revised-AK.pdf

In **Ghana**, the IWMI acts as coordinator and facilitator of the SSI-MSD dialogues. Since late 2022, the SSI-MSD have been institutionalized by several OneCGIAR initiatives such as the [Initiative Mixed Farming Systems](#) and [the Initiative West and Central African Food Systems Transformation](#). In Ethiopia, IWMI, the Agricultural Water Management-Task Force, the Ministry of Agriculture (AWM-TF), and the World Bank's 2030 WRG are co-hosting the SSI-MSD. Inputs from MSD meetings contributed to one policy change in the irrigation development area. Since January 2023, the Water Productivity Open Access Portal ([WaPOR](#)) project has joint sponsored the SSI-MSD, thereby sustaining the dialogue beyond the ILSSI project.

Activity 1.3 Identify entry points to reduce supply constraints on irrigation technology markets

Activity 1.3.1 Determination of marketing margin along different points of SSI chain of actors in Ethiopia and Ghana

Sub-Activity 1.3.2 Identification and piloting of SSI scaling pathways with private entities

In Year 10, two technical reports ([Marketing margin of irrigation technologies in Ghana: An analysis from a supply chain perspective](#) and [Marketing margin of irrigation technologies in Ethiopia: An analysis from a supply chain perspective](#)) were published.

In **Ethiopia**, results indicated that the supply chain for solar, motor pump and rope pumps are short, i.e., the importer or supplier of the locally manufactured irrigation technologies and wholesaler and retailer is the same company, sometimes using intermediary agents as the final link to end users by charging an additional commission of 10–15 % of the sale price.

In **Ghana**, the supply chains for irrigation equipment supply are short. Actors in the supply chains play multiple roles as importers/suppliers, wholesalers, and retailers. They offer products and accessories that may be sold to the buyer as a package or as individual components. Marketing margins vary from product to product as well as transaction to transaction.

Sub-Activity 1.3.2 Identification and piloting of SSI scaling pathways with private entities

In year 10 IWMI developed an impact assessment framework to monitor and assess investment partnerships for sustainability. The framework was tested through the private sector scaling partnership with Pumptech and Tech2 in Ghana. IWMI has finalized the framework and data analysis is in process.

IWMI finalized the systemic, adaptive scaling toolkit including 1) tools to facilitate scaling partnership; 2) Diagnostic tools for decision-making; and 3) Scaling and impact assessment tools. Due to funding challenges, IWMI focuses on completing the toolkit in word/PDF form. In total, eight tools have been consolidated, including:

1. [How to assess client credit worthiness](#)
2. [How to develop a demand-driven capacity strengthening program](#)
3. [How to segment the demand for the scalable innovation bundle](#)
4. [How to develop scalable innovation bundles](#)
5. [How to organize a supply and demand linkage workshop](#)
6. [Example of bundling solar-based irrigation technologies and services](#)
7. [Solar suitability mapping](#)
8. [Enabling environment analysis tool](#)

Additionally, IWMI has developed a **framework to assess the performance and impact of scaling partnership for sustainability (SPS)**. The framework is tested with the private sector scaling partnership with Pumptech and Tech2 in Ghana. The framework has been developed to assess whether the partnership for sustainability is relevant, coherent, efficient, and effective in achieving sustainability impacts.

In Year 10 IWMI analyzed market segmentation and discussed different farmer demand segments for SBIBs in three technical reports: 1) Demand segmentation for solar-based irrigation bundles in Ziway and Wereta, Ethiopia, 2) [Demand-supply linkage pathway to scaling solar-based irrigation along irrigated vegetable value chains in Upper East Region, Ghana](#), and 3) [the exposure-based pathway to scaling best-fit bundles of irrigation technologies, services, and practices in Koutiala, Mali](#).

ILSSI also leveraged resources with the Africa Rising project. Through this partnership, **five business-research partnerships to scale SBIBs** were established among ILSSI-IWMI, private sector partners, and public sector actors. During Year 10, the two partnerships in Ghana and Ethiopia have continuously mobilized resources to 1) establish sales and service networks, 2) increase the private sector's visibility and outreach in the regions, 3) capitalize on the sale of PAY-OWN solar-powered pumps, and 4) facilitate environmental and social sustainability and inclusivity of scaling solar-based irrigation in the region.

In **Ghana's** partnership organized six demand-supply linkage workshops, twelve field demonstrations, and established four sale and service networks in Upper West, Upper East, Northern, and Northeast regions. These activities benefited 1,622 farmers, extension officers and other value chain actors. Of that, 32.43% are female participants and 89.89% are farmers.

In **Ethiopia's** three demand-supply linkage workshops, six demonstrations to establish and expand the Rensys's existing sale and service network to Ziway and Bahir Dar were organized. These activities benefited 353 farmers, extension officers and other value chain actors. Of that, 21.25% are female participants and 71.95% are farmers.

In **Mali's extended business-research partnership**, the private sector partners navigated their entrepreneurial and collaborative practices to enable the forming of collaborations to optimize and harmonize different companies' investments in marketing SBI-related products and services. Four companies (EMICOM, EcoTech, Sonikara, and Horonya) have joined the demand-supply linkage and marketing activities organized by the partnership with ILSSI research activities.

Sub-Activity 1.3.3. Assess blocking and enabling mechanisms and develop systematic scaling approaches for Ghana and Ethiopia

In Year 10, [Enabling environment analysis tool](#) was developed to help in the design of scaling strategies that are adaptive to context and available resources. The enabling environment analysis aims to understand enabling and hindering factors for scaling suitable irrigation technology packages, identify constraints and opportunities for scaling technology, and develop recommendations for policy makers and practitioners to scale irrigation technology practices. This tool was applied in Ghana, [Ethiopia](#) and [Mali](#). Recently it was integrated in [the World Bank's FLID guide](#).

IWMI applied the enabling environment analysis tool to analyze the policy and intervention environment in Ghana, Mali and Ethiopia to identify pathways for scaling irrigation technologies and services for SSI/FLID. Two technical reports were submitted/published, including:

- [The enabling environment to scale water and irrigation solutions and services in Ethiopia](#)
- Analysis of policies and interventions for scaling irrigation technologies and services in Mali (*Submitted to ILSSI in 01/2022*)

Objective 2: Identify and test approaches to scale SSI to be sustainable and support resilience

Activity 2.1.: Assess tradeoffs between environmental and human resilience to climate shocks and stressors

Sub-Activity 2.1.2. Irrigation and water pollution analysis

IFPRI paper on the extent to which returns from irrigation can be affected by sub-optimal uses of complementary inputs has been accepted for publication. The descriptive analysis shows that fertilizer use is more likely to be combined with purchased seed. Although the share of plots that use only fertilizer (without purchased seed, agrochemicals, and hired labor) is about the same for irrigated and non-irrigated plots at about 32%, the share of plots with both fertilizer and purchased seed is higher in irrigated plots by about 12% than plots without irrigation. The econometric analysis is identifying more concrete relationships on the impact of irrigation on input complementarity.

The IFPRI paper titled "[Toward a better understanding of the environmental impacts of expanding farmer-led irrigation in Sub-Saharan Africa: an exploratory assessment of irrigation-induced risk of nutrient water pollution in Ethiopia](#)" was published in June 2023 in Environmental Research Communications. The assessment finds small increases in agricultural nutrient loadings from expanding small scale irrigation. However, growth in nutrient loadings from small scale irrigation is highly heterogeneous spatially and risk of local water quality deterioration exists.

A further study on the performance of Ethiopia's duty-exemption policy reform for irrigation pumps and equipment was completed in 2023. The study revealed that the reform had several positive impacts: According to key informants, the reform attracted several new importers, but there is no evidence that end users had better pump access as a result of the reform, and there is also no evidence that the affordability of pumps and other irrigation equipment improved. Moreover, even if the reform would have been successful, the main stumbling block for importers in Ethiopia remains the lack of foreign exchange to pay for imports. The study was presented at a final ILSSI workshop in Ethiopia in May 2023.

Sub-Activity 2.1.5 Assess potential trade-offs in irrigated fodder production; Sub-Activity 2.1.6 Validate alternative irrigated forage options for different contexts

ILRI completed the evaluation and screening of ten forage genotypes suitable for SSI to identify the forage genotypes or varieties that perform well under minimal irrigation and nutrient input, which can in turn reduce risks of crop failure for smallholders. Some of the selected varieties are in the national variety registration process.

ILRI published the results of analysis on the tradeoff of irrigated fodder production vis-à-vis crop cultivation have been analyzed considering three business case scenarios: 1) irrigated fodder, 2) irrigated vegetables and other crops, 3) irrigated khat. A key finding in this research was that adopting improved agricultural and livestock technologies has a high potential to improve economic and nutritional

wellbeing and resilience in the face of climate variability in Ethiopia and an opportunity to meet its goals of economic development and food security.

Activity 2.2: Assess approaches to reducing risks associated with irrigation investments.

Sub-Activity 2.2.1: Climate risk assessment; Sub-Activity 2.2.2: ENSO assessment, Ethiopia

IFPRI paper on "The role of small-scale irrigation for climate resilience: Insights from the 2015 ENSO event in Ethiopia" shows that irrigating households had higher resilience to extreme weather events than non-irrigating households. The paper is to be resubmitted for publication.

Sub-Activity 2.2.3. Identifying cropping systems (including legume crops, fodder, etc.) that provide the best productivity under different climatic scenarios

The Integrated Decision Support team assessed current water extraction from Inner Niger Delta (IND) in Mali for irrigation by farmers and estimate optimal crop water requirements by crops and overall water to be used for optimal and efficient production. Also, assessed the environmental risks, and the potential for climate adaptation (e.g., irrigation) and mitigation (conservation agriculture) in Mali. Results are being used by the Sene Yiriwa project (supported by USAID).

Activity 2.3.: Assess the potential for innovative technology and scheduling tools to contribute to social-ecological resilience

Sub-Activity 2.3.2. Estimating the potential of solar pumps in improving irrigation access vis a vis energy intensity

IFPRI finalized two policy notes on the economics of solar irrigation in Ghana and Mali. The total potential is approximately 3 million ha.

The two policy notes have now been published as:

Xie, H. and C. Ringler. 2023. [Financial feasibility of developing solar groundwater irrigation in Ghana](#). Feed the Future Innovation Lab for Small Scale Irrigation (FTF-ILSSI) Project Notes 4. Washington, DC: IFPRI.

Xie, H. and C. Ringler. 2023. [Financial feasibility of developing solar irrigation in Mali](#). Feed the Future Innovation Lab for Small Scale Irrigation (FTF-ILSSI) Project Notes 5. Washington, DC: IFPRI.

The IFPRI paper on food security and nutrition linkages in Mali that was published as a discussion paper remains under review as a journal article. Findings include that crop income and diversification, market participation, employment, and dietary quality were substantially higher in irrigated farms compared to non-irrigated farms. Likewise, irrigating households had higher food security and higher dietary diversity. However, the low adoption levels of improved water-lifting technologies are a major challenge. Limited promotion of solar and motorized pumps has contributed to the low adoption of these improved water-lifting technologies.

Activity 2.4.: Identify pathways from water access and management to improved water and food security, and sustainable resilience (Mali)

Sub-Activity 2.4.1. Irrigation-nutrition linkages assessment Mali

While *security issues in Mali negatively affected progress*, IFPRI has completed a paper "Turning drylands into breadbasket: Drivers of Adoption of Small-Scale Irrigation in Mali and Its Impacts on Nutrition and Income"; the paper is currently under review by *Food Security*.

Activity 2.5.: Approaches to catalyze scaling of SSI within market system

Sub-Activity 2.5.1. Identify scaling pathways within market and food system for irrigation

WorldVeg completed a survey (N: 923 vegetable farmers) in Mali to evaluate the impact of solar power irrigation on vegetable production. A strategy for developing and promoting irrigated vegetable production in Mali has been drafted in French and English.

A technical report is drafted on co-identification of pathways for scaling SSI along the irrigated vegetable value chain in Koutiala and Sikkaso (Mali).

Sub-Activity 2.5.4. Business model and finance credit modalities for scaling inclusively

Under the scope of this activity, and in leveraging with the Africa Rising project, IWMI published a technical report '[The enabling environment for gender and youth inclusion in the irrigated vegetable value chain in Mali](#)' and a water issue brief '[Inclusive agriculture: Creating opportunities for women and youth in Mali's irrigated vegetable value chain](#)'. These publications highlight a strong political will to develop Mali's agriculture sector. However, irrigated vegetable production is not a policy or intervention priority compared to other crops such as cotton, cereals and rice.

Objective 3: Identifying and testing approaches to maximize inclusivity, effective governance, women's empowerment, and involvement of youth for nutrition-sensitive irrigated production

Activity 3.1: Institutional and policy analysis & strengthening of governance

Sub-Activity 3.1.1. Design and pilot governance studies using different methods

In year 10, the IFPRI team finalized baseline and endline data collection for the Ghana groundwater governance intervention and analyzed the baseline data. A draft paper on the study was finalized, in addition IFPRI published a [blog piece](#) on interventions in Ghana on groundwater use and management.

Sub-Activity 3.1.3. Conduct cost-benefit analysis of irrigated fodder production

ILRI published a working paper on the economic viability of irrigated fodder in the Bahir Dar milk shed, which showed that irrigated fodder production is a viable agribusiness for smallholder dairy producers with economic net return higher than that of fresh fruits and vegetable cultivation but lower than khat.

Activity 3.2: Analysis of approaches for equity (along value chains), focused on women and youth

Sub-Activity. 3.2.2. Gender and inclusivity

ILRI completed analysis on irrigated fodder and women empowerment. A paper has been submitted for publication in a peer reviewed journal.

IFPRI drafted a paper titled "Small-scale irrigation and women's time allocation (Ethiopia)" on: How does small-scale irrigation influence women's time allocation?; Does women's time use differ by irrigation type? Results showed that if small-scale irrigation is adopted, women's time allocation may shift among different livelihood activities. If women switched from not irrigating to using irrigation, it may lead to a change in women's time use (e.g., decreasing their time allocation in unpaid household activities). The paper was presented at the AAEA conference in Washington DC in July 2023.

3.2.2b. Gender sensitive business models and scaling, aligned with private partners

IWMI completed two briefs on irrigation inclusivity: 1) Inclusive agriculture: Creating opportunities for women and youth in Mali's irrigated vegetable value chain; 2) [Enhancing gender and youth inclusion in Ghana's irrigated vegetable value chain](#).

IMWI also published a research report 'Gender mainstreaming from an institutional perspective: Cases of small and micro irrigation projects in Ethiopia'. This research report highlights two gender mainstreaming approaches that are used by different irrigation development projects in Ethiopia

IFPRI published "[Demand and supply constraints of credit in smallholder farming: Evidence from Ethiopia and Tanzania](#)" in the journal *World Development*, which identified gendered constraints.

IFPRI published "[Does small-scale irrigation provide a pathway to women's empowerment? Lessons from Northern Ghana](#)" in the *Journal of Rural Studies*, which found that supplying men and women farmers with motor pumps for small scale irrigation did not increase women's empowerment but had negative spillover effects on women from households that did not receive the pumps. The benefits of the pumps for women were indirect and include increased household assets holdings.

Sub-Activity 3.3: Assess approaches for more nutrition- and health-sensitive SSI

ILSSI has studied the effect of engaging in irrigated fodder on the dietary diversity of households by comparing the diets of adopters and non-adopters.

IFPRI finalized a draft of the nutrition-sensitive guidance in Mali, and a webinar was held at the end of July.

Objective 5: Assessment of watershed and SSI interventions on nutrition and resilience under PSNP in Ethiopia

Econometric, qualitative and model-based analysis has been completed on the impacts of watershed and small scale irrigation interventions under PSNP's public works program on resilience and nutrition.

A full set of results has been submitted to BHA and presented in a webinar. A paper on the modeling results has been accepted for publication.

Sub-Activity 5.1: Assessment of the implementation PSNP watershed rehabilitation approach; identification of limitations to the approach and role of upstream watershed rehabilitation on irrigation sustainability

The assessment has been completed and the results were presented to USAID (virtually) on April 26 and again in Addis Ababa on May 26, 2023. Three rounds of comments from USAID have been incorporated into the final three documents: A report, a policy (summary) note and a nutrition guidance.

Sub-Activity 5.2: Qualitative assessment of watershed rehabilitation and small-scale irrigation

The qualitative study had a series of findings: PSNP interventions supporting PW are linked to a series of watershed, community, household, and individual resilience capacities. These capacities are mediated (1) by improving water availability and use at the watershed level for productive and domestic uses, (2) by increasing capacity of local communities, and (3) by strengthening institutions for natural resource management. Participation in PSNP's PW on natural resource management interventions can result in increased productive uses, such as irrigation, but can also lead to an improved water, sanitation, and hygiene environment, along with increased household income and assets. Women's empowerment can potentially also be improved (1) through reductions in the amount of time they have to spend collecting water, (2) by improving their control over irrigation assets, (3) by enhancing their decision-making power over irrigated land (such as which crops to plant), and (4) by increasing their participation in institutions associated with irrigation.

Sub-Activity 5.3: Quantitative assessment of watershed rehabilitation and small-scale irrigation

Results from this study showed that households in BHA woredas had smaller food gaps, and this association is statistically significant. The nutritional status of households was measured by household

dietary diversity score (HDDS), and we used a panel Poisson random effect model to estimate the relationship between this indicator and BHA interventions. Our results show that the nutritional outcome of households in BHA woredas is not statistically different from non-BHA households. This suggests that the BHA intervention has no or little impact on the HDDS of the households during the study periods.

To measure the resilience capacity of households, we used the FAO RIMA II methodology and constructed resilience as a latent construct using the Resilience Capacity Index (RCI), with multiple predictors and multiple outcomes. The econometric results suggest that BHA woredas are more resilient than non-BHA woredas. However, we do not find resilience benefits from PSNP PW activities of water harvesting and SWC for PSNP beneficiaries. This suggests that the real outcome of rehabilitation practices may take much more time to appear, as it is a long-term investment. On the other hand, those households that practice irrigation on their own land are identified as more resilient to shocks than their counterparts. Thus, irrigation interventions are more important for short-term resilience capacity building strategies for rural households and can address short-term shocks.

The following recommendations are suggested to increase the nutrition and resilience benefits of PSNP's watershed and irrigation investments:

- If nutrition and resilience to shocks are goals of PSNP investments, then intentional actions are needed that strengthen both goals, supported by a strengthening of interventions that support nutrition and resilience and a reduction of those activities that adversely affect nutrition and resilience. Discussions with implementers, local governments and PSNP beneficiaries suggest that there is currently no common understanding that PSNP aims to improve nutrition and resilience outcomes.
- Irrigation has been shown to support both resilience and nutrition, but current support to irrigation does not necessarily reach PSNP beneficiaries directly, particularly not landless beneficiaries and those who own land outside rehabilitated areas or irrigation schemes. Direct support to individual groundwater irrigation could be one solution for beneficiaries with land holdings.
- PSNP participants in Amhara sites reported 10–12 months of engagement in PSNP public works. Such apparently excessive time spent on public works activities could lead to shortages of time available for domestic activities and alternative gainful economic activities. This may in turn negatively affect the household's nutrition status. Thus, we find reducing the time spent by the beneficiaries on PSNP public works could increase the time available to affected beneficiaries to engage on their own land and for income-generating activities, particularly in Amhara sites.
- Increased emphasis needs to be placed on the functionality and maintenance of constructed irrigation and watershed infrastructure, as the current focus is primarily on construction.
- Monitoring and evaluation approaches should be revisited in order to help realize positive outcomes from the interventions; priority needs to be given specifically to revising indicators toward resilience and nutrition capacities and outcomes, and by using modern technologies, such as computers and remote sensing to monitor outcomes from watershed rehabilitation.
- Long-term rehabilitation practices should be coupled with immediate income generating activities as a potential solution to ensuring sustainability.
- Alternative and innovative PW activities should be identified targeting area-specific problems along with contextual solution approaches. Alternative intensification approaches are particularly needed in land-scarce areas.
- Introduce periodic and targeted capacity-building for user associations (e.g., water user associations, forest user associations), community leaders, community facilitators, and other

entities that can strengthen the sustainability of investments. Experience-sharing programs among kebeles, woredas, or implementing partners can promote peer learning and capacitate PSNP beneficiaries. Enhanced capacity would help to ensure sustainability and a sense of ownership of rehabilitated watersheds and irrigation infrastructures.

3. Objective 4 - Achieve impact through uptake of ILSSI research results and/or methods.

Activity 4.2. Short-Term and Long-Term Training on subject matter

Sub-Activity 4.2.4. Short-term training targeted at producers, technical experts, other local and national stakeholders and private sector.

- **Integrated Decision Support System Trainings:** Three trainings on the use of the Integrated Decision Support Systems (IDSS) tools for a total 156 participants: Arba Minch University, Ethiopia (74), University of Rwanda, (51), Prairie View University, Texas (31), University of Ghana (92).
- **Private sector capacity development:** IWMI organized 01 Demand-supply linkage workshop and 02 field demonstrations for solar-based irrigation technologies with private partners in Sikasso.
- **Forage Technology Park established:** ILRI established a forage technology park at Bahir Dar University. The forage technology parks are intended to be used as learning and research centers for students and staff in relation to irrigated fodder development in the smallholder system. Apart from being a learning center, the forage park is planned to serve as a source of seeds and planting materials to distribute to surrounding communities.

Sub-activity 4.2.5. Post-graduate research training/mentoring

Candidates were expected to complete all field work before the end of the ILSSI project in August 2023. Continuing graduate students and post-docs supported by ILSSI are listed in Table 2.

Table 2. Long-term Trainees

M/F	University	Degree	Major	Program End Date	Home Country
M	Bahir Dar University	Ph.D.	Water resources engineering and management	May 2023	Ethiopia
M	Texas A & M	PhD	Water Program (inter-disciplinary)	2024	U.S.
F	Michigan State	PhD	Women's time use and irrigation in Ethiopia	2023	NA
Male	Bahir Dar University	MSc	Agricultural Sciences	May 2023	Ethiopia
Male	Bahir Dar University	MSc	Agricultural Sciences	May 2023	Ethiopia
Male	Bahir Dar University	MSc	Agricultural Sciences	May 2023	Ethiopia
Male	Bahir Dar University	MSc	Agricultural Sciences	May 2023	Ethiopia
NA	Bahir Dar University	MSc	Water resources engineering and management	May 2023	Ethiopia
NA	Bahir Dar University	MSc	Water resources engineering and management	May 2023	Ethiopia

M/F	University	Degree	Major	Program End Date	Home Country
NA	Bahir Dar University	MSc	Water resources engineering and management	May 2023	Ethiopia
Female	University of Ghana	MSc	Social science	May 2023	Ghana
Male	University of Ghana	PhD	Geological/hydrological science	NA	Ghana

Sub-Activity 4.2.7. Innovation Scholarships and Internships

All internships under the Innovation Scholarships were completed. All interns in Ghana (3) from the year have obtained full-time employment in related fields since completion.

Bahir Dar University MakerSpace students built a new app for and completed a post-sales customer survey to support Rensys Engineering in improving their after-sales service and marketing strategy.

Activity 4.3. Engage with stakeholders and other potential end users of research

Sub-activity 4.3.2.-4.3.3. Sub-national and national events, platforms/dialogues, and other convenings

- Multi-stakeholder Dialogue Platform Meetings (3)
- Demand-supply linkages workshops and field demonstrations (27)
- Workshops in the three districts on irrigated fodder: Kedida Gamela district (17 November 2022); Lemo district (19 November 2022); Bahir Dar Zuria district (25 November 2022). Participants in the three workshops were researchers, district and zonal office of agriculture experts, university instructors, and dairy cooperative representatives.
- Exchange visits for dairy cooperative management members. Cooperative management members from Bahir Dar zuria district (Amhara region) travelled to Lemo and Kedida Gamela districts (SNNP region) for a five-day working visit to learn and share good practices. A similar visit was organized for the cooperative management teams to travel to the north.

Sub-activity 4.3.4. Regional and global events, platforms/dialogues, and other convenings

ILSSI targeted global, regional and national events to share research and engage potential end users.

Notable events include:

- [ILSSI Symposium](#) (March 1, 2023) and Congressional Reception (February 28, 2023)
- HBCU Student and Young Scientist conference (March 8-9, 2023, Prairie View A & M University)
- IWMI co-convoked 'Inclusive Farmer-led Water Management for enhancing climate change resilience' at 2nd WASAG International forum Making Agriculture Resilient to Climate Change (Feb 7-10, PRAIA Cabo Verde)
- IFPRI organized two UN Water 2023 conference side events focused on groundwater in Africa and on water-nutrition linkages. The virtual groundwater event ([Groundwater: Potential and Pitfalls for Africa | IFPRI : International Food Policy Research Institute](#)) had 1,233 viewers and feature a presentation by Hagar EIDidi on the ILSSI groundwater governance interventions, while the face-to-face inside UN event on nutrition had about 70 participants and included a presentation on the HWISE scales in addition to fundamental studies on water-food security-nutrition, that built on ILSSI research outputs. The groundwater event was summarized by an

intern from High Atlas Foundation in Morocco: [Groundwater: Potential and Pitfalls for Africa | High Atlas Foundation](#).

- IWMI organized a two-day conference '[Investing in Farmer-Led Irrigation Development in Sub-Saharan Africa: Business, Development, and Research Practices](#)' in Accra, Ghana on April 26th -27th, 2023.

Activity 4.4. Outreach and communications

Sub-Activity 4.4.3-4.4.5. Outreach knowledge products and communications

- **Website:** 8,277 page views have been recorded for the [ILSSI website](#) during this period.
- **Social media presence:** On social media, [tweets from the ILSSI profile](#) gained more than 5,000 impressions, and [Facebook posts](#) reached more than 700 readers during this period.
- **Newsletter:** Celebrating Ten Years of ILSSI [June 2023] (open rate 36.28%, click rate 10.18%); World Food Day [October 2022] (open rate 43.1%, click rate 11.9%); Planning for the Future of Research in Agricultural Water Management [January 2023] (open rate 55.8%, click rate 11.5%); Celebrating World Water Day [March 2023] (open rate 47.0%, click rate 14.6%). The number of newsletter subscribers grew by 6 during the past year with a total of 234 subscribers.
- **News stories:** 15 news stories were produced and published on the ILSSI website, including [Unlocking the Potential of Irrigation for Improved Nutrition in Ethiopia](#), [Small Scale Irrigation and Nutrition: Lessons from East and West Africa](#), [Governing Water—A South-South Exchange with Insights from Ethiopia and Ghana](#), as well as [How can we address recurring global food and fuel crises? The role of solar powered irrigation](#) and [A glimpse of hope in the role of private sector engagement for scaling irrigation innovation bundles in Ethiopia](#).
- **Briefs:** 13 ([See Annex 2, Briefs](#))

Sub-Activity 4.4.7. Scientific conferences and invited scientific presentations

ILSSI partners contributed 26 presentations to conferences and events at the global, regional and national scale. [See Annex 2. Data and Publications.](#)

Sub-Activity 4.4.8. Publications and data

ILSSI continued to see strong collaboration across research partner institutions on both publications and outreach materials. The figures for each type of publication are summarized in Table 3 below, while the full list of publications with links to web access can be found in [Annex 2. Data and Publications.](#)

Table 3. ILSSI Publications (October 1, 2022 – August 10, 2023)

Category of publication and/or knowledge product	Total Number (all partners)
Peer-reviewed publication	8
Discussion/Working paper	3
Brief	13
Technical report	3
Conference paper, poster, and/or presentation	26
Outreach and social media (e.g., blogs)	22
Capacity development material or product	0
Submitted and under review, and/or accepted with revisions	12

4. Technology transfer and scaling partnerships

- ILSSI project site in Amhara region has been taken as a model and learning center on the development of fodder and dairy value chains for Ethiopia.
- Multi-stakeholder dialogues and sub-national workshops build company capacities, enhance partnerships and knowledge sharing, contributing to increased sales of irrigation equipment; co-convened with World Bank in Ethiopia and a partner has been identified for Ghana.
- South-South knowledge exchange (Ethiopia, Ghana, India) on community-scale groundwater governance to ensure continued activities beyond project exit.
- Numerous development programs and projects are now using ILSSI research outputs, for example: World Bank supported AICCRA and Farmer Led Irrigation Initiative; Water and Energy for Food; USAID-supported country projects Sene Yiriwa (Mali) and Market Systems Resilience (Ghana). While ILSSI has not directly showed high results in Feed the Future Indicators, the influence on other development investments is leading to substantial outcomes.
- ILSSI exceeded the targets for supporting graduate students; innovative internship program has resulted in full-time employment in the sector (Ghana) and new tech start-ups (Ethiopia).

5. Issues, Concerns, and Lessons from the reporting period

Summarizing lessons from the 10-year ILSSI program is time consuming but summary notes will likely have a large readership and be useful for additional final outreach in Ethiopia and Ghana. The results generated by the ILSSI project are increasingly taken up by next users and will continue to influence future research on irrigation. Results dissemination is aided by shorter synthesis documents that were prepared for the final ILSSI outreach event in Washington DC in March 2023.

The contributions of ILSSI irrigated fodder research and development work has received recognition from the local administrations in Ethiopia. In this regard, a certificate was awarded to the project by Kedida Gamela district administration. In addition, a high-level field day was organized by the Amhara region administration to show the progress and achievements of the dairy cooperative at Robit Bata kebele or Bahir Dar zuria district. The ILSSI project site has now been taken as a model and learning center on the development of fodder and dairy value chains. The engagement with the farmer cooperatives for irrigated fodder adoption has been instrumental in this achievement.

The vegetable sector is growing rapidly in Mali. Small-scale irrigation is important and is widely practiced among vegetable producers. Irrigation is particularly important for vegetable seed production in the dry season. However, vegetable seed production is constrained by low technical capacity among seed producers, unfavorable rules and regulations (favoring seed imports), and lack of investment.

Annex 1. Private sector partnerships: Progress toward milestones and key lessons

Rensys Engineering (Ethiopia)

Achievements

1. Sales target: sold 260 pumps in reporting period
2. Marketing outreach: Sales were supported by events organized by IVMI to link Rensys with potential clients. High interest in Amhara region that did not translate to sales given inflation and continued conflict.
3. Projects and opportunities generated from initial support from ILSSI:
 - Mercy corps RIPA project partner for productive use of energy (\$45,000 grant)
 - Developed working associations with Farm Africa, Terepeza, MEDA to sell pumps to farmers in their projects.

Issues and challenges

1. Policy and macro-economic: Continued negative impact of policy-related issues, e.g. forex, importation procedures; inflation (devaluation); and insecurity/instability
2. Pump range offered: Need larger range of pumps to supply irrigation to farm size (current SunCulture pumps < 1 ha); Farmers seek to increase farm size and size up pumps and other farmers have >1 ha
3. Costs/revenue: High cost of purchase and maintaining inventory of spare parts for after-sales services and for compliance with terms of warranty

EcoTech Mali (ETM)

Achievements

1. Marketing outreach: Directly met with 1,000 farmers, including more than 400 women. Target 22 villages in the regions of Koutiala, Sikasso, Ségou, and Koulikoro.
2. Sales target: Following import delay related to economic sanctions and alternative import routes, ETM sold 27 pumps (produced by ENNOS) in the reporting period. Low percentage of sales to farmer cooperatives.
3. Finance: Installment/PAYGO (20) sales. Repayment period of one year (17), two years (3). ETM provided a total credit of 11,275,000 XOF (\$18,700), through PAYGO sales.
4. Gender and inclusivity: ETM has not found that women sales agents are more (or less) effective than men sales agents, including in terms of reaching women clients. Women show interest but purchase is low (more time required to plan and save, more risk averse, permission from household/family head). Also, women tend to share land that is divided too small for a single pump, requiring a group purchase that is more complex. Husbands do not appear to share pump with wives.

Issues and challenges

- Policy and macro-economic: Continued negative impact of conflict and insecurity/instability; harvest for cotton and maize were low and that reduced farmers' ability to invest (cash on hand low)
- Market perceptions and decision-making: several reasons for interest but not purchasing, including: price, time required for planning/investing, fear of disrepair (distrust of solar pumps), waiting to see if government or donor will give for free, family head often makes decision and they are more 'patient'

Annex 2. Data and publications

Datasets

Published

1. Bizimana, Jean Claude, 2023, "Household survey in cocoa producing regions of Ghana", <https://doi.org/10.18738/T8/7YFIVK>, Texas Data Repository, V1, UNF:6:8rnTnk0AJysERS8So+2uAQ== [fileUNF]
2. Derseh, Melkamu, 2023, "[Characteristics of irrigated fodder adopter and non-adopters in Lemo and Bahir Dar Zuria districts of Ethiopia](https://doi.org/10.18738/T8/RLHVTS)", <https://doi.org/10.18738/T8/RLHVTS>, Texas Data Repository, V1
3. Derseh, Melkamu, 2020, "Inventory of feed prices and quality across major feed market places in southern Ethiopia", <https://doi.org/10.18738/T8/BJ0MRQ>, Texas Data Repository, V2
4. International Food Policy Research Institute (IFPRI). 2023. [Tanzania Feed the Future Innovation Lab for Small-Scale Irrigation](#) (ILSSI) Baseline Survey, 2015. Washington, DC: IFPRI [dataset]. Harvard Dataverse. Version 1.
5. International Food Policy Research Institute (IFPRI). 2023. [Ethiopia Feed the Future Innovation Lab for Small-Scale Irrigation](#) (ILSSI) Baseline Survey, 2014. Washington, DC: IFPRI [dataset]. Harvard Dataverse. Version 1
6. Stellbauer, Robert, 2023, "DATASET: Development of the vegetable seed sector in Mali and opportunities for irrigated Seed production - <https://doi.org/10.22001/wvc.74414>", <https://doi.org/10.18738/T8/l73XRC>, Texas Data Repository, V1

Publications

Peer-reviewed publications

- Balasubramanya, S.; Buisson, M.-C.; Mitra, A.; Stifel, D. (2023) [Price, credit or ambiguity? Increasing small-scale irrigation in Ethiopia](#). *World Development*. 163, 106149.
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- Bryan, E. (2023) [Does small-scale irrigation provide a pathway to women's empowerment? Lessons from Northern Ghana](#). *Journal of Rural Studies*. 474-484.
- Kuhlmann, K. A.; Francis, T.; Thomas, I.; Schreinemachers, P. (2023) [Laws and regulations enabling and restricting Africa's vegetable seed sector](#). *International Journal of Agricultural Sustainability*, 21, 1.
- Nejashemi, P.; Chikafa, M.; Moller, K.; Razavi, H.; Bizimana, J. C. (2023) [Multidimensional Evaluation of the Impacts of Agricultural Interventions to Achieve Food Security in Malawi](#). *Land Use Policy*.
- Sishu, F. K.; Tilahun, S. A.; Schmitter, P.; Steenhuis, T. S. (2023) [Investigating Nitrate with Other Constituents in Groundwater in Two Contrasting Tropical Highland Watersheds](#). Special Issue Editorial Board Members' Collection Series: Integrated Surface Water and Groundwater Resources Management. *Hydrology*. 10(4), 82.

Xie, H.; Dile, Y. T.; Ringler, C.; Srinivasan, R.; Worqlul, A. W. (2023) [Toward a better understanding of the environmental impacts of expanding small-scale irrigation in Sub-Saharan Africa: Insights into increased irrigation-induced risk of agricultural nutrient pollution from a case study in Ethiopia.](#) *Environmental Research Communications*. 5, 065001.

Discussion/Working Papers and Reports

EIDidi, H.; Zhang, W.; Gelaw, F.; De Petris, C.; Blackmore, I. Teka, N.; Yimam, S.; Mekonnen, D. K.; Ringler, C.; and Meinzen-Dick, R. S. (2023) [Getting ahead of the game: Experiential learning for groundwater governance in Ethiopia.](#) IFPRI Discussion Paper 2189. Washington, DC: International Food Policy Research Institute (IFPRI).

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Mekdes, M. Impact of small-scale irrigation technology adoption on women empowerment in Western Amhara regions, Ethiopia. Thesis Report. Bahir Dar University. May 2023.

Mekonen, B. Spatial prediction of daily groundwater level using machine learning approach in Gilgile Abay Watershed. Thesis Report. Bahir Dar University. May 2023.

Minh, T. T.; Naab, D. D.; Ofosu, A. (2023) [Marketing margin of irrigation technologies in Ghana: An analysis from a supply chain perspective.](#) IWMI Technical Report.

Minh, T. T.; Nigussie, L.; Melaku, D. (2022) [The enabling environment to scale water and irrigation solutions and services in Ethiopia.](#) IWMI Technical Report.

Schmitter, P.; Minh, T. T.; Soumya, B.; Hagos, F.; Melaku, D. (2022) [Marketing margin of irrigation technologies in Ethiopia: An analysis from a supply chain perspective.](#) IWMI Technical Report.

Sewnet, A. Effects of deficit irrigation levels and fertilizer rates on water use efficiency of grass forage at Robit Bata Site in Upper Blue Nile Basin of Ethiopia. Thesis Report. Bahir Dar University. June 2023.

Sishu, F. K. Nutrient and pesticide transport in two contrasting tropical volcanic highland watersheds. Thesis Report. Bahir Dar University. May 2023.

Wubet, C. Evaluating the effect of different levels of water and fertilizer application and forage type on residual soil nitrate: The case of Robit Bata, Ethiopia. Thesis Report. Bahir Dar University. June 2023.

Xie, H.; Ringler, C. (2023) [Financial feasibility of developing solar groundwater irrigation in Ghana.](#) Feed the Future Innovation Lab for Small Scale Irrigation (FTF-ILSSI) Project Notes. Washington, DC: International Food Policy Research Institute (IFPRI).

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Balana, B. [Effects of PW on watershed rehabilitation and irrigation interventions in BHA-supported PSNP areas of Ethiopia](#). Virtual Presentation to USAID BHA.

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- Derseh, M. Livestock production and resilience in African smallholder systems. Conference on Water, Climate, and Food Security for Students and Early Career Scientists. Prairie View University, March 2023.
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N/A

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Annex 3. Success Stories

Irrigation is increasingly recognized as a nutrition-sensitive intervention.

The Nutrition Center at USAID's Bureau of Resilience and Food Security requested information and an in-person meeting with ILSSI researchers on irrigation-nutrition linkages. Research shared includes:

- Summary brief that highlights some of the pathways and case studies: https://ilssi.tamu.edu/files/2023/03/ILSSI-Brief-Nutrition_INTERACTIVE_031723.pdf
- Project note from 2021 that summarizes the pathways: <https://www.ifpri.org/publication/exploring-small-scale-irrigation-nutrition-linkages>
- Irrigation improves weight-for-height z-scores of children under five, and Women's and Household Dietary Diversity Scores in Ethiopia and Tanzania (this includes analysis during drought): <https://onlinelibrary.wiley.com/doi/full/10.1111/mcn.13395>
- Ethiopia and Tanzania case study shows irrigators have higher dietary diversity: <https://www.ifpri.org/publication/evaluating-pathways-small-scale-irrigation-dietary-diversity-evidence-ethiopia-and>
- Irrigation income and production pathways affect dietary diversity in Northern Ghana: <https://www.ifpri.org/publication/irrigation-nutrition-linkages-evidence-northern-ghana>
- Mali case study shows irrigating households have higher dietary diversity and resilience: <https://www.ifpri.org/publication/pathways-irrigation-prosperity-nutrition-and-resilience-case-smallholder-irrigation>

[How solar-based innovations are helping farmers in Africa become water and food secure : IWMI Success Story \(cgiar.org\)](#)

[Enhancing Groundwater Governance through Experimental Games in Ghana](#)

[“When the water goes down, we remember the games” A Photo Story on Groundwater Governance in Ethiopia](#)