SCHOOL OF GRADUATE STUDIES

IMPACT OF SMALL SCALE IRRIGATION ON HOUSEHOLD INCOME: IN CASE OF MESKAN WOREDA, CENTRAL ETHIOPIA

MSC THESIS

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Impact of Small Scale Irrigation on Household Income: In Case of Meskan Woreda, Central Ethiopia

A Thesis Submitted to the Department of Economics, Wolkite University for the Partial Fulfillment of the Requirements of the Award of Master of Science Degree in Economics (Specialization: In Development Economics)

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DECLARATION

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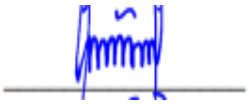
Mulatie Chanie (Assistant Professor)		22/11/2023
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Final approval and acceptance of the thesis is contingent upon the submission of its final copy to the council of postgraduate program (CPGS) through the candidate's department or school graduate committee (DGC or SGC).

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DEDICATION

I dedicated this thesis to my parents, especially

My Sister Jemila Muna and Leyla said

My wife Leyla said

For their sincere support and understanding during my study period.

BIOGRAPHY OF THE RESEARCHER

Redwan Muna Kemal was born in the Meskan Woreda in Misrak Guraghe Zone, Central Ethiopia Regional state, to his father Ato Muna Kemal and his mother W/o Zulefa Ebrahim on June 10, 1997 G.C. He attended his elementary school at Meskan Woreda Dobena junior school and secondary education at Enseno secondary school, and his preparatory School was Butajira preparatory School. He then joined Dilla University (College of Natural and Computational Science) in 2014 G.C in Departments of Statistics and also he was graduated first degree in 2016 G.C. After that he work on Meskan Woreda Administrative Office and in different positions until he joined the School of graduate Studies at Wolkite University in 2021/2022 G.C academic year to continue his studies towards MSc Degree. Now he attend post graduate program in Wolkite University Department of Economics, in Developmental Economics (MSc) program.

ACRONYMS AND ABBREVIATIONS

ADLI	Agricultural development led industrialization
BMC	Billion Metric Cubes
CSA	Central Static Agency
ELSEVIER	Earth and Land System and Environmental science
FAO	Food and Agriculture Organization
FGD	Focus Group Discussion
IWMI	International water Management Institute
MSI	Medium Scale Irrigation
LSI	Large scale Irrigation
MoARD	Ministry of Agriculture and Rural Development
MOFED	Ministry of Finance and Economic Development
MOWR	Ministry Of Water Resource
MOWIE	Ministry Of Water, Irrigation Energy
PSM	Propensity Score Matching
NGOs	Non-governmental organizations
RWH	Rain water harvesting
SSI	Small Scale Irrigation
SNNPR	South Nations Nationalities and People Region
TLU	Tropical Livestock Unit
WSDP	Water sector development program

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ABSTRACT

This study investigates the impact of small scale irrigation on household income by taking cross-sectional data obtained from Meskan Woreda, Misrak Guraghe Zone of Central Ethiopia. The study aimed at assessing the impact of small scale irrigation on household's income. Data for this study were collected from both primary and secondary sources. A sample of 372 households (120 households were user group whereas, 252 households were non-user group) from four kebeles was selected using multistage simple random sampling. The data were analyzed by using a combination of both descriptive statistics and econometric model such as, (PSM) were employed to analyze data. By applying a propensity score matching technique, the study found that the participation of small scale irrigation has increased the net income of user households by 10.65% per-annum compared to non-user households. The estimates of the propensity score matching of the logit model result showed that Access to Extension Services, Livestock Holding, farming experience and Sex of the respondent affects households' probability of participation in small scale irrigation have positive and statistically affected the income of small scale irrigation at 1% and 10% significance level. While, more precisely land holding size, Dependency Ratio and Age of household head affect households' probability of participation in small scale irrigation have negative and significant effect on income of small scale irrigation participation. The estimated results revealed that households, who owned larger land holding size, get technical advice, training or participated on field demonstrations by taking agricultural extension services, Livestock Holding and farming experience were more likely to benefit from the use of small scale irrigation, ceteris paribus. Accordingly, the result revealed that the most important small scale irrigation practice designed to increase production and productivity which reduces risk related with rainfall variability and increasing income of rural farm households. Hence, overall it can be concluded that participation in the small-scale irrigation has positive effect on most of the household income and that an expansion of small scale irrigation schemes there by improve small holder rural farm household's annual income. Therefore, policy makers and other stakeholder's should give due attention in irrigation technology.

Keywords: Small scale irrigation, Household Income, Propensity Score Matching

CHAPTER ONE

INTRODUCTION

1.1. Background of the Study

Agriculture contributes substantially to the economic growth of many low-income countries. It is often the leading sector of the economy as source of income, employment and foreign exchange. More than half of the less developed countries population gets their food from own-production. Agricultural output also is used as an input for industries so it can stimulate the growth of industrialization. Improving agricultural productivity thus contributes to income growth (UNDP,2007).

Irrigation is one methods of agricultural intensification and plays dominant role in increasing agricultural productivity. Accordingly, irrigation contributes to livelihood improvement through increased income, food security, employment opportunity, social needs fulfillment and poverty reduction (Ashu,2022).

Thus, as to Lipton et al., (2004) cited by Zeweld and Hidgot (2017) irrigated agriculture can have interrelated mechanisms with reduction of poverty by (i) increasing production and income and reduction of food prices, which help very poor households meets the basic needs and associated with improvements in household overall economic welfare (ii) promoting greater use of yield enhancing farm inputs (iii) protecting against risks of crop failure due to erratic, unreliable or insufficient rainwater supplies (iv) creation of additional employment that enables people to move out of the poverty cycle.

In the same way, According to (Zhou et al. ,2009)**,** mentioned that irrigation contributes to agricultural production in two ways: increasing crop yields, and enabling farmers to increase cropping intensity and switch to high-value crops. Therefore, small scale irrigation can be an indispensable technological intervention to increase household income. Furthermore, irrigated systems have expanded in recent years to bring water control which together with rapid increases in water productivity has greatly boosted agricultural production and incomes (FAO, 2011).

Accordingly, over 300million hectares of the world's agricultural land are irrigated and account for more than one-third of global food production (Fischer, 2008). Weak utilization of surface and groundwater for irrigation is already affecting natural water reservoirs around the world. This indicates that irrigation was become an issue of global

concern and competition in the future, especially in the arid and semi-arid regions of the world.

According to (FAO, 2007) estimated that the total irrigation potential for Sub-Saharan Africa is about 33.6 million hectares. Regarding the total irrigation area indicated that Africa south of the Sahara irrigates some 5 million hectares and the irrigated area has been growing at a rate of 5% per year. Meanwhile**,** Modern irrigation in Ethiopia began in 1950's by private and government owned schemes in the middle awash valley in which big sugar, fruit and cotton farms were established(FAO, 2006) .

In that, the main purpose of irrigation development was provision of industrial crops for the growing agro-industries. As a result, small scale irrigation has not been given much more consideration until the country's strategy i.e., Agricultural development led industrialization (ADIL) considers irrigation development as a key input for having sustainable development. That is why, irrigation development particularly small scale irrigation is being planned to be accelerated and also improved to have impact on the livelihood of farmers who was engaged on it (MoFED, 2010).

Ethiopia has a great irrigation potential, which is estimated as 5.3 million ha of land, of which, 3.7 million ha can be developed using surface water sources, and 1.6 million ha using ground water and rainwater management (MoFED, 2010; Awulachew and Mekonin, 2011). And also Ethiopia has a long history, mosaic of people and diverse cultures. It has reasonably good resource potential for agriculture development, endowed with rich biodiversity, water resource, minerals, etc.

The ground water potential of Ethiopia is estimated to be 2.6 billion cubic meters, eleven major lakes with a total area of 750,000 ha and total annual surface runoff of 123 billion cubic meters in Ethiopia. Yet, it is faced with complex income crisis, which is broad, deep and structural (MoFED, 2002).

Agriculture in Ethiopia is small-scale, rain-fed, and traditional and subsistence farming with limited access to technology and institutional supportive service (Desta, 2004). The development of small-scale irrigation is one of the major intervention areas to improve agricultural production in the parts of rural areas. This helps to poor farmer in order to reduce rainfall and water constraint by providing a sustainable supply of water for cultivation and livestock, strengthen the base for sustainable agriculture, provide increased income to poor communities through irrigated agriculture and contribute to the

improvement of human nutrition (FAO, 2003a). Small-scale irrigation contributes to household income improvement through increased income sources, employment creation and poverty reduction. Hussain and Hanjira (2004) confirmed a strong direct and indirect linkage between irrigation and income. Direct linkages operate through localized and household level effects; on the other hand, indirect linkages operate through aggregate or sub-national and national level impacts.

Small-scale irrigation system in Southern Nations Nationalities and People's Regions (BoWI, 2016) report the region has a total potential of 700,000 hectares of land that can benefit at least 142,707 households and potential developed irrigation scheme 161,718 hectares of land but it has been used only (26.18%) 42,339 hectares with irrigation (BoWI, 2016).

Moreover, Guraghe Zone's and the study area i.e., Meskan Woreda administration have their own plan in regard to small scale irrigation practice by households. Thus, 15,120 and 4600 hectares of lands by 17,870 and 960 households have been planned by Zonal Department and Woreda Office, Water and Irrigation respectively. But, as to the same source above discussed, the achievement has been 14,900 hectares of land at Zonal and 3500 hectares of lands Woreda level with 12,150 households in Guraghe Zone and 890 households in Meskan Woreda have been participate on small scale irrigation. Therefore, this study was intended to assess the impact of small scale irrigation on household income the case of Meskan Woreda, Misrak Graghe Zone, and Central Ethiopia.

1.2. Statement of the Problem

Agricultural production in Ethiopia is primarily rain-fed and depends on erratic and insufficient rainfall. As a result, there are frequent failures of agricultural production. Irrigation has a high potential to stabilize and increase agricultural production and mitigate the negative impacts of variable or insufficient rainfall. Irrigation plays a great role in agricultural production by improving crop yields and enabling farmers to increase cropping intensity and switch to high value crops (Belay and Beyene, 2013; Adugna et al., 2016)**.** Thus, irrigation based agricultural production of households level has been the way forward to tackle many of the challenges related with rain water inadequacy. The irrigation development, particularly small-scale irrigation is one of the major programs to improve agricultural production and income in the rural households of a country.

Based on his study findings (Ahmed, 2021) , small-scale irrigation practice had been challenged by lack of extension services provision, shortage of needed inputs, and poor infrastructure such as access to road, information, and market. Thus, different investigations the practice of small-scale irrigation has been facing different challenges.

Moreover, small scale irrigation product type, market link, various pests and insects infection and small scale irrigation technology related issues have been also creating problems on small scale irrigation practice (Aklilu et al.,2016). Similarly, agricultural production activities are challenged by other factors such as: degradation of land and soil, deforestation, population boom, epidemic and transmittable diseases (Wolde Mekuria, 2013). Several impact analyses have been conducted in many developing countries like Ethiopia where SSI is a popular source of rural household's income. However, limited researches were conducted in the area of impact of small scale irrigation on household income in Ethiopia; Specifically study has been conducted concerning the impact on SSI participation on rural households income in Bambasi District, Benishangul-Gumuz Region, Ethiopia (Tsegazeab and Dr. Surajit,2016, Ahmed, 2021) and also (Belay & Beyene 2013) analyzed small scale irrigation and household income linkage: Evidence from Deder district, Ethiopia. Their study mainly focused on local institutional failure was a more important challenge than hydrological factors in managing the irrigation system.

In line with this fact, the existing small scale irrigation practice has other drawbacks including: absence of examining how participation in irrigation projects is determining the livelihood of households and presence of poor practice of irrigation management being discouraging efforts to improve livelihoods and expose people and the environment to risks and so failure mainly as of insufficient participation by beneficiaries (Abdi, 2015; Mengistie and Kidane, 2016).

Irrigation increases agricultural productivity and farm income per hectare, according to previous studies (Nhundu & Mushunje, 2006, and Ahmed, 2021;Surajit Bera, 2017). It insulates the national agricultural economic sector against weather-related shocks and provides a more stable basis for economic growth and poverty reduction. Similarly, according to (Abraham et al.,2015) states that, irrigation practice is an important strategy in reducing risks associated with rainfall variability and improving the capacity of rural farm households in having more agricultural production. Irrigation development is the most important interface between water and land resource, and these resources are an

adequate amount resources existing in the country. Irrigation has been regarded as a powerful factor for providing food security, protection against adverse drought conditions, increased prospects for employment and stable income, and greater opportunity for multiple cropping and crop diversification (Seifu, 2021).

However, it can be understand as the small scale irrigation practice by households has been challenged by shortage of investigation about participation determinant factors. Therefore, there is information access on the benefit of small scale irrigation, poor infrastructure, low productivity leads to the use of irrigation, low small scale irrigation participation management at least and resulting in its efforts unrealized there is a gap between what is planned to achieve and the actual performance. The study area, Meskan Woreda is affected by rainfall variability, reduce crop yield and threaten food security in low income and agriculture based economies. Rainfall in the area is uneven and erratic which makes worth recurrent drought and food shortage. To manage up this problem households level in the study area have been applying different small scale irrigation schemes with the objective of increasing agricultural productivity in order to improve the food security and to reduce dependency on the erratic and often insufficient rainfall.

However, there was no found specific study conducted Meskan Woreda, to my awareness even in Misrak Gurageh Zone on the impact of small scale irrigation on household income. Specifically in the Meskan Woreda there are no any studies conducted regarding this topic as the researcher referred still and this study was help to narrow the knowledge gap in the topic especially in the study area. It can fill the knowledge gap, contributes for the existing literatures, policy makers and practitioners as references in designing new strategies for improving household (private) irrigation practices.

To this end, the motivation for this study is to fulfill this gap. Accordingly, this study was intended to assess the impact of small scale irrigation on household income in the case of Meskan Woreda.

1.3 Research Questions

1. What factors affect a household's decision to participate in small-scale irrigation in the research area?
2. What is the impact of small-scale irrigation on household income in the study area?

1.4 Objectives of the study

1.4.1General objective

- The general objective of this study is to examine the impact of small scale irrigation on household income in Meskan Woreda, Misrak Guraghe Zone, Central Ethiopia.

1.4.2 Specific Objectives

- To identify determinants of small scale irrigation participation in the study area
- To examine the impact of small scale irrigation on household income in the study area

1.5 Significance of the study

Assessing individuals 'understanding regarding factors that affect household's participation in small scale irrigation and its impact on household's income is important in policy planning for successful sustainable household's income generation. Moreover, this study is timely and relevant and in line with the government objectives of reducing poverty and enhancing household income in sustainable basis.

The Government, non-governmental organizations (NGO), farmers, the private sector, communities and extension agents, policy makers, and other interested groups who are stakeholders in irrigation development was benefited from the study's findings. Additionally, as policymakers and planners develop small scale irrigation projects to raise household income at the macro or micro levels, this study was contributed to the discussion on the effects of small scale irrigation. Moreover, it could enable all stockholders to identify the existing strengths and weaknesses including positive outcomes as well as lost economic opportunities. Additionally, it might make it possible for all stakeholders to recognize the company's strengths and flaws, including both successful outcomes and missed business chances. The study also offers baseline data for future research and development interventions that aid farming populations in regards to household level small-scale irrigation involvement.

1.6 Scope and Limitation of the Study

The study has thematic as well as geographic delimitation: due to this thematically the research is confined to investigate the impact of small scale irrigation participants rather the whole irrigation participants, geographically, it is delimited to investigate the small scale irrigation participant only in single Woreda that is Meskan Woreda based on households' survey data base across four kebeles collected from 372 households in 2023

production year. This study principally surveyed on the impact of small scale irrigation, determinants of households' participation and household's income in the study area. This study focuses on the impact of irrigation on net income at household level. However, there are limitations that need further in-depth analysis, including the net income analysis of irrigation technologies using cost benefit analysis.

Furthermore, the study focuses on the impact of small scale irrigation on household income Meskan Woreda. Since non-experimental data and statistical techniques were used to model the behavior of participants and non-participants households, using them requires a high level of precaution to avoid or minimize estimation biases. The first kind of estimation bias arises from failing to account for unobservable variables, called omitted variables estimation bias. The second kind of estimation bias is called selection bias and comes from endogenous program placement (Rubin, 1974). The other problem might be non-probability selection of the Woreda. To minimize the selection bias, the researcher will use a regression model referred to as regression on covariates and matching methods in which we control for selection bias by including a large set of observable covariates.

1.7 Organization of the Study

This thesis is organized into five main chapters. The first chapter introduces the background of the study, statement of the problem, objectives of the study, significance and scope and limitation of the study. Second chapter covers both related theoretical and empirical literature review. Chapter three presents the methodology that describes the study area, data sources and data collection methods, sampling technique and empirical specification of model variables. The fourth chapter is fully devoted to empirical analysis. It presents results and discussion in relation to major objectives of the thesis. Chapter 5 provides summary and conclusions of the study as well as some suggestions for further research respectively.

CHAPTER TWO

REVIEW OF RELATED LITERATURE

This chapter all about review of related literature from various sources such as; books, researches, magazines, newspapers, articles, websites, journals and other literatures. Therefore, it had included; theoretical perspectives, definitions of terms and concepts of irrigation, methods of irrigation, types of irrigation, status of irrigation development and experience, irrigation development experience and potential in Ethiopia, small scale irrigation schemes management, review of impact evaluation methods, empirical literature review on factors affecting small scale irrigation impact on households income. At the last section of this chapter, the conceptual framework for this study, which is drawn from the theoretical perspectives, is explained briefly.

2.1. Theoretical Literature Review

2.1.1Definition of Terms

Irrigation is defined as the artificial application of water to the crop for the purpose of food and fiber production overcoming deficiencies in rainfall and help in creating stabilized agriculture (FAO, 2006). Or it is the process of applying water to meet the water needs of growing plants Water from rivers, reservoirs, lakes, or aquifers is pumped to or flows by growing through pipes, canals, ditches, or even natural streams (ELSEVIER, 2013).Irrigation is widely defined as the practice of applying water to the soil to supplement the natural rainfall and provide moisture for plant growth. Water from rivers, reservoirs, lakes, or aquifers is pumped to or flows by growing through pipes, canals, ditches, or even natural streams.

Irrigation has been practiced in Egypt, Ethiopians, China, India and other parts of Asia for a long period of time. Irrigated farms produce higher yield for most crops. 30-40 percent of world food production comes from an estimated 260 million hectare of irrigated land. Small-scale irrigation can be defined as irrigation, usually on small plots, in which small farmers have the controlling influence, using a level of technology, which they can operate and maintain effectively. There are three broad types of smallholder schemes: government managed, farmer managed, and jointly managed schemes.

Irrigation reduces the risk of these expensive inputs being wasted by crop failure resulting from lack of water (Gidey,2020) Droughts are frequent in most African countries and

each year more people are at risk from the effects of inevitable droughts of greater or lesser severity. Furthermore, Africa's water resources are relatively less developed than those in other regions.

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 regions and even in areas where total seasonal rainfall is adequate an average (FAO,2007).Thus, as of the above definition, irrigation can be understood in as a method that can be applied in agricultural production activities to combat the challenges of shortage or absence of rainfall. Furthermore, according to (FAO,2011) irrigation is defined as a continuous and reliable water supply to the different crops in accordance with their different needs. Accordingly, with employment of irrigation farmers could be able to use the water sustainably and as to the requirement of the plants in their agricultural field. Accordingly, this study has taken the definitions given by for its appropriateness to specifics objectives desired to be achieved.

2.1.2. Concept of Irrigation

Irrigation is a very old practice in the world. It is an old human activity and been practiced in the some parts of the world for several thousand years. Irrigation is a very ancient agricultural practice which was extensively used by a number of early civilizations such as the ancient Egyptians and Ethiopians (Grove, 1989). According to (FAO, 1996a), irrigated agriculture can be the supply of water increased by artificial means, involving the use of water controls technology and including drainage to arrange excess water. Irrigation has been practiced in Egypt, Ethiopians, China, India and other parts of Asia for a long period of time. Rice has been grown under irrigation in India and Far East for nearly 5000 years. The Nile valley in Egypt and the plain of Tigris and Euphrates in Iraq were under irrigation for 4000 years (Peter, 1997).

Irrigation has long played a key role in feeding expanding populations and is undoubtedly destined to play a still greater role in the future. It not only raises the yields of specific crops, but also prolongs the effective crop growing period in area with dry seasons, thus permitting multiple cropping (two or three and sometimes four crops per year) where only a single crop could be grown. Otherwise the security provided by irrigation, additional inputs needed to intensify production centered pest control, fertilizer, improved varieties and better tillage become economically feasible. Irrigation

reduces the risk of these expensive inputs being wasted by crop failure resulting from lack of water (Gidey,2020).

According to (Gidey,2020) 30-40 percent of world food production comes from an estimated 260 million hectare of irrigated land or one-sixth of the world‘s farmland. Irrigated farms produce higher yield for most crops. (FAO, 2001) also reports that the role of irrigation in addressing food insecurity problem and in achieving agricultural growth at global level is well established.

Clearly, irrigation can and should play an important role in raising and stabilizing food production especially in the less developed parts of Africa south of the Sahara. For instance, in Sub-Saharan Africa, only about 10% of the agricultural productions come from irrigated land. Trends in irrigated land expansion over the last 30 years show that, on the average, irrigation in Africa increased at a rate of 1.2% per year; this rate began to fall in the mid-1980s and is now below 1% per year, but varies widely from country to country. Therefore, in a more practical sense, small scale irrigation developments are concentrated with the upgrading of traditional community irrigation or village irrigation systems, newly designed and constructed irrigation systems and ground water and pump development (Smith, 1998).

In highlands areas like Ethiopia, where water is delivered through gravity, small scale irrigation schemes concern the upgrading of irrigation works, where the diversion structures constructed by traditional communities with local means such as stone and brushwood have been replaced by small concrete or masonry weir, which divert water in a more effective and durable way. Such upgrading of irrigation works are the major functions of all river diversion irrigation projects that have been undertaken in different parts of Ethiopia.

Moreover, small-scale irrigation can be defined as irrigation, usually on small plots, in which small farmers have the controlling influence, using a level of technology, which they can operate and maintain effectively. In terms of management, there are three broad types of smallholder schemes: government managed, farmer managed, and jointly managed schemes. Farmer managed schemes are developed either by community or by government but owned and managed by farmers' irrigation management committees or water users' associations with minimal government interventions.

Small-scale irrigation (SSI) refers to a wide range of approaches by which soil-water

can be increased and soil-water management improved. These approaches include techniques for catching, storing and using rainfall at or near the place where it falls (usually called rainwater harvesting); diverting flowing water by gravity; using stone/earth/brushwood or concrete structures (run-of-river or spate irrigation systems); lifting water by human or motor power (lift irrigation); conveying water by canal or pipe; and applying water to land by controlled or uncontrolled flooding (gravity), overhead sprinklers (pressurized), or drip irrigation (in the present context, usually at very low pressure) (Richard and Kerstin, 2006).

It is also one of the most useful irrigation systems designed to increase production and productivity and reduces risk related with rainfall variability and increasing income of rural farm households indeed. Small scale irrigation is an irrigation that can be practiced on small plots where small farmers have the controlling influence using a level of technologies which they can operate and maintain effectively (Dessalegn & Merrey , 2016).

2.1.3 Methods of Irrigation

Irrigation methods are the system how to obtain water for irrigation purposes from its sources. The study by (Dupriez and De Leener , 2002), stated that irrigation methods depend on several factors such as topography, water resources, the plants cultivated, the land tenure systems, the growing seasons and the rain and water regimes.

There are only two general methods of applying irrigation water.

i. Surface irrigation

ii. Sub-surface irrigation

I .Surface Irrigation: Surface irrigations are the oldest methods of irrigation, which convey water from the survey to the fields in lined or unlined channels. Surface irrigation is the introduction and distribution of water in a field by the gravity flow of water over the soil surface. One can choose these irrigation methods depending on the nature of the soil, the form of the land, the head of the water stream, the quantity of water available and the nature of the crop. Basin irrigation is the most common form of surface irrigation, particularly in regions with layouts of small fields. A basin is a piece of land, small or large, surrounded by earth bunds in which water is pounded. The field to be irrigated is divided in two units surrounded by levels or dams. Gated outlets, siphon tubes, spiels, and

hydrants conduct water from delivery channels in to each basin. This type of irrigation is suitable for all types of soil and efficient use of water but it needs high initial cost for leveling land.

II. Sub-Surface Irrigation: Sub-surface irrigation is the application of irrigation water from below. Sub-surface irrigation has the advantage that water so applied is not subject to such direct evaporation from the surface as of necessity accompanies surface irrigation. Thus, the most commonly practicing irrigation techniques/methods/ in which irrigation water can be applied to the farm fields.

As regard with the ways of supplying irrigation water to the farm, the following four types are identified: i. Sprinkling or Spray Irrigation, ii. Drip Irrigation, iii. Furrow irrigation and IV. Flood Irrigation.

I Sprinkler Irrigation: According to (Dupriez and De Leener , 2002), Sprinkler irrigation imitates rainfall. It is also called overhead irrigation. It is a method whereby the water is applied to the soil in the form of a spray through a network of pipes and pumps. It is a kind of artificial rain and gives very good results in terms of fulfilling the normal requirements of the plant and uniform distribution of water.

II Drip Irrigation: Is the latest technique of irrigation. It is applied in dry and arid region where there exists acute scarcity of irrigation water. In this method water is slowly and directly applied to the root zone of the plant, thereby minimizing the losses by evaporation. Therefore, the principle of drip irrigation is to wet dry ground with small amounts of water just where the plants can absorb it.

III Furrow Irrigation: Is the technique in which the water is guided in the furrow or channels that pass through the whole field. In this method, only some part of the land surface is covered and wetted by water it therefore, results in less evaporation. The furrows are separated with ridges. At each ridge, water is conveyed into furrows. Furrowing irrigation method is applied on steep slopes.

IV Flood Irrigation: Unlike that of furrow irrigation, in flooding method of irrigation water covers the entire surface of the field to be irrigated. In this method water is conveyed in a ditch at the upper part of plot and allowed to spread over the land in a manner directed by the natural landscape. As a result, it is considered to be the least controlled of all irrigation techniques.

2.1.4 Types of Irrigation

Irrigation structures can be divided into different scales based on their irrigating potential of a given land. For instance, in (IWMI Gaafar et al.,2016) stated that there are three types of irrigation systems based on the size of area under irrigation. These are:

Small Scale-Irrigation (SSI): Small scale irrigation (SSI) schemes conventionally, are those cover an irrigated area of land up to 200 hectare. Method of small scale irrigation is often community based and traditional. Examples of SSIs include household based rain water harvesting, hand-dug wells, and shallow wells, flooding, individual household-based river diversions and other traditional methods.

Medium-Scale Irrigation (MSI): which is community based or publicly sponsored, covering 200 to 3,000 hectares.

Large-Scale Irrigation (LSI): Large scale irrigation (LSI) schemes are those irrigation systems that cover an area of 3000 hectares or more. Consequently, small scale irrigation schemes are the responsibility of the MOARD and regions, while MSI and LSI are the responsibility of the MOWRI. Small-scale irrigation is widespread and has a vital role to play in Ethiopia. The success of small-scale systems is due to the fact that they are self-managed and dedicated to the felt needs of local communities. In reality, small-scale schemes are defined as schemes that are controlled and managed by users themselves (IWMI Gaafar et al., 2016).

An important aspect in 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. Accordingly, this study has the types of irrigation which is SSI for its appropriateness to specifics objectives desired to be achieved.

2.1.5 Sources of Rural Household Income

According to (Pratap et al., 2014), the "value of output" from an activity was considered as income from that activity. The concept of income used in the study reckons with income earned both in cash and in kind. Therefore, money values were allocated to receipts of income in kind and household consumption of crops and livestock produced

based on prevailing market prices. Values were also computed for houses occupied by their owners. Recognition was made of whether incomes recorded were incomes before or after taxation.

The study identified the following sources of income:

Non-farm income: includes income realized from non-farm labors, government and private sector, employment (full or part time), and profits from non-farm enterprises.

Agricultural income: includes net income from all crop production with imputed values from home production and agricultural labors.

Transfer income: includes income from relatives within and outside the country, government pension and other gifts received.

Livestock income: includes net income from cattle, poultry, sheep, goat, pigs etc.

Rental income: includes net income received from ownership of assets as regional wage rates raise the composition of the rural non-farm economy changed and returns to labor increase enabling the poor as well as the rich to benefit from regional growth via nonfarm diversification **(**Barret et al., 2001).

2.1.6 Determinants of Adoption of Small Scale Irrigation

To enhancing small-scale irrigation agricultural productivity requires that the farmers gain access to reliable and good quality farmer services assistances like extension, finance and opportunities. Improving this agricultural productivity is important in the view of the increasing scarcity of land for cultivation which makes intensification an ineffective response to the demand for increased agricultural production. Thus, farmers should be assisted to produce more from the existing land because prospects for increasing agricultural production through land expansion are not good (Rukuni et al., 2006).

2.1.7. Status of Irrigation Development and Experience

Over 300 million hectares of the world's agricultural land are irrigated and account for more than one-third of global food production (Fischer, 2008) Of these almost three-quarters of the total irrigated area is found in Asia. Many studies suggest that large investments in irrigation have been an essential element in increasing food production to sustain the ever-growing population. To meet food requirements by 2020 (world population is estimated to reach 8 billion), (FAO**,** 1995) estimated that food production

from irrigated areas will need to increase from 35 percent in 1995 to 45 percent in 2020. This indicates that access to water for irrigation will become an issue of global concern and competition in the future, especially in the arid and semiarid regions of the world.

When we look at the situation in Africa, frequent drought conditions and ever-increasing population in most countries have attributed to the increasing expansion of irrigation farming since the 1960s. (FAO, 2007) estimated that the total irrigation potential for Sub-Saharan Africa is about 33.6 million hectares. Regarding the total irrigation area (FAO, 2007) indicated that Africa south of the Sahara irrigates some 5 million hectares and the irrigated area has been growing at a rate of 5 per cent per year in 1965-74 and less than 4 percent a year in 1974-1982. It was also estimated by (FAO, 2007) that irrigation development in Sub-Saharan Africa contributes 10 percent of the region's cereal supplies. Indicated that small scale irrigation schemes are generally financially viable for third world countries. Irrigation consumes about 70 percent of the world available water. There is urgent need for the new strategies to improve the productivity of water in both irrigated and rain-fed agriculture and ensure access to water and technologies by the poor (Baker and Koppen, 1999). Furthermore, the area equipped for irrigation is projected to increase by about 6 percent by 2050. Water withdrawals for irrigation are projected to increase by about 10 percent by 2050. Irrigated food production is projected to increase by 38 percent, due to projected increases in cropping intensities and increases in productivity (Tubiello and van der Velde, 2010).

Overall, the scope to improve both land and water productivity on irrigation schemes is considerable, as illustrated by the large discrepancies observed between schemes and within schemes. It is predictable that cropping intensities on irrigated land actually in use will increase worldwide from 127 percent to 129 percent by 2050. In developing countries, higher intensities are expected, rising from 143 percent in 2005-7 to 147 percent by 2050 (Bruinsma, 2009; Frenken, 2010).

These increases are technically feasible, and the best-managed system already has cropping intensities of 200 percent or more. Key factors in achieving higher intensity will be modernization of infrastructure and institutional change to improve water service, together with the development of profitable agricultural markets (Nachtergaele et al., 2010b).

2.1.8. Irrigation Development Experience and Potential in Ethiopia

Ethiopia has a long history of traditional irrigation systems where simple river diversion still is the dominant irrigation system. In this regard, (Kloos, 1990) argued that in Ethiopia, irrigation has a long tradition. According to the report of (FAO, 1995c), modern irrigation was started at the beginning of the 1960s by private investors in the middle awash valley where large quantities of sugar cane, fruit and cotton are produced. With the 1975 rural land proclamation, the large irrigated farms were placed under the responsibility of the Ministry of State Farms.

Almost all small-scale irrigation schemes built after 1975 were organized into producers' cooperatives. For much of the lifetime of the Derg, very little attention was paid to small-scale and traditional irrigation schemes constructed and managed by peasant farmers. With the nationalization of industrial and agricultural enterprises, the government's emphasis was to promote high technology water development schemes managed by state controlled agro-industrial and agricultural enterprises. It was only in the second half of the 1980s, as a result of devastating famine of 1984/85 that the Derg began to show interest in small scale water management schemes. The establishment of the Irrigation Development Department (IDD) within MoA at the end of 1984, a body entrusted with the development of small scale irrigation projects for the benefit of peasant farmers, signaled a new approach to water development by the military government. However, progress was slow. From the mid-1980s to 1991, IDD was able to construct some 35 small schemes, of which nearly one-third was formerly traditional schemes used by peasants (MoA, 1993; Dessalegn & J.Merrey, 2016).

Small-scale irrigation developments were carried out by the surface water division of the Soil and Water Conservation Department (SWCD) of the Ministry of Agriculture (MOA). In 1984, the division were separated from SWCD and upgraded to IDD. In 1987, the activities of MOA were being decentralized to zonal offices, and IDD staffs were being transferred to strengthen the capacity of the zones. However, in 1992, a new Ministry of Natural Resources Development and Environmental Protection (MNRDEP) was established, with the responsibility for soil and water conservation, rural water supply and sanitation. Although the Ministry retained responsibility for providing agricultural support services, the IDD was dissolved and its responsibilities were transferred to regional Natural Resources Bureau.

In August 1995, MNRDEP was dissolved and its responsibilities were shared between MOA and the Ministry of Water Resources (MOWR). Under the new arrangements, responsibility for irrigation development was given to the Bureau of Water, Minerals, and Energy Resources Development (BWMERD) while, MOWR has an overall policy, planning and regulatory role in respect to water resource development (Jica & Oida, 2001). Ethiopia has a high potential for irrigated agriculture. It is endowed with abundant water resources; lakes covering 7400 square kilometers, 10 major rivers, and other water bodies, which are expected to provide extensive potentials for irrigation and fish farming (Dessalegn & J.Merrey (2016).

Study by (Gebremedhin, 2015 and Peden, 2002) stated that Ethiopia‘s irrigation potential ranges from 1.0 to 3.7 million hectares but the recent studies indicate that the irrigation potential of the country is higher. According to (Awulachew et al., 2010) estimates of the irrigation potential of Ethiopia may be as large as 4.3 million hectares. Traditional irrigation schemes cover more than 138,000 hectares whereas modern small-scale irrigation covers about 48,000 hectares. The total current irrigation covers only about 6% of the estimated potential land area.

It is therefore clear that, although, water resource potential is said to be abundant in Ethiopia; the country's use of its water resources is seems to be very limited. About 6 percent of the country's irrigable land is now under irrigation. Another sources from Ministry of Agriculture and rural development, indicated that the irrigation potential of the country is estimated to be about 3.7 million hectares. However, until now only about 20 to 23% of this potential is put under irrigated agriculture (both traditional and modern irrigation systems). Recent estimates indicate that the total irrigated area under small scale irrigation in Ethiopia has reached to 853,000 hectare, and by the end of 2015 it is planned to achieve the development of 1850,000 hectares (MoARD, 2010).

The same source showed that the existing irrigation development in Ethiopia, as compared to the resources potential that the country has, is not significant and the irrigation sub-sector is not contributing its share accordingly. However, irrigation development remained a key to the sustainable and reliable agricultural development, and thus, for the overall economic development of the country. Therefore, in order to ensure food security at the household level for Ethiopia‘s fast growing population, smaller, medium and large scale irrigation infrastructure needs to be developed MoARD(2010).

Ethiopia covers less than three percent of the country's cropped land. Assuming that all the irrigated land is utilized to produce food crops, the contribution of irrigation to the production of food would not be significant when compared to the area under rain-fed (Dessalegn & J.Merrey, 2016). Therefore, a rational management and development of water resources is required to effectively and efficiently utilize water resources to achieve food self-sufficiency and food security. Thus, it is essential to develop a small-scale irrigation system. Harnessing some of the sizable rivers can produce some medium-to small-sized irrigation projects (Taffa, 2002).

In Ethiopia, there has been a revival of irrigation during the last decades in order to enhance rural development and food security (FAO, 2006). Given that 85 percent of the people are employed in agriculture (Dessalegn & J.Merrey ,2016) ,developing this sector could help to reduce poverty and enhance food security of the majority of the Ethiopian people. With ever increasing number of population and highly variable nature of rainfall, Ethiopia cannot meet its large food deficits through rain-fed agricultural production alone. Cognizant to this fact; the government has taken initiatives towards developing irrigation schemes of various scales, giving special emphasis to small scale irrigation schemes. The total area indicated to be currently under irrigation agriculture is estimated at about 6% of the potential, accounting for merely 3% of the country's total food production. In the short-term, however, the irrigation development program gives emphasis to the development of small scale irrigation in which capacity building in the study, design and implementation of irrigation projects are the forefront.

According to (IWMI Gaafar et al., 2016), Ethiopia has vast cultivable land (30 to70 Million hectare), but only about a third of that is currently cultivated (approximately 15 Million hectare), with current irrigation schemes covering about 640,000 ha across the country. However, the total irrigable land potential in Ethiopia is 5.3million hectare assuming use of existing technologies, including 1.6 Million hectare through rain water harvesting and ground water. This evidence clearly indicates that in Ethiopia there are potential opportunities to vastly increase the amount of irrigated land.

According (MoWE, 2012) modern irrigation has documented in the 1960s, where the government designed large irrigation projects in the Awash Valley to produce food crops for domestic consumption and industrial crops for exports and it was strongly believed that rain fed agriculture should be supplemented by irrigation in order to achieve national food self-sufficiency and ensure household food security. The total irrigation potential in

Ethiopia is 3798782 hectares, but currently irrigation schemes are covering only 368160 hectares, 10% of the potential (MoFED , 2012).

According (MoWI,2016), SNNPRS region has 700,000 hectares irrigation potential of land that can benefit at least 142,707 households and potential developed irrigation scheme 161,718 hectares of land but it has been used only (26.18%) 42339 hectares with irrigation (BoWI, 2016). The region has been used only 26.18% of its irrigation potential. Accordingly, it has vast unused potential of irrigation resources.

2.1.9. Small Scale Irrigation Schemes Management

The most important performance in the distribution of irrigation water includes adequacy, timeliness and equity in the supply of water (world bank, 2016). In addition, improvements in irrigation performance and water management are critical to ensure the availability of water both for food production and for competing human and environmental needs (IWMI, 2005). Similar to, in Ethiopia irrigation development planners have more emphasized on the agronomic and technical aspects of irrigation projects and most decision have been made by technical experts with little attention to the issue of management (Takele, 2008). Accordingly, the main stockholder should be participated in the management of irrigation water while, the government formulate clear rules and responsibilities in management systems.

Furthermore, in most parts of the country small-scale irrigation infrastructures are not being managed effectively and efficiently as they are supposed to be as well as the scheme performance is low and unprofitable. As a result, improving the capacity of extension services in irrigated agriculture, which includes improving on-farm water and crop management and increasing farmers' know-how and practical skills in operation and maintenance of irrigation systems, is important (FDRE , 2011).

Similarly, according to (IWMI Gaafar et al., 2016) the development of irrigation and agricultural water management holds significant potential to improve productivity and reduce vulnerability to climactic volatility in any country. Improved water management for agriculture has many potential benefits in efforts to reduce vulnerability and improve productivity. The government of Ethiopia and other stakeholders improving agricultural water management is hampered by constraints in policy, institutions, technologies, capacity, infrastructure, and markets. Therefore, addressing these constraints is highly vital to achieve sustainable growth and accelerated. Finally, the management of water

resources shall ensure social equity, economic efficiency, systems' reliability and sustainability norms.

2.2 Review of Impact Evaluation Methods

The word "Impact" is the power to produce change. Impact evaluation is intended to determine more broadly whether the program had the desired effects on individuals, households, and institutions and whether those effects are attributable to the program intervention (Baker, 2000). In the analysis of economic and social impact, knowing the effect of an intervention or a program on a participating individual, one must compare the observed outcome with the outcome that would have resulted had that individual not participated in the program. However, as stated earlier two outcomes cannot be observed for the same individual. In other words, only the factual outcome can be observed. Thus, the fundamental problem in any social program evaluation is the missing data problem (Ravallion, 2005; Bryson et al., 2002).

Estimating the impact of a program requires separating its effect from intervening factors which may be correlated with the outcomes, but not caused by the project. This task of "netting out" the effect of the program from other factors is facilitated if control groups are introduced. "Control groups" consist of a comparator group of individuals or households who did not receive the intervention, but have similar characteristics as those receiving the intervention, called the "treatment groups". Identifying these groups correctly is a key to identifying what would have occurred in the absence of the intervention (Ezemenari et al., 1999).In theory, evaluators could follow three main methods in establishing control and treatment groups: randomization/pure experimental design; non-experimental design and quasi-experimental design. In practice, in the social sciences, the choice of a particular approach depends, among other things, on data availability, cost, and ethics to experiment. In what follows, brief descriptions of the main impact evaluation methods mentioned above.

2.2.1 Propensity Score Matching (PSM)

Propensity Score Matching (PSM): The most widely used type of matching is propensity score matching, in which the comparison group is matched to the treatment group on the basis of a set of observed characteristics or by using the "propensity score" (predicted probability of participation given observed characteristics); the closer the propensity score, the better the match. A good comparison group comes from the same economic environment and was administered the same questionnaire by similarly trained interviewers as the treatment group. The idea of PSM is to find a comparison group that is similar to the treatment group in all respects except the exclusion from the program. It is useful to evaluators with time constraints and do not have baseline data but use a single cross-sectional data (Ravallion, 2005).The inherent problem in practice is usually how to define "similar''. Matching may be done on many characteristics and it is not clear whether a match has to be similar in all these characteristics, and (if not) what weight should be given to each characteristics (Caliendo and Kopeinig, 2005). Recently, PSM has been applied into different subjects to identify casual effect of Interventions, projects and programs in Africa and other developing countries.

Propensity score matching (PSM) Propensity score matching is a statistical matching technique that estimates the effects of a treatment given the covariates. It allows finding a control group from a sample of non-participants closest to the treatment group in terms of observable characteristics so that both groups are matched on the basis of the propensity score. Propensity score is a predicted probability of participation given observed characteristics Ravallion et al. (2008). The propensity score is estimated using statistical models, logit, and the average treatment effect (ATE) of the outcome of the two groups in absence of baseline data is calculated Abadie et al. (2004). It is used when it is possible to create a comparison group from a sample of non-participants closest to the treated group using observable variables. Both groups are matched on the basis of propensity scores, predicted probabilities of participation given some observed variables. Propensity score matching consist of four phases most commonly: estimating the probability of participation, that is, the propensity score, for each unit in the sample; selecting a matching algorithm that is used to match beneficiaries with non-beneficiaries in order to construct a comparison group; checking for balance in the characteristics of the treatment and comparison groups, along with estimating the program effect and doing sensitivity analysis (Caliendo & Kopeinig,2008). Propensity score matching (PSM) has two key

underlying assumptions. These are conditional independence (CI) and the existence of common support region (Baum, 2013).

Conditional Independence: It states that there exists a set of 'X' observable covariates such that after controlling for these covariates, the potential outcomes are independent of treatment status.

The Common Support: It states that for each value of 'X', there is a positive probability of being both treated and untreated. It is used when creating a comparison group is possible from a sample of non-participants closest to the treated group using observable variables.

The most widely used type of matching is propensity score matching, in which the comparison group is matched to the treatment group on the basis of a set of observed characteristics or by using the "propensity score" (predicted probability of participation given observed characteristics); the closer the propensity score, the better the match. A good comparison group comes from the same economic environment and was administered the same questionnaire by similarly trained interviewers as the treatment group. The idea of PSM is to find a comparison group that is similar to the treatment group in all respects except the exclusion from the program. It is useful to evaluators with time constraints and do not have baseline data but use a single cross-sectional data Ravallion et al. (2008).The inherent problem in practice is usually how to define "similar''. Matching may be done on many characteristics and it is not clear whether a match has to be similar in all these characteristics, and (if not) what weight should be given to each characteristics Caliendo & Kopeinig (2008). Recently, PSM has been applied into different subjects to identify casual effect of Interventions, projects and programs in Africa and other developing countries.

2.3 Empirical Literature Review

There are different factors which challenges small scale irrigation impact on household's income generation. For instance, participation of household small scale irrigation can be considered as a factor affecting the impact of SSI on household ability to have income generation. In addition, small scale irrigation practice by households can bring various significances as well play different roles.

A study by (IFAD, 2005) states that in Ethiopia, the construction of small-scale irrigation schemes has resulted in increased production, income and diet diversification in the

Oromia and Southern Nation and Nationalities People (SNNPR) regions. According to this study, the cash generated from selling vegetables and other produce is commonly used to buy food to cover the household food demand during the food deficit months.

Study conducted in Ethiopia by (IWMI, 2009) shows that irrigation generates an average income of approximately US$323/hectare under small householder-managed irrigation systems compared to an average income of US$147/ha for rain fed systems. This indicates that after accounting for annual investment replacement cost, the adjusted gross margin from irrigation is 219.7% higher than the gross margin from rain fed agriculture.

Similarly, as various scholars like (Asayehegn, 2012), revealed that small scale irrigation contributes to the overall livelihood improvement through agricultural productivity, increased income, food security, employment opportunity, social needs fulfillment and also poverty reduction. A study conducted by (Jemal et al., 2013; Anwar et al., 2014) in different parts of Ethiopia support the positive and significant effect of irrigation on income and household expenditure.

According to (Birhane, 2013; Workayehu 2014), put that the emergence and spread of engagement on small scale irrigation that enable farmers to irrigate their small plots has begun to boost harvests and family income in some world's deepest (Tsegazeab and Dr. Surajit, 2016) packets of hunger, including parts of sub-Saharan Africa. Thus, small scale irrigation practice by farmers result in resisting various problems particularly these related with shortage or absence of rainfall and can scale up their yield. According to (Asfaw and Blair, 2014), stated that, farmers who engaged on small scale irrigation have been found out as being able to resist the frequently occurred drought and more yield. Irrigation contributes to agricultural productivity through solving the rainfall shortage, motivates farmers to use more of modern inputs and harvest throughout the year and creates employment to members of the households especially to wife and children (FAO,2011).

Moreover, irrigation enhances farm output and thus, with prices remaining constant, raises farm incomes. Output levels may increase for any of at least three reasons. Firstly irrigation boosts yields by mitigating crop loss due to unpredictable, unreliable or inadequate rain water supply. Secondly, irrigation permits the possibility of multiple-cropping and a boost in total output. Thirdly, irrigation enables a greater area of land to be used for crops in times where rain-fed production is not possible or insignificant (Abdi

,2015). As a result, irrigation is expected to increase output and income levels. Small scale irrigation is also an important driving tool to development effort to ensure better income (Sinyolo et al., 2014).

Accordingly, (Ahmad et al., 2014) estimation results indicate that there are significant differences in farm income and food security status between treatment and comparison households, which could be attributable to the participation in small-scale irrigation. Similarly, (Kinfe ,2012)had conducted a study by taking 130 households samples half engaged on small scale irrigation and the other half not and also by using Heckman two stage econometric model to analyze data and reported their findings that irrigation intensifies labor and irrigated farming households' labor consumption ratio is double as compared rain-fed framing households. Thus, small scale irrigation activities excluded households with small family size and high dependency ratio from participation. The result revealed that households who have more adult family labor are more likely to adopt motor pump, and other needed improved inputs. The results showed that irrigation beneficiaries earned an annual mean income of 10161.5 Birr per household, which is 33.6% higher than that of non-users. Irrigation use has a positive impact on households earning from crop, and livestock, while the value of off farm income earning was higher for non-users. This study indicated that irrigation is linked to poverty reduction through its effect on crop production and increased farm income.

According to (Tadesse et al., 2014) had found out that, household characteristics such as: sex and age of household heads were affecting participation of farmers in small-scale irrigation water use. He concluded that male headed households were found to be more likely to adopt irrigation technologies as compared to female headed counterparts. This indicates that women have not benefited much from innovations in micro-irrigation technologies. To change this gender imbalance, programs that target both gender groups will be necessary to ensure equitable adoption of practice between male and female headed households.

In relation to this (Lijalem,2013 and Adugna et al., 2016), detailed that agricultural extension service is vital for the development of irrigated agriculture through adapting and introducing improved technologies, providing training, accessing and supplying inputs timely and giving different information that ranges from production to marketing to the farmers. Hence, provision of the extension service, enhance farmer's knowledge and skills towards practice of small-scale irrigation water.

According to (Aklilu et al.,2016) suggest that engaged on small scale irrigation do increase their agricultural production through diversification and intensification of crops grown, increased household income.

Irrigation is general and small scale irrigation is particular plays a major role as a method for agricultural intensification. Extension system development can increases the agricultural production and income of the households and helps to improve their overall economic welfare.

Study by, (Surajit and Tsegazeab ,2016) had conducted similar study by selecting 363 samples and had analyzed the data by using probit model as well as PSM econometric model and detailed as agricultural extension service has been vital for the development of irrigated agriculture by households through adopting and introducing improved technologies, providing training, accessing and applying inputs timely and giving different information which ranges from production to marketing to framers. Hence, provision of the extension service could enhance framers not only knowledge and skills but also encourage towards practice of small scale irrigation based agriculture production.

Moreover, (Dereje and Desale, 2016) systematically investigated the issue by taking 344 samples and employing SPSS version 19 and descriptive statistics for data analysis and then explained their findings and concluded that so as to improve the impact small scale irrigation on households livelihood, many factors must be considered: high water and labor supply, provision of credit service and agricultural inputs, good irrigation infrastructure and management practices, support of government and development agents (DAs) are all very essential.

Therefore, by using these inputs, we can increase rural people's household incomes, livelihood diversification, agricultural intensification, productivity, employment opportunities, income variance and resilience to risk, and participation in community decisions. Therefore, it proved that 32.1% of irrigators increased their frequency of production due to irrigation. Furthermore, rural associations are vital instruments to bring attitudinal change and motivate households to adopt new technologies through informal education, panel discussion, public meetings and other demonstrations (Nigussie et al. ,2018).

Thus, the finding of this study showed that rural associations have a statistically significant influence in explaining the irrigation participation decision. Households, who

are members of rural associations have higher 5% probability to access and use irrigation than households who are not members of the associations. Similar, finding had also showed that the ratio of small scale irrigation user to non-user farmers who are members of the formal and informal institutions water user association, peasant associations and local leadership exceeds by 47.7% (Asayehegn & Gebru 2012). (Bacha et al., 2011) put that the type of peasant associations has positive and statistically significant effect in explaining the farmers' likelihood of access to irrigation. Thus, rural associations are one of the main factors that importantly prompt rural people to access and use irrigation in the study area. (Woldegebrial et al., 2013) Participation in the small-scale irrigation has robust and positive effect on most of the livelihood indices and that an expansion of irrigation schemes is a good strategy in the water-stressed and drought-prone area.

In addition, as to (Nigussie et al.,2018); Asayehegn, 2012 and Hanjra, 2009) had employed various sizes of samples and PSM and Heckman two stage econometric models to had data analysis indicated that information access motivates households to adopt new technologies and also education plays a key role in household decision for technology participation and can bring positive attitudinal changes. Thus, households who have access to information, and education have higher likelihood to participate in irrigation compared to their counterparts. For example, literate households have 17% higher probability to use and access to irrigation than the illiterate households. Households with information access have 21% higher likelihood to participate in irrigation than that of counterpart households (Nigussie et al., 2018). (Hanjra, 2009) found that one grade increase in educational level increases the probability of adopting new technologies by 2.7% but, unlike this study, the value of mass media and communication facilities in irrigation participation was insignificant and weak. Educational standard in south eastern and northern part of Nigeria was lower for dry-land farmers than irrigation farmers (Dauda et al., 2009). 75% and 29% of the irrigation users and nonusers have respectively access to fixed telephone, mobile and person-to-person sharing (Asayehegn, 2012). So, information and education are the basis for awareness, and adopting new agricultural technologies.

Moreover, the major challenges of the SSI include i) irrigation water conflict ii) lack of improved seed for vegetables iii) poorly developed marketing system iv) weak extension, credit, local community rules and research support and v) lack of collective action at each stage of the market participants (Hassen , 2011).

Finally, according to, (Kuwornu and owusu, 2012) on their analysis on the sources of household income in Ghana revealed that non-farm income for respondents could be as much as 12 to 15%. Thus, as much as 85 to 87% of household income is reinforced by farming income. For irrigators, average income from irrigation activity is about 45%. Irrigated income thus accounts for the highest proportion of total income. Accordingly, it was observed by many scholars that the size of land operated by a household increases, and irrigation participation are negatively related. This implies that irrigators tend to intensify their farming, while rain-fed farmers try to put more land under cultivation.

Many studies as seen above will be emphasized about small-scale irrigation on household income. But this study will add the research question like potential source of household income, to analysis the Impact of small-scale irrigation on household income.

2.4 Conceptual Framework of the Study

Access to reliable irrigation water can enable farmers to adopt new technologies and intensify cultivation, leading to increased productivity, 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, food security, and the quality of life in rural areas. Overall, irrigation water, like land, can have an important income-generating function in agriculture.

There are five key dimensions of how access to good irrigation water contributes to socioeconomic uplift of rural communities and alleviates poverty. In rural areas where most of the people depend on agriculture for their food and income, water and food security are closely related (FAO, 2003). These are production, income and consumption, employment, food security, and other social impacts contributing to overall improved welfare. These poverty reducing variables are interrelated. In general, 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 agricultural production and external shocks. It should be noted that the poor also use water for other farm and non-farm production activities, particularly small-scale rural enterprises such as livestock rearing, fish production, brick making and so on.

In general, in order to enhance selected small-scale irrigation schemes to improve households' income, many factors must be considered: physical and demographic factors,

which includes age of household, sex of household, educational level of the household head and dependency ratio. Institutional factors category includes Access to credit, extension service, distance market link, access to agricultural inputs. Socio-economic factors involve land holding size, livestock holding, farming experience all are very essential and infrastructural development variables. Therefore, by efficiently managing and using these inputs, small-scale irrigation schemes can increase rural households' income through, agricultural intensification, productivity, employment opportunities and resilience to risk. Accordingly, irrigation lowers food prices so that the poor can afford and get access to the required food at fair prices (Huang et al., 2006).

Irrigation enables the poor and smallholders to achieve higher yields. The productivity of crops grown under irrigated conditions is often substantially higher than that of the same crops under un-irrigated rain fed conditions. Higher productivity helps to increase returns to farmers' endowments of land and labor resources. Access to good irrigation enables crops witching: substituting low-yielding and low-profitable crops with new high-yielding and more profitable crops. Implicitly, this implies switching from subsistence production to market-oriented production. Further, crops can be grown year-round. Thus irrigation culminates in what is commonly known as crop diversification, and enables the poor and smallholders to spread risk more evenly over the course of a year (Reardon and Taylor, 1996). In fact, crop diversification is both an income maximization and risk minimization strategy. Reliable small scale irrigation increases land productivity, crop yields and application of mineral fertilizers, which, in turn, enables to diversify into non-conventional and market oriented products (high value crops, vegetables and fruits (Eshatu et al., 2010), which positively improves farm households' diet, incomes, health and food security (Torell and Ward , 2010).

Increased employment for the poor may originate from the labor-intensive nature of irrigation developments construction and subsequent maintenance, and from intensive cultivation both on their own farm, as well as on the farms of other large farmers who may find it difficult to provide extra labor from family resources during peak times. Additional employment opportunities may come from non-farm activities generated through increased demand for inputs and increased supply of outputs. Generally irrigation has positive impact on farm household income through enhancing agricultural performance, using inputs and high value crops that give rise to increase in production which in turn gives rise to household income and finally to poverty reduction.

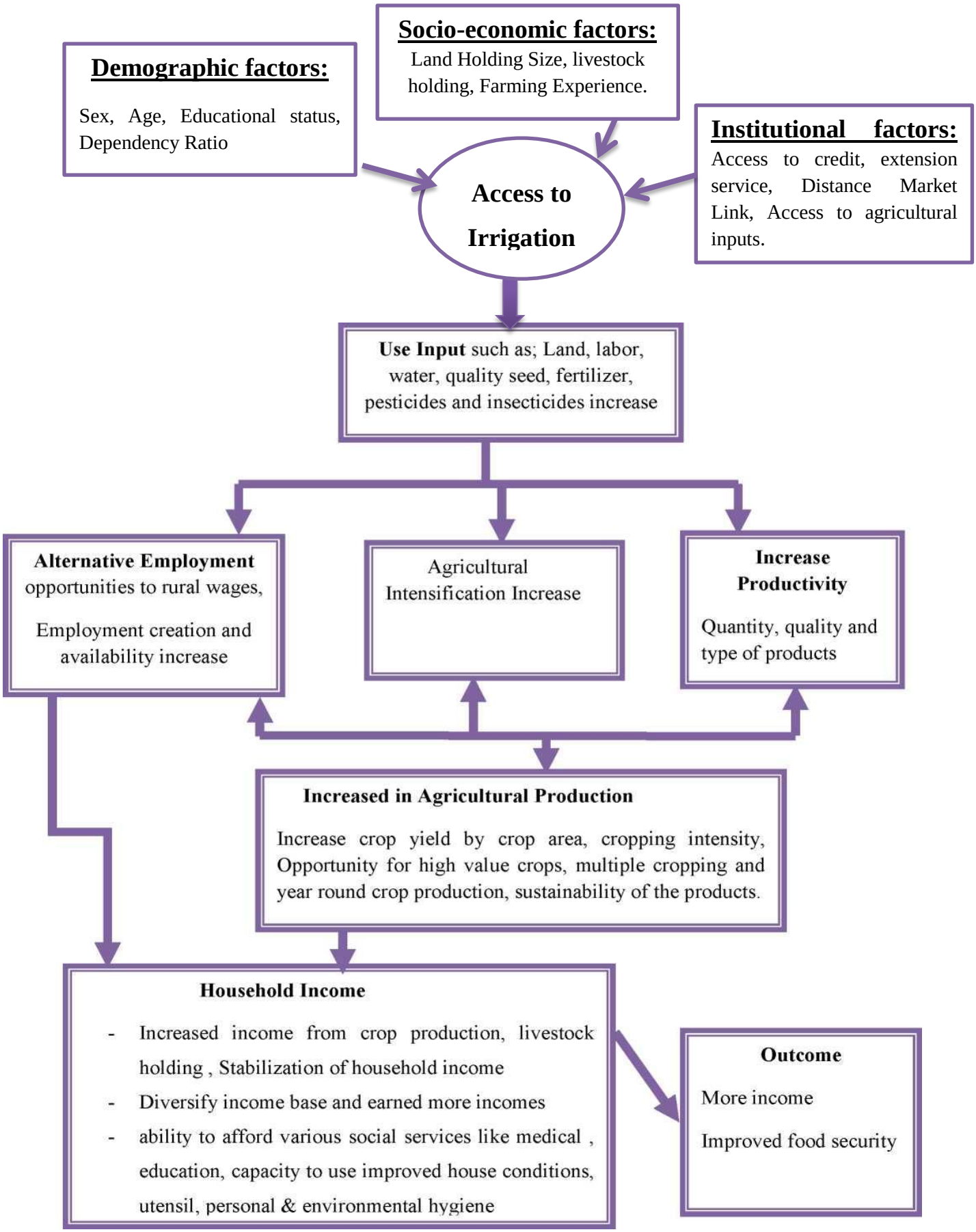


Figure 1 Conceptual Framework of the study

Source: Adapted from Hussain & Hanjra (2004)

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Description of the study area

The study was conducted in Meskan Woreda in Misrak Guraghe zone. The Woreda is located between 7.9935150 - 8.2781010 latitude north and 38.2631310 - 38.57860 longitude East. The Woreda is bordered by Sodo Woreda at the North, Silte Woreda at the south, Misrak Meskan Woreda and Mareko Woreda at the East and Muhurna Aklil at the west, (CASCAPE ,2015). It is 130 km from Addis Ababa and about 96 km from Wolkite (the capital city of Guraghe zone). Furthermore, it is located at an altitude range of 1501-3500 meter. The mean annual rainfall of the area is 1001-1200mm.

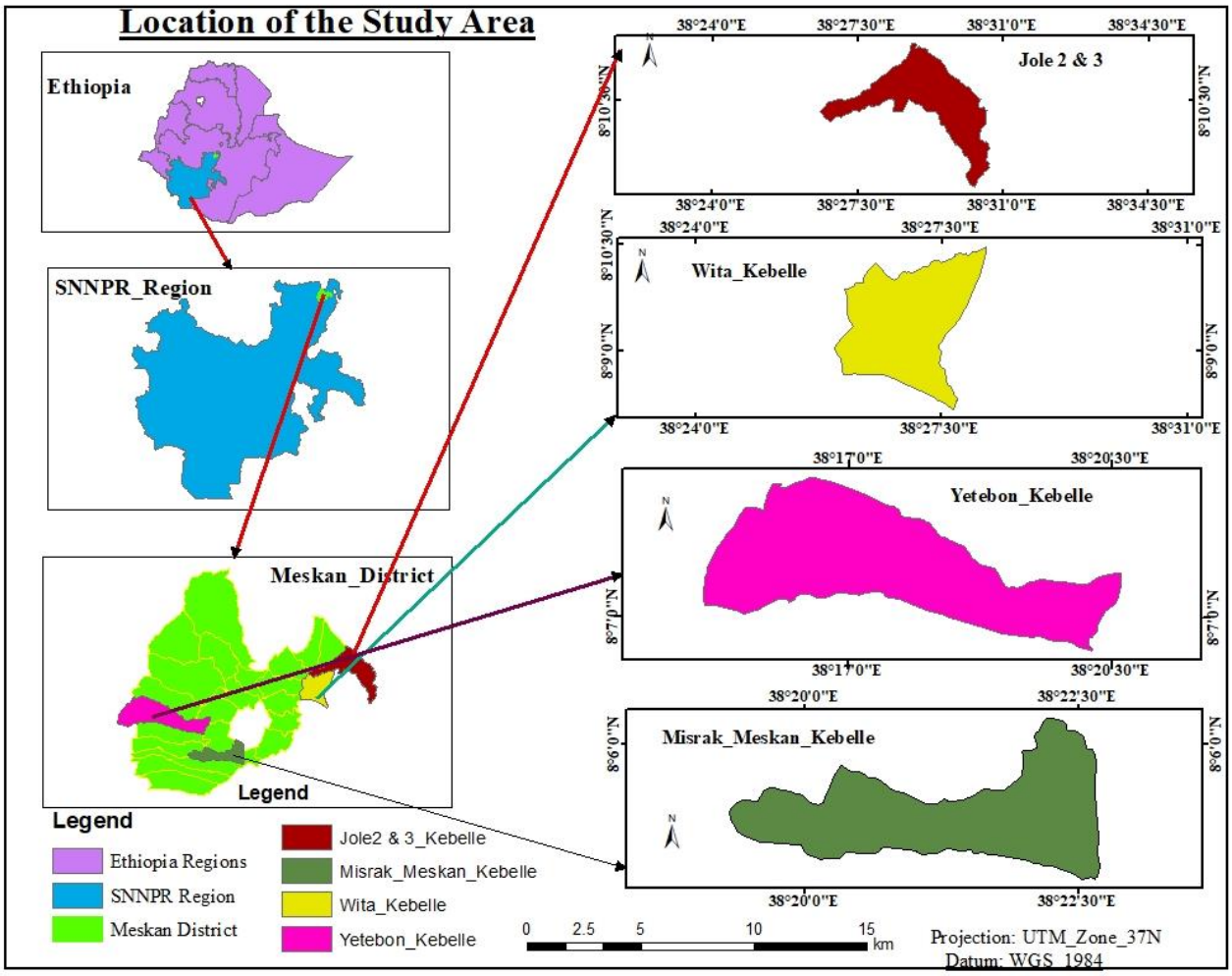
The mean maximum and minimum temperature is 10.5 and 17.5°C respectively. The Woreda receives a rainfall between 1001-1200mm, (CASCAPE, 2015).

The topography of the district is 10% highland, 55% leveled land and 35% sloppy. The total area coverage is 50,177 ha; out of this 13,579 hectare land used for cultivation. The agro-ecological zone is 20% Dega and 80% Wena Dega agro climate. The altitude range of 1501m to 3500 meters elevation above sea level in this Woreda (MWFEDD, 2019)

The majority of the rural people are engaged in subsistence agriculture taking place on small and fragmented plots through the employment of oxen and traditional farm implements. Maize and Enset (false banana) are the major staples in the Woreda. Poor households often take recourse to petty trades and hired labor to supplement meager incomes derived from farm activities. Due to the recurrent drought and low agricultural productivity in most parts of the Woreda, the challenges imposed on many rural households. Meskan Woreda is categorized as Chronically Food Insecure (CFI) Woreda. The district is one of the targets of Productive Safety Net Program (PSNP) and Household Asset Building Program (HABP). The main goal of PSNP is to ensure food consumption and prevent asset depletion for food insecure households while stimulating markets, improving access to services and natural resources, and rehabilitating and enhancing the natural environment. On the other hand, the main goal of complementary livelihoods program called HABP is to increase and diversify income sources of PSNP clients through technical support (extension service provisions) and linking them with access to rural financial services (MOA, 2010).

Meskan Woreda is characterized by semi-arid and unreliable rainfall pattern with high evaporation. The livelihood of the people in the Woreda depends on subsistence agriculture dominated by rain-fed mixed crop livestock system and about 92% of the Woreda population depends on agricultural crops such as Maize, Wheat, Teff, Barley, Sorghum, and other products like Avocado, Mango, Banana, Enset, Chat, and Berbere. The remaining people are engaged in trade, service sectors and employments in the public or private sectors while the rest depend on temporary (seasonal) income or remained jobless (Kessler and Zenebe ,2017).

Figure 2 : Geographical location of the study area; Meskan Woreda



Source: MWFEDD (2023).

3.2 Research Design

The aim of this thesis was to analyze the impact of small scale irrigation on household income. In order to achieve the aim of this study a mixed-mode of research design that combines qualitative and quantitative approach were used.

Qualitative method is used to capture data pertaining local perception and opinions on the contribution of irrigation to household income using focus group discussion and key informant interview. Quantitative data on household's resource ownership, income status, food security status, demographic characteristics and other basic information were collected.

To collect the needed data cross-sectional survey was employed. This type of survey had been used because of expected constraints such as time, financial and logistic supports which was encountered during data collection. Cross-sectional survey relies on existing differences rather than change following intervention; and, groups are selected based on existing differences and the collection of data is undertaken at one point in time.

1.3 Data Sources and Data Collection Techniques

Both qualitative and quantitative data had been collected from ``primary and secondary sources. Primary data for the study was collected from selected sample households and using focus group discussion. The questionnaires are both closed ended and open ended questions. Closed-ended questions were used to collect background information about the respondent whereas open ended questions were employed to collect more information, including feelings, attitudes and understanding of the small-scale irrigation. From the household survey, the data about social, demographic and economic aspects of the respondents and the study area were collected. Moreover, qualitative method to capture data in regard to local perception and attitude of households toward small scale irrigation, as well as quantitative one in order to analyze quantitative data such as: households income status, resource and wealth ownership and other basic information has been employed.

Furthermore, qualitative data had been collected using the Participatory Rural Appraisal (PRA) methods involving Focus Group Discussions (FGDs) at small scale irrigation level. The quantitative data was collected using structured questionnaire which has been pre-tested on few respondents. For the collection of primary data, the enumerators would have kebele development agents as they are more familiar and have acceptance by local peoples which helps to obtain reliable data and helps to well manage the data collection process. The enumerators would have an intensive training on data collection procedures, interviewing techniques and the detailed contents of the questionnaire. Strict supervision was made by the researcher during the course of the survey.

Secondary data was collected from documents and publications of different organizations, Woreda annual reports (Agricultural office and water and irrigation office) and from journals which are relevant to irrigation. Articles, magazines, statistical reports of World Bank and IMF, Ministry of Finance and Economic Development, Bureau of Finance and Economic Development, District Office of agriculture, other relevant offices and local authority records.

Focus Group Discussion (FGD): One of the most prominent advantages of the FGD is that it revealed how the group participated and viewed the issues with which they were confronted. Two focus groups, one from each selected kebeles consisting of 7 to 12 purposively selected households heads who engaged in small scale irrigation, small scale irrigation water user management committee, district agricultural and natural resource office and district water, irrigation, mineral and energy office experts of small scale irrigation, kebele administration officials and kebele agricultural development agents did have a focus group discussion. Thus, the researchers will be chaired the focus group discussion and will be used for collecting the detailed data. Using guiding questions, in the focus group discussion the socioeconomic and institutional issues that determine the use of small-scale irrigation was stressed and data that could support household survey data had been collected.

3.4 Sampling Techniques

In this study a multi - stage sampling procedure was employed. Meskan Woreda is selected purposefully according to its potential for small scale irrigation and the researcher's familiarity to the area that helps to get reliable information about the area and reduces language and other constraints during data collection. There are a total of 26 Kebeles in the Woreda and small- scale irrigation participating four rural kebeles namely Jole 2 and 3, Yetbon, Wita and Misrake Meskan are selected by discussion with Woreda agricultural office as the kebeles are among the most potential kebeles where small-scale irrigation had been used.

The total households in the sample Kebeles was stratified into the two strata (SSI participants and non- participants households) and then simple systematic random sampling techniques had been applied to select the sample unit from each strata at each kebele via probability proportionate to size procedure in the respective sample frame. In order to select best representatives of the target population the study was

employed appropriate sampling method.

In the first stage selection of kebele but 4 kebele from total 26 rural kebeles. Since the total number of HHs participants in small scale irrigation agriculture in the 4 (four) sample kebele were 819 and non- participants on small scale irrigation 4594, the total sample size required (n) in the study were about, 372 HHs from the population.

In the second stage, target population was stratified based on those households who were participants and not participants on small scale irrigation.

In the 3 third stages, households' respondents from each stratum selected through simple random sample size from each Kebeles. Totally, 372 respondents (i.e. 120 participants and 252 non-participants) were selected. The total numbers of households in these kebeles were 5413 This number is the sum of the households number for Yetbon, 1869; Wita, 803, Misrake Meskan ; 947 and Jole 2 and 3;1794.

3.5 Sample Size Determination

To determine the sample size determination formula of (Yamane, 1967) applied to estimate the required sample size from the study population. The study is based on Taro Yamane's simplifies formula to calculate sample sizes is used. According to the estimates of (CSA, 2007), the total population of the Meskan Woreda is 148,355, male 71,210 and female 77,145 ,respectively. Total household of the Woreda are 27,596.

Formula used for sample size determination is: - $n = \frac{N}{1+N(e)\ 2}$ Where, n = № of target sample size

N = Total № of population e^2 = the variance of attribute in the population which is assumed to be (5%).

Then: N=5413, e= 0.05 Therefore the sample size computed as:

$$n = \frac{5413}{1+5413(0.05)2} = 372$$

Therefore the total sample size for this study is **372**

Table 1 Distribution of sample by Kebele and proportion sample size

Kebele Name	Number of households		Number of sample Households	
	Participants	**Non Participants**	**Participants**	**Non Participants**
Yetbon	289	1580	38	75
Jole 2 and 3	234	1560	33	68
Misrake Meskan	154	793	26	59
Wita	142	661	23	50
Total	**819**	**4594**	**120**	**252**

Source; Meskan Woreda Administration and own computation (2023)

3.6 Method of data analysis

In this study, descriptive statistic and econometric model such as estimated using logit Models, Propensity Score Matching method (PSM) used to analyze the collected primary data.

This probability is obtained from the "participation equation": a logit regression in which the dependent variable is dichotomous, taking the value of 1 for those who took part in the intervention, and 0 if they did not. The explanatory variables include all observed variables (individual, household or firm, and community or market) that may affect participation, but that are not affected by the intervention.

3.6.1 Descriptive statistics

After data collection, the data was coded and entered in to STATA software version 13 and then, the data had been analyzed by using descriptive statistics such as frequency, mean, variance, standard deviation and percentage used to describe socio-economic, institutional and demographic features of the selected households.

The statistical significance of the variables in the descriptive part had been tested for both dummy and continuous variables using t-test and chi-square test.

3.7 Econometric model specification

3.7.1 Estimating a Participation

Concerning about the model, since this study had been binary treatment (participation and non-participation in small scale irrigation), application of logit model was appropriated.

When estimating the propensity score, two choices have to be made. The first one concerns the model to be used for the estimation, and the second one had been about the variables to be included in that model (Caliendo & Kopeinig, 2008).

In recent years, propensity score matching (PSM) has gained attention as a potential method to estimate causal treatment effects. It was also, used as a proper impact evaluation method for policy makers in the absence of experimental evaluations to provide necessary feedback for policy modification and adjustment of the programmed. Even it was used as method of analysis to evaluate and cancel inefficient programmed. Inference about the impact of a treatment on the outcome of an individual involves speculation about how this individual would have performed if had not received the treatment. The standard framework in evaluation analysis to formalize this problem is the potential outcome approach (Rubin, 1974).

As indicated by (Gujarati, 2003) a model for studies that deal with dichotomous dependent variables the suggested the logit model. To select a model different scholars indicate Varity of reasons. According to (Patnaik, 2013). The logit models are almost identical and the choice of the model is arbitrary, although logit model has certain advantages (simplicity and ease of interpretation) However, the parameters of the two models are scaled differently. The parameter estimates in a logistic regression tend to be 1.6 to 1.8 times higher than they are in a corresponding probit model. The logit models are estimated by maximum likelihood (ML), assuming independence across observations. The ML estimator of β is consistent and asymptotically normall+y distributed. The previous studies in determinants small scale irrigation use(utilization) adopt the logit model, for instance (Agidew, 2016;Petros & Gecho, Woldemariam, 2017)

The main pillars of this model are individuals, treatment and potential outcomes. The impact study of small scale irrigation on household's income is to reveal the changes in household's income after the small scale irrigation programmer. The asset will be expressed in estimated birr value by calculating all types of assets using the price of the current year 2017.

The treated households will be from the small scale irrigation programmer participants and the control group will be from the non-participants for comparison.

However, the main problem of such impact evaluation is a missing data problem. In order to overcome the problem, Propensity score matching method will be applied for impact evaluation in the absence of baseline survey data. When applying the propensity score matching method for estimation two choices were made. The first one is the choice of the model to be used for the estimation and the second one is the choice of the variables to be included in the model.

In principle, any discrete choice model could be used. However, preference to use Logit models (compared to Linear probability models) would be given in view of shortcomings of the linear probability model, especially the unlikeness of the functional form when the response variable is highly skewed and predictions that are outside the [0, 1] bounds of probabilities. The selection of the participants will not relate to the outcome of the program Rosenbaum and Robin (1983).

For the binary treatment case, where we estimate the probability of participation Vs non-participation, the choice of the model is very important. Amongst the different econometric model estimation techniques used in identify factors that determine the level of participation small scale irrigation; logit model is the most commonly preferred done. As outlined in Gujarati (2003), logit models are widely applied to analysis of determinant studies for a limited dependent variable. Despite this, Green (2003) argues that although both model results with similar outputs, the logit model is easier in estimation.

The study used to estimation, the status of household to be participates or non-participation estimation approach.

$Y_i = \beta' X + U_i$...………………………………………………………... (1)

Where: Y_i is the dependent variable of the model (binary logit analysis) representing the household's participation in SSI and X is vector of explanatory (independent) variables; β' is a vector of parameters to be estimated and U_i is the error term. The model was written as follows:

$L_i = \ln\left[\frac{P_i}{1-P_i}\right] = \quad Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \ ... \ + \beta_n X_n + U_i$…..…...... (2)

Where log of the odds ratio. It shows how log odd in favor of change in participation status of households in SSI as respective independent variables (X_i) change by a unit.

Where: P_i = probability of non-participation (1) and 1 - P_i = probability of participation (0);

X_i = explanatory variables (demographic, institutional and socio-economic variables);

$\beta_0 =$ Is the constant term; β_i = Slopes of the equation in the model; Z_i = is a function of n explanatory variables (x); and U_i = is the error term.

The binary logistic regression equation from the above function becomes;

Develop the model in equation dependent variable in terms of independent variable. Just like this

$L_i = \ln\left[\frac{P_i}{1-P_i}\right] =$ $Z_i = \beta_0 + \beta_1 SEXR + \beta_2 AGEHH + \beta_3 EDUCHH + \beta_4 LANDHH + \beta_5 EXT + \beta_6 TLU + \beta_7 ACC\ AGRII + \beta_8 DRATIO + \beta_9 Dmarket + \beta_{10} CREDIT + \beta_{11} FEXEPR + U_i$ ..... (3)

X_1 = Sex of the respondents X_2 =Age, X_3 = Education Level HHs, X_4 = Land Holding Size, X_5 = Access to Extension Services, X_6 = Livestock Holding, X_7 = Access to agricultural inputs, X_8 = Depedency Ratio HHs X_9 = Distance Market Link X_{10}= Access Credit, and X_{11} = Farming Experience

Hence the binary logit model will be employed in this study. To analyze the factors that determine the levels of participants SSI at household, households were classified into two categories as participants and non- participants.

3.7.2 Impact of small-scale irrigation on household income

Propensity Score Matching (PSM) is used to compare irrigation participation households (treatment group) and non-irrigation participation households (control group) lying in the common support region. Propensity Score Matching (PSM) is a statistical matching technique that estimates the effect of treatment or intervention given covariates. It allows a comparison group from a sample of non-participants closest to the treatment group in terms of observable characteristics so that both groups are matched on the basis of the propensity score, which is a predicted probability of participation given observed characteristics (Ravallion, 200). Propensity value is estimated using logit and used to estimate the average treatment effect of the outcome in absence of baseline data using observable variables (Abadie et al., 2004).

Propensity score matching (PSM) is used in this study for different reasons i.e., there is

no baseline data to see the difference between before and after, there may be self-selection bias as small-scale irrigation participant households may be self-selected to participate, the cross-sectional survey data is used for matching the participant and non-participant groups, and etc. PSM controls for self-selection bias by creating a statistical comparison group by matching every individual observation of the treatment group with individual observations from the control group with similar observable characteristics.

These groups are matched based on the propensity scores, which is the predicted probability of participation given some observed variables. Even though PSM has many advantages, it has limitations such as requiring large samples, lack of common support region and hidden bias since matching controls only for the observables.

The Propensity score is defined as the probability of receiving treatment based on measured covariates.

$E(x) = P(D=1 \mid X)$ ---------- (3)

Where E(x) = propensity score, P = probability, D=1 a treatment indicator with values 0 for control and 1 for treatment "|" = is a symbol stands for conditional on (predicted), and X = is a set of observed covariates.

As stated in Caliendo and Kopeinig (2008), there are five steps of performing Propensity Score Matching. These are: Estimating PS, choosing matching algorism, restricting common support region, balancing test and sensitivity analyzing. Each five steps are described as follows:

Step 1: Estimation of Propensity Scores

A Logit model is used to estimate PS for both participants and non-participants. Using logit model has an advantage since the probabilities are limited between zero and one. The dependent variable takes the values of one if an individual is participating in small scale irrigation and zero otherwise.

In studying the impact of small-scale irrigation on income of rural households, Propensity Score Matching (PSM) method was applied. According to (Baker, 2000) illustration, analyzing the impact of project interventions requires the establishment of the requisite counterfactual that represents what would have happened had the project not taken place or what otherwise would have been true. The establishment of this counterfactual often poses problems where before intervention situation remains missing. Under such

circumstances appropriate estimation of the counterfactual is established by way of a comparative group that does not participate in the intervention. Therefore, analysis of the impact based on a "with and without" approach yields inaccurate results Friedlander and (Robins, 1995), and any attempt to net out actual project impact must factor in the underlying selection process. Propensity Score matching model was employed for appraising the impact of small-scale irrigation on income of rural households. Impact through this end result variable (small-scale irrigation effect on household income) is found by matching comparative group (non-irrigation users) to the treatment group (irrigation users) on the basis of propensity scores (P-scores) of X. X is the set of observable characteristics that govern small-scale irrigation participation. By so doing the selectivity bias is largely eliminated. The empirical evidences showed that, propensity score matching model have been applied in different studies like (Pufahl and Weiss 2009; Rahma 2016; Leuven and Sianesi 2003; Getinet 2011).

According to Dehejia and Wahba (2002) illustration, the propensity score matching method takes care of the bias, so that estimated irrigation impact is largely consistent. The method identifies and matches households within the irrigating farmers that are similar in observable characteristics Xi, to those of non-irrigating farmers.

(Becker and Ichino, 2002) also provide a program for PSM estimation in Stata that includes estimation routines for nearest neighbor, kernel, radius, and stratification matching and balancing tests can also be performed with this program.

To appraise the second objective of this study determinant of smallholder farmers' decision to participate in small-scale irrigation participation in this research binary logistic regression model was deployed. The importance of preferred this model is because of the model relevance to deal with dependent variables that are dichotomous in nature. That is household Participate on small-scale irrigation or not. The model assists to estimate the probability of small-scale irrigation participation status of a household that can take one of the two values, participation of irrigation and non-participation small-scale irrigation. According to (Gujarati, 1995) as cited by (Woldemariam and Gecho, 2017) the functional form of the logit model is presented as follows:

$$P_i = E\left(\frac{Y_i}{X_i}\right) = \left[\frac{1}{1 + e^{-(\beta o + bixi)}}\right].$$

In simplified form Eq. (1), rewrite as

$$P_i = E\left(\frac{Y_i}{X_i}\right) = \frac{1}{1 + e^{-Z_i}},$$

Where Pi is a probability of a i^{th} household being participation of irrigation and ranges from 0 to 1; Zi is a functional form of explanatory n variables (X).

Step 2: Choosing the Matching Algorism

The second step is choosing the matching algorithms that match the estimated propensity score to the best level from the Nearest Neighbor Matching, Caliper and Radius Matching, Stratification and Interval Matching, Kernel and Local Linear Matching (Caliendo and Kopeinig, 2008). Choosing matching method comprises a tradeoff between matching quality and its variance. The matching algorithm which has high matching sample size, low R square value and high matching balance is selected among the methods (Dehejia and Wahba, 2002).

The Nearest Neighbor Matching Method: For each control unit, the nearest neighbor matching method assigns a weight of one for the nearest comparison unit and zero to the other comparison observations. So, a single comparison unit can be used as a matching for more than one control unit. The Radius Matching Method: The nearest neighbor matching method may face the risks of bad match when the closer neighbor is far away. This problem can be corrected by adjusting the tolerance level to the maximum propensity score distance (caliper). By using this method, the bad match will be adjusted and the matching quality rises. This is another way of imposing the common support region.

Kernel Matching Method: In all matching algorithms discussed yet, few observations from the comparison group are used to construct the counterfactual outcome (unobservable outcome) of the treated individual. But, Kernel matching (KM) is non-parametric matching method which uses weighted averages of all individuals in the control group to construct the counterfactual outcome. The choice of matching estimator depends on available data set, and there is no winner for all cases and matching estimator choice mainly depends on the situation at hand. It is widely accepted that a good

matching estimator is the matching which gives the lower pseudo R square , statistically insignificant likelihood ratio test after matching and the matching with larger observations (Caliendo and Kopeinig, 2008; Leuven and Sianesi, 2006).

The choice of the matching algorithms will be based on the most important tests to reduce the bias and inefficiency simultaneously. These tests include mean bias, number of matched samples, value of pseudo-R square, and number of the balanced covariates. When considering the mean bias, the one with lowest mean bias is better matching algorithm. Based on number of samples matched, the one with the highest matched number of observations is the best and selected. When coming to the value of the pseudo-R-square after matching, the matching algorithm with the lowest pseudo-R square is the best matching algorithm. On the other hand, the matching algorithm with the highest number of balanced covariates is more appropriate (Dehejia and Wahba, 2002).

Radius Matching (RM): Applied to overcome the short coming of caliper matching. The basic idea of this is to use not only the nearest neighbor within each caliper but all of the non-participants within the caliper. A benefit of this approach is that it uses as many comparison units as are available within the caliper and therefore allows for usage of extra units when good matches are not available. Hence, it avoids the risk of bad matches (Caliendo and Kopeinig, 2005).

Caliper Matching (CM): Applied to overcome the drawback of nearest neighbor matching that arises from risk of bad matches, when the closest neighbor is far away. This can be avoided by imposing a tolerance level on the maximum propensity score distance (caliper). Bad matches are avoided and hence the matching quality will rise (Caliendo and Kopeinig, 2005). The final choice of the best matching algorism should be guided by three matching criteria. Matching algorism that shows no statistical significant difference of the mean of covariates of both groups bears medium pseudo- R^2 and results large matched sample size should be considered as best matching algorism in impact assessment of certain intervention. The pseudo-R^2 shows how best the repressors explain the probability of participation and it shouldbe fairly medium since there should not be significant difference in the distribution of both groups after matching (Caliendo and Kopeinig, 2005).

Step 3: Restricting Common Support Region

After identifying the probability of participation in small scale irrigation based on

identified observable covariates through the use of logit model, the second step of PSM is defining common support region, where distributions of the propensity score for participants and non-participant's households overlap because average treatment effect on treatment group and on control group is only defined in the common support region (Khandker et al., 2010). The common support region is the area within the minimum and maximum propensity scores of participants and non-participants households groups, respectively and it is done by cutting off those observations whose propensity scores are smaller than the minimum and greater than the maximum of participants and non-participants groups, respectively (Caliendo and Kopeinig, 2005). Specifically, the effectiveness of PSM also depends on having a large and roughly equal number of participants and non-participant observations so that a substantial region of common support can be found (Khandker et al, 2010).

Step 4: Testing Matching Quality or Balancing Test

When using PSM method, balancing test is very important. The quality of matching depends on the ability of the procedure to balance the relevant covariates. (Rosenbaum and Rubin, 1985) proposed a standardized bias which is commonly used method to quantify the bias between control and treated groups. The comparison of the pseudo R-square before and after matching, in which the value of pseudo R-square after matching should be lower because of the matching use those households that have similar characteristics which mean that no significant difference of covariate of treated and the control group is also proposed. In other word, the t-test value of all covariate after matching is insignificant (Leuven and Sianesi, 2006). It helps us to evaluate the impact of treatment on the treated groups. It is the difference between the outcomes of treated and the outcomes of treated observations had they not been treated (counterfactual) computed as: ATT = E (Yi1 - Yi0 | D = 1) ---------- (4)

E (Yi1 | D = 1) – E (Yi0 | D = 1) ---------- (5)

The average treatment effects (ATT) are defined as the average effect for sampled households with a given value of the explanatory variables. It is estimated by taking the difference between the treatment and control averages that are matched through the propensity scores (Khandker et al., 2010). Thus, this study was employed the average effect of the treatment on treated [ATT] and the standard representation can be [D = 0 for control group and D = 1 for treated group]

$$Y = \begin{cases} Yi^{C} \; if \; D = 0 \\ Yi^{T} if \; D = 1 \end{cases}$$ =Observed outcomes, X = set of observed households characteristics,

accordingly, $\Delta Yi = Y^{T} - Y^{C}$ = treatment effect

Following (Ravallion, 2005), the average treatment effect (ATE) the impact can then ATE = E [YT |X, D=1]-E [YC |X, D=O] ---------- (6) Where, ATE represents the average (mean) difference in outcomes between household's participants and households non-participants. The PSM average treatment effect is equal to the mean difference in outcomes over the common support, weighting the comparison units by the propensity score distribution of participants. When a simple mean difference is taken, as given in equation (6), between the variables in treatment and control groups to measure the treatment effect, it is subject to a bias as given in equation expressed as:

B= (Y|X, D=1) - (Y|X, D=0) ---------- (7)

Therefore, {E (YT | D =1, X) can be taken as a counterfactual to the treatment. Hence, the average treatment effect on the treated can be written as:

ATT = E (YT - Y C | D=1) = E (YT | D=1)- E(Y C | D =1)----------(8)
The fundamental evaluation problem in estimation of impact is that it is impossible to observe a household's outcome for with and without treatment at the same time. Although the post-intervention outcome E (YT - Y C|D=1) is possible to observe, however, the counterfactual outcome of the i th households when she/he does not use the treatment is not observable in the data.

Step 5: Sensitivity Analysis

The main question needs to be answered in sensitivity analysis is how strongly an unmeasured variable influences the selection process in order to undermine the implication of matching analysis (Caliendo and Kopeinig, 2008). Hence, sensitivity analysis was undertaken to detect the identification of CIA (conditional independency assumption) is satisfactory or affected by the dummy confounder.

This is the final step in the application of PSM model. Matching has become a popular method to estimate average treatment effects. It is based on the conditional independence or un-confoundedness assumption which states that all variables simultaneously influencing the participation decision and outcome variables should be considered (Becker and Caliendo, 2007). The estimation of treatment effects with matching

estimators is based on the selection on observables characteristics. However, a hidden bias might arise if there are unobserved variables which affect assignment into treatment and the outcome variable simultaneously (Rosenbaum, 2002). Since matching estimators are not robust against hidden biases, it is important to test the robustness of results to departures from the identifying assumption. However, it is impossible to estimate the magnitude of selection bias with non-experimental data.

Therefore, this problem can be addressed by sensitivity analysis (Caliendo and Kopeinig, 2005). To check the sensitivity of the estimated Average Treatment Effect (ATT) with respect to deviation from the conditional independence assumption, this study has applied Rosenbaum bounding approach suggested by Rosenbaum (2002).

3.8 Description of variables and Hypothesis

The Dependent Variable:

The dependent variable is participation decision in small scale irrigation. It's defined as having access to the small scale irrigation project or being part of the project households. It is represented by a dummy variable which takes value of 1 if the households is participate and 0 if non-participate of small-scale irrigation practice.

The main intension here is to identify the impact of decision of the household's access to small-scale irrigation practice.

Outcome Variables

The outcome variables include:

The Household Net Income: This variable is a continuous variable, representing the difference between household total earning and annual expense. It was hypothesized that the technology improves both household earning and expense. It affects total household income from different sources such as income from farm and nonfarm activities are calculated for the 12 months period prior to the survey in Ethiopian Birr.

Independent variables

The Independent Variables: Different exogenous variables were expected to affect the impact of small scale irrigation on household's income in the study area. The demographic, economic and institutional factors hypothesizing variables that potentially are expected to affect the participation decision and the outcome variable is hypothesized

to affect by participation as follows.

1. **Sex of the respondent (SEXR):** This variable is dummy variable taking value of 1 if the sex of the household head is male or 0 if the sex of the household head is female. Men and women have different access to resources and opportunities (Asayehegn, 2012).This variable is found that as the probability of using irrigation practice and irrigated area will be higher for male headed household as compared to female headed households. As evidence (Mamo ,2018; Agidew, 2016; Agerie,2016; Asayehegn, 2012; Muez, 2014 ; Seifu, 2021) have gotten the same result. The cultural restrictions and double responsibilities of females make it hard to engage in irrigation activities. Therefore, sex of household head is hypothesized to be positively influence the participation of households' engagement in small scale irrigation.
2. **Age of household head (AGEHH**): This variable is continuous measured in years. From the findings of different studies age of household head is found negatively affected the using of irrigation practice by farmers and its intensity. According to (Belay & Beyene, 2013) reported that younger household heads is aspirations to adopt new production systems, whereas, older household heads relinquished their irrigable land to their younger descendent and became non-users. Therefore, age of household head is hypothesized to be negatively influence the participation of households' engagement in small-scale irrigation.
3. **Education level of the Household Head [EDUHH]:** This is a continuous variable measured in formal schooling years completed by the household head. That is the number of years of schooling attained by the sampled households" heads up to the time of the survey. Thus, scholars in the field such as (Dereje and Desale, 2016) explained it when the household head has good educational level, then there can be good possibility of willingness and adoption of new and improved agricultural methods and technologies. From the evidences it is hypothesized that Education level has positive relation with irrigation participants.
4. **Land Holding Size [LANDHH]:** This variable is a continuous variable measured in timid [1 timid which is equivalent to 0.25 hectare] and it refers to the total cultivated land of the household. As most of the households in the study area were smallholders, one of the possible ways to increase their output is by intensive farming. More land size holding means more cultivation and more possibility of production which in turn increases farm income and improves food security (Abdi, 2015). As a result, total

cultivated land could have a positive with agricultural productivity and income generation capacity of a household which has been engaged on small scale irrigation.

5. **Access to Extension Services [EXT]**: This refers to an access for extension services from development agents or not. This is a dummy variable with values of 1 if the household head has access to extension service and 0 otherwise. As a dummy variable, extension services availability and access to households on small scale irrigation practice could have increase productivity. (Bacha et al., 2011 and Surajit and Tsegazeab, 2016) found significant difference between irrigators and non-irrigators in access to extension. The higher is the probability for the farmers to access and use irrigated agriculture. As a result, the study will expect a positive coefficient for such variable with that of engagement to small scale irrigation.
6. **Livestock Holding [TLU]:** This is a continuous variable measured in Tropical Livestock Unit (TLU). In Ethiopia livestock including oxen were important source of income, food, manure and draught power for crop cultivation in agriculture. Continuous variable, larger size of livestock could make better chance to have better income from livestock. Livestock ownership is important not only for income generation but also as a saving option or proxy for household physical assets and risk management mechanisms. According to (Abdi, 2015) indicate the negative relationship between numbers of livestock owned and total land area cultivated indicating the difficulty of combining large livestock population with field cultivation. However, due to competition with crop, livestock will be expected to be negatively affecting irrigation participation.
7. **Agricultural Inputs Use [AGRIIU]:** This refers to availability of variable is a dummy variable 1 for user and 0 for non-user, refers to use of fertilizer such as, DAP and UREA, improved seed, high yielding varieties and pesticides. Households using fertilizer high yielding varieties were expected to have better food production capacity than the non-users. Use of farm input improves productivity per unit area; which could be taken as intensification of agriculture and helps the household to meet food needs. (Sisay & Fekadu, 2013) find out that, use of such technology will increase productivity of irrigation farm and improvement in productivity will lead to improvement in income. So that, it will be hypothesized as, accesses to improved technology for irrigation activity could positively affect utilization of irrigation water use. Therefore, it was assume to have positive impact on decision of the household on irrigation use.

8. **Dependency Ratio [DRATIO]:** This variable is continuous, referred had been to the proportion of economically inactive labor force (less than 15 years and above 65 years old) to the active labor force (Between 15 and 65 years old) with in a household. A household with more economically inactive labor force compare to the active age shows a high dependency ratio and the vice versa holds true. A higher dependency ratio would have showed that there are fewer workers or income earners and more consumers. As a result, the food security status of the household would negatively be affected (Regassa, 2015 and Abraham et al., 2015) Hence, it had been logically hypothesized that a higher dependency ratio would negatively affect participation in irrigation.
9. **Distance Market Link [Dmarket]:** This variable is a continuous; it is distance from household residence to the district market in kilometers. This variable showed that, the distance between household residence and the market center. According to (Surajit and Tsegazeab, 2016), forwarded that market place is located far away from the farms of the households, especially perishable commodities may perish before reaching the market. So to avoid such incidences the farmers may sell his/her products for the cheaper price which reduces the income and hence negatively affect the decision of household' to engagement small-scale irrigation schemes. Moreover, as the farmers' closer to the market center, the higher chance of small scale irrigation engagement decision. Therefore, this variable was hypothesized to influence the household's decision for irrigation water utilization negatively.
10. **Access to Credit [CREDIT]:** This variable is dummy variable taking on 1 if a household access to credit and used before and, 0 otherwise. Thus, the availability of credit helps to finance small scale irrigation practices of households and enable them to have to more agricultural products and generate income (Abraham et al., 2015) Hence, it was hypothesized that access to credit would influence participation in irrigation positively.
11. **Farming Experience [FEXEPR]:** This variable is continues represents the year of employment in the agricultural strategy achieved at the study time. Longer farming experience implies accumulated farming knowledge and skill which will contribution for adoption. Many studies supported this argument. For instance, (Abdi, 2015) reported positive relationship of farming experience with adoption. Further, it is assumed that more farming experience had been related to increase personal experience of the household to diversify and increase participation in irrigation.

Therefore, it has been expected to affect HH participation in irrigation positively.

Table 2: summary of the variable types, codes, hypothesis and description of explanatory variables

NO.	Variable code	Variable description	Variable type	Hypothesis
1	SEXR	Sex of the respondents	Dummy	+
2	AGEHH	Age of household head	Continuous	-
3	EDUCHH	Education level of the Household Head	Continuous	+
4	LANDHH	Land Holding Size	Continuous	+
5	EXT	Access to Extension Services	Continuous	+
6	TLU	Livestock Holding	Continuous	-
7	ACC AGRII	Access to agricultural inputs	Dummy	+
8	DRATIO	Dependency Ratio	Continuous	-
9	Dmarket	Distance Market Link	Continuous	-
10	CREDIT	Access to Credit	Dummy	+
11	FEXEPR	Farming Experience	Continuous	+

+, Positive effect; -, Negative effect

3.9 Model Diagnostics

3.9.1 Multicollinearity

Existence of strong Multicollinearity affects the parameter estimates of the regression models seriously. So, it is necessary to check the occurrence of Multicollinearity among the independent variables. Accordingly variance inflation factor (VIF) technique was used to detect the problem of multicollinearity for continuous variables (Gujarati, 2004). Every Selected variable is regressed on all the other variables, the coefficient of

determination (R_j^2) being constructed in each case. There exists strong linear relationship among the explanatory Variables if VIF value is large. VIF value greater than 10 is used as a signal for the existence of a severe Multicollinearity among the explanatory variables. VIF can be defined as:

$$VIF = 1 / 1 - R_j^2 \quad \text{---------- (9)}$$

3.9.2 Heteroscedasticity

The other problem in regression analysis is the problem of heteroscedasticity in the variables. The statistical test for heteroscedasticity the Breusch-Pagan test hettest (after regression). Here Ho: is homoscedasticity (i.e. constant error variance). We thus want a high p-value. Robust standard errors were correct heteroscedasticity problems.

To check for heteroscedasticity, robust standard errors were used to analyze the data by employing STATA version13 software. The other problem in regression analysis is the problem of Heteroscedasticity in the variables.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

In this research, the result discussion is presented using of descriptive statistics and econometric model to see the findings of impact of small-scale irrigation on household income. Descriptive statistics such as mean, maximum, minimum, percentage, standard deviation, chi-square test, and t-test used for results of data analysis. The t-test is used to test the significance of the mean values of continuous variables of two groups of treated and controlled group. On the other hand, the Chi-square is used to test the significance of the mean values of dummy variables, with comparison of the two groups of irrigators and non-irrigators (treatment and controlled groups).

Propensity score matching (PSM) and binary logistic regression econometric models was employed to estimate the impact of small-scale irrigation on household income. T-test and $\chi 2$-test are used to compare participants and non-participants in terms of continuous and discrete explanatory variables respectively.

4.1 Descriptive statistics

Both continuous and discrete variables were used in order to describe the sampled households included in this study. A combination of different descriptive statistics such as mean, standard deviation, percentage, t-test and $\chi 2$-test were performed based on household data to support the subsequent empirical data analysis. Table, 3, 4 and 5 present the structure of sample household characteristics.

Sex of the household head

Sex (biologically being male or female) of household head has positive or negative implication towards utilization of irrigation and income status of household. As presented in Table 3 for descriptive statistics summary for categorical variables of household characteristics result depicted that from 372 total sample households of both user and non-users of irrigation, Male respondent counts 261 and female 111 which were, respectively, about 70% and 30%. Based on chi-square test result, the sex of the household head has significant relationship with irrigation Participants and non-Participants at 1% significance level. The variable sex of the household head is hypothesized to influence participation small scale irrigation on positively and its sign was consistent with priori expectation and Pearson chi-square test at 8.1907. The

statistical analysis showed that there was statistically significant difference in the sex of household head between participants and non-participant's household head at 1% level of probability. The percentage shows those male-headed household are more likely to participate in irrigation activities than female headed counter parts (Table 3).

Agricultural Inputs Users:-Agricultural Inputs Users has measurable impact for the increment of crop production of the household head. It is believed that agricultural technology contributes for household income and encourage household to participate in irrigation activity. From Table 3, the result shown for agricultural technology utilization of household head, 90% irrigators and 91% non-irrigators are used agricultural technology. Whereas, 10% and 8% of irrigation participants and non- participants are not used agricultural technologies like improved seeds, inorganic fertilizers, water pumps, pesticides, composts and etc.…

The chi-square test revealed that using of irrigation and Agricultural Inputs Use**rs** has insignificant relationship at 1% significant level. The variable is hypothesized to influence participation on small scale irrigation negatively and its sign was consistent with priori expectation and Pearson chi-square test at 0.2793 statistical insignificant at 1% level of significance. In addition, utilization of agricultural technology is very high among irrigation participants than non-irrigation participants. Therefore, agricultural technology utilization has vital role to the enhancement of participation among household heads in small-scale irrigation works.

Access to Credit: - From Table 3, the total sample (372) respondents 208 household (56%) were not access to credit service and 164 household from both participant and non-participant (44%) have access to credit service. Likewise, from 120 participants, 72 households (60%) are having access to credit service and 48 households (40%) have not access to credit service, while, 252 non-participants, 136 households (54%) were not get access to credit service and 116 households (46%) are having access to credit service. Hence, 60% of participant and 46% of non-participants were access to credit service which had Pearson chi-square test at 1.1998 and statistical insignificance. Credit access for rural community has potential contribution for increasing income of rural households by filling family consumption gaps and catalyst for investment for small farmer to increase capacity of producing more through purchasing of valuable agricultural inputs like motor pump, improved seed, pesticide and fertilizer etc. The Chi-square test indicated that access credit has insignificant relation-ship with irrigation use. The sources

of credit in the study area are ACSI, Government, and friends. Much of sampled household respondents preferred receiving credit from informal sources like relative and friends instead of taking credit from formal credit institutions such as ACSI and Vision fund. As the result of this, 60% were received credit from relative and friends and the rest 46% of sampled household head were received from ACSI and Government.

Access to Extension Services:-From Table 3, each group 98% and 88.5% of participant and non-participant obtained agricultural extension services, training, and advice service while the others did not. The result revealed that 31 (8.3%) of the total respondent did not receive agricultural extension service while, remaining received. Analysis of awareness towards agricultural extension service revealed that majority of participant strongly recognize agricultural extension service, advice and trainings delivered at village level helped them. Meanwhile, majority of non-participant perceived the service comparatively helped. However, according to the planned extension service provision participation practical training centers (PTC) was not practically conducted at all the study Kebeles. The development agents provide only technical advices on farm which was not practically supported by demonstration as per the program scheduled three development agents are assigned to each kebele. Most of the kebeles have maximum of three development agents each. The variable is hypothesized to influence participation on small scale irrigation positively and its sign was consistent with priori expectation and Pearson test at 10.3065 statistical significant at 1% level of significance.

Table 3 the chi-square test for dummy (categorical) variables of household characteristics.

Categorical variable		Participant N=(120)	Non-Participant N=(252)	Total N=(372)	$\chi 2$-test
Sex of HH head	Male	96	165	261	8.1907 *
	Female	24	87	111	
Agricultural Inputs User	Yes	108	231	339	0.2793
	No	12	21	33	
Access to Credit	Yes	72	136	208	1.1998
	No	48	116	164	
Access to Extension Services	Yes	118	223	341	10.3065 *
	No	2	29	31	

Own survey result, 2023, ** and *** shows significant at 5, and 1% probability level

Age of household head

The minimum and maximum ages of sampled household head age were 27 and 64 years, respectively, with age mean of 40.783 years. T test result of Table 4, indicated that the age mean of sampled respondents of irrigation Participants were 40.783 years with 12.376 standard deviation. In the case of non-irrigation participants, the mean age of sampled respondents were 41.801 years with 13.194 standard-deviations. According to t test result shown in Table 4, the age mean difference for irrigation Participants and non-Participants were statistically significant (t= 2.3766) and there is significance difference of age among Participants and non-irrigation users of sampled household head. This means that age has no matter for the participation decision of household heads in small-scale irrigation works. Participation on small-scale irrigation works does not necessary depends on for household head ages get increased. Contrary to this study result, (Hadush, 2014) revealed that age has significant effect for household head for participation decision in micro-irrigation activities.

Dependency ratio among household members

The definition of dependency ratio is the number of children (0–14 years) and older persons (65 years or over) to the working-age population (15–64 years). Based on the result of household survey, the mean dependency ratio for total sample households is 0.21. This is interpreted as there are 0.21 children and oldies dependent on each worker of the households. In another interpretation 21 children and oldies are dependent in every 100 individuals within workers population groups sustained not only themselves but also additional 21 economically inactive persons with all basic necessities. Comparing irrigator and non-irrigator groups, the mean dependency ratio for irrigation users and non-irrigation users were found to be 0.21 and 0.31. The comparison for the two groups tells that dependency ratio for irrigation Participants lower than non-irrigation Participants. The dependency ratio among non-irrigation Participants is higher than the treated. However, the t-test result shows that there is significance difference (t=2.1197) in dependency ratio between irrigation and non-irrigation Participants (Table 4).

Distance Market Link

The distance of irrigation sources from living house of household head has matter either positively or negatively to the participation of household heads in irrigation activities.. The mean distance of irrigation users from irrigation source is 10.39 KMs with standard deviation of 2.55. In addition, the dwelling distance of non-users from irrigation source is 10.25 KMs with standard deviation of 2.502. Irrigation users are closer to irrigation sources than non-irrigation users. The t-test result shows that there is statistically insignificance difference (t=-0.5017) between irrigation Participants and non- Participants of irrigation regards to distance of dwelling distance of household head from irrigation sources.

Livestock size of household head (TLU)

Having of more livestock are very essential and determinant factor for rural household head of producing crops thereby being power for plowing their lands and a means for getting income for purchasing of agricultural inputs and increasing family income and additionally uses for means of transportation of agricultural goods to and from farms. In the study area, livestock's such as Oxen, Cow, sheep, goat, donkey, and chicken are majorly reared among sampled household respondents. It is observed that from all sampled household heads, 96% were having livestock, and the remaining 4% do not have.

In this study, to convert the numbers of deferent livestock owned by HH head into standard unit, every type of livestock were converted into a Tropical Livestock Unit. Regarding to estimating tropical livestock unit (TLU) of each sampled household, Conversion factors that was formulated by Storck et al. (1991) used. The minimum and maximum Livestock holding size of irrigation Participants are 1 and 16.94 Whereas, minimum and maximum livestock holding size of non-irrigation Participants are 0 and 16.85. It is evidenced from Table 4, the result showed that the mean livestock size of household hold for irrigation users and non-irrigation users were found to be 10.083 and 9.576, respectively, with standard deviation of 2.364 for treated and 2.460 for controlled. The t test result for mean comparison of irrigation users and non-users connected to livestock size of household head in tropical livestock unit revealed that there is statistically significant difference (t=-1.8846) at 1% significance level.

Farming Experience of household head

The variable is hypothesized to influence participation small scale irrigation on positively and its sign was inconsistent with priori expectation. This implies that the age of the household head has an influence on household decision because of farming experience and risk taking differences between old and young farmers. The compression by the farming experience in small scale irrigation reveals those 7.883 participants and 7.952 non-participants are found to be farming experience. The average farming experience of the participant was less than that of non-participant. The t-test statistical analysis revealed that there is significant difference (t=-4.4035) in farming experience between irrigation participant and non-participant at less than 1% level of probability.

Table 4 T test contrast for continuous variables of treated and control groups

continuous variable	Participant N=(120)		Non-Participant N=(252)		Mean difference	t-value
	Mean	Standard deviation	Mean	Standard deviation		
Age	40.783	12.376	44.18	13.13	3.399	2.3766 *
EDUCHH	8.283	3.101	8.512	3.23	0.2286	0.6458
LANDHH	1.929	0.5578	2.1667	0.7485	0.2375	3.0903 *
TLU	10.083	2.364	9.576	2.460	-0.508	-1.8846 *
DRATIO	0.2083	0.4078	0.31349	0.4648	0.105158	2.1197*
Dmarket	10.39	2.55	10.25	2.502	-0.1401	-0.5017
FEXEPR	9.375	2.9365	8.099	2.4434	-1.2758	-4.4035 *

Own survey result, 2023, ** and *** shows significant at 5 and 1% probability level

Household Income

To estimate the difference in the net income of participants and non-participants the total annual household's income was computed for the year 2022. The respondents were asked about their farm and non-farm income sources such as crops, vegetables, fruits, livestock sale and income from off/non-farm activities, remittance and other sources to calculate total income based on the price of 2021/22. Simultaneously data on household annual expenses/expenditure/ were collected for the same year and based on this the annual net income was computed. The descriptive result shown in (Table, 5) reveals that the average annual household net income of the small scale irrigation participants was estimated at 65,383.92birr and that of non-participants was 58,419.939 birr. Mean difference between the net income of the small scale irrigation participants and non-participants was 6964.524 birr which is statistically significant at less than 1% probability level.

There was about 10.65% difference in net-income of the participants and non-

participants. Therefore, household's participants have higher total income than non-participants households. The statistical analysis showed that there was significant difference between participants and non-participants at 1% probability level. A small-scale irrigation participant has a positive impact on households earning from crop, and livestock, while the value of off farm/non-farm-income earning was higher for non-participants.

Table 5 Total Income in participants and non-participants

Variable	Participants N=(120)		Non -Participants N=(252)		Mean difference	T-value
Outcome	Mean	Standard Deviation	Mean	Standard deviation		
Total income	65383.92	13826.12	58419.939	19955.04	6964.524	-3.45 *

Own survey result, 2023, Significant at 1% probability level

4.1 Econometric Model Results

In the descriptive analysis part of this thesis the important explanatory variables, which had been expected to have effect on households decision to small scale irrigation participation were presented. In this section, the selected explanatory variables were used to analyze the determinants of small-scale irrigation participation and outcome using PSM model. It had explained the estimation of propensity scores, defining common support region, choosing matching algorism, testing matching quality, calculating average treatment effect on treated, sensitivity analysis and factors influencing treatment effect on the treated.

4.1.1 Estimation Propensity Scores

We use the logit to calculate the propensity score based on observables characteristics of the two groups. Before evaluating the impact of the programmed by employing PSM matching algorithms, logit regression model was used as a prerequisite to identify the factors participation irrigation schemes.

As indicated in the former sections the dependent variable in this model is a binary variable indicating whether the household head was participation decision small scale irrigation or not. In households the estimation process data from the two groups, namely

For example, the study area in small scale irrigation main schemes Yetbon and Jole 2 and 3 farmers who have irrigated land don't participate in irrigation where as some farmers with no irrigated land participates in irrigation in the study area. This implies that irrigation decision is with 1 for decision to participate and 0 decisions to non-participate. Before running the regression model, the explanatory variables were checked for the existence of Multicollinearity and Heteroscedasticity.

The variance Inflation Factor (VIF) and contingency coefficient (C) tests of the variables in the model showed that there were no serious problems of Multicollinearity. Hence all explanatory variables are used for estimating the model. Robust standard errors were also tested to detect the problem of Heteroscedasticity by using STATA 13 software. As shown in the (Appendix Table, 1), the values of the VIF for the all independent variables were found to be small (i.e. VIF values less than 10), indicating the data have no serious problem of Multicollinearity. Similarly, the contingency coefficient, which measures the association between various categorical variables based on the Chi-square, were computed in order to check the degree of association or the existence of Multicollinearity problem among the categorical explanatory variables.

The decision rule for contingency coefficients states that when its value approaches 1, there is a problem of association between the dummy variables, i.e., the values of contingency coefficients ranges between 0 and 1, with zero indicating no association between the variables and values close to 1, Based on the above conditions, the result of the Multicollinearity for both participation equation and outcome equation shows that the values of the VIF for the continuous variables were found to be small (i.e. VIF values less than 10), indicating the data have no serious problem of Multicollinearity. Similarly, there was no problem of association among the dummy variables. Therefore, after checking of it, model analysis was conducted. Because of the various encouragements from the government, the number of farmers in the study area who are participating in small-scale irrigation has increased. However, still there are several farmers who don't participate in irrigation.

not an easy and is made within a wider context. In this sub section, we treat results concerning net income at household level as well as the socio economic, demographic and other factors that affect the net income of households. This study identified the potential factors that motivate farmers to practice irrigation farming using the participation logit model.

After having all the above checking and tests, the model analysis was conducted. The variables included in the model were hypothesized to influence household head's participation in the small scale irrigation and the outcome variables household income. The estimated coefficients showed that out of the eleven explanatory variables entered into the model seven explanatory variables significantly influenced in participation in small scale irrigation either positively or negatively while the rest four variables were not significant in explaining the variations in the dependent variable. More precisely land holding size, Dependency Ratio and Age of household head affect households' probability of participation in small scale irrigation negatively and significantly at 1% and 5% significance level. Whereas, Access to Extension Services, Livestock Holding, farming experience and Sex of the respondent affects households' probability of participation in small scale irrigation positively and significantly at 1% and 10% significance level respectively (Table, 6).

The logit estimation provides information about some of the driving forces behind farmers‟ decisions to participate in small scale irrigation farming. The pseudo R-squared is about 13.26 %. This low pseudo R-squared suggests that the proposed specification of the propensity score is fairly successful in terms of balancing the distribution of covariates between the two groups. The log likelihood ratio was -202.89304 and that follows the likelihood ratio chi-square value at 11 degrees of freedom was found to be 62.04 which is significant at 10%, indicating that the explanatory variables together explained the variation in the dependent variable.

Table 6 Result for Logit regression

Variables	Coefficient	Odds Ratio	Std. Err	Z	P>z
SEXR	0.6063963	1.833811	0.2847348	2.13	**0.033 ***
AGEHH	**-0.0184103**	0.9817582	0.0095508	-1.93	**0.054 ****
EDUCHH	**-0.0486007**	0.9525614	0.0401104	-1.21	0.226
LANDHH	**-0.5363796**	0.5848618	0.1934693	-2.77	**0.006 ***
EXTSR	1.830679	6.238123	0.7823582	2.34	**0.019 ***
TLU	0.1072729	1.113238	0.050505	2.12	**0.034 ***
AGRIIU	**-0.6742957**	0.5095151	0.4787772	-1.41	0.159
DRATIO	**-0.6435407**	0.5254287	0.2835728	-2.27	**0.023 ***
Dmarket	**-0.0239391**	0.9763451	0.0495956	-0.48	0.629
CREDIT	0.0819923	1.085447	0.2528069	0.32	0.746
FAEPR	0.2024092	1.224349	0.0481872	4.20	**0.000 ***
_cons	-2.473465	0.0842923	1.43143	-1.73	0.084

Sample size (n) = 372 pseudo R-squared = 0.1326 LR chi2 (11) = 62.04

Prob>chi2 =0.000 Log likelihood = -202.89304 * and ** means significant at the 5 % and 10 % probability levels respectively.

Source: own survey result (2023)

Interpretation of the Coefficients of logistic regression

Independent variables used in the logistic regression are: age of households head, sex, dependency ratio, education, land holding size, total livestock unit, farm experience, access to credit service and access to extension service, distance to district market and access to use improved agricultural input use. Therefore, landholding size, farming experience, dependency ratio, total livestock unit, sex, age of household head affect

households' and access to extension service were significant variables that affected the use of small scale irrigation.

Land Holding Size: was both hypothesized and also found out as having negative influence significance at 1% probability level (Table, 6). A one hectares increase in land change in the predicted odds ratio with a factor of 0.5848618 or increase 58.5% with other variables in the held constant. In addition, such reality can be understand as households which have been engaged on SSI could have additional land on rent so to acquire large amount of agricultural yields and similar had been explained by Kinfe et al., (2012).

In this regard, Tsegezeab and Surajit (2016) found out similar results and explained that more land holding size means more cultivation that could results in larger agricultural products. Thus, households who are engaged on small scale irrigation can be encouraged as well as reinforced to have more farming land so to increase their product both quantitatively and qualitatively and also to generate more income.

Access to Extension Services: was both hypothesized and also found out as having positive influence significance at 5% probability level (Table, 6). The odds ratio of agricultural extension, training, and advice service indicates that, unit's increases in agricultural extension, increases the probability of participation in small scale irrigation and non-participant by 6.238123 units or increase 23.8% with other variables in the held constant. The positive relationship may indicate that in the study area, those households who get technical advice, training or those who participated on field demonstrations are well aware of the advantage of agricultural technologies and willing to adopt new technologies and produce more, thereby improving the household level of income. This result is conducted by (Dereje M. and Desale K. 2016 and Abraham et al., 2015) found out similar findings and explained the result as extension service access being playing great role in obtaining all the important advices supports, trainings and follow-up with all agricultural activities that encourage households to practice small scale irrigation.

Agricultural Inputs Use: is factor for influence participation or not. As a result of the logit regression was found as expected negative sign and statistical insignificance at 1% level of significance (Table, 6). One percent increases the availability of access to use improved agricultural input it lead to raise farm productivity of household and the income of participant household increase. The improved seed, fertilizer and chemical had

determined participation in small scale irrigation and being a user of input use increases participation by odd ratio factor of 0.5095151 units or increase 50.95% with other variables in the held constant. This result suggested that those who were better off could afford to buy fertilizer and those who were poor might not.

As a result, input participant might be producing more per-unit area than non- participant and could have access to large quantity of food and diversify income sources for accumulation. Moreover, as households who are participating on credit could have the capacity to buy and employ inputs for their SSI practice. And similar findings were forwarded by Sisay and Fekadu (2013)

Distance to the Market: The variable is hypothesized to influence small scale irrigation negatively and its sign was consistent with priori expectation. The result of logit regression model showed that distance to district market was non-significant and negatively related to participation small scale irrigation at 1% level of significance (Table, 6). The odds ratio of distance to the market indicates that, a unit increases in distance to the market, decrease the probability of participation in small scale irrigation and being non- participant small scale irrigation by 0.9763451 units with a unit decrease in distance to district market or decrease 97.6% with other variables in the held constant. The result is consistent with that of Abraham et al (2015) who found that lack or absence of infrastructure particularly road as well as transportation accessibility for households who engaged on small scale irrigation could bring short comings on their success of more agricultural production and gaining more income.

Access to Credit Service: is a factor for influencing participation in small scale irrigation the result of logit regression model showed that access to credit service was non-significant and positively related to small scale irrigation at 1% probability level of significance (Table, 6). The odds ratio value showed that an increase in access to credit service change in the predicted odds ratio with a factor of 1.085447 units or increase 8.54% with other variables in the held constant. Thus, those households which are members of credits could have many benefits and advantages than those who are not.

For instance, participation in cooperatives for farming households enable in having easy access to inputs, technical advice, markets link, and renting a car to transports their agricultural products to distant market to sell in a fair price. Thus, this result supports the study of Abraham et al (2015) and Desta and Almaz (2015).

Farming Experiences: was both hypothesized and also found out as having positively influence significance at 10% probability level (Table, 6). The result of logistic regression also showed that farm experience positively affected participation in small scale irrigation at (P<0.000) probability level. The odd ratio indicated that participation in small scale irrigation increased by odd factor of 1.22435 with a unit increase in farm experience or increase 22.43% with other variables in the held constant. The probable reason is that more experienced farmers in small scale irrigation accumulated capital and shifted their livelihood strategy, and income sources out of agriculture. This, results supports the study of (Asayehegn et al., 2012; Abdi Etafa 2015).

Finally, above all significant variables and non-significant variables that affected the use of small scale irrigation were the odds ratio implies that, household who have landholding size, Access to Extension Services Agricultural Inputs Use, distance to district market, Access to Credit Service and farming experiences are more 58.5%, 23.8%, 50.95%, 97.6%, 8.54% and 22.43% likely to participate in small scale irrigation than those have non-participate in small scale irrigation respectively.

4.1.2 Matching Small Scale Irrigation Participants and Non- participants

Before implementing the matching task, three main steps were followed: predicted values of propensity scores should be estimated for all treated and control households, a common support condition should be imposed on the propensity score distributions of small scale irrigation participants and non-participants, finally from the observations whose predicted propensity scores fall outside the range of the common support region should be discarded. In this study the estimated propensity score of households (Table, 7), the predicted propensity scores range from 0.0539353 to 0 .5972778 with mean value 0.3569395 and standard deviation 0.0872801 for the participants, while it range from 0.0298486 to 0.5677556 for non-participants household with mean score of 0.3062193and standard deviation 0.1076808 for the non-participants. Accordingly, the common support region was satisfied in the range of 0.0539353to 0.5677556 by deleting 11 observations out of the overlapping region.

Table 7 Distribution of Estimated Propensity Score of Households

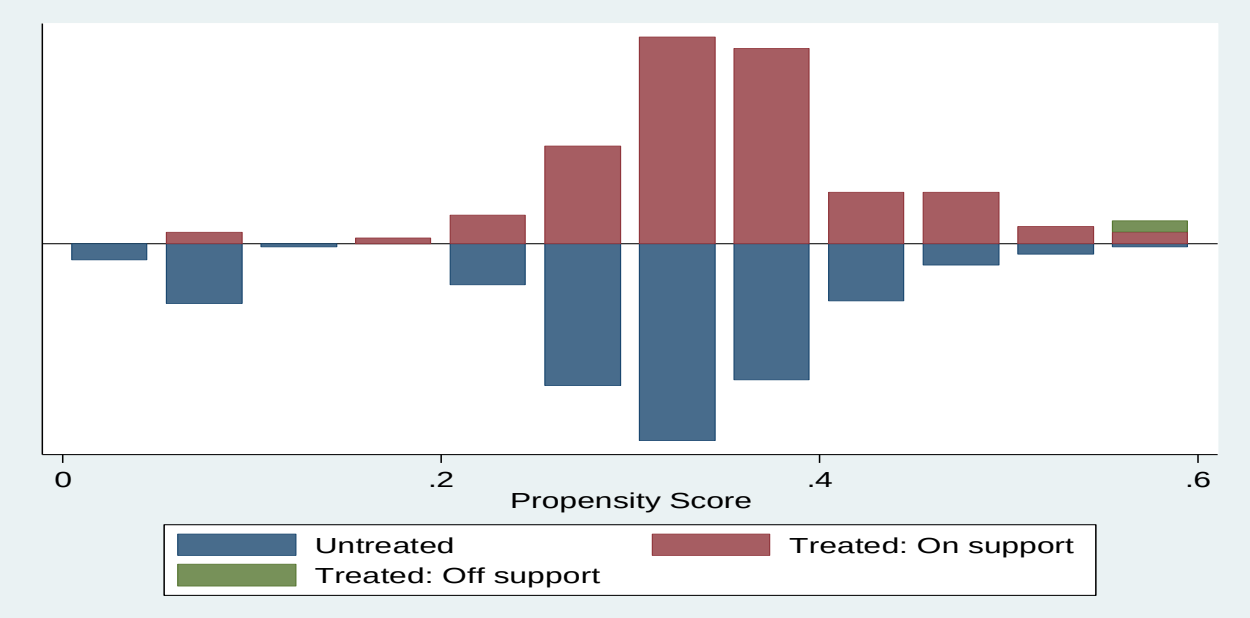
Group	Observation	Mean	Std. Dev	Min	Max
All households	372	0.3225807	0.1041721	0.0298486	0.5972778
Participants	120	0.3569395	0.0872801	0.0539353	0.5972778
Non–participants	252	0.3062193	0.1076808	0.0298486	0.5677556

Source: Own survey result, (2023)

From the below (Figure, 3) that showed density distributions of propensity score in the common support, the bottom halves of the psgraph shows the propensity score distribution of non-participant households and the upper halves shows the propensity score distribution of participant households.

The red colored (treated on support) and the blue colored (untreated on support) indicates the observations in the participant group and non-participant group that have suitable comparison respectively, whereas the green colored (treated off support) indicates the observations in the participant group that do not have suitable comparison. Based on those criteria, radius caliper matching of was found to be best estimator for this study. Therefore, impact analysis procedure was followed and discussed by using radius caliper matching of 0.1 levels.

Figure 3 Density Distributions of Propensity score in the Common Support



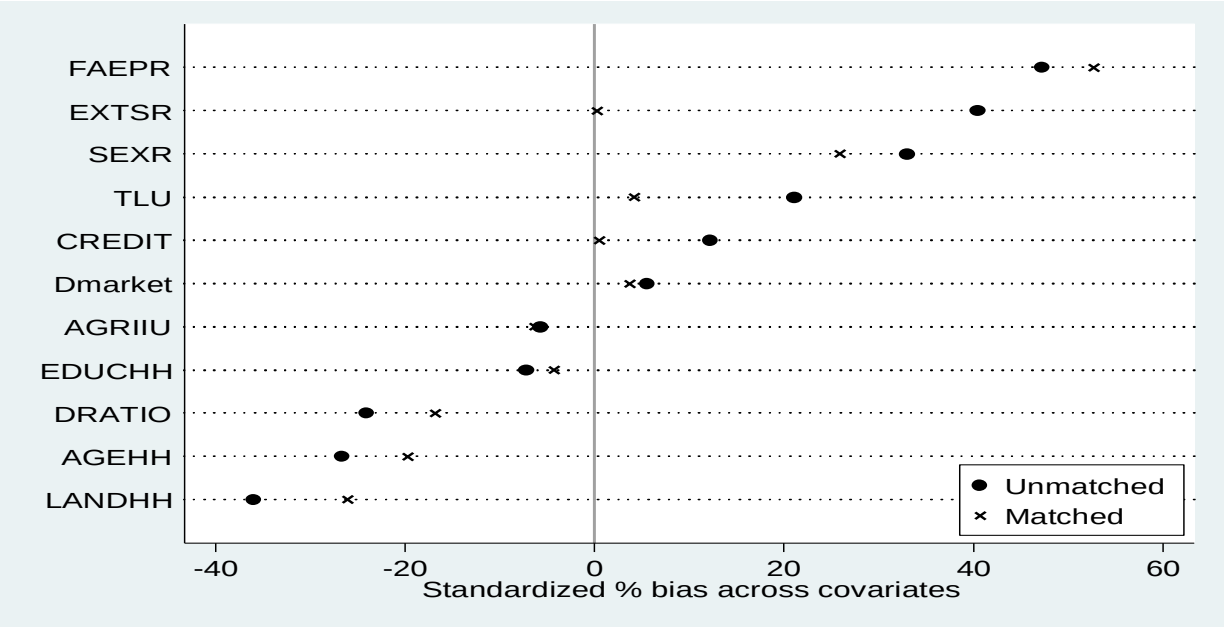
4.2.3 Choice of Matching Algorithm

Different matching estimators had been tested in matching the small scale irrigation participants and non-participant as a control group from rural kebeles in the common support region. To choose the best matching estimator for the analysis, different guiding criteria, such as equal means test referred to as the balancing test (Dehejia and Wahba, 2002), low Pseudo R^2 and matched sample size were taken into consideration. Matching estimators like nearest neighbor, caliper radius matching and kernel with different band width were tested. Thus, a matching estimator which balances all the explanatory variables that results insignificant mean differences between the two groups, bearing low pseudo R-square value and also results in large matched sample size was taken as the best estimator. Results show that among estimators, radius caliper (0.1) was found to be the best estimator for the collected data.

4.2.4 Testing of Balance of Propensity Score and Covariates

After selecting best performing matching algorism which satisfied prior identified performance criteria, balance of propensity score and explanatory variables were checked by the selected matching algorism (Radius caliper 0.1 in this case). As indicated earlier, the main purpose of the propensity score estimation is not to obtain a precise prediction of selection into treatment, but rather to balance the distributions of relevant variables in both groups. The balancing powers of the estimations were ascertained by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched households, equality of means using t-test and chi-square test for joint significance of the variables used. Depicts the estimated results of test matching quality based on the selected best estimator (Radius caliper 0.1).Appendix Table 4

Figure 4 Balance check or balance sample test with in graph



Source: own computation, (2023)

4.2.5 Estimating Treatment Effect on the Treated

In order to attain the above stated objective the following impact indicators of the treatment effect were performed using the PSM model. Based on the logistic estimation results, participant and non-participant were compared using household outcome indicators: income. The small scale irrigation participation was intended to bring about a change in household income of participant households.

To check how robust and sensitive our estimates are to the different matching functional forms, four different matching algorithms have been estimated and results were found to be quantitatively as well as qualitatively similar, this shows the robustness of the results. Hence, the four different matching algorithms: nearest neighbor, radius and kernel, stratification, are used in order to estimate the outcome effect of small scale irrigation program households.

Nearest neighbor matching (NNM), which is one of the four matching algorithms, can be estimated either with or without weights. But, since estimating average treatment effect using NNM with or without weights does not affect the results (Khandker, n.d), the nearest neighbor estimation results for each of the outcome indicators in this analysis are without weights. In addition, the “reps” option used in the kernel matching method performs the bootstrapping 50 times.

Impact on Households Income

The ATT results and their respective t-value for income of households using the four matching methods are presented in (Table, 8 below).

Table 8 ATT results for Impact on Income of Households

Matching Algorithms	Treated	Control	Difference	S.E	T-stata
Net income unmatched	65383.92	58419.92	6964.524	2019.749	3.45*
ATT of net income	65432.797	57987.36	7445.43	2703.02	2.75 *

***** means significant 1% probability level**

Source: Own estimation result based on survey, 2023

After correcting for pre-intervention differences in demographic structure, location, farm land and livestock holding characteristics of the participants and non-participants households, it has been found that, on average, the technology has increased net income of the participating households by 7445.43 birr. This showed that the use of small scale irrigation has increased net income of the participating households by 11.4%.

4.2.6 Estimation Results of the Sensitivity Analysis

Propensity score matching provides an estimate of the effect of treatment variables that is largely free of bias arising from an association between treatment status and observable variables. However, propensity-score matching estimators are not consistent estimators for treatment effects if the assignment to treatment is endogenous, i.e., if unobserved variables that affect the assignment processes are also related to the outcomes. In order to estimate the extent to which such "selection on un observables" may bias our qualitative and quantitative inferences on the effects of small scale irrigation benefits sensitivity analysis was conducted. One strategy to address this problem is the (Rosenbaum , 2002) approach, which allows the analyst to determine how strongly an unmeasured confounding variable may affect selection in the treatment. In this study, sensitivity analysis was carried out on the estimated average treatment effect using alternative matching estimators for outcome variable, which were mentioned earlier. All matching estimators resulted in statistically significant effects of the program on participating households' income. The sensitivity analysis also showed that the estimates are almost free from unobserved covariates.

Appendix Table 1: Simulation-Based Sensitivity Analysis Results

```
. mhbounds HHINCOME, gamma(1 (0.05) 2)

Mantel-Haenszel (1959) bounds for variable HHINCOME

Gamma         Q_mh+     Q_mh-     p_mh+     p_mh-
----------------------------------------------------
    1             .         .         .         .
 1.05       -.071132  -.071132   .528354   .528354
  1.1       -.071132  -.071132   .528354   .528354
 1.15       -.071132  -.071132   .528354   .528354
  1.2       -.071132  -.071132   .528354   .528354
 1.25       -.071132  -.071132   .528354   .528354
  1.3       -.071132         .   .528354         .
 1.35       -.071132  -.071132   .528354   .528354
  1.4       -.071132  -.071132   .528354   .528354
 1.45       -.071132  -.071132   .528354   .528354
  1.5       -.071132  -.071132   .528354   .528354
 1.55       -.071132  -.071132   .528354   .528354
  1.6       -.071132  -.071132   .528354   .528354
 1.65       -.071132  -.071132   .528354   .528354
  1.7       -.071132         .   .528354         .
 1.75       -.071132         .   .528354         .
  1.8       -.071132  -.071132   .528354   .528354
 1.85       -.071132  -.071132   .528354   .528354
  1.9       -.071132  -.071132   .528354   .528354
 1.95       -.071132  -.071132   .528354   .528354
    2             .         .         .         .

Gamma : odds of differential assignment due to unobserved factors
Q_mh+ : Mantel-Haenszel statistic (assumption: overestimation of treatment effect)
Q_mh- : Mantel-Haenszel statistic (assumption: underestimation of treatment effect)
p_mh+ : significance level (assumption: overestimation of treatment effect)
p_mh- : significance level (assumption: underestimation of treatment effect)
```

Source: Own estimation result based on survey, 2023

4.2.7 Problems of small scale Irrigation Management and Performance

This subchapter had contained summarized result of the focused group discussion. Thus, participants had forwarded the following main points. As of the existing canal and other related problem it had been found out as heavy sedimentation around head work, cracking and fracturing of the canal wing, erosion at wing wall and weir foundation, siltation at diversion head work as well as Cracking of the plastic sheet. In addition, Canal breach in advance which enforces water to pond & finally allowed seepage & low flow velocity

due to this it had reduced the capacity of the scheme so by maintain the damaged structure it can back to efficient capacity.

In regard to distribution and allocation water, it had been found out as absence of formal rules and regulation and as a result there has been high chance of conflicts and trouble among farmers who were engaged on small scale irrigation. In addition, because of absence of formal rules and regulation for the distribution and allocation water, there had been misappropriation and mishandling of water particularly by the upper canals user s which is unfair. Similarly, some people had been damaging and also removing some materials being fixed on structures and so had been exposed to measures action which were taken water users associations. As of the irrigation agronomic situation participants of the focus group discussion had pointed out that they faced crop agronomic problems and as a results products such as onion, tomato and maize had faced attacks of various disease, pests and insects. In addition, there had been problems related with watering problems (over watering), improper planting density, delayed employment of inputs, under-utilization of fertilizer, use of local varieties, lack of access to quality and certified vegetable seed had been the challenges. This includes method of cropping (intercropping, sole cropping ,relay cropping multiple cropping ,double cropping and alley cropping), proper choice of suitable crop varieties, agronomic management practices (timely and proper land preparation, proper sowing weeding watering timely harvesting), soil type, fertilizer utilization soil fertility management and importantly soil type, fertilizer utilization/soil fertility management and more importantly soil moisture/water. Finally, small scale irrigation practice by household had been found out as coming across with some problems that comprised, canal related problems, water distribution and allocation problem and irrigation agronomic problem. Thus, the researcher had forwarded some points as recommendation so as to solve the existing problems.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 Summary

In this study the impact of small scale irrigation on household's income has been analyzed using cross sectional data obtained from Meskan Woreda, Misrak Guraghe Zone of Central Ethiopia Regional State. The main research question of the study was "What is the impact on household income with and without participation in small scale irrigation the study area? And what are the factors which affect small scale irrigation impact on household income?" The general objective of this study was to assess the impact of small scale irrigation on household income in the study area.

The primary data for this study were collected in 2023 from 372 households from both small scale irrigation participation and non- participation in Meskan Woreda using structured questionnaire. This study also examined the process of participation targeting and found that household assignment to the participation was a simple random selection process. Therefore, this study has employed a propensity score matching technique, which is capable of extracting comparable pair of treatment-comparison households in a simple random participation setup and in absence of adequate baseline data. The data were analyzed by using descriptive statistics and econometric model (logit and PSM). The descriptive statistics the results revealed that from total sampling households 120 (32.26%) were participants and 252(67.74%) non-participants in small scale irrigation. The result reveals that the average annual household net income of the small scale irrigation participants was estimated at 65,383.92 birr and that of non-participants was 58,419.939 birr. These result showed that participants of the small scale irrigation gained a positive benefit compared to non-participants. This study indicated that 10.65 % of as expected; the participation of small scale irrigation was determined by a combination of factors. More specifically, the use of small scale irrigation technology is significant for seven explanatory variables. These variables, land holding size, Dependency Ratio and Age of household head affect households' probability of participation in small scale irrigation negatively and significantly at 1% and 5% significance level. While, Access to Extension Services, Livestock Holding(TLU),farming experience and Sex of the respondent affects households' probability of participation in small scale irrigation positively and significantly at 1% and 10% significance level. The estimated results

revealed that households who owned larger land holding size, by taking agricultural extension services, access to credit service and improved agricultural input uses had were more likely to benefit from the use of small scale irrigation, ceteris paribus. Propensity score matching has resulted in 109 participant's households to be matched with 252 non-participants households. Accordingly, a matched comparison of income was performed on these households who shared similar characteristics except small scale irrigation. The resulting matches passed a variety of matching quality tests and were sufficient enough in answering the main study's questions. After controlling for other characteristics, it has been found that the small scale irrigation has significantly increased the net income of participant's households in the study area. More specifically, the technology increased participant's households' net income by 7779.675 birr per year. Consequently, the result of study found that the participation has increased the net income of participants households by 10.65% per-annum compared to non-participants households.

5.2 CONCLUSION

Based on the results discussed earlier, this study was examined the impact of smallscale irrigation on households income in the Meskan Woreda Central Ethiopia. In this study, we utilized both primary and secondary data. We followed propensity score matching model (PSM) approach to analyses the impact of smallscale irrigation on income of rural households to fill the gap studies conducted in this field of study. We examined the impact of small-scale irrigation on income of rural households through using the most common matching algorisms including nearest neighbor, caliper, radius and kernel matching estimators. Determinants of household heads that significantly influence the participation to irrigation activities were analyzed by binary logistic regression model.

First, the findings in this paper provide sufficient evidences that small scale irrigation played a key role in improving the household net income in the rural areas. Second, the result indicated that households land holding size is significant impact in small scale irrigation participation. Accordingly, land holding size means more cultivation and more possibility of production which in turn increases farm income and improves food security. Thus, we understand from this as household who were engaged on small scale irrigation would positively reinforced to had more land with rent or other methods and cultivate through small scale irrigation. Third, it also showed that the significant role of the households that engaged to small scale irrigation and being having access to agricultural

extensions service could realize the desired improves yield of agricultural production activities and generation of more income. Similarly, the presence of easy access to various agricultural extensions service for rural households plays great role in obtaining valuable advices in regard to improved methods, inputs and techniques employment and so encourage them to engage on small scale irrigation. Fourth, input use that could be proved with very realistic nature of the households had been termed differently as access of inputs and so being hypothesized as positively correlated to participation on small scale irrigation and negatively vice versa. As a result, it was found out that it had been positively correlate as the household was participating/practicing small scale irrigation and the household was able and willing to employ various types of modern and improved input. As a result, there would been increased income gained out of the small scale irrigation practice.

Fifth, an improvement in road access and transportation facilities would also facilitate improved marketing and thereby, participation. Accordingly, the result revealed that the most important small scale irrigation practice designed to increase production and productivity which reduces risk related with rainfall variability and increasing income of rural farm households. Therefore, small scale irrigation participants were able to have more earners income than the non-participant had been. Finally, the implication of the findings is straight forward; even if the participants of small scale irrigation is quite low in Meskan Woreda those households who could use the SSI improve their income.

5.3 Recommendation

Based on the findings of the study, the researchers have forwarded the following points as recommendation to improve the impact of small scale irrigation on household's income in the study area. The empirical findings provide important messages for policy makers. They provide evidence that small scale irrigation participation played a key role in improving household income in study areas.

1. The empirical results of this study showed that the Size of cultivated land and household participation in small scale irrigation farming are positively and significantly related indicating larger farm size improves household participation. Households with large farm size are found to be participated more than others however; there may not be a possibility of expanding cultivated land size anymore because of increasing family size and degradation of the existing farm land. Therefore, household must be trained as to how to increase production per unit area (productivity).

2. The participation of small scale irrigation has a strong positive relationship with access to extension service and access to credit service. This suggests that policy makers can maximize the impact of the participation of small scale irrigation by allowing creating easy and more accessible credit prevision and agricultural extension service; to engage or to maximize their practical endeavor for both newly joining and already engaged ones by creating easy accessed branch office and also involving more agricultural development agents and other skilled man power in the support activities.

3. Lastly, further research should also be undertaken using much larger sample size with more controls relative to treatment and in different locations to provide further insight on the intervention and draw context-specific lessons to improve management in similar participation.

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APPENDICES

Appendix Table 2: Test Multicollinearity

```
. estat vif
```

Variable	VIF	1/VIF
EXTSR	1.20	0.835995
AGRIIU	1.15	0.867212
LANDHH	1.13	0.888079
CREDIT	1.09	0.914384
EDUCHH	1.08	0.924065
FAEPR	1.07	0.938750
AGEHH	1.06	0.939619
Dmarket	1.06	0.946922
SEXR	1.04	0.956971
DRATIO	1.03	0.969480
TLU	1.02	0.978707
Mean VIF	1.08	

Conclusion: From the output above VIF is 1.08. There exists the problem of Multicollinearity when VIF is greater than 10. But in this research there is no Multicollinearity problem in the model; because of value of VIF=1.08 is less than 10.

Appendix Table 3 The summary statistics

```
. summarize SEXR AGEHH EDUCHH LANDHH EXTSR TLU DRATIO AGRIIU Dmarket CREDIT FAEPR
```

Variable	Obs	Mean	Std. Dev.	Min	Max
SEXR	372	.7715054	.4204283	0	1
AGEHH	372	41.47849	12.92763	27	64
EDUCHH	372	8.438172	3.188413	1	18
LANDHH	372	2.05914	.5608497	1	3
EXTSR	372	.9166667	.2767576	0	1
TLU	372	9.739247	2.438299	1	16
DRATIO	372	.2204301	.415095	0	1
AGRIIU	372	.8978495	.303254	0	1
Dmarket	372	10.29677	2.514709	6	13
CREDIT	372	.5591398	.4971588	0	1
FAEPR	372	7.930108	2.286833	5	14

Appendix Table 4 : The relationship (correlation) of variables

. correlate SSI SEXR AGEHH EDUCHH LANDHH EXTSR TLU AGRIIU DRATIO Dmarket CREDIT FAEPR
(obs=372)

	SSI	SEXR	AGEHH	EDUCHH	LANDHH	EXTSR	TLU	AGRIIU	DRATIO	Dmarket
SSI	1.0000									
SEXR	0.0468	1.0000								
AGEHH	-0.0372	-0.0225	1.0000							
EDUCHH	-0.0336	-0.1443	0.0073	1.0000						
LANDHH	-0.0677	-0.0054	-0.0701	-0.2278	1.0000					
EXTSR	0.1665	0.0676	-0.0837	-0.1204	-0.2807	1.0000				
TLU	0.0975	-0.0451	0.0639	-0.0116	0.0931	-0.0083	1.0000			
AGRIIU	0.0049	0.0701	-0.0274	-0.1515	-0.1664	0.4122	-0.1309	1.0000		
DRATIO	-0.0201	0.0268	0.0355	-0.0895	0.0249	0.1134	-0.0016	0.1151	1.0000	
Dmarket	0.0261	0.0748	-0.1133	-0.0458	-0.0269	-0.0387	-0.0350	-0.0768	-0.0099	1.0000
CREDIT	0.0568	0.0455	-0.0250	0.0865	-0.2760	0.1437	-0.0150	0.0759	-0.1025	0.0193
FAEPR	-0.0141	0.0198	-0.1040	-0.0475	0.0568	0.1100	-0.0434	0.0247	0.1185	0.1425

	CREDIT	FAEPR
CREDIT	1.0000	
FAEPR	-0.1623	1.0000

Appendix Table 5: Balancing test results of Covariates using kernel matching algorithmthm.

```
. pstest  SEXR AGEHH EDUCHH LANDHH EXTSR TLU AGRIIU DRATIO Dmarket CREDIT FAEPR, sum both
```

Variable	Unmatched / Matched	Mean Treated	Mean Control	%bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
SEXR	U	.8	.65476	33.0		2.89	0.004	.
	M	.8	.68585	25.9	21.4	2.03	0.043	.
AGEHH	U	40.783	44.183	-26.6		-2.38	0.018	0.89
	M	40.783	43.302	-19.7	25.9	-1.55	0.123	0.93
EDUCHH	U	8.2833	8.5119	-7.2		-0.65	0.519	0.92
	M	8.2833	8.4203	-4.3	40.1	-0.32	0.746	0.82
LANDHH	U	1.9292	2.1667	-36.0		-3.09	0.002	0.56*
	M	1.9292	2.1012	-26.1	27.6	-2.01	0.046	0.54*
EXTSR	U	.98333	.88492	40.4		3.25	0.001	.
	M	.98333	.98275	0.2	99.4	0.03	0.972	.
TLU	U	10.083	9.5754	21.1		1.88	0.060	0.92
	M	10.083	9.9831	4.2	80.3	0.32	0.749	0.91
AGRIIU	U	.9	.91667	-5.8		-0.53	0.598	.
	M	.9	.91836	-6.3	-10.2	-0.49	0.622	.
DRATIO	U	.20833	.31349	-24.0		-2.12	0.035	.
	M	.20833	.28203	-16.9	29.9	-1.33	0.186	.
Dmarket	U	10.392	10.252	5.5		0.50	0.616	1.04
	M	10.392	10.298	3.7	33.0	0.29	0.772	1.06
CREDIT	U	.6	.53968	12.2		1.09	0.275	.
	M	.6	.59756	0.5	96.0	0.04	0.969	.
FAEPR	U	9.375	8.0992	47.2		4.40	0.000	1.44*
	M	9.375	7.952	52.7	-11.5	4.14	0.000	1.56*

* if variance ratio outside [0.70; 1.43] for U and [0.70; 1.43] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.133	62.33	0.000	23.5	24.0	90.2*	0.75	33
Matched	0.093	31.01	0.001	14.6	6.3	73.8*	1.15	33

* if B>25%, R outside [0.5; 2]

Appendix 1 Survey Questionnaires

IMPACT OF SMALL SCALE IRRIGATION ON HOUSEHOLD INCOME: IN CASE OF MESKAN WOREDA, MISRAK GURAGHE ZONE CENTRAL ETHIOPIA REGIONAL STATE.

Part I: Questionnaires for Household Interview

This questionnaire was prepared to undertake a study on the Impact of small scale irrigation on household income: in case of Meskan Woreda, Misrak Guraghe Zone Central Ethiopia. The purpose of the questionnaire is to gather information on small-scale irrigation participation and non- participation household of source of income, Determinant factors that affect small scale irrigation participation and also the contributions of small scale irrigation on farm incomes. Thus, I would like to assure you that questionnaire is used only for the academics purposes. Dear Respondents are you willing to respond appropriately to the following questions? If you are volunteers, you can proceed to kindly requested to provide genuine responses. Thank you for your cooperation.

I. GENERAL INFORMATION

1. Enumerator's Name----------Date of interview----------

Signature---------- Questionnaire code----------

2. Category of the household (put X mark) a) Irrigation user----------b) non-user--

3. Irrigation Type (put X mark) a) Modern------- b) Traditional----------

II. HOUSEHOLD CHARACTERISTICS

2.1 Name of respondent----------Name of Kebele----------

Name of village---------- Age of the household head---------- Signature----

2.2 Sex of the household head---------- 1= Male 0 = Female

2.3 Education of the household head formal schooling years ----------

2.4 How many household members are there in each age group? Age, sex and education of all household members including permanently employed laborer, husband and wife.

Age	Male	Female	Education/Grade
Seven year and under			
7 – 14 years			
15 – 64 years			
above 64years			
Total			

2.5 Total family numbers of the household----------

III Issues of Household's Income

3.1 What is the major source of your income? ----------

3.2 If you have more than one income source please list each amount of incomes do you have in ETB? ----------

IV. SOCIO-ECONOMIC CHARACTERISTICS

A. TOTAL LIVESTOCK HOLDING & INCOME FROM LIVESTOCK HOLDING

B. Number of livestock owned at current? And sold in the past 12 months----------

FARM CHARACTERISTICS

Own land				Rented in now	Rented out Now	Shared in Now	Shared out now	Grazing Land	Total land Operate	
Irrigable		Rain fed							5yrs ago	Now
5yrs Ago	Now	5yrs Ago	Now							

4.2 Can you please indicate the total land operated by your household accordingly?

Note; Use the local unit and specify the unit in terms of hectare

4.3 If rented in/shared in what was the reason (s) for?---------- 1) Availability of farm inputs 2) Shortage of land 3) Extra labor 4) To Increase income 5) no cultivable land.

4.4 If renting out/ sharing out, what was the reason? ----------1) Shortage of money to buy inputs 2)

Disabled 3) Shortage of oxen 4) for urgent money need 5) no labor to support

4.5 If you rent in/out land, Rate of payment Birr/hectare/year.----------

4.6 Do you or any other member of your household own any cultivated Land?---------- 1=Yes, 0=No

4.7 Household land holding size in timed.---------- 1=Fertile---------- 2=moderately fertile--- 3=Unfertile---------- 4 =Total land holding timed----------

4.8 How do you plough your land?---------- 1=Using Family Labor 2=Using hired Labor 3= Using Owned oxen 4=using rented oxen 5=using borrowed oxen 6=other

4.9 How do you compare existing production with that of 5 years ago? ----------1/ Increased 2/ Decreased 3/ No change

4.10 If your answer is ‘'Production has decreased" what are the reasons? ----------

1/ shortage of rain fall 2/ shortage of new technologies 3/ Pest and disease 4/ Shortage of land 5/ Shortage of input 6/ Shortage of labor 7/ Other/specify

C. Determinant factor that affect participation of small scale irrigation in the study area

5. SMALL SCALE IRRIGATION RELATED

5.1 Do you have access to small scale irrigation? 1= Yes, 0= No

5.2 If yes, how much area of your land is accessible to irrigation in hectare?

5.3 If your answer Yes, Which Small-Scale Irrigation Type Do You Use? 1. Modern Micro Dam, 2.Traditional River Diversion, 3. Motor Pump, 4.Treadle Pump, 5.Others

5.4 How many times do you produce within a year using small scale irrigation? 1. Once 2.Twice 3.Three times

5.5 Have you been cultivating all of your irrigable land totally? 1= Yes, 0=No

5.6 Do you use the irrigation for your farm every time you need? 1= Yes, 0= No

5.7 How long do you use irrigation farming in years? 0= No irrigation farming before 1= 0-2 Years 2= between 2 to 4 years 3= between 4 to 6 years 4= between 6 to 8 years 5=8 and above

5.8 What are the major problems you face/observe in your irrigation farming?

5.9 What actions do you take to solve the problem?

5.10 Who controls the irrigation system? 1. Model farmer 2. Development agent 3. Community leader 4. Nominated person in the community 5.Others specify

5.11 How do you evaluate the power relationship between irrigation users and irrigation water Managers? 1. Very bad 2. Bad 3. Medium 4. Good 5. V. good

5.12 If bad, what would you recommend to make it good?

5.13 Is there a fair distribution of water between users? 1= Yes, 0= No

5.14 Is the amount of water obtained at once is enough to irrigate your land? 1= Yes, 0= No

5.15 Are you a member of water user association? ----------0= No, 1= Yes

5.16 If answers question 5 .14 is yes, what do you contribute to manage the irrigation system? -----1)Money 2) Labor 3) membership fee 4) nothing/ use freely 5. Other specify

5.17 What are the benefits obtained from the association and your role?----------

5.18 Do you satisfied with the irrigation management system?---------- 0= No, 1= Yes

5.19 If yes, what makes you satisfied? ----------1) Fairness in distribution 2) frequency of access 3)Rules and regulation of WUA 4) others specify

5.20 If is no access to irrigation what are the problems? ----------1=No farmland in surface water Access 2= No awareness about it 3= Sufficient rain and moisture 4 = others

5.21 What happened to your household's living condition over the last five years? ------ 1= Big Improvement 2= Small Improvement 3= Remained the same (No change) 4=Worsening (going from bad to worse)

5.22 The major factors which affects your small scale irrigation

No	Type of factor	5.22				
		1=strongly Affect	2=somehow Affect	3=don't know	4= not affect	5= totally affect
1	Having similar type of agricultural product					
2	Water					
3	Land					
4	Labor					
5	Lack of provision of improved Inputs					
6	Credit					
7	Marketing					
8	Poor extension services					
9	Pest and diseases					
10	Poor canal management and cleaning					
11	Others (specify)					

5.23 How does each constraint affect your participation in irrigation farming? Give possible solution to each----------

D. AGRICULTURAL CROP PRODUCTION

6.1 Did you participate in rain-fed agriculture in the last cropping season? 0= No 1= Yes

6.2 Major Crop production from rain fed farm in the last year 2015 E.C. 1, Onion 2, Tomato 3, Cabbage 4.Pepper 5, Potato 6, Fruits of various types 7, Maize 8.Others

6.3 What are the major cash crops you produce using irrigation? 1, Onion 2, Tomato 3, Cabbage 4.Pepper 5, Potato 6, Fruits of various types 7, Maize 8.Others **List major crop production from your irrigated land in 2015 E.C. (**Only for irrigated farm)

E. INPUT USE AND SERVICE

6.1 Do you use inputs in the last 12 months?---------- 0=No, 1=Yes

F. NON-FARM AND OFF-FARM INCOME

7.1 Do you or any of your family participate in off farm activity in the last year.-------

Yes=1, No=0

8.1 Do you or any of your family participate in Off/non-farm activity in the last 12 months Yes=1 No=0

Types of job	Annual income	Remark

TYPES OF JOBS 1 Livestock trade 2.Employed 3. Pity trade (grain, vegetables Fruits, etc.) 4. Sell of firewood and grass 5.Charcoal making 6. Others (specify)

V. INSTITUTIONAL FACTORS

A. AGRICULTURAL EXTENSION SERVICES

9.1 Do you receive any sort of extension services available in your locality?---------- ---- 0 = No 1 = Yes

9.2 If yes, did you gain any knowledge from the extension agents that could help you to do things differently on the specific commodities? ----------0 = No 1 = Yes

9.3 If no, specify your reason----------

B. ACCESSIBILITY TO OTHER SERVICES

10.1 Do you get market information about prices and demand conditions of agricultural Inputs and outputs? ----------1=Yes, 0= No

10.2 If your answer is yes to 9.1, indicate the sources of information----------

10.3 Do you have access to market? ----------1=Yes, 0=No

10.4 How far is the distance of district market from your community in kilometers?-------

10.5 Did you get reasonable price for your produce at the place you used to sell to?------- 1=Yes, 0= No

10.6 Did you need credit for the production of your agricultural product?--------- 1 =Yes, 0=No

10.7 If your answer is yes for the above question, did you have access to credit for the production of the Commodities?---------- 1=Yes, 0=No

10.8 Is credit timely and adequately available for agricultural commodities development?----------1=Yes, 0=No

Part II: Checklist Used For Conducting Focus Group Discussion (FGD)

1. What are the major crops produced in your Woreda/Kebele, through irrigated agriculture?
2. When did your SSI scheme start irrigated crop cultivation? What is your general Opinion on the irrigated agriculture production to household income?
3. What are the major crops produced in your SSI scheme through irrigated agriculture?
4. How do you evaluate the price and demand for your irrigated production?
5. From which source do you get your major income? What is determinant of participation Irrigated income? What factors do affect your irrigated income and how?
6. What economic effects do you observe as a result of small scale irrigation agriculture?

What benefits do you get from irrigated agriculture?

7. Which do you prefer irrigated agriculture or rain fed agriculture? Why?
8. From your experience irrigated or rain-fed is more productive per hectare? What is the Role of irrigated crop production in facilitating households 'access to different services (Health service, Education, input supply and others)
9. According to your opinion what are the socio -economic benefits of irrigation Practices in your Districts?
10. What do you suggest for the improvement of your irrigation performance in the future?

Part III: For key informants

1. What is the impact of small scale irrigation agricultural production and income in particular?
2. What is the impact of the small scale irrigation for the household's income?
3. According to your opinion what is the contribution of the small scale irrigation for the local and regional income growth?
4. What do you think are the major benefits of irrigation to farm households?
5. What are the major factors that facilitate irrigated agriculture?

THANK YOU!!