FEED THE FUTURE
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Left photo: Farmers discuss irrigated fodder production practices at cooperative site in Bahir Dar zuria
Right photo: Dairy cooperative members process and store dairy products at cooperative site in Bahir Dar zuria

Feed the Future Innovation Lab for Small Scale Irrigation

ANNUAL REPORT *ETHIOPIA*: October 1st, 2021- September 30, 2022

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

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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 (BIIAD) at Texas A & M University (TAMU). One set of activities in Ethiopia is primarily supported through a buy-in by Bureau for Humanitarian Assistance. This report describes progress toward objectives in fiscal year 2022; the project ends August 11, 2023. In Ethiopia, the project has sub-awards with the International Water Management Institute, International Livestock Research Institute, International Food Policy Research Institute, Rensys Engineering and Bahir Dar University and 3 sub-sub awards with cooperatives.

2. Issues, Concerns, and Lessons

Issues and concerns

Analyses show irrigation benefits for household nutrition and resilience through multiple pathways. Irrigated production continues to increase by farmers who invest own resources in labor-saving, water lifting and field equipment, especially as climate change continues to increase the need for supplemental and dry season irrigation across crops. However, market sales are currently unable to meet demand; weak market integration, financial sector constraints, relatively low private and financial sector capacity, and continued insecurity limit growth of equipment supply chains. Companies are beginning to offer consumer finance and PAYGO options, but these are less available relative to countries in the sub-region. In addition, approaches are needed to lower pump and equipment costs for the poorest farmers. Enhancing competitiveness by developing the supply chain and improving policy-related implementation issues such as import tariff exemptions and access to foreign currency, is critical for a better business environment to make irrigation technologies directly available to smallholder farmers.

Areas requiring further investment

Poorest smallholders need interventions to be able to invest in irrigation, but it is unclear which approaches to reduce prices are good practice and which might undermine the market. Development partners are implementing various approaches to reduce costs for solar and other pumps to farmers, including finance to different actors and pump subsidies (e.g., Rwanda, Uganda). Anecdotal evidence suggests public subsidy schemes benefit high income farmers and exclude women, but analysis is needed in the sub-region on what is effective to reach poor smallholders without disrupting market development. Alternatively, a subsidy on water resource access, i.e. borehole drilling, may incentivize farmer investment in pumps without undermining the irrigation equipment market.

Planning, monitoring and managing water in agriculture at different scales is needed to support sustainability. Smallholder irrigation is largely outside of public, formal schemes; the lack of plans, monitoring and regulation for smallholders with dispersed, self supply systems, increases potential water scarcity and pollution. Community approaches and capacity strengthening in water governance is needed, especially in high-risk watersheds, until government capacity increases.

Skilled, human resource pipeline for private and public sectors will be critical to the expansion of the market in irrigated agriculture and in particular, sustainability (regulatory and planning). Private companies will likely be expected to self-regulate in the water sector for business sustainability, but lack of skilled staff already constrains private company growth, even without tasks related to self-regulation. At the same time, tertiary education institutions need to adapt their curriculum and skills training to develop a relevant human resource pipeline. Investment is needed to expand and upgrade capacity.

Supportive intersectoral water policies and institutions. Continued policy support is important to align national goals in agriculture, especially horticulture, with nutrition, climate, and water, within a suitable institutional framework. While Government of Ethiopia makes efforts in institutional reform, targeted intervention is needed to ensure smallholders are not omitted from planning and monitoring. ILSSI continues policy related work, such as the tariff exemption for imported irrigation equipment, and co-convenes meetings of the Agricultural Water Management Task Force to ensure private sector is invited. Market system interventions to strengthen the equipment supply chain for self-supplied pumps and materials is necessary for inclusive irrigation development.

3. Progress toward research objectives

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

Identify upscaling opportunities for resilient SSI systems

ILSSI's private partner in Ethiopia Rensys Engineering, made mixed progress against milestones and offered lessons relevant to solar irrigation scaling and market development (SPIS), See Annex 1. Rensys terminated the plan to import and install solar-powered cold stores, following continued lack of access to land for cold stores near irrigated areas. Solar pump sales began around May 2022. The company offered limited asset-based financing to only a few clients.

Support to Rensys by IWMI includes:

- Digitalization of credit assessment scorecard and inclusive marketing approach
- Segmentation of market for SPIS bundles in Oromia and Amhara regions
- Demand-supply linkage workshops and field demonstrations in Hossana and Lemo
- Company-based customization of solar irrigation suitability maps to support market targeting

Constraints include:

- Supply chain issues: delayed delivery of pumps (solar pumps arrived in country in May 2022)
- Political insecurity/conflict: reduced market attractiveness and increased risk averse behavior
- High costs of navigating tax exemptions and access to foreign exchange (Ethiopia)
- High costs of inputs (fertilizer) reduced ability of farmers to invest in pumps
- Increased financial risk decreased distributors' willingness to provide farmer credit
- Lack of cellular network coverage disrupts mobile money payment, PAYGO pump control

Identify constraints and assess impact of policy

Constraints Analysis

IFPRI analysis on constraints to the adoption of SSI technologies (Hierarchical modelling of the constraints to irrigation adoption in Ghana, Ethiopia, and Tanzania) found that locale-specific targeting of small-scale irrigation technologies is essential. There is a positive association between plot-level use of irrigation and the intensity of agricultural labor and inorganic fertilizers applied on the plot, as well as type of land ownership and type of irrigation system.

Role of credit constraints

IFPRI analysis "Are Smallholder Farmers Credit Constrained? Evidence on Demand and Supply Constraints of Credit in Ethiopia and Tanzania" and "Demand and supply constraints of credit in smallholder farming: Evidence from Ethiopia and Tanzania" (*World Development)* show:

- demand-side credit constraints are at least as important as supply-side factors in both countries
- women are more credit constrained than men (from both the supply and demand sides)
- two-pronged approach to address credit constraints is needed (i.e. interventions should not focus on supply alone)
    - supply-side factors (e.g. asset-based financing rather than a land title for credit issuance; better understanding farmer risk perception/behavior); access to larger, initial credit for technology purchase and smaller credit for running costs
    - demand side factors, focusing on human capital, strengthened farmer financial literacy, information, extension services, and risk mitigation (e.g., bundling irrigation technology with insurance)

Assess impact of change in cost of water lifting technologies related to reduction in tariff

In response to continued interest from Government of Ethiopia, IFPRI is conducting an in-depth study based on import data of irrigation pumps (Ethiopia Customs Commission) and importers' forms to request the duty-free provision (Ethiopian Ministry of Agriculture). However, customs data is based on pump weight, so IFPRI is exploring how to make meaningful analysis. This adds to FARMSIM ex-ante study: "Preliminary economic impacts assessment of tariff reduction on water lifting technologies".

Determination of marketing margin along different points of SSI chain of actors

The estimated marketing margin is greater than expected (usual marketing profit of about 20%) Margins were identified as: solar 12-48% (60% for Grundfos); diesel, or petrol motor pump 23-50%; rope pumps greater than 70%. Import/manufacturing cost, duty tax, and marketing (including storage and logistic) costs are important factors influencing the sales price. Estimated marketing margin high risk perception may influence margins.

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 middlemen as the final link to end-users by charging an additional commission of 10-15 % of the sale price. The marketing structure is characterized as a segmented monopolist. Also, suppliers do not keep stocks of pumps and accessories because of the shortage of hard currency, which weakens after-sales services and undermines consumer confidence.

Solar and diesel/petrol pumps are not low-cost for smallholder farmers and there are no financial products, either from microfinance institutions or suppliers, to enable loans.

Policy changes on tax breaks have not been effectively implemented. Stakeholders point to unclear import duties, lack of clarity on which accessories (e.g., solar pump vs panel) are tax exempt, and problems of long import procedures. The constraints to the importation of irrigation equipment is contributing to the slow market growth for irrigation technology, contrary to the intent of policy.

Entry points to reduce supply constraints on irrigation technology markets

Market support activities with private sector

IWMI and Rensys co-organized demand-supply linkage workshops and demonstrations for solar-based irrigation bundles (Hossana, Lemo: 31 March - 2 April 2022; 284 farmers and other value chain actors) and two demonstrations in Hosanna town and Jawe kebele.

IWMI and Rensys conducted market segmentation based on multiple methods for solar-based irrigation bundles in the Oromia region and Amhara region (September 2022; 96 women and 334 men); 5 field demonstrations (Lorentz PS2-100 solar pump) and 2 stakeholder consultation workshops were held.

Facilitating dialogue between key stakeholders to strengthen SSI scaling

Multi-stakeholder dialogues are convened and facilitated by IWMI through ILSSI, to bridge information gaps and strengthen irrigation equipment/input markets. Events in FY2022:

- **'The role of offtake markets in unlocking small scale irrigation investments'** (14 October 2021; 48 individuals; 28 stakeholder organizations). Co-convened by IWMI, World Bank Water Resources Group 2030 and Agriculture Water Management – Task Force, Ministry of Agriculture. Highlights: offtake market actors and other stakeholders have multiple roles in unlocking SSI investment, but are constrained by informal processes, high risk and price fluctuation, low transparency, and unbalanced decision-making power between actors.
- **'Scaling Sustainable and Inclusive Farmer-Led Irrigation'** (May 2022; 41 individuals/18% women; 20 organizations), co-convened with the Agriculture Water Management Task Force at the Ministry of Agriculture (MoA), and the 2030 Water Resources Group (2030WRG). Highlights: lack of access to water resources, low quality of available technologies, underdeveloped aftersales and financial services, inadequate support for local manufacture. In the policy environment, inefficient management/regulatory framework for shallow groundwater development, poor tax exemption policy implementation, limited access to forex, and gaps in awareness, coordination, and collaboration among users, implementing institutions, and technology importers. Participants suggested digitization and stakeholder training to improve tax exemption implementation while prioritizing forex allocation for the irrigation sub-sector.

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

Assess tradeoffs between environmental and human resilience to climate shocks and stressors

Assess potential tradeoffs in irrigated fodder production; Validate alternative irrigated forage options for different contexts

ILRI is evaluating and screening ten forage genotypes suitable for SSI to identify varieties that perform well under minimal irrigation and nutrient input, which can in turn reduce risks of crop failure for smallholders. Preliminary analysis showed large variability in biomass yield and quality among forages; promising varieties are being recommended to national development partners for further scaling.

ILRI analysis of the tradeoff of irrigated fodder production vis-a-vis crop cultivation showed:

- Adoption of irrigated fodder induces competition for land, labor and water between crop and khat cultivation.
- Irrigated fodder requires less water and chemicals (fertilizer, pesticide applications) resulting in environmental advantages compared with khat and vegetable production.

- Marginal rate of return indicates that shifting from vegetable production to irrigated fodder increases farm income by approximately 17%; but, khat production provides higher farm income.
- Despite the economic tradeoffs, adopters of irrigated fodder are keen to expand their fodder plots, partly due to the strong connections farmers have to their livestock and unaccounted benefits in terms of improved household nutrition and manure from livestock.

Assess approaches to reducing risks associated with irrigation investments

Climate risk and ENSO assessment

IFPRI's study 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 compared to non-irrigating households. The paper is submitted to *Climatic Change*.

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

ILSSI studied gaps and constraints of vegetable and fodder production under SSI systems using field data collected from multiple sites across Ethiopia. Although diverse agroecosystems help with pest and disease suppression and serve as a buffer to climate variability, most farmers in sub-Saharan Africa cultivate a few staple crops, e.g. teff, wheat, and maize covers about 75% of agricultural land in Ethiopia. Legumes can grow with a relatively minimal amount of soil moisture, improve soil fertility and enhance nutrition, but are not extensively cultivated. Ex-ante analysis is underway on impacts of legume cropping systems on agricultural production, environmental sustainability, and household income and nutrition, including common bean (Phaseolus vulgaris L.), cowpea (Vigna unguiculata L.), and vetch (Vicia villosa). The FARMSIM model will assess household income and nutritional impacts of legume cropping systems.

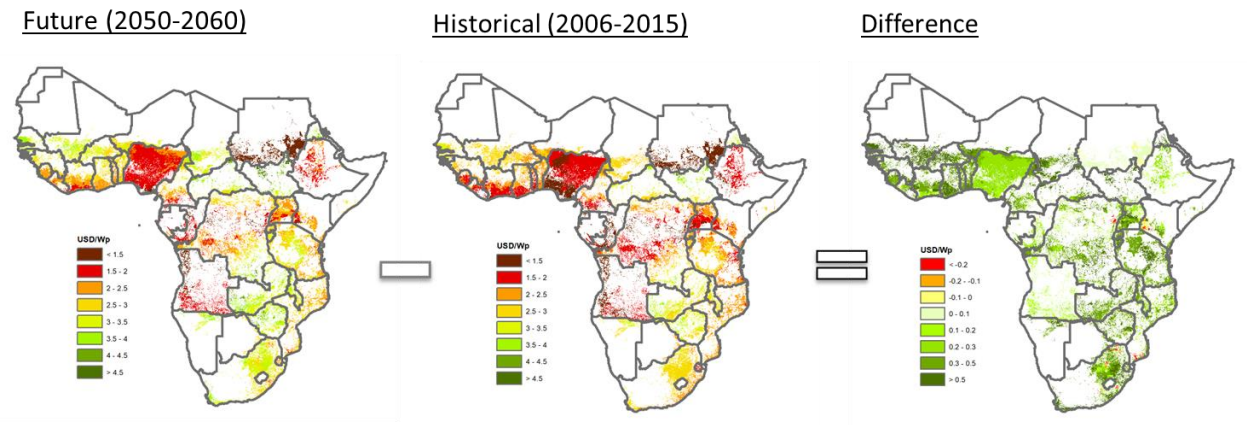
Yield-Index insurance and farmers' resilience: premiums and indemnity schedule

The IDSS team developed an integrated yield-based index insurance modeling approach that assesses the economic impacts of different insurance schemes or coverages. Crop insurance is an effective strategy to prevent smallholder farmers from falling deeper into poverty and is an important factor in encouraging farmers to invest in risky businesses, but crop index insurance basis risk means that a farmer might experience a yield loss and receive no insurance payment because the loss is not captured in the index. To improve the quality of the index insurance, the study integrated a plant growth model: Agricultural Policy/Environmental eXtender Model (APEX) and a farm simulation model (FARMSIM) to build yield-based index insurance. The first part of the study on developing the yield index insurance and estimating premiums and indemnity schedule was completed.

Assess the potential for innovative technology and scheduling tools to contribute to social-ecological resilience

Estimating the potential of solar pumps in improving irrigation access vis-a-vis energy intensity

IFPRI analysis on the impact of climate change on the cost-effectiveness of solar irrigation relative to diesel irrigation shows that climate change supports further adoption of solar as compared to diesel, notably as water scarcity grows the need for lifting groundwater from greater depths and temperature increases crop water demands. The competitiveness of solar irrigation is growing further with climate change, as a result of complex interactions across higher solar irradiation levels, increased crop water demands and higher temperatures. Solar has higher economic viability over diesel pumps; irrespective of and in addition to, the food-security enhancing climate mitigation benefits of these systems.



IFPRI presented the results on the relative benefits of solar versus diesel irrigation at the African Water and Sanitation Week, Stockholm World Water Week ("Solar irrigation in Africa: Bright future or broken promise?") and in the March 2022 ILSSI-USAID World Water Day virtual event.

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

Institutional and policy analysis & strengthening of governance

Design and pilot governance studies using different methods

Most farmer-led, self supply irrigators are outside of formal water management plans and systems, so local cooperation is critical for water sustainability. Community-scale groundwater governance activities have been completed and Ethiopian stakeholders are now participating in South-South knowledge exchange with counterparts in Ghana. See video about the groundwater game intervention in Ethiopia.

Conduct cost-benefit analysis of irrigated fodder production

ILRI findings on the economic viability of irrigated fodder in the Bahir Dar milk shed suggest improved forage production and quality feed supply are key for smallholder dairy transformation. Results identified three classes of variable costs: labor inputs, farm inputs, and animal inputs; the largest share (61%) is labor. Analysis showed irrigated fodder production is a viable agribusiness for smallholder dairy producers. On average, dairy producers obtained a net return of ETB 20,000 (ha) from the production of irrigated fodder per household per year, higher than fresh fruits and vegetables, but lower than khat.

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

ILRI completed analysis on irrigated fodder and women empowerment. The Women Empowerment in Livestock Index (WELI) tool was applied to evaluate the levels of empowerment among farmers. Research showed men view an empowered woman as a renegade going against the grain of the community's culture, norms, and social relations, while some women agreed that women's empowerment is disruptive to the community's 'order'. However, a few women interviewed aim for their own empowerment in rural areas and in livestock product marketplaces. Two of the three dairy cooperatives in partnership with ILSSI are led by women and perceived as innovative. See the blog on the ILRI study.

Gender and inclusivity

Gender sensitive business models and scaling, aligned with private partners

ILSSI private partnerships generated lessons related to aims at inclusive market access to irrigation inputs. Despite the co-development of a gender-responsive credit/customer assessment scorecard with the private companies, sales agents work on commission and only target individuals they perceive to be likely clients. Sales agents act on bias in client acquisition: agents perceive women as unlikely to qualify for credit, and therefore do not pursue pre-sales assessments. Other interventions will be needed to support companies to reach women as clients.

IWMI analysis on 'Gender mainstreaming from an institutional perspective: Cases of small and micro irrigation projects in Ethiopia' highlighted that social structures continue to present barriers despite the 'rule-based' project strategies on irrigation schemes.

Assess approaches for more nutrition- and health-sensitive SSI

IFPRI paper "Seasonal variation in maternal dietary diversity is reduced by small-scale irrigation practices: A longitudinal study" showed irrigators were more likely to meet the MDDW than women from non-irrigating households ($p < 0.05$). The main finding from the study is that high seasonal variation of diets can be offset, at least in part, by irrigation.

A second paper "Irrigation improves weight-for-height z-scores of children under five, and women's and household dietary diversity scores in Ethiopia and Tanzania" in *Journal of Maternal and Child Nutrition*, showed that small-scale irrigation has a strong effect on households' economic access to food and on nutritional outcomes of women and children. Among Ethiopian households who reported having faced drought, women in irrigating households had higher Women's Dietary Diversity Score (WDDS) compared to women in non-irrigating households. Children in irrigating households in Ethiopia had weight-for-height z-scores (WHZ) 0.87 SDs higher, on average, than WHZ of children in non-irrigating households. The policy conclusion is that small scale irrigation can be a nutrition intervention.

Assessment of WASH-irrigation interlinkages

IFPRI's study on water supply, sanitation and hygiene (WASH)-irrigation linkages points to irrigators being more likely to have sufficient water available for domestic use and better access to improved sanitation facilities, but the source of water is the key determinant for a household's hygiene practices. Groundwater likely is an overall better-quality source for domestic purposes than surface water; multiple uses of irrigation water for WASH are more promising for households using groundwater. For small-scale irrigation to effectively support WASH and, thus, to strengthen nutrition and health outcomes, systems need to be co-designed by irrigation and health specialists. Women farmers are responsible for providing WASH and need to participate in the design and management of dual-purpose systems.

Examining the impact of production systems that include improved irrigated fodder on livestock productivity (milk and meat production), household nutrition and economic improvement

FARMSIM model analysis showed that the increase in animal products availability and purchase can potentially lead to higher consumption of animal products at the household level and increase nutrient intake for better nutrition. Profitability varied across scenarios, suggesting climate change would reduce likely income.

Objective 5: Assessment of watershed and SSI interventions on nutrition and resilience under Productive Safety Net Program (PSNP) in Ethiopia

A draft final report, as well as two policy notes were developed to address all three research questions jointly. Results focused on the implementation of PSNP found that Bureau for Humanitarian Assistance (BHA)-supported interventions strengthened institutional infrastructure and built up the technical and managerial capacity of communities, government experts, and local governments; it also contributed to developing a sense of ownership and to the sustainability of positive outcomes.

Assessment of the implementation of the PSNP watershed rehabilitation approach; identification of limitations and role of upstream watershed rehabilitation on irrigation sustainability

Remote sensing analysis and biophysical modeling showed that implementation of interventions improved greenness in intervention areas in dry season, including in years dominated by drought. Soil erosion was lower after the implementation of the interventions. Biophysical modeling using the SWAT model generally showed positive impacts of watershed interventions on soil erosion, surface runoff generation, groundwater recharge and soil moisture. See Annex 4.

Qualitative assessment of watershed rehabilitation and small scale irrigation

Qualitative data analysis from Amhara and Oromia regions indicate the following:

- Modalities should be revised. PSNP participants do not own land in rehabilitated areas or irrigation schemes. Farmers need to build resilience based on their own farming practices, which is a key component of graduating from the PSNP program. Groundwater irrigation using pumps could help to resolve this issue, but land ownership needs to be considered in business models for pump ownership or irrigation service provision.
- Reductions in the time spent by farmers on public works activities could increase the time available to affected beneficiaries for engagement on their own land (even if small) and for income generating activities.
- 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; priority needs to be given to revising indicators and georeferencing rehabilitated watersheds and irrigation works.
- Long-term rehabilitation practices should be coupled with immediate income generating activities as a potential solution to ensuring sustainability.

Based on analysis, the research highlights 12 suggestions to enhance the nutrition and resilience benefits of the PSNP public works program.

Quantitative assessment of watershed rehabilitation and small scale irrigation investments

Quantitative analyses were completed, but no additional data (specifically endline data directly collected by BHA) could be accessed as the endline was not collected. Results indicate that PSNP has rehabilitated degraded lands and increased water availability for multiple uses, improving local livelihoods for PSNP beneficiaries and non-beneficiaries. Some beneficiaries, however, and in particular female headed households, remained highly vulnerable to shocks. Prior to PSNP, intervention sites experienced high vulnerability and low resilience to shocks due to erratic rains and poor soil fertility. PSNP investment in soil and water conservation through public works helped improve soil fertility and increase availability of food and livestock feed. The expansion of irrigation practices was key to improving food and feed availability. These results were seen from both the biophysical analysis and socioeconomic assessments.

4. Objective 4. Progress toward impact through research uptake

Short-term trainings

- ILRI organized forage seed threshing cleaning and packaging training, Ethiopia: six cooperative members across three sites.
- ILRI provided two-day training on hygienic milk handling, and processing, Ethiopia: staff of cooperatives (5 hired workers)
- IWMI co-organized with Rensys demand-supply linkages workshops and field demonstrations, as noted above.
- Research methods training, Wachamo and Bahir Dar Universities, Ethiopia.
- Quantitative data collection methods training for 12 young researchers from national universities on using the ODK platform and WELI tool.

Post-graduate research training

Candidates are 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 1.

Table 1. Long-term Trainees

M/F	University	Degree	Major	Program End Date	Home Country
Male	Arba Minchi University	Ph.D.	Biotechnology	January 2023	Ethiopia
Male	Bahir Dar University	Ph.D.	Water resources engineering and management	May 2023	Ethiopia
Male	Bahir Dar University	MSc	Agricultural Sciences	Completed	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
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
NA	Bahir Dar University	MSc	Water resources engineering and management	May 2023	Ethiopia

Innovation Scholarships and Internships

Interns (6) from an Agri-hackathon at Bahir Dar Institute of Technology (BiT)/Bahir Dar University finished their internships with Rensys. One student group formed a tech start-up that is being contracted by other companies for software development. Another 8 students have been selected to intern before end of project to support Rensys business operations.

Sub-national and national events, platforms/dialogues, and other convenings

Multi-stakeholder Dialogue Platform Meetings: 2 completed in Ethiopia (as noted above)

Outreach and communications

See Annex 2. Data and Publications for the full list of datasets and papers. Research partners published over 20 papers in the fiscal year based on research in Ethiopia.

5. Technology transfer and scaling partnerships

Institutional Capacity Development (examples)

- Multi-stakeholder dialogues co-convened with World Bank to ensure continuation post-project exit
- ILRI's performance-based sub-sub-awards with dairy cooperatives led World Bank to give technical and financial support to these and more cooperatives. See Annex 3. Success Stories.
- Support provided to dairy cooperatives enabled cooperatives to serve as a source of forage seeds, planting materials, compound feeds, and milk and milk products. Cooperatives reportedly earned USD 2000+ from planting material sales. See Annex 3. Success Stories.

6. Future work

Objective 1. Identify and Test Approaches to Sustainably Scale SSI through Reducing Constraints and Strengthening Opportunities for Access

- Close out scaling partnerships with private sector partners
- Close out partnerships with dairy cooperatives; support exit to be operational in forage seed market
- Complete studies on: changes in tariffs on the importation of solar pumps into Ethiopia; approaches for equity (along value chains)

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

- Complete studies on: cropping systems (legume crops, fodder, etc.) that provide best productivity under different climatic scenarios; performance of forage varieties under irrigation

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

- Complete community-level water governance approaches, scaling and South-South initiative
- Complete analysis on irrigated fodder, empowerment, household nutrition, climate resilience

Objective 4. Achieve impact through uptake of ILSSI research results and methods

Short-term and long-term trainings

- Dairy and irrigated fodder partner cooperative trainings
- Producer and public agency trainings on solar irrigation (IWMI with Rensys)
- Mentor/support graduate students and field assistants; Complete Innovation Grants, Internships
- Analytical model trainings (Arba Minch University, February 2023)

Outreach

- Multi-stakeholder dialogue meeting
- Irrigated fodder workshop to engage national and international partners (May 2023 TBC)
- Policy guidance and briefs on the role of watershed rehabilitation and small-scale irrigation in selected PSNP areas

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

Rensys Engineering (Ethiopia)

Observations and lessons

ILSSI revised the sub-award with Rensys in February 2022 to address the delays related to COVID, the conflict in Ethiopia, and supply chain/shipping constraints that delayed delivery of pumps. Pumps were delivered around May and sales began. However, Rensys has faced substantial constraints on accessing land for cold stores and distribution hubs, on accessing foreign exchange and therefore letters of credit to import, and on establishing solid business relationships (e.g. mobile money system). While Rensys identified a solar powered cold room supplier, localized conflicts thwarted all attempts to acquire land for solar powered cold room installation; that activity has been removed from the milestones.

Milestone progress

- Milestone 5 completed. Distribution hubs established in 4 sites (Amhara, SNNPR, Oromia); Marketing activities begin
- Milestone 7A partially completed. Sales records (pumps).

Activities

- Imported pumps and began selling
- SunCulture (manufacturer/supply) conducted quality control and provided training for Rensys staff
- Demonstrations and demand-supply linkage workshops in targeted areas
- Created mobile app (market linkage between producers and off takers) through the Hack-a-thon with Bahir Dar University

Annex 2. Data and publications

Datasets

1. Worqlul, Abeyou W., 2022, "Tropical Livestock Unit (TLU)", https://doi.org/10.18738/T8/KMGGRR, Texas Data Repository, V1
2. Worqlul, Abeyou W., 2022, "Potential land suitable for fodder production", https://doi.org/10.18738/T8/Z2T57I, Texas Data Repository, V1
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Publications

Peer-reviewed publications

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Annex 3. Success Stories

Collaboration between ILSSI and Word Bank funded livestock and fisheries sector development (LFSD) in Bahirdar zuria district

In Bahirdar zuria district, the ILSSI project has been collaborating with the livestock and fisheries sector development (LFSD) project, which is a World Bank funded project and implemented by the Ministry of Agriculture of Ethiopia. In this district, the LFSD project has partnered with the ILSSI to promote some of the fodder technologies that have been evaluated and recommended by the ILSSI. Recently the project has announced that it would provide material support/donation to one competitive dairy cooperatives from across the fifteen kebeles they are operating. In the selection process, the dairy cooperative which has been working with the ILSSI, Genet Lerobit, was nominated to receive the in-kind award amounting to 1.3 million ETB. The in-kind donation include cream separator, churn, milking cans and a vehicle. The selection of this cooperative was a direct result of ILSSI's investment in terms basic infrastructure development and human capacity building. As a result the cooperative was found to be in a much better position to utilize the new resources and hence was nominated for the award. This is a good success story how the ILSSI support have helped to strengthen local institutions to serve their communities at a higher capacity.

The training was organized to capacitate enumerators who participate in the ILSSI gender analysis study to determine the gender dynamics around irrigated fodder production

Group photo of participants of enumerators training workshop, held in the ILRI Addis Ababa campus from 25 February to 1 March

Participatory forage variety evaluation field day in SNNP region, Ethiopia

Farmers invited to visit the ILSSI irrigated fodder demonstration and research site for participatory variety evaluation to promote irrigated fodder cultivation among livestock farmers

Dairy cooperatives earning income from sale of forage seeds

In Ethiopia the majority of farmers have no access to affordable forage seeds/planting materials. When the ILSSI phase II was launched, it was planned to support local institutions to engage in forage seed business. Dairy cooperatives were chosen for this purpose as private companies were not available in the project sites. The cooperatives were supported technically and financially to establish forage seeds/planting material multiplication, storage and sales shop facilities. The support started to bear fruit in the reporting physical year as the cooperatives were able to multiply and sale forage seeds of oat, vetch, lablab, and cuttings/root splits of Napier grass. The records showed that the cooperatives sold forage seed worth more than two-thousand dollars. This was considered a good beginning to strengthen the local forage system and position the cooperatives as important input suppliers. Such activities are also expected to diversify the income of farmers and increase the adoption of irrigated fodder by dairy producers.

Annex 4. Impacts of the PSNP watershed rehabilitation and irrigation interventions

The impacts of the watershed rehabilitation and irrigation interventions implemented in Productive Safety net Program (PSNP) woredas of Ethiopia were evaluated to explore their benefits in terms of improving the livelihood of the society, granting food security and environmental sustainability at large. These investments were financially supported by the USAID Bureau of Humanitarian Assistance (BHA) in collaboration with other international organizations that include World Vision (WV), Food for Hungry (FH), Relief Society of Tigray (REST) and Catholic Relief Services (CRS). These international organizations have an indispensable role in implementing the watershed rehabilitation and irrigation intervention mainly in Amhara, Oromia, and Tigray regions, and Dire Dawa administration in Ethiopia.

There were 75 watershed outlets primary identified in Productive Safety Net Programme (PSNP) woredas and a total of 17 watersheds were initially selected for the deep dive analysis with a joint effort with IFPRI partner using the selection criteria that include mainly the availability of development map, availability of different types of interventions, area of the watershed, and the availability of Feed the Future (FtF V02) secondary data. Percentage coverage of the interventions varies from one watershed to another. The interventions cover upto 100% of the total area of smaller watersheds as compared to the bigger watersheds. Equal weights were assigned for each criterion and then watersheds that scored relatively the higher value were identified and used for the deep dive analysis. The implementers also forwarded their feedback on the selected watersheds and suggested to drop out some of the watersheds from the deep dive analysis due to the age of the interventions and accuracy of the development maps. For example, the implementers confirmed that the watershed treatments in Ija Bowa and Didimtu watersheds were commenced since 2020 and there is short record length of data length to pursue the evaluation before and after intervention. In addition, there is also accuracy issues on the development map obtained from WV watersheds. More accurate and representative development maps were reproduced later by WV through conducting the field survey for Lawber, Abriko and Kolaye watersheds. Therefore, a total of nine watersheds were finally selected for further use in this study. These watersheds include Feresmay (REST), Zergawido, Ganwuha, Tilikwenz (FH), Bereka, Garalakole (CRS), Lawber, Qedelit, and Qolaye (WV).

This section summarizes largely the findings of the remote sensing and biophysical modeling-based analyses performed to evaluate the impacts of the watershed rehabilitation and irrigation interventions in terms of enhancement in vegetation greenness, actual ET, soil water availability, groundwater recharge, and reduction in soil erosion, and runoff generation. The evaluation process, in general, requires the utilization of several input variables, including the development map, weather, biophysical (i.e., land use, soil, dem and NDVI) and other data acquired from governmental and non-governmental organizations and other sources. The development maps which show the location, types and extents of the interventions implemented on the ground in each study watershed were acquired from the implementing organizations. In the remote sensing-based analysis, long-term Landsat based Normalized Difference Vegetation Index (NDVI) was used to contemplate the change in vegetation greenness due to the implementation of watershed rehabilitation and small-scale irrigation interventions. The time series NDVI data was clustered into "*before*" and *"after"* the intervention's periods using the threshold years (2008 and 2017) for the evaluation process. Majority of the interventions were implemented, and extensive rehabilitation and maintenance activities were commenced since these threshold years. The improvement in vegetation greenness was also assessed during the dry and wet seasons to explore the enhancement in vegetation greenness under different weather conditions. Due to improved soil

moisture holding capacity and soil fertility in the rehabilitated watersheds, better vegetation may be observed in the rehabilitated watersheds during the dry and wet seasons. In addition, the analysis was expanded to explore the drought resilience of the vegetation greenness as a result of the interventions. Historic drought years before and after the intervention periods were identified and used to explore the benefits of the interventions to enhance the greenness during shock years. Besides the remote sensing analysis, the biophysical modeling approach was also applied in this study to explore and quantify the outcomes of the interventions in terms of changes in actual ET, surface runoff generation, sediment yield, soil water availability, and groundwater recharge.

Remote sensing and biophysical based results indicated an overall improvement in vegetation greenness and water budget components in the watersheds due to the interventions although the change varies per type of interventions, and from one watershed into the other. Water availability has improved since there is enhancement in actual ET, soil water content and groundwater recharge in most of the watersheds. While soil erosion and surface runoff have reduced with a magnitude that varies from one watershed into another. Since most of the interventions are implemented with the financial support from the international donors including USAID, the finding of this study supports the positive impacts of those investments and an indirect benefit on improving the livelihood and household level income in the watershed. Pronounced improvement in vegetation greenness has been observed during dry season compared to the wet season in the majority of the watersheds. In addition, the vegetation greenness has improved during dry season after the interventions compared to before the intervention period. The interventions have the potential to enhance the soil fertility and water holding capacity of the soil to retain more soil moisture during the dry season somehow to enhance vegetation greenness. There is no consistent improvement in vegetation observed during the rainy season due to perhaps sufficient rainfall amount to satisfy the water requirement of the plants before and after the interventions. The interventions further helped to improve drought resilience due to an increase in water availability during drought years to mitigate/reduce drought impacts on vegetation greenness although the level of vegetation greenness largely depends on drought severity at the local scale. This might allude an indirect benefit of the interventions to grant food security in the watersheds. Area closure enriched with plantation and other soil conservation activities, and irrigation interventions are more effective in terms of enhancing the vegetation greenness and soil erosion. While other soil water conservation structures (i.e., bunds, check dams, terraces have also contributed towards improving the vegetation greenness and water budget components. Despite the fact that the analysis of this study is good enough to support the positive impacts of the investment, follow-up research using an integrative approach between the remote sensing-based vegetation indices and biophysical modeling with the field level measurement and qualitative household level data will certainly offer an opportunity for better understanding of the biophysical changes linked to the soil and water conservation investments. Remote sensing is also able to provide collaborative evidence to complement with the biophysical modeling, however biophysical model provides more detailed sub-component output such as water budget components, biomass, crop yield etc. Moving forward, biophysical modeling-based analysis can be expanded further to conduct econometric and other types of analyses, which satellite based assessment limited to address.

The analysis in this study is fully based on the existing interventions on the ground. Future study may require to identifying the potential sites for further implementation to culminate the net benefits at watershed to basin scale. The biophysical modeling analysis can be upscaled and expanded to the basin and country scale to assess the overall benefits of the BMPs to the downstream hydraulic structures such as dams. Although the biophysical modeling is capable to show the benefits of the BMPs, integrating ground observation and field data may further improve the finding of this study. The accuracy and

number of observations of the remote sensing largely depends on the availability clear sky imageries which is difficult to get particularly during the wet season due to cloud cover. Therefore, the biophysical model can complement this limitation and can be extensively used for future study. The age of the interventions is one of the limiting factors that significantly affects the effectiveness of each intervention particularly if there is no routine maintenance activity. Future studies through addressing the limiting factors are paramount to support further the finding of this study.