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IMPACT OF SMALL SCALE IRRIGATION SCHEMES ON FARMERS LIVELIHOOD, THE CASE OF MEKDELA WOREDA, NORTH EAST ETHIOPIA.

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M.Sc. THESIS

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THESIS APPROVAL SHEET

As member of Board examiners of the masters of sciences (MSc.) thesis open defense examination, we have read and evaluated this thesis prepared by Mr. Eliyas Assefa Aregaw entitled **"Impact of Small-Scale Irrigation Schemes on Farmers Livelihood. The Case of Mekdela Woreda, North East Ethiopia."** We hereby certify that; the thesis is accepted as fulfilling the requirement for the award of degree of Master Science (MSc.) in Agricultural Economics.

Board of Examiners

1._____ _____ _____

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2._____ _____ _____

Name of Internal Examiner Signature Date

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Name of Chairman Signature Date

DECLARATION

This is to certify that thesis entitled **IMPACT OF SMALL SCALE IRRIGATION SCHEMES ON FARMERS LIVELIHOOD. THE CASE OF MEKDELA WOREDA, NORTH EAST ETHIOPIA,** submitted in partial fulfillment of the requirements for the award of the degree of Master of Science in Agricultural Economics to the Graduate Program of College of Agriculture and Environmental Sciences, Bahir Dar University by Mr. Eliyas Assefa Aregaw **(**ID. No. BDU0805921PS) is an authentic work carried out by him under our guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of our knowledge and belief.

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Co-Advisor	Signature	Date

DEDICATION

To the entire Eliyas family for tending me with love and for their wholehearted partnership in the success of my life.

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First and for most, I praise Allah, the cherisher and sustainer of the world. it is because of you that I am where I am today. Allah is the Greatest!

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LIST OF ABBREVIATION

ATT	Average Treatment Effect of the Treated
BH	Base Heterogeneity
CSA	Central Statistical Agency
DA	Development Agent
ESR	Endogenous Switching Regression Model
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
Ha	Hectare
KM	Kilometer
MOA	Ministry of Agriculture
MOFED	Ministry of Finance and Economic Development
MOWR	Ministry of Water Resource
NGO	Nongovernmental Organization
OARD	Office of Agriculture and Rural Development
SLA	Sustainable Livelihood Framework
SPSS	Statistical Package for Social Sciences
SSI	Small Scale Irrigation
TH	Transitional Heterogeneity

ABSTRACT

The extent to which small scale irrigation has been able to improve household's livelihood in the rural areas of Ethiopia is not well understood. Thus, this study focused to examine the impact of small scale irrigation on farmers' livelihood in Mekdela woreda. The study employed 'with' and 'without' approach by comparing farmers who used irrigation and farmers who did not use irrigation. Both quantitative and qualitative data types were used for analysis. Stratified random sampling technique was used to select the respondents of irrigation user and non-user households for the survey. Quantitative data for the study were collected from randomly selected 258 farm households were 96 users and 162 non-users using semi-structured questionnaire. Secondary data were collected from different sources. Binary logit ad Endogenous switching regressions model were employed to identify the determinant of small scale irrigation participation and its impact on farmers' livelihood respectively. The logit model result indicates that age and age square of the household, adult lab our, extension contact, access to off farm income, distance from homestead to nearly local market and distance from home to the scheme are significant factors affect farmers' decision to practice irrigation. To capture the impact of irrigation on households' livelihood, in Endogenous switching regressions model, two indicators were considered, that is household total income and household fixed asset formation (evaluated at market price of survey period). The result shows that positive and significant impact of participation in the irrigation scheme had increased irrigation users' income by 8.5%, and fixed asset formation by 26% as compared to non-users. This shows how significance role of small scale irrigation scheme are in improving the livelihood condition of poor farmers in the study area. The research result also identified problems of small scale irrigation as presence of pests and diseases, lack of access to market, lack of water, and lack improved inputs. The study recommends access to market, extending appropriate crop protection mechanisms, educating and raising farmers' awareness through extension and provision of other complementary services would enhance the participation of irrigation for livelihood improvement.

Key words: Endogenous switching regressions, impact, livelihood, small scale irrigation, stratified random sampling

1. INTRODUCTION

1.1. Background of the Study

Ethiopia is one of the agrarian economies in East Africa with a total area 1.13 million km^2. Of which, 1.12 million km^2 is covered by land and 0.01 million km^2 by water bodies. The country has an arable land area of 10.01% (0.11 million km^2) with only 0.65% covered by permanent staple crops according to (MoWR, 2002). Furthermore, the country has many international rivers, high groundwater potential and natural lakes, which have high potential for irrigation. Despite the large range of the river network, irrigated area only about 10% of the total cultivated land. The area under agriculture is also a modest 15% of the cultivable area in Ethiopia (MoWE, 2012).

Agriculture contributes significant share to the Gross Domestic Product (GDP) of many low income countries. In Ethiopia, agriculture contributes for 36.7% of the nation's GDP, 81.1 % of exports, and 80% of the labor force (MoFED, 2016). However, the sector has remained in its rudimentary stage because of environmental degradation, unchecked population growth (2.4% per annum), small and fragmented landholding, high rate of urbanization (5%), and limited access to new agricultural technologies, traditional methods of cultivation, high dependence on natural factors and institutional support services (MoFED, 2014).

Ethiopia is believed to have the potential of 5.1 million hectares of land that can be developed for irrigation through pump, gravity, pressure, underground water, water harvesting and other mechanisms (MoFED, 2010). However ,the erratic nature of rainfall and natural resource degradation are major bottlenecks struggle to enhance agricultural productivity, which in turn threatens the lives and livelihood of millions of people in Ethiopia (Hadush Hailu, 2014).

Small scale irrigation is irrigation on small plots, in which small farmers have the controlling influence and Covers less than 200 hectares of the command area (MoWR, 2002). Small scale is potential to stabilize agricultural production and mitigate the negative impacts of erratic or insufficient rainfall, but lack of better irrigation management prevents results to improve livelihoods, and leads people and the environment to risks. Irrigation projects have been

unsuccessful mainly due to inadequate participation by beneficiaries and unstable land tenure(Dereje Magisite and Desale Kidane,2016).

Small scale irrigation serves as one of the strategies to reduce poverty, to ensure household food security and improving the livelihood situation of the community. It enables to meet food self-sufficiency, obtain reasonable income and accumulate different assets,(Bekele, 2011).Irrigation is linked to poverty reduction through its effect on crop production and increased farm income. There is a need to expand the capacity of the small-scale irrigation scheme to significant welfare, consumption expenditure, on participants' households. Irrigation is the best alternative way to sustain food production and increased income (Jema Haji *et al*;2013).

Ethiopian government gives more emphasis to small-scale irrigation as a means of achieving food self-sufficiency (MoFED, 2010). The development of small-scale irrigation is one of the major intervention areas to improve agricultural production in the rural parts of the country. Small-scale irrigation schemes enable greater agricultural production than is achieved with rain-fed agriculture, help poor farmers overcome rainfall and water constraint by providing a sustainable supply of water for cultivation and livestock, strengthen the base for sustainable agriculture, provide increased food security to poor communities through irrigated agriculture, contribute to the improvement of poor nutrition level, provides a source of household income.

Mekdela *woreda*, endowed with beautiful diverse natural resources and has a great potential of small scale irrigation through underground water, river diversion, surface water harvesting and other mechanisms. Even though, low income and low land holding of the farmers in the study area, small scale irrigation was found to be a proper and comprehensive approach for improving farmer's livelihood. However, irrigation is not a simple silver bullet (Awulachew, 2010). It brings positive returns only if it is complemented by other components of the agricultural system. Unfortunately, the country's agricultural sector is characterized by traditional technologies and poor systems. Furthermore, because of irrigation in our country is constrained by different socioeconomic and institutional challenges, thus, identifying these challenges and putting the possible implications are essential. Expanding irrigation requires quantifying and examining the real impact of these schemes on household's livelihoods. In this context, this study was conducted.

1.2. Statement of the Problem

Agricultural production in Ethiopia predominantly depends on rainfall. In addition, drought is becoming frequent and many people have been repeatedly exposed to hunger and famine. In Ethiopia most of the settlement areas are degraded, per capita land availability is diminished and productivity of land and labor are reduced and agricultural production is also affected by variability of rainfall and drought (Seleshi Bekele et al., 2007).As a result, low farm production, widespread poverty, poor health, remain to be widespread problems in Ethiopia (Pendon, 2007) as cited in (Tedros Tsehaye, 2014).All these situations expose the country to exacerbate the problem of poverty.

On the other hand, small scale irrigation could provide opportunities to cope with the problem of rainfall variability, enhance productivity per unit of land, and increase the volume of annual production significantly, enhancing food security, earning higher and more stable incomes (Smith, 2004).

There are many farmers who have irrigated land but don't engage in irrigation. Furthermore, providing irrigation infrastructure to farm households is not a guarantee to reduce rural poverty and improve livelihood. In addition to that, an enabling socio-economic environment (like access to roads, markets, credit, training and information about innovations) must be provided to the poor farmers to actually make them engage in small scale irrigation farming and ensure livelihood improvement (Norton *et al;* 2010).

Small scale irrigation is an endeavor to improve the livelihood of the rural people. It remains a pressing issue as economic and social problems continue to affect small holders to an extent that food shortages persisted in the area. This give the scheme a negative impression. The empirical studies about the impact of small scale irrigation on households livelihood like Kuwornu & Owusu (2012) in Ghana; Zhou *et al.* (2009) in china ; Sheetal (2013) in India; Sikhulumile *et al*.(2014) in south Africa;(Abraham Gebrehiwot *et al.*,2015;; Anwar Alamin, 2014; Ayana Anteneh, 2016; Jema Haji *et al.,* 2013; Kinfe Aseyehegn *et al;*2012; Woldegebrial Zeweld *et al*;2015) in Ethiopia found positive impacts of using small-scale irrigation on income. Seleshi Bekele (2010) also argues that water resource management in agriculture is a critical contributor to households economic and social development of Ethiopia. Other studies failed to

show significant positive results. For example, (Podmore, 1983) Southern Africa, small-scale irrigation schemes have had limited performances of operating has averaged less than 50% efficiency as cited in Nahusenay Teamer & Rao (2015).Pender et al. (2002 indicated that in irrigation has less impact in agricultural yields than expected. Another study by (Haile Tesfay, 2008) has indicated that irrigation through pond water had not significant effect in increasing the livelihood of beneficiary households. Conversely, Lipton et al. (2003) acknowledged the various forms by which the benefits of irrigation can improve the livelihoods of both irrigators and non-irrigators that include increased production and income, reduced risk and application of agricultural inputs and job creation for rural landless people. However, Related studies on small scale irrigation-livelihood linkages have been less explicit on the magnitude of small scale irrigation impacts on household livelihood. Such issues instigate for further study.

Despite a number of irrigation impact studies elsewhere there still remains a need for quantitative impact evaluations of Ethiopia's specific irrigation schemes. This is because irrigation schemes are not homogenous between (and even within) countries but are case specific due to factors such as objective, natural resource base, technology, scheme and plot size, farmer profile and marketing opportunities. Therefore, the livelihood impact of small scale irrigation and determinant factors of participation in the study area is an empirical question. Given these fact, this study tries to investigates determinant factors of participation in small scale irrigation and its impact on farmers' livelihood.

1.3. Objectives of the Study

1.3.1. General Objective

The general objective of this study is to examine the impact of small scale irrigation schemes on farmers' livelihood in the study area.

1.3.2. Specific Objectives

- ✓ To analyze the impact of small scale irrigation schemes on farmers' income
- ✓ To analyze the impact of small scale irrigation schemes on farmers' fixed asset formation
- ✓ To identify the determinants of small scale irrigation participation
- ✓ To identify the major constraints encountered in irrigation farming

1.4. Research Questions

In line with the above objectives; the following questions raised by the investigator. The research question focus mainly on farmer's problems along with issues that are interrelated with small scale irrigation impact on income, fixed asset and livelihood status.

1. To what extent do irrigation schemes impact on farmer's income for livelihood improvement?
2. To what extent do irrigation schemes impact on farmer's asset formation?
3. What are the determinants of small scale irrigation participation?
4. What are the major constraints encountered in the use of the small-scale irrigation systems?

1.5. Scope and Limitation of the Study

The study was undertaken to evaluate the impact of small-scale irrigation schemes on farmers' income and livelihood in Mekdela woreda. This research focuses on two small scale irrigation schemes and the concept of livelihood is very broad, so it is not possible to capture all aspects at a single study due to limitations imposed by time, financial resources other related problems. So, this study examines only the contribution of small-scale irrigation schemes on users' income and asset formation. Moreover, the information was gathered through semi- structured questionnaire survey, the quality of the information depends on the willingness, knowledge and recalling capacity of respondents. However, maximum efforts were made to gather reliable information by convincing farm households about the objectives of the study.

1.6. Significance of the Study

The findings of this study contributes to the theoretical and empirical knowledge on small scale irrigation development for household income and asset formation in improving the livelihood of the rural households. It is also contributing in identifying the core problems that hinder irrigation practice and factors determining irrigation participation in the study area. The result of the study will help local authorities and development agents to formulate appropriate intervention mechanism. In addition, the findings of the research work give insight for researchers and students for further research interested on the issue.

2. LITERATURE REVIEW

This chapter takes a critical look at what other authors and theories have said in relation to the subject of the study. The content of this chapter reviews discussions on irrigation as an innovative farming tool, its types and approaches, livelihood patterns as related to irrigation practice and the linkage between irrigation practice and livelihood and the conceptual framework for the study.

2.1 Basic Concept of Irrigation

According to FAO (1997), irrigation is "the supply of water to agricultural crops by artificial means, designed to permit farming in arid regions and to offset the effect of drought in semi-arid region". Mutsvangwa & Doranalli (2006) also define irrigation as the ministering of land through the artificial application of water to ensure double cropping as well as steady supply of water in areas where rainfall is unreliable.

Irrigation has the potential to increase agriculture production and improve the livelihoods of small-scale farmers. Irrigation is linked to poverty reduction through its effect on crop production and increased farm income. Adequate water supply to crops increases the production available for household consumption and or sale. Irrigation can enable farmers to have a second and sometimes a third crop planting, increasing income for the farmer. Furthermore, to increasing overall production, irrigation increases the reliability and consistency of production (Smith, 2004).

2.2. Small Scale Irrigation

Small scale irrigation is 'Irrigation, usually on small plots, in which farmers have the major controlling influence and using a level of technology which the farmers can effectively operate and maintain small-scale irrigation systems are defined by the FAO as being controlled by single farmers or farmers' groups and are usually less than 200 hectares (MoWR, 2002).

The promotion of small-scale irrigation has been to increase farmers' involvement in the planning, implementation, operation and management of irrigation systems. The participation of farmers as direct beneficiaries in the construction of the schemes and their responsibility in the operation and management could considerably reduce development and management costs

and improves performance. According to (FAO, 2000) reported that projects that are planned with farmer participation perform better than that are planned by experts on their own.

According to FAO (2003), smallholder irrigation development has shown throughout the developing world that it can be used as a key drought mitigation measure and as a vehicle for the long-term agricultural and macroeconomic development of a country. Successful smallholder irrigation schemes can result in increased productivity, improved income and nutrition, employment creation and food security. However, socio-economic evaluation of smallholder irrigation systems is very essential to be able to derive lessons from the past experiences and to help policy makers in formulating sound policies for further irrigation development. Currently, the government of Ethiopia is developing master plans for various types of irrigation, including diversion/gravity schemes from major rivers, pumping from rivers, and small storage reservoirs by giving priority to low cost small-scale irrigation systems.

2.3. Classification of Irrigation Schemes in Ethiopia

Irrigation schemes differ considerably in size and structure. In the Ethiopian context, irrigation schemes are categorized in to three classes. They are small, medium and large-scale irrigation schemes. Small-scale irrigation schemes are those which have less than 200 hectares of area. Medium- scale schemes cover an area of 200-3000 hectares while large-scale irrigation schemes cover an area greater than 3000 hectares (MoWR, 2002). Small-scale irrigation schemes are the responsibility of the MoARD and regions, while Medium- scale schemes and large-scale irrigation schemes are the responsibility of the MoWR (Awulachew, 2010).

2.4. Challenges Faced on Small Scale Irrigation Scheme

Chazovachii (2012) identifies the major problems tinted on small scale irrigation scheme include lack of capital for input acquisition, markets, water pricing, labor and transport. Moreover Nugusse Zeweld (2013) also identifies the major constraints of irrigated agriculture include marketing, input supply, financial resources, irrigation-water committee leadership, water inadequacy, and pests and diseases. Nugusse Zeweld (2013) outlines the main constraints of irrigation sector is mainly related to institution, market, infrastructure and input services.

Nahusenay Teamer & Rao (2015) identifies the major small-scale irrigation problems identified are financial constraints. Namara *et al*.(2011) most of the constraints observed are common to all forms of irrigation schemes. The major constraints can be grouped into six major areas are financial and institutional issue, access to inputs and service, output marketing and post-harvest handling or value additions, technical constraints, biophysical constraints and labor availability. Key constraints of irrigation in Ethiopia are explained as follows;

Poor irrigation management such as siltation and sedimentation are the major challenges for many of the schemes. The main cause of salinity is poor irrigation water management. Inefficient erosion drainage systems along the canals has caused severe siltation problem. This in turn affected seasonality, labor efficiency and cropping pattern (Awulachew *et al;*2010; Seleshi Bekele *et al* ;2013).

Imperfect Market in all over the rural areas of Ethiopia market access and marketing facilities are the major constraint influencing farmers' success. There is no rational place or customer for selling their farm output. The middlemen and brokers were exploiting their benefit. It's not the market structure which determines price, but the brokers and merchants. The farmers have not the bargaining power. Input price is so much expensive. Market problems mainly related to irrigation agriculture are acute due to perishability of irrigation based agricultural commodities. In addition, lack of storage facilities and processing agro industries in many of the schemes caused a great loss. Price instability and lack of market are almost invariability confirmed as major constraints to irrigated agriculture. Marketing cooperative were conspicuously missing or proved to be too ineffectual to reduce risks arising from price instability and marketing problems. Small farmers face high costs and risks when entering markets, which severely limit the returns from irrigation (Seleshi Bekele *et al*., 2013).

Insufficient technical skill such as, low capacity of farmers and in sufficient technical skill by many stakeholders, weak economic base of most farmers and the relatively high development costs involved in developing irrigation schemes are also the other key constraints (Awulachew et al., 2010). In many parts of the country, the farmers are practicing irrigation without essential know-how on crop water need, water application method and irrigation interval. Lack of knowledge on irrigation water management aspects has resulted in wastage of irrigation water,

deterioration of some structures and water logging problems on some farms (Gebremedhin & Asfaw, 2015).

Financial shortages like, lack of long and short-term credit provision affects the production of the scheme. The input for production like fertilizers, improved seeds and chemicals requires high financial input for purchasing. Moreover, lack of legal status for Water Users' Associations (WUAs) can present a challenge to farmers. Unlike cooperatives, which are legal entities, WUAs cannot access credit or hold bank accounts. That is why relatively better-off households benefited more because they have more land, labor and money to buy farm inputs, which allow them to exploit irrigation opportunities (Seleshi Bekele *et al.,* 2013).

Socio-institutional constraints at all levels, there exists low institutional capacity which is critical to enhance development of irrigation schemes with respect to development planning, design, implementation, and operation and maintenance including irrigation advisory services (Awulachew *et al.,* 2010).Water theft, conflict on land, and water distribution is a common scenario in many schemes.

2.5. Farm Household Livelihoods

Livelihood "comprises the assets (natural, human, financial, and social capital), the activities and the access to these (mediated by institutions and social relations) that together determine the living gained by the individual or household (Ellis, 2000). When it comes to an individual, a livelihood is the ability of that individual to obtain basic requirements in life, which are food, water, shelter and clothing. Therefore, all activities involved in finding food, searching for water, shelter, clothing and all necessities required for human survival at individual and household level are referred to as a livelihood.

Chambers & Conway (1991) defined that livelihood comprises the capabilities, assets (stores, resources, claims and access) and activities required for a means of living. It comprises the adequate stocks and flows of food and cash required to meet basic needs. It is made up of a range of farm and off-farm activities that together provide a variety of sources of procurement for food and cash. Thus, each household can have several possible sources of entitlement that constitute its livelihood. These entitlements are based on the endowments of a household, and

its position in the legal, political and social fabric of society. A livelihood is sustainable when it: i) can cope with and recover from stress and shocks that determine vulnerability; ii) maintain or enhance its capabilities and assets; and iii) provide sustainable livelihood opportunities for the next generation.

Livelihood Security is the adequate and sustainable access to income and other resources to fulfill basic needs (Frankenberger, 1996).Livelihood can be seen to consist of a range of on-farm and off-farm activities which together provide a variety of procurement strategies for food and cash. The risk of livelihood failure determines the level of vulnerability of a household to income, food, health and nutritional insecurity. Therefore, livelihoods are secure when households have secure ownership of, or access to, resources and income earning activities, including reserves and assets, to off-set risks, ease shocks, and meet contingencies (Chambers, 1988).

The livelihood approach stresses the significance of assets or capitals and their contribution of household livelihood outcomes. (DFID, 1999) distinguishes five capitals or assets: physical, human, financial, natural and social owned and used in a variety of combinations to achieve livelihood outcomes. Household assets represent the stock of resources on which they can depend to generate income, meet their basic needs, manage risk, and cope with stresses and shocks. A larger stock of assets generally means a greater livelihood opportunities and greater livelihood and economic security.

Natural capital – the natural resource stocks (soil, water, air, genetic resources etc.) and environmental services (hydrological cycle, pollution sinks etc.) from which resource flows and services useful for livelihoods are derived.

Economic or financial capital – the capital base (cash, credit/debt, savings, and other economic assets, including basic infrastructure and production equipment and technologies) which are essential for the pursuit of any livelihood strategy.

Human capital – the skills, knowledge, ability to labor and good health and physical capability important for the successful pursuit of different livelihood strategies.

Social capital – the social resources (networks, social claims, social relations, affiliations, associations) upon which people draw when pursuing different livelihood strategies requiring coordinated actions. This is clearly not an exhaustive list, and other forms of ‘capital’ can be

identified. To create livelihoods, as result people must combine the 'capital' endowments that they have access to and control over. These may be made up of personal capabilities, tangible assets (e.g. stores and material resources) and intangible assets (claims and access).

2.6. Impact of small scale Irrigation on Livelihood: Empirical Literature

Irrigation water is a critical production input in agriculture. Irrigation directly impacts on household incomes by increasing farm revenues. It increases annual revenue per acre of land through its direct positive effect on total crop production. The irrigation scheme farmers have more income sources than non-irrigator (Mtonga, 2014) .Similarly small-scale irrigation has positive and statistically significant effect on annual income, total food and non-food expenditure, food consumption, agricultural inputs expenditure and asset building (Nugusse Zeweld, 2013). Small scale irrigation is an important strategy in reducing risks associated with rainfall variability and increasing income of rural farm -households (Abraham Gebrehiwot et al., 2015).According to Gebregziabher & Namara (2008) farming income is more important to irrigating households than to non-irrigating households, while off-farm income is negatively related with access to irrigation. They also found that irrigating households' average income is above the regional average, while non-irrigating households' average income is 50 percent less than the average income of irrigating households and the mean income of irrigators is significantly higher than that of rain-fed farmers.

Access to good irrigation water contributes to socioeconomic improvement of rural communities and alleviates poverty trough five different dimension. These are production, income and consumption, employment, food security, and other social impacts contributing to overall improved welfare. over-all, access to good irrigation allows poor people to not only increase their production and incomes, but also enhances their opportunities to diversify their income base, and to reduce their vulnerability to the seasonality of agriculture and external shocks (Hussain and Hanjra 2004).

The negative effects of irrigation are the environmental impacts are the loss of natural habitat. Hussain & Hanjra(2004) argues that irrigation water become a socioeconomic ''bad'' when it leads to problems such as waterborne diseases and land degradation including waterlogging and salinity, water pollution and associated destruction of living beings and natural ecosystems

(negative externalities associated with irrigation). Furthermore, irrigation and irrigation dams have negative impact in animal production through reduction of grazing land throughout the year and lack of free communal land for movement. It also reduces crop production because of pest infestation, lack of aeration, water logging and percolation that leads to swamps. It affects public health through infestation of malaria and other water borne diseases (Asayehegn , 2012).

Land and water are two key natural resources upon which poor people depend for their livelihoods, and often more heavily than the non-poor. Irrigation agriculture is an essential component of any strategy to increase global food supply. The benefits of irrigation have resulted in lower food prices, higher employment and a more rapid agricultural and economic development. Irrigated farming even on tiny plots could greatly exceed returns from rain-fed production (Burrow 1987).

Gebregziabher G *et al*. (2009) and Kuwornu & Owusu (2012) evaluated the impact of access to small-scale irrigation on farm household welfare using the propensity score method (PSM). According to Gebregziabher G *et al*. (2009), the average income of non-irrigating households was less than that of the irrigating households by about 50% in Ethiopia. The study also found that farm income is more important to irrigating households than to non-irrigating households, and off-farm income was negatively related with access to irrigation. Kuwornu & Owusu (2012) concluded that irrigation investment in Ghana is justified due to significant irrigation contribution to consumption expenditure per capita in farm households. Dillon (2011) investigated the impact of small-scale irrigation investments on household consumption, assets and informal insurance in Mali using both PSM and the matched difference-in-difference method. The strength of this study was its use of panel data. Both estimation methods confirmed the positive role played by small-scale irrigation on household consumption and asset accumulation.

Abonesh Tesfaye *et al.*(2008) and Bacha *et al*. (2011) both assessed the impact of small-scale irrigation on household livelihood in Ethiopia using the Heckman's two-step estimation procedure. Both studies observed significant welfare differences between irrigators and non-irrigators, and concluded that access to irrigation had played a part in those observed differences. Abonesh Tesfaye et al.(2008) found that about 70% of the irrigation users were food secure while only 20% of the non-users were food secure in *Filtino* and *Godino* irrigation

schemes in Ethiopia. The two studies found that irrigation participation was also influenced by unobservable factors, highlighting the need to model for unobservable variables in irrigation impact evaluations.

Small-scale irrigation has multi-dimensional impacts on the livelihood development of the rural people both directly or indirectly and has a positive impact on food security, asset ownership and well-being of rural farm households; there are clear increases in agricultural production through diversification and intensification of crops grown, household income, sources of animal feed, human health improvements, and asset ownership (Dereje Mengistie and Desale Kidane,2016). Similarly Chazovachii (2012) income gained from irrigation farming satisfied and afford to meet some of the basic requirements like sending children to school, buying groceries for the family and income to cover some farm inputs. Chitsiko (1999) also argues that irrigation schemes are important in augmenting government policy of reducing rural to urban migration.

Gor-Cornist (1999) noted that irrigation schemes provide a source of self-reliance, livelihoods and income to some young children who did not intend to move to town. These schemes helped in reducing rural-urban migration by offering rural population an alternative source of employment and income. Livelihood improvement is likely to improve in households practicing irrigation farming. The availability of water throughout the year ensures that cultivation is done all year round. Double cropping ensures that farmers get income from the crops they grow.

Hasnip et al.(2001) outlines the processes of irrigation impact on livelihoods four inter-related mechanisms through which irrigated agriculture can enhance and sustain rural livelihoods are:
I) improvements in the levels and security of productivity, employment and incomes for irrigating farm households and farm labor;
II) the linkage and multiplier effects of irrigation development for the wider economy;
III) increased opportunities for rural livelihood diversification (Expansion of the non-farm labor market also provides opportunities for diversification of livelihoods for rural households
IV) multiple uses of water supplied by irrigation infrastructure.

Access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns

from farming. This, in turn, opens new employment opportunities, both on-farm and off-farm, and can improve incomes, livelihoods, and the quality of life in rural areas. Overall, irrigation water, like land, can have an important income-generating function in agriculture (Hussain & Hanjra 2004).

There is an attempt to evaluate the impact of small scale irrigation on household livelihood in different part of Ethiopia. Using the OLS procedure, those study mentioned earlier concluded that irrigation plays a central role in the improvement of rural livelihood and food security. However, Baker (2000) and Bacha et al. (2011) point that self-selection and endogeneity associated with irrigation participation results in biased estimates from the OLS estimating technique (Greene, 2003). The impact of access of irrigation is either overestimated or underestimated by OLS regression depending on whether the irrigation scheme beneficiaries are more or less able to realize the potential benefits of irrigation due to certain unobservable factors (Baker, 2000).

The above literature indicates that although there have been a number of comprehensive irrigation impact evaluations in other countries, this has not been the case in Ethiopia. Since small irrigation schemes are not homogenous between countries, there remains a case for in depth quantitative impact evaluations specific to Ethiopian irrigation schemes.

2.7. Conceptual Framework

Access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, overall higher production, and greater returns from farming. This, in turn, opens up new employment opportunities, both on-farm and off-farm, and can improve incomes, livelihoods, and the quality of life in rural areas.

Irrigation water is a critical production input in farmer's production. It is an important socio-economic good with a positive role in poverty alleviation. Irrigation directly impacts on household incomes by increasing farm revenues. There are two potential ways through which irrigation increases farm revenues. Firstly, it increases annual revenue per acre of land through its direct positive effect on total crop production in a given cropping season. Irrigation enhances

the use of agricultural inputs (such as fertilizer and high yielding varieties), which in turn improves the productivity of land (Gebregziabher G. et al;2009).

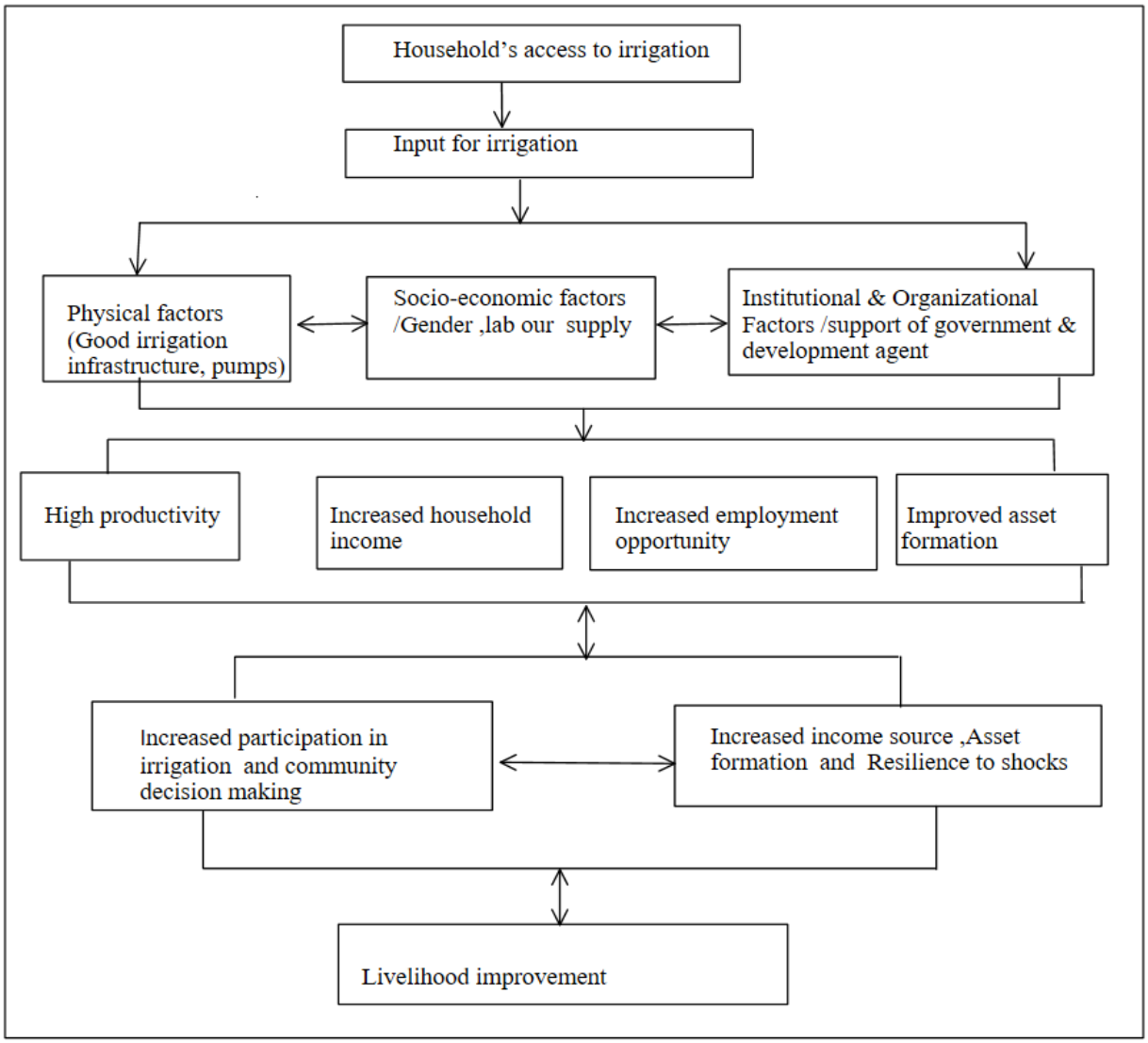

Figure 1.Linkages between small scale irrigation and household livelihood.

Source: Adopted from (Smith, 2004)

The above framework portrays the different mechanisms through which farmer's participation in small-scale irrigation to improve households' livelihood. Many factors must be considered such as physical, socio –economic, institutional and organizational factors. The physical aspect of irrigation includes the good irrigation infrastructure and management practices, high water and lab our supply, pumps, and others that ensure reliable water supply. The socio-economic

circumstances of the farmer are the factors (such as gender, income sources, geographic location) in the scheme, which influence access to irrigation water. The institutional and organizational structure involves irrigation committees, farmer associations, and rules and regulations, provision of credit services and agricultural chemicals, and support of government and development agents are all very essential. Therefore, by improving and using these inputs, can increase rural household's incomes, livelihood diversification, productivity, employment opportunities, improve asset formation and resilience to risk, and participation in community decisions. Therefore, keeping other variables constant, all these and other outputs of small scale irrigation developments combined have the capacity to achieve livelihood development in rural areas, thereby reducing the present chronic food insecurity problem. Hussain and Hanjra (2004) irrigation can benefit the poor through raising yield and production, lowering the risk of crop failure and generating higher yield and year round farm production. It can enable smallholder to adopt more diversifying cropping pattern and to shift from low value subsistent production to high value market oriented production, which increase income of households.

The conceptual framework of this study also indicates that increased cash income through high value crop production through irrigation. Furthermore, farmers who use irrigation also able to increase their asset base through saving their income in the form of livestock and household asset. In general, the conceptual framework shows how farm households able to generate high income through production of high value crops using irrigation and at the same time it indicates how income to be generated for livelihood improvement.

3. RESEARCH METHODOLOGY

This chapter discusses description of the study area; the process and techniques employed for the research, these include the discussions on the research design, the population that was studied and how the sampled was selected. This chapter also gives description of how the data were collected and analyzed.

3.1.1. Description of the Study Area

Mekdela district is one of the rural *woreda* of *Amhara* National Regional State. Located in South *Wollo* zone, 553 Km North East of Addis Ababa and 152 km of the West direction of *Dessie,* Ethiopia. It is bordered by *woredas* of *Dawunt* & *Delanta* to the North, *Saint* to the South, *Tenta* to the East and South *Gonder* to the West. The district comprises 28 *Kebele* Administrations (KAs) each KA has one development center.

The district is inhabited by 165,754 people, out of which 80,452(48.5%) are males and 85,302 (51.5%) females(CSA, 2013). Only 5 % of the populations -lives in- urban area. Total area of the woreda is 147,384 hectares with diverse landscape features of which 37,189 ha cultivable out which 8,271 ha irrigable (with tradition and modern irrigation), 37,294 ha grazing, 36,995 ha forestry and grass land, 26,417 ha bare land ,1203 ha institutional buildings & residential lands and 15 ha water body (OARD, 2018)

The livelihood of people living in the study area is mainly dependent on agriculture, the area is known for its low productivity due to land degradation. Crop and livestock production systems are the main livelihood strategy for much of the population in the district. The crops grown includes *teff*, barley, wheat, bean, malt barley, sorghum, finger millet, haricot bean, chickpea and others. Different vegetables and fruits such as tomato, potato, onion, lettuce, carrot, garlic, banana, mango and apple are grow in the area using irrigation both at the rainy and dry seasons. Irrigation in the study area practiced from different sources such as micro dams (earth and concrete), river diversion, Arce ware dams, shallow wells and ponds (OARD,2018). The livestock reared include cattle, equines, shoats and poultry, which is the main source of household income and employment in the study area.

3.1.2. Description of Irrigation Schemes

This study was conducted on Tebi and *Qebitia* irrigation schemes that are found in mekdela district respective kebele's. According to district office of agriculture and rural development these schemes were constructed in 1993 E.C by the Former Sustainable Agriculture and Environmental Rehabilitation in the Amhara Region the current Amhara Water and Energy development bureau through Ethiopian Social Aid Development Fund.

Tebi irrigation scheme construction cost was 3,251,169 Birr, has a capacity to irrigate 183 ha of land. *Qebitia* irrigation scheme construction cost was 1,322,632 Birr, has potential to irrigate 43 ha. The average land size of the beneficiary is 0.25 hectare. The major crops and vegetables produce are onion, lentil, garlic and potato (OARD, 2018).

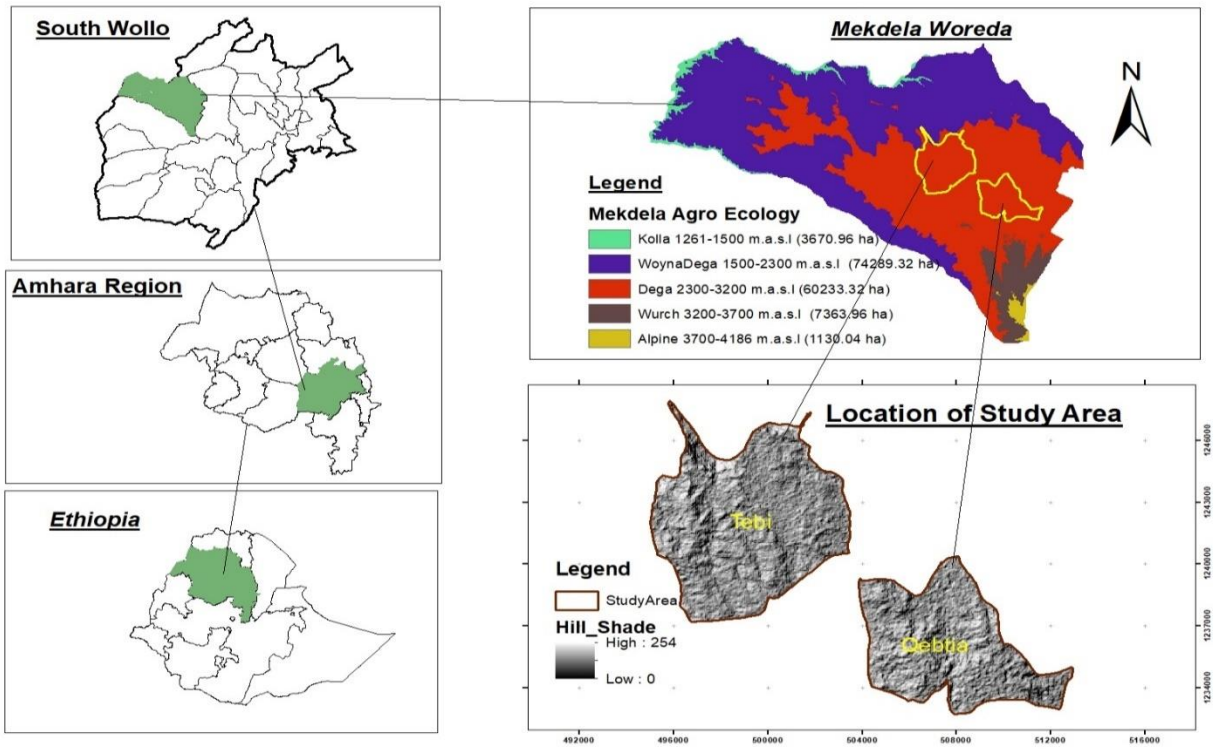

Figure 2. Location and Agro-ecology Map of the study area**.**

Source: OARD,2018

3.2. Research Design

The study employed both qualitative and quantitative data collection methods. Qualitative method is used to capture data pertaining local perception and opinions on the contribution of irrigation to household income and asset formation using focus group discussion and key informant interview.

Quantitative data on households 'asset ownership, income status, livelihood status, demographic characteristics and other basic information was collected from sample households using semi-structured questionnaire.

3.3. Sampling Techniques and Sample Size Determination

Out of six Kebele's that practiced small scale irrigation extensively in *Mekdela* district, two kebele's namely, *Qebtia* and *Tebi* were randomly selected. Target Population of the study consists of all farmers from the selected communities that are irrigation users and non-users in the selected study area.The study employed the 'with' and 'without' approach by comparing farmers who used irrigation and farmers who did not use irrigation.

A stratified random sampling technique (proportionate) was used to select sample respondents. Households were categorized into two strata: irrigation user and non-user. Household heads from the two kebele's with respective irrigation scheme were identified and stratified in to two strata user and non-user households. To ensure a fair representation of irrigation user a list of the irrigating farmers was obtained from scheme management, and farmers stratified according to their location on the scheme. From these sub-strata, random selection was done to obtain a sample of 96 irrigating farmers and 162 non-irrigators in the same geographic area were selected using simple random sampling technique.

Table 1.List of Target Population of the Study

Kebele	Target population		
	Irrigation user	Irrigation Non User	Total population
Qebtia	507	1393	1900
Tebi	887	966	1853
Total	1394	2359	3753

Source: Own survey data (2018)

Therefore, the researchers used the (Yamane, 1967) to determine the required sample size at 95% confidence level.

$$n = \frac{N}{1+N(e)2} \quad \text{..... (1)}$$

where: n = the number of required sample of each irrigation scheme (sample size);

N = total households of each irrigation scheme (population size);

e = confidence level (0.06)

$$n = \frac{3753}{1+3753(0.06)2} = 258$$

Therefore, 96 irrigators and 162 non-irrigators with a total of 258 sample households was taken, respectively.

Table 2.Sampled Household of the Study

Kebele	Sampled Household						
	Irrigation user			Non-user			Total
	Male	Female	Total	Male	Female	Total	
Qebtia	32	2	34	79	17	96	130
Tebi	58	4	62	54	12	66	128
Total	90	6	**96**	133	29	162	258

Source: own computations from survey data, (2018).

3.4. Methods of Data Collection and Types of Data

To examine the impact of small scale irrigation schemes on farmer's livelihood of the study area, the data was collected from both primary and secondary data sources.

3.4.1. Primary Data

Primary data were collected using structured questionnaires, key informant interviews and focus group discussions. In this regard, both sample household's users and non-users of small-scale irrigation schemes were interviewed using open and close-ended questionnaires consisting of interrelated issues that was administered by five trained enumerators under the supervision of the researchers and the development agents of the respective *kebele's*. Before data collection, all the enumerators were trained about the methods of data collection, content of survey and how they approach the interviewee.

The questionnaire also included measures of household wealth such as the household assets, livestock, and houses; agricultural production activities; household expenditure, income amounts and sources. The same questionnaire was used for both irrigators and non-irrigators, but with extra sections to cover specific questions related to the irrigation activities. For the sake of checking the reliability, Questionnaires pre-test was administered for a few randomly selected households in the study area. To convey the questions effectively to the rural interviewees, the questionnaires was translated into the local language (Amharic).

3.4.1.1. Focus Group Discussion

Focus group discussion (FGD) with farmers was one of the qualitative data collection methods for this study. Discussion with development agents, district agricultural and rural development office irrigation experts and irrigating and non-irrigating farmers to gather qualitative data was collected from two FGD. Each focus groups comprise 7 (seven) individuals who are found in the same village in the study area. FGD were used to generate data that complemented the structured questionnaire by providing the explanations and issues behind quantitative data.

3.4.1.2. Key Informant Interview

Individuals who are considered knowledgeable and rich in experiences about irrigation activities, rural livelihood and the socioeconomic conditions of the community in the study was identified and interviewed. Sixteen key informants were interviewed, four of which were

extension officers while twelve involved farmers who were knowledgeable with issues pertaining to the farming activities in the scheme.

Prior to primary data collection, a thorough review and analysis of published papers. Secondary information was obtained from documentary sources such Journals, Reports, Articles and others. The essence of this was to review literature about irrigation, income, asset and livelihoods.

3.5. Methods of Data Analysis

The main issue in impact evaluation is that of missing data. Subjects cannot be observed in both statuses at the same time, that is participation in an irrigation project and non-participation in the project is mutually exclusive. In the absence of data on counterfactual outcomes that is outcomes for irrigation participants had they been non-irrigators, the impact evaluation problem becomes that of missing data. Unless the irrigation project participation was randomized, the missing data is not random (Cuong,2007). Irrigators select into the project based on their decisions and project administrators' decisions, implying that project participation is non-random. Impact evaluation can be rigorous in identifying project impacts by using different models to construct comparison groups for participants (Khandker *et al.,* 2010). In light of these challenges, the data collected from sample households was analyzed by using both descriptive statistics and econometric analysis. The investigator also analyzed the qualitative data by narrative form.

Descriptive statistics like mean and percentages were used to examine and understand the socio-economic situations of the sample households. Moreover, t-test and chi-square test were used to compare irrigation users and non-users in terms of different explanatory variables. While econometric analysis (logit model) was used to identify the determinants of participation of small-scale irrigation. Endogenous switching regression (ESR) model was used to analyze the impact of the small-scale irrigation scheme on farmers' livelihood. For this study, income and fixed asset (evaluated at market price of survey period) used to measure their livelihood status. For quantitative analysis both SPSS and STATA software were used as tools of analysis.

3.5.1. Econometric Analysis

This paper pursued to examine the impact of small-scale irrigation on farmers' livelihood by examining their income and fixed asset formation of respondent's using Endogenous switching regressions model in the study area.

Contrasting, the previous studies those have been conducted in Ethiopia. This paper attempt to address the self-selection bias by using different indicators to measure the livelihood implication of small scale irrigation participation.

Endogenous switching regressions model: In the study area, the interventions of small-scale irrigation schemes were not randomly distributed and the decision to participate in small-scale irrigation farming is voluntary. Therefore, it should be emphasized that smallholder farmers may self-select themselves as the irrigation users. In this regard, they use irrigation, if they perceive that irrigation will provide them with more income and asset than rain-fed agriculture. Hence, it is not possible to directly compare income of the irrigation user and non-user households because of selection bias. This selection bias may result from both observed (observed to the researcher) and unobserved (observed to the respondent but not the researcher) characteristics. According to (Alene & Manyong, 2007) self-selection into an intervention utilization would be the source of endogeneity, and failure to account this bias would obscure the true impact of the intervention.

The major econometric problem in evaluating project impacts is selection bias (Maddala, 1983). Instrumental variables or statistical control methods, in which one uses one or more variables which matter to participation, but not to outcomes given participation. This identifies the exogenous variation in outcomes attributable to the program recognizing that its placement is not random but purposive. Measuring the impact of the program when treatment has not been randomly assigned is by using the instrumental variable (IV) method. The IV estimation regards the treatment variable as endogenous. The idea is to find an observable exogenous variable or variables (instruments) that influence the participation variable but do not influence the outcome of the program if participating (Khandker *et al;*2010).

Selection bias arises from the fact that treated individuals may differ from the non-treated for reasons other than treatment status. Smallholder irrigation usually purposively targets the poor,

which are more likely to be poor without access to irrigation (Baker, 2000). It is expected that irrigation participants would have had far less income in the absence of the irrigation project (Baker, 2000).

Selection bias could be as a result of selection on observables or unobservable. Selection on observables can be controlled by including all the variables in the model. Selection on unobservable is difficult to control by adding these variables as these variables are difficult to capture and not observed. Variables such as managerial ability, motivation, propensity to bear risks, etc., are some examples of variables that are hard to capture.

Selection bias can be overcome in three ways using instrumental variables, using panel data, or by assuming normality in the error distribution of the outcome variable before the treatment happens (Moffitt, 1991). Furthermore Holvoet (2005) recommended minimizing selection bias by gaining a good understanding of the subject under study and potential selection processes, which can help identify the persistent matching characteristics of participants and non-participants and controlling of other differences statistically. As a result, we looked at characteristics related to households, such as socioeconomic status and whether the household is an irrigation user or not, and whether program placement strategies is non-random or random. In this study, the endogenous switching regression model is used to minimize the problems of self-selection bias and unobserved characteristics.

ESR designs account for both endogeneity and sample selection bias by estimating a simultaneous equations model using full information maximum likelihood method (Lokshin & Sajaia, 2004). Moreover accounting for selection bias arising from unobserved factors that potentially affect both the decision to use irrigation and the outcomes, it controls for structural differences between the irrigation users and non-users regarding the outcome functions (Alene & Manyong, 2007). Therefore, the main significance of ESR is that it allowed us to control both selection and unobserved heterogeneity issues that may arise onwards doing the basic estimation procedure (Lokshin & Sajaia, 2004). Previous empirical studies have employed the framework to study the impact of an intervention on household livelihood and poverty (*e.g.* Owusu *et al*., 2011; Kuwornu and Owusu, 2012; Kidanemariam G. Gebrehiwot *et al*., 2017).

Following (Lokshin & Sajaia, 2004), in this approach, there are two stages, first the decision to use irrigation (selection equation) is modeled by standard limited dependent variable models, and second the outcome variables are then estimated separately for each group (as irrigation users and non-users), conditional on having the selection equation. Therefore, the selection equation is a dichotomous choice, where a smallholder farmer decides to use irrigation when there is a positive perceived difference between having the scheme and not having the scheme. Consider a farm household **i** that faces a decision on whether or not to use irrigation. Let the indicator variable be $\mathbf{S_i}$ taking a value of **1** for households who decided to use irrigation and **0** otherwise.

This leads to two possible states of the world: a decision to use irrigation ($\mathbf{S_i}$=1) and not to use irrigation (S_i=0), and two population units: irrigation users and non-users.

Let's denote the benefits to the household of using irrigation (U_1) and the benefits of the household not using irrigation (U_0). Under a non-random utility framework, a rational farm household will choose to use irrigation if the benefit of participation is positive i.e. $\mathbf{U_1 > U_0}$ or $\mathbf{U_1 - U_0 > 0}$.The net benefit ($\mathbf{U^* = U_1 - U_0}$) is represented by a latent variable.

Conditional on households' decision to use irrigation denoted by a selection function ($\mathbf{S_i}$), there are two potential outcomes to the two population units: the outcome of the irrigation user ($\mathbf{L_1}$) and the outcome of the non-user ($\mathbf{L_0}$). This can be put in a potential outcome framework as:

$$L_i = (1 - S_i)L_{0i} + S_i L_{1i}$$

$$L_i = \begin{cases} L_{1i} \text{ if } S_i = 1 \\ L_{0i} \text{ if } S_i = 0 \end{cases}$$

The gain from the intervention is provided as $L_1 - L_0$. Hence, taking a simple difference and averaging cannot give the effect of the intervention, causing a 'missing data' problem (Heckman *et al*; 2001). Therefore, following Lokshin & Sajaia (2004) the selection equation as latent variable framework can be expressed as:

$$S_i^* = \beta Z_i + v_i \qquad (1)$$

$$S_i = \begin{cases} 1 \text{ if } S_i^* > 0 \\ 0 \text{ if } S_i^* \leq 0 \end{cases}$$

Conditional on selection, the outcomes are represented by a switching regime as follows:

$$\text{regim 1: } L_{1i} = \begin{cases} Y_{1i} \\ F_{1i} \end{cases} = \alpha_1 \chi_{1i} + \varepsilon_{1i} \text{ if } S_i = 1 \quad (2)$$

$$\text{regim 2: } L_{2i} = \begin{cases} Y_{2i} \\ F_{2i} \end{cases} = \alpha_2 \chi_{2i} + \varepsilon_{2i} \text{ if } S_i = 0 \quad (3)$$

Where Z are vectors of observed characteristics that determine the selection equation (includes household, demographic, socioeconomic and farm characteristics); χ_{1i} and χ_{2i} are vectors of explanatory variables assumed to be weakly exogenous and determine the outcomes of irrigation users and non-users. Although, Z and X can overlap, but there must be at least one variable in Z is required not to be included in X to properly identify the outcome equations and α_1, α_2 and β are vector of unknown parameters to be estimated. The L_{1i} and L_{2i} are livelihood indicators (outcome variables), in this case, income and fixed asset for regime 1 and regime 2 respectively. According to this study, income (Y) and fixed asset (F) where Y_{1i} and F_{1i} represents income and fixed asset of the irrigation users respectively whereas, Y_{2i} and F_{2i} are income and fixed asset of the non-users respectively. The error terms of the continuous outcome equations (ε_1 and ε_2) and selection equation(v_i).

Following Foltz (2004), this paper, first assume that the unobserved residual effects of the selection equation are independent of unobserved residual effects of the outcome equations of the two regimes. That is

$$E[\varepsilon_{1i} | s_i = 1] = E[\varepsilon_{2i} | S_i = 0] = 0$$

$$\text{cov}(v_i, \varepsilon_i) = 0$$

This implies that sample partitioning between the irrigation user and non-user is entirely exogenous to their behavior so that an exogenous switching structure results. The unconditional expectation of these models can be expressed by Applying ordinary least squares to give consistent estimate of the α.

$$E(L_{1i} | \chi_{1i}) = \alpha_1 \chi_{1i} \quad (4)$$

$$E(L_{2i} | \chi_{2i}) = \alpha_2 \chi_{2i} \quad (5)$$

However, there is a high likelihood that uncontrolled factors (for example, expectation of yield gain from irrigation use, risk taking ability, managerial skills, and/or motivation) simultaneously influencing the selection equation and the level of outcomes (of both livelihood indicators), so that $\text{cov}(v_{i,} \varepsilon_i) \neq 0$. Under this scenario sample separation between the irrigation users and non-user households become endogenous to their behavior and governed by selection equation regime. Here, the paper assumed a trivariate normal distribution of error terms, with zero mean and a covariance matrix represented by Σ i.e. $(v, \varepsilon_1, \varepsilon_2) \sim (0, \Sigma)$. Further justification, the error term v of selection equation is correlated with the error terms ε_1 and ε_2 of outcome equations. Accordingly, the expected values of ε_1 and ε_2 would be non-zero conditional upon the selection equation. This makes ordinary least square estimates to be more biased. The covariance matrix Σ is expressed as follows:

$$\mathbf{cov}\,(v_i, \boldsymbol{\varepsilon_1}\ \mathbf{and}\ \boldsymbol{\varepsilon_2}) = \begin{cases} \boldsymbol{\sigma_v^2} & \boldsymbol{\sigma_{1v}} & \boldsymbol{\sigma_{2v}} \\ \boldsymbol{\sigma_{1v}} & \boldsymbol{\sigma_1^2} & . \\ \boldsymbol{\sigma_{2v}} & . & \boldsymbol{\sigma_2^2} \end{cases}$$

Where var $(v_i) = \sigma_v^2$ is the variance of the error term in the selection Eq. (1), var $(\varepsilon_1) = \sigma_1^2$ and var $(\varepsilon_2) = \sigma_2^2$, are the variances of the error terms in the outcome functions Eq. (2) and (3) respectively, and cov $(\varepsilon_1, v_i) = \sigma_{1v}$, cov $(\varepsilon_2, v_i = \sigma_{2v})$. Whereas, the cov $(\varepsilon_{1,} \varepsilon_2)$ is not defined, as L_1 and L_2 are never observed simultaneously (Lokshin & Sajaia, 2004) . σ_v^2=1, because β is estimable up to a scalar factor (Maddala, 1983).

The endogeneity can be tested with estimates of the covariance terms. If $\sigma_{1v} = \sigma_{2v} = 0$, one has a model with an exogenous switching; on the other hand, if either σ_{1v} or σ_{2v} is non-zero, one has a model with an endogenous switching (Maddala ,1986).Consequently, significance of the correlation coefficients between ε_1 and $(\mathbf{v}\ \boldsymbol{\rho_{\varepsilon 1 v}} = \boldsymbol{\sigma_{\varepsilon 1 v}^2 / \sigma_{\varepsilon 1} \sigma_v})$ and between ε_2 and v $(\rho_{\varepsilon 2 v} = \sigma_{\varepsilon 2 v}^2 / \sigma_{\varepsilon 2} \sigma_v)$ needs to be tested (Lokshin & Sajaia, 2004)**.**

Not that; in line with standard statically arguments, $\rho_{\varepsilon 1 v}$ and $\rho_{\varepsilon 2 v}$ must lie between -1 and 1, and σ_{1v} and σ_{2v} must be always positive

Based on the argument on the distribution of disturbance terms, the logarithmic likelihood function can be formulated following the procedure by (Lokshin & Sajaia, 2004) whom they depend their derivation on (Maddala, 1983).

$$\mathbf{lnL} = \sum_{\mathbf{i}} (\mathbf{S_i}\, \mathbf{w_i} \left[\mathbf{ln}\{\mathbf{F}(\boldsymbol{\eta}_{\mathbf{1i}}\} + \mathbf{ln} \left\{ \frac{\mathbf{f}(\frac{\boldsymbol{\varepsilon}_{\mathbf{1i}}}{\boldsymbol{\sigma}_1})}{\boldsymbol{\sigma}_1} \right\} \right] + (\mathbf{1} - \mathbf{S_i})\mathbf{w_i} \left[\mathbf{ln}\{\mathbf{1} - \mathbf{F}(\boldsymbol{\eta}_{\mathbf{2i}})\} + \mathbf{ln} \left\{ \frac{\mathbf{f}(\frac{\boldsymbol{\varepsilon}_{\mathbf{2i}}}{\boldsymbol{\sigma}_2})}{\boldsymbol{\sigma}_2} \right\} \right]$$

Where F (**.**) is a cumulative normal distribution function, f (·**)** is a normal density distribution function $\mathbf{w_i}$ is an optional weight for observation i, and

$$\boldsymbol{\eta}_{\mathbf{ji}} = \frac{(\boldsymbol{\beta}\mathbf{Z_i} + (\boldsymbol{\rho}_\mathbf{j}\boldsymbol{\varepsilon}_{\mathbf{ji}}/\boldsymbol{\sigma}_\mathbf{j})}{\sqrt{\mathbf{1}-\boldsymbol{\rho}_\mathbf{j}^\mathbf{2}}} \quad \text{Where j =1, 2}$$

In addition to the endogeneity test, $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{1}v}$ and $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{2}v}$ provide economic interpretation depending on their signs. If $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{1}v}$ and $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{2}v}$ have opposite signs, households decide whether to have irrigation or not based on a comparative advantage (Fuglie & Bosch, 1995; Maddala, 1983).That is, irrigation users enjoy above average income and fixed asset holding once having irrigation whereas, non-users enjoy above income and fixed asset when not having irrigation. Alternatively, if $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{1}v}$ and $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{2}v}$ have the same signs, it demonstrates "hierarchical sorting" (Fuglie & Bosch, 1995) , suggesting that the irrigation users income is above the average level whether or not they have irrigation but get better off having than not having. Similarly, the non-user's income is below the average level in either case but get better off choosing not having irrigation. Moreover, the coefficient $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{1}v}$ and $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{2}v}$ can give evidence for model consistency under a condition $\boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{1}v} < \boldsymbol{\rho}_{\boldsymbol{\varepsilon}\mathbf{2}v}$ (Trost, 1981). This implies that the irrigation user enjoys income and fixed asset level than they would if they did not have irrigation.

The key issue in controlling for the endogeneity of the selection equation is identification. It is necessary of finding instrumental variables that could be strongly correlated with the selection equation (Eq. 1) but not the livelihood outcome equations (Eq.3 and 4). From the variables in our data set, this study uses distance from household's residence to the irrigation scheme and social participation as instrumental variables are properly identify the model. In developing countries, social networks, such as irrigation, peasant and cooperative association, friends are the main source of information and confidence in the process of technology or new practice. Hence the existence of social participation (farmer –to- farmer contact) is expected to influence to use irrigation scheme, but not the income and asset holding of households. Following (Di Falco *et al;*2011), the validity of the selection instruments was tested. According to his argument, a variable is a valid selection instrument, if it will significantly affect the selection

variable but it will not affect the income households and fixed asset that did not use irrigation (appendix 3).

The average treatment effect on the treated (ATT) and untreated (ATU) were computed by comparing the expected values of the outcome of the irrigation user and non-user households in actual and counterfactual scenarios. The estimates from endogenous switching regression allow for the computing of the expected values in the real and hypothetical scenarios: Following model estimation, Stata allows calculation of the following conditional expectations (Lokshin & Sajaia, 2004).

Actual expected outcome: irrigation users

$$E(L_{1i}|S = 1, \chi_{1i}) = \alpha_1\chi_{1i} + \sigma_1\rho_1 f(\beta)/F(\beta Z_i) \quad (6)$$

Counterfactual expected outcome: irrigation users

$$E(L_{1i}|S = 0, \chi_{1i}) = \alpha_2\chi_{1i} - \sigma_1\rho_1 f(\beta Z_i)/\{1 - F(\beta Z_i)\} \quad (7)$$

Counterfactual expected outcome: non- users

$$E(L_{2i}|S = 1, \chi_{2i}) = \alpha_1\chi_{2i} + \sigma_2\rho_2 f(\beta Z_i)/F(\beta Z_i) \quad (8)$$

Actual expected outcome: non-users

$$E(L_{2i}|S = 0, \chi_{2i}) = \alpha_2\chi_{2i} - \sigma_2\rho_2 f(\beta Z_i)/\{1 - F(\beta Z_i)\} \quad (9)$$

Equation (Eq. 6) and (Eq. 9) represent the actual expectations observed from the sample, while (Eq. 7) and (Eq. 8) are the counterfactual expected outcomes. Given the above formulation, the following mean outcome difference can be calculated and compared. The expected change of irrigation users that means the effect of treatment on the treated (ATT) is computed as the difference between Eq. (6) and (7):

$$ATT = E(L_{1i}|S = 1, \chi_{1i}) - E(L_{1i}|S = 0, \chi_{1i}) \quad (10)$$

Similarly, the expected change in the non-users, the effect of the treatment on the untreated (ATU) is the difference between Eq. (7) and (9):

$$ATU = E(L_{2i}|S = 1, \chi_{2i}) - E(L_{2i}|S = 0, \chi_{2i}) \quad (11)$$

The treatment effects can be differentiated from the heterogeneity effect because the presence of unobservable characteristics. Therefore, "the effect of base heterogeneity" (BH_u) for the group of households that decided to use irrigation is defined as the difference between (Eq.6) and (Eq.7):

$$BH_u = E(L_{1i}|S = 1, \chi_{1i}) - E(L_{1i}|S = 0, \chi_{1i}) \quad (12)$$

Similarly, "the effect of base heterogeneity" (BH_N) for the group of households that decided to not to use irrigation is defined as the difference between (Eq.8) and (Eq.9)

$$BH_N = E(L_{2i}|S = 1, \chi_{2i}) - E(L_{2i}|S = 0, \chi_{2i}) \quad (13)$$

Finally, the effect called "transitional heterogeneity" (TH), estimates whether the effect of having irrigation is larger or smaller for households that use irrigation or for the households that did not use in the counterfactual case that they did use. It is the difference between (Eq.10) and (Eq.11), i.e. (ATT) minus (ATU):

$$TH = ATT - ATU \quad (14)$$

Table 3. Conditional expectations, treatment and heterogeneity effects

Subsamples	Decision stage		Treatment effect
	To use irrigation	Not to use	
Households use irrigation	(a)$E(L_{1i}\|S_i = 1)$	(c)$E(L_{2i}\|S_i = 1)$	ATT
Households not use irrigation	(d)$E(L_{1i}\|S_i = 0)$	(b)$E(L_{2i}\|S_i = 0)$	ATU
Heterogeneity effects	BH_u	BH_N	TH

Note :(a) and (b) represents observed expected income of irrigation user and non-user ;(c) and (d) represents counterfactual of irrigation user.

Source: Authors' illustration, 2018

3.6. Definition of Variables and Hypothesized Relationships

3.6.1 Description of the dependent variables

The endogenous switching regression model is simultaneously determined the selection and outcome equations. The dependent variables of this model is the selection variable (use of irrigation), which is a dummy variable taking a value one if the household use irrigation and zero otherwise.

3.6.2. Outcomes Variables

Income (Y): the main indicator of the irrigation represents the amount of income the farmer or any of the household members earned (in cash or in kind) from their farm production, non-farm income and off-farm income. It is measured by the amount earned per year from those sources in birr.

Fixed Asset (F): Household physical asset (such as build houses, furniture, livestock breed, electronics, Grain milling, farm materials like motor pumps,) are among the asset that evaluated at market price of during survey period measured in birr.

3.6.3. Description the Independent Variables

The independent variables that are hypothesized to affect the farmers' decision to use small-scale irrigation and level of income and fixed asset are combined effects of various factors such as: demographic, socio-economic and institutional factors in which smallholder farmers operate are hypothesized to explain in the study area. Based on past research findings, the affect the decision to use irrigation and both outcome variables used for this study, are presented as follows:

Age (AgeHH) and Age square of the household head (AgesqHH): It is continuous variable measured in years. Age of a household head can generate confidence on new technologies. According to Motamed & Baldev (2003), young people are more flexible in deciding for change than aged people. Therefore, at younger ages the probability of using irrigation will increase and simultaneously, increase income and fixed asset holding positively. On the other hand, as the farmer gets older and older his managerial ability and physical capacity are expected to decrease as a result the overall labor hours will decline and the demand for leisure will increase and older the household head the less inclined he is to adopt new irrigation

technology (Phoeb *et al;* 2000). Hence, age square is hypothesized to have negative effect on farmers' decision to use irrigation and simultaneously, income and asset formation.

Sex of the household (Sexhh): This is a dummy variable, which takes 1 if sex of respondent is male, 0 otherwise. Since the participation of women both on farm and off farm activities are by far limited due to cultural impediments than male, female headed households are expected to be less participated in micro irrigation than male headed households.

Adult Lab our (Adult lab): It refers to active family members of a household. Availability of labor is likely to influence the gross margin of different technology innovation. This indicates that households with large number of active family members will supply more labor for different activities and want to diversify their capital need. Therefore, a farm with larger number of workers is more likely to be in a position to continue using a potentially profitable innovation technology. Therefore, it is hypothesis that, adult lab our positively influences the decision to use irrigation, and income and fixed asset formations.

Education Level of the household head (EDLVHH): It is a dummy variable, which takes 1 if the respondent can read and write, 0 otherwise. Educated farmers would more readily adopt irrigation technologies and may be easier to train through extension support. Therefore, use of irrigation needs technical knowhow, head of the household need to read and understand some guiding irrigation materials. Therefore, education level increases smallholder farmers' ability to obtain, process, and use information relevant to the participation of small-scale irrigation use. Thus, it is hypothesized that literate household heads are more likely to use irrigation and expected to have a positive relationship with household income and fixed asset formation.

Size of own cultivated land (owncultland): It refers to the total cultivated land size (both irrigated and rain fed) of a household measured a continues variable measured in hectare. This means that those households having more cultivated land are active to adopt new technology and want to diversify their farming activities. As most of the households in the study area are smallholders, one of the possible ways to increase their output is by intensive farming. Hence, this variable is hypothesized to have a positive effect on participation in the irrigation and increases income and fixed asset formation.

Distance to the irrigation scheme (dischme): This variable is a continuous variable measured in kilometers. Distance of the households to the water source is expected to determine the household's use of irrigation. The residence of households nearby irrigation scheme is expected to have positive relation to the probability of use of irrigation. The nearer the households" residence to a water source, the higher the probability he/she has to use irrigation, due to the fact that the opportunity cost of time lost in travelling to and from an irrigation farm for households. Hence, it is expected that the distance of residence from the scheme and the use of irrigation are negatively related.

Social participation(socialpart): This is a dummy variable with 1 for participated and 0 otherwise. Farmers Participation and membership in different community organization assume that farmers who have some position in rural kebele's and different cooperatives are more likely to be aware of new practices as they are easily exposed to information. (like irrigation, peasant and cooperative association) assume that more likely to be aware of new practices as they are easily exposed to information (Habtemariam Abate, 2007). Therefore, hypothesized that those farmers who participated in some social organization as a member or leader are more likely to participate in irrigation and are positively related but no effect on income and fixed asset formation.

Access to credit (Accesscr): This is a dummy variable with 1 for user and 0 otherwise. Those households, who have credit user, spend on activities they want. Either they purchase agricultural input (improved seed, fertilizer, etc.,) or they purchase livestock for resale after they fattened them. All these activities increase income of the household. Previous research result reported by Tesfaye & Alemu (2001) confirmed that access to credit positively influence adoption of technology. Those households who have access to credit became capable of using irrigation than those who have no access to credit. Hence, it is expected that, access to credit will have a positive relation with the use of irrigation, increased income and fixed asset buildings.

Livestock owned (TLU): Livestock is the farmers' important source of income, food and draft power for crop cultivation. Hence, a household with large livestock holding can have good access for more draft to take its product market. Like many other similar studies, it was measured in terms of Tropical Livestock Units (TLU) developed by Storck *et al*.(

1991).Livestock are source of income for farming households through sales and income generation for any possible spending in the use of technologies. Previous research result reported by Tesfaye and Alemu (2001) confirmed that livestock holding have positive influence on technology adoption. The positive relationship indicates that households with larger livestock holding may have money to spend on any possible cost to adopt technology. Therefore, it is expected that, total livestock owned and use of irrigation are positively related.

Distance from the nearest market (Distmkt): This is continuous variable that measured in kilometers. Easily access of market is important to buy input and/or to sell output as well as to purchase food and nonfood products. The closer the respondents to the market, the more likely it is that they will receive valuable information (Gecho & Punjabi, 2011).The farther the households home to the nearest market the lesser the income from the sale of farm produce, especially perishable commodities may perish before arriving the market if the distance is too far. Hence, to avoid such incidences, the farmer may sell his output to the neighbor traders for cheaper price, that reducing his income. Therefore, distance from nearest market is hypothesized to influence negatively the farmers' decision to use irrigation, income and fixed asset building.

Off-farm job participation (off part): It is a dummy variable, which takes 1 if the respondent has participated in to off-farm activities, 0 otherwise. Participation into off-farm job is an income diversification strategy for households that have the possibility to sell their labor on the non-farm labor market (Yee *et al;*2004). Hence, farmers engaged in off-farm activities appear to be less likely to participate in irrigation, suggesting that participation in off-farm activities may be restricting the allocation of labor to farming activities, which in turn, negatively influence the adoption of irrigation farming. Therefore, it is expected to influence the decision to use irrigation negatively whereas, positively influence income and fixed asset formation.

Extension contact (Extencontact). This refers to the number of contacts the respondents made with extension agents with a year. The effort is to disseminate new and improved agricultural practices within farmers. This means farmers, who have frequent contact with extension agents, can develop their knowledge and decision making ability to easily adopt new technologies and technical skills. Therefore, it is hypothesized that the number (frequency) of extension contact positively influences the decision to use irrigation, income and fixed asset formation

Table 4 .The description of variables and their measurements used in ESR

Variable code	Type	definition of variables	Measurement	Expected sign in the selection equation	Expected sign in income equation	Expected sign in fixed asset equation
Agehh	Continuous	age of household head	In years	-	-	-
Agesqhh	Continuous	age of household head	In years	-	-	-
SexHH	Dummy	Sex of household heads	1 if male, 0 otherwise	+	+	+
HHSize	Continuous	Household size	Number	+	+	+
HHedu	Dummy	level of Education	1 literate, 0 otherwise	+	+	+
Adultlab	Continuous	Adult lab our	Adult equivalent	+	+	+
Owncultland	Continuous	cultivated land	Hectare	+	+	+
Dischemе	Continuous	Distance from home to scheme	Kilometers	-	No effect	No effect
Accredit	Dummy	Credit user	1 if user, 0 otherwise	+	+	+
Farmexp	Continuous	Farm experience (Age as proxy)	In years	+	+	+
Livestock	Continuous	livestock owned	TLU	+	+	+
Offpart	Dummy	off farm job participation	1 if yes, 0 otherwise	-	+	+
Distmkt	Continuous	distance from respondents' home to local market	Kilometers	-	-	-
Extncont	Continuous	Number of visits by extension agent	Number	+	+	+
Socialpart	Dummy	Social participation	1 if yes, 0 otherwise	+	No effect	No effect

4. RESULTS AND DISCUSSION

This Chapter presents and discusses the results on the socio-economic characteristics of rural livelihoods, determinants of household participation in irrigation and analysis of the impact of small scale irrigation on farmers' livelihood.

Section 4.1 provides the descriptive analysis of model variables, section 4.2, presents constraints of irrigation farming. Section 4.3, deals with econometric analysis logit regression and ESR models.

4.1. Descriptive Analysis

Descriptive analysis of selected demographic and socioeconomic characteristics of sample households. Accordingly, the t-test is used to test the significance of the of continuous variables while chi-square test is used to test the significance of the potential dummy variables.

4.1.1. Household Demographics and Socio- economics Characteristics

Some demographics and socio economic characteristics of the sample population of the irrigation users and non-users with comparison group are presented in (Table 5 and Table 6) for continuous and categorical variables, respectively. The sample under consideration is composed of 96 (37.2%) irrigation-users and 162 (62.8 %) non-user households (Table 5).

The average age of household heads of the irrigation user is nearly 39.5 years while that of the non-user is approximately 45.7 years (Table 5). The mean comparison test shows there is statistically significant difference in the distribution of household head age between user and non-user household heads.

In the study area, the average household size of the treatment (irrigation user) was 4.4 and control group (non-users) was found to be 4.7. The mean comparison test shows that there is significant difference in household size between user and non-user groups at 1% level of significance.

Table 5.Summary statistics for continuous variables of the Household characteristics

Variable	**User** (N=96)	**Non-user** (N=162)	**Combined**	**Difference**
	Mean	Mean	Mean	Mean
Agehh	39.5	45.7	43.4	-6.2***
	(.658)	(.690)	(.532)	(1.030)
Agehh2	1618.1	1862.3	1771.4	244.2*
	(56.38)	(71.73)	(50.15)	(102.84)
HHsize	4.4	4.7	4.6	-.26***
	(.117)	(.102)	(.078)	(.160)
Adaltlab	4.3	4.1	4.2	.2*
	(.118)	(.077)	(.065)	(.135)
Owncultland	1.4	1.04	1.1	.36***
	(.024)	(.024)	(.020)	(.036)
Farmexpe	22.1	22.1	22.1	.079
	(.525)	(.734)	(.500)	(1.036)
Dischme	1.7	3.3	2.7	-1.6***
	(.062)	(.040)	(.061)	(.070)
Tlu	5.3	4.8	5.04	.5*
	(.175)	(.134)	(.107)	(.220)
Distmkt	4.76	4.77	4.76	-.011
	(.162)	(.104)	(.088)	(.183)
Extncont	7.10	7.08	7.09	.02
	(.086)	(.110)	(.076)	(.158)

*** p<0.01, ** p<0.05, * p<0.1 represents levels of significance. The values in the parenthesis are standard errors

Source: Computed from own survey data, (2018)

Adult labor of the irrigation users was approximately 4.3 compared with the non-users 4.1. The size of labor force in the household is expected to contribute for variation on participation decision in small-scale irrigation and level of income. The mean comparison test shows that

there is significant difference in adult labor between user and non-user groups at 10% level of significance (Table 5). According to FGD report, in the study area, labor is highly required in time of weeding, harvesting, threshing, watering, livestock herding and ploughing, especially in time of watering for irrigation users because it is a daily and year round activity.

Cultivated land appears to be the most important scarce factor of production. In the study area, own land, rented and shared lands was used for cultivation. The average owns cultivated land holding of the sampled households was 1.37 hectare. In comparing with the user and non-user, the average cultivated land size of the irrigation user was 1.4 ha and the non- users was 1.34ha (Table 5). The mean comparison test revealed that means difference between the two groups with regarding land holding sized is statistically significant at 1 % significance level. According to FGD report, in the study area, own land, rented land, shared cropping lands and gift lands are a common practice of farming. Shared cropped land and rented land are mainly done through contractual arrangements to share the harvest and tends to occur when the owner of the land cannot cultivate by himself/herself. Mostly, the agreement is for a short temporary period (e.g. one year or two to three years) on the basis of money (rented) or different crop sharing agreements.

Farm animals have an important role in rural livelihood. They are source of draught power, to supplement protein needs, as prestige, cash, animal dung for organic fertilizer and means of transport. Like many other similar studies, it was measured in terms of Tropical Livestock Units Storck *et a*l.(1991) see (appendix18). The number of livestock owned by a farmer was hypothesized to be positively related to the adoption of small scale irrigation. The average livestock holding of respondents was 5.04 TLU (Table 5). The mean comparison test result showed that the two groups with regard to livestock holding is statistically significant.

Distance of irrigated land from water sources in comparison with irrigation status, non-irrigation users are located far away from the irrigation scheme with an average distance of 3.3 km compared to users 1.7 km. The mean comparison test result of the two groups with regard to distance to the irrigation scheme is statistically significant (Table 5).

Sex of the household is an important variable determining the decision to use irrigation. With regard to gender of household heads, female headed households accounted for approximately

16% in both user and non-users. About 94% of the user households were male-headed and hence there is a significant difference in the distribution of the gender of household heads between participant and non-participant. This show as that female households have lower participation in irrigation (Table 6). According to FGD and KI report, in the study area, female headed households hardly faced labor shortage for irrigation as well as rain-fed farming due to physical, technological, socio-cultural and psychological fitness of farm instruments to females than males. To overcome the challenge, different governmental and non-governmental organizations were given training, demonstration, irrigation technology and improved seed for female household heads. This motivates them to use irrigation farming as male headed households and increases their income and fixed asset formation

Table 6.Summary statistics for categorical variables on household by access to irrigation

Variables	Categories	User (96)		Non –user (162)		Combined		x^2-test
		Freq.	%	Freq.	%	Freq.	%	
Sexhh	0=Female	6	(6)	29	(22)	35	(16)	6.978***
	1=Male	90	(94)	133	(78)	223	(84)	
Edu level	0 = Illiterate	54	(57)	123	(76)	177	(69)	10.834***
	1= literate	42	(44)	39	(24)	81	(31)	
off job participation	0=No	60	(62)	40	(25)	100	(38)	36.302***
	1=yes	36	(38)	122	(75)	158	(62)	
Social part	0=No	17	(18)	106	(65)	123	(48)	55.034***
	1=yes	79	(82)	56	(35)	135	(52)	

*** p<0.01, ** p<0.05, * p<0.1 represents levels of significance. The values in the parenthesis are percentages.

Source: Computed from own survey data, (2018)

It is widely believed that education level of household heads is a decisive factor in affecting the adoption of irrigation technologies and improving agricultural productivity. The education level of household heads was found to be higher for irrigating households. The chi-square test revealed that there is relationship between education level and use of irrigation at 1 %

significance level (Table 6). This indicates that household heads with more years of schooling would be expected to better visualize the benefits of irrigation and the more easily they adopt and utilize agricultural technologies.

Off-farm income participation of the households the survey result revealed that 38.7 % of sampled respondents had no off-farm job (Table 6). In comparison to irrigation access 38 % of the irrigation users and 75% of the non-users had off-farm job. The chi-square test result revealed that significant relationship between use of irrigation and access to off farm income.

Credit is the main source of finance for poor farmers to purchase input and ultimately to adopt new technology. The main source of credit in the study area is Amhara Credit and Saving Institution (ACSI) and saving and credit cooperatives. The survey revealed that 41 % of the sample households take credit. The comparison by access to irrigation the survey result revealed that 58 % of the irrigation users and 31% of the non-users had utilized credit, while 42 % of the irrigation users and 69 % of the non-users did not take credit. The chi-square test revealed that significant relationship between access to credit and use of irrigation at 1 % significance level (Table 6).

Farmers Participation and membership in different community organization assume that farmers who have some position in rural kebele's and different cooperatives are more likely to be aware of new practices as they are easily exposed to information. The survey revealed that 52 % of the sample households actively participate in in different community organization. About 79 % of irrigation user participated in different community organization as leader, committee members and members. The chi-square test revealed that there is a significant relationship between social participation and use of irrigation at 1 % significance level.

4.1.2. Household Income Sources

In the study area respondents depend on agriculture for their livelihood, employment, income generation, food and non-food production and consumption.

Crop income (irrigated and rain-fed crops), off-farm and non-farm income were the source of income in the study area. As stated in (Table 7), In the study area, as it is observed from the survey results the relative share of income from cereal to the total annual household income is

the largest. Hence, cereal production is the most important source of income in the study area. It is followed by livestock production, off-farm and non-farm respectively.

Table 7.Household income comparison level by Birr

Income gained from	User (N=96)	Non –user (N=162)	Combined	Difference	t- test
	Mean	Mean	Mean	Mean	
Crop income	80468.3	30056.6	48814.4	50411.7	-15.957***
	(2378.8)	(1981.4)	(2152.5)	(3159.1)	
Off- farm income	6979.9	8793.3	8118.5	-1813.3	0.951
	(1915.6)	(929.4)	(920.6)	(1904.8)	
Livestock and livestock	10965.4	11113.7	11059.8	-148.3	0.035
product income	(3899.2)	(2243.2)	(2007.4)	(4181.2)	
Non-farm income	965	787	853	-178	-1.013
	(161.4)	(95.9)	(85.03)	(175.9)	
Total income	98921	50682	68632	48239.9	-8.987***
	(4477.3)	(3167.7)	(2969.8)	(5367.2)	

*** p<0.01, ** p<0.05, * p<0.1 represents levels of significance. The values in the parenthesis are error.

Source: Computed from own survey data, (2018)

Irrigating households had significantly (at 1% levels) higher farming income and total income than only rain-fed farming households. The survey result revealed that the mean annual crop income of the users was ETB 50411 (168%) higher than non- users (Table 7).The result is consistent with (Kinfe Aseyehegn *et al., 2012*; Woldegebrial Zeweld *et al;* 2017) they found similar results in Northern Ethiopia. The mean off-farm income, Livestock and livestock product income and off -farm income on the other hand, was higher for rain-fed households compared to irrigating households, although no significant difference was observed. This result is in line with Gebregziabher & Namara (2008) found that no significance difference income of non-farm activities.

Furthermore, the irrigation users had ETB 48239 (95%) far higher annual mean total income compared to non-users (Table 7). Hence, the descriptive result analysis suggests that the irrigation user households have earned more income on average and can enjoy a higher standard of living and better quality of life than the non-users assuming other variables remaining constant. This survey result is similar to (Ayana Anteneh, 2016; Dereje Magisite and Desale Kidane, 2016).

4.1.3. Household Physical Asset and Saving

Household assets are vital resources for livelihood improvements. Respondents physical asset (such as build houses, furniture, livestock breed, electronics, Grain milling) are among the respondent's asset that are evaluated at market price of during survey period measured in Birr.

Table 8.Asset possessions and saving mean comparison result

Variable	User (N=96)	Non-user (N=162)	Combined	Difference	t- test
	Mean	Mean	Mean	Mean	
Saving	4625	1253.7	2508.1	3371.3	-6.2652***
	(563.5)	(245.5)	(278.8)	(538.1)	
Asset value	98681	30067	55598	68614	-85.4646***
	(573.2)	(516.2)	(2104.7)	(802.8)	

*, ** and *** represents significance at 0.1,0.05 and 0.01 levels respectively. The values in the parenthesis are standard error.

Source: Computed from own survey data, (2018)

Assets can help the poor to meet their present and future needs, enhance their wealth and reduce their exposure to external risks and shocks. In a rural setting where secondary asset markets are absent or poorly developed, it is difficult to ascertain the resale values of assets accurately (Barrett et al;2001).However , respondents were asked to list the their asset and evaluated at the current market value during survey period .

As shown in (Table 8) the mean asset value of household assets owned by the user is ETB 68614 (228%) higher than the non-user. The t-test result revealed that the asset holding between

irrigation user and non-user found to be significant at 1 % probability level relative to the comparison group whose asset ownership is concentrated in the basic household items. This result shows that, participation of small scale irrigation allows households to promote and expand their assets and activities which in turn improve their livelihood. This results similar with (Kidanemariam G. Gebrehiwot *et al*, , 2017).

Saving allow savers to conveniently and safely accumulate surplus funds to create financial and livelihood stability. The average saving for the sample respondents who save during the past 12 months prior to the survey was found to be 2508 ETB. As shown in (Table 8), the mean saving for the user is higher than the non-user by (3371 ETB), the mean difference using t-test was found to be statistically significant at 1 % probability level.

In summary, the descriptive statistics indicate that irrigators are better off in terms of income and fixed asset formation other livelihood indicators. But this does not imply that the difference is solely due to access to irrigation. Other factors (both observable and unobservable) might have contributed to the income and asset or livelihood status difference between irrigators and non-irrigators.

4.2. Constraints Encountered in Small Scale Irrigation

The problems of small-scale irrigation technology development range from individual households biased attitudes to institutional arrangements. The major problems encountered in small-scale irrigation in the study area are problems related to cost, institutional problems, the policy environment and environmental problems.

The survey result with focus group discussion and key informant interviews indicates that small-scale irrigation's great benefit is accompanied with various problems. The problems associated with small scale irrigation farming, in the study area, were, presence of pests and diseases, lack of access to market for farm product at production seasons, lack of sufficient irrigation water, lack modern inputs such as improved seed (Table 10). Out of this problems mentioned here above 84.4 % of the respondents have stressed on the problem of lack of access to market, the presences of pest and disease are the major once. Alongside to these all problems the importance of small scale irrigation in the study area has significantly increased year after year. The result in line with (Ayana Anteneh, 2016; Chazovachii 2012, Hadush Hailu, 2014).

Table 9.Major constraints of small scale irrigation farming in the study area

Major Constraints in small scale irrigation	Small scale irrigation users	
	Observation	Percent
Water	65	67.7
Lab our	28	29.2
Credit	17	17.7
Market	81	84.4
Pest and disease	94	97.9
Input	71	74

Source: Computed from own survey data, (2018)

4.3. Econometric Results and Discussion

4.3.1 Factors influencing participation in Irrigation

The binary logit model was estimated to find out the main determinants of farm households' decision to use irrigation presented in (Table 10).

Link test was done to determine the association among the independent variable (Pregibon, 1979; Tukey, 1949). The values of the link test, in the logit regression model looks every bit as reasonable as the original model. The link test reveals no problems with our specification having seen a dataset, as shown in the (appendix 1 and 2). More over the of the link test p value (0.990) is statically insignificant means there is no enough evidence to say that the model is miss specified. Therefore, the irrigation decision model can be explained through the included explanatory variables. Additionally, the Pseudo R-square indicates that about 84.5% of the variation in the irrigation decision model can be explained through the included explanatory

variables. The overall model is statistically significant at a P-value of 0. 000.Hence, the chosen observable characteristics adequately explain the probability of participation (Table 10).

The output of the binary logit model showed that seven variables were identified as significant variable out of the fourteen hypothesized variables that affect the household participation decision in the irrigation scheme in the study area. These are age of the household (Agehh) and age square of the household(Aghh2), adult labor (Adult labor), off farm job participation (offpart), extension contact(Extencontact), distance from homestead to market (Distmkt), distance from homestead to scheme (Dischme) in (Table 10).

Age of the household. The sign of this variable is consistent with the prior expectation that means negatively and significantly influenced the probability of household heads to use irrigation at 1 % significance level. This may be because the use of irrigation is labor intensive and exhaustive work that the older household heads cannot tolerate this challenge. In another way the negative sign indicates that younger farmers use irrigation than the older farmers. (Phoeb et al., 2000) also found that the older the household head the less inclined to adopt new irrigation technology. The marginal effect also confirms that age of the household head increases by 1 year to certain level, the probability of participation in small scale irrigation would decreased by 3 %, other variables in the model remaining constant.

Adult labor: The model result shows that adult labor had positive and statistically significant effect on the decision to use irrigation at 5 % significance level. Due to the reason of, irrigation is mostly labor intensive; farm households with more adult labor are more likely encouraged in the use of irrigation. The marginal effect of this variable also revealed that a unit change in adult labor of the household head the probability of participation would increase by 3.7 % other variables in the model remain constant. This finding is in line with the previous studies conduct (Kidanemariam G. Gebrehiwot *et al*;2017; Woldegebrial Zeweld *et al*;2015) they found that adult labor positively and significantly increases the probability of participation in irrigation practicing in the northern part of Ethiopia. In contrast, Anwar Alamin (2014) was found that adult labor significantly and negatively correlate to irrigation participation.

Off-farm job participation; was found negative and significantly affects the decision to use irrigation at 5% significance level. Thus, farmers engaged in off-farm activities less likely to participate in irrigation. Participation in non- farm activity may restrict the allocation of labor to farm activities. The marginal effect of this variable also confirms that household heads that are engaging in non-farm participation are 6.5 % less likely to participate in small scale irrigation than those household heads that have not participated in non-farm activities. Similar result reported by (Awudu & Wallace, 2014, Gebregziabher & Namara,2008) whereas, Ayana Anteneh (2016) and Hadush Hailu (2014) found that off-farm activities positively affect the level of irrigation participation.

Extension contact: the finding shows that positive and significant effect on the decision to use irrigation at 5% significance level. It indicates that sampled households having more number of contacts with development agents are more likely to use irrigation compared to households with no or little extension contact of their counterparts. This result is consistence with Sikhulumile et al. (2014) found that farmers experience on extension service and access to updated information leads the probability of adopting new technology. The marginal effect of this variable also revealed that the probability of using irrigation increased by 3.4 % as household have extension contact. Moreover , this finding is in line with (Fekadu Abdissa *et al*;2017; Anwar Alamin, 2014) they found positive and significant effect of number of extension contact on the decision to use irrigation.

Distance from residents' homestead to nearly local market: The model result shows that distance from resident's homestead to nearly local market negatively and significantly affected household's participation decision at 5% significance level. As the distance far from the homestead of households, incur high marketing and transportation cost while producing and marketing farm products inconvenience of in transporting perishable products. The households might choose to sell their product with cheaper price to neighbor traders. The marginal value of this variable suggests that for one kilometer distance from a market a household resides the possibility of partaking in irrigation scheme decreases by 2%. Therefore, households that are far apart from the local market might discourage to use irrigation. This result is in line with other studies conducted by (De Haan, 2012; Fekadu Abdissa *et al;*2017; Sikhulumile *et al*;2014;

Woldegebrial Zeweld *et al*; 2017) and suggests that the better the household head had the market they are more probable to participate in irrigation practices

Table 10.Marginal effects from logit estimation for determinants of participation in irrigation

Variable	Marginal Effects	Std. Err.	Z	P>z
Agehh	-.0307	0.3344	-3.10	0.002***
Agehh2	.0003	0.0033	3.12	0.002***
Sexhh	.0141	1.0057	0.47	0.635
Adaltlab	.0374	0.6235	2.03	0.042**
Foredu	-.0009	0.9954	-0.03	0.974
Owncultland	-.0042	1.2693	-0.11	0.911
Farmexpe	.0007	0.1206	0.20	0.842
Tlu	.0065	0.2231	0.99	0.322
Accesscr	.0281	0.8801	1.08	0.280
Offpart	-.0651	0.9122	-2.41	0.016**
Extencontact	.0348	0.5013	2.35	0.019**
Distmkt	-.0219	.4008	-1.85	0.064*
Dischme	-.1547	1.1647	-4.49	0.000***
Socialpart	.0315	.8549	1.25	0.212
_cons	-	8.9568	2.93	0.003
Observations			258	
LR chi2(14)			288.09	
Prob > chi2			0.0000	
Pseudo R2			0.8458	
link test P-value			0.990	
Log likelihood			-26.2529	

*** p<0.01, ** p<0.05, * p<0.1 represents levels of significance.

Source; own survey result (2018).

Distance of residence from irrigation scheme: had negative and statistically significant effect on household's decision to use irrigation at 1% significance level. The negative relationship tells us that when the household head's residence is far from the irrigation scheme; the household heads have less probability to use irrigation. The marginal effect also describes that when a household became far from water source by 1 kilometer, the possibility of partaking in irrigation scheme decreases by 15.4%.The result is consistent with the finding of (Kuwornu & Owusu, 2012; Owusu et al., 2011).They found a negative and significant effect of distance from irrigation scheme to homestead in Ghana. Similarly, in Ethiopia, (Fekadu Abdissa *et al.,* 2017; Kidanemariam G. Gebrehiwot *et al.,* 2017) were found similar results.

4.3.2. Impact of Small-Scale Irrigation on Livelihood Improvement

Small scale irrigation has multi-dimensional impacts on the livelihood development of the rural people. Irrigation has positive impact on food security, asset ownership and well-being of rural farm households; there are clear increases in agricultural production through diversification and intensification of crops grown, household income, sources of animal feed, human health improvements, and asset ownership (Tilahun & Paulos, 2004; Tucker & Yirgu, 2010).

The principal objective of this study is to show if there is any considerable impact of small-scale irrigation on household's livelihood. To this end, an effort was made to examine whether the irrigating farmers had been aware of the changes in their mode of life or not. Income and fixed asset holding were livelihood indicators of the study; estimated using the selection equation as bases of separation across the two groups of households (users and non-users) and the estimation was carried out by using ESR model with full information maximum likelihood (FIML) procedure presented in (Table 11). As expected, the model diagnostics are satisfactory. Wald chi2 (11) indicates the overall fitness of the model at less than 1% significance level for both outcome variables. The likelihood ratio test of independence equations for both (income and fixed asset conditional on the selection equation) test reported in (Table 11), rejects, the hypothesis that the three equations are jointly independent.

The correlation coefficients were significant at 1% significance level for both income and fixed asset. Moreover, this result suggests that the three equations were jointly dependent, providing evidence of endogeneity that needs to be controlled in the model specification of income and

fixed asset equations. Moreover, the estimated coefficient of correlation between the selection equation and the household income (ρ_{1Y}) and fixed asset (ρ_{1F}) of irrigation users were negative and statically significance at 1% and 5% respectively, indicating a failure to reject the hypothesis of sample selection bias (Table 11).This confirms the presence of selection bias suggesting that addressing the self-selection bias issue by accounting for both observable and unobservable factors are a prerequisite for obtaining consistent and unbiased treatment effect of small-scale irrigation.

The negative and significance of $\boldsymbol{\rho_{1Y}}$ and $\boldsymbol{\rho_{1F}}$ clearly indicates negative selection bias, suggests that farm households that choose to use irrigation obtain higher income and fixed asset formation due to unobserved characteristics than a random farm household in that regime. It further suggests that farm households that did not use irrigation receive neither higher nor lower income and fixed asset formation than a random farm household in that regime. Similarly, the correlation coefficient irrigation participation and non-user income and fixed asset formation ($\boldsymbol{\rho_{2Y}}$ and $\boldsymbol{\rho_{2F}}$) were negative but not significantly different from zero. It indicates that, without use in irrigation, there would be no significant difference in average behavior of the two farm household groups which arises from unobserved effects.

The estimated results presented in (Table 11), also demonstrate that, a significant variation on the impacts has been revealed across the two groups of households. These variations were accounted for irrigation user status of households, keeping other things remain constant. This implies that the condition to use irrigation distorted the effect of explanatory variables across the two groups of households. Accordingly, endogenous switching regression model estimates, significant determinant variables of livelihood outcomes, from the estimated result were age and age square of the household, adult lab our, farming experience (age as proxy), Distance from residents' to local market, own cultivated land, extension contact, size of livestock holding access to credit and sex of the household.

Table 11.Endogenous switching regression model parameter estimates

Variables	**Income(Y)**		**Fixed asset (F)**	
	User	Non-user	User	Non-user
Agehh	0.0086**	0.0011	0.0085**	-0.0009
	(0.0037)	(0.0028)	(0.0037)	(0.0025)
Agehh2	-0.0001**	-0.0001***	-0.0001**	-0.0001*
	(0.0000)	(0.0000)	(0.0000)	(0.0000)
Sexhh	-0.0103	0.0666	-0.0076	0.0817**
	(0.0181)	(0.0468)	(0.0192)	(0.0392)
Adaltlab	0.0231***	-0.0064	0.0231***	-0.0090
	(0.0056)	(0.0215)	(0.0056)	(0.0189)
Foredu	-0.0063	0.0014	-0.0060	0.0022
	(0.0089)	(0.0415)	(0.0089)	(0.0358)
Owncultland	-0.0018	0.1237*	0.0049	-0.0315
	(0.0181)	(0.0645)	(0.0185)	(0.0276)
Farmexpe	0.0019*	0.0119***	0.0017	0.0077**
	(0.0011)	(0.0035)	(0.0011)	(0.0031)
Tlu	-0.0027	0.0245*	-0.0025	0.0134
	(0.0027)	(0.0125)	(0.0027)	(0.0110)
Accesscr	0.0085	0.0341	0.0080	0.0672*
	(0.0087)	(0.0410)	(0.0088)	(0.0366)
Offpart	0.0081	0.0054	0.0073	0.0577
	(0.0105)	(0.0423)	(0.0105)	(0.0370)
Distmkt	-0.0073*	-0.0044	-0.0074*	0.0012
	(0.0039)	(0.0154)	(0.0039)	(0.0132)
Extencontact	0.0099	0.0324**	0.0098	0.0385***
	(0.0061)	(0.0141)	(0.0062)	(0.0122)
Constant	11.15***	9.69***	11.169***	9.919***
	(0.0993)	(0.1932)	(0.0995)	(0.1698)
σ	.04090	.21245	.0408	.1843

	(.0029)	(.01182)	(.0029)	(.0103)
ρ	-.8121***	-.1210	-.6488 **	-.3097
	(.2469)	(.6175)	(.2831)	(.5713)
LR test of indep. eqns. :			ESR	
chi2(1) 3.33*			chi2(1) 2.88*	
Wald chi2(12) 30.51***			Wald chi2(12) 29.33***	
Log likelihood 172.18412			Number of obs 258	

*** p<0.01, ** p<0.05, * p<0.1 represents levels of significance. The value in the parentheses are Standard errors.

Source; own survey result, (2018)

In the switching regression estimates, the coefficient of age was positive and significant for irrigation user income and fixed asset holding. In contrast, age square of household head was negatively and significantly affected both user and non-user income and fixed asset formation. The negative sign showed that older farmers were found to be relatively less active in use of irrigation and technology adoption. However, the relationship between age square of the household and irrigation participation is not linear but inverted U-shaped, suggesting that beyond a certain age users and non- users increased their income and fixed asset formation significantly. This implies that although increasing age increases the likelihood of irrigation participation, it reduces it at a certain stage. This result is similar to the findings of (Awudu & Wallace, 2014; Kidanemariam G. Gebrehiwot *et al.*, 2017; Owusu et al., 2011).

Sex of the household affected non users fixed asset holding positively and significantly at 5 % significance level. The asset of non-user male-headed households is higher, compared to female-headed households further increasing the comparative advantage of male-headed households to engage in non-farm activities than users' households. This result in line with (Kidanemariam G. Gebrehiwot *et al;*2017, Kinfe Aseyehegn *et al., 2012*)

Adult labor was significantly and positively affected irrigation user's income and fixed asset holding at 1% significance level. The larger households size with more labor endowment more likely to use irrigation. In contrast, it was insignificant negative effect for non-user income and

fixed asset holding. This result shows that the irrigation users having more adult labor are very likely to enjoy more income and fixed asset, suggesting the important role of adult labor force in improving rural farmers' income and fixed asset formation. This result is consistent with Awudu & Wallace (2014) found that households with more labor endowment more likely to adopt new technologies.

Cultivated land size was positively and significantly affected the non-user's income at 10% significance level in regime 1. Households have cultivated land produce relatively sufficient amount of crop by their own or through different contractual agreements such as share cropping. This result is similar with (Fekadu Abdissa *et al;2017*). Another study by Abonesh Tesfaye *et al.*(2008) found that irrigators tend to intensify their farming, while rain-fed farmers try to put more land under cultivation.

Livestock holding was positively and significantly affected the non-user's income at 10% significance level. The households with more livestock produce livestock products for direct consumption of their family. Besides, holding more livestock enables the farm households to have better chance to earn more income from the sale of the livestock. Similar study was conducted by (Fekadu Abdissa *et al;*2017) .

Farming experience (age as proxy) was found positive and significant effect for both irrigation users and non-user's income. This result is consistence with Abay Asfaw and Assefa Admassie (2004) found positive relationships between age and chemical fertilizer adoption in Ethiopia and Polson and Spencer (1991) positive relationships between age and improved cassava variety adoption in Nigeria. Whereas, Kidanemariam G. Gebrehiwot *et al.*(2017) found that negetive and siginificant effect on adoption of irrigation. Age when taken as proxy for farm experience (human capital theory) will be positive; but older farmers with a very short planning horizon and high risk averse age can be negatively associated with technology adoption (Zepeda, 1990).

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Access to credit affected non user's household fixed asset holding positively and significantly at 10 % significance level. The positive sign indicates that household which use credit does initiate investment in farm and non-farm activities for their livelihood improvement. This result is in line with Fekadu Abdissa et al. (2017) found that access to credit service might encourage

households to decide in irrigation participation as it enables them to afford input and labor costs of their farm activity.

Distance from residents' to nearly local market was negative and significance for irrigation users' income and fixed asset formation at 10% significance level. The negative sign indicates that households far from local market, incur high marketing and transportation cost while producing and marketing farm products inconvenience of in transporting perishable products. the households might choose to sell their product with cheaper price to neighbor traders. The same result was found by (Woldegebrial Zeweld *et al*, 2017) found that the participation of small-scale irrigation reduced by because of the opportunity cost of time and transaction costs.

Extension contact was positive and significance for non-user income and fixed asset holding. Provision of extension service to farmers play important role in terms of creating knowledge and skills in different income generation activities such as off farm and non-farm activities. Awudu & Wallace (2014) argued that positive and statically significant indicating that farmers with extension contact likely to adopt new technology.

Table 12.Test of predicted livelihood outcomes with endogenous switching regression model

Outcome variable	**Household type and treatment effects**	**Decision stage**		**Treatment effects**
		user	Non-user	
Income(Y)	Irrigation user	(a) 99852.03	(c) 92023.4	ATT_y= 7828.627***
	Non-user	(d) 36304.4	(b) 29433.32	ATU_y= 6871.079***
	Heterogeneous effects	BH_{1y}= 63547.63	$BH_{2y=}$62590.08	TH_y= 957.55
Fixed asset(F)	Irrigation user	(e) 99849.94	(g) 79249.28	ATT_F= 20600.66***
	Non-user	(h) 34483.5	(f) 30754.47	ATU_F= 3729.035***
	Heterogeneity Effects	BH_{1F}= 65366.44	BH_{2F}= 48494.81	TH_F= 16871.63

*, ** and *** represent significance at 0.1, 0.05 and 0.01 levels respectively.

Source: own survey calculation (2018)

An important question is whether farmers that use small-scale irrigation improve their livelihood status in terms of income and fixed asset formation. The results, obtained using equations (6 up to 14), are presented in (Table 12). In other words, to evaluate the impacts of small scale irrigation on farmers' livelihood; the conditional expected income and fixed asset by the irrigation users $E(Y_{1i}$ and $F_{1i}|S = 1)$ are compared with what they would have enjoyed the non-users $E(Y_{2i}$ and $F_{2i}|S = 0)$. As shown from (Table 12), the observed difference in income and fixed asset formation between the irrigation users and non-users (ATE) were ETB 70419 (240%) ((a) – (b)) and ETB 71002 (224%) ((e) – (f)) respectively. However, this simple comparison is misleading because unobserved factors that may impacted of both outcome variables was not accounted.

Hence, following Carter & Milon (2005), the base heterogeneity due to the potential unobservable effect on the livelihood outcome variables was included to get the true impact estimate. BH (referred as base heterogeneity). Within the counterfactual condition, that irrigation users placed in the non-users status (BH_{1Y} and BH_{1F}) in (Table 12) households

would be expected to earn , an average of, ETB 63547 more income and earn ETB 65366 more fixed asset formation Similarly, the counterfactual condition that the non-users placed in the irrigation users status (BH_{2Y} andBH_{2F}), would expected to earn , an average of, ETB 62590 earn income and more fixed asset formation ETB 48495.Therefore, from both outcomes (income and fixed asset) counterfactual conditions, the non-users under the status of access to irrigation were performing better than the irrigation users. This results access to irrigation effects is larger for the counterfactual non-user households, resulting in a positive transitional heterogeneity effect of both outcome variables TH_Y (ETB 958 more income) and TH_F (ETB 16871 more fixed asset formation).

The survey result revealed that, the actual expected income of the irrigation users $E(Y_{1i} | S = 1)$ was approximately ETB 99852, while the expected income that the same irrigation users would have enjoyed if they did not use irrigation (counterfactual of the irrigation users) $E(Y_2 | S = 1)$ was approximately ETB 92023. Therefore, the observed income gap (ATT) was found to be ETB 7829 (8.5 %) due to irrigation access. Similarly, the counterfactual of the non-users (if non- users decided to use irrigation) (ATU) was ETB 6871 (23.3%) higher income than their counterpart. Both results were statically significant at less than 1% significance level. The results are in agreement with other studies that reports positive link between irrigation participation and income and asset building (Anwar Alamin, 2014; Kidanemariam G. Gebrehiwot et a*l*., 2017; Woldegebrial Zeweld *et al.*, 2015).It is also the same to (Owusu *et al*., 2011), the study conducted in northern Ghana.

The other outcome variable, the actual expected fixed asset value of the irrigation users $E(F_1 | S = 1)$ was found to be approximately ETB 99849, while the expected fixed asset value that the same irrigation users would have enjoyed if they did not use irrigation (counterfactual of the irrigation users) $E(F_2 | S = 1)$ was approximately ETB 79249. Therefore, the observed fixed asset formation gap (ATT) was found to be ETB 20600 (26%) due to irrigation access. Similarly, the counterfactual of the non-users (if non-irrigation users decided to use irrigation) had 12% higher fixed asset formation compared to their counterpart. Both results were statically significant at less than 1% significance level. The results are in agreement with other studies that report positive link between use of small scale irrigation and fixed asset formation (Abraham Gebrehiwot *et al.*,2015; Anwar Alamin, 2014; Eshetu Tefera and cho, 2017;

Kidanemariam G. Gebrehiwot et al., 2017; Gebremariam & Surajit ,2016). This study indicates that irrigated agriculture has brought positive changes on respondents' expenditures, which enable them to send their children to schools, buy livestock, build up assets, cover medical expenses, purchase inputs, buy more food and non-food items. Generally, the estimated treatment effects show that use of small-scale irrigation places farmers in a better livelihood position.

5. CONCLUSION AND RECOMMENDATION

5.1. Conclusion

This study analyzes the impact of small scale irrigation scheme on farmers' livelihood in *mekdela woreda,* North East Ethiopia. This study revealed that, even though, irrigation users and non-users had the same demographic patterns, the income and asset accommodation of the irrigation users was found to be better than that of non-users.

This study applied Logit and ESR model to determine the participation decision and examine the impact of small scale irrigation on farmer's livelihood respectively. The logit model result indicates that age and age square of the household, adult lab our, extension contact, access to off farm income, distance from homestead to nearly local market and distance from home to the irrigation water source are significant in explicating farmers to practice small scale irrigation.

Age of household head is negatively and significantly influenced the use of irrigation. The negative sign showed that young farmers were found to be relatively active in use of irrigation and technology adoption and the operations of use of irrigation which is exhaustiveness that cannot be tolerated by old aged farmers. Thus, strategies should have to encourage and provide training for the youth for technology adoption.

Adult labor has positive and statistically significant effect on the decision to use irrigation indicates that adult labor increases the probability of being irrigation user. Due to the reason of, irrigation is mostly labor intensive; farm households with more adult labor are working on the farm reduces the farm's external labor requirements more likely encouraged in the use of irrigation. Furthermore, irrigation user was more likely to employ more labor as compared to non-user. Therefore, it was concluded that small scale irrigation plays a positive role in generating employment opportunities.

Extension contact had positive and significant effect on the probability of participating in using irrigation. Therefore, exposing farmers to new market driven crop varieties, providing training on irrigated agriculture, arranging visits to other better irrigation schemes expose to farmers to other better practices would contribute to utilization of the scheme.

Distance from local market center is also found to be significantly and negatively affecting the probability of participation in irrigation. The negative sign indicates that households far from local market, incur high marketing and transportation cost while producing and marketing farm products inconvenience of in transporting perishable products.

Distance from the irrigation water source to homestead was found a negative and significant relationship to use irrigation. This indicates that their proximity to irrigation farm enable them to manage properly their crop with minimum cost.

The impact estimates from the ESR analytical methods employed in this study. The model considers selection bias associated with endogeneity of irrigation participation. Variables distance from homestead to irrigation scheme and household's participation in social organization where used as instrumental variable.

The ESR result shows that estimated coefficient of correlation between the irrigation selection equation and the outcome equations (income and fixed asset holding) were found to be significant. This implies that bias would have resulted in the livelihood function had it been estimated without correcting for selection bias associated with irrigation participation in the study. After controlling the selection bias in the estimation process showed that participation in the irrigation program had increased household livelihood of users 's income by 8.5%, and fixed asset formation by 26% as compared to non-user. Generally, the estimated treatment effects show that use of small-scale irrigation places farmers in a better livelihood position.

The study revealed that the main problems of irrigation development in both schemes have been challenged by a number of constraints among which are presence of pests and diseases, lack of access to market for farm product, lack of sufficient irrigation water, lack modern inputs are most prominent.

5.2. Recommendation

The results indicate that small irrigation schemes have a profound effect on household income and fixed asset formation for livelihood improvement. Hence, such schemes need to be encouraged and scaled up to other areas and involve more households. Based on the findings of this study the following general recommendations are given:

- Distance from the irrigation scheme affects use of irrigation negatively. This implies that the closer the household to the scheme, the higher is the probability of participation decision and the better household livelihood. Thus, the construction of irrigation schemes should consider the distance between the water source and households' residence for proper utilization of the schemes.
- Distance from the market center was negatively affecting participation decision. Therefore, market infrastructure, like rural road construction and provision of transportation facilities could connect irrigating farmers to the market and minimizes their marketing cost. Thus, striving to create market linkage for their farm product could raise farm income, asset formation and would be the most urgent action required.
- One of the main constraint of irrigation farming is crop pest and disease infestation. Distribution of insect and disease resistant crop and vegetable varieties could reduce the yield loss and maintain the production potential of the study area.
- Expanding the capacity of small scale irrigation and creating additional access through integrated water investment is important to increase users' agricultural income and asset formation, hence leads to households' livelihood improvement.
- The policy implications of the above findings are that improve access to water for irrigation and market, educating and raising farmers' awareness through extension and provision of other complementary services would enhance the participation of irrigation.

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7. APPENDECIES

Appendix 1.Logit Estimation for Participation in Irrigation

logit irrigation agehh agehh2 sexhh adaltlab foredu ownland Farmexpe tlu Accesscr offpart extencontact distmkt difschme socialpart

Iteration 0: log likelihood = -170.29554

Iteration 1: log likelihood = -44.343834

Iteration 2: log likelihood = -31.728587

Iteration 3: log likelihood = -26.876845

Iteration 4: log likelihood = -26.270343

Iteration 5: log likelihood = -26.252334

Iteration 6: log likelihood = -26.252321

Iteration 7: log likelihood = -26.252321

Logistic regression Number obs = 258

LR chi2(14) = 288.09

Prob > chi2 = 0.0000

Log likelihood = -26.252321 Pseudo R2 = 0.8458

Irrigation	Coef.	Std. Err.	Z	P>|z|	[95% Conf.	Interval]
Agehh	-1.038244	.3343949	-3.10	0.002	-1.693646	-.3828426
agehh2	.0102358	.0032769	3.12	0.002	.0038131	.0166584
Sexhh	.4776966	1.005683	0.47	0.635	-1.493406	2.448799
Adaltlab	1.266211	.6235446	2.03	0.042	.0440857	2.488336
Foredu	-.0330588	.9953708	-0.03	0.974	-1.98395	1.917832
Owncultland	-.1421408	1.269334	-0.11	0.911	-2.62999	2.345708
Farmexpe	.0239846	.1206328	0.20	0.842	-.2124513	.2604206
Tl u	.2208096	.2230607	0.99	0.322	-.2163813	.6580004
Accesscr	.9507585	.8800624	1.08	0.280	-.7741321	2.675649
Offpart	-2.201603	.912162	-2.41	0.016	-3.989407	-.413798
Extencontact	1.177819	.5012549	2.35	0.019	.1953775	2.16026
Distmkt	-.7415461	.400799	-1.85	0.064	-1.527098	.0440056
Dischme	-5.23199	1.16468	-4.49	0.000	-7.514722	-2.949259
Socialpart	1.066228	.8548932	1.25	0.212	-.6093318	2.741788
_cons	26.23233	8.956831	2.93	0.003	8.677263	43.78739

Appendix 2. Link test Result

Logistic regression — Number of obs = 258

LR chi2(2) = 288.09

Prob > chi2 = 0.0000

Log likelihood = -26.252239 — Pseudo R2 = 0.8458

Irrigation	Coef.	Std.Err	Z	P>|z|	[95% Conf.	Interval]
_hat	.9996913	.1801958	5.55	0.000	.6465139	1.352869
_hatsq	-.0006738	.0526961	-0.01	0.990	-.1039563	.1026088
_cons	.0027786	.4317682	0.01	0.995	-.8434714	.8490287

Appendix 3.Instrumental variables (2SLS) regression test

ivregress 2sls logY agehh agehh2 sexhh Adallab foredu ownland Farmexpe tlu Accesscr offpart extencontact distmkt (irrigation= difschme socialpart), robust

Instrumental variables (2SLS) regression — Number of obs = 258

Wald chi2(13) = 3173.49

Prob > chi2 = 0.0000

R-squared = 0.9183

Root MSE = .17748

LogY	Coef.	Robust Std. Err	Z	P>|z|	[95% Conf.	Interval]
Irrigation	1.239351	.0418544	29.61	0.000	1.157318	1.321384
Agehh	.0028115	.0027887	1.01	0.313	-.0026542	.0082773
agehh2	-.0000814	.0000315	-2.58	0.010	-.0001431	-.0000197
Sexhh	.0519838	.0385401	1.35	0.177	-.0235535	.1275211
Adaltlab	.0080047	.0119936	0.67	0.505	-.0155023	.0315117
Foredu	-.0098453	.0232762	-0.42	0.672	-.0554659	.0357752
Owncultland	.0472016	.0428198	1.10	0.270	-.0367236	.1311268
Farmexpe	.0076777	.0021783	3.52	0.000	.0034083	.0119471
Tlu	.0110916	.0063874	1.74	0.082	-.0014274	.0236106
Accesscr	.0198422	.022473	0.88	0.377	-.0242041	.0638884
offpart	.0291364	.0277464	1.05	0.294	-.0252456	.0835184
Extencontact	.0167435	.0108589	1.54	0.123	-.0045395	.0380265
Distmkt	-.0034095	.0085318	-0.40	0.689	-.0201314	.0133125
_cons	9.816631	.1653295	59.38	0.000	9.492591	10.14067

Instrumented:irrigation

Instruments: agehh agehh2 sexhh adaltlab foredu ownlandc Farmexpe tlu

Accesscr offpart extencontact distmkt difschme socialpart

Appendix 4.Tests of Endogeneity

Ho: variables are exogenous

Durbin (score) chi2(1) = 6.81099 (p = 0.0091)

Wu-Hausman F (1,243) = 6.58894 (p = 0.0109)

Robust score chi2(1) = 8.51044 (p = 0.0035)

Robust regression F (1,243) = 8.85089 (p = 0.0032)

Appendix 5.Instrumental Variable Test

First-stage regression summary statistics

Variable	R-sq.	Adjusted R-sq.	Partial R-sq.	Robust F(2,243)	Prob > F
Irrigation	0.7577	0.7437	0.5411	162.346	0.0000

Minimum eigenvalue statistic = 143.245

Critical Values # of endogenous repressors: 1

Ho: Instruments are weak # of excluded instruments: 2

	5%	10%	20%	30%
2SLS relative bias	(not available)			
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92

Appendix 6.Test of over identifying restrictions

Sargan chi2(1) = .157023 (p = 0.6919)

Basmann chi2(1) = .147984 (p = 0.7005)

Score chi2(1) = .149468 (p = 0.6990)

Appendix 7.Endogenous switching regression model parameter estimates for income

movestay (logY agehh agehh2 sexhh adaltlab foredu ownlandc Farmexpe tlu Accesscr offpart distmkt extencontact), select (irrigation agehh agehh2 sexhh adaltlab foredu ownlandc Farmexpe tlu Accesscr offpart distmkt extencontact difschme socialpart)

Iteration 0: log likelihood = 171.24139

Iteration 1: log likelihood = 172.04192

Iteration 2: log likelihood = 172.17933

Iteration 3: log likelihood = 172.18379

Iteration 4: log likelihood = 172.18412

Iteration 5: log likelihood = 172.18412

Endogenous switching regression model Number of obs = 258

Wald chi2(12) = 30.51

Log likelihood = 172.18412 Prob > chi2 = 0.0023

	Coef.	Std. Err.	Z	P>|z|	[95%Conf.	Interval]
logY_1						
Agehh	.0086233	.0036772	2.35	0.019	.0014161	.0158304
agehh2	-.0000957	.0000429	-2.23	0.026	-.0001798	-.0000115
Sexhh	-.010318	.0181345	-0.57	0.569	-.0458609	.0252249
Adaltlab	.0231064	.0055652	4.15	0.000	.0121989	.0340139
Foredu	-.0062645	.0088789	-0.71	0.480	-.0236669	.0111379
Owncultland	-.0017863	.0181304	-0.10	0.922	-.0373212	.0337486
Farmexpe	.0018743	.0011067	1.69	0.090	-.0002947	.0040433
Tlu	-.0027324	.0027488	-0.99	0.320	-.0081199	.0026552
Accesscr	.0084794	.0087036	0.97	0.330	-.0085794	.0255382
Offpart	.0080685	.0105006	0.77	0.442	-.0125124	.0286494
Distmkt	-.0072674	.0038834	-1.87	0.061	-.0148788	.0003439
Extencontact	.0099398	.0061423	1.62	0.106	-.0020988	.0219784
_cons	11.17248	.0992713	112.54	0.000	10.97792	11.36705
logY_0						
Agehh	.0011379	.002836	0.40	0.688	-.0044205	.0066964
agehh2	-.0001229	.0000431	-2.85	0.004	-.0002074	-.0000385
Sexhh	.0666255	.0467904	1.42	0.154	-.0250819	.158333
Adaltlab	-.0064231	.0214613	-0.30	0.765	-.0484865	.0356404
Foredu	.0013672	.0414569	0.03	0.974	-.0798869	.0826213
Owncultland	.1237242	.0645181	1.92	0.055	-.002729	.2501773
Farmexpe	.0118909	.0035341	3.36	0.001	.0049643	.0188176
Tlu	.0244852	.0125236	1.96	0.051	-.0000607	.0490311
Accesscr	.0341034	.0410441	0.83	0.406	-.0463415	.1145483
Offpart	.005412	.0423121	0.13	0.898	-.0775182	.0883422
Distmkt	-.0043925	.0154082	-0.29	0.776	-.034592	.025807
Extencontact	.0323853	.0140921	2.30	0.022	.0047653	.0600054
_cons	9.697097	.1931785	50.20	0.000	9.318474	10.07572
Irrigation						
Agehh	-.4447624	.1791085	-2.48	0.013	-.7958085	-.0937162
agehh2	.0044523	.0017468	2.55	0.011	.0010286	.007876
Sexhh	.1059272	.5693289	0.19	0.852	-1.009937	1.221791
Adaltlab	.3319653	.2901873	1.14	0.253	-.2367915	.900722

Foredu	.5676627	.5024602	1.13	0.259	-.4171412	1.552467
Owncultland	1.747244	.6850808	2.55	0.011	.4045104	3.089978
Farmexpe	.0080619	.0540727	0.15	0.881	-.0979187	.1140425
Tlu	.0605034	.1366075	0.44	0.658	-.2072423	.3282492
Accesscr	.3928976	.4876137	0.81	0.420	-.5628077	1.348603
Offpart	-1.004812	.4765883	-2.11	0.035	-1.938908	-.0707163
Distmkt	-.2446102	.1971446	-1.24	0.215	-.6310065	.141786
Extencontact	.4373554	.2531039	1.73	0.084	-.0587192	.9334299
Dischme	-2.49495	.5531353	-4.51	0.000	-3.579075	-1.410825
Socialpart	.3191448	.4919174	0.65	0.516	-.6449957	1.283285
_cons	10.78692	4.565921	2.36	0.018	1.837879	19.73596
/lns1	-3.196522	.0729559	-43.81	0.000	-3.339513	-3.053531
/lns2	-1.549015	.0556689	-27.83	0.000	-1.658124	-1.439906
/r1	-1.133417	.7255864	-1.56	0.118	-2.55554	.2887065
/r2	-.1216291	.626777	-0.19	0.846	-1.350089	1.106831
sigma_1	.0409042	.0029842			.0354542	.047192
sigma_2	.2124571	.0118273			.190496	.23695
rho_1	-.8121854	.2469569			-.9880131	.2809438
rho_2	-.1210328	.6175954			-.8740744	.8029394

LR test of indep. eqns. : chi2(1) = 3.33 Prob >chi2 = 0.0680

Appendix 8.Average treatment on treated(ATT) /user for income

Two-sample t test with equal variances (test yc11 =yc01, unpaired)

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
yc11	96	99852.03	242.2486	2373.542	99371.1	100333
yc01	162	92023.4	448.7385	5711.509	91137.23	92909.57
Combined	258	94936.38	378.1499	6073.987	94191.71	95681.05
Diff		7828.627	612.396		6622.651	9034.602

diff = mean(yc11) - mean(yc01) t=12.7836

degrees of freedom = 256

Ha: diff <0 Ha: diff ! = 0 Ha: diff >0

Pr (T < t) =1.0000 Pr (T > t) =0.0000 Pr (T > t) =0.0000

Appendix 9.Average treatment effect on untreated(ATU) (non-user) income

Two-sample t -test with equal variances **(ttest yc10=yc00**, unpaired)

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
yc10	96	36304.4	481.7847	4720.506	35347.94	37260.87
yc00	162	29433.32	216.229	2752.145	29006.31	29860.33
Combined	258	31990	305.3491	4904.633	31388.7	32591.31
Diff		6871.079	464.9792		5955.407	7786.75

diff = mean(yc10) - mean(yc00)		t = 14.7772
Ho: diff = 0		degrees of freedom = 256
Ha: diff <0	Ha: diff ! = 0	Ha: diff >0
Pr (T < t) =1.0000	Pr (T > t) =0.0000	Pr (T > t) =0.0000

Appendix 10.Instrumental variables (2SLS) regression test for fixed asset

ivregress 2sls logF agehh agehh2 sexhh adaltlab foredu owncultland Farmexpe tlu Accesscr offpart distmkt extencontact (irrigation= dischme socialpart), robust

Instrumental variables (2SLS) regression

Number of obs = 258
Wald chi2(13) = 4017.47
Prob >chi2 =0.0000
R-squared = 0.9329
Root MSE = .15356

LogF	Coef.	Robust Std. Err	Z	P>|z|	[95% Conf.	Interval]
Irrigation	1.220994	.0365456	33.41	0.000	1.149366	1.292622
Agehh	.0012354	.0025554	0.48	0.629	-.0037732	.0062439
agehh2	-.0000474	.0000271	-1.75	0.080	-.0001006	5.73e-06
Sexhh	.0573647	.0313732	1.83	0.067	-.0041257	.1188551
Adaltlab	.0056959	.0105818	0.54	0.590	-.015044	.0264358
Foredu	-.0115051	.0207152	-0.56	0.579	-.0521061	.029096
Owncultland	-.0323174	.017643	-1.83	0.067	-.0668971	.0022622
Farmexpe	.0049152	.0016235	3.03	0.002	.0017333	.0080971
Tlu	.0061399	.0057853	1.06	0.289	-.0051992	.0174789
Accesscr	.0336912	.0188519	1.79	0.074	-.0032579	.0706403
Offpart	.0478149	.0260641	1.83	0.067	-.0032699	.0988997
Distmkt	-.0008064	.0077634	-0.10	0.917	-.0160224	.0144096
Extencontact	.0279681	.0089464	3.13	0.002	.0104334	.0455028
_cons	9.93948	.1556685	63.85	0.000	9.634375	10.24458

Instrumented:irrigation

Instruments: agehh agehh2 sexhh adaltlab foredu ownlandc Farmexpe tlu
Accesscr offpart Extencontact Distmkt difschme socialpart

Appendix 11.Tests of Endogeneity for fixed asset

Ho: variables are exogenous

Durbin (score) chi2(1) = 8.26917 (p = 0.0040)

Wu-Hausman F (1,243) = 8.0463 (p = 0.0049)

Robust score chi2(1) = 8.35393 (p = 0.0038)

Robust regression F (1,243) = 8.47046 (p = 0.0039)

Appendix 12.Instrumental variable test for fixed asset

First-stage regression summary statistic

Variable	**R-sq.**	**Adjusted R-sq.**	**Partial R-sq.**	**Robust F(2,243)**	**Prob > F**
Irrigation	0.7459	0.7312	0.5728	219.587	0.000

Minimum eigenvalue statistic = 162.894

Critical Values # of endogenous repressors: 1

Ho: Instruments are weak # of excluded instruments: 2

	5%	10%	20%	30%
2SLS relative bias	(not available)			
	10%	15%	20%	25%
2SLS Size of nominal 5% Wald test	19.93	11.59	8.75	7.25
LIML Size of nominal 5% Wald test	8.68	5.33	4.42	3.92

Appendix 13.Tests of over identifying restrictions for fixed asset

estat overid, forcenonrobust

Sargan chi2(1) = .000113 (p = 0.9915)

Basmann chi2(1) = .000106 (p = 0.9918)

Score chi2(1) = .000114 (p = 0.9915)

Appendix 14.Endogenous switching regression model estimate result for Fixed asset

move stay (logF agehh agehh2 sexhh adaltlab foredu ownlandc Farmexpe tlu Accesscr acoffinc Distmkt Extencontact), select (irrigation agehh agehh2 sexhh adaltlab foredu ownlandc Farmexpe tlu Accesscr offpart Distmkt Extencontact difschme socialpart)

Iteration 0: log likelihood = 191.05197

Iteration 1: log likelihood = 191.56176

Iteration 2: log likelihood = 191.58871

Iteration 3: log likelihood = 191.58876

Iteration 4: log likelihood = 191.58876

ESR model Number of obs=258

Wald chi2(12) =29.33

Log likelihood = 191.58876 Prob >chi2=0.0035

	Coef.	Std. Err.	Z	P>|z|	[95%Conf.	Interval]
logF_1						
Agehh	.0085055	.0036875	2.31	0.021	.0012781	.0157329
agehh2	-.0000952	.0000436	-2.18	0.029	-.0001805	-9.79e-06
Sexhh	-.0075723	.019192	-0.39	0.693	-.0451879	.0300434
Adaltlab	.0231022	.0056018	4.12	0.000	.0121228	.0340815
Foredu	-.005952	.0088606	-0.67	0.502	-.0233184	.0114144
Owncultland	.0048693	.0185425	0.26	0.793	-.0314734	.0412119
Farmexpe	.0017087	.0011064	1.54	0.122	-.0004598	.0038772
Tlu	-.0024916	.002734	-0.91	0.362	-.0078501	.002867
Accesscr	.0080086	.0087569	0.91	0.360	-.0091547	.0251718
Offpart	.0073272	.0104699	0.70	0.484	-.0131935	.0278478
Distmkt	-.0074372	.0039245	-1.90	0.058	-.0151291	.0002547
Extencontact	.0097661	.0061525	1.59	0.112	-.0022925	.0218247
_cons	11.16869	.0994581	112.30	0.000	10.97375	11.36362
logF_0						
Agehh	-.0008973	.0025261	-0.36	0.722	-.0058484	.0040539
agehh2	-.0000666	.0000376	-1.77	0.076	-.0001403	7.03e-06
Sexhh	.0816659	.0391907	2.08	0.037	.0048535	.1584782
Adaltlab	-.0089808	.0189415	-0.47	0.635	-.0461055	.0281439
Foredu	.0021563	.0357984	0.06	0.952	-.0680073	.0723199
Owncultland	-.0315148	.0275699	-1.14	0.253	-.0855508	.0225212
Farmexpe	.0076989	.0031055	2.48	0.013	.0016122	.0137856
Tlu	.0133641	.0110371	1.21	0.226	-.0082682	.0349963
Accesscr	.0672019	.0366467	1.83	0.067	-.0046242	.1390281
Offpart	.0576906	.0369935	1.56	0.119	-.0148154	.1301966
Distmkt	.001177	.0132237	0.09	0.929	-.024741	.027095
Extencontact	.038534	.0122089	3.16	0.002	.0146051	.0624629
_cons	9.919373	.1698038	58.42	0.000	9.586564	10.25218
Irrigation						
Agehh	-.5514085	.1788961	-3.08	0.002	-.9020383	-.2007787
agehh2	.0054596	.0017805	3.07	0.002	.0019699	.0089493
Sexhh	.2473287	.5440677	0.45	0.649	-.8190245	1.313682
Adaltlab	.5766681	.3137612	1.84	0.066	-.0382925	1.191629
Foredu	.3402455	.504824	0.67	0.500	-.6491914	1.329682
Owncultland	.1448893	.6511408	0.22	0.824	-1.131323	1.421102
Farmexpe	.015682	.0571657	0.27	0.784	-.0963606	.1277247

Tlu	.0659686	.1168973	0.56	0.573	-.1631459	.2950831
Accesscr	.6013051	.4462324	1.35	0.178	-.2732943	1.475904
Offpart	-.9815315	.4912191	-2.00	0.046	-1.944303	-.0187597
Distmkt	-.3800092	.2082965	-1.82	0.068	-.7882628	.0282443
Extencontact	.5649478	.2694656	2.10	0.036	.0368049	1.093091
Dischme	-2.731927	.5826904	-4.69	0.000	-3.873979	-1.589875
Socialpart	.4413006	.4453075	0.99	0.322	-.431486	1.314087
_cons	14.28481	4.71599	3.03	0.002	5.041638	23.52798
/lns1	-3.198888	.0730254	-43.81	0.000	-3.342015	-3.055761
/lns2	-1.549015	.0556689	-27.83	0.000	-1.658124	-1.439906
/r1	-.7732718	.4889638	-1.58	0.114	-1.731623	.1850797
/r2	-.32024	.6319441	-0.51	0.612	-1.558828	.9183477
sigma_1	.0408076	.00298			.0353656	.0470869
sigma_2	.1843935	.0103796			.1651318	.2059019
rho_1	-.6488279	.283121			-.9392475	.182995
rho_2	-.3097239	.5713224			-.9152303	.7251148

LR test of indep. eqns. : chi2(1) = 2.88 Prob >chi2 = 0.0900

15.Average treatment on treated/user for Fixed Asset

Two-sample t test with equal variances (test yc11 =yc01, unpaired)

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
yc11	96	99849.94	238.7574	2339.336	99375.95	100323.9
yc01	162	79249.28	1064.441	13548.12	77147.22	81351.35
Combined	258	86914.64	916.1554	14715.63	85110.52	88718.77
Diff		20600.66	1395.968		17851.61	23349.7

diff =mean(yc11) - mean(yc01) t= 14.7573

degrees of freedom = 256

Ha: diff <0 Ha: diff ! = 0 Ha: diff >0

Pr (T < t) =1.0000 Pr (T > t) =0.0000 Pr (T > t) =0.0000

Appendix 16.Average treatment effect on untreated/non user for Fixed Asset

Two-sample t test with equal variances (**ttest yc10=yc00**, unpaired)

Variable	Obs	Mean	Std. Err.	Std. Dev.	[95% Conf.	Interval]
yc10	96	34483.5	334.4031	3276.468	33819.63	35147.38
yc00	162	30754.47	191.2955	2434.794	30376.69	31132.24
Combined	258	32142.01	205.9543	3308.117	31736.44	32547.59
Diff		3729.035	357.6864		3024.653	4433.417

diff = mean(yc10) - mean(yc00) t = 10.4254

degrees of freedom = 256

Ha: diff <0 Ha: diff ! = 0 Ha: diff >0

Pr (T < t) =1.0000 Pr (T > t) =0.0000 Pr (T > t) =0.0000

Appendix 17.Conversion factors used to compute adult equivalent

Labor class	Age (years)	Conversion factor
Children	<7	0
Children	7-14	0.4
Adult male	15-64	1.0
Adult female	15-65	0.8
Old male	greater than 65	0.5
Old female	greater than/equal 65	0.5

Source: (Storck et al., 1991)

Appendix 18.Conversion factors used to compute tropical livestock units (TLU)

Livestock Category	Conversion factor
Calf	0.25
Oxen / Cow	1.00
Bull	0.75
Heifer	0.75
Horse /mules	1.10
Donkey adult	0.70
Donkey young	0.35
Goats /sheep adult	0.13
Goat /Sheep young	0.06
Poultry birds	0.013
Weaned calf	0.34

Source:(Storck et al., 1991)

Appendix 19.Questionnaire

BAHIR DAR UNIVERSITY

College of Agriculture and Environmental Science

Department of Agricultural Economics

The Impact of Small Scale Irrigation Schemes On Farmer's Livelihood: The in the case of Mekdela Woreda.

Survey Questionnaire

All the information provided here will be treated as **Strictly Confidential**

Survey area (Kebele) ……...……

Name of Enumerator ……..……

Signature ……..……

Date……

Household reference number…….…….

I: Basic Household information /characteristics

1. Name of the household head_____
2. Age of the household head_____ years
3. Sex of household head_____ 1. Male 0. Female
4. Marital status (circle one) 1. Single 2. Married 3. Divorced 4. Widowed
5. Religion of the household Head (circle one)

   1. Orthodox 2. Muslim 3. Protestant 4. Catholic 5. Others (Specify) _____
6. Household size _____
7. Household age and sex composition.

Age Group	Gender		Total
	Male	Female	
Under 15years			
15-30 years			
> 30 <65 years			
Above 65 years			

8. How do you categorize your family labor for your irrigated land activities?
   1. small 3. large
   2. enough 4. excessive
9. Have you attended any formal education? 1. Yes _____0. No_____
10. If yes, education level _____
11. Major job/occupation of the Household Head?
    1. Farming 2. Weaving 3. petty Trading 4. carpentry
    5. Black Smith 6. Daily Lab our 7. pottery
    8.other specify----------

II. Household expenditure (food and non-food) expenditure

11.1. Food expenditure Please indicate the food items your household purchased, the frequency and the cost incurred in buying the food items.

Item	Own consumption in 2017/18 (specify units e.g., kg, l)	Consumed from purchase in 2017/18 (specify units e.g., kg, l)	Price/unit (Birr)	Total amount (Birr)
Cereals				
Teff				
Barley				
Wheat				
Maize				
Sorghum				
Peas				
Beans				
Chickpea				
Fruit &vegetables				
Banana				
Onions				
Potatoes				
Carrot				
Keisir				
Cabbage				
Animal source				
Butter				
Milk				
Egg				
Meat				
Spices				
Salt				
Oil				
Sugar				
Coffee				
Paper				
Other				

11.2 How much does your household spend on average (using the year 2010 E.C.) for one month on food consumptions? Birr _____

12. Non-Food Expenditure

Number	Item	Unit price (birr)	Total expense (birr)
1	Expenses on Clothing		
	Student Uniforms		
	Clothing for father/mother		
	Clothing for other family		
	Shoes		
	Bed sheets and Blankets		
2	House rent (if any)		
3	Water expense (if Any)		
4	Transport and communication		
5	Entertainment /visit of relatives		
6	Expenditure on Education		
	Exercise books and books		
	Pens and pencils		
	Transport to and from school		
7	Health care		
8	Religious and culture expense		
	Tsebel, Mahber		
	Eddir		
	Wedding		
	Teskar/sedeqa/		
	Kiristina		
9	Animal health expense		
10	Government tax		
11	Labor expense		
12	Input expense		
13	Construction expense		
14	Fire wood and Fuel /Cooking/lighting Gas, Match		
15	Cleaning, and Personal Care items		
16	Household Items and Jewelry Purchases		

13. Did you have some social organization (PA, Idir) in the community so far? 1.Yes 0. No

Organization	Frequency of participation in activity	Role in organization

	Never	Sometimes	Always	Member	Leader	Committee Member
Idir						
Iqub						
Religious Association						
Irrigation association						
Cooperative/union						
PA leader						
Saving and credit						

III. Farming and Crop production

14. Total land size _____ Timad

1. Fertile ------- Timad 2. moderately fertile------- Timad 3. unfertile------- Timad

15. From the total land you owned, how much are cultivable ----------Timad

16. What is the total area of land you cultivated last year (2017/2018)? ---------Timad

1. Owned __ 2. Rented in ___ 3. Share cropped _ 4. Received as a gift___

17. How long have you practiced irrigation/rainy season farming?.....…(years).

18. Patterns of rain fall in the area 1. enough 2. moderate 3. low

19. How was your agricultural production for the last five years?

1. excess for annual household consumption 2. sufficient for annual household consumption

3. sufficient for six months only 4. sufficient for less than six months 5. others (specify) __

20. what type of crop do you grow in the land in rained?

Crop type	Area in Timad	Production in (Qui/Timad)	Price per Quintal	Total Birr sold
Teff				
Barley				
Wheat				
Peas				
Beans				
Chickpea				
Onion				
Garlic				
Other				

21. How do you compare existing production with that of 5 years?

1.Increased 2. Decreased 3. No change

22. If production has decreased what are the reasons?

1. shortage of rain full 2. shortage of new technologies 3. pest and disease

4. shortage of land 5. shortage of improved input 6. shortage of labor 7. poor soil fertility

8. specify----------

IV. The Use of Small Scale Irrigation

23. Do you use irrigation? 1.yes 0. No

24. If your answer for question 23 is no what are the reasons?

1. No farmland in surface water access 2. No awareness about it

3. Sufficient rain and moisture 4. shortage of irrigation technologies 5. others----------

25. If your answer for question 23 is yes, how far you from the irrigation scheme in KMs? ----

26. What kind of crops do you produce using irrigation? 1. grain 2. vegetables 3. fruits

27. What are your main objectives for doing irrigation? 1. to gene rate cash income 2.to produce food for the household 3. produce livestock feed 4. specify----------

28.How do you perceive the income you have generated from irrigation?

1. Low 2. Medium 3. High

29. Which small-scale irrigation type do you use?

1. Modern micro dam 2. Traditional river diversion 3. Motor pump 4. others specify--------

30. How many times do you harvest in a year using micro irrigation? ----------

31. what type of crop do you grow using irrigation?

Crop type	Area in tsimad	Production in (Qui/tsi.)	Price per Quintal	Total Birr sold
Onion				
Garlic				
Potato				
Lentil				
Others				

32. Why do you select the above type of Vegetable /crops for your irrigation farming?

1. Better price 4. Easiest to cultivate
2. Good production yields 5. Seed availability
3. High disease tolerance 6. Nonperishable 7. other……

33. How would you describe the yields and quality of the crops? (Good, Bad and Average

34. Before irrigation farming, what was the estimated monthly income of your HH?.....

35. What is the estimated monthly income of your HH now?.....

36. What is the estimated monthly expenditure of your HH now?.....

37. In which specific way(s) has this irrigation farming being help to you? ----------
---

V. Agriculture Production and household income

38. Land use, crop production and utilization in the year 20017/18

Type of Crops	Plot Size (Timad)		Total production (Kg)	Consumed at home (Kg)	Sold		
	Rain Fed	Irrigated			Amt (kg)	price /Kg.	Total Value
Teff							
Wheat							
Barely							
Beans							
Peas							
Chickpea							
Lentil							
Garlic							
Feno- Greek							
Tomato							
Potato							
Onion							
Cabbage							

VI. Livestock and livestock product income (2017/18)

39. Do you have livestock? 1. Yes 2. No

40. If yes to question 39 above fill the following table?

Type of Animal	Number of animals	Total Owned	Current market price	If there is any animal Sold (2017/18)	
				Sold Amount	Total Income gained (Birr)
Cow					
Bull					
Heifer					
Calf					
Ox					
Mules					

Horse					
Donkey					
Goat					
Sheep					
Poultry					
Bee					
Milk					
Butter					
Egg					
Hide					
Honey					

VII. Sources of Income and their Proportionate Contribution to HH Income

41. Do you or any member of your family engage in any Non-Farm Activity? 1.yes 0. No

42. How long are you or any member of your family engaged in non-farm activities? _____ (In Years)

43. Household other income source and yearly income

S/N	Source of income	Yes	No	Income per Month birr	Annual HH income
1	Off – farm casual labor				
2	Remittances (from relatives)				
3	Trade in off- farm goods				
4	Food Aid				
5	Rent income				
6	Sale of wood item				
8	Self-employment (Artisan blacksmith, weaving, potter, handicraft and carpenter)				
9	Others (specify)				

VIII. Credit, input and extension service supports in production (2017/18)

44. Have you ever used Access to credit for your agricultural activities? 1.Yes 0. No

45. If yes to question 45, why? 1. to purchase house 2. to purchase farm implements 3. to buy modern farm inputs 4. to build house 5. to buy improved seeds 6. others (specify)-------

46. What is the source of your Credit? 1. Banks 2. Friends/relatives 3. Traders 4. Microfinance/ ACSI/Cooperative

47. During the last 12 months did you have voluntary saving? 1. yes 0. No

48. If yes, to question 48 where or how did you keep your savings?

1.In my house/under mattress 2. Traditional RUSSACO 3. Bank

4. Save in the form of jewelry 5. Buy livestock 6. Other specify----------

49. Amount of saving ----------Birr.

50. Do you receive any sort of extension services available in your locality? 1.Yes 0. No

51.If yes, during which operation? 1. land preparation 2. planting/transplanting 3. weeding

4. applying agro chemical 5. watering 6. Harvesting 7. marketing

52. If yes to question 8, how frequent it is?

1.Never 2. weekly 3. biweekly 4. monthly 5. once in a year.

53. Do you have access to market? 1. yes 0. No

54. Did you get reasonable price for your produce at the place you used to sell to? 1. Yes 0. No

55.Do you get market information about prices and demand conditions of agricultural inputs and out puts? 1. Yes 0. No

56. if yes to question 56, indicate the source of information.?

1.personal 2. extension agents 3. marketing agency 4. cooperatives

57. How long does it take you access the main road from home ----------(Hrs.)?

58. How long does it take you to the main nearest market place from home? ____ (Hr.)

IX. Overall Assessment and Impact for small scale Irrigation Users

59. Do you think that irrigation has a positive effect on household livelihood condition?

1. Yes 0. No

60.If your answer is yes, to question 60, what are the positive effects of irrigation that you have got? 1. Diversification of crops grown 3. Increased household income

2. Increased agricultural production. 4. Other specify----------

61.What happened to your household 's living condition over the last five years?

1.Big Improvement 2. small improvement

3. Remained the same 4. worsening (going from bad to worse)

62. If improved how was it improved using irrigation have you observed? (Multiple answers, possible.

1. Change in the number of meals eaten per day

2. Change in the variety of food eaten.

3. Changing the amount of money spent on education.

4. Change in the amount of money spent on health.

5.Change in the amount of money spent on clothing.

6. Change in the ability to cope with draught.

7.Change in coping strategies during times of food shortage.

8.educe in crop failure and increase production.

9. Change in the number of products sold for income.

10. Increase employment opportunity during irrigation season.

63. What can you say about the impact of small scale irrigation on your household's livelihood?

1.Very big positive impact (i.e., long term and permanent positive impact)

2.Good impact (mainly temporary benefit, but some permanent impact

3.Very small positive impact (small temporary benefit)

4.Partially positive, partly negative (mixed with the overall impact being almost zero)

5.Negative impact (I got into problem as a result).

X. Household fixed and Productive Asset possession

64. Can you give financial estimate (current market value) of fixed assets under your possession?

Item	**Quantity**	**Unit price (ETB)**	**Total value (ETB) current market price**
House & Household Assets			
House(Houses)			
Telephone(mobile)			
Radio			
Tape Recorder			
Chairs /Benches/stools			
Gold			
Silver			
TV			
Solar			
Bed /wood or metal/			
Livestock			
Ox			
Cow			
Heifer			
Bull			
Calf			
Sheep			
Goat			
Donkey			
Mule			
Horse			
Poultry			
Productive Assets			
Bee hive (traditional)			

Bee hive(Modern)			
Farm materials			
Motor pump			
Drip Irrigation			
Cart			
Mill			
Others			

XI. Constraints Confronting Irrigation Farmers

65. Have you cultivated the total of your irrigable land during the last dry season? 1.Yes 0. No

66.What are the constraint that affect your participation in irrigation farming??

1.water 2. land 3. labor 4. inputs 5. credit 6. market 7. pest and disease 8. other specify---

67. What are the major problems encountered in the use of upgraded small-scale irrigation, what is your opinion about the solution----------
----------?

68.What help do you need from the government or any organization on your irrigation farming?

THANK YOU FOR YOUR COOPERATION!!!

Appendix 20.Focus Group Discussion Checklist

1. Opportunities, challenges and constraints faced as farmers/irrigators?

2. Solutions to the challenges and constraints?
3. What are the challenges faced in irrigation farming?
4. What are the challenges faced when marketing?
5. Does small scale irrigation scheme improve livelihoods of irrigators significantly more than that of non-irrigators or community at large? In what ways? ----------
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Appendix 21.key Informant Checklist

1. What is the role of small scale irrigation in improving the livelihood of farm households and farm household ‘s income and asset formation? ----------
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2. According to your opinion what is the contribution of the small scale irrigation for the local and regional income growth?
3. What do you think are the major benefits of irrigation to farm households?
4. What are the major factors that influence irrigated agriculture?

BIBLIOGRAPHIC SKETCH

Eliyas Assefa was born in South *Wollo Zone* at *kutaber Woreda* in *Amhara* region, on September 1982 E.C. He completed grade 1-8 and grade 9 - 10, at kutaber town. He attends Grade 11 and 12 at Memehirakalewoled preparatory School at Dessie town. He joined *Jimma* University College of Agriculture and Veterinary Medicine science in 2001 E.C. Accomplished his Bachelor of science degree in Agricultural Economics in 2003 E.c. Immediately after graduation, he was employed as Household Asset Building Program Monitoring and Evaluation officer on 2003 E.c at Mekdela Woreda office of Agriculture. After he served for five years, he got the chance to study M.Sc. degree in Agricultural Economics at Bahir Dar University College of Agriculture and Environmental Science. The author is married and has one daughter.