COLLEGE OF DEVELOPMENT STUDIES

CENTER FOR FOOD SECURITY STUDIES

DETERMINANTS OF SMALL SCALE IRRIGATION PARTICIPATION DECISION AND ITS IMPACT ON HOUSEHOLD FOOD SECURITY IN LUME DISTRICT OROMIA REGION

BY
NIMAJE WORKU

A THESIS SUBMITTED TO CENTER FOR FOOD SECURITY STUDIES, COLLEGE OF DEVELOPMENT STUDIES ADDIS ABABA UNIVERSITY

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN FOOD SECURITY AND DEVELOPMENT STUDY

JUNE, 2022
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DECLARATION

I, the undersigned, declare that this thesis is the result of my own work and that all sources or materials used in this thesis have been properly acknowledged. I confidently declare that this thesis has not been submitted to any other institutions anywhere for the award of any academic degree.

Declared By:

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Date: ____________________

I certify that the above declaration made by the candidate is correct to the best of my knowledge as an advisor.

Advisor Confirmed

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Signature:

Date: June 12/2022

STATMENT OF CERTIFICATION

This is to certify that the thesis prepared by Nimaje Worku entitled "**Determinants of small scale irrigation participation decision and its impact on household food security in lume district Oromia Region"** and submitted in partial fulfillment of the requirement for the degree of master of science in food security and development, complies with the regulations of Addis Ababa University and meets the accepted standards with respect to originality and quality.

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External Examiner: ______________________Signature ___________Date ______________

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Advisor: ______________________________ Signature ___________ Date______________

Name of Chairman _____________________ Signature ___________ Date______________

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Table of Contents

Contents **Page**

List of Tables

Page

List of Figures

Page

List of Abbreviations

ADLI	Agricultural Development Led Industrialization
ATT	Average Treatment on the Treated
CSA	Central Statistical Agency
GDP	Gross Domestic Product
MoA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
SSI	Small-Scale Irrigation
WFP	World Food Program
DA	Development Agent
FANTA	Food and Nutrition Technical Assistance
FAO	Food and Agricultural Organization
GoE	government of Ethiopia
FCS	Food Consumption Score
HFIAS	Household Food Insecurity Access Scale
IFPRI	International Food Policy Research Institutes
MoARD	Ministry of Agriculture and Rural Development
OIDA	Oromia Irrigation Development Authority
PSM	Propensity Score Matching
TLU	Tropical Livestock Unit
SSI	Small-scale Irrigation

Abstract

Small-scale irrigation is one of the most promising approaches to enhance smallholder farmers' livelihood enabling to produce twice or more per year. However, there are still farmers who are not participating irrigation, and depend on rain fed agriculture even if there is the access for irrigation in the area. The study area, Lume district, is one of the potential districts for irrigation having more than 4120 hectares of land suitable for irrigation. Despite the potential, farmers in the district are not participating in irrigation to the expected level. This study was intended with the main objectives of assessing factors affecting smallholder farmers' participation in irrigation, and the impacts of small-scale irrigation on farm households' food security. Both primary and secondary data were used. The primary data were collected from 112 non participants, and 77 participant households were selected using simple random sampling. Inferential and econometric data analysis methods were employed. Demographic, institutional, and socio-economic factors were summarized using Inferential statistics, and to identify determinants of decision of households to participate in irrigation logistic regression model was used and based on the result, age of the head, family size, livestock holding, crop failure, land rent out, extension contact, and credit access significantly affected household decision to participate in small scale irrigation. From the result of propensity score matching method, family members of participant households have more food consumption score of 3.5 compared to family members of non-participants, and this difference is statistically significant. The sensitivity analysis proved that the estimated average treatment effect on the treated was insensitive to unobserved bias. Therefore, the estimated ATT is the pure impact of participation in irrigation. Based on this result, policy interventions related with improving the hindering factors that affecting irrigation participation decision are recommended which intern improves households' food security.

Key words: *Impact, Small-scale irrigation, Food security, Lume district, PSM*

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Food insecurity, Huger and undernourishment are on rising over the world. Following the eight Millennium Development Goals seated in 2000 to eradicate extreme poverty by 2015. Hanger steadily declined and the number of undernourished people also decreased. Following this, the world signed new set of Sustainable Development Goals (SDGs) to end hunger, achieve food security and improve nutrition and promote sustainable agriculture by 2030. But, from 2019 to 2020, the number of undernourished people increased overwhelmingly making the achievement of the goal questionable. Climate change and conflicts mentioned as a driven factors (WHO, 2020).

According to the report of FAO (2018), above half of the global acutely food-insecure people were in Africa. In 2017, Among 257 million hunger population of Africa, about 237 million were in sub Saharan Africa. Ethiopia is among the poorest countries in the world, at the rank of 173rd out of 189 countries (UNDP, 2018), having 105 million people estimated for 2017 (World Bank, 2019) with an annual per capita income of USD 850 (World Bank 2019). About 22 million people were below the national poverty line during 2017. And more than 8.1 million people were seeking food assistance during 2019 (FAO, 2019).

Agriculture is the leading sector of the country's economy; however, it is not beyond its subsistence level yet. The most mentioned driven factors for this are steak with rain-fed agricultural production, fragmented landholding, environmental factors, population growth, lack of access to new agricultural technologies, using traditional way of cultivation, and low support from rural institutions, are the most common reasons (MoFED, 2012).

Agricultural Development Led Industrialization (ADLI) national strategic plan was developed in 1991 to bring overall development and enhance the subsistence farming system of the country that was also aimed to focus on irrigation development, improve cooperative societies and enhancement of agricultural technologies. According to Damtew (2017) small-scale irrigation development is one of the major strategic interventions to increase agricultural production and productivity in the rural areas of Ethiopia.

Irrigation is one of the ways of increasing agricultural production to address the growing food need in Ethiopia. Small scale irrigation is one of the most promising approaches to enhance smallholder farmers' livelihood. (Jirane 2015). It helps the farmers to increase their purchasing power of farm inputs which led to invest more on their production and bring over all enhancements of rural livelihoods Temesgen (2017)

Oromia is one of the ten regional states in Ethiopia with its surface area of 359.620 square kilometers, constituting about one third of the total area of the country, the region has about 1.7 million hectares of land suitable for irrigation. However, only 800,000 hectares were irrigated yet and the trend of production and productivity is not rising to change this and to ensure food security in the region in line with this, the regional government has planned to utilize the exiting irrigation potential focusing on small scale irrigation (OIDA, 2014).

The study area, Lume district, is one of the districts in Oromia region, east shewa zone. Small-scale irrigation is being practiced officially since 2012. The study area has more than 4120 hectare potential cultivable land suitable for irrigation with different water sources including river, lake and easily constructed shallow well. Following this, certain farmers practice small scale irrigation by constructing irrigation scheme in order to increase production and productivity, and increase income and for overall development. Based on the information obtained from district agriculture and rural development office, it is not surprising to see farmers not willing to participate in irrigation practice using the potential of the area. And such a study on the determinants of irrigation participation decision and on its impact of using irrigation on household food security has not been conducted in the area, and was found demanding to help encourage all potential smallholder farmers benefit from the service.

1.2 Statement of the problem

In developing countries like Ethiopia irrigation agriculture has a significant direct and indirect impact on farm household's income, agricultural problem production and productivity and food security.(Mengistie and Kidane, 2016).Irrigated agriculture can be mentioned as a way to improve food security by reducing rainfall risk and improve production which led to increasing income of households and can increase food access and availability. Therefore, irrigation can be viewed as a promising approach to ensure food security even under the pressure of population growth and climate variability (Passarelli et al., 2018).

Agricultural production is predominantly dependent on rainfall in Ethiopia. Rainfall dependency kept the country's economy from the sector vulnerable to climate related impact on the crop production which led to frequent famine and food shortage. (Molla, 2017).According to Awulachew et al. (2010), in 1990, Ethiopia had total area of 161,000 ha of irrigated agriculture, from that 64,000 ha were under small-scale schemes, 97,000 ha were in medium-and large-scale schemes and approximately 38,000 ha were under implementation. This had grown to more than 247,000ha by 2004, with traditional irrigation schemes alone covering more than 138,000 ha. As a result, the Ethiopian government gives more emphasis to small scale irrigation as a means of achieving food security (MoFED, 2014).

According to OIDA (2014), Oromia region is rich with huge amount of irrigation potential water and land resources. From the 1.7 million hectares of irrigable land, only 800,000 hectares (47.05 percent) were irrigated yet both in traditional and modern schemes. The study area Lume district has 4120 hectare potential of cultivable land suitable for irrigation and different water sources like river, lake with easily constructed shallow well. According to OIDA (2014), the regional government planned to use this potential because of the growing concern over food security. The study district also started to use the irrigation to ensure food security and increase production and productivity. About 3913 households are known to have the practice and employ irrigation out of the planned population about 5000.There are still farmers who are not participating irrigation, and depend on rain fed agriculture even if their is the access for irrigation in the area. To fill this knowledge gap, this study focused on studying factors affecting smallholder farmers' participation in irrigation agriculture and impacts of small-scale irrigation schemes on farm household food security.

1.3 Objectives of the Study

General objective

This research aims to assess the determinants of small scale irrigation participation decision and its impact on household food security in lume district oromia region

Specific objectives of this study

- To identify factors affecting household participation on small-scale irrigation in study area.
- To analyze the impact of small-scale irrigation on household food security in the area.

1.4 Research Questions

1. Are irrigating farmers food secures than non-irrigating farmers?
2. Does use of small scale irrigation have any impact on food security of the household?
3. What are the factors that affect irrigation participation in the study area?

1.5 Significance of the Study

The finding of this study can help to understand and identify the determinant factors that hinder household's participation decision in small scale irrigation and the impact of small scale irrigation on household food security in the study area and gives baseline data to address the factors with policy interventions. The findings of this study can also be used as a reference for policy makers and agricultural development planers and concerned bodies on irrigation development for household food security. And also it can provide initiative idea for researchers to conduct further research.

1.6 Scope and Limitations of the thesis

The objective of this study is to assess the impact of small-scale irrigation on rural household food security. The study is conducted in one district, and purposively selected three kebeles this cannot let for generalization at regional level. The study used cross sectional survey and only describe food security status and irrigation participation of one season. The data collection was difficult as the study is conducted in rural area infrastructure and the willingness of the respondents was bothered the data collection.

1.7 Organization of the study

This thesis is organized in five chapters. chapter one contains background of the study, statement of the problem, objectives of the study, significance of the study and scope and limitation of the study, chapter two contains review of literatures concerning concepts of small-scale irrigation, methods of measuring food security, impact assessment methods and empirical literature reviews on the impact of irrigation on household food security are discussed. The third chapter presents the description of the study area, types, sources and methods of data collection, and methods of data analysis. In chapter 4, the findings on the socio-cultural and demographic characteristics of sample households, factors affecting household participation in small scale irrigation, and impacts of irrigation on household food security were presented. Finally, chapter 5 presented summary, conclusion and recommendations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Theoretical Literature Review

2.1.1 Definition and Concepts of Food Security

According to FAO (2014), food security is defined as situation when people, at all times, have physical and economic access, safe and nutrition food to meet their dietary needs and food preferences for an active and healthy life. According to this definition, there are four important pillars of food security: availability, access, utilization and stability.

Food availability means when food is physically exists through different ways it can be grown, processed, manufactured, etc. **Food access** means the way people gain available food from home production, purchase, borrowing, food aid, etc. **Food utilization** is a way of how people consume food with respect to the food quality, preparation method, and way of storage, health status of the users and knowledge of nutrition value of the food they consume. FAO (2014), and **Food Stability** refers to be the sustainability of all the above mentioned three pillars at all time. It refers to when people has both access and food availability without fear of losing as a result of natural disaster or economic factors (FAO, 2014),

House hold food security is access to safe and sufficient food needed for healthy life for all its members and when it is not at risk of losing such access (FAO, 2003).**Food insecurity** is a condition people lack economic and physical access to safe, nutritious and sufficient food that demanded to obtain active and healthy life (FAO, 2003).

2.1.2 Household Food Security Measurement

According to Maxwell et al (2008) food security measurements can be dietary diversity and food frequency and consumption behaviors. Food frequency and Dietary diversity take the number of different kinds of food or food groups that people consume and the frequency with which they consume them to be significantly correlated with caloric adequacy measures while consumption behavior measures take food security indirectly, by measuring the behaviors which related to food consumption.

There are different methods to measure food security at household level: some of them are; Dietary diversity index, Food consumption score, Individual dietary intake, Household food insecurity access scale and copying strategy are the most commonly used measurement methods.

2.1.3 Household food consumption score (FCS)

The Food Consumption Score (FCS) is a commonly used indicator of food access measuring tool that created by world food program. Food consumption score calculated by using a data collected from food items eaten by a household within 7 days before the data collection and the foods will be grouped into eight food groups and the weight of each food groups(which has been determined by WFP in 2008 based on the nutritional content of the food group) multiplying by frequency of food eaten and sum up all the scores. as described below

FCS=$a \times f$(staple)+$\beta \times f$(pulse)+$\gamma \times f$(vegetables)+$\gamma \times f$(fruit)+$\delta \times$f(animal)+$\times f$(sugar)+$\delta \times f$(dai

ry)+$\times f$(oil)

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, β, γ, $\delta$and = weight/nutritional value of each food group.

According to (WFP, 2008), And based on the result households who score 0-28 will have poor food consumption score and score between 28.5-42 will be borderline food consumption and above 42 will be adequate food consumption.

2.1.4 Household dietary diversity score (HDDS)

Household dietary diversity score is an access indicator revealed in 2006 by FANTA II Project as described by recording the number of food groups consumed by a household within 24 hours. (Kennedy et al., 2011)A diversified household diet is related with protein adequacy, caloric intake, and household income (Swindale & Bilinsky,2006).

2.1.5 Household hunger scale (HHS)

This method is appropriate to use to measure food security for the population in a higher level of hunger, since it used to measure the severity of household food insecurity. This method is estimated by using the perception of the household about the varying degree of hunger by asking tree questions. And, their perception is measured from the number of times experienced hunger during the past 30 days before the survey day. This scale is used in monitoring the progress of the implementation of programs, policies and for warning about food and nutrition security (Ballard et al. 2011).

2.1.6 Individual's daily calorie intake (DCI)

Individual daily calorie intake method is allows to measure food security at individual level and this let us to compute intra household food security status this makes the method different from other household food security measuring methods. This method can be measured by using different ways these are 24-hour recall method, individual food records method and using questionnaires of food frequency. The most common way is the 24 hour recall method. The drawback of the 24 hour and the food frequency questionnaire methods is that they depend on the memory of respondents and the recording of foods method requires individual's ability of recording consumed food. (Pérez and Segall, 2008).

2.1.7 Household Food Insecurty Access Scale (HFIAS)

HFIAS is a measure developed by Food and Nutrition Technical Assistance Project (FANTA)in 2006. For the measurement of household food insecurity in a comparable way, like with cross-cultural considerations. The tool works by using nine occurrence questions and nine frequency-of-occurrence questions. The HFIAS occurrence questions asked if a specific condition related with food insecurity experience ever happened in the previous 30 days before the survey. Based on the information get from HFIAS households can be categorized into four levels of food insecurity: food secure, mildly food insecurity, moderately food insecure and severely food insecure.

2.1.8 Concepts of irrigation

Irrigation is artificial water application to plants for agricultural production to overcome rainfall variability and for sustainable agricultural production (FAO, 2005). Irrigation agricultural is one means used to increase food production to answer the food need in Ethiopia. Small-scale irrigation can be defined as a production on small plots up to less than 200 hectares in which small holder farmers can controlled by themselves using a technology that they can operate easily.(FAO, 2003).

2.1.9 Irrigation based agricultural development strategies in Ethiopia

Irrigation Agriculture development has been a priority for the Ethiopian government since 1991 promotion of small-scale irrigation (SSI) is identified as one of the priority policies for improvement of food production and insuring food security in Ethiopia (MoFED, 2010).following this, huge efforts and investments have been done to increase the irrigated area. As major strategy of the Growth and Transformation Plan of Ethiopia, the SSI development was increased rapidly from 853,100 ha in 2009/10 to 1,853,100 ha in 2012/13 (MoFED, 2014) which shows the government's hard work on the sector.

2.1.10 Irrigation potential of Ethiopia disaggregated by river and ground water

According to Awulachew (2010) Ethiopia has 12 river, 11 fresh and 9 saline lakes, 4 crater lakes and over 12 major swamps or wetlands and the total surface area of these natural and artificial lakes about 7,500 km2 potential suitable for irrigation. Compared to the surface water potential the ground water potential of Ethiopia is low even if there is no enough knowledge on the real ground water resources based on the above estimated potential it is higher when compare to many countries of total exploitable groundwater potential

2.1.11 Challenges and Opportunities in the development of Irrigation in Ethiopia

The main challenges and opportunities for the development of small-scale irrigation in Ethiopia is listed as followed: According to the Awulachew (2010), the main challenges mentioned most of the time are lack of adequate knowledge about irrigation water management ,lack of basic technical knowledge on operating pumps, drip and sprinkler irrigation systems. These are the most commonly mentioned challenges of SSI in Ethiopia.

Basic concepts which can be mentioned as an opportunity regarding irrigation developments in Ethiopia are the government gives priorities to irrigation in the growth and transformation plan of the country and also the government encouraged private sector and public enterprises involvement in irrigation development, above all the abundant water and land resources of the country, and climate suitability, availability of labor, suitable for irrigation developments more at arid and semi-arid areas of the country mentioned as a good opportunity for irrigation development.

As a future plan for irrigation development of Ethiopia, the Ethiopian Irrigation Development Plan (IDP) plans to emphasizes the development of small-scale irrigation by giving highest priority for capacity-building in the study, design, and implementation of irrigation projects. And also the country has designed a Water Sector Development Program (MoWR, 2010). With the aim of developing irrigation in small scale and medium scales. By the end of the water sector development program (WSDP), the total area under irrigation expected to be 5.1Million ha by next two decades (Awulachew, 2010).

2.1.12 Irrigation Development and Food Security in Ethiopia

Irrigated agriculture started in Ethiopia in the 1960 by diverting water from rivers in the dry season with the objective of producing industrial crops (sugar and cotton) on large-scale basis and for the production of subsistence food crops as traditional irrigation. The modern small scale irrigation (SSI) development and management trend were started in the 1970s by the Ministry of Agriculture (MoA), driven by major droughts, which caused wide spread crop failures and led to frequent starvation (Teshome, 2006).According to MoWR (2010) the irrigation potential of Ethiopia is expected at about 2.7 million ha, considering the availability of water and land resources, technology and finance.

Irrigation development is vital to the sustainable and reliable agricultural developments in subsistence dominated smallholder farmers' economy and to meet the growing food demands of rapid population growth in Ethiopian. Similarly, irrigation agriculture development is going to be a best way to increase agricultural production(MoA, 2011b).

Irrigation development in Ethiopia can be considered as a foundation of food security and poverty reduction tool as it has a power to boost economic growth and ensure rural developments. As a result, irrigation infrastructures are progressing nowadays, which show countrywide development implications in small- and large-scale irrigation schemes (Hagos et al., 2012).To bring sustainable and reliable food security development one of the best alternatives is considered to be expanding irrigation development on various scales and through different techniques (Awulachew et al., 2010).

2.1.13 Small scale Irrigation contribution on Household Food Security

One of the best methods to grow smallholder agriculture and so help reduce poverty is to invest in smallholder irrigation. Countries like Bangladesh, where development in public sector-funded canal irrigation and private sector-funded tube-well irrigation have played a prominent role, have shown how irrigation contributes to the reduction of poverty. Shaha T. (2003) conclude that Smallholder agriculture intensification can help reduce poverty and promote agricultural growth by increasing sustainable management and productivity of land and water in sub-Saharan Africa Irrigation development benefits the rural poor in various ways including (a) a decrease in food prices as a result of more output; and (b) increased work both on and off farms generating cash for the poor So irrigation helps ensure the availability of foods.

The expansion of small-scale irrigation schemes was taken as the main development strategy in order to reduce crop failure due to drought and erratic rainfall conditions in Ethiopia by preparing a National Medium-Term Investment Program (NMTIP) for Water Sector Development Program (WSDP) for 15 years (2002-2016)(WFP, 2008).

Both irrigated and rain-fed agriculture is important in the Ethiopian economy by reducing poverty and promoting food security. Virtually all food crops in Ethiopia come from rain-fed agriculture with the irrigation sub-sector accounting for only about 3 percent of the food crops. Most of the time exporting crops like coffee, pulses and oilseeds are under rain-fed, but most industrial crops like sugar cane, cotton and fruit under irrigated agriculture and other important irrigated crops produced by irrigation divided in different scales these are like vegetables and fruit trees in medium- and large-scale schemes and maize, wheat, vegetables, potatoes, sweet potatoes and bananas in small-scale schemes. There is a marked value added in irrigated agriculture (Getaneh, 2011).

Moreover, irrigation development in Ethiopia is considered to be an important investment for improving rural household food security status through increased agricultural production and for reducing the pressure on currently cultivated land by bringing unused land under cultivation. The rapidly rising food needs due to increasing population and progressively shrinking per capita agricultural land availability, warrants the intensification of cropping systems in the country. To cope with both population growth and limitation of agricultural production, irrigation development is identified as a vital strategy for food security and alleviating rural poverty. In this regard most small-scale irrigation systems that involve effective management and institutional support from the local government are likely to be successful in contributing to poverty reduction and household food security (IFPRI, 2011).

Although Ethiopia has abundant rainfall and water resources, the agricultural system is not fully utilizing technologies of water management and irrigation. Improved water management for agriculture has many benefits in efforts to reduce vulnerability and improve productivity such as increase productivity of land and labor, reduced reliance on rainfall, reduced degradation of natural resources, increased job opportunities, and promotion of a dynamic economy with rural entrepreneurship (Nega, 2012)

2.2 Empirical Literature Review

2.2.1 Determinants of household participation in small-scale irrigation

Regassa (2015), by using logistic regression model conclude that; farm experience, total livestock holding and distance from district market are negatively and significantly affected farmers irrigation participation decision, and income, farm input, participation in cooperatives, age and sex are positively and significantly affect irrigation participation.

According to Agerie (2013) distance from the nearest market, education level of household head, total livestock holding, distance to water sources, access to information, family labor, access to credit and gender of household head were found significantly affected participating in small scale irrigation scheme by using probit model.

As a research result of Haji et al. (2013) using logit model found that dependency ratio, family size, size of land holding and education of household head were significantly affected household participation decision in small scale irrigation scheme. Owusu et al. (2011) also found that farm land size and age of the household are significantly and positively related with the farmers' decision to participate in irrigation.

2.2.2 Impacts of small-scale irrigation on household food security

Hadush (2014) by using Propensity Score matching method conducted research in Tigray region and confirmed presence of important and significant differences between farm households who

did and did not adopt micro irrigation technologies. Elemo (2014) the logit model results indicated that age of household heads, total size of cultivable farmland, farm insect and pest infection and distance of irrigated farm land from the main road were found negatively and significantly affect utilization of small-scale irrigation water. While, education level of household heads, access to improved technology, number of oxen owned and total active family labors were positively and significantly related with utilization of small-scale irrigation water.
Gadisa (2020) by using binary logistic regression model found that distance of the irrigation scheme, number of livestock holding, total annual income, access to market information, dependency ratio, age and sex of household head were found to be the determinants of small-scale irrigation scheme use and the development of small-scale irrigation positively impacted food security of beneficiary households.

Haileyesus (2019), by using Tobit model conclude that age of the household head and crop disease are found to affect food security negatively, access to extension services, land holding size, livestock ownership and market access are positively affected food security status of households.

2.3 Conceptual Framework of the Study

Based on the empirical results all the determinant factors can be categorized in five major categories these are: demographic factors (Sex of household head, age of household head, education level of household head, family labor and dependency ratio), socio-economic factors (cultivated land size, livestock holding and non-farm income) institutional factors (distance to the nearest market, distance from water sources, contact with development agents and access to credit) and other factors (crop failure and land rent out) are all very essential. Small scale irrigation has direct and indirect benefit for livelihood enhancement of farm households and improves food security status. Accordingly, small-scale irrigation development creates employment opportunities, increases consumption expenditure and accumulating assets (Torell and Ward, 2010).

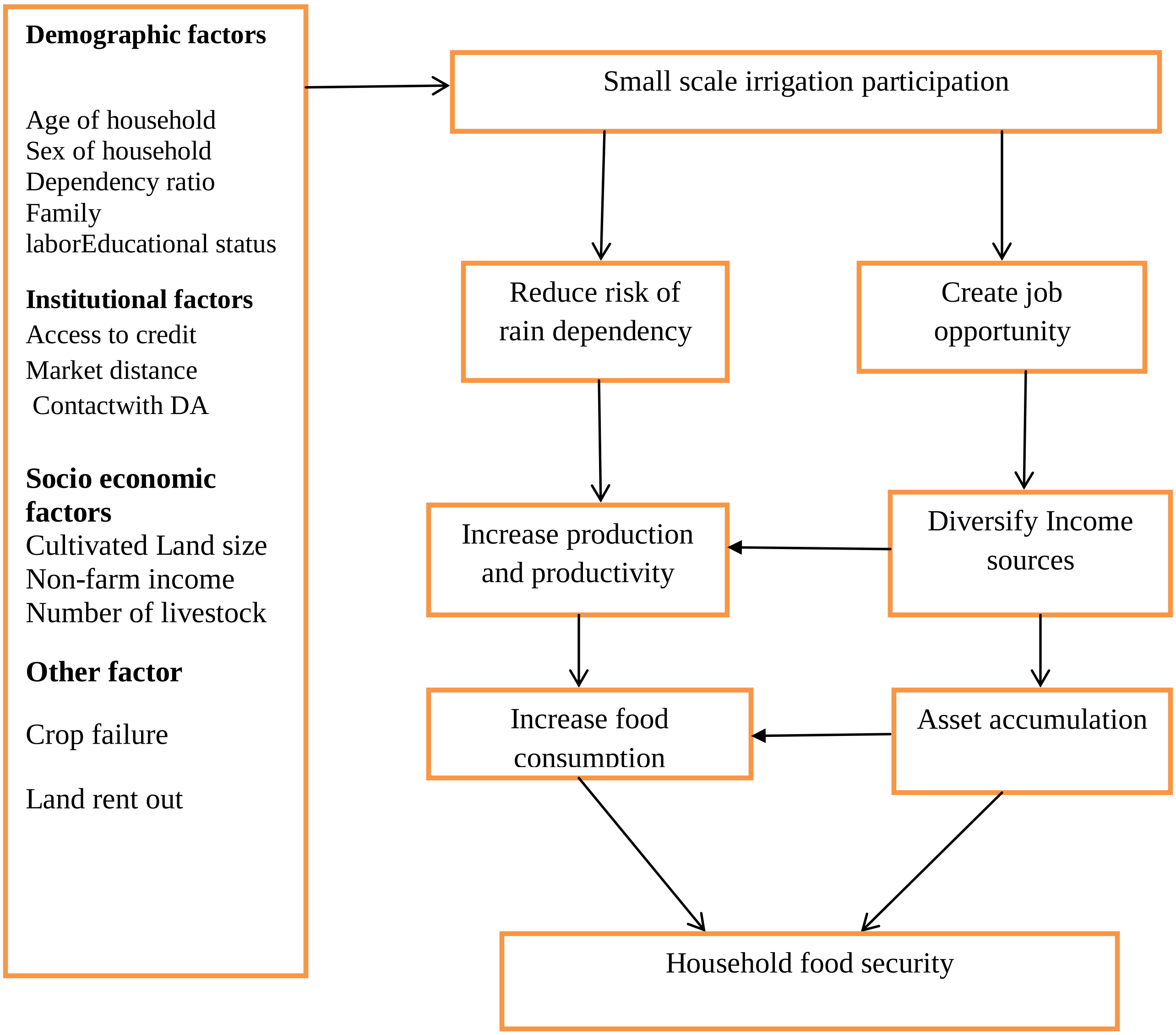

Figure 1: Conceptual framework of the study

Sources: Adapted and modified from Molla (2017)

CHAPTER THREE: METHODOLOGY

3.1 Description of the study area

3.1.1 Location

Lume district is located in East Shewa Zone Oromia Region. Lume woreda is located 25 km to the west of the regional capital, Adama. It is located between $8^0$12' to 8^0 50' latitude and between 39^0 01' to 39^0 17' longitude. The area has wide range of altitudes from 1500 to 2300 meter above sea level., including a small portion in the northern part, excide over 2300. Abrham Feyissa. (2009).

3.1.2 Climate condition of the area

Agro- ecologically, the study district is classified as moist woinadega (30%), dry woinadega (45%) and kola (25 %). The major soil type of the Woreda is vertosol and the monthly temperature ranges 22^0C to 34^0C, with annual averages ranging from 750mm to 1100mm, uni-modal rainy season which falls between June to September (Fikru Tesfaye, 2008).

3.1.3 Socio economic condition of the area

According to the 2007 national census report, the total population of Lume district is 117,080, with 60,125 men and 56,955 women; and there are about 14,576 total households. About 34% of its population were urban dwellers. A land survey in the district shows that 55% of the land of the area is arable, 3% pasture, 2% forest, and the remaining 20% is considered degraded. Vegetables are important cash crops in the area (CSA, 2012). Koka Lake is the major lake which gives economic importance by irrigation production in the district that mainly used during the dry season for the production of horticultural crops, mainly vegetables

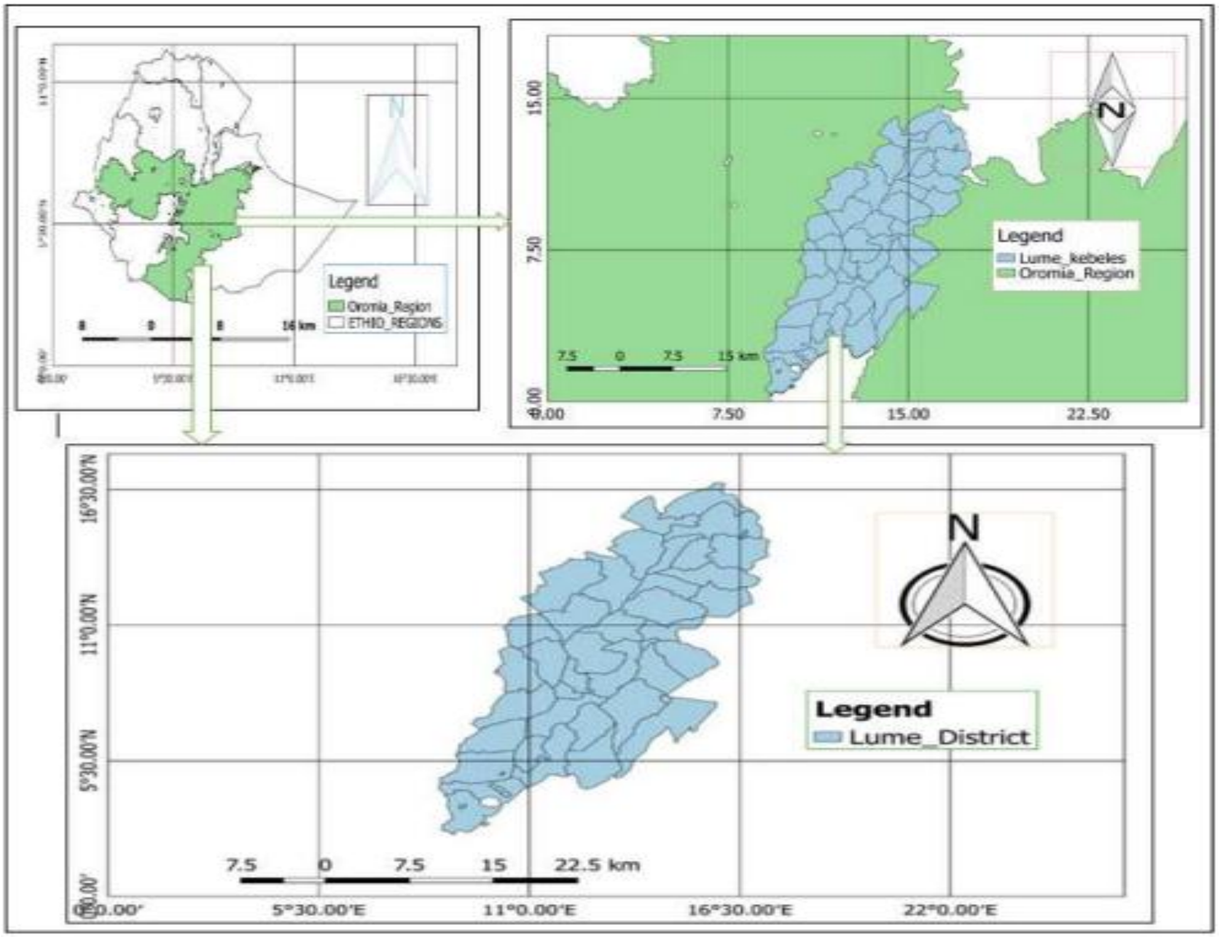

Figure 2: Map of the study area

Source: Adopted from the work of Hailu (2021)

3.2 Research Design

The research design was cross-sectional survey conducted at a single point in time and with both quantitative and qualitative instruments over a study population.

3.2.1 Sampling Technique and Procedure

The sampling procedure for this study is a multi-stage sampling procedure. In the first stage, the study district selected purposely where irrigation is accessible and well-practiced. Secondly three kebeles were selected randomly which have access to irrigation. Thirdly sample households were selected using systematic random sampling.

Yamane formula was implemented to decide the required number of samples. Mathematically, Yamane formula can be expressed as:

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

Where n= sample size

N= the population size

e = the level of precision (0.07)

Based on the data obtained from the district agricultural administrator, the total farm households in the three kebeles is 2467. Therefore,

$$n = \frac{N}{1+N(e)2} = \frac{2467}{1+2467(0.07)2} = 189$$

A Sample of 189 was taken from the sampled kebeles based on proportional sampling and the sample selected from each kebele proportional to the population in each Kebele using the following formula:

$$ni = \frac{(Ni)(n)}{\sum Ni} \text{..........} 2$$

Where ni - the sample to be selected from i^{th}kebele

Ni - the total population living in i^{th}kebele.

ΣNi - the summation of population living in selected four kebeles

n - total sample size for the district

Finally, sub-samples from the three Kebeles for each stratum was described in the table below by taking the number of users (treatment group) and non-users (control group).

Table 1: Sample size distribution

Kebeles	Total Households	Proportion	Sample Size	participants	Non participants
Dungugi	961	39%	74	30	44
Koka	563	23%	43	18	26
Ejersa	943	38%	72	29	42
Total	2467	100%	189	77	112

Source: District office of agriculture and own computation result

3.2.2 Data Types and Data Collection Techniques

Both primary and secondary data was used in this study. Primary data were collected directly from the respondents.

3.2.3 Primary Data Collection Techniques

Primary data was collected using different data collection techniques like household survey, Focus Group Discussion and Key Informants interview.

Household survey

Household survey was undertaken by using structured questionnaire to generate quantitative and qualitative information at household level. The questionnaire was initially prepared in English and translated into the local language as it is needed (Afan Oromo and Amharic).Enumerators were employed based on their experience on data collection and knowledge of local language. Training was provided to the data collectors to make the questioner clear to let them and make them know how to ask the respondents.

Focus Group Discussions (FGD)

FGD was conducted to understand about the effect of small scale irrigation on household food security and factors affecting household participation in irrigation. The FGD participant was selected from each purposely selected kebeles. One FGD was conducted in per kebele. The total numbers of members in one FGD was 6-8 participants. Participants from each kebeles were selected randomly from both irrigation users and non-users

Key Informant Interview

Additional information was collected from key informants. The interview was managed with key informants from the three selected kebeles development agents, and model farmers.

3.2.4. Secondary data source

Secondary data were collected from both published and unpublished documents, journal articles, books, statistical abstracts, study reports and thesis. These sources of secondary information was be accessed from the internet, institutions and organizations.

3.3. Techniques of data analysis

Both descriptive statistics and econometric models were employed to analyze the data. STATA V17 was the package used for data analysis. The descriptive statistics were used to summarize socioeconomic, demographic and institutional variables. Logistic regression model was chosen in this research to analyze factors affecting farmers' choice to engage in small-scale irrigation, food security food consumption score (FCS) used as independent variable in logistic regression and propensity score matching (PSM) was the method used to estimate average treatment effect on the treated (ATT).

3.3.1. Model description

Irrespective of its shortcomings, propensity score matching (PSM) method was used to measure the impact of small-scale irrigation on households' food security. It is chosen among other non-experimental methods because it does not require baseline data, the treatment assignment is not random and considered as the best alternative to experimental methods in minimizing selection bias. PSM also attempts to balance treatment and control groups on a large number of covariates without losing a large number of observations.

Furthermore, the Propensity score matching approach aims only to compare households that lie in the common support and exclude others from the analysis. PSM compares observations and does not rely on parametric assumptions to identify impacts of projects. PSM also has some limitations such as it requires large sample, group overlap and hidden bias may remain because it's matching only controls for observed variables. It attempts to estimate the average impact of treatment on treated/ATT (Haile, 2008).

The Propensity score is defined as the probability of receiving treatment based on measured covariates. $E(x) = P\ (D=1 \mid X)$ …………………………………………………………………..…….. 3

Where $E(x)$ = propensity score, P = probability,

D=1 a treatment indicator with values 0 for control and 1 for treatment

"|" = is a symbol stands for conditional on (predicted), and X = is a set of observed covariates.

3.3.2. Steps in propensity score matching

PSM has five steps: estimation of the propensity scores, choosing a matching algorithm, checking for common support region, testing the matching quality and sensitivity analysis Kopeinig (2008).

Estimation of the propensity Scores

The first step in PSM method is to estimate the propensity scores. A logit model was used to estimate propensity scores using pre-intervention characteristics of the sampled households and matching conducted using propensity scores of each sample observation. In estimating the logit model, the dependent variable was irrigation participation that is users of irrigation, which takes the value of 1 and 0 otherwise.

Choosing the Matching Algorism

According to Caliendo and Kopeinig (2008) there are many matching criteria which can be used to allocate participants to non-participants on the basis of the propensity score by calculating a weight for each matched participant-nonparticipant set. The most commonly applied matching estimators are Caliper and Radius Matching, Nearest Neighbor Matching, Kernel and Local Linear Matching, Stratification and Interval Matching. Therefore, one of the matching algorithm among matching estimators is selected the algorism which has the highest matching sample size, with low R^2 value and high matching covariates (Dehejia and Wahba, 2002). The choice of a particular matching technique may therefore affect the resulting program estimate through the weights assigned as discussed below:

The Nearest Neighbor Matching Method: One of the most frequently used matching techniques is nearest neighbor matching, where each treatment unit is matched to the comparison unit with the closest propensity score. One can also chose nearest neighbors and do matching (usually n = 5 is used). Matching can be done with or without replacement. Matching with replacement, for example, means that the same nonparticipant can be used as a match for different participants.

The Radius Matching Method: One problem with nearest neighbor matching is the propensity score difference between a participant and its closest nonparticipant neighbor and that may still be very high difference between them. This situation results in poor matches and can be avoided by imposing a threshold or “tolerance” on the maximum propensity score distance (caliper). This procedure therefore involves matching with replacement, only among propensity scores within a certain range. A higher number of dropped nonparticipants are likely, however, potentially increasing the chance of sampling bias.

Kernel Matching Method: One risk with the methods just described is that only a small subset of nonparticipants will highly satisfy the criteria to fall within the common support and thus construct the counterfactual outcome. Nonparametric matching estimators such as kernel matching and local linear matching use a weighted average of all nonparticipants to construct the counterfactual match for each participant

Stratification or interval matching: This procedure partitions the common support into different strata (or intervals) and calculates the program’s impact within each interval. Specifically, within each interval, the program effect is the mean difference in outcomes between treated and control observations. A weighted average of these interval impact estimates yields the overall program impact, taking the share of participants in each interval as the weights.

Restricting the common support region

Common support restriction is the important step that ensures the characteristics observed in the treatment group can also view in the control group. The common support region can be restricted by taking the area of the minimum and maximum propensity scores of treatment and control group households and/or by estimating density distribution (Caliendo and Kopeinig, 2008).

Testing the matching quality / Balancing test

The matching quality is dependent on the capacity of the process of balancing covariates. According to Rosenbaum and Rubin (1985) comparing pseudo R^2before and after matching is the most commonly used method to clarify the bias between the comparisons which means the r2 value after matching should be lower than before and the t-test of all covariates should not revel significant difference between the treatment and control groups.

Sensitivity Analysis

Sensitivity analysis answers the question how strongly unmeasured variable influences the selection process in order to undermine the implication of matching analysis (Caliendo and Kopeinig, 2008) using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT with respect to deviation from the CIA (Conditional Independence Assumption).

3.3.3 Measuring food security status of sample households

As a measure of food security status, Food Consumption Score (FCS) method will be used. Household food consumption data for the period of 7 days before the survey will be collected and regrouped into eight standard food groups (Table below).

Table 2: Food consumption score table

Food items	Food group	Weight
Cereals: Corn, Wheat, Sorghum, Rice, Bread	Staples	2
Roots and Tubers:	Root crops	2
Pulses/Beans/ Nuts Pulses	Pulses	3
Milk/ Milk Products Milk	Milk	4
Animal Proteins: Fish, Meat, Eggs	Meat and fish	4
Vegetables (including green, leafy vegetables)	Vegetables	1
Sugar/ Honey	Sugar	0.5
Fruits	Fruits	1
Oil and Fats	Oil	0.5

Source: World Food Program (2007)

The score is calculated by using the formula below,

FCS=$a\times f$(staple)+$\beta\times f$(pulse)+$\gamma\times f$(vegetables)+$\gamma\times f$(fruit)+$\delta\times$f(animal)+$\times f$(sugar)+$\delta\times f$(dai ry)+$\times f$(oil)

Where FCS = food consumption score,

f= frequencies of food consumption during the past 7 days

β, γ, and δ = are the weight for each food group.

According to WFP (2008), households with food consumption score of 0-28 are considered as poor food consumption, borderline if food consumption score is between 28.5 to 42and considered as food secure if the food consumption score values exceeding 42.

3.4 Definition of variables and working hypothesis

Dependent, outcome and independent variables used in this research were explained as follows:

3.4.1. Dependent variable

Participation in Small scale irrigation used as dummy dependent variable having a value of 1 for irrigator and 0 otherwise.

3.4.2. Outcome variables

As an outcome variable, food consumption score (FCS) was used. Households whose FCS below 28 were taken food insecure, those whose FCS between 28 and 42 were determined as borderline, and households with a score value greater than 42 were considered as food secure (WFP, 2008).

3.4.3. Independent variables

Household headship (HH_SEX): This is a dummy variable, which takes 1 if sex of respondent or head of the HH is male, 0 otherwise. Since the participation of women both on farm and off farm activities are by far limited due to cultural impediments than male, female headed households are expected to be less participated in small scale irrigation than male headed households. Empirical study results reported by Jema et al. (2013) and Hadush (2014) revealed that irrigation users household heads were significantly male headed relative to non-users.

Household age (HH_AGE): It is a continuous variable measured in a number of years. Age of a household head can generate or erode confidence on technologies. In other words, with age a farmer can become more risk averse to new technologies .However, there are mixed results as to the direction of influence. Previous research result reported by Getaneh (2011) there were no significant differences in the distribution of household head age of the sampled households between irrigation user and non-user household heads. To the contrary, the marginal effect estimation of the logit model by Hadush (2014) dedicated that age of the household head positively affects the probability of participation on micro irrigation. As the age of the household head increases by 1 year up to a certain level, the probability of participation in micro irrigation would increase by 1.41% marginal effect, other variables in the model remaining constant. So, it is hypothesized that younger farmers have more probability of participating in irrigation practice.

Education status of the household (HH_EDUC): It is a continuous variable. Level of education will assumed to increase farmers' ability to obtain, process, and use information relevant to the use of irrigation. Education is therefore expected to increase the probability participating in irrigation technology. Getaneh (2011) reported that, the education level of household heads was higher for irrigating households than non-irrigating households. Kinfe et al. (2011) also found that the number of irrigation users who completed nine years of schooling and above was twice as compared to nonusers.

Dependency ratio (DEP-RTIO): This variable is measured as the ratio of household member not in the labor force, child or old, to those household members in the labor force. It refers to the number of household members whose age are less than 15 plus the number of household members whose age are greater than 64 divided by the total family members. The dependency ratio reflects the pressure and responsibility on household member in the labor force. Hence, this variable will hypothesized to have a negative relationship with participation in the small-scale irrigation scheme i.e. as the dependency ratio increase, the participation decreases in the irrigation scheme decreases and vice versa.

Adult labor availability (AD_LAB): It is a continuous variable measured in terms of Man Equivalent. (Adult equivalent conversion factor in the Appendix table 1) Availability of labor is likely to influence the gross margin of the innovation. It is one of the determinant factors for households' participation in small scale irrigation. Households with more adult labor will have the probability of participating in irrigation practice. As to marginal effect estimation of the logit model report by Hadush (2014) there was a significance difference in availability of adult labor between irrigation users and non-users and households with irrigation have owned better labor input than non-irrigation participant households. Sikhulumile (2013) also found in his research that irrigators were found to have bigger families (both in numbers and adult equivalents) compared to non-irrigators, indicating a high labor demand for irrigation farming.

Non-farm income (NON_FAR_IN): It is treated as a continuous variable taking 1 if a household head participated in off-farm income generating activities; 0, otherwise. A study by Habtewold (2018) additional income earned from agricultural activities outside the farm, increases the farmers' financial capacity and increases the probability of investing in new technologies. Hadush (2014) found that household heads who were engaged in nonfarm participation were 25.12% more likely to participate and adopt a micro irrigation system than those household heads that had not participated in nonfarm activities. It is, therefore, expected to affect the use of irrigation technology positively.

Total cultivated land holding (LAN_SIZE): It is a continuous variable measured in hectare and represents the total cultivated land size a household owned. Abdissa et al. (2017),reported that land holding of the household had positively affected the participation of households in irrigation participation. Therefore, this variable is hypothesized that farmers who have larger cultivated land are likely to participate in irrigation and have more income than those with smaller area. A positive relationship is expected between household's participation in irrigation and cultivated land size.

Number of livestock holding of a household head (NO_TLU): It is a continuous variable measured in terms of Tropical Livestock Units (TLU). Abonesh (2006) reported, those households with access to irrigation have a better livestock holding than those households with no access to irrigation. Similarly, Hadush (2014) also reported that non adopters of micro irrigation had less holding of livestock compared to adopters of micro irrigation. Hence, livestock ownership is hypothesized to have a positive relation with the participation decision of agricultural technologies (irrigation).

Distance to market (DIS -MKT):is a continuous variable which measured in kilometer. It refers to the distance from farmers home to nearest market. Being near to the market increase the farmer's market information and access to purchase input and sell their products.Therefore, households who are near to market have better chance to participate in small-scale irrigation (Abonesh 2006).

Contact with development agents (DA-CON): It is dummy variable which takes a value of 1 if the household head has contact with developmental agents on irrigation support service and 0 otherwise. The number of contact with DA's are more likely to be aware of new practices as they are easily exposed to information Habtewold (2018)A study in South Africa by Sikhulumile (2013) access to agricultural extension services improved the likelihood of irrigation participation, and agricultural extension officers(DAs) are more visible in irrigation projects. Contact with developmental agents is hypothesized, in this study, to influence the farmers' decision to participate irrigation positively.

Access to credit (ACC_CREDT): It is dummy variable which takes a value of 1, if the household head had the access to credit, 0 otherwise. Access to credit creates an opportunity for farm households to invest on new technologies that enhances productivity (Gadisa 2020). Hence, it is expected that access to credit will increase the probability of participation in irrigation farming.

Land rent out (LAN-RO): It is dummy variable which takes a value of 1, if the household head rent out land and, 0 otherwise. According to Han et.al (2021), revealed that the farmland renting out found to reduce household on-farm income, as the same time its impact on off-farm income was not satisfactory. Therefore renting out farm land reduces farmer's engagement in on farm activities like small scale irrigation. Land rent out hypothesized in this study to influence farmer's decision to participate in irrigation negatively if the farmers rent out there farm land they won't participate in irrigation.

Crop failure (CR_FL): This variable is a dummy variable of value one if crop failure were occurred during the main season of the research year and zero otherwise. Crop failure is one of the main factors that potentially affects production and productivity of the farmers and led to food insecurity. Crop failure can be occurred by different reasons the most common reasons are occurrences of crop pests and diseases and climate variability. in this research crop failure hypothesized as positively affecting factor for farmers irrigation decision if farmers face crop failure because of rainfall variability the probability to use irrigation will increases.

Table 3: Definitions of hypothesized explanatory variables

Variable Definition	Symbol	Expected sign	Types
Age of household head	AGE	-	Continuous
household headship	SEX	+	Dummy
Education level of households	EDUC	+	Continuous
Labor availability	ADLAB	+	Continuous
Number of Livestock holding	TLU	+	Continuous
Dependency ratio	DEPR	-	Continuous
Cultivated land size	LSZ	+	Continuous
Contact with development agents	EXTF	+	Dummy
Access to credit	ACT	+	Dummy
Distance from the nearest market	MTDS	-	Continuous
Non-farm income	NONIN	+	Continuous
Crop failure	CR_FL	+	Dummy
Land rent out	LAN-RO	-	Dummy

CHAPTER FOUR: RESULT AND DISCUSSION

This chapter presents the result and discussion of the results in four subsections. The first sub section presents the descriptive results in percent and frequency and inferential statistics of chi square and t test results to describe the characteristics of sample households. The second subsection describes the determinant factors of irrigation participation decision by using logistic regression. And the final subsection describe the result on the impact of small scale irrigation on household food security which conducted by using propensity score matching.

4.1. Descriptive results

4.1.1 Descriptive Results for Dummy Variables

The variables are described their significance difference between the irrigation adopter and non-adopter groups.

Household headship: as the result shows in table 4, from 189 sample households, only 26 (14%) of the households were female-headed households, and the rest 163(86%) were male heads. Based on their participation in irrigation, 7 out of 26 female-headed households, and 70 out of 163 male-headed households were irrigation participants. But, the difference is not statistically significant. Based on the information get from key informant interview and focus group discussion there is less participation of females in agricultural activities and also less participation in small scale irrigation the possible reasons raised was the cultural is exclusive.

Credit access: based on the result in Table 4, 118 households out of 189 households have access to credit service. Similarly, 54 households out of 77 (70%) of the irrigation user households and 64 households out of 112 non-irrigation users have access to credit service. From this result, households that have credit access are more probability to engage in irrigation than the households not getting access to credit services, and the difference is significant at a 10% probability level. from the qualitative analysis the since irrigation farming needs more capital having credit access let farmers get startup capital to participate in irrigation.

Crop failure: according to the result, crop failure faced 91 sample households, out of which 47(57.14%) were nonparticipants. From the KII and FGD results farmers whose crop production was affected in the main production time are more probable to use irrigation in the offseason than the households whose crop didn't affect, and the difference is significant at a 5% probability level.

Extension contacts: according to the survey result shown in Table 4, out of the 77 irrigation participant households, 66(85.7%) households get access to extension services. Similarly, out of 112 irrigation nonparticipant households, 71(63.3%) households were getting access to extension services. This shows that households having access to extension services are more likely to participate in small-scale irrigation compared to households without access to extension services, and the difference is significant at a 1% probability level. based on the result of FGD and KII irrigation participants households are more willing to contact and get advice from extension agents.

Land rent out: According to the survey result, from the total 189 sample households, 97(51.32%) households rented out their farmland. Out of those who rented out their farmland, only 29 (29.89%) were irrigation participant households and 68 (70%) were non-participant households. From this result, households that are renting their farmland are less likely to participate in small-scale irrigation, and the chi-square test showed that the difference is statistically significant at a 1 percent probability level. based on the qualitative analysis irrigation participants households need more farm land in consistent with they did not rent out their farm land on the other hand non participant households rent out their farm land preferring to get ready made money rather than producing using irrigation.

Table 4: Descriptive results for dummy variables

Dependent variable	Dummy independent variables														
	Sex of the head			Credit access			Crop failure			Extension contacts			Land rent out		
Irrigation participation	Female	male	total	Yes	no	total	Yes	no	total	Yes	no	total	Yes	no	total
Yes	7	70	77	54	23	77	44	33	77	66	11	77	29	48	77
No	19	93	112	64	48	112	47	65	112	71	41	112	68	44	112
Total	26	163	189	118	71	189	91	98	189	137	52	189	97	92	189
Percent%	13.8%	86.2%	100	62.4	37.5	100	48.1	51.8	100	72.4	27.5	100	51.3	48.6	100
chi2(1)	2.4			3.2813			4.2108			11.3996			9.7057		
Pr.	0.123			0.070*			0.040**			0.001***			0.002***		

Source: Own computation from survey data
Note: the stars *, **, and*** show the significance level at 10%, 5%, and 1% accordingly.

4.1.2 Descriptive results for continuous variables

The variables are described their significance difference between the irrigation adopter and non-adopter groups.

Age of the head: according to the survey result, the age of the head had a significant difference between irrigation participants and non-participant households at a 5% probability level. As shown in table 5, the mean age of the non-participant households is 47, and that of participants is 44 while the combined mean is 45 years. This result is showing that younger household heads are more irrigation users than older household heads.

Educational status of the head: based on the result of the survey, the mean year of schooling for irrigation participant households is 3.8, and 3.30 for non-participants, with 3.77 and 3.51 standard deviation respectively while the combined mean of the year of schooling is 3.6. From the result, the mean age of non-irrigators is greater than that of the irrigators, but the difference is not statistically significant.

Dependency ratio: based on the result in table 5the mean dependency ratio of irrigation participant households is 0.61 and 0.66 is the non-participants with 0.47 and 0.32 standard deviation accordingly the combined mean is 0.64 based on the result the mean dependency ration of non-participants is greater than participants but there is no significant difference between participant and non-participants.

Livestock holding in TLU: based on the survey results in Table 5, the mean livestock holding for irrigation participant households was 7.66 and that of non-participants was 6.38 while the combined mean is 6.90. this shows that households who have more livestock are more irrigation participants. This can be because livestock is the most important factor for farming activity in the study area as the KII and focus group discussion confirmed. The t-test showed that the mean difference is statistically significant at a 1% probability level.

Family size in AE: family size in terms of adult equivalent is an important factor of farm production and source of family labor. The result in Table 5showed that the mean family size for irrigation participants and non-participant households was5.09 and 4.41 respectively. This means there was 5 active or working age for irrigators and 4 for non-irrigators. As confirmed by KII and

FGD results this shows that households having more family labor are more irrigation participants. There is a significant difference at a 5% probability level.

Non-farm income: according to the survey result, the major sources of non-farm income in the study area were petty trade, transport service delivery, handcraft, and sand and stone inquiry were the most common sources of non-farm income. As the result in table 5 shows, the mean non-farm income of irrigation participant households was 6159.75 birr, while it is 8373.96 birr for non-irrigators. This shows those non-participant households were more engaged in a non-farm activity but as the t-test result shows, the difference was not statistically significant. Based on the KII and FGD results participating in non-farm activities decreases participation of on-farm activity.

Market distance: according to the survey result, the mean distance from the nearest market in km for the whole sample households was 5.77km, while it is 5.51 and 5.59km for irrigation participant households and non-participants respectively. From this result, households living nearer to the market are more irrigation participants than those living far away from the market. But the difference is insignificant**.**

Landowned: According to the focus group discussion and KII, the land is the most important factor of production in the study area. The result in table 5 showed that the mean land holding of the total sample households was 1.35 hectares. Similarly, the mean land owned by irrigation participants and non-participants was 1.53 and 1.22 hectares respectively. This shows that irrigation participant households have more land compared to the non-participants. From the t-test result, the difference is statistically significant at a 5% probability level.

Table 5: descriptive results for continuous variables

Variables	Participant		Non-participant		Combined		T value	P-value
	Mean	St.dev	Mean	St.dev	Mean	St.dev		
Age of the head	44.28	10.43	47.03	8.48	45.91	9.39	-1.99	0.02**
Education of the head	3.80	3.77	3.30	3.51	3.50	3.62	0.93	0.17
Dependence ratio	0.61	0.47	0.66	0..32	0.64	0.39	-0.75	0.22
Livestock (TLU)	7.66	3.33	6.38	3.51	6.90	3.49	2.50	0.006***
Family size (AE)	5.09	2.12	4.41	2.01	4.69	2.08	2.20	0.01**
Nonfarm income	6160	9869	83734	10481	7472	10268	-1.46	0.14
Market distance	5.51	3.02	5.95	2.63	5.77	2.79	-1.05	0.85
Land owned	1.53	1.15	1.22	1.26	1.35	1.22	1.70	0.04**

Source: Own computed from survey data

Note: the stars *and** show the significant level of variables at 10% and 5% accordingly.

4.2 Summary of Food consumption score by participation in irrigation

Food consumption score was the method used to measure household food security status. Based on the result in Table 6, from the total 189 sample households, 134 (71%) households were in the range of acceptable food consumption score, 53 households (28%) were in the range of borderline and 2 households (1%) were in the range of poor food consumption score. From this result, the food security status of the sample households can be generalized as good food security status. Similarly, 63 out of 77 (82%)of irrigators and 71 out of 112 (63%)of non-irrigators were in the range of acceptable food consumption, while 14 out of 77 (18%)of irrigators and 39 out of 112 (35%)of non-irrigators were in the range of borderline food consumption score.

From the result, majority, (63%) of the farm households in the study area were food secure. But this could be because the time of data collection was during the time at which more food is available since the time was at the harvesting season. This shows irrigation participant households have better food security status than non-participant households as the t-test result is ensuring that the difference is significant at a 5% probability level.

Table 6: Food consumption score by participation in irrigation

Food consumption score category	Irrigation participation				Total	
	Participants		Non-participants			
Acceptable	63	81.8%	71	63.3%	134	71.0%
Borderline	14	18.2%	39	34.8%	53	28.0%
poor	0	0%	2	1.78%	2	1.0%
total	77	100%	112	100%	189	100%
Pearson chi2(2) = 8.0652 Pr. = 0.018						

Source: Own computed from survey data

4.3 Econometric results

4.3.1 Determinants of household small scale irrigation participation

Before running the model, multi-collinearity test was done using variance inflation factor (VIF), and from the result in table 7, the mean VIF is 1.10 and that ranged from 1.18 to 1.04. Therefore there isno multicollinearity problem and all the variables were included in the model to assess factors affecting households' decisions to participate in irrigation.

Table 7: VIF test

Variable	VIF	1/VIF
Land owned	1.18	0.847009
Age of the head	1.15	0.871668
Livestock TLU	1.13	0.884700
Market distance	1.10	0.908248
Nonfarm income	1.10	0.909920
Family size, AE	1.10	0.911791
Sex of the head	1.12	0.895609
Credit access	1.09	0.919675
Dependency ratio	1.09	0.921148
Extension contacts	1.08	0.923099
Education of the head	1.05	0.950679
Land rent out	1.05	0.956314
Crop failure	1.04	0.964653
Mean VIF	**1.10**	

Similarly, contingency coefficient estimation also done to check for the association among variable, and the result also confirmed that there is no problem of association between the variable. Therefore, all the variable were included in the model.

Table 8: Contingency coefficient for dummy variables

Variables	Sex of the head	Credit access	Crop failure	Extension contacts	Land rent out
Sex of the head	1.0000				
Credit access	0.0391	1.0000			
Crop failure	-0.0763	-0.0178	1.0000		
Extension contacts	0.0979	-0.1109	-0.0228	1.0000	
Land rent out	-0.1124	-0.0778	0.0698	-0.0311	1.0000

After testing for multicollinearity and the degree of association between variables, determining factors in household decision to engage in irrigation were assessed using logistic regression and the result is presented in Table 9.

Table 9: Factors affecting household decision to participate in irrigation

Irrigation participation	Coef.	St. Err.	t-value	p-value	[95% Conf.Interval]	
Sex of the head	0.098	0.573	0.17	0.864	-1.025	1.221
Age of the head	-0.047	0.020	-2.36	0.018**	-0.086	-0.008
Education of head	0.064	0.047	1.35	0.177	-0.029	0.156
Family size AE	0.222	0.084	2.63	0.009***	0.056	0.387
Dependency ratio	-0.373	0.486	-0.77	0.444	-1.326	0.580
Livestock TLU	0.109	0.052	2.08	0.038**	0.006	0.212
Land owned	0.236	0.157	1.50	0.134	-0.073	0.544
Nonfarm income	0.000	0.000	-0.40	0.689	0.000	0.000
Crop failure	0.909	0.373	2.44	0.015**	0.178	1.641
Land rent out	-1.085	0.361	-3.01	0.003***	-1.793	-0.378
Extn contact	1.418	0.471	3.01	0.003***	0.496	2.341
Market distance	-0.072	0.062	-1.17	0.242	-0.193	0.049
Credit access	0.769	0.381	2.02	0.043**	0.023	1.516
_cons	-1.468	1.145	-1.28	0.200	-3.713	0.777
Mean dependent var		0.407	SD dependent var			0.493
Pseudo r-squared		0.214	Number of obs.			189.000
Chi-square		38.137	Prob> chi2			0.000
Akaike crit. (AIC)		228.800	Bayesian crit. (BIC)			274.185

**** p<0.01, ** p<0.05, * p<0.1*

Source: Own computed from survey data

According to the logit model result in table 9, from 13 hypostasized explanatory variables,7 variables, namely age of the head, family size, livestock holding, crop failure, land rent out, extension contact, and access to credit were significantly affected household irrigation participation decision.

Age of the head: similar to the hypothesis, the result in Table 9showed that the age of the head negatively and significantly affected irrigation participation at a 5% probability level. This shows that younger household heads are more irrigation participants than older household heads. This could be because younger household heads are more likely to be educated and adopt new technologies than elder heads. Based on the KII results elder heads fear to take risks for trying new technologies. This result is consistence with the finding of Gadisa (2020) and Molla (2017)

Family size, AE: as shown in table 9, family size affects irrigation participation positively and significantly at a 5% probability level. Family labor is one of the most important production factors that can determine the decision of households to participate in small-scale irrigation. So, households having more family labor are expected to be more participants than households having less family labor. According to FGD family labor is more initiative to participate in irrigation. this similar with the finding reported by Hadush (2014).

Livestock holding: similar to the hypothesis, the result showed that livestock holding has a positive and significant effect on a household's irrigation participation decision at a 5% probability level. Having more livestock led to irrigation participation since livestock is an asset and source of farming force as confirmed by FGD and KII having more livestock increase participation in irrigation. This result is similar with the finding of Hadush (2014).

Crop failure: unlike the hypothesis crop failure determine irrigation participation decision positively and significantly at a 5% probability level. Based on the FGD and KII results, households who faced crop failure in the main season because of different factors especially because of rainfall variability and occurrence of different pests and diseases decided to participate in irrigation to cope with the lack of food availability. This result is contradictory to the hypothesis because the hypothesis was households decide not to participate in irrigation fear of crop failure since producing using small-scale irrigation is more costly than rain feed production. This result is consistent with the findings of Gadisa (2020).

Land rent out: as hypostasized, land rent out negatively and significantly affected household decision to participate in irrigation at 1%. Based on the KII and FGD results, the possible reason for farmers to rent out their farmland is preferring to get readymade money rather than making more effort on irrigation agriculture and lack of physical and financial capital that hindering them from using irrigation. According to Han et.al (2021), farmland renting out was found to reduce household on-farm income, this led to conclude renting out farmland reduce irrigation participation which is consistence with the finding of this study.

Extension contacts: contact with agricultural extension agents is important for agricultural development. According to the result of FGD and KII, households who have more contact with extension agents have more knowledge of small-scale irrigation and irrigation participants. As shown in table 9, extension contact has a positive and significant effect on irrigation participation at a 1% probability level. similar with finding reported by Hadush (2014).

Credit access: based on the result in Table 9, credit access positively and significantly affected irrigation participation by 5% probability. Households with more credit acess are more participants in irrigation. This might be because having credit access increase farmers' opportunity to buy farm inputs, especially for irrigation since small-scale irrigation needs more farm inputs than rain-fed production. This result is consistence with the finding of Temesgen (2019).

4.3.2 Impact of small-scale irrigation on household food security

The impact of small-scale irrigation was analyzed by using the propensity score matching (PSM) model since there is no baseline data. The PSM model has five steps. The first step is estimating the propensity score for each sample observation. The second step is choosing the matching algorism. The third step is checking for the balancing test. The fourth step is computing the average treatment effect on the treated and the last step is checking the sensitivity analysis for unobserved covariates.

Estimation of propensity score

To estimate propensity score, the logit model was used to regress participation in irrigation on 13 independent variables. As shown in table 10, the logit model performed well since the value of R^2 value is fairly smaller (0.21) and the likelihood ratio is significant at 1%. This indicates there could not be much difference between non-participants and participants that cannot be matched.

Logistic regression	Number of obs. = 189
	LR chi2(13) = 54.69
	Prob> chi^2 = 0.0000
Log likelihood = -100.40024	Pseudo R^2 = 0.2141

Irrigation participation	Coef.	St. Err.	z	P>z	[95%Conf.	Interval]
Sex of the head	0.098	0.560	0.180	0.861	-1.000	1.197
Age of the head	-0.047	0.020	-2.360	0.018	-0.086	-0.008
Education of head	0.064	0.049	1.300	0.194	-0.033	0.160
Family size AE	0.222	0.090	2.460	0.014	0.045	0.398
Dependency ratio	-0.373	0.460	-0.810	0.418	-1.275	0.530
Livestock TLU	0.109	0.052	2.090	0.036	0.007	0.211
Land owned	0.236	0.152	1.550	0.122	-0.063	0.534
Nonfarm income	-0.000	0.000	-0.420	0.678	-0.000	0.000
Crop failure	0.909	0.358	2.540	0.011	0.207	1.612
Land rent out	-1.085	0.358	-3.030	0.002	-1.788	-0.383
Extn contact	1.418	0.447	3.170	0.002	0.542	2.294
Market distance	-0.072	0.065	-1.120	0.265	-0.199	0.055
Credit access	0.769	0.379	2.030	0.043	0.026	1.513
_cons	-1.468	1.221	-1.200	0.229	-3.860	0.925

Table 10: Estimation of propensity score

Source: Own computation from survey data

The propensity score can also be expressed graphically. As shown in the below graph, the blue line (the solid line) represents the total sample households, the red line (short dash line) represents the participant households and the green line (long dash line) stand for the non-participant households.

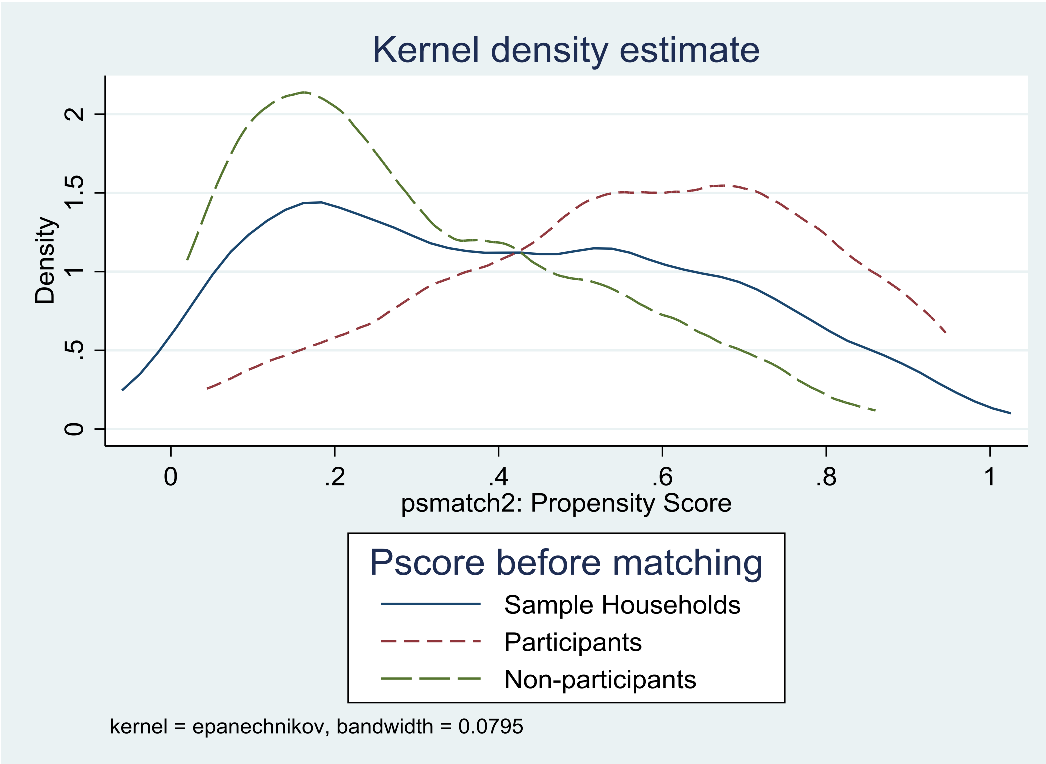

Figure 3: kernel density estimates before matching

After estimation of the propensity score, restriction of the common support region was done. To restrict the common support region, the propensity score values that lie in between the maximum of the minimums and the minimum of the maximums were taken. As shown in table 11, the common support region is the propensity score value between 0.0440407 and 0.8601138. Based on this, 14 observations (4 non-participants and 7 participant households) were out of the common support region.

Table 11: Restriction of the common support region

Variable	Observation	Mean	Std. dev.	Min	Max
Nonparticipants	112	.299225	.2057358	.019789	.8601138
Participants	77	.5647636	.2302485	.0440407	.94594

The result can also be visualized by using kernel density for participant and non-participant households that are in the common support region as shown in figures 4 and 5.

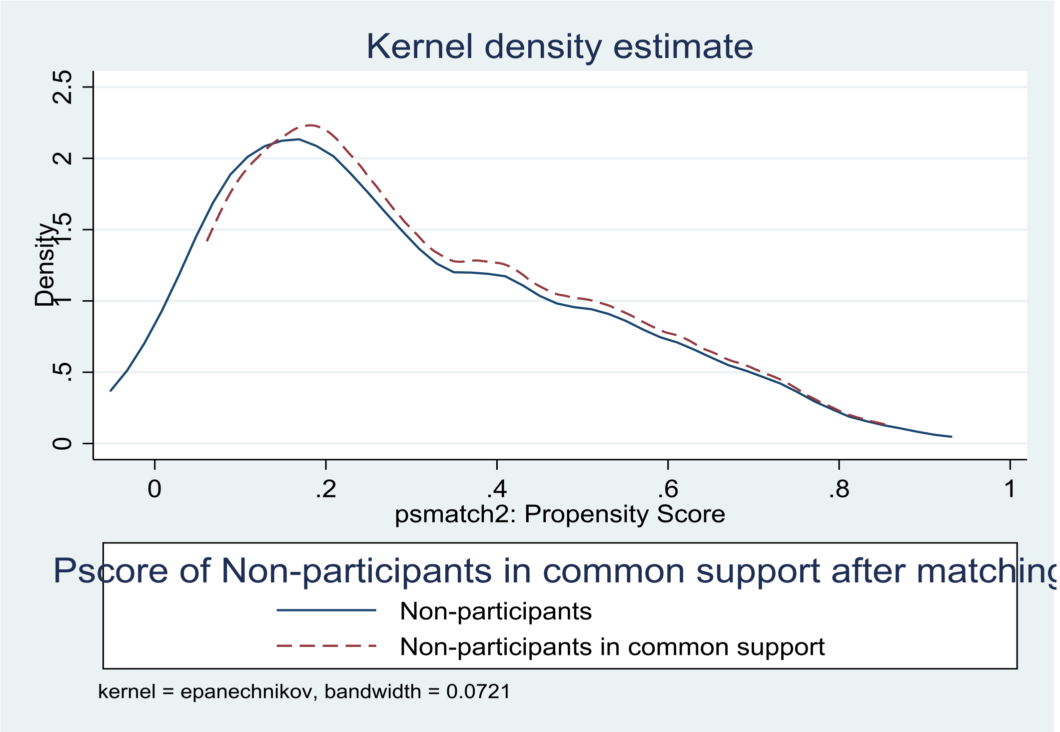

Figure 4:kernel density of non-participants in a common support

The kernel density for participant households in the common support region is also shown in figure 5.

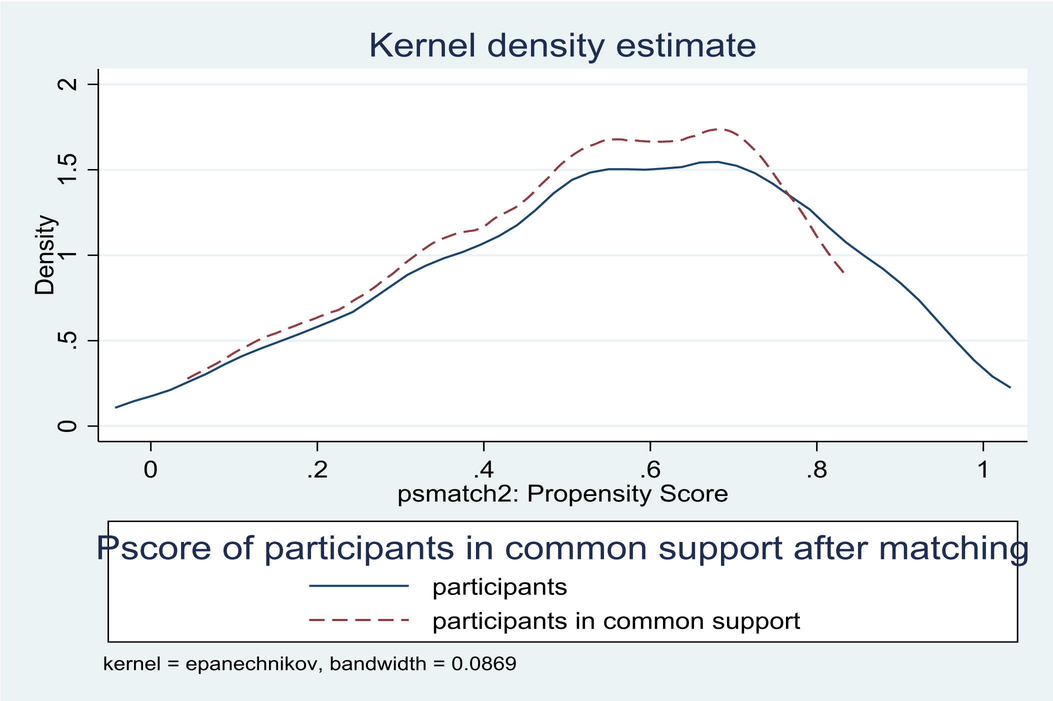

Figure 5:kernel density for participants in the common support region

The histogram visualization of households in common support region can also be expressed as in figure 6.

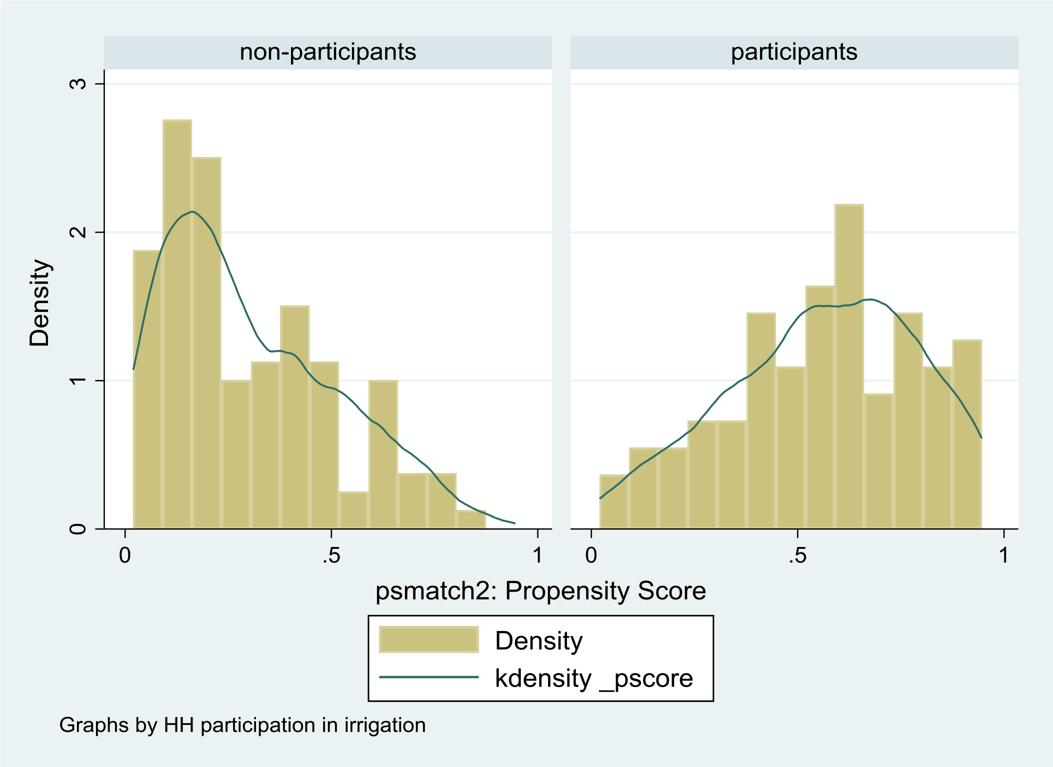

Figure 6:Histogram expression of participant and nonparticipants

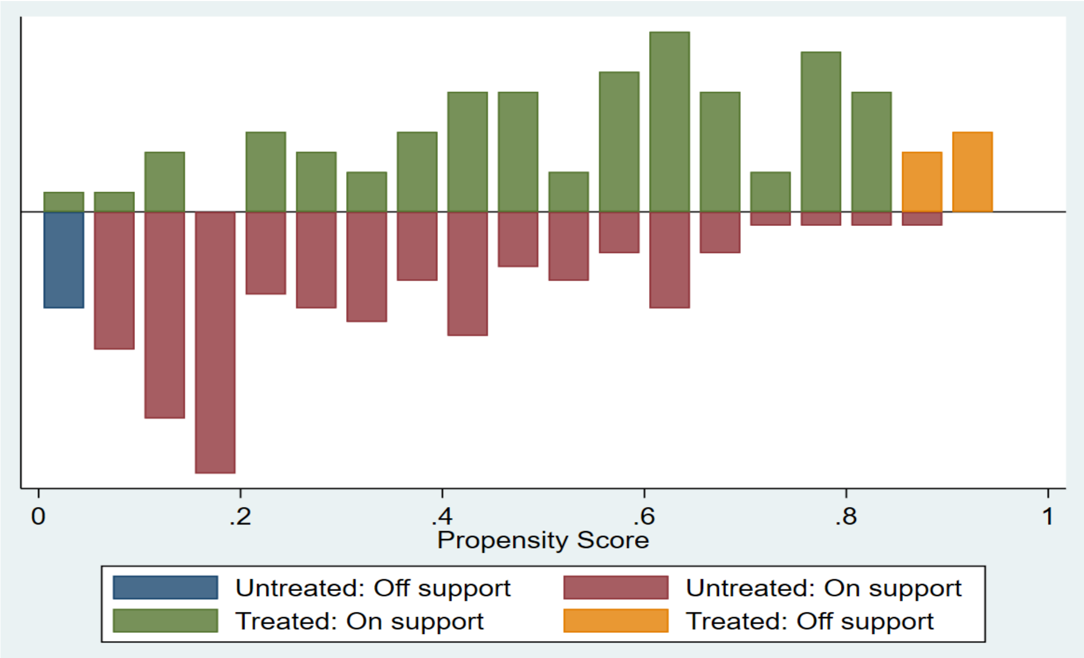

Figure 7:Propensity score of treated and untreated on and off support

Choosing the matching algorism

In this step, the best matching method was chosen using different methods.A matching method is said to be good if it matches the maximum sample size with all covariates and a smallerpseudo R^2 value. The results of matching by using the common matching techniques: nearest-neighbor matching, caliper matching, radius matching, and kernel matching are shown in table 12.

Table 12: Choosing the matching algorithm

Matching method	Matched sample size	Balancing test	Pseudo R^2
NEAREST NEIGHBOR MATCHING			
Neighbor(1)	175	13	0.062
Neighbor(2)	175	13	0.044
Neighbor(3)	175	13	0.030
Neighbor(4)	175	13	0.026
CALIPER MATCHING			
Caliper(0.01)	76	13	0.160
Caliper(0.10)	105	13	0.043
Caliper(0.25)	118	13	0.065
Caliper(0.50)	105	13	0.043
RADIUS MATCHING			
Radius caliper(0.01)	117	13	0.062
Radius caliper(0.10)	175	13	0.020
Radius caliper(0.25)	175	13	0.029
Radius caliper(0.50)	175	13	0.119
KERNEL MATCHING			
kernel bandwidth (0.01)	117	13	0.061
kernel bandwidth(0.10)	175	13	0.020
kernel bandwidth (0.25)	**175**	**13**	**0.019**
kernel bandwidth(0.50)	175	13	0.070

Source: Own computation

From the result, kernel matching with bandwidth 0.25 was selected for its quality of the smallest pseudo $R^2$of 0.19, a larger sample size of 175, and all 13 covariates were balanced.

Based on the result of the best matching algorithm, 14 observations (7 from treated and 7 from control) were excluded from the matching as they were off the support region.

Table 13: Summary of observations on and off support region

psmatch2: Treatment assignment	psmatch2: Common support		Total
	Off support	On support	
Untreated	7	105	112
Treated	7	70	77
Total	14	175	189

Source:

Assessing the matching quality (Balancing test)

After choosing the best matching method, a balancing test was done to check the matching quality. To conclude that the selected matching method is the best, all the covariates should not show significant differences after matching, the pseudo-r-square value should be fairly smaller, and the mean bias after matching should be around five.

The result in Table 14 showed that the matching quality is high because 7 variables that were significantly different for irrigation participants and non-participants before matching become insignificant after matching.

Similarly, the result of the joint significance test presented in Table 15 also revealed that the value of the pseudo-r-square become very smaller after matching (reduced from 0.212 to 0.012), and the mean bias also reduced to the commonly used standard value (reduced from 28.2 before matching to 5.8 after matching).

Table 14: Covariate balancing test

Variable	Unmatched/Matched	Mean Treated	Mean Control	% Bias	%reduce |bias|	T-test t	T-test p>|t|	V(T)/V(C)
Sex of head	Unmatched	.90909	.83036	23.4		1.55	0.124	.
	Matched	.9	.8933	2.0	91.5	0.13	0.897	.
Age of head	Unmatched	44.286	47.036	-28.9		-1.99	0.048	1.51
	Matched	44.957	45.24	-3.0	89.7	-0.18	0.860	1.48
Education of head	Unmatched	3.8052	3.3036	13.8		0.94	0.351	1.15
	Matched	3.5143	3.4201	2.6	81.2	0.15	0.878	1.11
Family labor	Unmatched	5.0915	4.4172	32.5		2.21	0.029	1.11
	Matched	4.956	4.6923	12.7	60.9	0.74	0.459	0.97
Dependency ratio	Unmatched	.61857	.66221	-10.8		-0.75	0.453	2.05*
	Matched	.62986	.66512	-8.7	19.2	-0.52	0.606	1.94*
Livestock	Unmatched	7.6647	6.3867	37.3		2.51	0.013	0.90
	Matched	7.4237	7.4247	-0.0	99.9	-0.00	0.999	0.74
Land owned	Unmatched	1.5331	1.2266	25.4		1.70	0.091	0.83
	Matched	1.5471	1.5918	-3.7	85.4	-0.20	0.843	0.65
Nonfarm income	Unmatched	6159.8	8374	-21.8		-1.46	0.146	0.89
	Matched	6297.2	7588.9	-12.7	41.7	-0.75	0.457	0.95
Crop failure	Unmatched	.57143	.41964	30.5		2.06	0.040	.
	Matched	.55714	.5367	4.1	86.5	0.24	0.810	.
Land rent	Unmatched	.37662	.60714	-47.1		-3.18	0.002	.
	Matched	.41429	.42698	-2.6	94.5	-0.15	0.880	.
Extension access	Unmatched	.85714	.63393	52.7		3.46	0.001	.
	Matched	.84286	.8059	8.7	83.4	0.57	0.569	.
Market distance	Unmatched	5.5195	5.9554	-15.4		-1.05	0.294	1.32
	Matched	5.6286	5.3968	8.2	46.8	0.48	0.631	1.37
Credit access	Unmatched	.7013	.57143	27.1		1.82	0.071	.
	Matched	.67143	.63927	6.7	75.2	0.40	0.691	.

* If variance ratio outside [0.64; 1.57] for U and [0.62; 1.61] for M

Table 15: Joint significance test

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.212	54.16	0.000	28.2	27.1	117.1*	1.02	13
Matched	0.012	2.25	1.000	5.8	4.1	25.4*	1.97	13

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

The bias reduction after matching can also be expressed graphically as shown in fig. 8below. As can be seen from the figure, there is a high reduction of bias after matching. This can guarantee us that the estimation of the treatment effect on the treated (ATT)can be done

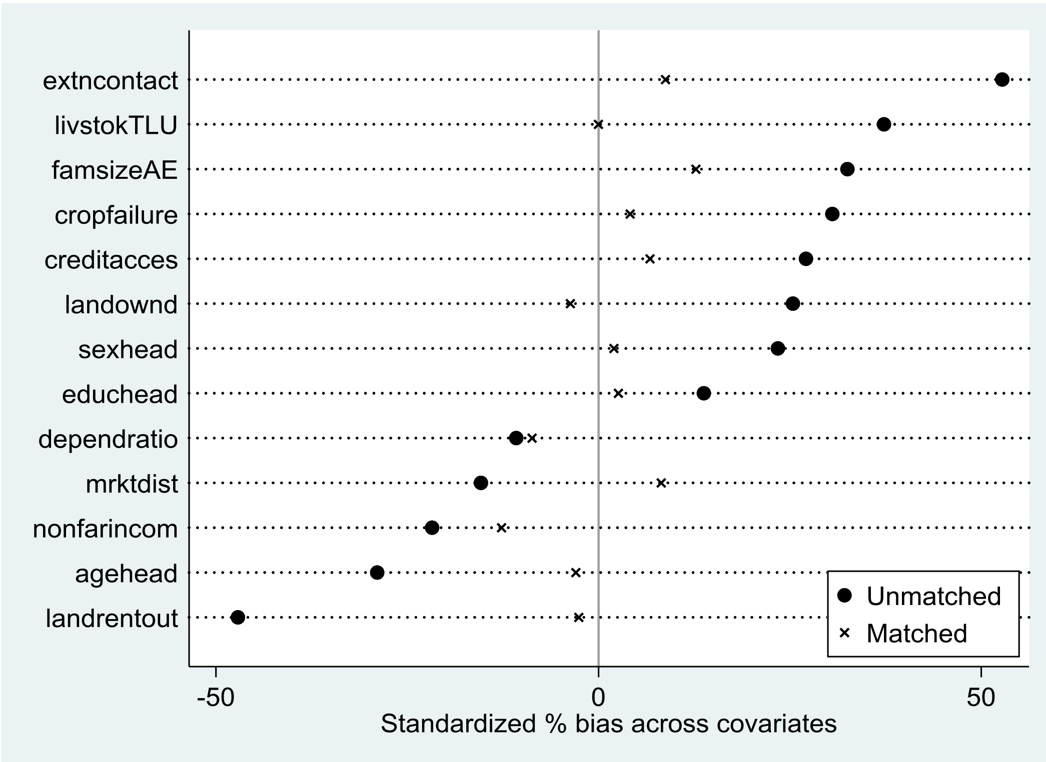

Figure 8: standard bias across covariates

Average treatment effect on the treated (ATT)

All the propensity score steps gone through is a ground to conduct average treatment effect on the treated, and the steps confirmed the similarity of treatment and control after matching that making it possible to conduct average treatment effect on the treated. Therefore, the ATT was estimated, and as presented in Table 16, the mean food consumption score for irrigators was 48.5 while that of non-irrigators was 45, with a mean difference of 3.5. This shows irrigator households have a better food consumption score than non-irrigator households, and the difference is statistically significant at a 5% significance level.

Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
Food consumption score	Unmatched	48.383	45.464	2.919	1.394	2.090
	ATT	48.557	45.012	3.545	1.645	2.150

Table 16: Average treatment on the treated (ATT)

Source: Own computed from surveyed data

Sensitivity analysis

Sensitivity analysis is very important to check whether the ATT result is free from hidden bias. Therefore, the sensitivity analysis was conducted using Rosenbaum bounds of1-3 Gama value by adding 0.25. As shown in table 17, the ATT result is not sensitive to unobserved bias up to 200%. Therefore, the estimated result of the ATT is the pure impact of participation in irrigation.

Table 17: Sensitivity analysis

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	46.25	46.25	45	47.75
1.25	0	0	45.5	47.25	44	48.75
1.5	0	0	44.75	48	43.25	49.5
1.75	0	0	44	48.75	42.75	50.25
2	0	0	43.5	49.25	42.25	51
2.25	1.0e-15	0	43	49.75	41.5	51.5
2.5	2.3e-14	0	42.75	50.25	41.25	52
2.75	3.2e-13	0	42.5	50.75	40.75	52.5
3	2.9e-12	0	42	51	40.5	52.75

* gamma - log odds of differential assignment due to unobserved factors
sig+ - upper bound significance level
sig- - lower bound significance level
t-hat+ - upper bound Hodges-Lehmann point estimate
t-hat- - lower bound Hodges-Lehmann point estimate
CI+ - upper bound confidence interval (a= .95)
CI- - lower bound confidence interval (a= .95)

CHAPTER FIVE: CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The study was initiated to address the specific objectives of assessing factors determining participation in small scale irrigation, and analyze the impact of small-scale irrigation on household food security.

The logistic regression model result revealed that,7 variables out of 13,namely:age of the head, family size, livestock holding, crop failure, land rent out, extension contact, and credit access significantly affected household decision to participate in small scale irrigation. Among these variables, land rent out and age of the head were variables that negatively and significantly affected irrigation participation decision, while the rest positively affected households' decision to participate in small-scale irrigation. Age of the head found to affect small-scale irrigation participation negatively, to mean young households are more irrigation participants than the elders. Family size also positively affected participation in irrigation as increase in AE family size adds working force to the household. Similarly, livestock holding also positively affected irrigation participation. Crop failure during the main season also positively affected irrigation participation during the off-season. Extension contacts also positively affected irrigation participation. Credit access also positively affected irrigation participation decision since small scale irrigation participation needs high capital than rain feed agriculture. Finally, land rent out negatively affected irrigation participation. Moreover, from the propensity score matching analysis, participation in small scale irrigation had a positive and significant impact on household food security status, in which the of the family member of irrigators on average have 3.5 more food consumption score compared to family members of non-irrigators.

5.2 Recommendation

Depending on the findings of this research, the following recommendations were forwarded:

Extension contacts significantly affected participation in small scale irrigation. Therefore, they should emphasize the work in initiating farmers to participate in small-scale irrigation by creating awareness and motivate elders to participate.

The result also noted the importance of credit access for irrigation participation. Therefore, institutions responsible for providing credit access should work more to address all the farmers in need of credit services.

Households those renting their farm-land are less participant in irrigation, and also less food secure. Therefore, governmental and non-governmental organizations should work on solving the problems driving farmers towards renting out their farm-land, and giving subsidies and credits and provide overall financial and technical support to make them produce on their own farm land. And policy makers should work emphasizing policy interventions on farm land rent out policy in terms of irrigation participation.

Finally, participation in small-scale irrigation had positive and significant impact on household food security status. Therefore, policy interventions and awareness creation focusing on determinants of participation of small-scale irrigation in Lume district and other similar areas of the country is highly recommended to improve food security status of the farm households.

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APPENDIX

Appendix I: Tables

Appendix Table 1. Conversion factor of Tropical Livestock Units (TLU)

Livestock Category	TLU	Livestock Category	TLU
Oxen and cow	1.00	Horse and mule	1.1
Bull/heifer	0.75	Sheep and goat (adult)	0.13
Calf	0.25	Sheep and goat (young)	0.06
Donkey (adult)	0.70	Chicken	0.013
Donkey (young)	0.35	Camel	1.25

Appendix Table 2 :Conversion factor for Adult –Equivalents

Age group (years)	Male	Female
Less than 10	**0.6**	**0.6**
10-13	**0.9**	**0.8**
14-16	**1.00**	**0.75**
17-50	**1.00**	**0.75**
Above 50	**1.00**	**0.75**

Appendix II Survey Questionnaire
Questionnaire for Respondents

Dear Respondent

The purpose of this questionnaire is to gather information which will be used for study on the impact of small scale Irrigation on household food security in lumeworedaoromia Ethiopia.. This study is going to be conduct for the partial fulfillment of MSc degree in food security atadissabeba University. You full support and willingness' to respond to the question is very essential for the success of the study. Therefore, you are kindly requested to answer all questions and give clear, appropriate and reliable information on the issues. Be sure that the information you provide is only for the purpose of this study. Thank you.

Date of interview (dd/mm/yy) ___________ / _________ / ____________
Kebele: - _____________
Name of interviewer: - ________________________ Signature _____________
Participant status: 1. Participate in irrigation 0. Non participate in irrigation

I. Section one

Demographic characteristics

1. Household head's Name: _________________________________ Sex: 1= Male, 2= Female
2. Household ID ---
3. Age of respondent_______(Years)
4. Sex of respondent: 1) Male 2) Female
5. Family size Female _____ Male ______ Total _________
1. Children < 10 years; M _____, F____ 2. Children from 10-13 years; M_______, F ______
3.Children from 14-16 years; M ______, F______ 4.Number of adult from 17-50 years; M_____, F____ 5.Elderly from 50-60 years; M______, F______ 6. Elderly above 60 years; M_________F, ___________ (M=Male, F=Female)
6. Household type: 1) Male headed 2) Female headed
7. Marital status of households? 1. Married 2. Unmarried 3.Divorced 4.Widowed
   5. Other (specify)__________
8. Education level of households? Years of schooling ___________________
9.Did your household members participate in farming work? 0. No 1. Yes

10. If yes, how many of them participated ___________________ (in number)

11.Did you face labor shortage? 0. No 1. Yes

12. If yes, how did you solve the problem of labor shortage? 1. Hiring 2. Labor exchange
Others (specify) ____

II. Institutional factors

Credit issues

1. Do you have access to credit for your agricultural activities? 0. No 1.Yes

2. If yes, where do you get the sources? 1. Commercial banks 2. Service cooperatives 3 Neighbors and relatives 4.Micro finance institutes 5. Other (specify) _______________

3. For what purpose do you take credit? 1. Purchase of seeds 2. Purchase of fertilizer 3. Purchase of oxen 4. For family consumption 5.Others (specify) ____________

4. If you say No#1, what are your reasons? 1. Collateral problem 2. No access to credit supply 3. No need 4. High interest rate 5. Others (specify) ___________________________

Agricultural Extension

1. contact with DA/ Development agent? 1. Yes 2. N

2. If yes, how frequent per month? 1. One 2.Two 3.More than two

5. What supports are you get from DA's? 1. Advice 2. Training 3.Demonstration of fields 4.Conflict resolution 5. Others (specify) ____

Market issue

1. The distance between your house and market place __________________ (in Km)?

2. Means of transport? 1. vehicles

Animal labor 3. Human labor 4. Others (specify)________________________

3. is the price fair? 1. Yes 2. No

4. If no, reasons? 1. No demand 2. More supply 3.Others(specify)______________

5. Why did you sell at that particular time? 1. To appropriate family requirements 2. To pay debts 3. Other_

III. Socio economic factors

Other sources of Income

1. Have you engaged in off/non –farm activities? 0. No 1. Yes

2. If you say yes, indicate the income earned from non-farm activities in the table below using the code listed above the table.

Pity trade =1, sand and stone quarry=2, Weaving =3, Handcraft =4, Sale of local drinks =5, transport service=6, others (specify) =7

	Description income sources (use code)	Annual income (Birr)
1		
2		
3		
4		

Livestock holding

1. Do you have livestock? 0. No 1. Yes

2. If yes, indicate the number of livestock in the table below?

	Type of livestock						
	Oxen	Cow	Calf	Hen	Donkey	Goat	Sheep
Livestock number							
Livestock sold							
values in birr							

3. The total expected income of your livestock in 2013? _______________________birr

Cultivated land holding

1. Do you have your own land? 0. No 1. Yes

2 If yes, its total land size _____ha; Area under irrigation _____, area under rain fed ______

3, Total area of land cultivated during the last one year (2013 E.C) ____________ (In ha).

4. Do you shared out your cultivated land in 2013 cropping year? 0. No 1. Yes 2.4. If you say yes, write your reasons ____

Farming inputs and activities

1. Have you used farming inputs in 2013 E.C. production year? 0. No 1. Yes

2. If you say yes, indicate the inputs you used and the cost incur in the table below

Type of input	Yes=1	No=0	Amount	cost incurred (birr)	
				Rain fed farming	Irrigable farming
Fertilizer					
Manure					
Improved seed					
Chemicals					

3. Have you incur costs for your farming activities? 0. No 1. Yes

4. If you say yes, please fill the activity you did in the last one year in the table given bellow

Activities	Rain fed farming		Irrigation farming		Total cost (birr)
	No of day	Cost in birr	No of day	Cost in birr	
Weed					
Harvesting					
Threshing					
Oxen rent					
total					

IV. Use of small scale irrigation

1. Frequency of production per year through irrigation?

2. Have you ever faced crop failure in this production year?
   1. Yes 0. No

3. If yes, what were the causes for this problem? 1. Water shortage 2. Damaged by disease 3.Poor adaptation of varieties used 4. Poor administration of water distribution 5.Others, specify

4. source of irrigation water? 1. Rivers 2. Springs
   3. Ponds 4. Well 5. Other, specify ______________

5. If you donot participate in irrigation, what is the reason?
1.Lack of effective marketing system 2.Lack of input supply and irrigation facilities 3.Presence of pests and diseases 4.Lack of irrigable land6.Others/specify___________

V. Checklist for focus group discussion

1. Is there a shortage of availability of food in your kebele in the past 12 months? If yes, in which year or month this problem face to you and what did your measurement at that time or how did you solve this problem?

2. What is your general opinion on the role of small scale irrigation to household on household food security?

3. What are the determinant factors do affect your household food security?

4. What are the major factors constraining irrigation activities in your area?

5. Which do you prefer irrigated agriculture or rain fed agriculture? Why?

6. Is there any difference food security status between irrigator and non-irrigator? What is the difference between these two groups?

7. Is there equal right to use irrigation water in your area?

VI. Questions Used to Key Informants interview (KII)

1. What do you think about the impact of SSI on household food security?

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2. What are the major factors constraining irrigation activities in your area?

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3. Is there any difference on food security status between irrigators and non-irrigators?

4.Do you have anything else you would like to say or comment on?

VII. Household food security Questionnaires

Food Consumption Score

Food items	Food group	No of days the food item eaten	Weight	Food consumption score Value
Cereals: Corn, Wheat,	Staples		2	
Sorghum, Rice, Bread				
Roots and Tubers:				
Pulses/Beans/ Nuts Pulses	Pulses		3	
Milk/ Milk Products Milk	Milk		4	
Animal Proteins: Fish, Meat, Eggs	Meat and fish		4	
Vegetables (including green, leafy vegetables)	Vegetables		1	
Sugar/ Honey	Sugar		0.5	
Fruits	Fruits		1	
Oil and Fats	Oil		0.5	

Data was collected on the number of days in the last 7 days before the survey a household ate specific food items. As express in the above table, and the food consumption score value resulted by computing using this formula.

$FCS = a \times f(\text{staple}) + \beta \times f(\text{pulse}) + \gamma \times f(\text{vegetables}) + \gamma \times f(\text{fruit}) + \delta \times f(\text{animal}) + \times f(\text{sugar}) + \delta \times f(\text{dai}$
$\text{ry}) + \times f(\text{oil})$

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,)

β, γ, δ and = weight/nutritional value of each food group.

Thank you!!!