

Addis Ababa

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COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY

**CONTRIBUTION OF SMALL-SCALE IRRIGATION ON RURAL
HOUSEHOLD FOOD SECURITY IN MEREWA AND MUTIFECHA
OROMIYA SPECIAL ZONE, ETHIOPIA**

**BY
NATAN WUBE**

**OCTOBER 2020
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NATAN WUBE

THESIS SUPERVISOR: MESKEREM ABI (PhD)

**A THESIS SUBMITTED TO CENTER FOR FOOD SECURITY STUDIES,
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DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND
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STATEMENT OF THE AUTHOR

I, **Natan Wube**, do hereby declare to Addis Ababa University School of Graduate Studies that this thesis is a product of my original research work, and it has not been submitted to any other university for any academic degree. The materials and information on this thesis work is duly acknowledged as my own work.

Name of the candidate

Signature

Date

APPROVAL SHEET

Under my guidance and knowledge, **Natan Wube** has done the thesis entitled “**Contribution of Small-Scale Irrigation on Rural Household Food Security**” in Merewa and Mutifecha, Oromiya Special Zone of Amhara Regional State, Ethiopia’

I evaluated the thesis and certify its submission for public defense.

_____	_____	_____
Name of the advisor	Signature	Date

Approval by Examination Board

As the member of Board of Examiners of the MSc Thesis Open Defense, we certify that we read and evaluated the thesis prepared by **Natan Wube** entitled “**Contribution of Small-Scale Irrigation on Rural Household Food Security**” in Merewa and Mutifecha, Oromiya Special Zone of Amhara Regional State.

We recommended that this thesis acceptance as fulfilling the requirements for the Degree of Master of Science (MSc) in Food Security and Development Studies.

Meskerem Abi (PhD)

Thesis advisor

Signature

Date

Temesgen Tilahun(PhD)

Internal Examiner

Signature

Date

Negussie Semie (PhD)

External Examiner

Signature

Date

Chairperson

Signature

Date

Approval by the Center Head

Head, CFSS

Signature

Date

Biography

The author was born on 20 JUNE 1983 in Ephratanagidem woreda, North Shewa Zone, Ethiopia from his Mother Belayinesh G/beza and His father Wube Awoke. He attended his primary and secondary education at Karakorie and Ataye primary and Senior Secondary School. Once he completed his primary and secondary education, he joined St.Marry University on September 2004 and graduated with Diploma in Law in 2007. Thereafter, he was employed by World vision Ethiopia Jille Timuga districts development program as community development worker. He continued his studies at the Haramaya University and graduated with B.Sc. degree in Agricultural economics in 2016. Once completed his BSc degree, he came together with his family and began functioning at Woreda 09 Yeka sub-city with the position of Reform and Good Governance team leader from effective 20 September 2016 to 30 August 2019. Later, he has been working in Yeka Sub-city administration as a Green and Basin Development Expert effective 01 September 2019. He joined to attend his MSc degree in Food Security and Development Studies at Addis Ababa University as a self-sponsored extension program from September 2016 to October 2020. Having MSc in food security and development study helps to up-skill the authors knowledge, deep understanding of concepts and theoretical analysis on development issues and contribute to the communities to secure their food and nutrition through Basin development as a base of growing vegetables and stock production to get financial gain.

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Abstract

The extent of small-scale irrigation has successfully increased the food security of households in rural Ethiopia. However, it is not well understood that households face a food insecurity problem due to natural induced hazards. The households in Merewa and Mutifecha area introduced small-scale irrigation to improve food security. The main aim of this study was to examine the contribution of small-scale irrigation to the food security of rural households and to identify the factors that limit participation in irrigation. Data was collected from 202 irrigation users and non-users selected randomly by taking from two sampled rural Kebeles of Merewa and Mutifecha. Survey questionnaire, focus group discussions, observations and key informants' interview were used to collect the data. Data analysis was performed using descriptive statistics and econometric models using SPSS version 20 and STATA version 14. Statistical Techniques, including the t-test and the X²-test, were used to analyze the descriptive results, while the probit and poisson regression model was used to determine the determinant of participation in small-scale irrigation and its role in the Identify household food security. The finding of the study revealed that, the status of food security using FCS cut-off point was 61.39% with adequate food consumption, 30.69% with borderline food consumption and the poor food consumption households' being 7.92% for irrigation participants which was higher than non-irrigation participants 25.49% adequate, 33.34% borderline and, 41.17% poor FCS and statistically significant at 5% level. The Study also found Education, access to market information, access to training, male gender in the household, total livestock size are the main factors that largely explain rural participation and access to irrigation significant at 5% which that there are statistically significant differences in the use of improved seeds, fertilizers and pesticides, as well as in the production of diversified agricultural products, between irrigation users and users who do not use 5% irrigation. Market access, lack of capital to buy agricultural products, frequent diseases Infestation, lack of knowledge of the use of modern irrigation technology, and lack of supply of irrigation inputs were the five main restrictions for participating in small-scale irrigation practices within the study area. The study recommends market access, the expansion of appropriate crop protection mechanisms, provision of education and awareness of farmers through extension experts and the provision of other complementary services in order to increase the participation of irrigation to improve food security. Therefore, the Woreda Department of Agriculture, the division of natural resources and crop production should meet in coordination with interested development partners in order to promote funding development of these small irrigation schemes.

Keywords: *Small-scale irrigation, food security status, Irrigation users, Merewa and Mutifecha, Ethiopia.*

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Acronyms

ANRS	Amhara National Regional State
CS	Coping Strategies
DA	Development Agent
ETB	Ethiopian Birr
FCS	Food Consumption Score
GO	Government Organization
HH	House Hold
IDD	Irrigation Development Department
JTDAO	Jille Timuga Woreda Agricultural Office
KAs	Kebele Administration
LSI	Large Scale Irrigation
MoA	Ministry of Agriculture
MoARD	Ministry of Agriculture and Rural Development
MSI	Medium-Scale Irrigation
PASDEP	Plan for Accelerated and Sustained Development to Eradicate Poverty
PSNP	Productive Safety-Net Program
SPSS	Statistical Package for Social Science
SSI	Small Scale Irrigation
TLU	Tropical Livestock unit
UNDESA	United Nations Department of Economics and Social Affairs
FANTA	Food and Nutrition Technical Assistance Project
WVE	World Vison Ethiopia

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Irrigation is a very ancient practice that dates back to the oldest civilizations of humans and has acted as one of the major drivers of growth in agricultural production, boosting household income, and alleviating rural poverty, emphasizing the numerous ways that irrigation may influence poverty (Dereje and Desale, 2016). To meet the food supplies by 2050, food production from irrigated areas will need to expand from 35% in 1995 to 45% in 2020. By 2030, food demand projected to increase by 50% and 70% by 2050. This shows that access to irrigation become an issue of global concern and competition in the future, especially in the arid and semi-arid regions of the world (UNDESA, 2015). Even though irrigation is an essential approach for enhancing agricultural productivity, improving nutrition security, and mitigating climate-related hazards in rural Africa, it has not been widely adopted in several communities for a number of reasons. It is high time to change the scenario and make sure food security as set UNDESA. Supporting farmers' access to and use of small-scale irrigation with integrated technologies will continue to be critical to African countries' food security objectives. Many African countries still rely on rain-fed agriculture, leaving farmers and rural populations vulnerable to unpredictable rainfall and harsh climatic conditions.

Ethiopia is a country, which had been practicing inescapable rain-fed agricultural practices that led to the sustained dilapidation of the natural resource base, to be specific in places where extremely vulnerable areas of the highlands of the lands coupled with climate variability have aggravated the incidence of poverty and food insecurity (Awulachew et al. 2005). In most parts of Ethiopia, crop production from rain-fed agriculture has been extremely fluctuating, corresponding to the amount and distribution of rainfall. When there is too little rainfall with uneven distribution, crop failure is inevitable. Despite all this, agricultural growth nevertheless contributes to the enhancement of food security and household empowerment in the country. However, as it now stands, droughts arise a long way too often and food security in all its extent could no longer be sustained. Irrigation would have to be brought in an extensive way for a sustainable attainment of food security and rural transformation at the national level (Awulachew and Merrey, 2008).

According to the MoWE (2011), there were identified 560 irrigation possible locations on the main river basins. The entire attainable irrigable land in Ethiopia estimated to be around 3.7 million hectares. The promotion of small-scale irrigation practices among smallholder farmers is one of the principal intervention areas that would help increase overall national agricultural productivity. Smallholders have substantial potential to increase crop production and livestock productivity that would enhance food security at household level and ensure food self-sufficiency at the national level (MOA, 2011). Despite the fact that agriculture is one of the most significant sectors of the Ethiopian economy, its overall performance has been poor, and food production has lagged behind population growth (Demeke, 2008). This might be because agriculture in Ethiopia is mostly small-scale, rainfall dependent, backward and subsistence. This has resulted in reduced productivity and shortages in the national aggregate grain supply.

Like in the other regions of Ethiopia, the economy of Amhara is essentially dependent on small-scale agriculture. Oromiya zone is one among the ten zones of ANRS and is found in the eastern side of the region. Farming households in the zone built their livelihoods predominantly on the production of cereal and vegetable crops for local consumption and sale. The zone is one among the drought prone zones in the region and has for a long time been food insecure. This is due to a number of factors, including irregular and unreliable rainfall, a large population density, and low production because of poor agricultural management techniques. Crop output inside the zone has been insufficient to meet the region's population's consumption demands. (OAZDOA, 2014). However, the zone is naturally gifted with attractive & various natural resources, and the capacity to grow diverse annual and perennial crops. It also features a great potential for small-scale irrigation, due to the abundant supply of surface and sub-surface water resources.

This study was designed to look at the contribution of small-scale irrigation to food security in rural farm household' in Jille Tumuga woreda of Amhara Regional State. The study also designed to research the critical factors that constraint irrigation uses, assess the socio-economic conditions of irrigation users and non-irrigation users within the study area and to forward some policy recommendations to enhance the effectiveness of irrigation scheme interventions.

1.2 Statement of the Problem

Farmers are more susceptible to external shocks than other populations. Subsistence and pastoral agriculture, which rely on rainfall, are under risk in many parts of Ethiopia due to poor rainfall and significant instability. (Misganaw, 2008). The drought happens in row resulting major natural disaster affecting food security. These communities have a number of problems in maintaining food security because of the following factors: Local agricultural productivity was falling, and population demand was growing, necessitating special attention to water resource management and restricted irrigation expansion (Haile, 2008). Irrigation practice was introduced and implemented in places where agro-ecological conditions were linked to interventions (Eshetu and Young B, 2017). Irrigation has the potential to enhance agricultural production and advance farming communities' livelihoods. Irrigation methods boost agricultural production by increasing farm income. Adequate water supply to plants increases productivity for home use or sale. Farmers are distressed as a result of this scenario, which puts them at risk of food insecurity. Irrigated agriculture in Africa is being scrutinized as a driver of agricultural growth and productivity transformation in terms of food security and poverty reduction. (Kalunde, 2008). Low-level irrigation is a priority for Ethiopia's rural poverty and growth policy (MOFED, 2006; Gebrehiwot et al. 2015). Despite all desires, irrigation development in Ethiopia continues to lag and does not contribute enough to agricultural sector growth. However, the country has growth potential due to a sufficient amount of land and the availability of appropriate clean water supplies for irrigation purposes. (MOA, 2011). However, small-scale irrigation contributes significantly to the food security of rural communities across the country, where agriculture is seen as the backbone of people's lives. The problem of food insecurity is worsening in Ethiopia's low-lying areas, which represent about 30 percent of the world's population. The contribution of rural farms to small-scale irrigation investments has not been thoroughly researched although such strategies cover more than 40% of the country's irrigated land. For example, Seleshi et al., (2005) pointed out the need to conduct a feasibility study of small-scale irrigation especially in the production and production of rural households. However, there is a gap in the impact of irrigation on agricultural production and its implications for reducing poverty and food insecurity.

The study focuses on the Merewa and Mutifecha small irrigation system located in the Oromiya Special Zone in the Amhara region with an area of 1657 hectares of irrigation (JTDAO, 2019). Rural households 'in the study area have a long history of traditional irrigation practices and so far

with better irrigation work that gives the government the opportunity to develop modern small irrigation schemes. However, the overall effectiveness of local irrigation and the number of beneficiaries is still limited by their reluctance to participate in small-scale irrigation schemes that lead to a farming community based on rich agriculture. Therefore, in view of the great potential of arable land with food insecurity, this study was conducted to investigate the contribution of small-scale irrigation to rural households in terms of improving income and food security.

1.3 Objective of the Study

1.3.1. General Objectives

The main objective of this study is to investigate the contribution of small-scale irrigation on rural household food security in Merewa and Mutifecha, Oromiya Special Zone.

1.3.2. Specific objectives

The specific objectives of this study are to:

- Examine the socioeconomic status of irrigation and non-irrigation users.
- Identify the determinants of small-scale irrigation participation.
- Assess households' food security status of the study area
- Analyze the link between small-scale irrigation and food security situation of rural households in the study area.

4.1. Research Questions

- How do the socioeconomic statuses of the study households look like?
- What are the factors constraining irrigation use in the study area?
- Does small-scale irrigation have effect on household's food security?
- What interventions mechanisms take by local government offices and development actors to improve small-scale irrigation for improving food security?

4.2.Scope and Limitations of the Study

The study was provided with two local kebeles irrigation schemes in one Woreda administration and 202 respondents. The research data were based on cross-sectional research. Rural farm households do not have the habit of taking a record of the value of agricultural production, food and non-food expenditure in their daily lives. This situation makes difficult to obtain secondary data at farm family level to support primary data analysis. Investigating on the contribution of small-scale irrigation to household food security assessments requires a very multifaceted, robust and multi-pronged approach, using a variety of methods based on group interests, sectors, technologies and values. This study, however, is limited to investigating the impact of irrigation on household's food security.

4.3.Data Validity and Reliability

Validity and reliability of the survey as a significant research instrument tool were reviewed. Reliability is about the consistency of a measure, and validity is about the accuracy of a measure. The collected data is valid and reliable as it collected directly from households with pre-tested before conducted the survey and the researcher briefly talk about with data enumerators to inform and introduce the purpose of the data collection is for educational purpose. Cronbach's alpha is a convenient test used to estimate the reliability, or internal consistency, of a composite score. The average value of Cronbach alpha and internal consistency reliability estimation were 0.871 and 0.852 in which α is the mean of all possible split-half correlations for a set of items that validate the reliability of the data (Konting et al, 2009). To this end, the researcher is confident to say the data is valid and reliable as the value of Cronbach's Alpha indicated a very good status.

4.4.Ethical Consideration

The study adopted the research ethical standards. Permission is granted from Addis Ababa University College of development studies Centre for food security studies in accordance with the University's plagiarism policy. Before proceeding with the research, an official letter from the university was obtained to provide for woreda agricultural office and obtained approval, while the respondents were contacted, the purpose of the study was explained at the beginning of the discussion. Their full consent was first checked before starting negotiations or negotiations. Otherwise, they are told that their information will be kept confidential and will be used for

learning purposes. The study is committed to providing feedback, as it does not exist without misinterpretation or exaggeration.

4.5. Significance of the Study

The results of this study can serve to enhance current data on the topic under discussion and inform the design of alternative interventions in the learning environment. The findings of this study can also be used to guide policy makers and development planners concerned about the development of homegrown food security. In addition, the findings of the study are used as an input by researchers to advance knowledge on ideas related to the development of irrigation and food security.

4.6. Organization of the Thesis

The study consists of five chapters. The first chapter introduces the subject matter; problem statement, research objectives, significance and limitations of the study. The second chapter includes a review of the literature on concepts and issues about small-scale irrigation and food security. The third chapter is about the research methodology, which contains a description of the learning environment; styles of small irrigation schemes in the study area, research performance, sample size, sampling strategies and processes, data collection techniques and data analysis. Chapter four presents the findings and discussion that forms part of the study. Finally, chapter five presents the conclusions and recommendations based on the findings of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Concepts and Definitions

2.1.1. Concepts of Food Security

Various institutions and respective researchers have tried to describe food security at different times without addressing significantly changing to the basic concept. According to the World Bank (1986), food security has been described as "the universal access to adequate food for a healthy and active life". There are several aspects to this definition. It is responsible for production in terms of food security; Sales conversations should all have access to the product; involves using the idea that the needs of every food are met in order for the individual to function and be healthy. The availability and availability of food to meet the needs of each food should also be sustainable. The UN (1990) defined domestic food security as "The strength of family members to ensure adequate food and quality to lead a productive life. "Food security is defined as a state where there is a product, a market and a social system where food consumption is always needed by the country and its people.

Food security is defined by FAO and WHO (1992) not only in terms of availability and access to food, but also in terms of the supply of food production facilities and the purchasing power of the region where food is produced. Similarly, USAID (1992), WB and FAO (2010) define food security as: "where all people have access at all times to physical and economic access to adequate food to meet their nutritional and healthy eating needs." At least the availability of adequate nutritious and safe food, as well as a guaranteed ability to get fit food on a socially acceptable. The most common definition of food safety, referred to in many texts, is the World Food Summit (1996), which states that "food security exists where all people always have access to the physical and economic benefits of adequate, safe and food that meets their needs and appetites. According to Annie (2009), food safety is frequently evaluated in terms of four categories: food availability, food accessibility, food consumption, and food stability, which are discussed in the parts that follow:

Food Availability: The physical availability of food for households remains constant as it is grown, processed, produced, and imported into our country and beyond. The food exists in the market, in shops and at the household level, as it is made by farmhouses on local farms as gardens in the domestic or international market. Due to population growth and climate change, the pressure on

existing natural resources, i.e. land and water, is increasing. The effects of climate change often lead to soil degradation, lack of irrigation water, reduced soil moisture and therefore damage economic viability. This could be dangerous in the long run, with increasing opposition to the use of water resources (crop use for food consumption versus crop use for food, use by other sectors such as drinking water, industry and the environment); this may be a threat for long-term food security (USAID, 1992; Annie and Jacobs, 2009).

Food Access: When all households have sufficient resources to obtain sufficient quantity, quality and variety of food, they can guarantee a nutritious diet. This mainly depends on the quantity and price of the household resources. Accessibility to food is a matter of physical, social and political environment. Drastic changes in these areas can seriously alter production strategies and threaten access to food for affected households. Consequently, the harvest has decreased and the price of food has risen, affecting household food supply and access. To avoid such an unfavorable development, there are different technical adaptation measures. The construction of infrastructure such as small dams and reservoirs or the expansion of dams to store water and increase shallow water levels are one of them, dykes and improved flood drainage systems are others. In addition, ecosystem protection and restoration, flood-sensitive planning or early warning systems, and emergency plans have further enhanced the ability to respond to extreme weather events and protect the natural environment. (Degefa, 2008; Annie, 2009).

Food Utilization: Is the manner in which humans generally consume their meals. It is determined by a number of recurring components, such as the quality of the food and its preparation technique, storage facilities, and, as a result, the vitamin facts and the health repute of the person eating the food items. Food consumption is typically limited by reasons such as widespread sickness, poor cleanliness, a lack of acceptable nutritional information, and culturally dictated taboos (with regard to age or gender) that limit access to healthy food for a specific group or family member. Food consumption has also had an impact on those who have limited means for preparing ready meals, such as a lack of fuel and cooking tools (FAO, 2008; Annie, 2009).

Food Stability: To ensure food safety, the community, families, or individuals must have access to sufficient food. They should not be at danger of losing food access owing to unexpected shocks such as the economic crisis, the hazards of global climate change, and seasonal food poverty. As a

result, the concept of sustainability will center on characteristics of everyone's food security, availability, and accessibility (Annie, 2009; FAO, 2013).

On the other hand, the idea of Food insecurity outlined as a scenario wherever people, people at times, lack physical and economic access to enough, safe and nutritional food necessary to live a healthy and active life (FAO, 2005; Devereux, 2006). Food insecurity happens whenever enough and safe foods are not on the market or the flexibility to accumulate such foods is limited.

2.1.2 Food Security Indicators and Measurements

It depends on upon at the purpose of analyzing all food security measurements put in place by various researchers and there may be no single indicator to measure the level of food security. My food security metrics were needed to capture in different times within the same or different study location (Hoddinot, 1999 stated through Getinet K, 2011). Food Security has been impacted through a number of social and economic, environmental and political factors. However, it is tough to discover a single indicator that is used to measure the level of food security at household, individual, regional, domestic or international levels (Tassew, 2006). As a result, food security indicator has turn out to be greater complicated and has required a method starting from an easy to an aggregate of quantitative and qualitative measures (Ayalew, 2003). Combining great and quantitative research work, the facts discovered through taking the observed of food security activities allowed the researchers or scholars to recognize the entire scope while designed the metrics (Degefa T. 2006). Because some indicators are only suitable for evaluating the process while others, look at the results of a project goals.

This paper tries to rate of household consumption and the index of coping techniques are used as a result of it assumed to be the representative measures at household level. The Food Consumption Score (FCS) calculated the frequency of weighted varied meals utilized by households throughout the seven days before the study. An acceptable indicator of estimating calorie consumption associated food quality at the household level that offers an illustration of the households' food security. While dietary variations reflect the amount of different foods or foods, groups consumed at a given time like FCS, but usually have a 24-hour recall period without details of frequency or weighted segmentation. The coping strategy index reflect the problem-fixing method that measures households changes to apply and lives that would be modifications in use; lowering portion of meal, less spending; sales of assets (WFP and FAO, 2008; IFPR, 2009, quoted through Milkyas, 2019).

Coping Strategy Index (CSI) activities are those that sustain or battle food insecurity at the household level. Household duties, rather than external factors, cause disease-fighting strategies. According to the research (Hadley et al., 2007; Maxwell et al., 2008), strategy falls under four categories: usage, spending, income, and migration. Some usage strategies include purchasing food on credit, relying on less restricted food, reducing the amount of food consumed per day, skipping meals all day, eating only vegetarian foods, eating wild foods, preventing adult consumption so children can eat normally, and supporting active members at the expense of unemployed members. Savings and avoiding health or education expenditures to purchase food are examples of spending strategies. Pension expenditures, small enterprises, and the selling of home items and livelihoods such as animals are examples of income methods. Sending children to relatives or friends' homes, or relocating in pursuit of a job, are examples of migration tactics (Maxwell et al., 2008).

2.1.3 Definition and Concept of Irrigation

The idea of irrigation described through various scholars and various development organizations. FAO (2005) described irrigation because the setup of water in dry vicinity for food production and overcoming rainfall deficits that help stabilize agricultural production. Small-scale irrigation is a type of irrigation controlled, operated and maintained by households, individuals and communities (Woldeab, 2003). Another idea of small-scale irrigation is the kind of irrigation in which farm households have control over and should take part with the construction technique of the scheme and limit the boundary decisions (Tafesse, 2007).

Practicing irrigation has a great role in assisting farmers fulfilling the needs of the growing population (Awulachew et al. 2005). It is likewise it is one of the best approaches to examine techniques that trade reliable and ensure sustainable food security through growing diverse crops and increase livestock production through diverting rivers and constructing small dams, and using pumping facilities (Robel, 2005). Irrigation improvement depends upon on sustainable use of water resources, which in flip is resilient to weather change, and techniques want to be validated in evaluation to weather-associated risks. Equal techniques to water distribution and profit sharing are important.

2.2 Theoretical review on Irrigation development and food Security

History tells that irrigation has formed the statuesque of civilization in diverse areas distinctive countries. For a long time, the Egyptians believed that the delta Nile was flooded. This might be the longest stretch of continuous large-scale irrigation ever. Mesopotamia, the region between the Tigris and Euphrates, became the Sumerian Empire's granary. This civilization oversees an extremely created and centralized irrigation framework. At the same time, irrigation systems are said to have also developed in modern China and the Indus Valley. (Schilfgaard, 1994). Small-scale irrigation has given tremendous return shaping a key role in feeding the growing population of developing countries. There is no doubt that it is already set to play a more prominent role in the future. Not only does it increase the yield of specific crops and livestock production, but it also extends the effective growing period of crops in dry seasons, such that several agricultural seasons in a year are more than twice as good as one agricultural season. In addition, under the condition of ensuring the irrigation system and additional inputs, it is necessary to emphasize the use of chemical fertilizers to strengthen pest control; it is economically feasible to use improved crops or vegetable seeds and increase cultivation. Irrigation reduces the risk of crop loss due to lack of water for these expensive inputs. (FAO, 1997).

According to FAO (1997), an estimated 260 million hectares of irrigated land, or one-sixth of the world's farmlands, provide 30-40% of worldwide food output. Irrigated fields produce better yields, enabling increased agricultural and livestock output. According to FAO (2001), the importance of irrigation in alleviating food poverty and attaining agricultural expansion on a worldwide scale is well acknowledged. Irrigation has the potential to play a major role in enhancing and stabilizing food supply in Sub-Saharan Africa.

2.2.1 Irrigation Development and Food Security in Africa

Some institutions are conveying that food security in Africa and particularly in sub-Saharan Africa could be grave to ensure. While global food supply/demand looks to be relatively robust, food security in Sub-Saharan Africa has deteriorated, with grain imports expected to triple between 1990 and 2020; imports for the region were unable to pay. Apart from Australia, Africa has the driest climate and the most variable rainfall regime (FAO, 1997). Every year, most African countries suffer from drought, and more people are at danger due to various degrees of severity of

catastrophes. Furthermore, water resources in Africa are less developed than in other regions. Sub-Saharan Africa's agricultural production per capita has not kept pace with population growth, and the region is currently nutritionally worse off than it was 30 years ago. Food production increased at a pace of around 2.5 percent per year, while population increased at a rate of 2.6 percent per year on average. Increasing farmed acreage used to provide more food in Africa; but, as good land becomes scarcer, the region is being driven to boost yields using irrigation and a variety of trendy technology. All agriculture, including rain-fed and irrigated, must be compelled to improve; nevertheless, irrigated agriculture has a larger potential for intensification (FAO, 1997). Irrigated land accounts for just approximately 10% of agricultural output in the African desert. On average, trends in the growth of irrigated land during the last thirty years reflect this. The total irrigated land area on the continent is projected to be 124 million hectares. This figure includes all land on which water was supplied for agricultural production. It accounts for a median of 7.5 percent of cultivable land (FAO, 1995).

2.2.2. Irrigation Development and Food Security in Ethiopia

Agriculture is the main land use and remains the main source of livelihood for the poor in rural Ethiopia. Irrigation is a possible means of solving the problem of poverty in a rapidly growing population. As a result, the country has established several large and modern irrigation systems. There is growing interest in the development of small-scale irrigation (SSI) for food production and rural development. The development of SSI systems managed and controlled by small farmers is considered a viable alternative to large-scale irrigation systems. In the Ethiopian context, SSI refers to small farms with a farm size of less than 200 hectares. Adapt to local socio-economic and ecological conditions (Awulachew et al., 2007).

Small-scale irrigation systems account for 19% of all irrigation systems developed in the country. The development of irrigation in Ethiopia is divided into several categories in relation to the types of irrigation, yields, regions and properties. The agricultural sector remains the main source of growth in Ethiopia. Drought can be prevented through a more rational use of water resources. Through the development of small-scale irrigation, water and farm diversification, while strengthening the link between agriculture and agriculture to harness the potential of the land.

An agricultural industry that creates demand for agricultural products (MoFED 2006). Furthermore, due to the low irrigation efficiency of the country, there is no systematic and comprehensive

evaluation of the management of conventional irrigation and small-scale irrigation (Kebede, G., 2011). The focus of the development of irrigation in the 1960s was to provide industrial crops for the country's agro-industrial complex.

Traditional irrigation in Ethiopia is very old. Traditional small-scale irrigation projects are often simple river channels that have been used in Ethiopia to grow food crops for home consumption since ancient times. Ethiopia's modern irrigated agriculture began in 1960, with the large production of industrial crops (sugar and cotton). Large private investment firm in flooded areas. However, local farmers used traditional irrigation during the dry season and river-supplied water for agriculture (Awulachew, 2006). Modern SSI began in the 1970s under the initiative of the Ministry of Agriculture (MoA) to cope with major periods of drought that led to poor harvests and food insecurity. The Awash Valley saw the greatest expansion due to the construction of the Koka Dam and the reservoir to regulate water resources, which regulates flow through flood control, hydroelectric power generation and a guaranteed supply of irrigation water. For most of Derg's life, few people pay attention to the small, traditional irrigation systems built and operated by farmers. In the process of nationalization of industrial and agricultural enterprises, the government focused on promoting technological development in order to promote the flood development plan implemented by state-controlled agribusiness and agriculture. It was not until the second half of the 1980s, due to the devastating famine of 1984/85, that Draga became interested in small-scale irrigation management systems.

The Ministry of Agriculture was responsible for the development of small-scale irrigation projects that benefited farmers in late 1984, and the military government explained new methods for developing water resources. However, progress was slow. The IDD can implement about 35 small systems, of which almost a third are conventional procedures used by farmers (Ministry of Agriculture, 1993; Desalegn, 1999). According to Awelachew (2010), the scale and structure of irrigation methods vary widely, from micro-irrigation (RWH) to river diversion. Small or large pumps and dams. These systems are generally divided into traditional small-scale irrigation (SSI) and community irrigation, which cover an area of less than 200 hectares. Domestic RWH, hand-dug wells, shallow wells, floods (flooding), home drainage, and other traditional ways are examples of SSI; the scale and construction of these irrigation systems vary greatly, from micro-irrigation (RWH) to river diversion, from pump to big and small dams, and so on. These systems can be divided into the following categories: Medium Irrigation (ISM), which is based on community or

public funding and covers an area of 200-3000 hectares. The Sille, Hare and Ziway irrigation systems are an example of medium-scale irrigation (ISM). Large-scale irrigation (LSI) covering more than 3,000 hectares, usually sponsored commercially or publicly, such as Wonji-Shoa, Methara, Nura Era and Fincha irrigation systems

The MoARD and regional governments take the responsibility of overlooking SSI systems, while MSI and LSI are managed and operated by MoWR. Based on the perceived requirements of local populations, small-scale irrigation is common and significant in Ethiopia (Taffa, 2002). Irrigation development is supported by state budgets, donor programs, and non-governmental organizations. However, in comparison to its potential and the cultivation of the rainforest, irrigation's contribution to the economy is very small, accounting for around 2.5 percent of total GDP (Hagos et al., 2009; MoA, 2011a). Development in Ethiopia is not significant compared to the country's irrigation potential (MoA, 2011b), even if irrigation contributes significantly to the reduction of food insecurity and therefore to the reduction of poverty.

FAO (1987) has shown that irrigation has for long contributed towards feeding growing populations and will continue to similar role for years to come. Risk of these expensive inputs being wasted due to poor harvests due to lack of water. The crucial task of increasing and stabilizing food production in drought-prone regions must include concerted efforts to improve farm irrigation water management. As water and land resources are utilized in poorly managed and non-producing crops, which face the risk of soil degradation, the practice of a well-managed irrigation system is employed for immediate production with economic efficiency (FAO, 1987). Irrigation plays a key role in increasing agricultural production and mitigating the negative effects of variable or insufficient rainfall (Getaneh, 2011). It also has the potential to boost both yield and harvest intensity (Awulachew et al., 2010). In terms of income, irrigation has a strong impact to increase at the household level. It shown that the value of agricultural produce per hectare in irrigated areas is almost doubles that of wet areas. Household income and consumption are significantly greater in irrigated areas than in wet areas, with a 50 percent difference being frequent. Investing in irrigation can have a wider impact on food security and poverty reduction if efforts are aimed at revitalizing and improving existing traditional ISS systems, improving access to supplies, marketing and expanding products to include facilitating 'access to information and innovation (Awulachew) et al. . 2010).

Similarly, Desta (2013) discovered that the contribution of irrigated agriculture to profits is around 70% in highly irrigated villages compared to 60% in two distinct poorly irrigated locations. At the same time, the absolute amount of agricultural profits is also the ultimate greatest in the extremely irrigated village regardless of landownership size, and cultivated keeping is up by more than 30% over the low irrigated village. The large irrigated village has greater per hectare agricultural profits by using over 50% over the low irrigated village. Irrigation helps to improve food security through its direct and indirect benefits. Irrigation provides immediate advantages such as increased production, reduced crop failure risk, and more opportunities for year-round agricultural and non-agricultural employment, greater earnings, food security, and poverty alleviation. Irrigation enables smallholders to employ more diversified crop patterns and diversify their revenue sources (Hussein and Hanjira, 2004).

In addition to the increase in overall production, irrigation increases the responsibility and consistency of production (Ministry of Agriculture, 2011). Irrigation enables producers to control the available water during the growing season, increase production and reduce exposure to seasonal or drought. When rainfall is insufficient, unreliable or incorrectly planned, it is important to reduce farmers' dependence on appropriate weather patterns to achieve optimal production and thus contribute to the improvement of household food security (Mengistu, 2007). The construction of micro-irrigation systems has increased production and revenue and diversified the diet. Reducing the hunger months from 6 to 2 months (July and August), increasing plant diversity and changing from a grain diet to a grain, vegetable and livestock diet (IFAD, 2011). Irrigation benefits the poor by increasing production.

2.3 Empirical Reviews

Different researches have shown that small-scale irrigation plays a role in positively increasing the income of rural households. Gebrehaweria and Regassa (2007) investigated that farm incomes are more important in households with irrigation users than in non-irrigation households, as off-farm rents have a negative impact on the possibility of irrigation, which can be used by households for other expenses. The average income of irrigated homes is much higher than that of non-irrigated farm homes. The average income of irrigation users is higher than the regional average, and the average income of non-irrigated households is less than 50% of the average income of irrigated households. Between the two, there is a difference in the total household expenses. According to

FAO (2001), the study returns two decades ago; to meet current food needs (by 2020), estimated food production in irrigated areas had to grow from 35% in 1995 to 45% in 2020. Access to irrigated water will in future become a matter of global concern and competition, especially in the arid and semi-arid regions of the world. . By Adugna and colleagues (2014) explored the role of small-scale irrigation in poverty reduction in the Rift Valley basin in Ethiopia. The study showed that small-scale irrigation was evident in terms of increased production, income, wealth and employment opportunities, as well as poverty. Descriptive and econometric analyzes showed this irrigation. Its use has a positive effect on agricultural production, income, wealth, employment opportunities and the fight against poverty.

Getaneh (2011) estimated that farmers who use concrete canals and divert rivers / springs have a higher average income from crops per household than other types of irrigation. There is a difference between Local River / river diversion of concrete inland waterways and traditional river diversion system and pump pedal irrigation, but there is no significant difference between river / source concrete diversion and electric pump or traditional river and pedal diversion. The average total income of households using one of the four irrigation systems is statistically significantly higher than the income of households not using irrigation. Irrigation dams have a positive impact on food security, property ownership and household income. The average income ratio of irrigation water users and non-water users exceeds 37.03%, and the nutritional status and living standard of users also increased by the same factors as income. After the completion of the dam, revenues from irrigated agricultural areas of irrigated water users increased by 90.77% compared to those who are not water users. In addition, the use of irrigation greatly supports the existence of non-users through employment opportunities.

According to Dereje and Desale (2016), studies on the effects of small-scale irrigation on improving household livelihoods have shown that small-scale irrigation (SSI) has a significant impact on farmers 'livelihoods both directly and indirectly. Has diversified its crops and the growth of agricultural production, family incomes, employment opportunities and participation in Community decisions has shown that the average annual income of the sampled households has improved. The use of irrigation has an impact on improving the income level of irrigation households in the study area, which ultimately affects the irrigation community. According to Gebregziabher et al. Ethiopia is 50%. The study also found that compared with non-irrigated households, the agricultural income of irrigated households is more important, and that non-

agricultural income has a negative impact on access to irrigation. Kuwornu and Owusu (2012) concluded that Ghana's irrigation investment is reasonable because irrigation is the main contributor to the per capita consumption expenditure of agricultural households. A study on the socio-economic impact of ten irrigation systems on smallholder farmers in Zimbabwe (FAO, 2000) found that planned projects with farmers' participation are more effective.

Million (2016) also investigated the effects of small-scale irrigation on the livelihoods of agricultural households in the Amhara region. Participation in small-scale irrigation was shown to have favorably and considerably boosted family income, by about 15,295.55 birr per year for non-irrigated families. The relative contribution of irrigated land to household income is much higher than the contribution of all variables. He also revealed that the income analysis of the average annual income of non-irrigated households is only 21.4% of the income generated by irrigation participants and that income from irrigation practices accounts for about 65.3% of total income, 69.6% of farm income, income of households using irrigation products and 77.5% of harvest income.

2.4 Conceptual Framework

This conceptual framework suggests that the purpose of irrigation systems can relieve farming families from extreme dependence on rain by increasing irrigated farmland and generating additional income from agricultural employment. Encourage farming families to produce multiple times a year and invest more productivity enhancing inputs such as fertilizers. Large-scale irrigation has been used to increase production and reduce dependence on unpredictable rainfall and farm supply works for farms in developing countries (Chazovachii 2012). Participation in small-scale irrigation creates employment outside the agricultural sector. Increases consumer spending and asset accumulation. In addition, irrigation reduces food expenditure and allows the poor household to obtain a fair price to buy the food it needs (Huang et al., 2006).

Increased agricultural inputs and year-round production on irrigated farmland helps increase productivity and enhance the transfer of production from that of subsistence crops to high-value market crops. This in turn would allow people to have access to nutritious food and maintain a healthy lifestyle. According to Awulachew et al. (2007), the development of irrigation increases entry efficiency, reduces rainfall variability and supports the rural economy. Small-scale irrigation increases soil productivity, crop yields and fertilizer application, allowing farmers to diversify into non-traditional and products that

have higher market demand (high-value crops, vegetables and fruits), improving nutrition, income, farm health and food safety, and Ward 2010). As a result, the analysis creates a model that demonstrates the contribution of small-scale irrigation to household food security.

The engagement of growing farmers in the design, implementation, operation, and monitoring of irrigation systems has become a critical component in encouraging small-scale irrigation. Farmers' participation as direct beneficiaries of their engagement in the creation of schemes. The operation and administration of a business are important. The active participation of farm households increases the value of improved irrigation and improves performance. In order to beautify small irrigation systems and improve household food security, many factors need to be considered. These are availability of labor supply, provision of credit services and agricultural inputs (including fertilizers, pesticides and improved seeds). Agricultural technology, irrigation infrastructure and control practices, support from irrigation professionals and retailers are essential. Therefore, when different variables are kept constant, all of these and mixed different outputs of SSI tendencies have the ability to achieve eating safety in agricultural areas, reducing the prevailing persistent food insecurity and poverty in general. Dereje & Desale (2016) have identified a number of factors that are believed to have a very good impact on the profits of rural households and achieve to food security.

As indicated on Figure 2.1, the linkage between family food security and small-scale irrigation together with predicted variables assumed to be included in the model. Based on the nature of independent variables, the researcher grouped in to four categories. The first variables have been demographic characteristics, which includes age, sex, education and family labor and dependency status of the household head. The second grouped variables have been Institutional elements consists of get admission to credit, Access to agricultural inputs which include fertilizer, pesticides, stepped forward seeds, get admission to improvement agents, education and training. The third grouped variables have been the financial elements involves, market accessibility, farm size, livestock ownership and non-farm income. The fourth grouped variables were adoption of technologies, which include access to motor and treadle pumps, and adoption of crop diversification and commercialization of agricultural outputs.

(Getnet, 2011). Each variable explained on model specification part 3.2.5 (page30-37).

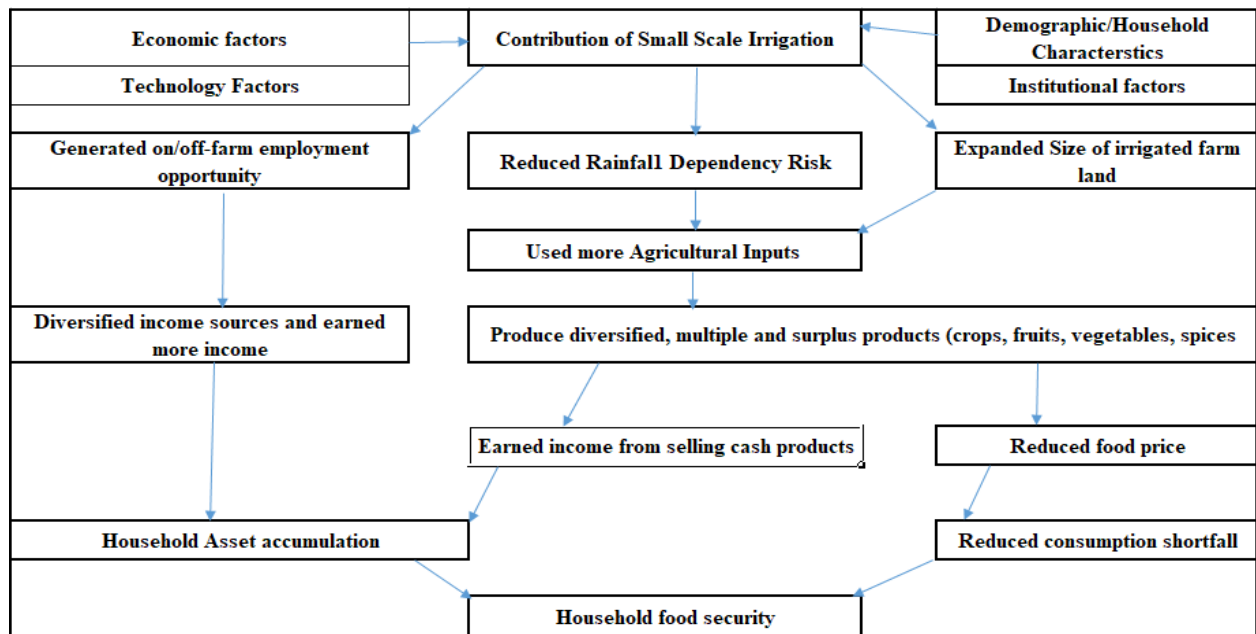


Figure 2. 1: Conceptual framework (sources: own construction based on the literatures and empirical review)

CHAPTER THREE: STUDY AREA AND RESEARCH METHODS

3.1 Description of the Study Area

The Amhara National Regional State is one of the regional governments of Ethiopia with a geographic region of about 153,000 km² and has vast potential both in land and water resources. According to the CSA, 310 irrigation schemes were built in the Amhara area in 2005. The irrigation project included 8,469.26 hectares of irrigated arable land and benefited 17,443 persons. From the overall irrigated area, 5,718.68 hectares were from small-scale and a pair of, 750.58 were from medium-scale irrigation schemes. The Jille Tumuga woreda is in Oromiya Special zone, Ethiopia. Its capital town is Senbete, which is 268 km off from national capital the capital city of Ethiopia to northeast direction (JTDAO, 2019). The woreda shares its boundary with Afar Regional State within the East, Artuma Fursi woreda within the North, Ephratagidim woreda within the West, and Kewot woreda within the South. The geographical location of the study area is found between 10°02' N to 10°25'N latitude and 39°55' E to 40°12' E longitude. The Woreda has 1 urban and 19 rural Kebeles and covers a whole area of 544.58 km².

Based on the information evidenced from Jille Tumuga Woreda Agricultural Office of the total surface area of the woreda, about 95% is low land/*Kola* climate and the rest 5% is Woyinadega climate. The woreda average annual rainfall is 700 mm. Furthermore, the average yearly temperature is 29°C. The rainy season in most regions of the region lasts from mid-June to the first week of September. The distribution of rainfall, on the other hand, varies greatly. (JTDAO, 2019).

According to the Central Statistical Agency, (CSA, 2017) population forecast, the Amhara region has a population of about 22.192 million and stands the 2nd most populous administrative region in Ethiopia. By this year, the woreda has a total population of 89,132. Among this, 51% of the total populations are female and 49 % is male. The total population living in rural area estimated to be 92.51 %. The ethnic compositions of the woreda among the total population were 85% Oromo, 14% Amhara, and 1% Argoba, Afar, and others. In relation to religion composition, 99.7% is Muslim, 0.3% is Orthodox, and Protestant and other followers (JTDAO, 2019).

Like other regions of the country, the economy of Amhara region largely reliant on agriculture with smallholder cultivation. Oromiya special zone is one of the ten zones of the region found in eastern part of the country. The zone is characterized by subsistence farming, with households mostly

growing grain and vegetable products for local use and sale. The zone is one of the most drought susceptible area in the region and known in its food shortage vulnerability status. The irregular and inconsistent rainfall, high population density, and low productivity induced by inadequate agricultural management techniques were all significant contributors in this low agricultural output (OAZDOA, 2014).

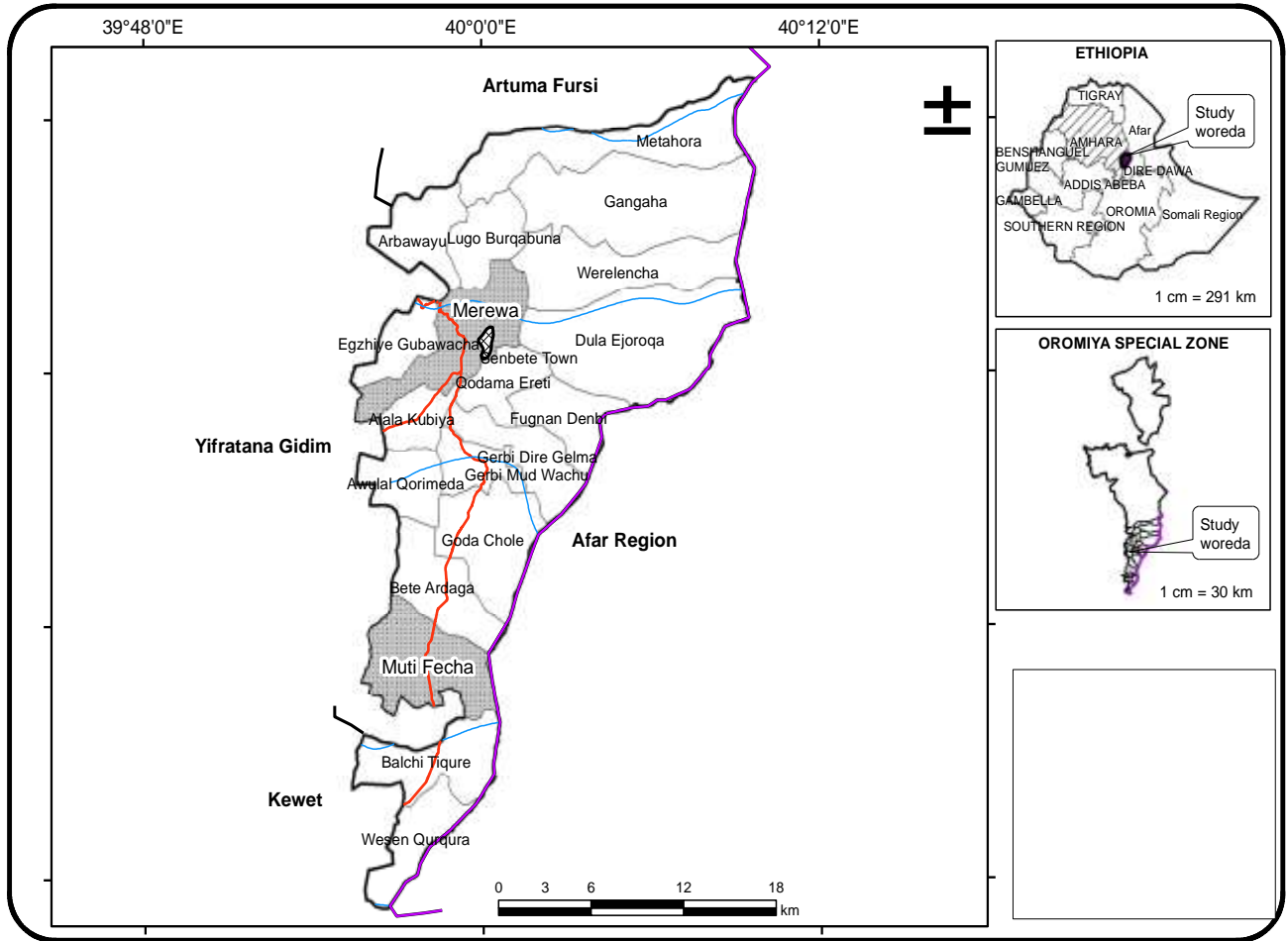


Figure 3. 1: Study area Location (Source: CSA 2007 and Ethio-GIS 2015)

The livelihood of the households in the study woreda mainly depends on subsistence rain fed agriculture and the agricultural sector is leading mixed farming, crop production and livestock rearing. Farm households in the district undertake agricultural activities with traditional farm management systems. They depend on Meher season for rain fed crop production, for this reason, farm households produced crops once in a year. The major crops that are growing in the area include Teff, Sorghum and Maize; and commonly farmers’ rearing cattle, goat, sheep and poultry. The area is a victim of drought. Due to this, the woreda is food insecure and Safety-Net program is implementing. The Woreda has been

getting food support for the last fifteen years by Safety-Net program and other NGOs. Consequently, out of 14,227 household heads of 19 rural kebeles, 9,592 household heads with total population of 35,920 people are from Safety -net program (JTDAO, 2019).

The district has endowed with water resources, which covered to irrigate 3,434 hectare of land that could be planted through irrigation. It has 10 big and small rivers. Three big rivers and five of small rivers utilized for irrigation. In recent times, the woreda administration in cooperation with the existed international non-governmental organization named World Vision Ethiopia in the woreda as well with the regional government is actively engaged in the development of small-scale irrigation schemes. However, as evidence obtained from the woreda agricultural office shows, it is estimated that only 1657 hectare of land has been irrigated as of 2019 that is 48 % out of potential irrigable land with total beneficiaries of 2707 Household heads (JTDAO, 2019).

Recently, the *district* implemented six modern small-scale irrigations scheme, which covered 937 hectares of the total irrigated land and benefited 1487 household heads. About 484 hectares of irrigated land has covered by three canals that are traditionally diverted to their farms. About 202.5 irrigated Hectare of land covered by 28 functional community ponds and it addresses 250 household heads. Jille Woreda Administration built the small-scale irrigation with the support of other development actors such as IFAD, World Vision Ethiopia Jille Timuga area program, Safety-Net Program, and Federal Food Security Program. The total modern irrigation scheme reaches about 8.4 kilometers with a cost of construction 16, 038,718 birr.

3.2 Research Method

3.2.1 Research Design

The research plan for this study was cross-sectional research plan since of the study was conducted with fixed time interim through utilizing both qualitative and quantitative investigate approach. The incorporation of quantitative and qualitative data in the form of a mixed methods study has the potential to greatly improve the accuracy of the research's analysis and findings. This was accomplished by using the mixed research design, which was compatible with the survey questions and met the resource restrictions. It also allows for a more in-depth awareness of both enumerators

and respondents, and it contributes to being more significant in terms of the effectiveness of the chosen model and data analysis.

3.2.2 Data Sources and Type

Data for this study were found from primary and secondary data sources. The primary data was obtained directly from respondents who were chosen from among irrigation users and non-users in each kebele. The quantitative data was collected by administering pre-tested structured questionnaires that were used to assess socio-demographic, socioeconomic characteristics, institutional aspects, and food security status by the coping strategy index and the food consumption score in both groups of the households. The qualitative method was used to collect data on local opinions and views about the role of irrigation in household food security. This was done through a group discussion that focused on each of the two selected Kebeles and through interviews with key informants. The secondary data were reviewed and sorted from different published and unpublished literature relevant to the study, with secondary data sources including Woreda's agricultural offices, specifically the natural resources and crop production (irrigation office), rural livelihood and safety net office, and World Vision Ethiopia Merewa and Mutifecha area.

3.2.3 Sampling design and sample size

Three-stage sampling procedures were used to select the sample for this investigation. Woreda's study was purposefully chosen at the first step. In the second step, two kebeles were chosen at random among those with small-scale irrigation access. In the third step, households in the two-chosen sample Kebeles were stratified into two strata, namely irrigation users and non-users, using Yamane's proportionate methods, from which sample households were randomly picked. In addition, access to road, its distance from the town, highest users of irrigation in the two kebeles apart from other irrigation kebeles, researcher's ability to speak, understand, and listen both Afan Oromo and Amharic language and the suggestion from Woreda Agricultural office, department of natural resource management irrigation expert lead to used purposively to select the two Kebeles. The researcher took representative sample size to decrease the sample error and to enable better generalization on the research objectives. A sampling percentage to population was utilized to determine the corresponding samples from the two Kebeles for each stratum. Finally, a

representative sample for each stratum was chosen using systematic random sampling procedures. The total number of household heads in the two selected kebeles was 1915, with 1065 in Merewa and 850 in Mutifecha respectively. The sample size for the study was identified by using Yemane (1967) formula.

$$n = \frac{N}{1 + N(e)^2}$$

Where:

n = the number of required sample size of both study area (two kebeles);

N = total households of both irrigation study area which is population size;

e = confidence level of precision. In this research confidence level 0.07(93 %) of precision chosen because the researcher believed to have a confidence interval of 93% is enough to conduct the survey.

Using the above formula, the sample size of both study area is 184. However, during collection of household survey, the intended number of sample households may not be available to increase response rate the researcher therefore added 10% contingency of sample households would consider which approximately 18 household heads. Therefore, the total sample households in this research were 202 household heads. In the process of screening respondents, random sampling method applied to minimize sampling error. To specify the sample sizes of users and non-users of small-scale irrigation from the total 202 sample household heads, the researcher took 50 % users and 50% non-users as shown in below Table 3.1.

Table 3. 1 Sampling distribution of irrigation users and non-users for each the study kebeles.

Population Size				Sample Size		
Sampled Kebeles	Total household heads	Total Irrigation users	Total Non-Irrigation users	Users	Non-users	Total sampled
Merewa	1065	670	395	52	64	116
Mutifecha	850	620	230	49	37	86
Total	1915	1290	625	101	101	202

Source: Researcher's own computation based on the data obtained from the study area (2020).

To show the details of the computation of irrigation users and non-users, Yamane (1967) proportional sampling techniques formula applied for each sampled kebeles.

$$n_1 = \frac{N_1(n)}{\Sigma N} \text{Where,}$$

n_1 is the required sample sizes of each study area, n is total number of both users and non-users of population size, N is total population of both users and non-users of irrigation in the study area, N_1 is population sample size of both sample study area. Using the formula, the Numbers of household heads in Merewa kebele were:

$$n_1 = \frac{202(1065)}{1915} = 112 \text{ household heads were the sample size from Merewa Kebele}$$

Numbers of household heads in Mutifecha Kebele study area were:

$$n_1 = \frac{202(850)}{1915} = 90 \text{ sample size}$$

The household heads sample size of users and non-users of irrigation in each study area were computed as:

$$\text{Sample of Merewa irrigation User} = \frac{100(670)}{1290} = 52.45 \approx 52$$

$$\text{Sample of Merewa non- irrigation User} = \frac{100(395)}{625} = 63.83 \approx 64 \quad \text{and}$$

$$\text{Sample of Mutifecha irrigation User} = \frac{101(620)}{1290} = 48.54 \approx 49$$

$$\text{Sample of Mutifecha non- irrigation User} = \frac{101(230)}{625} = 37.16 \approx 37$$

3.2.4 Data collection tools and Method of data collection

To generate the essential primary data, the researcher used household survey, key informant interview, focus group discussions and field observations were employed.

Household Surveys: Household surveys were held from 202 study households by making ready structured questionnaire. In thrives of obtaining complete and reliable information associated with analysis of the topic, further to household's questionnaire. Pretesting of questionnaire was done to make sure its validity and dependability. Provide training data collection techniques to equip the data enumerator's skill and knowledge for the contents of the questionnaire was conducted. Four enumerators were recruited from the study space and trained for in the future. The enumerators administered the structured questionnaires below the continual oversight of the man of science. The survey was distributed from APR to MAY 2020. Throughout surveys, information associated with the house demographic and socio-economic characteristics, current house food security status, household farming processes and food crop production, households' constraint to use irrigation, agricultural production with Irrigation and non-irrigation, contributions and constraints of irrigation

and household expenditure were collected as a primary data and supplemented by secondary information whenever necessary from governmental and non-governmental organizations.

Key Informant Interviews (KII): Eleven key informant interviews were performed at the district level in sampled Kebeles to investigate qualitative information utilizing an interview schedule. (See Annex I). The basis of selection procedure was based on the guidance and supervision of the district agricultural and rural development head who leads me to contact the more responsible person in related to irrigation. The key informants selected in each kebeles from members of water association committee (4), development agents/irrigation experts(2), Woreda Irrigation team leader (1), Kebele leaders (2), Head of woreda agricultural office (1), and world vision staff (1) to know more about the study subject.

Focus Group Discussions (FGD): Two focus group discussions conducted with selected participants in the two sampled Kebeles. The first FGD was undertaken with irrigation users and the second FGDs were held with non- irrigation users. Due to current situations, (COVID19) 5 to 6 peoples participated for each group discussions. Participants were chosen to represent many segments of the community, including kebele leaders, development agents/irrigation experts, representatives of associations of irrigation water users, women, irrigation users and non-users, and youth farmers. (See Annex III).

Field Observations: - Field observations were conducted to collect information on irrigation operations and food security settings in order to connect people's experiences with current challenges in the region. It was straightforward to obtain information and observe what was going on the ground because the researcher had a strong recall and understanding of the region from his previous working experience.

3.2.5 Data Analysis and Analytical Model

In this study, descriptive statistics, econometric analyses and food security measurement techniques were employed to analyze the contribution of small-scale irrigation to household food security. Computation of descriptive statistics and data analysis employed using Statistical Package for Social Sciences (SPSS, version 20) and Stata version 14.2.

i. Descriptive Analysis

Descriptive statistics such as frequency, percentage, mean, standard deviation, variance, t-test, and X² distribution were adapted to describe the socio-economic characteristics of households. This helps to investigate the objective one by applied as tools of study to present frequencies distribution, percentages, tables and bar charts to gift totally different variables. Then, within the second level the qualitative information was coded, ordered, compiled, and analyzed at the side of the qualitative information. Interpretation and discussion got once triangulation of the results of the analysis with the present reality and alternative similar literatures. Within the analysis of the info, the subsequent economic, institutional and demographic variables explained with their expected effects on the link between irrigation and unit food security.

ii. Econometric Analysis:

The econometric analyses were employed to analyze the contribution of small-scale irrigation to household food security and the factors that affect households' irrigation use. To achieve specific objectives two and three, the dependent and independent variables identified and explained along with computational model specifications. The specific analysis method for each objective presented as follows (Maxwell et al., 2008).

$$P_i = f(Z_1, Z_2, Z_3, Z_4 \dots Z_K) \dots\dots\dots 1$$

The econometric model for the probit model stated in equation can be specified as:

$$P_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \dots + \alpha_K Z_K + \mu_i \dots\dots\dots 2$$

Where, P_i = the dichotomous variable represents smallholder farm families' involvement in small-scale irrigation; it is equal to one if the household engages in small-scale irrigation and zero otherwise. Z₁, Z₂, Z₃, Z₄, Z_K are the vector of variables that affect smallholder farm households' decision to participate in small-scale irrigation.

iii. Food Security Analysis:

A detailed structured questionnaire was used to ask respondents about the frequency of their household's consumption of eight different food groups over the previous seven days. To calculate the FCS from these results, the consumption frequencies are summed and multiplied by the standardized food group weight (see the food groups and corresponding weights below). Households can then be further classified as having "poor," "borderline," or "acceptable" food

consumption by applying the WFP’s recommended cut-offs to the food consumption score (WFP, 2008). To this end, the study employed household Food Consumption Score (FCS) and food insecurity coping strategies to analyze the food security status of irrigation users and non-users (specific objective 3). To calculate the FCS, foods consumed by the study households were grouped into eight standard food groups (See Annex D). The FCS is a tool created and used as a proxy indicator for food access by WFP (2007). It's a weighted score based on eating frequency and the nutritional value of the food types ingested. Data on the number of days a household consumed specific food products in the preceding seven days was collected. The FCS was calculated by multiplying the frequency of each food category by its weight and then combining these numbers to produce a single composite score.

WFP (2007) determined the weighting of food groups based on the nutrient density of the food category. The logistic function is the most often utilized function in food security studies, according to available literature. As a result, the most essential estimate equation for the FCS used in this work Was: $FCS = a \times f(\text{staple}) + \beta \times f(\text{pulse}) + \gamma \times f(\text{vegetables}) + \delta \times f(\text{fruit}) + \epsilon \times f(\text{animal}) + \zeta \times f(\text{sugar}) + \eta \times f(\text{dairy}) + \theta \times f(\text{oil}) \dots$ (3) Where FCS = food consumption score, f = frequencies of food consumption = number of days for which each food group was consumed during the past 7 days, a, β, γ, δ and $\epsilon =$ weight/nutritional value of each food group.

According to the WFP (2007) and the International Food Policy Research Institute (2008), households with inadequate food consumption have a food score of 0-21, households with borderline food consumption have a food score of 21.5-35, and households with sufficient food consumption have a food score of 35 or higher, which is considered acceptable. The following logistic distribution take the dependent variable y_i assumed to be distributing as a Poisson distribution with parameter λ_i given as:

$$P(Y_i=y_i) = e^{-\lambda_i} \lambda_i^{y_i} / y_i! \dots\dots\dots(4)$$

Where λ_i is a vector specified by a vector of covariates X_i that determined by the explanatory variables. More often λ_i will be log linear function, which assumes the form:

$$\ln \lambda_i = \beta_i x_i \dots\dots\dots(5)$$

The log linear model ensures that the number of food categories consumed by the family is a non-negative integer and is expressed as:

$$E(y_i/x_i) = \beta_i = e^{\beta_i x_i} \dots\dots\dots(6)$$

The empirical model given as below:

$$Y = FCS = B_0 + B_1X_1 + B_2X_2 + B_3X_3 + B_nX_n + 1 + \varepsilon_i \dots \dots \dots (7)$$

Where $B_0, B_1, B_2, B_3,$ and B_n are the weight/nutritional value of each food group and $X_1, X_2, X_3 \dots X_n$ are of food groups consumed by the households. The adapting technique record was evaluated by assessing behavior, such as what a single family does when they do not have enough food (Maxwell et al., 2008). The approaches that are often distinguished by the individual who is in charge of preparing the food Security status of the households in the research region are dependent on the chosen food security metrics. In this manner, the adapting techniques noticed generally connected to food rehearses for the time being (Degefa, 2002). A few examinations have utilized the adapting methodology record to gauge the degree of family food instability. The most well-known transient adapting methodologies utilized by families are eating food sources that are less liked, decrease food taken, restricting part size, getting cash to purchase food and skipping suppers (Hadley et al. 2007).

Definition of Variables and Working Hypotheses

In the research area, many variables were predicted to influence rural families' usage of small-scale irrigation projects. This section describes the variables believed to impact small-scale irrigation participation decisions and food security status.

Dependent Variables: Participation in the small-scale irrigation system is the dependent variable in the first stage of this study, with a dichotomous value of 1 for those with access to irrigation and 0 for those who do not have access to the irrigation scheme in the survey region. Furthermore, the outcome variable for this study is the score for household food intake. It is expected that the dependent variable is impacted by its independent factors. Each variable is described by its hypothesis, which is based on economic theory and the findings of prior empirical investigations.

Independent variables: The independent variables were identified to meet to objectives of the research and based on the purpose of the study presented as follows:

Sex of household head (HHSEX): This is a dichotomous variable having a value of 1 for male and 0 for female. Male household heads are expected to earn more than female household heads due to better labor inputs and farming experience. Farmers with male heads do better than female heads when it comes to partaking in irrigation tasks. It was expected that male household heads are more exposed to and have more access to knowledge about new agricultural productivity initiatives than female household heads.

Age of household head (AGEHH): Age is a continuous variable that is measured in years. The family head makes farm operations decisions; elderly household heads are more reticent to accept new technology and agricultural production practices than younger household heads. As people get older, the need for irrigation technologies is expected to fall, reducing household food security.

Education Level of a Household Head (HHEDU): The number of formal school years completed by the household head is used to assess this continuous variable. That is the number of years of education attained by the heads of the sampled homes prior to the survey. Previous studies discovered that as one's education level increased, so did one's aptitude to adopt new farming techniques (Gebrehiwot *et.al*, 2015). That is, educated farmers are more likely to accept irrigation technology, to be taught through extension support, and to have a beneficial influence on irrigation participation.

Farming experience (FARMEXP): This continuous variable relates to the total number of years the sampled household spent farming. A farmer with greater farming experience, a broader viewpoint, and a personal understanding of agricultural operations and production systems. As a result, it was expected that this variable would have a positive relationship with participation in the small-scale irrigation system. Farmers with greater agricultural experience are more inclined to welcome change and implement new ideas and practices.

Household Size (HSIZE):- This is a continuous variable that is derived based on the total number of household members living under the same roof, adjusted to adult equivalent. Previous study found a bidirectional relationship between family size and the decision to participate in irrigation systems and other agricultural technologies. Therefore, this variable was hypothesized to have a positive influence on household heads' decision to participate in small-scale irrigation (John, 2002). A family with a large labor force is more likely to participate in small-scale irrigation than a family with a small labor force (Shimeles, 2009).

Dependency ratio/Family Dependency (DEPRATIO): Household members aged 15 to 64 were deemed dependent, and the dependency ratio was calculated by dividing the total number of dependents by the number of household members aged 15 to 64. (John, 2002). These groups were economically inactive, putting additional on other members of the home to fulfill their urgent food demands. As a result, it is predicted that the dependence ratio would have a detrimental impact on the household's food security status.

Access to Agricultural Extension Service (CONDAGE): A continuous variable relates to the number of times respondents contacted a development agent each month. Farmers that contact with development agents more frequently comprehend extension packages, including irrigation technology, better than the others. This enables them to boost productivity, which is necessary for food security.

Access to Credit (ACREDIT): Credit access is a significant source of investment and is assessed as a discrete variable. Farm households with access to finance have a better chance of obtaining farm supplies (Abonesh, 2006). As a result, a favorable connection between loan access and use and both irrigation participation and household food security is predicted.

Total Livestock Holdings (TLU): This is a continuous variable and refers to the total number of herd in TLU (Storck et al. 1991). The number of livestock held by a family is computed and converted to TLU using the Tropical Livestock Unit (TLU) conversion factor shown in the appendix. In Ethiopian agriculture, livestock is an important source of money, food, and draught power for crop development. Increased cattle ownership will enhance the possibilities of small-scale irrigation involvement.

Distance to Market (DISMKT): This is a kilometer-based continuous variable. It denotes the distance between the household's dwelling and the nearest market. This displays market access to purchase and sell input and output. A farmer's proximity to a market increases his or her likelihood of participating in small-scale irrigation and selling agricultural earnings. The characteristics of various locations may influence adoption decisions (Knowler and Bradshaw 2006). As a result, residents living closer to the market center will have a better opportunity to participate in small-scale irrigation and improve household food security.

Access to Irrigation (ACCIRR): It is a discrete variable with a value of 1 if the farmers have access to irrigation and a value of 0 otherwise. Irrigation, as one of several technology alternatives, enables smallholder farmers to directly produce edible food grains, diversify their crops, and replace moisture shortages in agriculture, boosting productivity and food consumption (Van der Veen and Tagel 2011). As a result, in this study, access to irrigation is predicted to have a beneficial influence on the extent of households' food security by increasing agricultural productivity and diversity.

Cultivated land holding (CULTLAND): Many prior studies have found that a sufficient size of land holding is a basic condition for the adoption of agricultural technology. Thus, cultivated land size predicted that the greater the household's farm size, the more likely it is to employ small-scale irrigation and agricultural technologies (Eshetu and Young, 2017).

Participation in Non-farm activity (NONFARM): It is a measure of each family member who works outside of the farm and earns money in Birr. Families were expected to spend non-farm money on agricultural inputs such as fertilizer, improved seeds, herbicides for irrigation production, and food grains, as well as non-food goods required by family members.

Access to Training (TRNG): It was discrete variables with values of 1 for households' access to training and 0 other wise. Training, demonstration, and workshops can provide the essential information. The farmer-training center serves as a resource for the research region. There are development agents in the study region who train local populations how to use new technology.

Application of Motor and Treadle Pumps (APMTP): The employment of motorized water pumps and treadle pumps, as well as other water lifting technologies, has enhanced agricultural productivity while also improving food security.

Access to Fertilizer (ACCFER): Input application; Fertilization of fields can enhance agricultural productivity and impact a household's food security status.

Access to Improved Seeds (ACCISED): Access to improved agricultural crop seeds to cultivate in irrigable land enable the farm households' and motivate to participate and increase productivity as a result improve food security so as access to improved seeds has positive relationship to participate irrigation activities and boost food security.

Access to Pesticides (ACCISED): The inputs used to enhance and promote agricultural production are measured in terms of accessibility as dummy variables, with 1 indicating access and 0 indicating non-access. It allows for the control of crop diseases as well as the motivation of farm households to participate in crop irrigation production, which is required to increase crop irrigation production.

Table 3. 2 Summary of Variables included in the models

Code	Variable definition	Variable type	Measurement Sign (1= Access/user, 0=no Access/non-user)	Expected
ACCIRR	Access to irrigation	Dummy	1 and 0	+ve
FARMSIZ	Land size	Continuous	Hectares	+ve
EDHH	Educational level	Continuous	Year	+ve
HHAGE	Age of a household head	Continuous	Year	+ve/-ve
TLU	Tropical Livestock Unit	Continuous	TLU	+ve
NON-FARM	Participation in nonfarm	Dummy	1 and 0	+ve
ACCRED	Access to credit	Dummy	1 and 0	+ve
DISMKT	Market distance	Continuous	Kilometer	-ve
CONDA	Contact with DA	Continuous	Number	+ve
HHSEX	Sex of household head	Dummy	1 and 0	+ve
FAMLA	Family labor	Continuous	Adult equivalent	+ve
TRNG	Access to Training	Dummy	1 and 0	+ve
ACCISED	Access to Improved Seeds	Dummy	1 and 0	+ve
ACCFER	Access to fertilizer	Dummy	1 and 0	+ve
ACCPES	Access to Pesticide	Dummy	1 and 0	+ve
APMTP	Application Motor and Treadle Pumps	Dummy	1 and 0	+ve
DEPRATIO	Dependency ratio	Continuous	Number	+ve/-ve
FARMEXP	Household Farming experience	Continuous	Number	+ve

Source: Own computation based on empirical reviews (2020)

CHAPTER FOUR: DATA ANALYSIS AND INTERPRETATION

This section presents the results of the research with four sub-sections. The first subsection gives the results of descriptive statistics such as means, percentages, and frequencies used to describe the socioeconomic characteristics of sampled households. The second subsection examines the elements that influence household irrigation participation. The third subsection offers food security metrics for families based on household food consumption and a food insecurity coping strategy index to evaluate the food security status of sample households. The fourth sub-section discusses the relationship between small-scale irrigation and family food security, with an emphasis on household dietary diversity and food consumption score.

4.7. Descriptive Analysis: Socioeconomic status of irrigation and non-irrigation users

Descriptive statistics such as mean, percentage, frequency, range, mean difference and standard deviation used to analyze the socio-economic and institutional characteristics of the respondents. It is used to examine the distribution of the independent variables. Socio-economic and institutional features of the respondents were age of household heads, sex of household heads, household head level of education, household farming experience, household size in adult equivalent, cultivated land holding, livestock holding, access to extension service, access to credit, distance to market, training, access to agricultural technology such as fertilizer, pesticides, improved seeds and water pump. From the total sample respondents, 101 sampled households were irrigation users and same numbers of household heads (101) were non-irrigation users, which were 50% equal proportion of sampled households. The chi-square (2) was used to determine the significance of the mean value of potential discrete (dummy) explanatory variables in both irrigation users and non-irrigation users, and the t-test was used to determine the significance of the mean value of continuous variables in the two groups of irrigation users and non-users.

Table 4. 1 Summary of descriptive statistics result of the dummy variables by access to Irrigation.

Variables	Irrigation Participant (N=101)		Irrigation Nonparticipants (N=101)		Total (N=202)		χ^2
	Frequency	%	Frequency	%	Frequency	%	
Household SEX							
Male=1	81	80.2	91	90.1	172	85.15	0.048*
Female=0	20	19.8	10	9.9	30	14.85	
Marital Status							
single=1	8	7.92	2	1.98	10	4.95	
Married=2	88	87.13	92	91.09	180	89.11	
Divorced=3	2	1.98	2	1.98	4	1.98	4.95
Widowed=4	3	2.97	5	4.95	8	3.96	
Training							
Yes=1	74	73.27	27	26.73	122.00	60.40	0.001*
No=0	48	47.52	53	52.48	80	39.6	
Credit							
User=1	43	42.57	44	43.07	87	43.07	0.887
Nonuser=0	58	57.43	57	56.44	115	56.93	
Fertilizer							
User=1	61	60.40	45	44.55	106	52.48	0.024*
Nonuser=0	40	39.6	56	55.45	96	47.52	
Manure							
User=1	32	31.68	37	36.63	69	34.16	0.458
Nonuser=0	69	68.32	64	63.37	133	65.84	
Pesticide							
User=1	80	79.21	64	63.37	144	71.29	0.013*
Nonuser=0	21	20.79	37	36.63	58	28.71	
Improved Seeds							
User=1	48	47.52	23	22.77	71	35.15	0.00*
Nonuser=0	53	52.46	78	77.23	131	64.85	
Water pump							
User=1	25	24.75	0	0.00	25	12.38	0.001*
Nonuser=0	76	75.25	101	100	177	87.62	
Market Information							
Yes=1	52	51.49	38	37.62	112	55.45	0.047*
No=0	49	48.51	63	62.38	90	44.55	

Source: Own survey result (2020),* 5% significant level

The gender of the household head is significant, as indicated in table (4.1), with a p value of (p=0.048). This means that 85.15 percent (172) of the total studied households were headed by

men, while 14.85 percent (30) were headed by females. The X2 result shows that the proportion of male-headed families among irrigation participants is greater (80.2 %) than in non-participants (19.8 %). Male-headed families were more likely than female-headed households to employ small-scale irrigation. This might be because male-headed households have better agricultural experience and knowledge of land cultivation. In terms of marital status, around 89.11 % of sample families were married, whereas 4.95 %, 3.95 percent, and 1.98 % were single, widowed, or divorced, respectively. According to the chi test, the marital status of the family has no related to irrigation participants. This implies that whether you were married, single, divorced, or widowed had no bearing on whether you participated in irrigation or not.

Access to training for farming households was significant to irrigation participants. The training service is mostly provided by Development Agents (DAs) and designated agricultural specialists, who share current agricultural expertise and information with the goal of improving farmers' lives. Households having training have better in participating irrigation, as training is very important to awareness of the possible advantages of modern farming techniques and irrigation activities. Thus, with a p-value of ($p=0.001$), the chi square test indicated a significant connection between irrigation users and non-users in terms of access to training services at a 5% level of significance. The distribution of better seeds, the effective use of water pumps, and the correct application of fertilizer and pesticides have all been identified as important variables in agricultural output and productivity. Consequently, the findings of this study are similar with the findings of another study, which found that irrigation participants benefited considerably from the use of agricultural inputs and technology. Thus, the chi test for access to fertilizer, pesticide, improved seed and adoption of water pump were significant to irrigation participants at 5% level of significance with a p-value of ($p=0.024,0.013,0.00,0.001$) respectively.

Credit is a vital institutional function that helps impoverished farmers acquire inputs and, eventually, embrace new technologies. However, some farmers have access to finance, while others may not owing to payback and down payment issues in order to obtain input from official sources. As a result, some farmers avoid taking out agricultural financing. The survey result indicated that 43.07% of the non-participants and 42.57% of the participants had taken credit. The test results reveal that access to credit was not statistically significant since irrigation participants and non-participants had equal access to credit. It is also the case that the use of organic manure as a

fertilizer was not statistically significant since irrigation and non-irrigation users had the same likelihood of using organic manure as a fertilizer.

The other influential variable is market for both agricultural input and outputs to sell and produce cash crops. As indicated on Table 4.1 households with access to market information have better aware to being irrigation participants. This proved with a chi test of 0.047 with 5% level of significance. This show out of the total sampled households, 55.45% (152 households) and 44.55% (90 households) had market information to sell their agricultural products and purchased agricultural inputs. Even if market is important for non-participants 37.62% (38 households) that the study shows, households with detailed market information have motive to use irrigation in their crop production which accounts 51.49% (52 households). This is because the demand for cash crops at the market inspired the households to produce with irrigation three to four times a year.

Table 4. 2 Summary of descriptive statistics with continuous variables

Variables	Irrigation Participant		Irrigation Non-participants		t-test
	N=101		N=101		
	Mean	Std.err	Mean	Std.err	
HHEDU	4.089109	3.059735	2.336634	2.589507	0.000*
HHAGE	45.26733	10.67323	45.39604	9.659275	0.9285
HHSIZE	5.833663	1.558895	5.475248	1.726864	0.0425*
CULTLAND	1.21099	0.415246	1.109901	0.333018	0.0289*
NONFARM	1770.198	4069.971	1601.089	4793.938	0.3936
DEPRATIO	0.845743	0.611507	0.906832	0.777433	0.7322
FARMEXP	16.019802	3.5692582	16.841584	3.6296905	0.9468
TLU	5.84698	3.413304	3.613416	2.059149	0.000*
FARMDIS	0.441584	0.191059	0.442079	0.216879	0.5069
FARMIM	68353.942	43731.564	14398.919	8221.525	0.000*

Source: Own survey result (2020), * 5% significant level

The result presented in the above table suggests the mean value of education of irrigation user household heads and non-users were 4.08 and 2.33 respectively. It was hypothesized that irrigation participation and household head education status had a favorable connection. People who are better educated are more likely to use these technologies. This result supports the hypotheses and prior findings, and the survey results demonstrate that there is a positive link between household head educational status and irrigation involvement, which is significant at the 5% level of significance. The study results show that educated people can more easily contribute to the adoption of small-scale irrigation technology and more readily utilize this technology-irrigating households have more educated household heads than non-irrigating households. This demonstrates that households with a higher level of education are more likely to employ small-scale irrigation. This is

similar with the findings of Gebrehiwot et al. (2015), who discovered that education has a significant impact in household decisions about technology adoption. It brings awareness and assists in the development of greater creativity and invention. It is one of the most significant elements influencing the use of irrigation technology to boost agricultural output.

For small-scale irrigation users, the average age of the heads of sample respondents was 45.23 years. The average age of non-users was 45.39 years. The age difference between the two groups was found to be statistically insignificant, suggesting that age had no influence on the decision to participate. This suggests that as people get older, they are less willing to embrace irrigation technologies. Therefore, the insignificant critical t-statistic of 0.9285 indicates that growing involvement in the small-scale irrigation system is unrelated to the age of the farmer. Unlike this study, Bacha et al. (2011) discovered that age is a significant continuous variable that influences the decision of household heads to engage in irrigation.

Irrigation users and non-users had 16.01 and 16.84 years of agricultural experience, respectively. This study's findings indicate that this variable is negligible. This implies that the agricultural experience of irrigation user household heads is virtually comparable to that of non-users. Regarding household size, the average household size for the small-scale irrigation users and non-users found to be 5.83 and 5.47. This result shows that there is association between irrigation participation and household size. Statistically significant value at 5% (0.0425) indicated as labor availability is an important factor influencing households' decision to participate in small-scale irrigation. The results also show that as a household's active family labor or work force in adult equivalent increases, the total income of the household increases, which contributes to improved food security, providing further evidence for the importance of labor availability in affecting household participation decisions in small-scale irrigation.

The mean cultivated land size of sample households of irrigation participants and non-participants are 1.21 and 1.10 hectare. One of the critical issues that in making decision to engage in irrigation is the ownership, one with who is the owner could decide to plough and prepare for irrigation if not he may not. This shows that land holding influences the participation decision-making behavior of farm households. This difference is statistically significant at 5% with a statistical value of 0.0289. Irrigation may produce revenue, allow the accumulation of other productive assets by irrigating

household, allowing for the cultivation of additional land through share in, and rent in from non-irrigating households.

Farmland and animal resources are important in rural areas. In the study area, the average livestock holding for irrigated and a non-irrigation user was 5.84 and 3.61, respectively. There is a definite direct link between household variations in livestock keeping between irrigators and non-irrigators at a 1% significant level. This demonstrates that a home with a livestock holding has a favorable influence on irrigation participation, which leads to families with a larger livestock holding having a higher likelihood of having extra cattle for sale. As a result, producing greater money, particularly as the owner of more oxen, leads to the capacity to plug more land on time, resulting in higher crop yields, higher income, and increased food security. Table (4.2) also shows the mean annual farm income, from both crop production and livestock rearing which significantly higher for users of the irrigation with 1% significant level. This shows farm households participate in irrigation activities have a probability of increase income by 99%. The average livestock holding for irrigated and a non-irrigation user was 5.84 and 3.61, respectively. At a 1% significance level, there is a clear direct relationship between household differences in livestock holding between irrigators and non-irrigators. Distance to farm, dependency ration, nonfarm income and farming experience were insignificant for irrigation participants. This shows that it has same factor for both user and non-users of irrigation households.

4.1 Household participation in irrigation

4.1.1 Determinates of Irrigation Participation

The number of farm households in the study area who are involved in irrigation has increased because of the diverse incentives from the government. However, there are still several farmers who do not use irrigation. However, there are still several farmers who did not participate in irrigation. Irrigation is a difficult decision that must be made in the context of a larger picture. Using the participation probit model, this study finds possible characteristics that drive farmers to undertake irrigated farming. The participation of respondents in irrigation is the model's dependent variable. The model estimates the factors that affect rural farmers to use irrigated agriculture. While heteroscedasticity and multicollinearity are predicted in cross-sectional data, the study used robust standard errors and VIF tests to address these issues (less than 10). The Wald chi-squares for an irrigation choice is 48.61(P0.000), indicating that at least one of the model's independent variables is not zero. The Pseudo R² indicates that around 22.6% of the variation in the irrigation decision model can be explained through the included parameters. Table 4.3 indicates that household head education level, households sex (being male), access to market information with available market, access to agricultural inputs such as pesticide, fertilizer and improved seeds, households training access, contact with development agent and livestock resources (TLU) are variables that have statistically significant effect in explaining the probability to access irrigation at 5% significant level. Alternatively, household size, marital status and age of the head, access to credit, farmland sizes, farm distance, farming experience and dependent ratio are statistically insignificant effect in the model.

Table 4. 3 Factors influence access to irrigation: coefficients and marginal effects of the model

accirr	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
-----+-----						
HHSEX	5429584	.3285333	1.65	0.048*	-.1009549	1.186872
HHMAS	-.1695473	.2515794	-0.67	0.500	-.6626339	.3235392
TRAINING	.8862898	.2107599	4.21	0.000*	.473208	1.299372
ACCFER	.405631	.1972428	2.06	0.040*	.0190423	.7922198
ACCISEED	.970238	.2141723	4.53	0.000*	.550468	1.390008
CREDIT	-.1433651	.2066209	-0.69	0.488	-.5483347	.2616045
DACONT	.4915978	.2044581	2.40	0.016*	.0908672	.8923283
ACCPEST	.6058846	.2217748	2.73	0.006*	.171214	1.040555
ACCMKT	.6436167	.201299	3.20	0.001*	.2490779	1.03815
HHEDU	.1401751	.0399341	3.51	0.000*	.0619057	.2184444
HHAGE	-.0003219	.012584	-0.03	0.980	-.0249862	.0243424
HHSIZE	-.0147419	.0640306	-0.23	0.818	-.1402397	.1107558
CULTLAND	.3383876	.2735412	1.24	0.216	-.1977432	.8745184
NONFARMI	2.57e-06	.0000225	0.11	0.909	-.0000415	.0000467
DEPRATIO	-.1729455	.161857	-1.07	0.285	-.4901793	.1442883
FARMEXP	-.0369437	.0296704	-1.25	0.213	-.0950967	.0212092
TLU	.212121	.0490518	4.32	0.000*	.1159812	.3082608
FARMDIS	-.011231	.4502538	-0.02	0.980	-.8937122	.8712502
_cons	-.9318239	.9310405	-1.00	0.317	-2.75663	.8929818

Source: Model output (2020)*5% significant

The level of education has positively and significantly stimulated farm households to start irrigation farming. The mean education level of households engaged in irrigated agriculture is 4.08 higher than 2.34 non-irrigation participants in year of schooling. A year of schooling increase the chance of participating irrigation with probability of 4.8%, thus, households having education in the study area have better important tools in the participation of irrigation decision. Accessibility of Market and market Information has a profound effect on the livelihoods of participate in irrigation agriculture. This is because irrigated farm households need market to sell irrigated agricultural production and to buy agricultural inputs and technology. As a result, the presence of large produce markets is a key factor in motivating respondents to engage in irrigation, and it is significant at 5% probability with a p value of (p=0.000). In other words, the less market knowledge rural people have, the less likely they are to participate in irrigation. In contrast to this study, Bacha et al. (2011) begin by stating that the likelihood of irrigation involvement for a household with rationally good access to market information and broad markets was roughly double that of a household with no access to market information and just local markets. Access to irrigation services and facilities, such

as training service and contact with development agent significantly matter for irrigation participation and access to irrigation by households. As indicated on Table 4.3, the study shows that the probability to access and use irrigation is directly related to training service and contact with development agent. This is because providing extension services and training to farm households encourage using irrigation and increasing their agricultural production. It was found that there was a statistically significant difference in access to extension workers in the areas between irrigators and non-irrigators. This study shows that credit and non-farm income does not matter to use irrigation as the participants in the group discussion explained that the credit is not allowed by their religion, as most of the households are Muslim.

4.1.2 Households' Constraints to use Small Scale Irrigation

Irrigated agriculture has grown in importance in the study area. It has evolved into a key source of food security. According to the study findings, small-scale irrigation has a significant potential to increase household food security, although it is fraught with challenges. The researcher ranked the major problems associated with small-scale irrigation based the discussion on irrigation participants', FGD and key informants held in the study area. The first ranked problem was marketing and market access to sell agricultural outputs and purchase agricultural inputs consist of 41.58%. Lack of initial capital to purchase agricultural inputs such as fertilizer, improved seeds, pesticides and water pump ranked as second constraints and account 37.62%. The third identified irrigation constraint was frequent incident of crop pest/disease infestations, which reduce irrigated crop production that leads to irrigation participants discourage to produce irrigated crops in next round and accounts 34.65%. Lack of knowledge on use of modern irrigation technology and lack of irrigation input supply such as water pump, fertilizer, pesticides, and improved seeds were the fourth ranked and had equal percentage share (31.68% and 31.68%) of the total. Lack of accessible irrigation water and irrigation facilities resulted conflicts in water use and use right, lack of irrigable farmland were the fifth ranked problems with equal percentage share of the total 29.70% and 29.70% of the total. The last but not the least constraints were weak and ineffective water users' committee to distribute the existing irrigation water to members (27.72%).

Table 4. 4 Main constraints of irrigation agriculture by irrigation participants

		Irrigation participants N= 101		
	Main constraints	Frequency	%	Rank
1	Marketing and market access	42	41.58	1 st
2	Lack of initial capital/access to credit to irrigation activities	38	37.62	2 nd
3	Frequent incidence of pest, diseases infestations	35	34.65	3 rd
4	Lack of knowledge on use of modern irrigation technology	32	31.68	4 th
5	Lack of irrigation input supply	32	31.68	4 th
6	Lack of irrigable farm land	30	29.70	5 th
7	Conflicts in water use and use right	30	29.70	5 th
8	Weak and ineffective water users' committee	28	27.72	6 th

Source: Own survey result, 2020

4.2 Small-scale irrigation and food security

4.2.1 Measuring Food Security Status of Sampled Households

Household food securities were assessed using household food consumption score and coping strategy index.

i. Household food Consumption Score (FCS):

The records on food consumption of 202 households was composed for this paper designed for capturing the variety and frequency of different foods consumed over seven days' recall period. Table 4.5 demonstrates the findings of the Food Consumption Score used to assess sample households' food security status for both irrigated and non-irrigation households. Using the Food Consumption Score cut-off, the results revealed that irrigation users with acceptable food consumption were 61.39 %, while non-irrigation users were 25.49 %. Irrigation users with borderline consumption were 30.69 % of irrigator households, while non-irrigation participants were 33.34 %. Only 7.92 percent of irrigation participants had a poor food consumption score, while 41.17 % had no irrigation participants with a poor food consumption score. There were 88 non-users with acceptable food consumption, 65 with borderline consumption, and 49 with poor food consumption.

Table 4. 5 Household Food Consumption Score

Food consumption score	Irrigation user (N=100)		Irrigation non-user (N=100)		Total		X ²
	Frequency	%	Frequency	%	Frequency	%	
Adequate food consumption (>35)	62	61.39	26	25.49	88	43.56	
Borderline food consumption (21.5-35)	31	30.69	34	33.34	65	32.18	
Poor food consumption (≤21)	8	7.92	41	41.17	49	24.26	
Total	101	100	101	100.00	202	100.00	
Mean	34.32941		30.18663		32.25802		0.011**

Source: Own survey result (2020), * Significant at 5% level

ii. Households' Major Coping mechanisms to Food Insecurity:

The study's findings indicated that households in the study area had been able to control a number of habits that allowed coping techniques during times of food scarcity and/or food insecurity. Accordingly, 55.45% of the sampled households pursued on less preferred or less expensive food as a coping tactics, followed by dropping the number of meals served (50.99%), Selling livestock (48.51%) and limit portion size at meal time (41.58%). This indicates that most of the households were adopting decreasing the number of meal serving time, size of meal and selling of livestock as their coping tactics to cope up with the risks of food shortage and/or food insecurity.

Furthermore, the study also pointed out that Limit consumption by adults in order to allow children to eat 37.62%, Borrow food, or rely on help from a relative 35.64%, Purchase food on credit 34.16% and Consume seed stock held for next season 27.23%. The other options were gathering wild food, hunt, or harvest immature crops Gather wild food, hunt, or harvest immature crops and Send households members to eat elsewhere as a coping mechanisms which accounts 25.74 and 21.78% of the sampled households respectively, as coping mechanisms against food shortage and food insecurity in the study area. This finding supported by Wolde Amanuel (2009), Sewnet (2015) and Sani et.al (2017) study which remarked that rural households pursued various coping mechanisms when food crisis hits them so as to reduce the risk associated with food insecurity.

Table 4. 6 Household Consumption based coping strategies

Households coping method as a response to food shortage in the last 30 days	Household response rate (N=202)	
	Yes	%
Rely on less preferred or less expensive food	112	55.45
Reduce the number of meals eaten in a day	103	50.99
Selling livestock	98	48.51
Limit portion size at mealtimes	84	41.58
Restrict consumption by adults in order to allow children to eat	76	37.62
Borrow food, or rely on help from a relative	72	35.64
Purchase food on credit	69	34.16
Consume seed stock held for next season	55	27.23
Gather wild food, hunt, or harvest immature crops	52	25.74
Send household members to eat elsewhere	44	21.78
skip entire days without eating	-	-
Send household members to beg	-	-

Note that a single household can present all the coping mechanisms used at the time of food insecurity and or shortage.

Source: Own survey result (2020)

Adding to Consumption based coping strategies, farm households in the study area have several coping mechanisms to respond mechanisms for shocks faced during food in-secured months. As indicated in Table 4.7, variety of coping mechanisms are conveyed which includes: Migration to nearer areas for wage labour 58.42% adopted to cope with food insecurity and Livestock sales 48.51%. While selling firewood 46.04%, Remittance and Food aid 43.56%, Drawing on rural savings 38.61%, land rent/contracted 37.62%, rented out land 44.16%, borrowed money at high interest rate 27.23% and 23.76% of the respondents remove children from school.

Table 4. 7 Households response to problems/shocks/facing as food shortage in the last one year

Response to problems/shocks/facing	Yes	%
Migration to nearer areas for wage labour	118	58.42
Livestock sales	98	48.51
Selling firewood	93	46.04
Remittance and Food aid	88	43.56
Drawing on rural savings	78	38.61
Land rent/contracted	76	37.62
Rented out land	69	34.16
Borrowed money at high interest rate	55	27.23
Remove children from school	48	23.76

N=202; a single household can present all the coping mechanisms used at the time of food insecurity/shortage Source: Own survey result, 2020

4.2.2 The Link between Small-scale irrigation and Food Security

Obtainability of irrigation permitted the farm households to grow crops three to four times a year and ensure to produce stable crop production, that result increase income and consumption; as well as improve the level of food security. Irrigation has role to farm household's food security through upsurge the level of food consumption as positively extent and significant with 5% probability. The bordering impact indicated that having access to irrigation raised the chance of the extent of food energy consumption in food insecure families by 31.07, 9.62 percent, and 40.69 percent, as shown in the table below. This suggests that families with access to irrigation were less likely to be food insecure than those without access to irrigation. The result supports the finding of Van der Veen and Tagel (2011). This is a clear indication of irrigation help communities to harvest more than once in a year through mitigating water stress and reducing risks of crop failures and obtains more yields; thereby ensure food security at household level. Henceforth, it can be concluded that small-scale irrigation significantly contributed to household food security.

Table 4. 8 Average marginal effects of small-scale irrigation on households' food security

FCS groups	dy/dx	Std. Err.	z	P> z 	[95% Conf. Interval]	
Poor FCS 0-21	-.3106976	.0545902	-5.69	0.000*	-.4176924	-.2037027
Borderline FCS 21.5-35	-.0962171	.0278702	-3.45	0.001*	-.1508417	-.0415924
Acceptable FCS >35	.4069146	.0577674	7.04	0.000*	.2936926	.5201367

Source: Survey output (2020), * significant at 5% level.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The main objective of this study was to look at the role of small-scale irrigation on households' food security using food consumption score as a proxy. Hence, this study examines the influential factor that explains rural households to participate in small-scale irrigation using participation probit model. Theoretically, the advantages of irrigation were realized through improvements in agricultural productivity, employment and wages, incomes, consumption, food security and overall socio-economic welfare. Irrigation can benefit the poor by enhancing productivity, decreasing the likelihood of failure, and creating more and year-round farm work. It has the potential to enable smallholders to diversify their cropping patterns and transition from low-value subsistence agriculture to high-value market-oriented production.

The findings of the research specified that access to small-scale irrigation could meaningfully influence positively and improve the revenue levels and food security status of beneficiary households. Farm households' who participated in the irrigation were interested to use more farm inputs and in sustained fashion than the others. Consequently, households in the irrigation practice could access high incomes and improved food security and a better Position on Livestock Ownership, Asset, and Livestock Income as well expand agricultural production and intensify cultivation, leading to attributes of higher productivity and higher agricultural yields. This higher return is gradually invested in other sources of income and subsistence activities. In relative terms, the yields from irrigated agriculture have increased the household income portfolio and therefore the potential for irrigation uses has not yet been realized on the aspired levels the probit model results show that the head of household's agricultural experience, size of land irrigated, income from producing irrigated crops, income from off-farm activities, income from employment and distance in Hours spent from market center was the most important factor that determine the extent of households' crop diversification using small scale irrigation in the study area.

The results of this study showed that due to higher incomes than non-users, irrigation participants used more inputs such as fertilizers and chemicals and participated in agricultural loans than non-users. The discussion with the farmers and the observation of the site showed that there are problems, especially in areas of the management of the irrigation system such as water distribution, liaison with government agencies and management mandate. Households also reported a significant

increase in investment in livestock as a key element and reported that they have been better able to cover the cost of living since irrigation was introduced. The benefits suggest that irrigation could be very useful in improving food security, reducing poverty, and promoting growth. However, the lack of enough knowledge about irrigation management and the improvement of agronomic practices were mentioned as a caveat. From the research results, we could summarize that small irrigation systems play a crucial role in ensuring food security in the study area. Access to irrigation resulted in more than one crop rotation per year, increased income and consumption, and diversified the agricultural system. Small-scale irrigation plays an important role in feeding rural households through the direct effects of annual productivity improvements and indirect effects of the creation of non-agricultural income and non-agricultural employment opportunities. This may confirm that the distribution of income from irrigated crop production, employment and non-farm income sources has a positive and significant impact on household food security.

Generally, we can summarize that household access to irrigation produced more than one crop rotation per year that could let them generate income as well supply families with diversified consumption, at the same time let them to and diversify their cultivation system through productivity and the indirect effect of generating off-farm and non-farm employment opportunities. This is proved and validated that income share from irrigated crop production, employment and off-farm income sources have positive and significant influence on ensuring food security at household level.

5.2 Recommendations

In a bid to translate the ascribed procedure here some of recommendations for productive irrigation practice the researcher wants to forward.

- Creating market linkages to the farmer communities and let be operational in more progressive fashion building the trust of communities, this activity should well addressed by Woreda Agriculture office, particularly the Agri-business and value chain office.
- Increase access to financial institutions and let farmers get credit in less interest rate and other services of finance.
- Revamp Natural Resources Management effort in the communities, mobilize the local administration/kebele for the proper use of water and awareness-raising measures, and enable users to use it efficiently and effectively.
- Increase skills and knowledge of farmers towards irrigation, crop production, natural resource management and agricultural through established training at the Farmer Training Centers (FTC) and beyond.
- Create job opportunities for communities without arable land and let them engage in productive life through coordinated follow up, diary and fattening practices
- Work on advancing access to irrigation and irrigation technologies.
- Strengthen monitoring and the follow-up in all households by pertinent stakeholders

According to the findings of the study, access to credit services has a significant positive effect on household participation in irrigation agriculture. However, the sample size of the participants in the study area is comparable, since credit customers for credit institutions because of their money interest, since 99.7% of the people are Muslims prohibit the Muslim faith.

In general, the researcher recommends, it high time to invest in rural water development as multiple use water systems to reduce poverty and improve livelihood through providing water for agriculture, livestock, domestic and sanitation. There is a strong need to enhance access to institutional support services such as credit and extension. Availing market information on input and output marketing will only achieve the desired impacts if an effective extension system is in place to guide farmers to understand the issues related to the optimal application inputs, targeted planting dates and product quality to enable them respond well to market incentives.

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APPENDIX

Annex A: Questionnaire

ADDISABABA UNIVERSITY

COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY

Household Surveys Questionnaire by Natan Wube for the fulfillment of Master of Science Program in Food security and Development Studies in Addis Ababa University

This Household Survey questionnaire is organized to carry out a study titled on “Contribution of small-scale irrigation on Food Security of Rural Households.” The study is undertaken in Amhara Region, Special Oromiya Zone, Jille Timuga Woreda sampling Mutifecha and Merewa KAs of irrigation user and non-irrigation users. The ultimate objective of the questionnaire is to gather relevant information of small - scale irrigation users and non-users’ household on socio-economic characteristics, institutional factors, agricultural and Food security related information and other important information that significantly contribute to the research.

Dear respondents, rightly and trustworthiness of your response is very crucial for the usefulness of this study. So, your kind response is essential and greatly appreciated and help to interpret the study result in a right manner. So that, the result of this thesis helps the woreda government, different stakeholders and policy makers to take part proper action on small-scale irrigation development and clearly see the extent to which socio-economic and institutional factors determine from participating in small-scale irrigation. Your responses are confidential. When you engaged in household survey, be informed that there is no benefit given to you either in cash or in kind. Therefore, I hereby kindly request you to provide right and clear responses. Thank you for devoting your time.

1. General Information

1.1. Name of Peasant Association _____

1.2. Name of village/Kebele _____

1.3. Interviewer name _____

1.4. Respondent name (optional) _____

1.5 Irrigation user _____ Non- irrigation user _____

1.6 If the respondent is irrigation user, please fill irrigation type he/she is practicing

Irrigation type 1. Modern _____ 0. Traditional ----- (Put √ mark)

Part One: Personal Data (Household Information)

1.1 Households' composition, education and occupation. (Please fill all your family members in the given table by using codes set below)

S/N	Name	Sex	Age	Marital status	Relation To HH	Education Level	Occupation
1							
2							
3							
4							
5							
6							
7							
8							

Variable Codes

Sex: 1 if Male 0 if female

Marital Status: 1= single, 2= Married, 3= divorced, 4= Widowed, and 5= other

Relation to HH: 1= Husband, 2=Wife, 3= Daughter, 4= Son, 5= Grandchild, 6= Step child 7= Parent, 8=Laborer, 9= if other Specify _____

Education level: 0= Illiterate 1= read and write /basic education 2= primary 1st cycle (1-4) 3= Primary 2nd cycle education (5-8) 4 = secondary education (9-10) 5= Preparatory (11-12) 6= Diploma and above

Occupation: 1=Farmer, 2= Merchant, 3=Housewife, 4= Weaving 5=Carpentry 6=Student 7=herdsman 8=others (specify) _____

Part Two: Household assets /Economic characteristics

2.1. Farm land size

1. Please list the land owned by your family and fill the codes for use of plot and, soil quality and Slope of land from the variable code given under the table.

No.	Land Use	Area in		Soil quality	Slope of the plot
		Timad	Hectare		
1	Homestead Farm				
	Rain feed Farm				
	Own				
	Rented in				
	Rented out				
	Shared in				
	Shared out				
	2	Irrigable farm			
Own					
Rented in					
Rented out					
Shared in					
3	Fallow				
	4	Private Pasture			
Other					

Variable codes; Soil quality: 1= Fertile, 2. Medium 3= Infertile, Slope of the plot: 1= Flat (Meda)
2= Gentle slope (Tedafat) 3= Steep-sloppy (Gedel)

2.2. Livestock holding: Number and value owned during the last one year (2011 E.C.)

Type of livestock	Number owned and present at your farm	If you would sell, how much you receive in the last year (2011 E.C? (Birr)	Total Income obtained (Birr)
Bull			
Oxen			
Cows			

Heifer			
Calves			
Sheep			
Goats			
Mules			
Donkey			
Camel			
Poultry			
Other (Specify)			

Part three: Household farming activities and Income

3.1 Farming

1. For how many years you have been experienced farming? _____ years
2. Did all your household members participate in farming work? 1= Yes 0= No
3. If no, how many of them participated? _____ (in number) 1=1 2=2 3=3
4. Did you face labor shortage? 1= Yes 0=No
5. If yes, how did you solve the problem of labor shortage? a. Hiring daily laborer
b. Labor exchange c. Other_____
6. Total area of land cultivated during the last one year (2011E.C) _____ (in Hectare).

Part Four: Irrigation related Issues

1. Are you practicing irrigation? 1= yes 0= No
If yes for how many years do you practice irrigation?,,,,,,,,,,,,,,,,,,,,,
If no please go to question No. 16

2. How do you express the size of land you have under irrigation? 1= Large 2= Sufficient 3= Small 4= very small
3. Did you irrigate all your irrigable lands? 1= Yes 0= No
4. If you are not irrigating all of your irrigable land, why?

Item	Yes	No
shortage of farm implements		
shortage of farm inputs		
shortage of labor		
lack of demand for your produce at market		
lack of extension service		
getting sufficient produce by rain feed agriculture		
others\specify		

5. How many times you produce annually by applying irrigation? _____ 1=one 2= two 3= Three 4= four times
6. What are the major agricultural cash crops you produce using irrigation? 1= Onion 2= Tomato 3= Potato 4=Pepper 5=Cabbage 6= Meng bean 7=Carrot 8= Others\Specify
7. Income obtained from cash crop in 2011 E.C farming years?..... (Birr)
8. Why do you prefer to grow such cash crops? 1= better price 2= good production 3= easy to operate 4= high disease tolerance 5= seeds availability 6=nonperishable 7= others (specify)

9. If you are not producing cash crops what is your reason? 1= lack of market 2=lack of pesticides 3=lack of storage facilities 4=lack of selected seeds 5=others\specify
10. Which of the food grain crops do you produce through irrigation?
Teff=1 Maize=2 Sorghum= 3 Chick pea= 4 Teff, 5= other specify_____
11. For how long you have been practicing irrigation farming? _____Years.
12. Distance of your irrigation farm from your dwelling house? _____km.
13. What is the approximate distance of main water source from your farm? _____km.
14. Which small-scale irrigation type do you practice?
1. Modern micro dam 2. Traditional 3.treadle pump 4 other (specify)

15. Do you get enough water for irrigation when required?

1= Yes 0= No

16. If no, what do you think are the reasons?

1= Water scarcity 2= Diversion by upstream traditional irrigators

3= Seepage loss 4= Illegal users in the scheme/water theft

5= I am tail-end irrigator 6= others (specify) _____

17. If not use irrigation, what is the reason for not using irrigation?

1= No irrigation land 2= No information about irrigation

3= Distance of homestead from the irrigation source 4= Tiresome 5= Lack of labor

6= Lack of interest 7= Distance from water source to farm land 8= others (specify)

Part Five: Agricultural technology utilization

1. Do you apply manure on your farmland? 1= yes 0= no

2. If your answer is no, why? 1= shortage of manure 2= alternative use of manure 3= labor shortage to handle & transport manure 4= others\specify_____

3. Do you apply fertilizer on your farmland? 1= yes 0= no

4. If yes, total area of land cultivated during last year on which fertilizer was used_____ (in hectare)

5. If no, Why? 1= cash shortage 2= fertilizer is not available 3= it is too cost 4= Not good for my farm 5= others (specify) _____

6. Have you ever used an improved seeds? 1= yes 0= no

7. If yes, please tell total area of land covered by improved seeds during the last one year_____ (in hectare).

8. If you do not ever used improved seeds, why? 1= too expensive to buy 2= not available 3= not better than the local ones 4= not heard or not aware 5= others (specify) _____

9. Have you ever used pesticides? 1= yes 0= no

10. If not, why? 1= too expensive 2= not available 3= not heard or not aware 4= others (specify)

Part Six: Institutional Factor

6.1 Credit access

1. Have you received any credit in the past one-year 2011 E.C? 1= Yes 0= No. if No please go to Q no 8
2. If yes, for what reason (s)? 1= Purchase of seeds 2= Purchase of fertilizer 3= purchase of oxen 4= for family consumption 5= others (specify) _____
3. When do you usually take the credit? _____ (months) 1= January 2=February 3= March 4= April 5=May 6=June 7= July 8= August 9= September 10= October 11= November 12= December
4. What are the sources of credit? 1= Amhara Credit and Saving Institution 2= Vision Fund 3= Friends 4= Government 5= Relatives 6=Other_____
5. Is there any credit service provided to purchase irrigation inputs? 1= Yes 0=No
6. If your answer is no, what is the reason? 1= No arrangement of Credit for irrigation 2= No responsible institution for providing credit for irrigation as per the time irrigation schedule
7. Are there any difficulties you faced due to absence of credit arrangement for irrigation? 1. Yes 0. No
8. If your response to question number 7 is 'yes', what are the reasons? 1= Shortage of money for purchase of inputs 2= Shortage of money for scheme maintenance 3= Shortage of money for hiring labor 4= other, specify _____
9. If no, why? 1= Lack of access to credit 2= No need for credit 3= High interest rate 4= Fear of ability to pay 5= Other_____

6.2 ACCESS TO EXTENSION PACKAGE

1. Is there an Agricultural Development Agent in your KAs? 1=Yes 0=No
2. If yes, how many times do you get advice from development agents?
 - a. once a per week, b. every 15 days, c. once a month d. once in three months e. others (specify).....
3. If your answer for question No. 2 is yes, during which operation? Multiple answer possible

Descriptions	yes	no
Applying agro-chemicals		
Watering		
Weeding		
land preparation		
Planting/ transplanting		
Harvesting		
Others (Specify)		

4. Is there any training organized by Development agents or Woreda agricultural experts organized last three months? 1= yes 0= No
5. If yes, in which topics you had been trained from the lists mentioned in the table below (see codes listed under the table).

Training topics	1. Yes 0. No	If yes, how many rounds you have been trained (numbers)	If yes, for how long you have taken (days)
Livestock production			
Fruits and vegetables			
Crop diversification			
Marketing			
Irrigation water management			
Post-harvest management			
Storage of farm produce			
Farm management			
Credit services			
Household food security			
Other, specify			

6. Did you have access market information from? 1= yes 0. no
7. Do you think the technical supports such as irrigation use/water use, raw planting, agricultural input use you got from the DA's are sufficient, up to date & helpful in developing your irrigation knowledge? 1= Yes 0= No

Part Seven: Crop output and sales

7.1. Please indicate the amount of food production you got from rain fed agriculture only in the last one year (2011/2012) in the table given below by using the above codes.

Crop type	Yield (Kg)	Value s (Birr)	For own consumption (kg)	Value s (Birr)	For sale (kg)	Value (Birr)	To others as payment for rent or gift (kg)	Values (Birr)	Total value (birr)

Variable codes:

White Teff=1 Maize=2 Sorghum= 3 Meng bean=4 Chickpea=5 Groundnuts=6 Sesame =7 Vegetables=8 Coffee =9 Khat=10 Bananas =11 Papaya =12 Avocado =13 Orange =14 Onion=15 Grass =16 other =99 (specify)_____

7.2. Please indicate agricultural product you got from irrigable land only in the last one year (2011/2012).

Crop type (see codes on part 7)	Yield (kg)	Value (Birr)	For own consumption (kg)	Value (Birr)	For sale (kg)	Value (Birr)	To others as payment for rent or gift (kg)	Value (Birr)	Total value (Birr)

7.3 Other sources of Income

1. Do you or your household members under take some additional income generating activities of off farm in the last one year? 1= Yes 0= No

2. If yes, indicate the income earned from other activities in the table below.

Source	1. Yes 0. No	Income obtained (Birr)
Non-farm employment		
Farm Work		
Hiring out oxen		
Renting/ Sharecropping outland		
Sale of fire wood /charcoal		
Petty trade (net profit)		
handcarts		
Livestock and livestock output trade		
Weaving		
Food aid		
Sales of livestock outputs (eg. Milk, Butter, chicken egg, and Honey)		

Part Eight: Household Consumption Expenditures (Food and Non-food consumption Expenditure)

1. Please fill your family food consumption and expenditure for the last 30Days consumption.

Please tell monthly expenditure of money value of each food items

Food group Item	Unit	Amount	Value in birr	Food Group item	Unit	Amount	Value in birr
Cereals				Oil & Fats			
Maize	Kg			Butter	kg		
Teff	Kg			Oil	kg		
Sorghum	Kg			Vegetables			
Rice	Kg			Onion	kg		
Barley	Kg			Tomato	kg		
Wheat	Kg			Sweet potato	kg		
Oats	Kg			Beetroot	kg		
Lentils	Kg			Cabbage	kg		
Pasta & Macaroni	Kg						
Pulses				Black Pepper	kg		
Beans	Kg			Carrot	kg		

Peas	Kg			Irish potato	kg		
Cow Pea	Kg			Coffee/ Tea			
Chick pea	Kg			Coffee			
Soybean	Kg			Tea			
Salt/sugar				Spices			
Salt	Kg			Meat			
Sugar	Kg			Milk and milk products			

2. Please also fill non- food expenditures of your family for the last one year (2011 E.C)

No	Item code	Expense in birr
1	Education	
2	Clothing including foot wear	
3	Transportation	
4	Medication	
5	Religious and cultural expense	
6	Livestock medication	
7	fuel and electricity	
8	Government tax	
	Social fund	

3. Household market and Information Access

1. Do you have market access to sell agricultural and non-agricultural business? 1. yes....., 0. No.....
2. Distance from market.....in km?
3. In what type of transportation system used to transport your product to market?
4. Do you have radio at your home? 1. Yes, 0. No.....
5. Do you have mobile access? 1. Yes, 0. No.....
6. If yes for what purpose do you use...?

Part Nine: Household food Security and Coping Strategy Mechanisms

Food Consumption Score (FCS) questions		
Could you please tell me how many days in the past week (7 days) your household has eaten the following foods?		
Food type	Food items	No. of days eaten over the past 7 days
Grains	Made of Maize	
	Made of Barely	
	Made of Wheat	

	Made of Teff	
	Made of Sorghum	
Tubers	Enset (Kocho)	
	Potatoes	
	Cassava	
Vegetables and leaves	Carrot and related	
	Cabbage	
Pulses	Bean	
	Pea	
	Haricot bean	
Fruits	Pineapple	
	Orange	
	Apple	
	Papaya	
	Banana	
	Others (specify)	
Meat and fish	Meat	
	Egg	
	Fish	
Milk related	Powder milk	
	Local Milk	
Sugar related	Sugarcane	
	Sugar	
	Honey	
Oil and fat	Processed oil	
	Butter	

A. Household Consumption based coping strategies			
In the past 7 days, was there a time your households use the following coping method as a response to food shortage	Yes	No	If yes, how often (number of days each is used)
In the past month, how often has the HH had to rely on less preferred or less expensive food?			
In the past month, how often has the HH had to borrow food, or rely on help from a relative?			
In the past month, how often has the HH had to purchase food on credit?			
In the past month, how often has the HH had to gather wild food, hunt, or harvest immature crops?			
In the past month, how often has the HH had to consume seed stock held for next season?			
In the past month, how often has the HH had to send HH members to eat elsewhere?			
In the past month, how often has the HH had to send HH members to beg?			
In the past month, how often has the HH had to limit portion size at mealtimes?			
In the past month, how often has the HH had to restrict consumption by adults in order to allow children to eat?			
In the past month, how often has the HH had to reduce the number of meals eaten in a day?			
In the past month, how often has the HH had to skip entire days without eating?			
B. Other coping strategies			
The past one year period as a response to problems/shocks/facing your household such as food shortage?			
Desperate migration			

Sold reproductive animals (not excess ones)			
Sold Oxen used for farming			
Sold land			
Rented out land			
Remove children from school			
Borrowed money at high interest rate			
Consumed seed stock held for next season			
Reduced number of meals			
Selling small animals			
Migration to nearer areas for wage labor			
Drawing on savings			
Selling firewood			
Selling nonproductive assets			
Diverting loan from microfinance institutions			
Appeal for food aid			

A. Key Informants for Experts

1. How do you explain the socioeconomic and living condition of the study area?
2. What are problems associated with irrigation development activities in your area?
3. What are the possible social economic and environmental problems in the study area?
4. What do you think the limitation of woreda/Woreda in relation to irrigation development?
5. What interventions should be taken for better implementation of modern irrigation technologies?

B. Checklist for focus group discussion

6. Is there a shortage of availability of food in your kebele in the past 12 months? If yes, in which year or month people in this kebele face? How do they solve this problem?
7. What are the determinant factors that affect household food security in your kebele?
8. What is your general opinion on the role of small-scale irrigation to household food security?
9. What are the major factors constraining irrigation activities in your area?

10. Is there any difference food security status between irrigator and non-irrigator? What is the difference between these two groups?
11. Is there any difference in diet diversity between irrigation use and non-user? What is the difference?

ANNEX B: Cronbach's Alpha results

Table Annex B1: Cronbach's Alpha results

Cronbach's Alpha	Cronbach's Alpha based on Standardized Items	Number of Items
0.871	0.852	21

$$\alpha = \frac{k}{k-1} \left(1 - \frac{1}{S_T^2} \sum_{i=1}^k S_i^2 \right)$$

Table Annex B2: The Alpha Cronbach's Value (Konting et al, 2009)

Cronbach's alpha	Internal consistency
$\partial \geq 0.9$	Excellent
$0.9 > \partial \geq 0.8$	Good
$0.8 > \partial \geq 0.7$	Acceptable
$0.7 > \partial \geq 0.6$	Questionable
$0.6 > \partial \geq 0.5$	Poor
$0.5 > \partial$	Unacceptable