Addis Ababa University
COLLEGE OF NATURAL AND COMPUTATIONAL SCIENCES
DEPARTMENT OF ZOOLOGICAL SCIENCES

IMPACT OF SMALL-SCALE IRRIGATION ON THE LIVELIHOOD OF RURAL FARM HOUSEHOLDS IN: ENDERTA WEREDA, TIGRAY REGIONAL STATE

BY:
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GRADUATE PROGRAMMES

Declaration

This is to certify that the thesis prepared by Kahsu Mehari, entitled: IMPACT OF SMALL-SCALE IRRIGATION ON THE LIVELIHOOD OF RURAL FARM HOUSEHOLDS IN: ENDERTA WEREDA, TIGRAY REGIONAL STATE and submitted in fulfillment of the requirements for the degree of Master of Science in Biology complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Abstract

Irrigation has become among the key agricultural practices. The present study examines on the role of small-scale irrigation by specifically investigating the factors that determine the adoption of small-scale irrigation, the impact on income as well as challenges in small-scale irrigation sector in Enderta Wereda, Tigray Regional State of Ethiopia. Data were collected by applying household surveys, questionnaires as well as field observation methods. A sample of 93 irrigation user and non-irrigation user households was randomly selected through lottery sampling methods from 5 villages of the study Wereda. The data were analyzed by Probit regression to identify the factors that determine the adoption of small-scale irrigation and Propensity score matching (PSM) was used to estimate the impact of using small-scale irrigation on income as a livelihood indicator. The findings of the present study revealed that there were significance differences between groups of irrigation users compared to non-irrigation users Use of small-scale irrigation was significantly ($P < 0.05$) influenced by land size, access to credit, household education and total household income. The present study found that age, of the household head, educational level, marital status, as well as access to credit of the household head were positively correlated, while land and family sizes were found to be negatively correlated with the adoption of small-scale irrigation. Households who used irrigation earned about 64,226 Birr higher per year with standard deviation ± 49,250 than those who failed to use irrigation. Most farmers (94%) intend to continue using small-scale irrigation, but, they face several challenges. The most important challenges include is the price of farm inputs (21.6%),water management and lack of technology for water use (13.5%), access to credit (8.1%) as well as access to markets(5.4%).

Key words/phrases: Agricultural practices, Birr, Irrigation scheme, Irrigation user, Probit regression, Propensity score matching, Water management

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List of acronyms

BoARD = Bureau of Agriculture and Rural Development

CSA = Central Statistics Authority

DA = Development Agent

DFID = Department for International Development

EARDO = Enderta Agricultural and Rural development Office

ETB = Ethiopian Birr

FAO = Food and Agricultural Organization

GTP = Growth and Transformation Plan

Ha = Hectare

LSI = Large-scale irrigation

MoA =Ministry of Agriculture

MoARD = Ministry of Agriculture and rural Development

MoFED = Ministry of Finance and Economic Development

MSI = Medium-scale irrigation

NGOs = Nongovernmental Organizations

NPV = Negative net present value

O&M = Operation and Maintenance

PSNP = Productive Safety Net Program

PSM = Propensity Score Matching

REST = Relief Society of Tigray

SAERT = Sustainable Agricultural and Environmental Rehabilitation of Tigray

SSA = Sub-Saharan Africa

SSI = Small-scale Irrigation

WUA = Water User's Associations

1. INTRODUCTION

1.1. Background of the Study

The small-scale irrigation is categorized under agricultural irrigation is linked to food security in most regions of the world due to the fact that it enables to harvest twice a year. Irrigated agriculture produces about 2/3 of the world's food on 1/3 of the arable. Land irrigators need better see wards of the environment. Small-scale irrigation consumes about two third of the world's fresh water, and are the longest of non-profit source polluters. Over the last 25 years, small-scale irrigation has been important in raising the standard of living of the poor, especially in rural areas (FAO, 2004).

Ethiopia is predominantly in rural area with the vast majority of its population directly or indirectly involved in agriculture. Agriculture in the country is mainly rainfall dependent, traditional and subsistence with limited access to agricultural technologies and institutional support services (Desta Beyera, 2004).

The development of small-scale irrigation is one of the major intervention areas to increase agricultural production in the rural parts of the country. According to FAO (2003), small-scale irrigation is found to help farmers to overcome rainfall and water constraint by providing a sustainable supply of water for crop production and livestock, strengthen the base for sustainable agriculture, provide increased food security to poor communities and contribute to the improvement of human nutrition. Both irrigated and rain fed Agriculture is plays an essential role in the Ethiopian Economy. 85 percent of the people are living in rural Ethiopia. 50 percent of the GTP is generated through agriculture. 90 percent of export earning is through Agricultural product (World Bank, 2010).

Ethiopia endows water resources which have 12 river basins with an annual runoff volume of 122 billion $m^3$of water and an estimated 2.6-6.5 billion $m^3$of ground water potential, which makes an average 1,575 $m^3$of physically available water per person per year. However, out of 4.3 million hectares of irrigable land only 5% is under utilization in the country. This shows indirectly that most of the water resource of Ethiopia is underutilized though irrigation agriculture is taken as a main strategy to tackle the problem of the growing demand for food crop production in Ethiopia (Seleshi Bekele et al., 2007).

The dependence of most of the farmers on rain-fed agriculture has made the country's agricultural economy extremely fragile and vulnerable. Due to rainfall variability in drought porn parts of the country there is a partial or a total crop failure which causes mostly food and feed shortage (MoWE, 2011).

During the last twenty or more years, millions of Ethiopian households have been suffering from continuing misery, characterized by recurrent droughts that led to shortage of food and severe famine and high levels of malnutrition and food insecurity. Among various region of the country, Tigray Regional State is one of the areas that were severally affected by frequent droughts. In this Region, about 621,000 households, constituting about 75%, of the total population is food insecure and seriously threatens by recurrent drought, which hit the region every 3-4 years (Hagos Fitsum, 2003). This is one of the major challenges in rural development as well as how to promote food production to meet the ever-increasing demand of the growing population under the situation of variable and erratic rain falls in the Region.

Thus, exploiting of the irrigation potential of the country in general and the region in particular has been taken as major component of the Growth and Transformation Plan (GTP) of the country to increase agricultural production and productivity through promoting and construction of irrigation infrastructure.

In response to severe environmental degradation, population-resource imbalance and food insecurity the Regional Government of Tigray has initiated different rural development programs at household level. Among others small-scale river diversions and micro dam construction through different projects Sustainable Agricultural and Environmental Rehabilitation of Tigray (SAERT) and Relief Society of Tigray (REST)) were initiated. Since May 2004, 86 Small-scale dams and 41,097 Water Harvesting Schemes were constructed in different parts of Region (Seleshi Bekele *et al*., 2007).

In the last 10 years, a massive scale up of micro-level water harvesting and diverting development in Ethiopia such as above ground tanker, ponds, earth dam, bore holes, shallow wells, deep well runoff diversion and river diversions are found in different places used for different purposes: particularly in food insecure localities.

Irrigation has many functions such as increases crop production and achieves higher yields, and reduces the risk of crop failure if rain fails. It also multiplies the positive effect of other inputs such as fertilizers and pesticides on crop yields. Because small-scale irrigation makes households to generate more income, raise their resilience, and in some cases change their livelihoods. With increased investment in the country's irrigation infrastructure and water management practices, resources could contribute significantly to increasing agricultural production and productivity (Hussain and Hanjra, 2004).

Farmers of Enderta Wereda, *Kebele* Didba-dergeagen irrigation participant are engaging in small-scale irrigational activities for a long period of time especially widely practiced in the present government by the means of giving information to those farmers who have access water in their villages in order to reduce/eliminate the degree of poverty and improve their living standards. Successful small-scale irrigation schemes can result in increased productivity, improved incomes and nutrition, employment creation, food security and livelihood improvement. However, assessment of small-scale irrigation schemes is needed in order to be able to identify their performance and specify their factors of efficiency and also help for future irrigation development.

1.2. Statement of the Problem

Agricultural production in Ethiopia is primarily rain fed, so it depends on irregular and often insufficient rainfall. As a result, there are frequent failures of agricultural production. Irrigation has the potential to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall. Irrigation has the potential to increase both yields and cropping intensity in Ethiopia (Seleshi Bekele et al., 2010). The development of water resources for agricultural purposes (irrigation) is rising rapidly. According to BCEOM (1998), Ethiopia had an estimated total of 161,000 hectares of irrigated agriculture, of which 64,000 hectare is in small-scale schemes, 97,000 hectare is in medium-scale and large-scale schemes approximately 38,000 hectare is under implementation. Currently, the Ethiopian government gives more emphasis to small-scale irrigation as a means of achieving food self-sufficiency (MOFED, 2010). It is worthy to assess to, how, the already existing small-scale irrigation schemes, have been performed in terms of improving upon the livelihoods of the people as an immediate intervention measure as well as their long term viability for the communities utilizing them. The assessment of the effect of the irrigation scheme to the improvement of the lives of the people in the Enderta Wereda of the Tigray Regional State of Ethiopia with evidence from the *Kebele* Didba-dergeagen, delimited the scope of this study. The selection of the irrigation scheme for this study is determined partly by the fact that it can be used by a large section of the rural people in the respective communities in the district. According to Enderta Wereda bureau of agriculture report like any other irrigation beneficiaries, the household of the study area are expected to be benefited from the irrigation scheme. However, most of the households of the irrigation scheme did not observed to utilize the irrigation opportunity and many of them are still reliant on food aid and Productive Safety Net Programmed (PSNP) rather to utilize being become the irrigation potential beneficiaries. Based on this the researcher will intend to assess the effect of small-scale irrigation on the livelihood of farm households of the study area.

2. OBJECTIVES OF THE STUDY

2.1. General Objective

The overall objective of the study was to assess the impact of small-scale irrigation on the livelihoods of rural farm households of Enderta Wereda, *Kebele* Didba-dergeagen, Tigray Regional State.

2.2. Specific Objectives of the Study were:

- To study the impact of small-scale irrigation on the livelihoods of farm Households;
- To identify the basic factors that influence small-scale irrigation utilization by the farm Households;
- To distinguish technical challenges related to small-scale irrigation systems; and,

2.3. Research Questions

In order to address effectively the stated study objectives a set of research questions are raised to guide the research process.

- ✓ To what extent does the small-scale irrigation contributes in improving livelihood of the farm households?
- ✓ What are the basic factors that influence small-scale irrigation in the study area?
- ✓ What are the technical challenges related to small-scale irrigation systems?
- ✓ What is the socio-economic contribution of small-scale irrigation on the livelihood of the house hold farmers?

LITERATURE REVIEW

3.1. Irrigation

Irrigation is a method by which land moisture may be maintained by supplying water to the intended farmland. In this case, water for agricultural production can be sought from flowing rivers, collection of rainwater by building dams and reservoirs and pumping up from the ground, (Michael, 1997). Irrigation can be defined as an artificial application of water to soil for the purpose of supplying the moisture essential in the plant root-zone to prevent stress that may cause reduced yield and/or poor quality of harvest of crops (Reddy, 2010). This is an intentional action made by human to apply water for growing crops, especially during dry seasons where there is a shortage of rainfall. Water applications to crop fields are of various types. The most commonly used and most ancient type is surface irrigation methods (FAO, 2002) through using gravity forces. This was used especially across river side’s and it doesn’t depend on mechanized equipment. Nowadays, modernized irrigation systems are mostly used which works based on the pressurized energy system (FAO, 2001). The sprinkler and drip irrigation systems are of this type of water application systems.

Nata Tadesse and Asmelash Berhane (2007); Abraham Bairu *et al*. (2011), listed out the benefits of irrigation that includes; increase food production in arid and semi-arid regions, promotes economic growth and sustainable development, create employment opportunities, and improve living conditions of small-scale farmers. As a result, irrigation contributes to poverty reduction and protects the environment from degradation and pollution. Furthermore, it increases subsurface water levels and recharges groundwater. As a result, small, medium and large-scale irrigation infrastructure needs to be developed in the country. This helps to produce export commodities that would earn foreign exchanges and provides raw materials to the local industries. Since, most of the irrigation development in Ethiopia is expressed through an expansion of small-scale irrigations. Medium and large scale irrigation developments are needed to be taken into consideration.

3.1.1. History of Irrigation

Irrigation is generally defined as the application of water to the land for the purpose of supplying moisture essential to plant growth. It is an age-old art. Irrigation was practiced for thousands of years in the Nile Valley. Egypt claims to have the world's oldest dam built about 5,000 years ago to supply drinking water and for irrigation. At that time basin irrigation was introduced and still plays a significant role in Egyptian agriculture. According to Zewdie *et al.* (2007), irrigation has been practiced in Egypt, China, India and other parts of Asia for a long period of time. India and Far East have grown rice using irrigation nearly for 5,000 years. The Nile valley in Egypt, the plain of Euphrates and Tigris in Iraq were under irrigation for 4,000 years. Irrigation is the foundation of civilization in numerous regions. Egyptians have depended on Nile's flooding for irrigation continuously for a long period of time on a large scale. The land between Euphrates and Tigris, Mesopotamia, was the breadbasket for the Sumerian Empire. The civilization developed from centrally controlled irrigation system (Schilfgaarde, 1994).

Evidence also shows that irrigation in China was begun about 4,000 years ago. There were reservoirs in Sri Lanka more than 2,000 years old. As far back as 2300 BC, the Babylonian Code of Hammurabi provided that 'If anyone opens his irrigation canals to let in water, but is careless and the water floods the fields of his neighbor, he shall measure out grain to the latter in proportion to the yield of the neighboring field.' Other indicator for irrigation development is found in the stony-gravel limestone desert of the Negev area in Israel. Remnants of these ancient irrigation systems date back from the Israelite period (about 1000 BC) and from the Nabataea-Roman Byzantine era (300 BC to 600 AD). In the absence of permanent water sources, the ancient farmers developed 'runoff' farm systems that used sporadic flash floods for irrigating (Shanan, 1989).

Ethiopia has a long history of traditional irrigation systems. Simple river diversion still is the dominant irrigation system in Ethiopia. According to Gebremedhin Berhanu and Pede (2002), the country's irrigation potential ranges from 1.0 to 3.5 million hectares but the recent studies indicate that the irrigation potential of the country is higher. According to Tilahun Hordof and Paulos (2004), as cited by Awulachew *et al*. (2010), estimates of the irrigation potential of Ethiopia may be as large as 4.3 million hectares. Traditional irrigation schemes cover more than 138,000 hectares whereas modern small-scale irrigation covers about 48,000 hectares. The total current irrigation covers only about 6% of the estimated potential land area.

Sulas *et al*. (2009), in the study conducted to investigate whether irrigation was a key factor in state formation and urban development in the ancient civilization of Axum, Northern Ethiopia, found non-sufficient information regardless of water managements of rain-fed agriculture. However, In Ethiopia, traditional irrigation was practiced before centuries (Bekele Yeshitela *et al.,* 2012). Moreover, in the highlands of Ethiopia, irrigation practices have long been in use since ancient times for producing subsistence food crops (Seleshi Bekele *et al*,. 2007*;* Bacha Dereje *et al.*, 2011; MoA, 2011). Different authors*;* Seleshi Bekele *et al. (*2007); Makombe *et al.* (2007); Hagos Fitsum *et al.* (2009); Bacha Dereje *et al.* (2011), stressed that supplementary irrigation has been practiced by smallholder farmers of Ethiopia for centuries to solve their livelihood challenges.

Spate irrigation has also been used traditionally in Ethiopia (Mehari Abraham *et al.*, 2011), particularly in Southern Tigray and in some semi-arid areas in Oromia regional State (MoA, 2011). This irrigation system has been used for water harvesting from flush floods flooded from larger catchments at upper streams. These traditional irrigation systems were developed and managed through forming a water user's association for functions of construction, water allocation, operation and maintenance and were headed by individuals (Belay Mehretie and Bewket Woldeamlak, 2013). This association comprises up to 200 users grouped in to20 to 30 groups of farmers who share a common main canal or its branches (MoA, 2011). From the above discussions, the exact date when irrigation was started in Ethiopia remains uninvestigated regardless of routinely saying "irrigation was started in Ethiopia during ancient times" (Seleshi Bekele *et al*, *(*2007); Makombe *et al. (*2007): (Hagos Fitsum *et al. (*2009): (Bacha Dereje *et al.* (2011).

Modern irrigation, however, was started in the early 1950's by the bilateral agreement between the government of Ethiopia and the Dutch company jointly known as HVA-Ethiopia sugar cane plantation (MoA, 2011; Bekele Yeshitela *et al.*, 2012). Most of the traditional irrigated lands in Ethiopia are dominantly supplied by surface water sources, while ground water uses has just been started on a pilot basis in the East Amhara region (MoA, 2011). According to MoA (2011), pressurized sprinkler irrigation system was once practiced in Fincha State Farm, Eastern Amhara, Southern Tigray and on some private farms in the Rift Valley. The Rift Valley is a place where modern irrigation in Ethiopia starts especially in the Awash River Basin at which adoption of pump-irrigation commences. Surface irrigation methods predominantly furrow irrigation and basin irrigation methods were practiced for cotton and wheat productions and for commercial fruits such as bananas respectively. Meanwhile, similar reports such as Sileshi Bekele *et al.* (2007), explained that irrigated agriculture was started in Ethiopia in the upper Awash Valley with the objective of producing industrial crops as sugarcane, cotton and horticultural crops.

On a large-scale basis, explained in a remarkable emergence of irrigation development and establishment of agro industrial centers. This was due to taking an advantage of the construction of Koka dam aimed as a reservoir irrigation water supply, flood control and hydropower generation. During the middle 1970s, windmills and hand pumps were introduced to lift water from groundwater for drinking water supply, domestic and gardening purposes (MoA., 2011). According to the Ministry of Agriculture, in Ethiopia, there were modern water storage and water management systems for irrigation purposes. This includes water diversion schemes, water storage dams, micro irrigation systems, rainwater harvesting and shallow groundwater harvesting techniques. These systems make use of different water drawing irrigation technologies for lifting, conveying and applying irrigation water for irrigation uses. Night water storage facilities, Treadle pumps for lifting water, smallholder drip systems and micro- sprinklers for irrigation application are used among others (MoA., 2011).

3.1.2. Importance of Irrigation

Modern technology spurs ways for confronting the effect of natural and man-made disasters by using irrigation development structures. Hence, a number of advantages of irrigation are known, some of which are briefly presented below:

a) Irrigation enables to bring uncultivated lands under cultivation. Bhargahvea (1980), states that irrigation facilitates extending the area of land under cultivation,
b) The use of irrigation contributes to stabilize fluctuation in food supply. Scientific management of irrigation water provides the best insurance against weather induced fluctuations in total food production (Michael, 1997)
c) Irrigation facilitates agricultural production intensification. FAO, (2000) described that irrigation scheme helped to increase agricultural productivity of a given land in Africa such as in Zimbabwe, and this can be explained by the level of input needed and utilized.
d) Irrigation helps to diversify product types. Many research findings (FAO, 2000) attempts to prove that choices of crop types could be facilitated by irrigation and increase food variety and availability.
e) Irrigation can facilitate to provide alternative cropping pattern decision between cash and food items (FOA, 2000).
f) Irrigation provides the chance for increasing income. It is found that existence of irrigation can increase income by creating more employment since it is labour intensive.

Irrigation can create or increase employment opportunities especially, surface irrigation is found to be labour intensive (FAO, 2000).

g) Irrigation makes it possible to grow cash crops, which give good returns to the cultivators than the ordinary crops they might have grown in the absence of irrigation (FAO, 2000).

h) Irrigation in Ethiopia is basically used for mitigating the negative impacts of drought in susceptible to danger areas (Desalegn Rhameto, 1999). Moreover Desalegn argue that with sound management and careful planning, irrigation use can improve the livelihood of rural poor.

3.1.3. Types of Irrigation and their Selection

There are different types of irrigation schemes: for instance, traditional and modern. Traditional irrigation schemes were developed in different parts of the world by communities as a response to climatic challenges over time. Since there can be different criteria for dividing such interventions, a number of classification can be drawn. For example, irrigation schemes can be classified other basis of their structure, into two groups: River diversion and Dam construction. Others distinguish between intensive versus extensive; yet other divisions can be made as productive versus protective irrigation systems (Rees Ton and Kees Dejong, 1991). As regards the ways of supplying irrigation water to the farm, the following four types are identified:

- Sprinkling or spray irrigation;
- Drip irrigation;
- Furrow irrigation and
- Flood irrigation

Modern irrigation systems basically serve the same purpose as those of traditional systems, except the differences in their technological advancement. Modern irrigation systems are well designed and studied with the aim of securing their sustainability and productivity. Moreover, it can be designed in a way it can serve multiple purposes flexibly according to the prevailing policy, market conditions, consumer tests and other comparative advantages. Irrigation structures can also be divided into different scales based on their irrigating potential of a given land. As stated in Desalegn Rhameto, (1999), and used in Ethiopia, these are:

a) Small-scale irrigation (SSI) schemes conventionally, are those with the discharge that can water up to 200 hectares of land.

b) Medium-scale irrigation (MSI) schemes are those that can supply adequate amount of moisture to an area of 200-3,000 ha of land.
c) Large-scale irrigation (LSI) schemes are those that can secure irrigation water availability to the land size more than 3,000ha.

This irrigation classification system is the most common in Ethiopia. Accordingly, 46% of proposed irrigation developments are in the small-scale irrigation category (Makombe *et al.*, 2011). According to Makombe the irrigation development in Ethiopia is also classified based on the uses of a mix of the history of establishment, management system and the nature of the structures as follows:

1) Traditional schemes: These are small-scale irrigation systems which usually use diversion weirs made from local material and needs annual maintenance. The canals are usually earthen and the schemes are managed by the community.
2) Modern schemes: These are small-scale irrigation systems with more permanent diversion weirs made from concrete that don’t require annual maintenance. They are mostly community-managed and the primary and secondary channels are made of concrete.
3) Public: These are large-scale operations constructed and managed by the government. Sometimes these schemes support out-growers (smallholder farmers who have farms in the vicinity of the large-scale schemes).
4) Private: These are privately owned systems in mechanized farms which need a highly intensive operation.

These two irrigation classification systems are the most used classification system in Ethiopia among others. This systematic classification has been used by different stakeholders in the sector for efficient planning and utilization of irrigation projects.

3.1.4. Small-Scale Irrigation

Small-Scale: this involves irrigation activities on small plots, comprising a small number of farmers, using relatively small reservoirs rivers, dams or a cluster of wells controlled by the farmers using technology they can operate and maintain. In highland areas like Ethiopia, where water is delivered through gravity, small-scale irrigation schemes concern the upgrading of irrigation works, where the simple diversion structures, micro-dams constructed by traditional communities with local means such as stone and brushwood.

Rural Ethiopia exhibits a huge variation along a number of social and economic dimensions: ethnic group, religion, and economic status are just there, (Seleshi Bekele *et al.*, 2005). After infrastructure development such as roads, investments in irrigation are a key factor triggering rural improvement. Moreover, the potential multiplier effects of investments in agricultural intensification are considerable. Studies in India and elsewhere reveal that for each dollar invested in agriculture, the value of economic activity in forward and backward linkages including input supply, trade, export, and processing adds another two dollars return. However, for these benefits to be realized especially in the African smallholder context, smallholder irrigation must satisfy the following conditions (Shah et al., 2002)*:*

- Irrigation must hold out a promise of making significant improvements in the livelihoods and food security situation of the irrigation farmers, i.e., it must be central in their livelihood strategies, and a large proportion of household income must come from irrigation (this relates to optimal plot sizes, crop choices, etc. that enhance viable production);
- The cost of sustainable farmer management of the schemes (including infrastructure, technology, water user associations, etc.) must be an acceptably small proportion of the income derived from irrigation, i.e., benefit cost ratios must give incentives that facilitate rational production decisions;
- The schemes must have a certain level of access to institutional support services, including access to inputs, output markets, credit, extension, institutional framework defining and enforcing secured and use rights to land and water.

Small-scale systems may have advantages over large-scale systems. These advantages include that small-scale technology can be based on farmers existing knowledge; local technical, managerial and entrepreneurial skills can be used; migration or resettlement of labour is not usually required; planning can be more flexible; social infrastructure requirements are reduced; and external input requirements are lower (Underhill, 1990). Except for a few countries in northern Africa, Madagascar and South Africa, the potential for irrigation development has not been effectively tapped in Africa. Out of a total arable land of about 874 million hectares (ha), the current area under managed water and land development totals 12.6 million ha, or 3.7 % of the surface area of Sub-Saharan Africa (SSA). In spite of this potential, and the demand for more dependable sources of water, the development of irrigation has not picked up. Furthermore, existing irrigation farm operate at sub-optimal levels. Until recently, irrigated agriculture was almost exclusively supported by the state. However, government-managed (large and small-scale) schemes have generally performed far below expectations and most of the time, initial capital costs have not been recouped and the financial returns have not been able to cover operation and maintenance (O&M) costs. Meanwhile, privately developed and managed (small-scale) irrigation schemes in most of the SSA countries show that there is business potential for private entrepreneur involvement in irrigation. Groups of farmers or water users' associations (WUAs) running parts of irrigation schemes for which responsibility was transferred to them by government, can also be considered as operating private irrigation schemes. Recent developments have shown the increasingly important role of these new operators. However, for private operators to function efficiently a clear institutional framework is required in many parts of SSA this framework is not in place.

In addition to the above, small-scale irrigation schemes are also being promoted because of the associated benefits listed below:

- Lower investment costs
- Ease in maintenance
- End-users being able to have more control of the water they need
- The possibility of remote areas (where there are poorer farmers) gaining access to controlled water
- Small-scale irrigation requires very little in terms of enterprise and management capability
- Their potentially less negative environmental impact.

Small-scale irrigation (those schemes under the direct management of smallholders) will also enable farmers (those outside of the major irrigation perimeters and who would otherwise have to depend on irregular and variable rainfall) to increase crop intensities through double cropping, through supplementary watering during drought, as well as enable crop/forage growth in dry areas (crop expansion). This type of irrigation may take many forms of water control:

- Rainwater harvesting

- Flood recession
- Flood water spreading
- River diversion
- Treadle pumps
- Motor pumps usually combined with sprinkler or drip systems
- Porous jars.

In short, access to small-scale irrigation technology will allow small-scale farmers to improve their livelihood through increasing their production more easily.

3.1.5. Water Resource and Irrigation in Ethiopia

Ethiopia has a long history of traditional irrigation systems. Simple river diversion still is the dominant irrigation system in Ethiopia. According to Gebremedhin Berhanu and Peden (2002), the country's irrigation potential ranges from 1.0 to 3.5 million hectares but the recent studies indicate that the irrigation potential of the country is higher. According to Awulachew *et al.* (2010), estimate, the irrigation potential of Ethiopia is 4.3 million hectares. In Ethiopia traditional irrigation schemes cover more than 138,000 hectares whereas modern small-scale irrigation covers about 48,000 hectares. The total annual water resource of the country is estimated at 122 km3, of which 76.6 km3 drain into the Nile basin. The usable ground water resource is estimated to be 2.6 km3. There are 12 major river basins that have their own irrigation potential. Most of them flow to Sudan, Eritrea, Lake Turkana and Somalia except Awash basin, which is endorsee (FAO, 1997). Ethiopia has also to combine these with enhancing water availability for production and expansion of irrigation that can lead to security in terms of getting a reliable harvest as well as intensification of cropping (producing more than one per year). This should be combined with improved partitioning, storage and soil water-retention capacity to increase plan water availability, and use of rainwater to overcome erratic rainfall especially in the relatively higher rainfall areas of highland Ethiopia. There are also important other ways to reduce risk for farmers (social, economic, spatial diversity) and for the government (trade, buffer, pricing) (Seleshi Bekele et al., 2005).

Irrigation and improved agricultural water management practice could provide opportunities to cope with impact of climatic variability enhance productivity per unit of land, increase the annual production volume significantly. Irrigated agriculture started in Ethiopia in the 1960 with the objective of producing industrial crops (sugar cane and cotton) on large-scale basis. In the country farmers however, had already been practicing irrigation by diverting water from rivers in the dry season for the production of subsistence food crops as traditional irrigation. The experience in modern small-scale irrigation (SSI) development and management started in the 1970s by the Ministry of Agriculture (MoA), in response to major droughts, which caused wide spread crop failures and consequent famine. The sector could be used to reduce family risks that are associated with crop failures resulting from droughts.

Currently government gives emphasis to develop the sub-sector to fully tap its potentials by assisting and supporting farmers to improve irrigation management practices and the promotion of modern irrigation systems, (Teshome Atnafie, 2006). Although irrigation potential in Ethiopia is estimated at 3.7 million hectares under conventional gravity irrigation, if rain water harvesting and supplementary irrigation, ground water use, and water lifting technologies are considered, it is believed that the potential could be more than the estimated hectares. The current level of irrigation development is about 250,000 hectares, with further planned for implementation. According to Teshome Atnafie (2006), currently, irrigated agriculture produces less than 3 percent of the total food production of the country, which is very low. Thus the government has revised its strategy for irrigation development with the target to added 274,612 ha by 2016, (Sileshi Bekele *et al.*, 2005), the ministry of water resources is currently undertaking a total of thirteen irrigation projects located in different parts of the Country. They constitute approximately a total area of 493,603 ha and envisaged to be completed before the end of the irrigation development program planning period in 2016, (Teshome Atnafie, 2006). This revised target is mainly related to large and medium-scale irrigation and it is expected that the small-scale irrigation sub-sector which is under the Ministry of Agriculture and Rural Development will also strive similar targets. Although irrigation has long history in Ethiopia, the traditional small-scale schemes are simple river diversions. The diversion structures are rudimentary and subject to frequent damage by flood. 'Modern' irrigation was started at the beginning of the 1960s by private investors in the middle Awash valley where big sugar estates, fruit and cotton farms are found. With the 1975 rural land proclamation, the large irrigated farms were placed under the responsibility of the Ministry of State Farms. Almost all small-scale irrigation schemes built after 1975 were made into Producers' Cooperatives. Over the last decade government agencies and NGOs have intervened to develop new irrigation schemes and improve the indigenous irrigation schemes by constructing more stable hydraulic structures. However the focus mainly on the development of physical structures not on the software and extension works that highly affects the sustainability of the irrigation schemes.

3.1.6. Factors Affecting Irrigation Development

Irrigation developments are determined by many factors for their success. As stated by (Brown Nooter, 1995), the performance of irrigation schemes depends on cropping pattern, market accessibility, maintenance and spare parts, social and political, and land tenure policies. Some major factors that negatively affect irrigation development are:

a) Salinity: in the long term irrigation can increase the salt content of the soil and may cause the land not to be used for cultivation any more.

b) Siltation: it is the process of filling canals and reservoirs with soil and sands leached from their respective up streams mostly due to poor catchments management.

c) Depletion of water resource and dependent life systems (i.e., ecological problem of surface and ground water development for marginal water quality areas).

d) Conflicts (e.g. trans-boundary, between upper and downstream users, between management and users, implementers and donors etc) (Desalegn Rhameto, 1999).

e) Flood and erosion: appropriate surface drainages and effective operation are, therefore, critical for productive and sustainable irrigation in particular since canals are long, and it is difficult to adjust head diversions. Since some are vulnerable to excess water, irrigation-system must be responsive not only to the problems of little rainfall but also to problems of too much rain.

f) Drainage challenges, renewability issues, seepages, canal lining, theft and vandalism of control structures (Donald Campbell, 1995).

g) Market prices for crops: irrigation projects may exhibit negative net present value (NPV) up on implementation due to change in market prices of goods from what is expected during the time of feasibility studies.

h) Change in interest rate: such huge investments are sensitive to cost of capital fluctuations.

i) Maintenance challenges and quality of design: the quality of design and maintenance system can also determine their sustainability.

j) Pest infestation and input shortages: are also some of the areas of concern due to their significant contribution as a threat.

k) Water born diseases: resulting from an irrigation projects are examples of diseconomies /external costs imposed by the project to the society. According to Mekuria Tafesse (2003), the problems related to irrigation development and management in SSA can be categorized as follows:

Environmental factors:

- Water scarcity and poor water quality especially as related to sediment concentration;
- Land degradation as a result of poor O&M activities this is partly related to inefficient water management resulting in water wastage and water logging as well as land-use regulation.

Capacity of the farmers:

- Lack of know-how in, and access to, the opportunities of irrigation technology;
- Weak economic base of most farmers and the relatively high development costs involved in developing irrigation schemes.

Government policy; institutional and legal support:

- Limited or no priority given to irrigation development during national and local planning and budgeting;
- Poor management structures in place to support farmers and promote irrigation development. For example, the infrastructure to facilitate agricultural development is underdeveloped;
- A land tenure system that does not encourage farmers to invest in permanent improvements on their plots and make improvements which can be used to obtain credits for further development;
- Unclear water rights and their enforcement.

Despite the myriad of problems facing formal small-scale and traditional irrigation WUA or cooperative societies, they can become more efficient and sustainable by:

- Upgrading small-scale irrigation techniques
- Putting in place a management structure responsive to water users
- Access to (innovative) credit schemes
- Good support services.

Government's role in supporting irrigation development is therefore important in terms of the policies and regulations formulated and implemented; the planning undertaken at the macro and micro levels; training and; provision of services to support development of the sector.

3.2. Livelihood

A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living. Livelihood includes human, social, natural, physical and financial assets. A livelihood is sustainable when it can cope with and recover from stress and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. (Chambers and Conway, 1992) Livelihood is more than just a man-to-land relationship, which was a major focus in the older livelihood literature. It is rather a holistic, causally interlinked and permanent process which is embedded in a larger social, economic and physical landscape and ends up with the aim of income earning or making a living. Bebbington (1999), defined livelihood as a process that encompasses income, both cash and in kind, as well as the social institutions, gender relations, and property rights required to support and to sustain a given standard of living. A livelihood also includes access to and the benefits derived from social and public services provided by the state, such as education, health services, roads, water supplies and so on.

3.2.1. Irrigation Development and Livelihood

3.2.1.1. The Linkages

In development policy circles, irrigation was seen as ‘a privileged solution’ (Moris, 1987). Yet the success of the many irrigation development efforts initiated by governments and donors has been disappointing. In spite of huge investments, productivity remains far below expectations. In addition to the criticism of not attaining anticipated increases in production, studies have also been critical of the tendency for irrigation development efforts to be accompanied by an increased differentiation between rich and poor. Irrigation projects tend to favor some farmers and households at the expense of others (Patnaik, 1990) irrigation often involves a switch to mono cropping, and because this requires expensive inputs it created difficulties for households without access to capital or credit. Increased dependency on money and markets for buying inputs and selling Products also tends to increase the vulnerability of large groups of farm households to livelihood insecurities (Patnaik, 1990).

The Kenyan experience of the Mwea irrigation settlement project, for instance, resulted in farmers not being able to generate sufficient income to sustain their families, due to the high cost of, in particular, fertilizers and other agro-chemicals (Alukonya, 1993). Whether and to what extent people were able to benefit from new irrigation opportunities depended very much on their ability correctly to apply water, purchases and required sets of inputs, and to follow prescribed cultivation techniques. There is no doubt that irrigation has a central place as an engine for rural economic growth and as a means to ensure food security. (Lankford, 2003), on his study on irrigation development in Tanzania identified three stages in the perspective of livelihoods based irrigation development: proto-irrigation, irrigation momentum and river basin management. According to him in the proto-irrigation stage farmers are dependent on other livelihood activities than based on irrigated agriculture. But as the irrigation development gains momentum, farmers start moving to irrigated agriculture as main source of livelihood. In the final stage, there is wide-scale increase in irrigation activities leading to water scarcity not only for agriculture but also for other sectors expressing growing water needs. This stage requires the need for sanctions, water management and conflict management. In response to the problems identified in the last stage role of end users in irrigation water management can be an important aspect. Hasnip (2001), identified four inter-related mechanisms through which irrigated agriculture can reduce poverty or in other words improve livelihoods. Important in respect of this study are:

a) Improvements in the productivity, incomes, employment for irrigators' households and farm labor; and
b) The linkage and multiplier effects of agricultural intensification for the wider economy.

Hussain (2007), in his study on exploring link between irrigation and poverty alleviation in six Asian countries found that poverty outside of irrigation systems (non-irrigated settings) is almost twice than that within irrigation systems. However badly designed and managed irrigation systems can have a significant impacts on the rural livelihoods. Some of these may include: a) unreliable supply of water to farmers leading to crop loss and diminishing returns (DFID, 1997) and b) inequitable distribution of water on account of sediment deposition and growth of weeds in the main channels which may force farmers especially at the tail end of the system to opt out of irrigated agriculture (DFID, 1997). Considering these all effects better operated and maintained irrigation systems especially with emphasis on end user managed systems becomes important.

Robert Chambers, a pioneer of livelihoods approaches, argued that the generation and support to livelihoods have a higher priority than production *per se* (Chambers, 1988). He emphasized that the impact of irrigation on the rural poor depends on who produces the food and who has the ability to obtain it, on who gains and who loses more generally. Overall, he argued that the poor gain from irrigation through increased employment and income, in improved security against impoverishment, from less out-migration and in improved quality of life. In irrigated agriculture there are four inter-related mechanisms which have the potential to enhance and sustain rural livelihoods. These include:

i. Improvements in the levels and security of productivity, employment and incomes for irrigating farm households and farm labour;
ii. The linkage and multiplier effects of irrigation development (as part of wider agricultural growth) for the wider economy;
iii. Increased opportunities for rural livelihood diversification;
iv. Multiple uses of water supplied by irrigation infrastructure.

According to Burrow (1987), small holder irrigated horticulture had proven to be a viable and attractive option for poor farmers in developing countries. He further asserted that returns from intensive irrigated horticulture even on tiny plots could greatly exceed returns from rain fed cereal production. In many developing countries, small-scale irrigation schemes were counted on to increase production, reduce unpredictable rainfall and provide food security and employment to poor farmers. Irrigation farming contributes significantly at the household in terms of income in rural areas. Having most of the rural household unemployed, most families' income levels are relatively low and possibly not enough to acquire basic commodities and services.

According to Moll (2004), a comparison of income earned from small-scale irrigation and that earned from dry land farming or from non-skilled work in Zimbabwe industries revealed that small-scale irrigation farmers earned more. In comparative analysis between irrigators at Nyanyadzi irrigation scheme in Zimbabwe and their dry land counter parts, irrigators' investment was estimated to be between $150 and $200 while dry land farmers' investment was estimated to be lower than $100. This indicated that irrigators were in a better position to invest in capital items than non-irrigators because of higher incomes. Irrigation developments have made it possible for other rural infrastructure to be developed in areas which could otherwise have remained without roads, telephones, schools and clinics. According to Chenje *et al.* (1998), in the study of irrigation schemes in Chakuda Village in Gambia, small irrigation schemes have resulted in increased income that was translated into increased expenditure, investment, construction and trade. At the village level, increased material wealth manifested in the form of construction of a large mosque built through farmers' donations and an improvement of the village clinic. At household level increased wealth could be seen in fifty-five houses built in the village and fourteen with corrugated metal roofing.

Irrigation schemes often function as a development 'pole' in rural areas, where increased output and population concentrations attract additional services and infrastructure. Irrigated agriculture contributes to increased incomes from production and employment, so that families can gain access to schooling, health and welfare services, which are more likely to be present. Irrigation brings a range of benefits to individuals and households that economists sometimes distinguish between primary and spill-over effects (Shah, 2002). Primary effects:

- Increased and more stable flow of income from farming made possible by increased intensity of cropping, improved yields and new farm enterprise/technology mixes.
- Appreciation of the value of land with access to water for irrigation. Spill-over effects
- Increased and more evenly spread farm labour opportunities and improved wage rates.
- Reduced out-migration and increased return migration.
- Improved security against impoverishment.
- Lower food prices and better nutrition throughout the year.
- Growth in non-farm employment.
- Greater urban-rural contact and new social networks.
- More water for non-agricultural uses, including domestic uses that improve health.

All rural households, and particularly those who are net purchasers of staple foods, will also benefit from lower food prices and potentially better nutrition throughout the year. Scoones (1996), states that, in semi-arid areas there is potentially no better way to reduce rural vulnerability and ensure the viability of people's livelihoods, than to enhance natural capital and the productive base. Protecting the system against drought requires investment in water management, and it is irrigation and the water storage provided by small dams or enhanced recharge of aquifers that can reduce the vulnerability of rural communities to periods of drought.

3.2.1.2. Livelihood Diversification among Irrigation Households

Ellis (2000), identifies six determinants of diversification: seasonality, risk, labour markets, credit markets, asset strategies and coping strategies. One dimension of a sustainable livelihood is adequate and stable flows of income and consumption the whole year round. Seasonality is known to cause troughs and peaks in labour utilization, and can lead to food insecurity, due to the mismatch between uneven farm income streams and continuous consumption requirements.

These are often called the 'labour smoothing' and 'consumption smoothing' problem, respectively. Diversification can contribute to reducing the adverse effects by utilizing labour and generating alternative sources of income during off-peak periods.

Livelihood diversification reduces the risk of losing all income sources simultaneously, for example in an emergency (Ellis, 2000 and Start, 2001). It also implies trading a higher but more risky income for a lower diversified and less variable income. However, this may not apply if households can exploit complementarities between their asset endowment and varying demand and returns in product and labour markets. Labour markets may offer opportunities to achieve higher returns to labour or prompt diversification because of the discontinuity of casual employment (Ellis, 2000).

Cash resources obtained from diversification may be used to invest in, or improve the quality of, any or all of the five forms of livelihood assets. They may be critical when access to credit is limited, for example, sending children to secondary school or buying equipment, such as an irrigation pump set, that can be used to enhance future income generating opportunities. It is also possible for diversification to improve the independent income-generating capabilities of women. By achieving this it also improves the care and nutritional status of children, since a high proportion of cash income in the hands of women tends to be spent on family welfare. Livelihood portfolios of most rural households comprise a number of livelihood strategies with some being more predominant than others (Ellis, 2000). Some households may have primarily irrigation-based livelihoods (Lankford, 2003), whereby more than half of their livelihood base rests on irrigation, while other households may access more than half of their income from a range of livelihood activities. The former scenario can be termed as 'specialization within diversification'. Specialization within diversification phenomenon dominated the previous livelihood policy thinking, which was tendered on the assumption that rural people always chose a particular livelihood strategy among available livelihood options and choices. However, there has been growing recognition of livelihood diversification as an option in itself and not always a process of screening for a better option or a response to crisis. Thus, households sometimes enter into diversification as a matter of choice (for example, as a coping strategy for rural poor and means of accumulating wealth for rural rich) and not always out of necessity (Ellis and Freeman, 2004). Various approaches have been devised which aid in explaining activity profiles and hence livelihood strategies for rural households. One commonly used approach is the income portfolios approach, which captures activity profiles by analyzing income portfolios across households (Ellis and Mdoe, 2003). This paper observed that the extent to which a community's livelihoods system is dependent on a certain livelihood activity is reflected in the level of income derived from that activity, and the impact of its absence in some livelihoods within the system. In support of this observation Ellis, (2000), asserted that livelihood and income are related and individual or household income is the most direct and measurable outcome of the livelihood process.

3.2.1.3. Livelihood Adaptation and Irrigation

Livelihood adaptation can be described as a process of 'changes of livelihoods, which either enhance existing security and wealth or try to reduce vulnerability or poverty' (Davies and Hossain, 1997). Besides, the adaptive capacity of a household also has to comprise the important element of enhancing abilities in order to address future risks (Eakin, 2005). For that reason, adaptation is a response to a rather long-term process in contrast to coping strategies, which refer to short-term livelihood reactions in the consequence of unplanned or unforeseen crises following events like droughts or floods. A typical sequence of response to such unforeseen events would be the rapid establishment and diversification of new income sources, the utilization of reciprocal social capital bonds, the reducing of the current household size (e.g. via temporary migration), the sale of movable assets like livestock and last the sale of fixed goods like farm land or other realties. This sequence implies that farm households naturally first of all struggle for maintaining their future income by generating assets before selling assets which are essential for their future survival (Ellis, 2000).

One key role for adaptation and the reduction of such vulnerabilities holds according to (Ellis, 2000), the diversification of livelihoods. The diversification of rural livelihoods is defined as 'the process by which rural households construct an increasingly diverse portfolio of activities and assets in order to survive and to improve their standard of living' (Ellis, 2000). The increase of a livelihood portfolio, in other words: the attempt to multiply the sources of income like off-farm labour, remittances from migration stays, etc., might be an outcome of a livelihood adaptation process, but diversification is not necessarily the only way of adaptation. Intensification, which is referring to existing income sources that are used more intensively to guarantee a higher income, is another option. According to (Agrawal, 2008), besides diversification and intensification, other instruments for livelihood adaptation especially under the conditions of climate change and increasing climate variability can be the storage of perishable food stocks and water. Furthermore, adaptive capacities can be strengthened with instruments clearly exceeding the borders of a sole rural household. Such measures would be the pooling of joint communal resources and activities, such as the sharing of labour, income from different sources or wealth among different households. But also (an increased) market exchange or a higher market orientation can be seen as a crucial instrument for adaptation in rural poor households. Additionally, an increased reliance on the factor mobility from a dislocation of livestock and the seasonal migration of one or more household members to the point of a complete and enduring dislocation of a whole household is an option in this context. All adaptive measures mentioned are of course not pure ideal types. Taken from real life experiences, livelihood adaptation instruments are nearly always a mixture of the different types named above. All these measures maintain, optimize, modify, rearrange the composition of livelihood strategies or change the geographical setting of the livelihood strategies a household relies on. Even the adaptation instruments themselves can to a large degree be a livelihood strategy; thus, livelihood adaptation and livelihood strategies are generating a close nexus. Choice of livelihood strategies is dependent upon a number of factors including capabilities one has such as social networks, skills and physical assets (Ellis, 2000). In his analysis of stages of irrigation development, Lankford (2003), identified factors that affect access to irrigation-based livelihoods, based on livelihood framework. He argued that natural and physical factors such as water, land and labour, and economic and financial factors such as market prices, inputs and credits, human and social factors such as social cohesion and conflict resolution, other livelihood strategies (diversified livelihoods), and skills and experience in irrigation and negotiation, all play a role in determining and household’s livelihood strategy.

3.2.2. Impact of Small-scale Irrigation on Livelihood

Through the Sustainable Development Goals, the global development agenda is moving towards more integrated approaches that aim to maximize goals across sectors. However, more research is needed on the potential for nutrition-sensitive agriculture interventions to deliver multiple benefits simultaneously. Xie et al. (2014) found that small-scale irrigation has the potential to boost agricultural yields by at least 50%, with the majority of the income benefits accruing to the smallholders themselves. Lipton and Litchfield (2003), showed that irrigation increased productivity by reducing crop losses that were due to limited water supply, enabling cultivation during the lean season, and making crop production possible on lands where rain fed agriculture is infeasible. As a result of a project that introduced 50,000 tube wells in Nigeria, farmers experienced increases in returns per hectare from 65 to 50% with an average rate of return on investment close to 40% (Burney and Naylor, 2012). Similarly in Malawi, treadle pump irrigation increased income per hectare by over 50% (Mangisoni, 2008). Irrigation enables farmers to participate in market-oriented production, thereby increasing income from agriculture. A study from Kenya and Tanzania found that 73 and 83% of irrigated crops grown were commercialized (Nkonya *et al.,* 2011). In addition to the overall economic benefits, irrigation may improve food security and nutrition outcomes where they are most needed early childhood wasting is more prevalent in the arid and semi-arid zones of sub-Saharan Africa, where agricultural water management is particularly crucial for food security and nutrition (Azzarri *et al.*, 2016).

A recent study by Alaofè *et al*. (2016), found increased production and consumption of fruits and vegetables, greater income, and more spending on food, education, and health care in villages receiving a solar-powered, drip irrigation intervention compared to control villages. Other studies that explore the association between irrigation and nutrition found that irrigation is associated with a reduced risk of stunting (height-for-age z-scores) and increased household dietary diversity (Benson, 2015; van der Hoek et al., 2002).

4. RESEARCH DESIGN AND METHODOLOGY

4.1. Description of Study Area

4.1.1. Location

Enderta is a Wereda found in south eastern Administrative Zone, Tigray Regional State, Ethiopia. It is located 785 km north of Addis Ababa, capital city of the country, and geographically laid on 13º 15'00"N to 13º 38' 30"N and 39º 17' 30"E to 39º 48' 30"E. It is bordered with Dogua Temben and Seharti Samre districts to the West, with Afar Regional State to the East, with Kilte Awlaelo district to the North and with Hintalo Wajerat district to the South. (EBoARD, 2016) It encompasses 17 *kebeles* and 57 villages with a population of 124,784 of which 62,184 are males and 62,600 females (CSA, 2007). All of the population belongs to the Tigrigna speaking people. The dominant religion is Orthodox with very few Islamic followers (CSA, 2007). The district is characterized by flat to undulating topography with altitude of ranging from1,400-2,600 m.a.s.l. It is also characterized by uni-modal rainfall pattern (one rainy season which occurs from June to end of August), and varies from 350–650 mm per annul and the minimum and maximum temperature is 14℃ and 26℃ respectively.

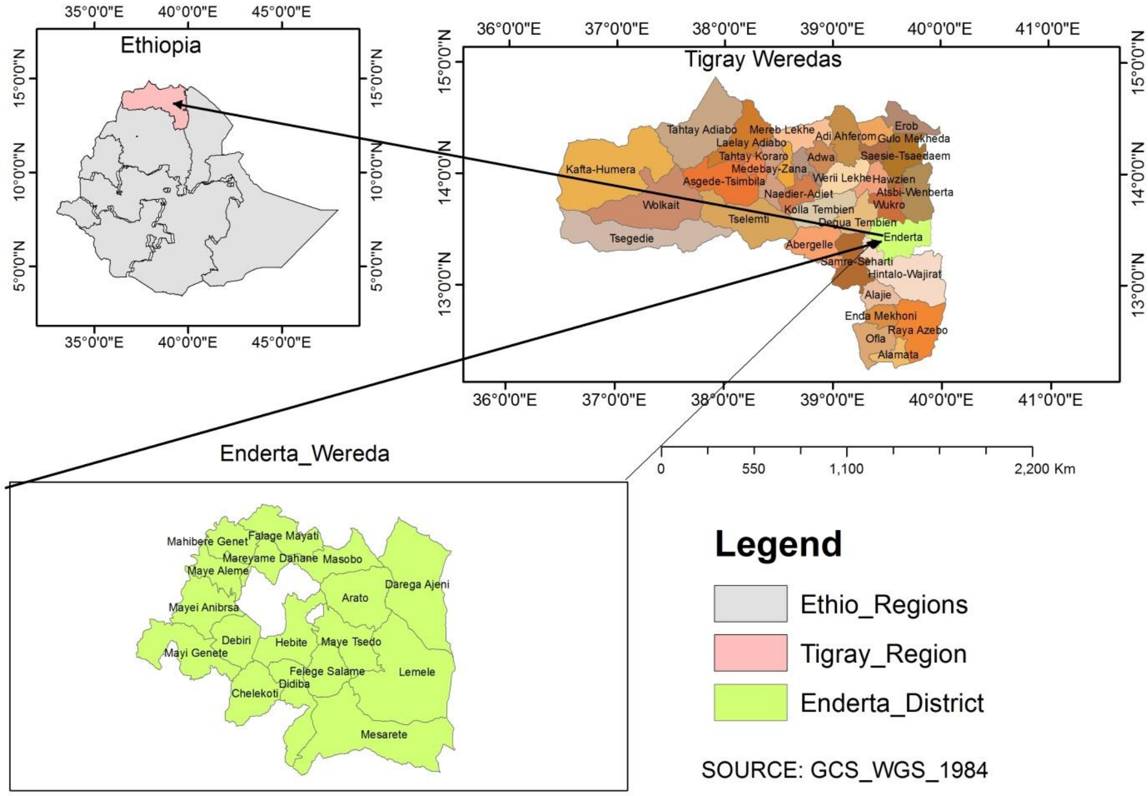

Figure 1. Map of Ethiopia Tigray and Enderta Wereda crossponding to its selected study *kebeles(Tabias).*

4.1.2. Livelihood Conditions in Enderta Wereda

The district is part of the dry midland zones of Ethiopia. This zone lies in a drought prone area exacerbated by infertile soils and suffers from food shortages. The middle and better-off households produce most of their own food, but the poorest household cultivates small areas of land as they do not have plough oxen and so purchase most of their food from local markets. Livestock provide the main source of income for the middle and better-off households. The incomes of the poor and the very poor come from a range of activities: Productive Safty Net Program (PSNP), cobblestone production, guard and labor sales.

4.1.3. Climate

According to the Enderta Wereda Agricultural and Rural Development Annual Report 2016 the district has a combination of three agro-climatic zones, namely 1% High land, 96% Midland and 3% lowland. The present study areas lie in the midland agro ecology, characterized by dry climatic Conditions and erratic annual rainfall of 450-600 mm. And the mean monthly temperature is around 18 ^{0}C.

4.1.4. Topography

According to the 2016 Enderta Wereda Agriculture and Rural Development Annual Report the topography of the area of the Wereda comprises, 35% plain land, 40% gentle slopping, 10% undulating and rugged terrain and, 15% steep mountains. The topographic features are from flatter to steeper slopes due to the presence of depression and ridges. The landscape is mostly plains and hills, with bush scrub vegetation. The land is rocky with limestone and marble resources.

4.1.5. Farming System

The district has a total area of 140,000 hectares. Out of this 32,490.525 hectares are cultivated land, 28,543.225 hectares grazing land, 23,314.5 hectares forest and bush land, and the rest 55,651.75 hectares are uncultivated land and waste land (EARDO, 2012). Agriculture is based on rain-fed subsistence mixed farming system and traditional oxen driven Implements type, where the major crops grown are wheat, barley, teff, and minor crops such as beans, chickpeas, lentils and flax, and accordingly there are vegetables in irrigable land such as carrot, cabbage, tomato, potato and onion. Animal population comprising about 48,129 cattle, 22,638 goats and sheep, 9,618 equines, 309 camels and 350,243 poultry, (EARDO, 2015). The vegetation cover of the study area has been disturbed because of illegal destruction either for domestic use like farm implements, fuel wood, or invading of marginal farm lands. This destruction of vegetation has in turn created an aggressive run off by eroding top soil loss and failure of soil fertility. Major live stock production constraints are shortage of animal feed and killing disease such as pastoralists, blackleg, anthrax, foot and mouth disease and internal and external parasites.

4.1.6. Population and Socio Economic Features

Based on the Enderta BoARD office report, 2016, the district has a population number of 124,784 households and a population density of 93.8 persons per km square. Shiguala, Mielate, Semha, Quihen and Arato are the five villages selected for study from *kebele* Didba-dergeagen. Shiguala, Mielate, and Semha are the village with micro-dam access; where as Quihen and Arato are a river diversion. The main livelihood activities carried out in the study area are crop production and animal husbandry. Since the study area is around 30km far from Mekelle, the capital city of the regional state, most of the households participate in off farm and non-farm activities like building construction and supply of stone quarry and other construction material preparation. There are also some supportive activities like food for work in governmental and non-governmental organizations. Semha dam is found in specific site, constructed by Relief Society of Tigray (REST) in 2007.

4.1.7. Irrigation and Water Source Potential

Based on the (Enderta water resources office report, 2016) the main water sources of the Wereda are dam, perennial streams, wells, rain water harvesting pond etc. in the present study area there is one micro dam, 5 river diversion, 2 water harvesting check dams, 3 communal reservoirs and 12 private open irrigation walls. According to (Enderta Wereda bureau of Agriculture report, 2012) the irrigation area of the Wereda is 7,696 ha that have 12,881 household beneficiaries. The micro-dam is irrigating 48 ha of the land for 93 beneficiaries.

4.2. Methods of Data Collection

Both primary and secondary data sources were used. Primary data were collected directly from respondents through household survey and questionnaires. Secondary data were collected through review of related unpublished documents the Wereda and the *Tabia* (*kebele)* agriculture extension offices.

The primary data collected from the households were also further strengthened by additional information which was gathered from focus group rich in experiences about irrigation activities and socioeconomic condition of the community in the study area were communicated individually with personal field observation.

Figure 2. This picture shows observation of irrigation in the study area of Enderta Wereda with farmers and Development Agents, March 2019 by Teklit Hagos (photographer)

4.2.1. Questionnaire

According (Best and Kahn, 1989), questionnaire enables a researcher to collect data from large group of individuals with a short period of time, and it is easy to administer to a number of subjects in one place at a time.

To gather the necessary data the researcher prepared questionnaire comprising 28 items that are 26 closed-ended questions and 2 open-ended questions. First these questions were prepared in English and translated in Tigrigna to collect reliable information enabling to achieve the stated research objective.

4.2.2. Checklists (notebook)

Checklists are instruments that are used to collect data from different documents of various offices, based on the set criteria. In this study, structured checklists were prepared by the researcher so as to search documents of the agricultural offices and to collect the necessary data for the present study.

4.2.3. Sample Size of the Study

The people's livelihood of the study area is dependent on irrigated and/or rain fed agriculture. Some of them have land in both rain fed and irrigated while others have only rain fed agriculture. Thus, both access with irrigation and without access to irrigation are target populations. With regard to the sample size the researcher believes that more sample households could have better representative of the whole population. However, to make the research more manageable a total of sample households, 20% of them were selected for this study as sample size i.e. 93 that comprises 50 from irrigation users and 43 households of the adjacent non-irrigation users from villages Shiguala who has total 94 household, Semha who has total 90 household, Quihen who has total 90 household, Arato who has total 100 household, and Mielate who has total 96 household that 470 total household through lottery sampling method were sampled as shown on table 1 below.

Table 1. Sample size of respondents and their proportion to the respective households

Villages	Total household	Sample households (20%)	Irrigation users		Non- irrigation users	
			Sample	%	Sample	%
Shiguala	94	18	10	55.5	8	44.5
Semiha	90	18	10	55.5	8	44.5
Quien	90	18	10	55.5	8	44.5
Miliate	96	20	10	50.0	10	50.0
Arato	100	19	10	52.6	9	47.4
Sum	470	93	50	53.8	43	46.2

4.3. Methods of Data Analysis

First data was organized in to different topics by following the objectives of the study and coded according to the topic already described. Various techniques were used for the analyses and presentation of data. These include both quantitative and qualitative techniques. In quantitative technique, the analyses were characterized by the use of statistical package, proportion, percentages and averages to arrive at a general picture for the generation of conclusion. Qualitative data from questionnaires as well as field observation was analyzed thematically.

Based on these facts I preferred using statistical methods the data collected through questionnaires was entered and analyzed using STATA software. This software was used to generate the results of Probit and Propensity Score Matching (PSM) in order to present and interpret the collected data. As the researcher believes that, these procedures were appropriate to the study.

Probit regression to identify the factors that determine the adoption of small-scale irrigation and propensity score matching (PSM) was used to estimate the impact of using small-scale irrigation on income as a livelihood indicator.

4.4. Ethical Consideration

To conduct this research, the researcher communicated with the household leaders and agricultural office workers legally and smoothly. The main objective of the study was informed to the concerned bodies well ahead of time. Every communication with the respondents was also accomplished by the voluntarily participation of respondents, besides the information that was obtained from the respondents was kept confidential, was only used for the fulfillment of the study.

5. RESULTS AND DISCUSSION

5.1. Household and Farm Characteristics

In table 2, summary statistics related to demographic and farm characteristics are reported. While small-scale irrigation users and non-users were found to have no significant differences in average age and gender of household heads, and marital status, small-scale irrigation users were found to have on average larger families and better education. These however show only mean (or distribution) differences among the two groups of households. At this point in time they do not show any relation with impact on livelihood. As far as farm attributes are concerned, small-scale irrigation users and non-users were found to have, on average, no significant difference in the ownership of livestock assets. On the contrary, small-scale irrigation users were on average found to have larger plots, compared to non-users. Again, the results reported in table 2 about farm attributes show only group-wise mean differences in the ownership of key farming assets (land and livestock).

Table 2. Summary statistics of variables among small-scale irrigation users and non-users

Descriptions for variables	Full sample /Mean(S.D)/	Users /Mean(S.D)/	Non-users /Mean(S.D)/	t-value/Chi-square value
Age of household head (years)	41 (8.8)	41 (8.8)	41 (8.3)	0.01
Gender of household head (1=male)	0.72 (0.45)	0.72 (0.45)	0.72 (0.45)	0.01
Household size (number)	4.6 (2.3)	4.2 (2.1)	5 (2.5)	1.72*
Household head education (1=literate)	0.38 (0.49)	0.48 (0.50)	0.26 (0.44)	4.95**
Marital status of head (1=married)	0.77 (0.42)	0.78 (0.42)	0.77 (0.43)	0.02
Land size (hectares)	0.75 (0.39)	0.69 (0.33)	0.83 (0.43)	1.85*
Livestock ownership (TLU)	6.2 (4.6)	6.5 (4.6)	5.8 (4.6)	0.72
Access to irrigation based extension (1=yes)	0.4 (0.50)	0.4 (0.50)	0	-
Access to credit (1=yes)	0.74 (0.44)	0.82 (0.39)	0.65 (0.48)	3.44*
Access to technical training (1=yes)	0.81 (0.40)	0.84 (0.37)	0.77 (0.43)	0.78
Irrigation use (1=yes)	0.54 (0.50)	-	-	-
Total household income (Birr)	103488 (103488)	179818 (118702)	113438 (67790)	3.2***

Note: *, **, and *** represent statistical significance at 10%, 5% and 1% significance levels, respectively. Values in parentheses are standard deviations.

Table 2 also reports results related to differences in access to agricultural institutional services such as extension, credit and technical training. Of these institutional services, results show that small-scale irrigation users on average had better access to credit for agricultural activities. It might show that irrigation access itself would create opportunities for taking loans for investment in irrigation activities, loans obtained from formal or informal credit-providing institutions (DFID, 2002). Mean comparisons for the variable of main interest, which is income indicate the existence of significant average income difference among small-scale irrigation users and non-users. Again, at this point we understand from the results reported in table 2 that on average irrigation users earned significantly higher income than non-users. But this does not tell us that the higher income was due to irrigation use solely. There may be other factors playing a role in the earning of the higher income by irrigation users. The analysis and discussion of the real impact of small-scale irrigation on income is left for section 5.4.

5.2. Determinants of Small-scale Irrigation Adoption

Although the adoption of small-scale irrigation can in many ways be determined by exogenous factors (such as rivers flowing nearby, downstream plots, etc.), there are still many factors that vary among households, which can still determine the adoption of small-scale irrigation. Hence, a study carried out by Desta (2004), on impact of community-managed irrigation on farm production efficiency and household income in Oromia National Regional State, Ethiopia found that education of the household heads, livestock ownerships, access to irrigation technology, amount of credit received, age of household heads as well as participation in extension package program, total income of house-holds and farm size were the significant determinants of household decision on irrigation utilization. In this section, results related to the factors that determine the adoption of small-scale irrigation based on Probit regression model are reported and discussed.

Table 3. Determinants of small-scale irrigation adoption (Probit model)

Variable	Coefficient	P-value
Age of household head (years)	0.19	0.000***
Gender of household head (1=male)	–0.35	0.382
Household size (number)	–0.99	0.000***
Household head education (1=literate)	1.10	0.049**
Marital status of head (1=married)	2.78	0.002***
Land size (hectares)	–1.90	0.009***
Livestock ownership (TLU)	0.01	0.963
Access to credit (1=yes)	1.70	0.003***
Access to technical training (1=yes)	–0.01	0.986
Constant	–5.32	0.000***

Note: *, ** and *** represent statistical significance at 10%, 5% and 1% level of significance, respectively.

Table 3 reports Probit estimation results related to the factors that determine the adoption of small-scale irrigation. It is shown that age of the household head, family size, educational level of the household head, marital status, land size and access to credit were among the factors that were found to have statistically significant effect on the adoption of small-scale irrigation. While age of head, educational level of heads, marital status, and access to credit were to be positively correlated, land size and family size were found to be negatively correlated with the adoption of small-scale irrigation.

The effect of age is positive. This shows that as age increases, the probability of adopting smalls-scale irrigation would increase. Often, age is used as a proxy variable for experience in farming. When farmers have several years of farming experience under their belt, they are expected to learn or become aware about how to avoid the water shortage (devise ways to ensure water supply for agricultural production continuously). Small-scale irrigation is one of the alternatives and even if farmers do not have land that can be irrigated they can still work with share cropping agreements or purchase production entitlements from other farmers who own irrigable lands. All these come with learning through building experience.

Educational level of heads was also found to be positively correlated with probability of adopting small-scale irrigation. Education is a tool that builds capacity of farmers to improve their decision making, manage their resources and make informed decisions when they make tradeoffs for example when they contemplate about adopting small-scale irrigation. Education presents an opportunity to weigh options farmers have and make informed decision when they take risky ventures such as purchasing production entitlements or entering share cropping agreement from farmers who have irrigable land. Investment in irrigable land may be huge that farmers need their education to weigh their costs and benefits and engage in small-scale irrigation.

Marital status and access to credit were the other two factors that were found to be positively correlated with adoption of small-scale irrigation. The result related to marital status shows that married household heads were more likely to adopt small-scale irrigation. Furthermore, the result related to access to credit shows that households who had access to credit were more likely to adopt small-scale irrigation. While credit may enable farmers to generate the liquidity (finance) to purchase agricultural inputs that go in tandem with irrigation for maximum yield and hence the positive effect on the probability of adopting small-scale irrigation, the positive effect of marriage on the probability of adopting small-scale irrigation is not entirely clear. It may be that marriage allows create and maintain network with other farmers and may increase access to irrigation through alternative means such as share cropping arrangements or purchasing of production right sin irrigable land from other farmers.

The results reported in table 3 show that land size and family size are negatively correlated with the adoption of small-scale irrigation. The indication is that as land size and family size increase, the probability of adopting small-scale irrigation decreases. The negative results related to land size and family size is unexpected. Naturally, irrigable land in Ethiopian agriculture are often much smaller that rain-fed plots. But, this still does not explain why probability of adopting small-scale irrigation decreases with land size. If there is water available (through different means), the expectation is that farmers would still be happy to work with larger (or very large) irrigable land. Rational farmers (farmers who aim for maximizing agricultural yield or profit) would not mind to cultivate a large plat that could be irrigated. They have said that irrigated plots often need significant investment in terms of labor and other recent inputs (such as seeds, fertilizer and other chemicals). In similar study stated that by (Nkonya *et al.,* 2011), in Africa in most cases witnessed that there is a negative correlation between yield and farm size. For example, in Zimbabwe and Kenya, the farmers with the smallest average farm size (as low as 0.1 ha) obtain the highest yields per unit of area. This could be due to the lack of sufficient labour and inputs for the larger sized farms. Farmers may be wary of such significant investment costs, which may discourage them from irrigating large plots. But this does not fully explain why farmers could not cover the costs with the much better yield expected from irrigation agriculture.

5.3. Impact of Small-scale Irrigation on Income

The impact of small-scale irrigation based on the method of Propensity Score Matching (PSM) on total income as the only livelihood indicator is reported in table 4. Before interpreting the results, it is necessary to point out that the balancing property of the matching method was ensured. The correlation of the covariates (factors that were found to determine adoption of small-scale irrigation) with adoption of small-scale irrigation is already reported and discussed in section 5.3 above.

Table 4. Average income (Birr) of irrigation users and non-irrigation users

Variable	Sample	Treated	Controls	Differen e	S.E.	T-Statistics
Total income	Unmatched	179,818	113,438	66,380	64,226	3.24
	ATT	162,823	98,597	64,226	27,842	2.31**

ATT: Average Treatment Effect on the Treated, S.E: Standard Error,

Treated: Irrigation user and control: non-Irrigation user

** denote statistical significance at 5% significance level

The impact of small-scale irrigation on income is reported in table 4. Households who had irrigation had on average higher income earning than household who did not have access to irrigation. Households who had irrigation on average earned about 64,226 Birr higher income than non-user households. It means that if there are no unobservable factors that determine income (other than irrigation), then the results show that participation in irrigation indeed helps improve livelihood (in terms of enhancing income as it is shown by the results). Related studies in Ethiopia by Bacha Dereje (2011) and Woldegebrial Zeweld *et al.* (2015) reported similar relationships between income and small-scale irrigation. These results however need to be taken with care as often there are factors that are unobservable and have impact on income and thus may misrepresent the impact of small-scale irrigation.

5.4. Sustainability and Challenges of Small-Scale Irrigation

Despite small-scale irrigation has been practiced for so long in Ethiopia. In the study areas, farmers reported that they have been practicing small-scale irrigation only for the last 20 years. But this is not true for all sample farm households. There are many farm household who had only a few years of experience in small-scale irrigation. Most farmers (94%) intend to continue using small-scale irrigation as it helps produce more than once a year and thereby improve livelihood.

In the midst of households plan to continue using small-scale irrigation however, they face several challenges. The most important challenge farmers reported (21.6%) is the prices of farm inputs including fertilizer, chemical and fuel. In addition however, there are other important challenges farmers reported that hamper their small-scale irrigation activities including water management (13.5%), lack of technologies for water use and saving (13.5%), pests and diseases (8.1%), limited credit (financial support (8.1%), limited access to energy (8.1%) and market problem (5.4%), among others. Therefore, the researcher is in apposition and able to state that lack of farm inputs (fertilizer and chemicals), lack of sufficient water use and market problem are the peak challenges to sustainable small-scale irrigation in the study area is similar to Ahmad, Shahid (1999) and Shimeles Dejene (2006).

Table 5. Challenges or problems in small-scale irrigation (percent)

Challenges	**Rank**		
	1st	**2nd**	**3rd**
Water source and water management	13.5	13.6	14.3
Topography	8.1	–	28.6
Access to energy source	8.1	9.1	14.3
Lack of technology water saving, post-harvest and maintenance of pumps	13.5	9.1	–
Financial support	8.1	13.6	28.6
Variety of seeds and seedlings	5.4	4.6	–
Climate	5.4	9.1	–
Market problem	5.4	9.1	14.3
Pests and diseases	8.1	13.6	–
The price of input such as fertilizer, chemicals and fuel	21.6	18.2	–
Lack of spare for motorized pumps	2.7	–	–

It can be seen from table 5 that there are 2nd and 3rd ranked challenges farmers face in their activities in small-scale irrigation. To continue using small-scale irrigation, farmers were asked what kinds of interventions they would want to be implemented so that these interventions also remove all or some of the challenges they are currently facing. A field survey indicates that small-scale irrigation's benefits are accompanied with multidimensional problem with loss of water through canal seepage. The earthen canal structure of the irrigation scheme in study area cause high water seepage from the main canals, the downstream beneficiaries didn't get enough water mostly except as supplementary during the end of the rainy season.

Figure 3. This picture showed that water loss through seepage from the main canal, in Semha village, March 2019 by Teklit Hagos (Photographer).

Again, agricultural inputs took center stage in the types of interventions farmers would like to see instituted so that they continue working with small-scale irrigation. About 24.3% of the farmers reported that the distribution of important agricultural inputs including fertilizer, chemical and motor pumps is the most important intervention they want to see for the improvement of their small-scale irrigation practices.

Table 6. Improvements farmers think should be made in small-scale irrigation (percent)

Types of improvement	Rank		
	1st	2nd	3rd
Build small dams	10.8	9.1	–
Use of improved varieties	10.8	4.6	–
Work on marketing linkage	5.4	4.6	16.7
Develop irrigation scheme	13.5	–	33.3
Arrangement of short long term financial credit	8.1	22.7	33.3
Strengthening technical support through extension service	10.8	13.6	16.7
Expanding irrigation cooperation	8.1	4.6	–
Improving the input delivery system	8.1	4.6	–
Attention for the distribution of inputs such as fertilizer, chemicals, motorized pumps etc.	24.3	36.3	–

In addition, the institutionalization of improved or additional irrigation schemes, strengthening technical support and cooperation in irrigation activities were also signed out as other important aspects for consideration by policy makers for instituting significant interventions. The 2nd and 3rd ranked interventions farmers would like to see also emphasize the importance of short and long term credit support, distribution of inputs and technical support that need to be considered for improving management of small-scale irrigation and livelihood of farmers.

6. CONCLUSION AND RECOMMENDATION

6.1. Conclusion

Given the expected role small-scale irrigation can play to improving smallholder farm households' livelihood, this study was carried to contribute to our understanding on the role of small-scale irrigation by specifically investigating the factors that determine the adoption of small-scale irrigation, the impact of irrigation on income, and the challenges in the small-scale irrigation sector. To do this, a sample of 93 irrigation user and non-user households was randomly selected from 5 villages in Enderta Wereda of Tigray Regional State. While Probit regression was used to identify the factors that determine the adoption of small-scale irrigation, Propensity Score Matching (PSM) was used to estimate the impact of using small-scale irrigation on income as a livelihood indicator.

Results showed that adoption of small-scale irrigation increases with age, educational level and marriage. Age often substitutes for experience in farming, which may allow farmers to learn or become aware about how to manage water resources or create possibilities for additional water sources for agricultural activities using irrigation. Small-scale irrigation is one of the alternatives, even when farmers do not have land that can be irrigated they can still work with share cropping agreements or purchase production entitlements from other farmers who own irrigable lands. Education on the other hand builds capacity of farmers to improve their decision making, manage their resources and make informed decisions when they make tradeoffs for example when they think about adopting small-scale irrigation. In addition, education presents an opportunity for farmers to weigh their options and make informed decisions when they take risky ventures such as purchasing production entitlements or entering share cropping agreements from farmers who have irrigable land. Investment in irrigable land may be huge that farmers need their education to weigh their costs and benefits and engage in small-scale irrigation. As it is the case for these reasons and others, those farmers with better education were found to use irrigation. Furthermore, credit may enable farmers to generate the liquidity (finance) to purchase agricultural inputs that go in tandem with irrigation for maximum yield and hence the positive effect on the probability of adopting small-scale irrigation.

As far as the impact of the use of small-scale irrigation on income is concerned, results indicated that those farm households who used small-scale irrigation were found to earn on average higher total income than those households who did not use small-scale irrigation. The estimated average income difference between the two groups of households appears to be significant, by farmers' income standard. In this regard, it can be concluded that the use of small-scale irrigation plays a big role in improving the income (and by translation, livelihood) of smallholder farm households. However, this holds true if participation in small-scale irrigation is governed only by observable factors. If there were unobservable factors that determined both participation in small-scale irrigation and income, it may be difficult to distinguish the real impact of participation in small-scale irrigation on income. The PSM method accounts only for observable effects and does not control for unobservable factors that influence participation in small-scale irrigation and income earnings, which is a limitation.

As far as sustainability and challenges of the use of small-scale irrigation is concerned, most farmers wanted to continue using small-scale irrigation as it has positive contributions to livelihood (in terms of increasing yield and income by translation). However, farmers reported that they were constrained by several factors from making their small-scale irrigation activities more effective and efficient. It was reported that the price of inputs (such as fertilizer and chemicals), limited capacity in water management and lack of water saving technologies and pests and diseases, among others, were identified as the most important challenges. As stated by (Brown Nooter, 1995), the performance of irrigation schemes depends flood and erosion, drainage, pests, market problem, conflict and others To reduce these challenges, farmers identified improving the distribution of inputs such as fertilizer, chemicals and motorized pumps, strengthening technical support through extension service, developing other irrigation schemes and expanding irrigation cooperation among farmers and improving the input delivery system as the most important intervention areas government and non-government bodies could carry out to improve the efficiency and effectiveness of small-scale irrigation and thereby improve livelihoods..

6.2. Recommendation

- The Wereda Agricultural Development Office should develop technical building capacity through functional training and make awareness to the farmers to disseminate the advantages of the SSI system.
- The farmer training centers setting up by the Wereda should make enough and functional on agronomic practices, crop protection aspects, irrigation practices, and product marketing.
- Offering a credit service to allow rapid progress in the introduction of technologies and farming practices, price bargaining power and profitability of SSI schemes.
- Trainings should be given based on the demand and gap of the irrigation and beneficiaries.
- Sharing of experiences on irrigation practices and extensive following up by the extension workers on farming activities should be mandatory.
- Expansion of irrigation cooperatives that farmers can join-hands in dealing with irrigation activities based on cooperative principles and values and solves their common problems through members' participation.
- At last but not the least, the government and other concerned body should encourage researches on agriculture in general and irrigation in particular on the Wereda.

REFERANCES

Abraham Bairu Gebrehiwot, Nata Tadesse, Bheemalingeswara K. and Mokennen Haileselassie, (2011). Suitability of Ground Water Quality for Irrigation: A Case Study on Hand Dug Wells in Hantebet Catchment, Tigray, Northern Ethiopia. *Journal of American Science*, 7(8): 191-199.

Agrawal, A. (2008). The Role of Local Institutions in Adaptation to Climate Change, Paper prepared for the Social Dimensions of Climate Change, *Social Development Department*, The World Bank, Washington DC, March 5-6, 2008.

Ahmed Shahid (1999). Achievement and Issues of Irrigation in the 20th Century. Proceedings of the National Workshop on *"Water Resources Achievements and Issues in the 20th Century and Challenges of the Next Millennium "*, Islamabad PCRWR/UNESCO, June 28-30, pp. 188-201.

Alaofè, H., Burney, J., Naylor, R. and Taren, D. L. (2016). Solar-Powered Drip Irrigation Impacts on Crops Production Diversity and Dietary Diversity in Northern Benin, *Food and Nutrition Bulletin*, **37**(2), 164-175. https://doi.org/10.1177/0379572116639710

Alukonya, S. (1993). Mwea Irrigation Agricultural Development Project in Kenya, *poverty in irrigated settlements*. A discussion Paper and replies from Network members, ODI Irrigation management Network, Network Paper 7.

Awulachew Yilma, Seleshi Bekele Awulachew, Lambisso Robel, Asfaw, Gezae, Aster Denkew Yilma and Moges, S.A. (2010). Characterizing: Assessment of Performance and Causes of Underperformance of Irrigation in Ethiopia. *Ethiopian Journal of Development Research,* (In press).

Azzarri, C., Bacou, M., Cox, C. M., Guo, Z. and Koo, J. (2016). Sub-national socio-economic data set availability. *Nature Climate Change*, **6(2),** 115-116.

Bacha Dereje, Regasa Namara, Ayalneh Bogale and Abonesh Tesfaye (2011). Impact of Small-Scale Irrigation on Household Poverty: *Empirical Evidence from the Ambo District in Ethiopia,* Irrigation and Drainage**, 60**: 1-10.

BCEOM (Bureau d'Etudes pour les Equipements d'Outre-mer). French Engineering Consultants (1998). "Abbay river basin integrated development master plan, section II, volume V Water resources development, part 1 Irrigation and drainage." Ministry of Water Resources, Addis Ababa, Ethiopia.

Bebbington, A. (1999). "Capitals and capabilities: a framework for analyzing peasant viability, rural livelihoods and poverty." *World Development* **27**: 2021-2044.

Bekele Yeshitela, Nata Tadesse and Bheemalingswara K. (2012). Preliminary Study on the Impact of Water Quality and Irrigation, Practices on Soil Salinity and Crop Production, Gergera Watershed, Atsbi-Wonberta, Tigray, Northern Ethiopia, Volume **4(1):** 29-46.

Belay Mehretie and Woldeamlak Bewket (2013). Traditional Irrigation and Water Management Practices in Highland Ethiopia: Case Study in Dangila Woreda, *Irrigation and Drainage*, **62**: 435– 448.

Benson, T. (2015). Association between irrigated farming and improved nutrition in farm households in Malawi, Agrekon, **54(3),** 62-86.

Bhargahvea, (Dr.) B.S. (1980). Irrigation Development Administration (A study in an Indian State). Ashish Publishing House, New Delhi, India

Brown, E.P. and Nooter, R. (1995). Successful Small-Scale Irrigation in the Sahel. World Bank Technical Paper, No. 171, Washington D.C.

Burney, J.A. and Naylor R.L. (2012). Smallholder Irrigation as a Poverty Alleviation Tool in Sub-Saharan Africa, *World Development* **40(1):**110-123.

Burrow, C. (1987). Water Resources and Agricultural Development in the Tropics: New York, John Wiley and Sons.

Chambers, R. (1988). Managing Canal Irrigation. Cambridge University Press. *Journal of international development*, Cambridge, 279 pp.

Chambers, R. and Conway, G. (1992). Sustainable Rural Livelihoods: Practical Concepts for the 21st Century, IDS Discussion Paper 296, Brighton: IDS

Chenje, M., Solar, C. and Manzungu, E. (1998). The State of the Environment in Zimbabwe, Harare, MMET.

CSA (Central Statistics Authority) (2007). Summery and Statistical Report of 2007 populations and housing census of Ethiopia: Population Size by Age and Sex. Addis Ababa, Ethiopia: printed by UNFPA.

Davies, S. and Hossain, N. (1997). "Livelihood Adaptation, Public Action and Civil Society: a review of the literature." University of Sussex, Institute of Development Studies Working Paper 57.

Desalegne Rhameto (1999). Water Resources Development in Ethiopia: Issues of Sustain Abilities and Participation, Forum for Social Studies, Addis Ababa Ethiopia.

Desta Beyera (2004). Impact of Community Managed Irrigation on Farm Efficiency and Household Income; the case of Weliso and Wenchi Districts of Oromia. Unpublished M.Sc Thesis, Haramaya University.

DFID (Department for International Development) (1997). *The Economics of Maintaining Irrigation Systems*. DFID's Water KAR (Knowledge and Research) Projects. R8027. October 1996-September 1997.

DFID **(**Department for International Development) (2002). *Contribution of Irrigation to Sustaining Rural Livelihoods*. DFID's Water KAR (Knowledge and Research) Projects. R7879.

Donald, C. (1995). Design and Operation of Smallholder Irrigation South Asia. (W.B Technical Paper No. 256), Irrigation and Drainage Series, Washington D.C.

Eakin, H. (2005). "Institutional change, climate risk and rural vulnerability: cases from central Mexico*." World Development* **33**:1923-1938.

EBOARD (Enderta Wereda Biro of Agriculture and Rural Development) (2016). Statistical magazine.

Ellis, F. (2000). *Rural Livelihoods and Poverty Reduction Policies*: London, Routledge, p.14-15.

Ellis, F. and Freeman, H. A. (2004). Rural livelihoods and poverty reduction strategies in four African countries. *The Journal of development studies*, **40**, 1-30.

Ellis, F. and Mdoe, N. (2003). Livelihoods and rural poverty reduction inTanzania. World Development.**31**, 1367-1384.

FAO (Food and Agriculture Organization of the United Nations) (1997). Farm Management for Asia: A Systems Approach, Department of Agricultural and Resource Economics, University of New England, Australia. *FAO STAT database and Agriculture Organization*, Roma,Italy.

FAO (Food and Agriculture Organization of the United Nations) (2000). The State of Food and Agriculture Proceedings of FAO, experts' consultation, Rome, Italy.

FAO (Food and Agriculture Organization of the United Nations) (2001). Irrigation Manual: Planning, Development Monitoring and Evaluation of Irrigated Agriculture with Farmer Participation, Volume III, Module 8.

FAO (Food and Agriculture Organization of the United Nations) (2002). Irrigation Manual: Planning, Development Monitoring and Evaluation of Irrigated Agriculture with Farmer Participation, Volume II, Module 7.

FAO (Food and Agriculture Organization of the United Nations) (2003). Irrigation in Africa, South of the Sahara. FAO Investment Center Technical Paper 5. FAO: Rome.

FAO (Food and Agriculture Organization of the United Nations) (2004). *The State of Food Insecurity in the World* (SOFI), Sixth edition, Viale delle Terme di Caracalla, 00100 Rome, Italy

Gebremedhin Berhanu, and Pedon, D. (2002). Policies and institutions to enhance the impact of irrigation development in mixed crop-livestock system. In Integrated Water and Land Management Research and Capacity Building Priorities for Ethiopia. Proceedings of MoWR/EARO/IWMI/ ILRI International Workshop held at ILRI, Addis Ababa, Ethiopia, 2–4 December; 168-184.

Hagos Fitsum and Holden, S. (2003). Rural Household Poverty Dynamics in Northern Ethiopia 1997-2000. Paper for CPRC Conference, Manchester.

Hagos Fitsum, Makombe, G., Namara Regassa and Sileshi Bekele Awulachew (2009). Importance of irrigated agriculture to the Ethiopian economy: Capturing the direct net benefits of irrigation. Colombo, Sri Lanka: International Water Management Institute. P. 37. (IWMI Research Report 128).

Hasnip, N. et al. (2001). Contribution of Irrigation to Sustaining Rural Livelihoods. Literature Review. Report OD/TN 109, September 2001, HR Wallingford, UK.

Hussain, I. (2007). Irrigation and poverty alleviation: pro-poor intervention strategies in irrigated agriculture in Asia. Paper presented in 4th Asian Regional Conference and 10th International Seminar on Participatory Irrigation Management.Tehran, Iran.

Hussain, I. and Hanjra, M.A. (2004). Irrigation and poverty alleviation: review of the empirical evidence. *Irrigation and Drainage*, Tehran, p.53, 1-15.

Lankford, B. (2003). Irrigation-based livelihood trends in river basins: Theory and policy implications for irrigation development. Physics and Chemistry of the Earth, 817-825.

Lipton, M. and Litchfield, J. (2003). Preliminary Review of the Impact of Irrigation on Poverty, with Special Emphasis on Asia; Food and Agriculture Organization (FAO): Rome, Italy,

Makombe, G., Kelemework Dawit and Aredo, D. (2007). A comparative analysis of rain fed and irrigated agricultural production in Ethiopia. Irrigation and Drainage Systems **21**: 35-44.

Makombe, G., Namara Regassa., Hagos Fitsum, Sileshi Bekele Awulachew, Ayana Mokennon and Bossio Deborah. (2011). A comparative analysis of the technical efficiency of rain-fed and smallholder irrigation in Ethiopia. Colombo, Sri Lanka: International Water Management Institute. 37p. (IWMI Working Paper 143).

Mangisoni, J. (2008). Impact of treadle pump irrigation technology on smallholder poverty and food security in Malawi: a case study of Blantyre and Mchinji districts. *International Journal of Agricultural Sustainability,* **6** (4), Pages 248-266

Mehari Abraham, Frank Van S. and Bart S. (2011). Modernization of Spate Irrigated Agriculture: A New Approach, Irrigation and Drain. **60**: 163-173.

Mekuria Tafesse, (2003). Small-scale irrigation for food security in sub-Saharan Africa. CTA Working Document, Ethiopia.

Michael, A.M.(1997). Irrigation: Theory and practice. Indian Agricultural Research Institute, Vikas Publishing House Pltd Newdelhi, India, 801 pp.

MoA (Ministry of Agriculture). Natural Resources Management Directorates (2011). Small-Scale Irrigation Situation Analysis and Capacity Needs Assessment, Addis Ababa, Ethiopia.

MoFED (Ministry of Finance and Economic Development) (2010). Trends and prospects for meeting MDGs by 2015, millennium development goal report. [Internet]. [cited 2011 July 4]. Addis Ababa, Ethiopia. Available from: http//www.dagethiopia.org.

Moll, H.A.J. (2004). Small Holders and Relationship Clusters with Rural Institutions. Weavers Press, Harare.

Moris, J. (1987). Irrigation as a privileged solution in African development, Development Policy Review, P. 5: 99-123.

MoWE (Ministry of Water and Energy) (2011). Water and Development quarterly bulletin 5. MWR: Addis Ababa.

Nata Tadesse and Asmelash Berhane (2007). Recharging Practices for the enhancement of hand dug wells discharge in Debre Kidane watershed, North Ethiopia. 4^{th} International Work Shop on Water Management and Irrigation: Focus on groundwater. Mekelle University, Mekelle, Ethiopia.

Nkonya, E., Geber, N., Von Braun, J. and Depinto, A. (2011). The Economics of Land Degradation and the Costs of Action versus Inaction, Center for Development Research (ZEF), University of Bonn, Germany

Patnaik, U. (1990). Economic and Political Consequences of the Green Revolution in India. In: Bernstein, B., Crow, B., Mackintosh, M. and Martin C. (eds), *The Food Question: Profits versus People?* London: Earth scans Publications.

Rees T. and Kees D. (1991). Irrigation Technology and Social Change: An analysis of the Social Variable of Technology: *Journal of Developing Areas*, Vol. 25, No. 2 January 1991. Ed. Ill Ions University, 900 West Adams Street, U.S.A.

Reddy, R.N. (2010). Irrigation Engineering, Gene-Tech Books, New Delhi

Schilfgaarde, V.J. (1994). "Irrigation, a Blessing or a Curse": Agricultural Water Management, P. 25: 203-219.

Scoones, I. (1996). Hazards and Opportunities: Farming Livelihoods in Dry land Africa, Lessons from Zimbabwe. Brighton, Institute of Development Studies at the University of Sussex. pp.283.

Seleshi Bekele Awulachew, Merry, D. J., Kamara, A. B., van Koppen, B., Penning de Vries, F., Boelee, E. and Makombe, G. (2005). Experiences and opportunities for promoting small-scale/micro irrigation and rain water harvesting for food security in Ethiopia. Colombo, Sri Lanka: International Water Management Institute (IWMI). 91p.(Working Paper 98).

Seleshi Bekele Awulachew, Aster Denkew Yilma, Loulseged Mokonen, Loiskandl, W., Ayana Mokonen and Alamirew Tena, (2007). Water Resources and Irrigation Development in Ethiopia. Colombo, Sri Lanka: International Water Management Institute (IWMI). 78 p. (Working Paper 123, P. 66).

Shah, T., Koppen van, B., Merrey, D., Lange de, M. and Samad, M. (2002). Institutional alternatives in African smallholder irrigation: Lessons from international experience with irrigation management transfer, Research report 60. Colombo: IWMI.

Shanan, L. (1989). The impact of irrigation In: Wolman, MG, Fourner FGA, editors. Land Transformation in Agriculture. Publishers: Wiley, J. and Sons Ltd., 1987.

Shimelis Dejene (2006). "Institution management and challenge of small-scale irrigation system in Ethiopia: A case study of Gibe Lemu and Gambella Terre in Western Oromiya". MSc Thesis. Addis Ababa University.

Sulas, F., Marco M. and Charles, F. (2009). State formation and water resources management in the Horn of Africa: *The Aksumite Kingdom of the northern Ethiopian highlands*. World Archaeology. 41(1): 2-15.

Teshome Atnafie (2006). Irrigation Policies, Strategies and Institutional Support Conditions in Ethiopia: Proceedings of Symposium on Best Practices and Technologies for Agricultural Water Management in Ethiopia. March 7-9, 2006, Addis Ababa, Ethiopia.

Tilahun, Hordof. and Paulos, D. (2004). Results to date and future plan of research on irrigation and its impact. *In Impact of Irrigation on Poverty and Environment*; International Water Management Institute (IWMI): Colombo, Sri Lanka.

Underhill, H.W. (1990). Small-scale irrigation in Africa in the context of rural development. Crafield Press, Bedford, UK.

Van der Hoek, W., Intizar, H., Liqa, R., Munir, A. H. and Fuard, M. (2002). Waste Water Use in Agriculture Review of Ture: *Review of impacts and methodological issue in valuing impacts.* International Water Management Institute, Working Paper 37

Woldegebrial, Z., Huylenbroeck, G. V., Assefa H., Chandrakanth, M. G and Speelman S. (2015). Adoption of Small-Scale Irrigation and its Livelihood Impacts in Northern Ethiopia. *Irrigation and Drainage,* **64:** 655-668.

World Bank (2010). Ethiopian Agricultural Growth Project. Project appraisal document. Addis Ababa: Ethiopia.

Zewdie, M., Moti, J. and Ascimelis, G. (2007). Assessment of Wendo Wesha irrigation scheme in Awassa Zuria. Proceedings of research project completion workshop;2007 Feb 1-2;Addis Ababa, Ethiopia.

Appendices

Appendix 1. Questionnaire for the impact of irrigation on the livelihoods of rural households

Declaration:

This data collection is part of the MSc study I am doing. Data to be collected is solely going to be used for academic purposes and your data will remain confidential and will not be disclosed to the public.

Thank you in advance for providing us the data that will help us study the impact of small-scale irrigation on the livelihood of rural households.

Name of interviewer: ______________________________

Date of interview: _________________________________

Questionnaire number: _____________________________ (Provide consecutive unique ID)

A. ADMINISTRATION INFORMATION

1. Name of region___________________________
2. Name of Wereda___________________________
3. Name of Kebelle__________________________

B. HOUSEHOLD GENERAL INFORMATION

1. Name of **household head** ________________________________
2. Please provide information about your household members in the table below. Start with the information of the **household head**.

№	Name of household member	village	Gender (1=male;0=female)	Age (years)	Educational level (1=literate,0=illiterate)	Marital status (1=married; 0=otherwise)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Village: 1= Shiguala 2= Semiha 3= Quien 4= Arato 5= Miliate

C. FARM CHARACTERISTICS, FARM ASSETS AND TECHNOLOGIES

1. Please provide information about the farm plots the household owns in the table below.

№	Plot number	Size of plot (hectares)	Fertility of plot (1=low; 2=medium; 3=high)	Type of crop grown **(*Use code A*)**	Irrigation status (1=yes; 0=no)	Irrigation type (1=dam; 2=wells; 3=rivers; 4=others)
1	Plot 1					
2	Plot 2					
3	Plot 3					
4	Plot 4					
5	Plot 5					

Code A: 1=Teff; 2=Wheat; 3=Sorghum; 4=Maize; 5=Barley; 6=Tomato; 7=Potato; 8=Cabbage; 9=Carrot; 10=Onion; 11=Lettuce; 12=Garlic; 13=Avocado; 14=Papaya; 15=Orange; 16=Apple; 17=Mango

2. What did you use (chemical) technologies in your farm for crop production?.

1=Urea/DAP(kg) ___, 2=Compost(qtl)__,3=Manure(qtl)___

4=Chemicals (pest/insecticide)(lit)___, 5=others specify____

3. Please provide information in the table below about your livestock population.

№	Types of livestock	Do you own this livestock?(1=yes; 0=no)	Total number owned
1	Oxen		
2	Bulls		
3	Cows		
4	Heifers		
5	Calves		
6	Sheep		
7	Goats		
8	Horse		
9	Mule		
10	Donkey		
11	Camel		
12	Chicken/Poultry		
13	Bee colony		
14	Others,specify _________		

D. TRAINING, EXTENSION AND CREDIT

1. Do you have access to credit for investment in your irrigation-based production activities?
   1=yes 0=no
2. Did you obtain technical training your irrigation-based production activities?
   1=yes 0=no
3. If you received any training, who provided the technical training?
   ____
4. How did you find the training?
   1= useful 2=,less useful 3= Useless 4= Do not know
5. Do you have access to extension services for your irrigation-based production activities?
   1=yes 0=no
6. Do you have access to extension for your general agricultural activities?
   1=yes 0=no
7. What are the sources of drinking water?

Code	Sources of drinking water	(√)
1	River	
2	spring	
3	Pond	
4	Hand dug well	
5	Others(specify)	

E. INCOME[A] FROM DIFFERENT OCCUPATIONAL ACTIVITIES

S/N	Types of activity /product /	Total harvest(yield)	Monetary value of this harvest (yield)	Did you sell? (1=yes;0=no)	Total income in Birr from the sell	Own consumption in Birr[B]	Total income
1	**Farming**						
	Crop farming: rain-fed						
	Vegetable farming: rain-fed						
	Fruit farming: rain-fed						
	Crop farming: irrigated						
	Vegetable farming: irrigated						
	Fruit farming: irrigated						
	Tree farming						
2	**Livestock**						
	Livestock products						
	Hides and skin						
	Milk and butter						
	Meet and eggs						
	Oxen rent						
	Honey, colony and wax						
	Dung						
	Others (_______________)						
3	**Non-farm activities**						
	Daily labor						
	Carpentry and wood work						
	Masonry and pottery						
	Weaving and tailoring						
	Petty trade						
	Wage employment in public organizations						
	Wage employment in private organizations						
	Others (_______________)						

[A]Income earned by **all household members** need to be accounted here in the table. [B]This represents the amount of a product consumed by the household itself in a monetary value.You just to have to ask the household head about for example the amount cereals consumed by the household, calculate the market value of the amount of cereals in Monetary value and record it here in the table.

F. INFRASTRUCTURE AND SERVICES

1. Does anyone in your household own a mobile phone? 1=yes 0=no
2. How many members of your household own mobile phones? _____(Number)
3. How far is the nearest all-weather road from your residence _________km?
4. How far is the nearest dry-weather road from your residence _________km?
5. How far is the nearest market from your residence _________km?
6. Is your farm or living house connected to electricity? 1=yes 0=no
7. Do you use any energy sources for your irrigation activities? 1=yes 0=no
8. If yes, which type of energy do you use?
   1=solar 2=generator 3=electricity
   4=manual pump 5=others (please specify)_____________

G. CHALLENGES AND SUSTAINABILITY

1. Do you continually use the irrigation system you are currently using? 1=yes 0=no
2. How long have you been using this irrigation system you are currently using? ______(years)
3. Do you intend to continue using this irrigation system?
   1=yes 0=no
4. Do you have technical challenges in your irrigation activities?
   1=yes 0=no
5. What challenges (obstacles) do you think are hampering the continued use of the irrigation system you are using?

5.1. ____

5.2. ____

5.3. ____

NB. 1: Water source, Water management 2: Topography 3: Access to energy source
4: Lack of technology water saving, post harvest and maintenance of pumps
5: Financial support 6: variety of seeds and seedlings 7: Climate 8: Market problem 9: Pests (disease)
10: The price of input such as fertilizer, chemicals, and fuel 11: Lack of spare for motorized pumps

6. For continue use of irrigation systems, what improvement do you think should be made (with the irrigation system)?

6.1. ____

6.2. ____

6.3. ____

NB: 1: Build small dams 2: Use of improved varieties 3: Work on marketing
4: Develop irrigation scheme 5: Arrangement of short long term financial credit
6: Strengthening technical support through extension service
7: Expanding irrigation cooperation 8: Improving the impute delivery system
9: Attention for the distribution of inputs such as fertilizer, chemicals, motorized pumps etc.

Thank you

Appendix 2. መፅናዕታዊ መሕትት ኣብ ውፅኢት ኣናእሽተይ መስኖ ምስ ምርግጋፅ ምግቢ ውሕስና ነብሲ ወከፍ ገጠር መራሕቲ ስድራ

መብርሂ

እዚ መሕትት መአከቢ ሓበሬታ ኣካል ንካልኣይ ድግሪ መመረቒ ፅሑፍ ኣብ ዝገብሮ ዘለኹ መፅናዕቲ ዝካተት'ዩ። ነዚ መሕትት ፍቓደኛ ኮይኖም/ኮይነን ሓሳብኩም/ሓሳብክን ዝሃብኩም/ዝሃብክን ወገናት ሐሳባትኹም/ሓሳባትኽን ነዚ መፅናዕቲ ግልጋሎት ጥራሕ ዝውዕልን ከምዘሎ ዝውሰድን ምኳኑ ከረጋግፅ እፎቱ።

ነዚ መፅናዕታዊ መሕትት ውፅኢት ኣናእሹተይ መስኖ ኣብ ምርግጋፅ ምግቢ ውሕስና ነብሲ ወከፍ ገጠር መራሕቲ ስድራ ብሰናይ ተበግሶኹም/ተበግሶኽን ንምምላእን ሓሳብ ንምሃብን ፍቓደኛታት ብምኳንኩም/ብምኳንክን ኣቐዲመ የመስግን።

ስም መሕትት ዝመልአ/ዝመልአት ________________________

ዕለት መሕትት____________________________________

ቑፅሪ መሕትት____________________________________

ሀ. ዝነብርሉ/ዝነብራሉ ከባቢ

1. ስም ክልል_________________________
2. ስም ወረዳ_________________________
3. ስም ጣብያ_________________________

ለ. ኣጠቓላሊ ሓበሬታ መራሕቲ ስድራ

1. ስም መራሒ/መራሒት ስድራ_________________________
2. ኣብ ቐጺሉ ንዘሎ ሰደቓ ኣባላት ስድረኦም/ስድረአን ዝምልከት ሓበሬታ በይዘኦም/በይዘአን ይሃባ/ይሃቡ

ሪጋ	ስም ኣባላት ስድራ	ቑሸት	ፆታ (1= ተባዕታይ 0= ኣንስታይ)	ዕድመ	ደረጃ ትምህርቲ (1= ዝተምሃረ/ት 0= ዘይተምሃረ/ት)	ኩነታት ሓዳር (1=ሓዳር ዘለዎ/ዋ 0= ሓዳር ዘይብሉ/ላ)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

መብርሂ ኣብ ሰደቓ ንዘሎ 'ቑሸት'፦

1= ሽንሳ 2= ሰምሃ 3= ቑሔን 4=ኣራቶ 5= ምልኣተ

ሐ. ኩነታት መሬት፣ ትሕዝቶ መሬትን ኣጠቓቕማ ቴክኖሎጅን

1. ኣብ ቐጺሉ ንዘሎ ሰደቓ ንዝጥቀምሉ/ዝጥቀማሉ መሬት ሕርሻ ኣመልኪቱ በይዘኦም ወይ በይዘአን ሓበሬታ ይሃባ/ይሃቡ

ሪጋ	ቑፅሪ ተሓራሲ መሬት	መጠን ተሓራሲ መሬት ብሄክታር	ልሙዑነት ተሓራሲ መሬት (1=ትሑት፣ 2=ማእኸላይ፣3=ልዑል)	ዓይነት ዝራእቲ (ኮድ'ሀ' ተጠቐም/ሚ)	ኩነታት መስኖ (1=እወ፣ 0=ኣይፋሉን)	ዓይነት መስኖ (1=ግድብ፣ 2= ጉድጓድ፣ 3=ሩባ፣ 4= ካልኦት)
1	መሬት=1					
2	መሬት=2					
3	መሬት=3					
4	መሬት=4					
5	መሬት=5					

ኮድ 'ሀ' ማለት 1= ጣፍ፣ 2= ስርናይ፣ 3= ሳዕሳዓ፣ 4= ዕፉን፣ 5= ስገም፣ 6= ኮሚደረ፣ 7= ድንሽ፣ 8= ጥቑሉል ሓምሊ፣ 9= ካሩት፣ 10= ሽንጉርቲ፣ 11= ሰላጣ፣ 12= ፃዕዳ ሽንጉርቲ፣ 13= ኣቮካዶ፣ 14= ፓፓየ፣ 15= ኣራንሺ፣ 16= ኣፕል፣ 17= ማንጎ

2. ምህርቶም/ምህርተን ንምድንፋዕ ዝጥቀምሉ/ዝጥቀማሉ ቴክኖሎጂ (ኬሚካል) እንታይ እዮም?

1=ዩርያ/ዳፕ (ኪሎ ግራም)___________ 2= ኮምፖስት (ኩንታል)_________
3=ድኹዒ(ኩንታል)_________ 4. ፀረ ባልዕ ኬሚካላት (ሌትሮ)__________
5= ካልኦት እንተለዉ ይዘርዝሩ/ይዘርዝራ_____________________

3. ኣብ ቐፂሉ ንዘሎ ሰደቓ ምርባሕ ሃፍቲ እንስሰኦም/እንስሰአን ኣመልኪቶም ወይ ኣመልኪተን በይዘኦም/በይዘአን ሓበሬታ ይሃቡ/ይሃባ

ሪጋ	ዓይነታት ሃፍቲ እንስሳ	ወናኒ/ወናኒት እዞም እንስሳታት ድዮም/ድየን? (1=እወ፣0=ኣይፋሉን)	በዝሒ ዝወነንወን/ዝወነነአን እንስሳት
1	ኣብዑር		
2	ኣታፊን		
3	ኣላሕም		
4	ኣርሕታት		
5	ኣምራኹት		
6	ኣባጊዕ		
7	ኣጣል		
8	ኣፍራስ		
9	ኣብቃል		
10	ኣእዱግ		
11	ኣግማል		
12	ደርሁ		
13	ኣናሂብ		
14	ካልኦት		

መ. ስልጠና፣ ደገፍን ልቓሕን

1. ንምስሳን ምህርቲ ሕርሻ መስኖኦም/መስኖአን ዕድላት ልቓሕ ኢንቨስትመት ኣለዎም/ኣለወን ዶ?
   1= እወ 0= ኣይፋሉን
2. ንምስሳን ምህርቲ ሕርሻ መስኖኦም/መስኖአን ዝሕግዝ ቴክኒካል ስልጠና ረኺቦም/ረኺበን ዶ?
   1= እወ 0= ኣይፋሉን
3. ቴክኒካል ስልጠና ረኺቦም/ረኺበን እንተኾይኖም/ እንተኾይነን መን ሂብዎም/ሂብወን?

   ____
4. ዝተውሃቦም/ዝተውሃበን ቴክኒካል ስልጠና ከመይ ረኺብምዎ/ረኺበንኦ?
   1= ጠቓሚ 2= ትሑት 3= ኣይጠቕምን 4= ኣይፈልጥን
5. ንስራሕቲ መስኖኦም/መስኖአን ደገፍ/ሓገዝ ሰብ ሞያ ሕርሻ ረኺቦም/ረኺበን ዶ?
   1= እወ 0= ኣይፋሉን
6. ንኹሉ ዓይነት ስራሕቲ ሕርሻኦም/ሕርሸአን ደገፍ/ሓገዝ ሰብ ሞያ /ረሻ ረኺቦም/ረኺበን ዶ?
   1= እወ 0=ኣይፋሉን
7. ንመስተ ማይ ዝጥቀምሎም/ዝጥቀማሎም ዓይነታት ማይ እንመን እዮም?

ኮድ	ምንጪ ዝስተ ማይ	(√)
1	ሩባ	
2	ፈሳሲ ምንጪ	
3	ራህያ	
4	ጉድጓድ	
5	ካልኦት	

ረ. ካብ ዝተፈላለዩ ስራሕቲ ዝተረኸበ እቶት[ሀ]

ረ ጋ	ዓይነት ምህርቲ	ኣጠቓላ ሊ ምህርቲ	ብገንዘብ እንትትመ ን	ካብ ዝተመረተ ሸይጥኻ/ኺ ዶ?	ካብ ዝተሸይጠ ዝተኸበ ብብር	ኣብ ረብሓ ስድራ ዝወዓለ ምህርቲ ብብር[ለ]	ኣጠቓላሊ እቶት
1	ሕርሻ						
	ብዝናብ ዝተረኸበ ምህርቲ						
	ብዝናብ ዝተረኸበ ገደና ኣሕምልቲ						
	ብዝናብ ዝተረኸበ ፍራምረ						
	ብመስኖ ዝተረኸበ እኽሊ						
	ብመስኖ ዝተረኸበ ገደና ኣሕምልቲ						
	ብመስኖ ዝተረኸበ ፍራምረ						
	ቀዋሚ ተኽልታት						
2	ውፅኢት እንስሳት						
	ቆርበት						
	ፀባን ጠስምን						
	ስጋን እንቋቑሖን						
	ክራይ ኣብዑር						
	ማዓርን ሰፈፍን						
	ድኹዒ						
	ካልኦት						
3	ካብ ስራሕቲ ሕርሻ ወፃኢ						
	መዓልታዊ ስራሕ						
	ስራሕቲ ፅንፀይቲ						
	ኢደ ጥበብ						
	ማእለማ						
	ንኡሽተይ ንግዲ						
	ቑፃር ሰራሕተኛ ማሕበራት						
	ቑፃር ሰራሕተኛ ውልቀ ትካላት						
	ካልኦት						

'ሀ'= ኣብዚ ሰደቓ 'ሀ' ዝመላኸቶ ብኹሎም መራሕቲ ስድራ ዝተረኸበ እቶት'ዩ።

'ለ'= 'ለ' ዝመላኸቶ ብመራሕቲ ስድራ ንባዕሎም ኣብ ረብሓ ዝወዓለ መጠን ምህርቲ ብገንዘብ ዝተተመነ'ዩ።

- ንመራሕቲ ስድራ ዝቐርብ ሕቶ ንባዕሎም መጠን ዝተጠቐምዎ/ዝተጠቐመኦ እኽሊ፣ ብእዋናዊ ዕዳጋ ብገንዘብ ክንደይ ከምዝኾነ እናተመዝገበ ክስራሕ ይግባእ።

ሰ. ኣገልግሎትን መሰረተ ልምዓትን

1. ካብ ኣባላት መራሕቲ ስድራ ሞባይል ስልኪ ዘለዎ/ዘለዋ ሰብ ኣሎ/ኣላ ዶ?

   1= እወ 0= ኣይፋሉን

2. ካብ ኣባላት መራሕቲ ስድራ ክንደይ ሰብ ሞባይል ስልኪ ኣለዎም/ኣለወን?________
3. ካብ መንገዲ ዋና ፅርጊያ መንበሪ ገዝኦም/ገዝአን ክንደይ ይርሕቕ?________ ኪ.ሜ.
4. ካብ ፅርጊያ ሓጋይ መንበሪ ገዝኦም/ገዝአን ክንደይ ይርሕቕ?________ ኪ.ሜ.
5. ራሕቂፅዳጋ ካብ መንበሪ ገዝኦም/ገዝአን ክንደይ ይርሕቕ?________ ኪ.ሜ.

6. ዝነብርሉ/ዝነብራሉ ገዛ ወይ ሕርሻ ዘሳልጥሉ/ዘሳልጣሉ ቦታ ኤሌክትሪክ ኣለዎ ዶ?
   1= እወ 0= ኣይፋሉን
7. ንስራሕቲ ሕርሻ መስኖ ዝኾነ ዓይነት ምንጪ ሓይሊ ይጥቀሙ/ይጥቀማ ዶ?
   1= እወ 0= ኣይፋሉን
8. ንሕቶ ተራ ቑፅሪ '7' ዝሃብዎ/ዝሃበኦ መልሲ "እወ" ዝብል እንተኾይኑ እንታይ ዓይነት ምንጪ ሓይሊ ይጥቀሙ/ይጥቀማ?
   1=ሶላር 2= ጀነሬተር 3= ኤሌክትሪክ 4= ስቲና 5= ኣልኦት____________

ሸ. ቐፃልነትን ማሕንቖታትን

1. እዚ ሎሚ ዝጥቀምሉ/ዝጥቀማሉ ዘለዉ/ዘለዋ ሜላ ሕርሻ መስኖ ብቐፃልነት እናተጠቐምሉ/እናተጠቐማሉ ድዮም/ድየን?
   1= እወ 0= ኣይፋሉን
2. እዚ ሎሚ ዝጥቀምሉ ስራሕቲ ሕርሻ መስኖ ንክንደይ ዓመት ሰሪሐምሉ/ሰሪሐናሉ? _______ (ዓመት)
3. ዝጥቀምሉ ዘለዉ ሜላ ስራሕቲ መስኖ ክቕፅለሉ'የ ዶ ይብሉ/ይብላ?
   1= እወ 0= ኣይፋሉ
4. ኣብ ስራሕቲ መስኖኦም/መስኖአን ቴክኒካል ማሕንቖታት ኣለዎም/ኣለወን ዶ?
   1= እወ 0= ኣይፋሉ
5. ኣብ ስራሕቲ መስኖኦም/መስኖአን ቀፃሊ ሜላ ኣጠቓቕማ ከይህሉ ዝዕንቅፉ ማሕንቖታት መስኖ እንታይ'ዮም?
   5.1. ___________________________
   5.2. ___________________________
   5.3. ___________________________
6. ቐፃላይ ዝኾነ ሜላታት ሕርሻ መስኖ ንምስላጥ ክመሓየሹ ዝግበኦም ጉዳያት ይግለፁ/ይግለፃ
   6.1. ___________________________
   6.2. ___________________________
   6.3. ___________________________

ንምትሕብባርኹም/ኽን ኣቐዲመ የመስግን!

Appendix 3. Name of irrigation user respondents

No	Name of respondent	village	Gender	Age
1	Abreha Kebede	Shigula	M	57
2	Alemnesh Negash	Semiha	F	40
3	Aregawi G/her	Semiha	M	35
4	Asfaw Abadi	Shigula	M	42
5	Asfeha Aemro	Arato	M	39
6	Askalu Halefom	Quien	F	47
7	Atsbeha Brhane	Semiha	M	32
8	Bereket Desta	Shigula	M	46
9	Berhane Zeray	Quien	M	34
10	Berhanu Gebru	Quien	M	48
11	Buruk Tadese	Semiha	M	48
12	Desta G/abezgi	Shigula	M	37
13	Embaye Kidanu	Quien	M	35
14	Eyob Tsegakiros	Arato	M	42
15	Fsehatsion tadele	Quien	M	50
16	Getu Ataklti	Quien	M	27
17	Goiteom Tesfu	Arato	M	61
18	H/kiros Gebre	Semiha	M	51
19	haben Hayelom	Miliate	M	50
20	Habenom Eyob	Shigula	M	43
21	Hadas Abadi	Arato	F	38
22	Haftay G/meskel	Arato	M	45
23	Hagazi G/kidan	Miliate	M	34
24	Hagos Kahsay	Miliate	M	32
25	Haregot Kahsay	Arato	F	32
26	Haregot Selomon	Miliate	M	51
27	Hiwot G/kiros	Semiha	F	31
28	Kahsay Abrha	Miliate	M	37
29	Kebedu Mulu	Miliate	F	35
30	Letay Atsbeha	Semiha	F	33
31	Leul Gidey	Semiha	M	42
32	Mahder Girmay	Miliate	F	31
33	Masho Haftu	Arato	F	31
34	Mearg Kiros	Shigula	F	29
35	Medhin Kahsay	Miliate	F	37
36	Meresa Areaya	Shigula	M	45

37	Meresiet Kalayu	Quien	F	32
38	Merhawi Kalayu	Miliate	M	33
39	Muez yaye	Arato	M	38
40	Mulu Berhane	Arato	M	63
41	Mulugeta Hagos	Quien	M	49
42	Musie Legese	Shigula	M	29
43	Tadesse Negash	Semiha	M	56
44	Teame Meresa	Quien	M	53
45	Teklit Equbay	Arato	M	53
46	Tirhas G/meskel	Quien	F	27
47	Tsega Haregot	Shigula	F	43
48	Tsegay Kahsay	Semiha	M	35
49	W/yesus H/Michael	Miliate	M	57
50	Yared Tesfay	Shigula	M	33

Appendix 4. Name of non-irrigation user respondents

No	Name of respondents	village	Gender	Age
1	Abeba H/slasie	Miliate	F	32
2	Abreha Hadush	Arato	M	39
3	Afera Abadi	Semiha	M	32
4	Almaz Ataklti	Semiha	F	38
5	Ameha Desta	Quien	M	62
6	Araya G/kidan	Quien	M	34
7	Aynalem Amare	Shigula	M	31
8	Baraki Beyane	Arato	M	57
9	Birey G/meskel	Miliate	F	35
10	Desta Adhana	Semiha	M	37
11	Dimtsu Alemseged	Miliate	M	45
12	Ebuy Desalegn	Quien	M	33
13	Feseha Alemayo	Semiha	M	42
14	Fitsum Asefa	Arato	M	42
15	G/her Kiros	Shigula	M	47
16	Genet Berhanu	Miliate	F	57
17	Girmay Baraki	Miliate	M	40
18	H/Michel Zemo	Miliate	M	43
19	Haftu Abera	Semiha	M	47
20	Haile Tikue	Miliate	M	35
21	hayelom Tesfay	Semiha	M	34

22	Hilftom Haftom	Shigula	F	32
23	Kahsay W/rufael	Arato	M	44
24	Kidusan Weldu	Arato	F	40
25	Kifle Fikadu	Quien	M	50
26	Kinfe Asgedom	Arato	M	29
27	Meresa Asfaw	Miliate	M	42
28	Mola Amare	Miliate	M	47
29	Negash Embaye	Arato	M	43
30	Nigsti G/tekle	Semiha	F	53
31	Redae Amare	Shigula	M	52
32	Rigat Meresa	Arato	F	43
33	Selomon Abera	Quien	M	38
34	T/kiros Aregawi	Shigula	M	43
35	Teklay Aregawi	Semiha	M	48
36	Temnit Desta	Quien	F	35
37	Tirhas Negash	Arato	F	31
38	Tsegay Degef	Arato	M	47
39	Tsehay Kahsay	Quien	F	28
40	Weldu Teame	Quien	M	49
41	Yared Tesfahunegn	Shigula	M	39
42	Yosef Amine	Shigula	M	27
43	Zayd G/her	Shigula	M	40

Appendix 5. የድጋፍ ደብዳቤ ከእንደርታ ወረዳ ግብርና ፅሕፈት ቤት

ቁጥር 1015 / ዝተ / 2ቶ / 11

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ጉዳዩ፦ ድጋፍ ደብዳቤ መስጠት ይመለከታል፣

ካሕሱ መሓሪ የተባለ የኣዲስ ኣበባ ዩኒቨርስቲ የሁለተኛ ድግሪ ተማሪ በትግራይ ክልል፣ ደቡባዊ ዞን በእንደርታ ወረዳ ግብርና ፅፈት ቤት *"IMPACT OF SMALL SCALE IRRIGATION ON THE LIVELIHOOD OF FARM HOUSEHOLDS"* በሚል ርእስ በአምስት መንደሮች በአካል መጥተው ጥናታዊ ምርምር ማድረጋቸው እየገለፅን የጥናታቸው ዉጤት በመስኖ ስራዎች ላይ ለምናደርገው ስራ የራሳቸው በጎ ኣሻራ እንደሚያስቀምጡልን ባለ ሙሉ ተስፋ ነን።

ከሰላምታ ጋር!

Berhe Girmay