



# FEED THE FUTURE

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



Checking wetting front detectors  
Photo: Apollo Habtamu

## ETHIOPIA

### Feed the Future Innovation Laboratory for Small Scale Irrigation (ILSSI) Research Results Discussion Brief

#### Key research findings

- There is high potential for small scale irrigation (SSI) in Ethiopia, particularly in the Ethiopian Highlands, the Lake Tana area and the Rift Valley.
- Scenario analysis showed positive income and nutritional outcomes from SSI technologies used to grow vegetables and fodder during the dry season.
- Integrated use of shallow groundwater and surface runoff can support irrigation water requirements for vegetables and fodder while avoiding negative environmental externalities. However, neither dry season rainfall nor shallow groundwater recharge alone would be sufficient given competing demands on water supplies.
- Women and men farmers prefer solar pumps to other SSI technologies because they reduce household labor and enable water to be used for multiple purposes.
- Irrigation scheduling increases water productivity, improves yield and crop quality, and increases profitability and income while reducing labor costs and fertilizer inputs.
- Nearly all water lifting technologies are economically feasible with high value crops and reasonable cost of credit.
- Labor is a major cost and constraint to sustainable SSI adoption and irrigated production in Ethiopia.
- Access to credit increases SSI adoption under favorable terms.
- Assessments based on forage yield, quality and farm gate prices for animal produce suggest irrigated fodder is economically competitive with other crops.
- SSI is not always associated with women's empowerment, so requires careful targeting.
- Homestead pocket gardens use less water and labor than conventional gardens, and so offer a potentially important avenue for improving household nutrition and diversifying livelihood options for women.



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## Introduction

The *Feed the Future Innovation Laboratory for Small Scale Irrigation*, initiated in 2013, has been a focal point of the USAID investment strategy to provide improved efficient methods of supplying water to small holder farmers. The project worked to create research-based evidence that would contribute to increased food production, improved nutrition, accelerated economic development and the protection of the environment. The project involved stakeholder-driven field studies to evaluate small scale irrigation (SSI) interventions, and household surveys to assess the impact of SSI on nutrition, economic status and women's empowerment. An integrated suite of analytical models, the Integrated Decision Support System (IDSS) was used to evaluate, and interpret results from field studies. Sustainability of the interventions employed through the project has been promoted through continuous dialogue with stakeholders and a strong focus on multifaceted capacity development.

The target beneficiaries were smallholder farmers, though a wide range of stakeholders were engaged by the research team. This included practitioners at the local level, national decision makers, private sector investors in technology, and future development donors. Studies conducted in farmer's fields, household surveys, analysis and capacity development (both at individual and institutional levels) formed the key components of the research process. These enabled investigation of the consequences of small-scale irrigation interventions on production, the environment, economic factors, nutrition and equity. The research team also explored opportunities and constraints to scaling up promising technologies, approaches and practices from the farm to national levels. To mitigate some of the risks of SSI, and as part of efforts towards ensuring improved sustainability of the interventions, ILSSI tested irrigation scheduling tools and trialed conservation agriculture (CA) with farmers. A number of unique data sets were also produced through ILSSI including ones on: gender and nutrition at the intra-household level, on-farm water management, and hydrological data (including shallow groundwater).

During the five year research project, the ILSSI team undertook a total of 28 water resources sustainability assessments in 19 basins, including 6 international trans-boundary basins. In Ethiopia, three national-level consultations on key policy issues related to irrigation and irrigated value chains, especially those linked to irrigated fodder, were conducted. ILSSI initiated research on 9 new technologies or management practices and in addition, undertook field testing of 8 new technologies, and at least 15 new technologies were made ready for transfer under the project. In general the technologies were found to be feasible, profitable and to have multiple benefits though it was clear that women face more constraints to accessing and using them than men.

In keeping with the strong focus of ILSSI on capacity development, short-terming training was provided to a total of 938 producers, 115 civil servants, 36 private sector actors and 193 members of civil society (907 men and 375 women overall) across the three countries. Training ranged from practices and tools for on-farm water management and fodder production for farmers, to use of data collection and analysis using the IDSS. Furthermore, as part of ILSSI's commitment to enhancing research capacity, a total of 26 graduate and 10 undergraduate students across the three countries received degree-related training and support, including research design, data collection, field research methods, publication preparation mentoring, and assistance to participate in national and global scientific conferences.

In order to achieve the goals ILSSI conducted research and piloted interventions in three countries: Ethiopia, Tanzania and Ghana. In Ethiopia this included approximately 200 women and men farmers, in the Dangila and Robit woreda of Amhara region, the Adami Tulu woreda of Oromia region and the Lemo woreda of SNNP region. ILSSI implemented three household level water lifting technologies (rope and washer, motor pumps, and pulleys), in four woredas and explored their use in the production of tomato, onion, cabbage, pepper, avocado fruit and fodder.

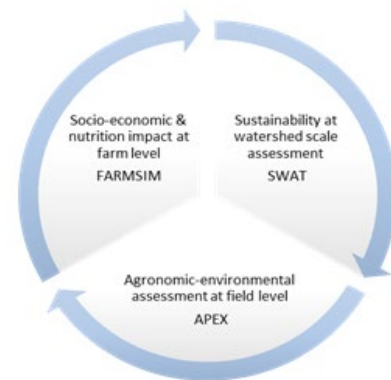
**Water sources:** ILSSI assessed the potential of a variety of site relevant water resources to sustainably meet productive water needs, as standalone sources or in some cases in combination to enhance sustainability, or because groundwater alone would be inadequate. Shallow groundwater was a focus in Ethiopia and Ghana.

**Water lifting technologies:** ILSSI research examined the use of motorized pumps in all three countries, solar pumps in Ethiopia and Ghana, and both rope and washer and pulleys in Ethiopia. Water lifting technologies alone provide benefits, but also carry risks, such as over or under application of scarce water and suboptimal yields and quality.

**Water application:** The benefits, constraints and impacts of both drip systems and furrow irrigation systems were examined in all three countries.



The Integrated Decision Support System (IDSS) enables assessment of the consequences of small scale irrigation interventions on production, environmental and economic outcomes, based on data collected from the field. IDSS is a suite of models including SWAT, FARMSIM and APEX, each of which examines a different set of key aspects. Analysis using IDSS was conducted to help scope existing SSI and to understand its varied impact on agricultural production, environmental sustainability, and both economic and nutritional outcomes. Analysis of gaps and constraints helped to identify factors that limit the adoption of SSI and to suggest mitigation options. The potential for expanding SSI in a given location was then studied through up-scaling analysis.



IDSS analysis capability  
Source: Project team

## Estimated small-scale irrigation adoption potential in Ethiopia

Use of IDSS analysis revealed potential for improved vegetable production yields in Ethiopia. Results show significant potential to expand SSI in Ethiopia with promising production and financial returns. About 0.8 million ha of land is economically and biophysically suitable for small-scale irrigation development in Ethiopia over the next decade – 0.44 million ha could be used for vegetables and pulses production and 0.37 million ha could be used for fodder crop production. If these production targets are achieved, net income from small scale irrigation adoption could be ~1.8 billion USD/year. As shown in Figure A, Amhara, Oromia and SNNPR have the highest small scale irrigation adoption potential.

Estimated small-scale irrigation adoption potential - ETHIOPIA -					
	Vegetables & pulses	Fodder	Total	Profits (Million USD/yr)	Number of beneficiaries (Thousand People)
Addis Ababa	0	0	0	0	0
Affar	32	20	52	0.1	0.3
Amhara	210,830	156,316	367,145	1,072	2,080
Benishangul-Gumuz	7,585	3,166	10,751	14	61
Dire Dawa	9	15	24	0.05	0.1
Gambella	247	0	247	0.5	1
Harari	0	41	41	0.2	0.2
SNNP	54,423	40,282	94,704	228	537
Tigray	4,088	6,440	10,528	25	60
Oromiya	162,913	164,956	327,869	441	1,858

Figure C: Summary of upscaling potential by region in Ethiopia  
Source: Project research results

## Probability of irrigation adoption and water scarcity

Sites in Ethiopia with adoption potential for small-scale irrigation identified through a Monte Carlo simulation and associated estimates for adoption probability are shown in Figure A. Areas stretching from the Lake Tana and Ethiopian Great Rift Valley are found to be the regions with highest adoption probability for small scale irrigation. At the same time, small scale irrigation development may pose risks for water scarcity in some areas, as shown in Figure B.



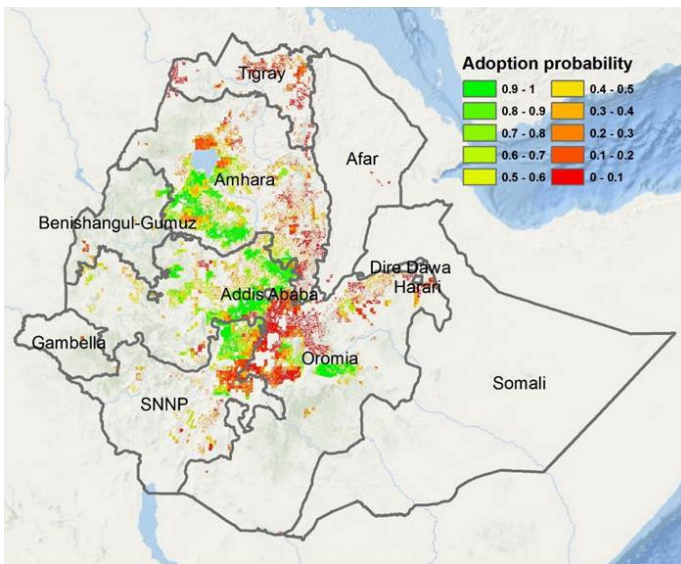


Figure A: Adoption probability of small-scale irrigation in Ethiopia  
 Source: Dile et al., 2017. Upscaling of small-scale irrigation in Ethiopia

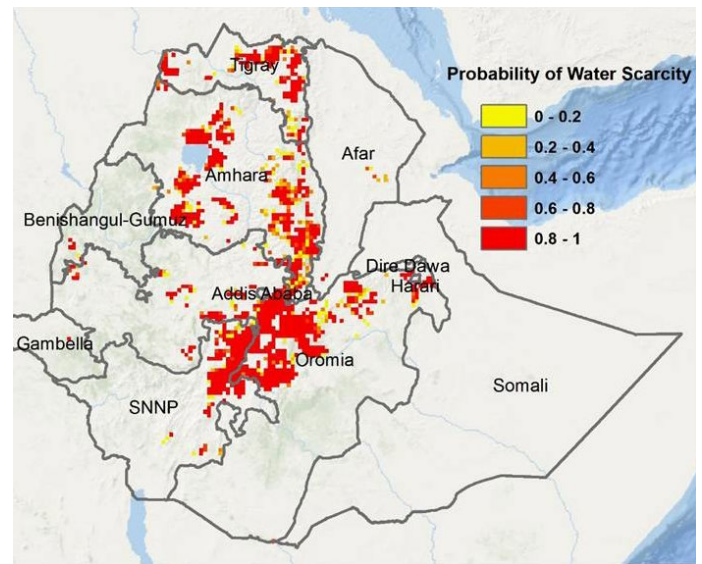


Figure B: Risk of water scarcity induced by small-scale irrigation development in Ghana  
 Source: Dile et al., 2017. Upscaling of small-scale irrigation in Ethiopia

### Improving irrigation scheduling

Research results show that irrigation scheduling tools may be key to enhancing SSI sustainability. In particular, irrigation scheduling tools were found to increase yields and profitability, improve water use efficiency and productivity, and improve fertilizer efficiency (in some cases). They were also found to promote water sharing. Since labor saving opportunities have been identified as important factors in the adoption and use of SSI technologies, particularly for women and primarily because labor is a major production cost (though differing across crops and technologies), its notable that irrigation scheduling tools were shown to reduce SSI labor requirements. The improvement in water use efficiency offered by these tools are particularly important where water is scarce, as it is in regions of all three countries studied. Production increases using irrigation scheduling tools varied by farmer field, but in some cases improved by 40% over traditional farmer practices. Nutrient loss commonly associated with over-watering also notably reduced with the use of mechanical irrigation scheduling tools.

As an example, Figure D clearly shows that using wetting front detectors (WFDs) to inform irrigation scheduling in Ethiopia resulted in improved yields and enhanced profits when growing carrots and cabbage using rope and washer irrigation technology. If the constraints women face in accessing irrigation scheduling tools are to be successfully overcome, and so lead to improvements in on-farm water management, there will need to be a stronger focus on ensuring women are able to access information and training on them.

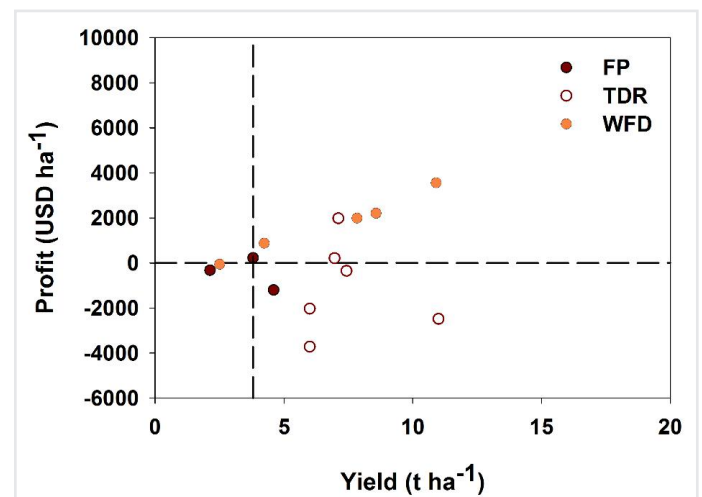


Figure: D Increased profits through improved water management  
**FP** = current farmer practice, **TDR** = tensiometer/Time Domain Reflectometry, **WFD** = wetting front detector  
 Source: project research results

### Benefits of conservation agriculture

Conservation agriculture (CA) aims to improve sustainability of agricultural production by offering benefits such as improved water resource efficiency and reduced labor costs. Conservation agricultural techniques such as mulching, biologically diverse crops in rotation and low tillage approaches, sometimes combined with drip irrigation, were trialed by ILSSI. These methods can have multiple benefits including some that support climate resilience. There are also some constraints to the use of, benefits derived from, and opportunities to scale up the use of, CA. Overall ILSSI research found that CA enhances SSI benefits, for instance when used in commercial home gardens, even under temperature stress conditions.





Improved vegetable yields were observed under CA for garlic, tomato and cabbage compared to conventional tillage practices, for example cabbage yields in Robit were found to increase by as much as 9%. Additionally, ILSSI found that irrigation water use was significantly reduced under CA across all vegetable types, by as much as 14-46% depending on the site and vegetable type. CA was also found to improve both soil quality and soil moisture content under practices. In some, but not all, cases CA was also found to reduce labor costs.

ILSSI also identified a number of key constraints to the success of CA in Ethiopia. These include potentially limited supplies of mulch or competition for other uses, such as animal fodder, and pest control challenges. Insufficient access to information and extension or other agronomic advisory services relating to CA. Constraints will all need to be addressed if the use of CA is to be scaled effectively.

### Scaling irrigated value chains - fodder for livestock

ILSSI found small scale irrigated fodder production to be profitable as a cash crop, for example growing it for sale in fodder markets. Assessments based on forage yield, quality and farm gate prices for animal produce suggest irrigated fodder is economically competitive with other crops. Other benefits include improving both on-farm livestock generally and more specifically the stock's productivity, for example in milk production, though the levels of profitability generated may vary.

**Fresh fodder biomass and quality obtained for a single cut within one irrigation cycle  
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Feed	Rainfall (mm)	Irrigation (mm)	Fresh yield (t/ha)	Dry yield (t/ha)	Crude protein (%)	Metabolisable Energy (MJ/kg)	Meat (kg)	Milk (kg)
Desho	182	56 ± 8	67.7 ± 13.5	13.3	17.8	6.96	24.5	163.4
Napier	282	342 ± 123	9.5 ± 5.3	2.2	8.6	8.00	5.4	32.3
Oats				12.8	9.2	7.92	30.5	184.7
Vetch	173	43 ± 9	65.3 ± 10.0	4.5	20.0	8.82	13.2	74.3
Weed				1.4	17.9	8.10	3.5	21.2

Figure: E Fodder biomass and quality. Source: project research results





Fodder cultivation, Ethiopia  
Photo: Deselegne Tadesse / IWMI

In Ethiopia farmers participating in ILSSI research were encouraged to grow Napier grass, Desho or Oats and Vetch, depending on the site. The total water applied during the irrigation season for the first cut of forage varied strongly for the different forages due to differences in climatic conditions at the site as well as crop water requirements and length of the growing period till the first cut. Differences in fresh biomass and feed quality obtained within the irrigated 100m (squared) plots led to significant differences in estimated meat and milk production, as detailed in Figure E. For example, feeding the produced oats and vetch would lead to higher meat or milk production.

As part of the ILSSI project irrigated fodder cultivation involved extension training, farmer field days and policy level engagement. Between 2014 and 2017 the number of farmers participating in the ILSSI irrigated forage trials in Ethiopia increased from 14 to 357, with land allocations to irrigated forage cultivation per farmer also increasing on many farms.

### Linkages between irrigation and nutrition

Significant differences were found between irrigators and non-irrigators in the areas of household food security, household dietary diversity and women’s dietary diversity. Irrigators performed better in measures of food security and dietary quality in all three countries, although the differences in female dietary diversity were not statistically significant in Ethiopia. Econometric results, using data from household surveys in Ethiopia, indicate that access to irrigation significantly improves both household agricultural income and production diversity. However, although increases in household income were found to lead to higher dietary diversity, increases in household production diversity did not necessarily contribute to increases in dietary diversity. This reveals that irrigation improves nutrition through an income pathway rather than through household consumption of the diversity of food grown.

### Irrigation for greater gender equality

Results from the Women’s Empowerment in Agriculture Index (WEAI) show that in general women irrigators are better off than non-irrigators. However, results also revealed that women and men do not have equal access to technologies, information, training, credit or inputs and that women have lower levels of access to technologies, or lose rights over them, to men within the household. Household survey results showed that small-scale irrigation does not always lead to women’s empowerment. As an example, irrigated fodder may have great potential, but women may end up losing out if the crop gets too profitable and is taken over by men in the household. In households where women’s labor is perceived to be plentiful, male decision-makers may be less apt to invest in irrigation technologies, which could otherwise reduce women’s labor burden.

Levels of empowerment, the roles of women and men, and the contributors to women’s disempowerment as well as the distribution of benefits and costs vary across the three study countries. However, women face a number of common constraints

to adoption of irrigation technologies. For example, technologies not matching women’s needs and preferences (with regard to affordability, maintenance needs, fuel requirements, transportability, and applicability for multiple uses). They also suffer lack of access to and control over the assets required for adoption (such as land), and lack of access to sufficient information (for example mobility constraints and/or not belonging to groups where information is disseminated).

	Non-irrigators n=185 (Mean)	Irrigators N=284
Household food insecurity access scale: 0-27 (higher = worse)	5.78	4.04
Female dietary diversity score: # of categories consumed	3.69	3.58
Household dietary diversity: # of food categories consumed	5.69	6.06

Figure F: Irrigation-food insecurity-dietary quality  
Source: Project research results

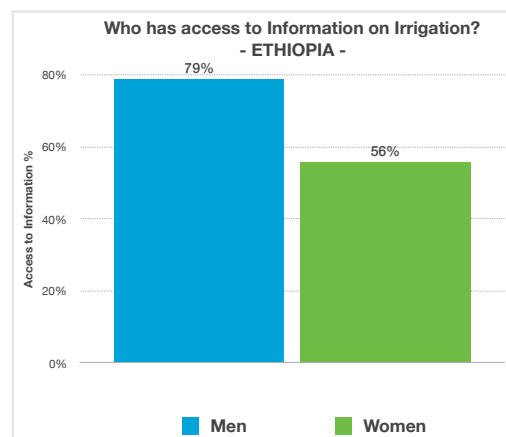


Figure M: Access to information on irrigation  
Source: Project research results

ILSSI identified a number of opportunities for the promotion of greater gender equality in irrigation, including:

- Capitalizing on the great potential for participatory, user-centered technology design to better address women’s needs and preferences
- Supporting women’s greater participation in group decision-making
- Developing new outreach models to ensure information effectively reaches both men and women
- Facilitating access to credit on both the supply and demand sides, providing financial literacy training for women and men and helping them to forming groups to manage and share risk
- Identifying ways to enable women to focus on under-explored crops which may be profitable and to capitalise on the high potential of seed production through approaches that don’t increase the risk of women losing profitable and preferred crops to men, such as fodder and leafy greens
- Enabling access to and control over assets and inputs and encouraging joint ownership of productive assets
- In some location specific cases, researchers found that women do not want to engage in irrigated farming at the plot level but may instead want to engage at other points in an irrigated value chain, such as in processing or marketing

Women often have limited ability to participate in decision-making over use of water resources for irrigation and low control over management of technologies and benefits of adoption by the household. Limited access to credit is also a common constraint. The work burden and lack of group participation for women were found to be common contributors to women’s disempowerment in all three countries. Understandably therefore women were found to favor labor saving technologies such as mechanized water lifting and solar pumps, and the installation of technologies for multiple uses and multiple growing seasons placed near to the home and suitable for home gardens. Efforts to ensure women’s equal access to irrigation will be crucial to achieving the goals of scaling up irrigation for climate resilience, improved productivity and enhanced food and nutritional security.

## Markets and returns on SSI investment

ILSSI results show that investments in SSI technologies and complementary inputs can contribute to poverty reduction in Ethiopia. More specifically, investments in SSI technologies can have a stronger effect on reducing poverty for women farmers and female-headed households than for male-headed households, notably through increasing consumption expenditure. Enabling access to rural finance increases the likelihood of adoption of SSI. Rural micro-finance institutions are the main sources of financing or credit available to smallholder farmers in Ethiopia in order to invest in irrigation technologies.

Three economic feasibility indicators were used to consider profitability; Net Present Value (NPV), Internal Rate of Return (IRR) and payback period (to return the cost of investment in the technology). Results of the feasibility assessment suggest that regardless of crop type (or differences in discounted interest rates) investments in diesel/petrol pumps are profitable in Ethiopia. However, the economic feasibility of manual pumps varied across sites and crop types. Labor costs comprise the major component of total production costs, suggesting that investment in labor saving water lifting and application systems for smallholder irrigation would enhance profitability. The feasibility of an SSI technology can also be influenced by biophysical characteristics (such as soil type, soil salinity, and temperature), as well as by access to markets.



## Project findings to development impact

The ILSSI research project analysed small-scale irrigation (SSI) interventions, and the impact of SSI on nutrition, economics and women's empowerment through household surveys, and the use of the IDSS to plan, evaluate and interpret results from the field studies. The results of the multidisciplinary research revealed a number of important findings to be considered for upscaling SSI and its benefits in Ethiopia. There is high potential for SSI in Ethiopia and using SSI technologies to grow vegetables and fodder during the dry season would help enhance profitability and achieve positive nutritional outcomes. Labor is a major cost and constraint to sustainable SSI adoption in Ethiopia, both women and men farmers prefer solar pumps which reduce this labor cost. Nearly all water lifting technologies are economically feasible with high value crops and when the costs of credit are reasonable. Irrigation scheduling can increase water productivity, and improve both yields and crop quality. However, SSI is not always associated with women's empowerment. The research also showed that there is a need to build rigorous business cases for SSI, including profitable irrigation business models for men, women and youth, and also to identify ways to enhance private investment in the various aspects related to the use of SSI in Ethiopia. By taking these insights into account, and acting on them, the goals of increased food production, improved nutrition, accelerated economic development and protection of the environment can be more affectively achieved.

### Recommendations

- Increase access to finance products and information
- Reduce labor requirements through technology and tools
- Apply solutions with youth entrepreneurs as entrepreneurs in service provision
- Adapt technologies and sites to women farmers' preferences
- Expand role of private sector actors in technology supply chain and finance provision
- Match technology packages suitable to context
- Improve governance mechanisms

### References

- Assessing Irrigation Potential and Land Suitability in Ethiopia <http://ilssi.tamu.edu/media/1307/assessing-irrigation-potential-and-land-suitability-in-ethiopia.pdf>
- Upscaling analysis – from small river basin to country <http://ilssi.tamu.edu/media/1398/upscaling-analysis-from-small-river-basin-to-country.pdf>
- Results and Impact of IDSS workshops in Ethiopia <http://ilssi.tamu.edu/media/1334/report-on-ethiopia-idss-workshops.pdf>
- Small -Scale Irrigation Applications for Smallholder Farmers in Ethiopia Ex Ante Analysis of Options <http://ilssi.tamu.edu/media/1330/final-ethiopia-report-ex-ante-analyses-of-ssi-interventions.pdf>
- An example IDSS gap and constraints analysis for small scale irrigation systems in the Robit watershed <http://ilssi.tamu.edu/media/1303/an-example-gaps-and-constraints-analysis-for-small-scale-irrigation-systems-in-the-robit-watershed.pdf>
- Assessing potential land suitable for surface irrigation using groundwater in Ethiopia. Applied Geography 85 (2017)
- Improving irrigation access to combat food insecurity and undernutrition: A review. (2015) Global Food Security (Vol 6): 24-33.
- Watershed modeling for reducing future non-point source sediment and phosphorus load in the Lake Tana Basin, Ethiopia. Journal of Soils and Sediments (2018) 18: 309. <https://doi.org/10.1007/s11368-017-1824-z>
- A review of trends, constraints and opportunities of smallholder irrigation in East Africa (2017) Global Food Security. In press. Available online November 2017. <https://doi.org/10.1016/j.gfs.2017.10.003>
- What happens after technology adoption? Gendered aspects of small-scale irrigation technologies in Ethiopia, Ghana and Tanzania. Agriculture and Human Values, 1-14. (2018) [https://link.springer.com/article/10.1007/s10460-018-9862-8?wt\\_mc=Internal.Event.I.SEM.ArticleAuthorOnlineFirst](https://link.springer.com/article/10.1007/s10460-018-9862-8?wt_mc=Internal.Event.I.SEM.ArticleAuthorOnlineFirst)
- Review paper on 'Garden Kits' in Africa: lessons learned and the potential of improved water management. (2014) Colombo, Sri Lanka: International Water Management Institute, IWMI Working Paper 162
- Irrigated fodder opportunities for small scale irrigators. Feed the Future Innovation Lab for Small Scale Irrigation/ Africa RISING Fact Sheet. (2016) Colombo, Sri Lanka: IWMI. <https://cgspace.cgiar.org/handle/10568/76259>
- Integrating gender into small-scale irrigation. FTF-ILSSI Project Note 2. Washington, D.C.: IFPRI and IWMI. (2017) <http://www.ifpri.org/publication/integrating-gender-small-scale-irrigation>

### Further information

This brief has been produced by the ILSSI project: [ilssi.tamu.edu](http://ilssi.tamu.edu) For more information on this project contact: Neville Clarke: [neville.clarke@ag.tamu.edu](mailto:neville.clarke@ag.tamu.edu)

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