

MEKELE UNIVERSITY



**COLLEGE OF BUSINESS AND ECONOMICS
DEPARTMENT OF ECONOMICS**

**THE EFFECT OF SMALL SCALE IRRIGATION ON HOUSEHOLD INCOME AND
FOOD SECURITY
(IN CASE OF LAELAY LEGOMTY, WEREDA ADWA)**

*A Thesis Submitted To Department of Economics in Fulfillment of the
Requirements for the Award of the Masters of Science Degree in Economics*

Submitted By

GebretsadkanTetemkeGebray

ID= cbe/psre/04/11

Advisor :GebremeskelBirhane (PhD)

**September, 2025
Mekelle, Ethiopia**

STATMENET OF DECLARATION

I hereby declare that the work which is being presented in this thesis entitled “**The Effect of small scale Irrigation on household income and food security/In the case Laelay Legomty , wereda Adwa, /**” is original work of my own, has not been presented for a degree to any other university and all the materials used for the thesis have been duly acknowledged.

Gebretsadkan Tetemke Gebray

Date

(Candidate)

STATEMENT OF APPROVAL

This is to approve that the thesis prepared by **Gebretsadkan Tetemke Gebray** entitled: **“The Effect of small scale Irrigation on household income and food security/ In the case of Laelay Legomty , Adwa, /”** and submitted in partial fulfillment of the requirements for the Masters degree complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

External Examiner:

Signature _____ Date _____

Internal Examiner:

Signature _____ Date _____

Chair Person:

Signature _____ Date _____

STATEMENT OF CERTIFICATION

This is to certify that MrGebretsadkanTetemkeGebray has carried out his research work on the topic entitled “**The Effect of small scale Irrigation on household income and food security/ In the case Laelay Legomty , wereda Adwa,**”. The work is original in nature which has not been A Thesis Submitted To Department of Business and Economics in Fulfillment of the Requirements for the Award of the Masters of Science Degree in Economics, Mekelle University.

Adviser Gebremeskel Birhane (PhD)

Signature _____

Date _____

ACKNOWLEDGEMENT

First, I want to thank God for giving me wisdom, strength and knowledge to help me overcome all the difficulties that I have encountered, giving me the guidance to make my study possible.

I also would like to thank all my friends who helped me and shared their invaluable knowledge with me to make this research be real.

I would like to express my sincere gratitude to my advisor, **Gebremeskel Birhane (PhD)** for his continuous support to my thesis, his patience, motivation, enthusiasm and immense knowledge. His guide helped me all the time during writing this thesis. I could have not asked and consulted a better advisor and mentor for my work.

All in all, unlimited thanks and love go to my dearest family for their loyalty and great confidence in me. I am greatly indebted to my father who is indeed my inspiration and the man who led me to the treasures of knowledge. And also, I would like to thank my lovely wife for her continuous support to me. Further, my endless love and thanks go to my mother, brother, and sisters

Thank you very much, everyone!

.

GebretsadkanTetemke Gebray

september, 2025

TABLE CONTENT

STATMENET OF DECLARATION	I
STATEMENT OF APPROVAL.....	II
STATEMENT OF CERTIFICATION	III
ACKNOWLEDGEMENT	IV
LIST OF TABLE	VII
LIST OF FIGURE.....	VIII
ABSTRACT.....	IX
Acronym.....	X
CHAPTER ONE	11
Introduction.....	11
1.1. Background	11
1.2. Statement of the problem	11
1.3. Research Questions	13
1.4. Objective of theStudy	13
1.4.1. Specific objectives of the study	13
1.5. Scope of the study	14
1.5.1. Conceptual Scope	14
1.5.2. Methodological Scope	14
1.5.3. Geographical Scope	14
1.6. Significance of the study	14
1.7. Organization of the study	14
CHAPTER TWO	15
Literature Review.....	15
2.1. Nature of Smallholder Agriculture.....	15
2.2. Role of Small-holder Agriculture in Rural Development	16
2.3. Role of Small-holder Irrigation in Agricultural	
Development	16
2.4. Constraints on Smallholder Agriculture	17
2.5. Irrigation Development and Food Security	17
2.6. Empirical Review on Irrigation in Ethiopia and Tigray	18
2.7. Conceptual and Theoretical Framework.....	18
CHAPTER THREE.....	20
Research Methodology	20
3.1. Study area description.....	20
3.1.1. Demographics	21

3.1.2.	Agriculture.....	23
3.2.	Research Strategy and Design.....	23
3.2.1.	Data collection and Method.....	24
2.	Secondary data.....	24
3.2.2.	Sampling technique and sample size determination.....	24
A.	Sampling Technique.....	25
B.	Sample size determination.....	25
3.3.	Method of Analysis and presentation	25
3.3.1.	Model Specification.....	26
3.3.1.1.	Model Specification For effect of Food Security of the household	27
C.	Description of Explanatory Variables	28
3.3.1.2.	Model specification for Income effect of the household	30
D.	Variables definition and hypothesis	31
CHAPTER FOUR.....		34
Result and Discussions		34
4.1.	Socio – economic characteristics of respondents	34
4.1.1.	Demographic character of the respondent	34
4.1.2.	Access to credit of respondent.....	35
4.1.3.	land size and livestock of respondent	36
4.1.4.	Market information of respondent	37
4.1.5.	Gender of the respondent	37
4.1.6.	Income of the respondents.....	37
4.2.	Factors Constraining (challenges) the Use of Irrigation in Study Area	38
4.3.	Econometric analysis of rural households’ income and the effect food security in relation with user of small scale irrigation	39
A.	Multi co- linearity test.....	39
B.	OLS regression irrigation use effect on income of the household	40
E.	Binary (Logit) regression the Effect of SSI on the household food security	41
CHAPTER FIVE		45
SUMMARY, CONCLUSION AND RECOMMENDATIONS		45
5.1.	Conclusion.....	45
5.2.	Recommendations	46
Reference		48

LIST OF TABLE

Table 2.1. A synthesis of smallholder cl smallholder classification -----	15
Table 4.1. demographiccharacterstic of respondent-----	34
Table 4.2 Access to credit-----	36
Table 4.3 land size and livestock of respondent-----	36
Table 4.4 Market information -----	37
Table 4.5 Gender of the respondent-----	37
Table 4.6 Income of the respondent-----	38
Table 4.7 VIF-----	40
Table 4.8 OLS regression -----	41
Table 4.9 logit regression of food security-----	42
Table 4.10 marginal effect after logit-----	43
Table 4.11 of Challenges of irrigation use-----	39

LIST OF FIGURE

Figure 2.1. Conceptual Diagram -----	19
--	----

ABSTRACT

Shortage in amount and variability in trends of rainfall, and crop failure are serious problems in developing countries like Ethiopia and in Weredaadwa in particular. Small-scale irrigation activities has been implemented by the rural households as a means of increasing productivity by reducing crop failure associated with erratic rain fed agriculture and ensuring smallholder farmers income through improving their production. This study was conducted to estimate the effect of small-scale irrigation of rural households' income and food security in Laelay Legomty weredaadwa. In order to achieve the objective, primary data was collected in the way of questionnaire survey, group discussion and key informant interviews in sample kebeles, and systematically and randomly selected 60 irrigation users and 60 non-users rural households. The propensity score matching technique was used to reduce the possibility of bias due to unobserved factors. Logit regression model and OLS model was used to estimate propensity score and to identify determinants of rural households' user in irrigation effects on income and food security of the household in the rural area. The average user effect of small-scale irrigation on the income of the rural households was identified by using the nearest-of non user of irrigation. Estimated outcome variable was statistically significant at 1% level of significance and insensitive to unobserved factors. Irrigation user rural households in the area improved their income by Birr 250,466 than non-users. Thus, the study concluded that user in small-scale irrigation has significant positive effect on rural households' income and food security of irrigation users in the area. The result revealed that user in small-scale irrigation was significantly and positively affected by age, educational level of the household head, active family labor, family size, land holding, credit access, livestock ownership of the household and market information services. But significantly and negatively affected by extension services of the household head.

Key words:- Small-scale irrigation

Acronym

ADLI	Agricultural Development Led-Industrialization
BOARD	Bureau of Agriculture and Rural Development
BOFED	Bureau of Finance and Economic Development
CSA	Central Statistics Agency
FAO	Food and Agricultural organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
Ha	Hectare
HH	Households
IWUAS	Irrigation Water Users Associations
MoA	Ministry of Agriculture
MoWRD	Ministry of Water Resources Development
NMTIP	National Medium-Term Investment Program
NGO	Non Governmental Organization
NAPAD	New African Partnership for Africa's Development
Qt	Quintal
REST	Relief Society of Tigray
SSA	Sub-Saharan Africa
SSI	Small Scale Irrigation
WoARDO	Woreda Agriculture and Rural Development Office
WSDP	Water Sector Development Program

CHAPTER ONE

Introduction

1.1. Background

Agriculture contributes substantial share to the GDP of many low-income countries. It is often the leading sector of the economy as source of income, employment and foreign exchange.

In Ethiopia agriculture employs more than 70 percent and contributes 41 percent of the gross domestic product (MoFED 2010). (though this citation is so old, it is still influential study in the world). More than half of the production of less developed countries get their food from own-production. Agricultural outputs also are used as an input for industries so it can stimulate the growth of industrialization. Improving agricultural productivity contributes to income growth (UNDP 2007).

Irrigation is a key driver behind growth in agricultural productivity and increasing household income which highlights the various ways that irrigation could have an impact on poverty. According to Lipton et al. (2004:cited by Haile 2008), there are four interrelated mechanisms by which irrigated agriculture can reduce poverty: (i) increasing production and income, and

Reduction of food prices, that help very poor households meet the basic needs and associated with improvements in household overall economic welfare, (ii) protecting against risks of crop loss due to erratic, unreliable or insufficient rainwater supplies, (iii) promoting greater use of yield enhancing farm inputs and (iv) creation of additional employment, which together enables people to move out of the poverty cycle. In the same way, Zhou et al. (2008) mentioned that irrigation contributes to agricultural production in two ways: increasing crop yields, and enabling farmers to increase cropping intensity and switch to high-value crops. Therefore, irrigation can be an indispensable technological intervention to increase household income.

In Ethiopia, agricultural production is primarily rain fed. It depends on erratic and often insufficient rainfall. As a result, there are frequent failures of agricultural production.

Irrigation has the potential to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall. Irrigation development also can help offset some of the negative effects of rapid population growth (2.6% per year in Ethiopia; CSA 2007).

1.2. Statement of the problem

In Ethiopia, most settlement areas are degraded, per capita land availability is dwindled and productivity of land and labour are reduced and agricultural production is also affected by variability

of rainfall and drought (Seleshi et al, 2007). As a result, low farm production, widespread poverty, poor health, etc; remain to be endemic problems in Ethiopia (Pendon,2007). All these situations expose the country to exacerbate the problem of poverty. On the other hand, irrigation and water management practice could provide opportunities to cope with the problem of rainfall variability, enhance productivity per unit of land, and increase the volume of annual production significantly. More to the point, irrigation development benefits the poor households by promoting the production of high value crops, generation of farm and off farm income opportunities and plays critical role in achieving household food security (Cornic et. al, 2003 cited in Azemer, 2006 and Mengistu, 2008). Irrigation increases agricultural productivity and farm income per ha, according to previous studies (Nhundu et al., 2010; Gebremedhin and Peden 2002; Hussain 2006). It insulates the national agricultural economic sector against weather-related shocks and provides a more stable basis for economic growth and poverty reduction. It supports the process of transforming subsistence agriculture into market-oriented production of high value crops (Asfaw 2007).

Like other parts of the country; Tigray is one of those with high irrigation potential areas in the country and as a result, irrigation vegetable and crop production is becoming a means to increase food production in the region (Alem, 2008). Hence in line with the development policy of the country, the Regional Government of Tigray is promoting irrigation development so as to increase and stabilize food production in the region.

According to reports of Tigray Regional Agricultural and Rural Development Bureau, in 2011 total of 104,256.75 hectares of land were irrigated and 9,570,456.75 quintal of production benefiting 392,687 households. In 2012 also total of 149,204.7 hectares of land were irrigated and 21,261,859 quintal of production benefiting 479,169 Households. (BOARD).

Adwa Woreda is found in the central zone of Tigray where insufficient and erratic rainfall is a recurrent phenomenon that causes crop failure. It is one of the chronically food insecure areas in Tigray Regional State and is among the 31 vulnerable districts that are targeted by the Regional food Security programs (BoARD). The district has been repeatedly hit by drought due to the insufficient and erratic nature of rainfall. In this respect, water use for agriculture by smallholder farmers is an appropriate choice. According to Adwa Woreda Agricultural and Rural Development Office, in 2011 total of 4,059.58 hectares of land was irrigated and 225,085.13 quintal of production benefiting 13,298 Households. In 2012 total of 5,501 hectares of land was irrigated and 508,451 quintal of production benefiting 18,221 Households. Therefore, the researcher was interested to see the implication of irrigation whether it helped to curb the consequences of drought and its contribution

to household income.

Laelay Logomti, like many rural areas in Ethiopia, faces significant challenges such as degraded land, reduced land availability per person, decreased productivity of land and labor, and variable rainfall leading to drought. These challenges contribute to persistent food insecurity, poverty, and low agricultural production. Irrigation development in Laelay Logomti is therefore crucial as it provides a means to mitigate the impact of rainfall variability and drought, improve agricultural productivity per unit of land, and increase overall farm output. It plays a key role in improving household income, food security, and poverty reduction in the area, as it enables farmers to grow higher value crops and diversify income sources. In short, the added idea emphasizes the importance of irrigation as a practical and strategic intervention in Laelay Logomti to combat the negative effects of environmental factors on food security and livelihoods. This frames the research focus on assessing the role and benefits of irrigation in this specific vulnerable district.

1.3. Research Questions

The main research question is

What is the effect of small scale irrigation on household income and food security and the factors that influence its effectiveness in the rural area

The specific research questions to be answered by the following.

1. What is the contribution of small-scale irrigation agriculture to increase agricultural production and household income?
2. What factors do promote or hinder small-scale irrigation?
3. What is the role of small-scale irrigation agriculture in improving farm households' food security?

1.4. Objective of the Study

The overall objective of this study is to assess the contribution of small -scale irrigation agriculture to households' Production and income in Laelay Legomti in Adwa woreda Central Zone of Tigray.

1.4.1. Specific objectives of the study

1. To assess the contribution of small-scale irrigation agriculture towards increasing agricultural production and household income.
2. To investigate the factors that promote or hinder small-scale irrigation in the study area.

3. To assess the role of small-scale irrigation agriculture in improving households food security.

1.5. Scope of the study

1.5.1. Conceptual Scope

This study was assessed the contribution of small-scale irrigation to farm households income based on the interlink age of access to irrigation, production, income employment and food security.

1.5.2. Methodological Scope

120 sample household heads were selected by lottery method from the household lists prepared in both study area to analyze and to give conclusions and recommendations. It focused on household heads those who have using irrigation for agricultural production from dam water.

1.5.3. Geographical Scope

The study has been conducted in WoredaAdwa, in the selected sample areas of LaelayLegomti and Gediba Small-Scale Irrigation Schemes. Temporal or Time Scope-Time series data(from2011-2013) will employed and the study will be completed within six months. The following conditions can be considered as a limitation of the study.

1.6. Significance of the study

Conducting the study would have the following contributions.

- ✓ It contributes to the theoretical and empirical body of knowledge available on irrigation development for Farm Production and household income.
- ✓ Moreover, it will serve as a spring board for further research on the issue.
- ✓ The result of the study will help local authorities and development agents to formulate appropriate intervention mechanism.

1.7. Organization of the study

This thesis is organized in to five chapters. The first chapter comprises the introduction part of the research consisting of statement of the problem, research questions, objectives of the study, scope and limitation of the study and significance of the study. The second chapter is overview of the literature deals with different concepts and definitions. The third chapter provides methodology of the research which consists of site selection and description of the study area, nature and sources of data, research strategy and design, sampling technique and sample size determination, data collection method, and data processing and analysis.

CHAPTER TWO

Literature Review

2.1. Nature of Smallholder Agriculture

Smallholder agriculture refers to farming systems where production is primarily dependent on family labor and small landholdings. Although the term is frequently used in agricultural and rural development literature, precise definitions are rare due to the complexity of farm structures, contextual variations, and historical factors (Machethe & Molle, 2000). Smallholder farmers are often referred to interchangeably as small-scale farmers, resource-poor farmers, subsistence farmers, peasant farmers, household food security farmers, or emerging farmers. Common criteria for classifying smallholders include landholding size, production purpose (home consumption vs. market), income level, and historical or socio-political context (particularly in South Africa). A synthesis of small-holder classifications is presented in Table 2.1:

Table 2.1. A synthesis of smallholder classification

Farmer Type	Characteristics	Production Purpose	Income/Resources
Resource-poor	Small landholding, reliant on family labor	Primarily subsistence	Low; often supplemented by non-farm income; high transaction costs
Smallholders and Herders	Moderate landholding, mainly family labor	Domestic and limited market	Low to moderate; engage in livestock and crops
Middle “progressive”	Larger farms, moderate risk-taking	Market-oriented	Moderate; can bear innovation risks, provide seasonal jobs
Large-scale/Commercial	Commercial focus, capital-intensive	Market-oriented	High; access to subsidies, political influence

Historically, in South Africa, commercial farmers were largely white, while smallholders were pre-dominantly black farmers in former homelands. Currently, some black farmers have entered

commercial farming, while resource-poor farmers continue to face high transaction costs and limited access to markets and support services (Delgado, 1998; Eicher, 1990).

Analytical Insight: Smallholder characteristics significantly influence access to resources, adoption of technology, and integration into market systems. Understanding these rural households' users crucial when designing interventions such as irrigation programs, agricultural extension, or credit facilities.

2.2.Role of Small-holder Agriculture in Rural Development

Agriculture remains a primary source of livelihood in developing countries, supporting employment, income, and social stability. In Sub-Saharan Africa, smallholder agriculture contributes to reducing rural-urban migration, creating economic linkages, and expanding markets for industrial goods (Eicher & Rukuni, 1996; Delgado, 1998). Globally, studies in Bangladesh and India demonstrate that small-holder farming supports rural employment and household welfare, even in densely populated regions (Shah, 1993; Reardon, 1998).

In Africa, small-holder agriculture drives poverty reduction and economic growth, provided productivity improvements are coupled with sustainable practices. Contrary to misconceptions, agricultural intensification and environmental sustainability can coexist, as evidenced by agroecological innovations in Kenya, Ethiopia, and Malawi (Reardon, 1998; FAO, 2003).

Transition to Irrigation: Given the centrality of smallholders in rural development, interventions that enhance productivity such as irrigation can have multiplier effects on employment, income, and food security.

2.3.Role of Small-holder Irrigation in Agricultural Development

Smallholder irrigation is widely recognized as a strategy to increase agricultural productivity and reduce poverty. International evidence shows that irrigation in Bangladesh and India has significantly improved yields, reduced vulnerability to rainfall variability, and increased household incomes (Shah, 1993; Sally et al., 2003). In Sub-Saharan Africa, smallholder irrigation has often underperformed due to water scarcity, poor management, and institutional weaknesses (Barghouti & Le Moigne, 1990; Postel, 1996).

Ethiopian Context: Small-scale irrigation (SSI) provides a buffer against climatic variability, enhances crop production, and increases income and employment opportunities (Makombe et al., 2007; Tadesse et al., 2004). Despite these benefits, SSI in Ethiopia faces challenges, including

inadequate institutional support, limited technical advice, market access constraints, and sustainability issues (Wagnew, 2004; Azemer, 2006).

Analytical Insight: The effectiveness of irrigation was mediated by farmer characteristics resource poor farmers may struggle to adopt new technologies due to limited access to capital and technical support, whereas middle-income small-holders are more likely to benefit from intensification and diversification.

2.4.Constraints on Smallholder Agriculture

Several constraints limit small-holder productivity:

1. Access to Inputs and Services: Limited access to extension, finance, and markets reduces adoption of modern practices (Timmer, 1990; Eicher & Rukuni, 1986).
2. Land Scarcity: With small landholdings, extensification is infeasible; intensification and efficiency gains are required.
3. Human Capital and Technology: Low literacy, lack of technical knowledge, and inadequate machinery limit production improvements.
4. Policy and Institutional Challenges: Weak institutions, inconsistent policies, and inadequate rural infrastructure hinder growth (Eicher, 1990).

Analytical Perspective: In Ethiopia, the most binding constraints are often institutional and technical, especially in Tigray, where conflict and climatic variability exacerbate vulnerabilities. Addressing these constraints requires integrated interventions combining technology, training, and policy support.

2.5.Irrigation Development and Food Security

Irrigation is central to food security, defined as access to sufficient, safe, and nutritious food for all household members (FAO, 1996b; WB, 1986). It stabilizes production despite rainfall variability, increases yields, enables multiple cropping, and allows high-value crops to be grown (Rahmato, 1999; Seid, 2002).

Global and African Evidence: In Bangladesh, irrigation has reduced vulnerability to droughts and increased cropping intensity (Shah, 1993). In Sub-Saharan Africa, irrigation contributes to household nutrition, income diversification, and rural employment (Delgado, 1998; Sally et al., 2003).

Ethiopian Evidence: Smallholder irrigation in Oromiya and Tigray has improved crop production and

food security but faces challenges in institutional support, water management, and market linkages (Tadesse et al., 2004; Wagnew, 2004; Girmay et al., 2000).

Research Gap: While irrigation improves productivity, few studies explore how different smallholder types in Tigray benefit or are constrained by irrigation interventions.

2.6. Empirical Review on Irrigation in Ethiopia and Tigray

Irrigation in Ethiopia is classified by scale: small (≤ 200 ha), medium (200–3000 ha), and large (>3000 ha) (Smith, 1998; Dessalegn, 1999). Traditional SSI has persisted due to low capital requirements and adaptability to local contexts, despite the introduction of modern schemes since the 1960s (Woldeab, 2003).

Key Findings:

- Ethiopia's small-holder dominated agriculture contributes 46% of GDP, 85% of exports, and 85% of employment (Makombe et al., 2007).
- SSI expansion (1995–2003) increased irrigated areas from 75,000 to 200,000 ha (Diao & Nin Pratt, 2007).
- Tigray and Oromiya studies show SSI improves yields, food security, and incomes but faces management, technical, and market challenges (Tadesse et al., 2004; Azemer, 2006).

Analytical Insight: SSI success depends on institutional capacity, farmer knowledge, water availability, and integration into local markets. Local adaptation and participatory management are critical for sustainability, especially in post-conflict or low-resource contexts like Tigray.

2.7. Conceptual and Theoretical Framework

This study adopts the Sustainable Livelihoods Framework (SLF) and elements of Rural Development Theory, linking smallholder characteristics, irrigation, and support services to socio-economic outcomes.

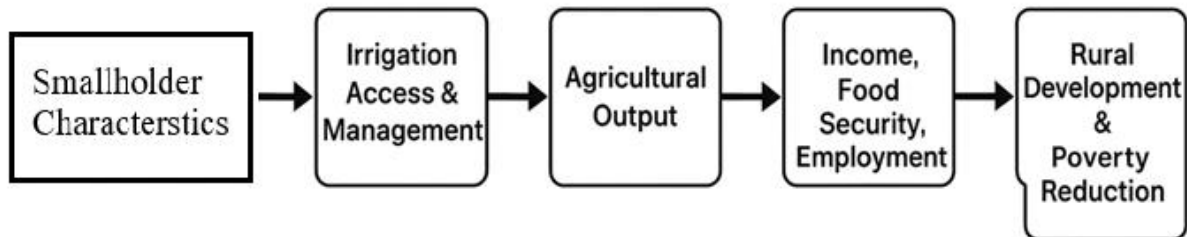
Five Dimensions of Irrigation Impact:

1. Production: Higher yields, cropping intensity, and diversification.
2. Income and Consumption: Increased earnings, household welfare, and poverty reduction.
3. Employment: Labor-intensive irrigation development and farm activities.

4. Food Security: Stability, accessibility, and self-sufficiency.
5. Social Impacts: Reduced vulnerability, strengthened community resilience, and improved quality of life.

Analytical Linkage: Resource-poor farmers may primarily benefit through enhanced food security, whereas middle-income farmers can leverage irrigation to diversify crops and increase marketable surplus. Large-scale farmers may focus on commercial benefits.

Figure 2.1. Conceptual Diagram



Research Gap: Despite extensive evidence on SSI benefits, few studies systematically explore how irrigation interacts with smallholder typologies and socio-economic outcomes in Tigray. This study addresses this gap.

CHAPTER THREE

Research Methodology

3.1. Study area description

This research is basically a survey case study focused on two community-based small-scale irrigation systems, namely LaelayLogomti. The reason for the selection of these irrigation systems is that both are found in the semi-arid areas where insufficient and erratic rainfall is a recurrent phenomenon that causes crop failure. Accessibility of both irrigation systems is also another factor for their selection. Besides the wereda is also one of the high irrigation potential areas in the region. In this respect, water use for agriculture by smallholder farmers is an appropriate choice. Therefore, the researcher is motivated to assess its contribution to household income.

Tigray is one of the national regional states of Ethiopia which is located in the northern part of the country between 12°15'N and 14°57'N latitude and 36°27'E and 39°59'E longitude and covers an area of 53,000 square kilometres (Solomon 2005). The region is bounded by Eritrea to the North, the Sudan to the West, and the Ethiopian regions of Amhara and Afar to the South and the East respectively.

Tigray consists of seven administrative zones including Mekelle town which are further divided into 34 rural districts and 12 town districts.

Mekelle is the capital city of the National Regional State of Tigray. Each district is subdivided into tabias and each tabia is divided into kushet. Thus, tabias are the lowest unit in the administrative hierarchy. The zones are the Western zone, North Western, Central, Eastern, Southern Eastern, Mekelle and Southern zone. The delineation is made based on natural boundaries like rivers, escarpments and mountain peaks; settlement, population size, agro ecology and convenience & proximity to administer centers (BOFED, 2004). Tigray has a total population of 4,316,988 (CSA, 2007) which is about 5.8% of the total population of Ethiopia.

The sex composition is 2,131,319(49%) male and 2,195,523(51%) female. 80.5% of the population lives in the rural areas (CSA, 2007). The economically active age group accounts about 51.8% of the total population. In terms of religion 95.6% of the population are orthodox Christians, 3.96% are Muslims, 0.36% are Catholics and 0.08% are Protestants (CSA, 2007).

Regarding ethnic composition, 96.54% are Tigraway, 0.2% Agew, 0.7% Erob and 0.07% Kunama and 2.49% others (CSA, 2007).Tigrigna is the working language of the state and Tigray has various natural resources which facilitate the development of agriculture.

3.1.1. Demographics

Based on the 2007 national census conducted by the Central Statistical Agency of Ethiopia (CSA), this woreda has a total population of 99,711, an increase of 17.74% over the 1994 census of whom 49,546 are men and 50,165 women; no urban inhabitants were counted in this woreda. With an area of 1,888.60 square kilometers, Adwa has a population density of 52.80, which is less than the Zone average of 56.29 persons per square kilometer. A total of 20,141 households were counted in this woreda, resulting in an average of 4.95 persons to a household, and 19,525 housing units. The majority of the inhabitants said they practiced Ethiopian Orthodox Christianity, with 99.3% reporting that as their religion.[3]

The 1994 national census reported a total population for this woreda of 109,203, of whom 53,324 were men and 55,879 were women; 24,519 or 22.45% of its population were urban dwellers. The largest ethnic group reported in Adwa have the Tigrayan (99.53%). Tigrinya spoken as a first language by 99.56%. The majority of the population practiced Ethiopian Orthodox Christianity, with 96.4% of the population reporting that belief, while 3.43% were Muslim. Concerning education, 25.33% of the population were considered literate, which is more than the Zone average of 14.21%; 34.92% of children aged 7–12 were in primary school; 5.7% of the children aged 13–14 were in junior secondary school, and 8.99% of the inhabitants aged 15–18 were in senior secondary school. Concerning sanitary conditions, about 65% of the urban houses and 24% of all houses had access to safe drinking water at the time of the census; 31% of the urban and 10% of the total had toilet facilities.

Laelay Logomti was located in the southern parts of Adwa town, distance around 22 k.m and the total population number are 6540, and the total area of the land 32.05 square meter or 3204.53 hectare were covered as the report of the agricultural office of the woreda. From different surrounding a number of collective rivers entered to this Tabia. According to the vast opportunity. the scheme was originally designed to irrigate for 650 hectares, with a potential irrigable area of 420.5 hectares and currently functional area of 306.166 hectares were irrigated. Seysa dam Located in La-elay logomti Kushet Debri has a height of Main channel Extends 12.053 Metres Constructed by the Enterprise Project; the Site lies at Coordinates:

X (Easting): 38.99453, Y (Northing): 10.12546 and Z (Elevation): 1943m .

Farmers report positive crop performance, especially with hybrid maize varieties, when irrigation water is consistently available.

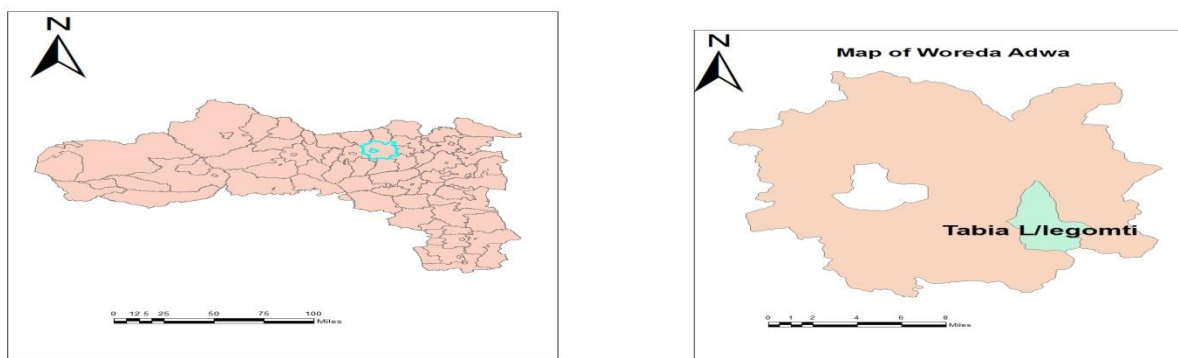
The project area has high potential for productivity improvement with proper management and regular maintenance. Coordination with local agricultural offices and water user associations remains crucial for long-term sustainability.

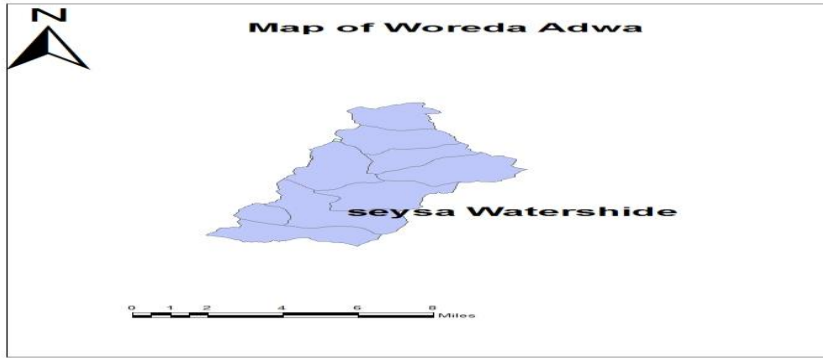
Overall performance is estimated around 70–80% functional, with room for improvement to reach full design potential.

For a specific soil characteristics in the study area Laelay Logomti and their implication for agriculture or land use, local soil surveys studies provided the most accurate information. Based on the report agricultural office of wereda Adwa provided, the soil composition can be summarized as -Sand soil =24.43, - caly soil = 19.75 - silt soil = 55.82 This composition indicates a soil type that is predominantly silt, which suggested good moisture and nutrient availability making it suitable for various agricultural practies. The presence of sand and clay soil in smaller amounts can contribute to the soil's drainage and texture, respectively.

The air condition of the study area partly cloudy to mostly sunny with the temperatures ranging from 15⁰c to 27⁰c depending on the time of day and season.

Figure 3.1. Administration map of Adwa and L/legomti





Source Arc GIS Woreda Adwa Agriculture office, 2025

3.1.2. Agriculture

A sample enumeration performed by the CSA in 2001 interviewed 23,613 farmers in this woreda, who held an average of 0.56 hectares of land. Of the 13,149 hectares of private land surveyed, 89.75% have in cultivation, 1.51% pasture, 3.22% fallow, 0.56% woodland, and 4.98% have devoted to other uses. For the land under cultivation in this woreda, 80.64% have planted in cereals, 7.48% in pulses, 0.61% in oil seeds, and 0.14% in vegetables. Fifteen hectares were planted in fruit trees and 47 in gesho. 78.71% of the farmers both raised crops and livestock, while 20.76% only grew crops and 0.54% only raised livestock. Land tenure in this woreda is distributed amongst 92.25% owning their land, and 6.97% renting; the percentage reported as holding their land under other forms of tenure is missing.[5]

3.2. Research Strategy and Design

The advantage of employing qualitative and quantitative methods in research is getting increasing recognition among researchers. It enables to benefit from the insights that the two methods provide when used in combination. Moreover, the most effective research is one that combines qualitative and quantitative components (Babbie, 2003). Thus, the research strategies employed in this study combine both qualitative and quantitative methods.

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

households using semi-structured questionnaire and by referring reports and documents of different Bureaus' and Offices'.

3.2.1. Data collection and Method

The nature of the data have both qualitative and quantitative collected from primary and secondary sources. Primary data for the study have been collected from selected sample households, focus group discussion, interview with key informants (committee members of water user's associations, peasant association executive committee members, Women development army, development agents and Wereda irrigation development experts) and field observations.

1. Primary data collection methods

Primary data have been collected using of household questionnaire, survey, focused group discussion (FGD) with the community members, and interviews with key informants. The study have been collected primary data with the help of semi-structured questionnaire designed to obtain information from selected sample households. The household survey covered personal data, household resources, production and income, issues related to irrigation practice, and support issues.

2. Secondary data

Secondary data were gathered by referring documents and reports of relevant offices. Secondary data have also collected from formal sources such as Bureau of Agriculture and Rural Development (BOARD), Bureau of finance and Economic Development (BOFED), Wereda Agriculture and Rural Development office (WoARDO) reports and Ceteral Statistics Agency CSA.

3.2.2. Sampling technique and sample size determination

The total household heads that were at Laelay Logomty watershed small- scale irrigation systems are 172. Although the size of population of the two study sites differ, equal number of sample houpositive were selected from each for the convenience of the study. Accordingly to make the data more manageable a total of 120 sample households that was 60 from each sample list of grouped household users and non users have been selected. Each sample household have been selected by lottery method fromthe prepared list of household heads (Sample frame) at each studyareas.

	Irrigation		
	Users	Non_users	
Watersed Lailay legomti	60	112	172

A. Sampling Technique

The researcher had taken sample techniques multiple sampling techniques. First We had taken the list of House hold of the users and non-users to be our sample and then we used simple random sampling method for our representative sample from each list of household grouped to users and non_users of irrigation. The simple random sampling method allows the participants' equal opportunity of being select for the study hence its selection as the method of choice for sampling by the researcher.

B. Sample size determination

There are different formulas given by different educationalists for the determination of appropriate sample sizes. The researcher chooses the formula according to their needs and convenience. In choosing the right one, the researcher has to take into consideration about the maximum budget, time limit, nature of the study along with desired level of precision, confidence level and variability within the population of interest. Thus, this study applies a simplified formula provided by (Yamane, 1967) to determine the required sample size at 95% confidence level. This formula is preferred over other formulae due to its simplicity and it is scientific. The total households of tabia Lailay legomty wereda Adwa were . Therefore, the sample size should be; Based on the assumptions and method of Yamane's (1967) formula for sample selection is adopted to determine the sample size.

The formula: $n = N / (1 + N(e)^2)$

Where;

n - Designates sample size for the study

N- Designates Number of employees in the region

e= designates maximum variability or margin of standard error at 95% Confidence Interval

1= designates the probability of the event occurring.

Therefore,

$n = N / (1 + N(e)^2)$

$n = [172 / (1 + 172 * (0.05)^2)]$

$n = 172 / 1.43 = 120$; and 5% (non- response) made the sample size of 120. The

3.3. Method of Analysis and presentation

Statistical analysis utilizing STATA software was used to process and present all data, both quantitative and qualitative. To obtain pertinent study-related information, the data cleaning, organizing, analysis, interpretation, presentation, and modeling tasks have completed. Both

descriptive and inferential analysis were employed for this data analysis. The mean, standard deviation, minimum and maximum values were all used in descriptive analysis to illustrate the broad characteristics of the data that was gathered. The project was employ inferential statistics for the extraction, interpretation, modeling, and decision-making of econometric data. In order to match observed baseline characteristics of users to baseline characteristics of non-users and to determine the effects of households' uses of small-scale irrigation farming (SSI) in the research area, ordinal list square (OLS) and logit regression models was used in this study. When SSI intervention actions are implemented at the household level, the average treatment effect on the treated (ATT) was estimated using the Nearest Neighbor Matching 3 (NN-3) for implementation of small scale irrigation intervention activities at household level. During the survey, information from focus groups and key informant interviews was captured, compiled, and utilized.

3.3.1. Model Specification

According to Gujarati (1995), three types of models have been proposed in the econometric literature for estimating binary choice models: the linear probability, logit and probit models represented by linear probability function, logistic distribution function and normal distribution function, respectively. These functions were used to approximate the mathematical relationships between explanatory variables and the food security situation that is always assigned qualitative response variables. According to Hosmer and Lemeshow, (1989) the major point that distinguishes these functions from the linear regression model is that the outcome variable in these functions is dichotomous. Besides, the difference between logistic and linear regression is reflected both in the choice of a parametric model and in the assumptions. Once this difference is accounted for, the methods employed in analysis using logistic regression follow the same general principles used in linear regression.

Available evidence shows that the logistic function is the most frequently used function in food security studies. According to Hosmer and Lemeshow (1989), there are two primary reasons for choosing the logistic distributions: from mathematical point of view; it is an extremely flexible and easily used function; and it lends itself to a meaningful interpretation. The interest of the study with regard to this objective was to analyze the determinant factors that affect the household food security. For this study, analytical model selected was binary logit model which significantly identifies the food security situation of households and for the effec agricultural the household income linear regression (OLS)

Food Security Model: Ordered logistic regression to estimate the association between irrigation access and ordered categories of food security levels

Income Model: Multiple linear regression (OLS) of household income on irrigation use and control variables (land size, educational level, household size, input use).

3.3.1.1. Model Specification For effect of Food Security of the household

Binary choice models are appropriate when the decision making choice between two alternatives (food secure and food insecure). Household food security is a dependent variable, which takes a value of zero or one depending on whether or not a household was food secure or not (i.e. Food secure=1 and Food insecure=0).

Following (Gujarati, 1995) the logistic distribution for the food security situation can be specified as:

$$P_i = \frac{e^{z_i}}{1 + e^{z_i}} \quad \text{-----1}$$

Where p_i was the probability that an individual is being food secure for the i^{th} household and ranges from 0 to 1. e = Respondent the base of natural logarithms and

Z_i = is the function of vector of n -explanatory (x) and expressed as

$$Z_i = \beta_0 + \sum \beta_j X_j + U_i \quad \text{-----2}$$

Where β_0 = is intercept β_j = is regression coefficients to be estimated X_j = is Variables and U_i = is a disturbance term

$1 - P_i$ = was represents the probability of not being food secured group and can be written as

$$1 - P_i = \frac{e^{-z_i}}{1 + e^{-z_i}} \quad \text{-----3}$$

Then Odds ratio can be written as:

$$\frac{P_i}{1 - P_i} = \frac{e^{z_i}}{1 + e^{-z_i}} = e^{z_i} \quad \text{-----4}$$

Equation (4) was indicates simply the odd ratio. It was the ratio of the probability that the household was food secure (P_i) to the probability that he/she was food secure. Finally by taking the natural logarithm of equation (4) the log of odds ratio could be written as :

$$\ln\left(\frac{P_i}{1 - P_i}\right) = \ln(e^{\beta_0 + \sum_{j=1}^n \beta_j x_{ji}}) = Z_i = \beta_0 + \sum_{j=1}^n \beta_j x_{ji} + u_i$$

$1 - p_i$

Where \ln was log of the odd ratio, which was not only linear in X_{ji} but also linear in the parameters

C. Description of Explanatory Variables

Based on the review of the literatures and practical experiences, explanatory variables which have logical and justifiable rational in determining household food security status are identified. These are presented as follows:

Age of a Household Head (HHAGE): Age is a continuous variable measured in years. It was one of the factors that determine household food security status. Thus, younger farmers were more innovative and open to technological advances and be more willing to adopt a new technology (Diederinet *al.* 2003). Babatunde (2007) and other related studies stated that young head of households were stronger and were expected to cultivate larger-size farm than old heads. Hence, the expected effect of age on household food security could be positive or negative.

Education Level of a Household Head (HHEDUC): It is a continuous variable measured in formal schooling years completed by the household head. Education is expected to have a positive effect on household food security status. Households with better education level was believed to have a chance to apply scientific knowledge and better manage their farm activities in good manner, hence boost domestic production to fulfil household consumption needs. Based on Amazaet *al.* (2006) and other literatures, the higher the educational level of household head, the more food secure the household was expected to be. Hence, education has positive contribution to household food security.

Household size (HSIZE): It was measured in the number of peoples living in the household converted in to adult equivalent. For farming activity, the labour force in the family is essential in order to be food secured. A household who has more number of family members could share the work load to them and contribute a lot to the food security situation of the specific household. Hence it is expected to influence the food security situation of the household positively.

Active family labor: Household members aged above 18 are considered as labor of the family which reduce expenses of labor. These groups were economically active and influential in the member of household to full fill their immediate food demands. Hence, it is expected that active family labor have a positive impact on food security situation of the household.

Health Status of the Household Head (HSHH): To work farming activity, physical wellbeing of the farmer was mandatory. The farmer was able to involve in farming work and management aspect of

the farm if he/she is healthy. So, health status of the household head was influence the food security situation. It was measured in days per year that the householdhead wassick (out of farming work). Good health status was expected to influence the food security situation of the beneficiaries positively.

Extension services: Refers to the frequency of contact that respondents made with development agent per month. It was the continuous variable. Farmers contact more with development agent have better knowledge about extension packages including irrigation technology than the others .This enables them to enhance production, which is one of the condition of food security. As a result, positive relationship would be expected between contacts with development agent and food security status.

Access to Credit (ACREDIT) was a dummy variable that takes the value 1 when the household takes loan and 0 otherwise. Credit was very much useful to purchase inputs such as improved seeds, other important inputs including staple food. Hence, farmers who have access to credit would have positive effect on crop production due to use of agricultural inputs which enhance food production and ultimately increase household food security status. Moreover, households with access to credit may purchase food when the need arises. Both pathways indicate that a direct relationship of credit access and household food security.

Total Livestock Holdings /TLU/:This refers to total number of livestock measured in tropical livestock unit (TLU). Livestock is important source of income, food and draught power for crop cultivation in Ethiopian agriculture. Household with more number of livestock have a chance to obtain more direct food or income to purchase foods commodities, particularly during food crisis. Therefore, higher livestock size would increase significantly the status of food security.

Market information: This was a continuous variable measured in kilo meter. It refers to the distance between the households+“ home and the nearest market”. As the farmer is nearer to a market, the higher would be the chance of increasing the household’s income, access to purchase food from market and to sell his/her outputs. It is, therefore, expected that households nearer to market would incur lower transaction cost and can easily access the market the required food.

Access to Irrigation (ACCIRR): was a dummy variable with values of 1 if the household head has access to irrigation and 0 otherwise. Irrigation, as one of the technology options available, enables smallholder farmers to directly produced consumable food grains or/and diversify their cropping and supplement moisture deficiency in agriculture. In doing so, it helps to increase production. It was assumed to have a direct relationship with household food availability. Hence, those household have an access to irrigation was expected to have positive impact on household food security status.

Cultivated Land size (CULTLAND): this refers to total cropping land cultivated by a household in the past one year production period. It has a direct relation with crop production. A larger size of cultivated land implies more production and availability of food grains. According to Haile *et al.* (2005) and Babatunde *et al.* (2007) and other literatures, food production can be increased extensively through expansion of areas under cultivation. Hence, size of cultivated land was expected to have positive effect on household food security status.

Participation in Non-farm activity (NONFARM): It is a measure of any household member participated in non-farming activities and generated an income in Birr. It was assumed that non-farm income earned by a household was primarily spent on food items such as on food grains, and non-food items required for household members. Therefore, in this study it was hypothesized in that non-farm income was positively associated with household food security status.

3.3.1.2. Model specification for Income effect of the household

This model can be estimated using the iterative maximum likelihood (ML) estimation procedure.

Therefore the OLS model is:

$$\text{Income} = \beta_0 + \beta_1 \text{AGE} + \beta_2 \text{SEX} + \beta_3 \text{EDUC} + \beta_4 \text{FS} + \beta_5 \text{AFL} + \beta_6 \text{LAND} + \beta_7 \text{EXS} + \beta_8 \text{LOS} + \beta_9 \text{CS} + \beta_{10} \text{MKI} + U_i$$

Where ,

SSIRRU = probability of the rural household using small scale irrigation farming

Bo = The intercept

Bi = Regression coefficient estimated for each covariates ($\beta_1 - \beta_{10}$)

AGE = Age of the respondent in number of years

SEX = Sex of the respondent household head male or female

EDUC = Educational level of the respondent in number of years

FS = Family size of the respondent in number of family member

AFL = Active family labor in the HH in number

LAND = Land holding size of the respondent in hectare

EXS = Number of visit for agricultural extension service in the year (frequency)

LOS = Live stock holding size of the respondent in TLU

CS = Credit service accessible to the respondent for agricultural production

MKI = Market information that the respondent have concerning about price of the product

$U_i =$ Disturbance term

D. Variables definition and hypothesis

In this study two types of variables (dependent variables, and independent/explanatory variable) were used to estimate the effects of SSI farming practice on income of the rural households in the study area. All selected types of variables in this study (dependent variables, outcome variables and independent variables) were defined in detail below

Dependent variables (Outcome variable)

Household income: the outcome variable for this study was the total income of the household measured in Birr.

Small scale irrigation user Income of the Household (SSIRRU) is considered as dependent variable, which is expected to be influenced by the explanatory variables covariates and influence total income of rural households in the Laelay Logomty district. It was a binary variable (i.e., 1 for users of SSI farming and 0 for non-users).

Independent variables

Age (AGE): - It is the age of the respondent in number of years. It was a continuous variable and is expected to be influenced negatively by households' users of SSI farming. According to some studies (Nhundu et al., 2015; Adam et al., 2016; Mohammed, 2016; Temesgen et al., 2018), the household head's age had a negative and significant impact on consumers of small-scale irrigation.

Sex of the household head (SEX): this variable was a dummy variable, which takes a value of 1 if the sex of a respondent was male and 0 otherwise. The variable is hypothesized to have a positive influence on users of small scale irrigation and income of the household. According to many studies, households with a male head of household are more likely to conduct irrigation than households with a female head of family (Abraham et al., 2015; Bedaso, 2018).

Educational level of the household head (EDUC): - It is the educational level of the respondent in number of educational years. It was a continuous variable and positively influences users of small scale irrigation farming. According to Muhammad et al. (2013), education improves farmers' access to information on irrigation technology and innovative techniques.

Family size (FS): - It is the number of family members of the respondent. It is a continuous variable and negatively influences users of small scale irrigation farming activities.

Active family labor force (AFLF): - It is the total number of the household members in active or productive age; can participate in productive works and generate income for the family. It was a continuous variable and positively influences households' users of small-scale irrigation farming in

the selected study area. According to several research, smallholder farmers' participation in irrigation practices is positively influenced by an active family labor force (Abebaw et al, 2015; Kumala and Mulubrihan, 2020).

Land holding (LAND): - It was the size of farm land (in hectare) that the respondent owned and used for farming activities. It was a continuous variable and influenced positively households' users of small-scale irrigation farming. According to research from (Beyan et al., 2014; Kane et al., 2018), farmers who had greater tracts of cultivable land were found to engage in irrigation practices more frequently than their counterparts. Farmland is the main input for agricultural output in rural households, according to Kane et al. (2018).

Extension services (EXS): - It was technical advisory services including trainings and awareness creations provided freely to the respondent in a year. It was a continuous variable explained numbers of frequencies in one farming year and influenced positively households' users of small-scale irrigation farming. According to a 2013 study by Sikhulumile in South Africa, the frequency of extension contact increased the possibility that people would participate in irrigation, and extension staff are more noticeable in small-scale irrigation.

Livestock ownership (LOS): - It was the number of livestock (in TLU) that the respondent owned. It was a continuous variable explained in TLU and influenced positively households' participation in small-scale irrigation farming. The quantity of each species of animal was multiplied by the relevant conversion factor to determine the amount of livestock that a household has in TLU. The prospect of leveraging the sale of cattle during the transition to irrigated farming as a source of money that can be used for investing in irrigated farming, according to Lefore et al. (2019).

Credit services (CS): - It was the accessibility of credit services for the respondent for agricultural production. It was a binary variable (i.e., 1 for 'Yes or accessible and 0 for 'No or not accessible'), and it influenced positively households' users of small-scale irrigation farming in the selected study area. Credit utilization can enable farmers to overcome their financial constraints associated with production and participation in irrigation (Desta and Almaz, 2015; Astatike, 2017). Credit utilization could enable farmers to use the irrigation technologies by purchasing the inputs on time (Kalkidan et al., 2017).

Market information (MKI): This variable was a dummy variable taking a value of 1 if the respondent has an information on the market concerning the demand and price issue of the product or 0 otherwise. The farmers did not have information on the demand of the product, they may not be encouraged to produce since they did not know that production that has a positive return or loss. This

variable was hypothesized to affect the irrigation user practice and income positively. This variable was found positively and significantly affected the participation decision of the farmers by several studies (Abebaw et al., 2015; Kane et al., 2018; Temesgen et al., 2018).

CHAPTER FOUR

Result and Discussions

This chapter presents the results and discussion of the study. It was divided into four sub-sections; the first sub section summarizes results by using descriptive statistics such as means, percentages and frequencies to describe the characteristics of sampled households by using explanatory variables. The second sub- section focuses on the measuring of food security using household food insecurity access scale in order to determine the food security status of sample households and focus on household dietary diversity and food consumption score of sample households. The third sub section presents the results from econometric analysis that identifies the factors affecting household food security. Finally, the fourth sub section discusses constraints that affect irrigation use.

4.1. Socio – economic characteristics of respondents

4.1.1. Demographic character of the respondent

Table 4.1. demographic characterstic of respondent

The mean age of household heads, mean family size and the mean number of active family labor availability of the household is shown in table 4.1

Variable	Irrigation		
	Stastics	none_user	user
age	mean	46.3333	50.3667
	SD	11.55043	9.45456
fs	mean	5.73353	6.15
	SD	1.055521	2.09782
afl	mean	2.58333	3.36667
	SD	0.9618426	1.54005
Education_status	mean	2.816667	2.35
	SD	1.420094	1.1619
Extension_-service	mean	0.2	0.08333
	SD	0.4033756	0.27872

Source : own survey 2025

Based on the result revealed in the table, there were significant difference in mean age, family size and active family labor between the irrigation user and non – user respondents. The study revealed that the users of irrigation are older than the non–users households indicating that younger households have been adopting irrigation less than the older households. The study further indicated that irrigation user households have high number of family members than non – users and the minimum and maximum family size of the study area was 1 and 9 respectively. Average family size at the national level in Ethiopia was 4.6 (CSA 2019). In the study area the average family size was 4.6

(Table 4.1). In this study family members are blood relatives, this was why the average family size is nearly equal to the average family size of the country. This implies that availability of active family labor in the household has significant positive effect on rural households' use in small – scale irrigation activities in the study area.

The mean formal school age of irrigation user and non –user household heads' was grade 1 and grade 4, respectively (table 4.1). The result indicated that mean formal school age of irrigation user households was significantly (0.001) higher than that for the non – user household heads. This implies that formal education level of the household heads have significant positive effect on the probability of their decision to use in irrigation in the study area. This finding was in lined with the finding by Engdasew Feleke et al. (2020); Temesgen, (2017) and Agerie N. W (2013) explained that as the formal educational year of the household head increases he/she can get wider opportunities to be use and understanding how to implement farming technologies. Similarly, Abrham et al. (2015) explained that better educated household heads are more likely to use in small-scale irrigation activities than less or non-educated household heads.

The mean number of visit of agricultural extension services for irrigation users and non – users households were 0.2 and 0.08, respectively (table 4.1). This implies that respondents who get better agricultural extension service were more likely to use in small – scale irrigation activities than those who did not get extension services. This implies that the number of contacts with agricultural extension service providers (Das) has significant positive effect on the probability of the rural households' decision to use in irrigation. In line with this result Muez, (2017), stated that farmers who get training and technical advices about the benefits and implementation of small scale irrigation activities are more user and successful implementers in small – scale irrigation farming practices than less trained rarely consulted farm households.

4.1.2. Access to credit of respondent

The frequency of users and non – users households who have got credit service on the table blow show is 48 and 14 respectively. The result implies that more irrigation users households have got credit service than non – users rural households in the study area. The survey reveals that about 51.66 % of the respondents accessed credit from formal financial institutions while the rest 48.34% of them haven't accessed credit from lending institutions. As indicated in table 4.2, 80% of SSI user households and 23.33% of non – users have accessed credit service while the rest 20% of irrigation users and 76.67% of non – users haven't accessed any credit service. The result shows that only 20% of irrigation user households haven't accessed credit service, but 76.67% of non – users haven't

accessed credit service. This finding is in lined with the finding reported by Abrhamet al., (2015) stated that access to credit to the farm households for their agricultural production determines positively the probability if their decision user in small – scale irrigation activities. The research findings by Temesgen, (2017), Muez , (2014) and Tale Geddafaet al (2012) are in lined with this finding.

Table 4.2 Access to credit

Acc_credit	Irrigation				Total	%
	Non_user		Users			
	HH	%	HH	%		
Non_user	49	76.67	12	20	58	48.34
user	14	23.33	48	80	62	51.66
Total	60	100	60	100	120	100

Source : own survey 2025

4.1.3. land size and livestock of respondent

The result revealed in the table blow shows that there is no significant differences in land holding size the mean land size of user is 0.83 and nonusers 0.76 but there is a significant differences in livestock ownership by income between irrigation users and non – users (table 4.3) the mean of the users 81,337 Birr and non users 60,501. This finding is in lined with the finding reported by (Abebaw et al, 2015; Leforeet al, 2019)

Table 4.3 land size and livestock of respondent

. tabstat ls income_livestock, statistics(mean sd) by(irrigation) columns(variables)

Summary statistics: mean, sd
by categories of: irrigation (Irrigation)

irrigation	ls income-k	
Irrigation_None_	.7658333	60601.67
	.3020399	59382.97
Irrigation_User	.8375	102073.3
	.3588618	90227.49
Total	.8016667	81337.5
	.3322279	78855.78

Source : own survey 2025

4.1.4. Market information of respondent

Market information access (table 4.4) on input and output price was analyzed across users and non-users in small – scale irrigation activities. For the total observation, 34.16% of households doesnot have any information on input and output prices, where as 45% of non – users and 23.33% of theusers have no information on input and output prices.

Table 4.4 Market information

```
. tab market_info irrigation
```

Market_Inf o	Irrigation		Total
	Irrigatio	Irrigatio	
No access	27	14	41
Access	33	46	79
Total	60	60	120

Source : own survey 2025

4.1.5. Gender of the respondent

Sex of users and non – users of small – scale irrigation (table 4.5) indicates that for the total observation, 38.33% of the households are female and 61.67% of the households are male where as81.67% irrigation users of the households are male and 58.34% irrigation non – users of the households are female.

Table 4.5 Gender of the respondent

```
. tab gender
```

Gender	Freq.	Percent	Cum.
Male	74	61.67	61.67
Female	46	38.33	100.00
Total	120	100.00	

```
. tab gender irrigation
```

Gender	Irrigation		Total
	Irrigatio	Irrigatio	
Male	25	49	74
Female	35	11	46
Total	60	60	120

Source : own survey 2025

4.1.6. Income of the respondents

There were significant difference in the total income of both irrigation users and non –users respondents inthe selected study area with Birr 250,466 and 98,061, respectively. The result showed that irrigation users respondents have generated Birr 250,466 more average total incomes than non – users and the overall respondents, respectively. As indicate in the table, the mean total income difference of irrigation users and non – users respondents is Birr 152,405.

Table 4.6 Income of the respondent

. tabstat total_income, statistics(mean sd) by(irrigation) columns(variables)

Summary statistics: mean, sd
by categories of: irrigation (Irrigation)

irrigation	total_~e
Irrigation_None_	98061.8 62951.57
Irrigation_User	250466.7 139063.2
Total	174264.2 131941.1

Source : own survey 2025

4.2. Factors Constraining (challenges) the Use of Irrigation in Study Area

The Third objective of the study was to identify the major constraints of irrigation use in the study area. The importance of small scale irrigation in the study area had increased from times to time. The survey results indicate that small scale irrigation had a great potential to improve the incomes and household food security of poor households. However, adoption of small scale irrigation is not an easy matter. The study identified several factors constraints using small-scale irrigation in the study area.

Table 4.11 shows that 19.17 % of respondents were reported that distance from water source was major constraining of irrigation use and there was shortage of water, especially, for irrigation non user households in the study area. Farmers who had far-off farm lands from water source didn't use irrigation as it involves high financial, time and labor cost to access the irrigation water.

The result of the descriptive statistics shows that lack of irrigation inputs that can be used for irrigation was constraints for 5.83 % of irrigation users and non-user households.

The survey result shows that 18.33 % of the respondents had problems of getting enough training of irrigation in study area (Table 4.11). The survey result indicated that farmers with no or little training in irrigation technologies and farm inputs such as seeds, fertilizers and chemicals, they could not engaged in irrigation activities.

Lack of effective marketing system was another constraint for irrigation use., Farmers would be discouraged to produce much as they were not getting rational price for their produce i.e. prices go down with high supply as result farmers couldn't store to sell latter because have no storage facilities. As indicated in Table 4.11 lack of effective marketing system was a major problem for 2.5% of respondents in the study area.

The presence of costly of inputs were the other constraints of irrigation for 4.17 % respondent in the study area. This implies the number of participants and irrigation practices would be reduced in demanding inputs.

The result of the descriptive statistics shows that lack of suitable land that can be used for irrigation (irrigable farm land) was the major constraints for 50% of irrigation non-user households. This implies that those farmers whose farm lands were located on sloppy lands. This farm lands were difficult to apply water though gravity force expect other water lifting mechanisms and improved irrigation technology.

Table 4.7 Of Challenges of irrigation use

. tab main_challenges

main_challenges	Freq.	Percent	Cum.
water shortage	23	19.17	19.17
inputs shortage	7	5.83	25.00
market problem	3	2.50	27.50
not getting enough training	22	18.33	45.83
costly of inputs	5	4.17	50.00
lack of suitable land for irrigation	60	50.00	100.00
Total	120	100.00	

4.3. Econometric analysis of rural households’ income and the effect food security in relation with user of small scale irrigation

In order to understand the relationship between the outcome variable incomes of the rural households’ in relation with their use of small scale irrigation were econometrically analyzed using STATA software. Logit regression model was employed in the analysis to estimate the effect of irrigation on rural households food security and the OLS regression for effect of irrigation on household income of households’ use of small – scale irrigation activities in the study area.

A. Multi co- linearity test

Multi co – linearity can be a problem in regression model because we would not be able to distinguish between individual effects of the independent variable on the dependent variable. It may not affect the accuracy of the model as much, but we might lose reliability in determining the effects of individual features in the model. If the degree of the correlation between independent and dependent variables is high enough, it can cause problem of when you fit the model and interpret the result. It can exist because of problem in dataset at the time of create, poor designed experiment, high observation data (Noora Shretha, 2020). Multi Co – linearity problem can be detected using variance inflation factor (VIF). The variance inflation factor (VIF) helps to identify correlations between

independent variables, and also determines the strength of the correlation. The VIF can be predicted by taking an independent variable and regressing it against every other independent variable. $VIF = \frac{1}{1 - r^2}$

, where, VIF =variance inflation factor, R^2 = the value of adjusted R^2 which ranges between 0 and 1. The value of VIF indicates existence and the strength correlation between independent variables. The value of VIF should not be greater than 5 for safe multi co – linearity problem. The higher the value of VIF (VIF > 5- infinite) there exist higher multi co- linearity problem. If the value of VIF was $1 < VIF < 5$. It specifies that the variables were moderately correlated to each other (Noora Shrestha, 2020). As indicated in table 4.8, the values of all analyzed covariates are in range of 1.27 – 2.39, in all cases VIF was less 5 except family size and active family labor. It indicates that the independent variables are not correlated to each other.

Table 4.8 VIF

Variable	VIF	1/VIF
fs	5.81	0.172111
af1	5.72	0.174685
age	2.39	0.419043
education	2.23	0.447432
ls	2.00	0.499840
acc_credit	1.52	0.656087
gender	1.49	0.673266
exten_serv-s	1.29	0.773108
market_info	1.27	0.788859
Mean VIF	2.64	

Source : own survey 2025

B. OLS regression irrigation use effect on income of the household

As indicated in table 4.8, except extension service of the respondents the p – values of all explanatory variables were less than 0.01 ($p < 0.05$). Therefore, the null hypothesis (H_0) was rejected in all cases except extension service to accept the alternative hypothesis (H_a). This implies that the p – value of explanatory variables age, gender, education, family size, livestock ownership and credit service and market information was statistically significant at 1% level of significance. Further, the p – value of active family labor, was statistically significant at 5% level of significance.

Table 4.9 OLS regression

. xi: reg income_irrig age gender fs education afl ls exten_services acc_credit market_info

Source	SS	df	MS			
Model	4.3597e+11	9	4.8441e+10	Number of obs =	120	
Residual	4.6087e+11	110	4.1897e+09	F(9, 110) =	11.56	
				Prob > F =	0.0000	
				R-squared =	0.4861	
				Adj R-squared =	0.4441	
Total	8.9683e+11	119	7.5364e+09	Root MSE =	64728	

income_irrig	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
age	2053.07	856.3718	2.40	0.018	355.9421	3750.198
gender	-47935.3	14811.36	-3.24	0.002	-77287.93	-18582.67
fs	-27350.15	8581.085	-3.19	0.002	-44355.85	-10344.46
education	19612.8	6755.778	2.90	0.004	6224.435	33001.17
afl	24434.69	10613.32	2.30	0.023	3401.576	45467.8
ls	71899.38	25261.98	2.85	0.005	21836.07	121962.7
exten_serv~s	-24098.35	19271.69	-1.25	0.214	-62290.31	14093.61
acc_credit	49979.27	14597.97	3.42	0.001	21049.51	78909.02
market_info	40841.62	14027.42	2.91	0.004	13042.56	68640.68
_cons	-44975.39	68317.12	-0.66	0.512	-180363.9	90413.11

Source : own survey 2025

In the table 4.9 shown that the variables supposedly influencing or affecting positively or negatively the income of irrigation users. These independent variables are supposed to determine that has effect on the household income of the household; 10 were selected based on theoretical literature and empirical studies done before.

In the table 4.9 shown that the standardized beta coefficients. A unit change in the independent variables (on income) would produce an effect on the dependent variable. From this table, age ($\beta=2053$, $p<0.018$), education ($\beta=19612$, $p<0.004$), active family size ($\beta=24434$, $p<0.023$). As well as market information ($\beta=40841$, $p<0.004$) and access to credit ($\beta=49979$, $p<0.001$) land holding size ($\beta=71899$, $p<0.005$) had the highest impact on on income followed by the market information and access to credit, was found to be positively and significantly related to the income effect on the household at 1% probability level, and active family labor positive and significant effect which did at 5% probability level. But gender and family size were negatively and significant effect of irrigation on the household income at 1% probability level. Where extension service were insignificant to effect on the house hold income.

E. Binary (Logit) regression the Effect of SSI on the household food security

Far more than the type and number of significant variables, model goodness-of-fit is the prior issue to discuss regression model results. The equivalence of F test statistic used in linear regression as a measure of model goodness-of-fit is Likelihood test statistic for non linear regression (logit). As

per the result, the Likelihood test statistic of the model (Wald Chi2 = 83.2) exceeded Chi-square critical value (Prob> Chi2 = 0.000) at 11 degree of freedom, justifying the model's goodness-of-fit or the fitted logistic regression model fitting the data well.

Table 4.10 logit regression of food security

```
. xi: logit fsecure irrigation age ls health_status meal_pday i.market_info income_livestock
i.market_info _lmarket_in_0-1 (naturally coded; _lmarket_in_0 omitted)
```

```
Iteration 0: log likelihood = -79.880688
Iteration 1: log likelihood = -28.07851
Iteration 2: log likelihood = -19.485646
Iteration 3: log likelihood = -13.613666
Iteration 4: log likelihood = -13.420954
Iteration 5: log likelihood = -13.418157
Iteration 6: log likelihood = -13.418155
Iteration 7: log likelihood = -13.418155
```

```
Logistic regression                Number of obs =      120
LR chi2(7)                        =     132.93
Prob > chi2                       =      0.0000
Pseudo R2                         =      0.8320
```

```
Log likelihood = -13.418155
```

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
irrigation	13.07308	3.708916	3.52	0.000	5.803735 20.34242
age	.0804739	.0668742	1.20	0.229	-.0505971 .2115449
ls	6.863518	3.07489	2.23	0.026	.8368448 12.89019
health_status	-.1143309	.0586259	-1.95	0.051	-.2292355 .0005736
meal_pday	2.255125	1.31671	1.71	0.087	-.325579 4.83583
_lmarket_in_1	-.6390568	1.324427	-0.48	0.629	-3.234886 1.956772
income_livestock	.0000536	.0000208	2.58	0.010	.0000128 .0000944
_cons	14.03334	14.88607	0.94	0.346	-15.14283 43.2095

Note: 0 failures and 27 successes completely determined.

Source : own survey 2025

Since, Food security is binary variable (0/1) logit regression model was used to estimate and to identify effects of the independent variable. Both users and non_user of irrigation included in the model we used.

Based on the result presented in table 4.10, health status of the households negatively influence the probability of rural households' food security in the use of small –scale irrigation activities. On the other side, the land size of the household heads, irrigation use, and livestock ownership are positively significant at 5% level of significance (p<0.00, 0.026, 0.000, 0.01) respectively; and meal per day are positively significant at 8% level of significance (p< 0.087) . The p – value of the covariates indicate that irrigation access of the household heads, land holding, meal per day and livestock ownership of the household heads were positively and significantly influence the probability of rural households food security to the use of small – scale irrigation. According to the econometric result (table 4.10), health status of household heads have negative significant effect on user of the household in small – scale irrigation activities. This implies that households which managed by un healthy household heads use less in small – scale irrigation activities than the healthy household head managed ones. On the other side, age of the household heads and market information

of the rural households have no significant effect on the households food security do to the use of small – scale irrigation. This shows that there is no significant effect among respondents in terms of their user in small – scale irrigation with respect to their age and use of market information of the household heads. The remaining statistically significant covariates (irrigation use/access of the household head, meal per day, land holding of the household and livestock ownership have significant positive effect and health status have negative effect on the rural households’ use in small – scale irrigation on the income and food security of the household at 95% level of confidence in the study area.

According to the result in table 4.10, marketing information of the household heads have insignificant negative effect on the households’ use in small – scale irrigation on food security of the household in the area. The implication of the result is the market information of the household head is insignificantly determine the rural households’ use in small – scale irrigation activities. age of the household heads have insignificant positive effect on the households’ use in small – scale irrigation on the food security of the household in the area.

Table 4.11 marginal effect after logit

Marginal effects after logit
 $y = \text{Pr}(f_{\text{secure}})$ (predict)
 $= .99682551$

variable	dy/dx	Std. Err.	z	P> z	[95% C.I.]	X
irrigation*	.6872057	.15415	4.46	0.000	.385074	.989337		.5
age	.0002547	.00042	0.60	0.546	-.000572	.001081		48.35
lands	.021719	.03569	0.61	0.543	-.048231	.091669		.801667
health	-.0003618	.00053	-0.68	0.498	-.001409	.000685		290.908
meal_per_y	.0071361	.01178	0.61	0.545	-.015945	.030217		2.50833
_lmark	-.0018595	.00479	-0.39	0.698	-.011249	.00753		.658333
income_k	1.70e-07	.00000	0.65	0.516	-3.4e-07	6.8e-07		71035

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Source : own survey 2025

When we see the marginal effect of the significant variable as we seen on the above irrigation, land holding, health status, meal per days and livestock ownership have significant effect do the of irrigation on the household food security their marginal effect is as follow:-

The marginal effect of irrigation who those household use (Table 4.11) implies that as the rural household are more accessible to irrigation, their probability of affecting the food security have been increased, on average, by 68.72% they became secured.

The marginal effect of meal per day who those household use the irrigation (Table 4.11) implies that as the rural household were more feed per day, their probability of affecting the food security would be increased, on average, by 0.7% they became secure.

A marginal effect of land holding size the irrigation user have effect on the food security, their probability affected be increased, on average, by 2%.

The health status of the household is negatively related to the food security of the significant at 5% significance level. A marginal effect of health status of the household as the health of the farmer loosed increase by 0.0003 the irrigation user have effected on the food security, their probability affected would be decrease, on average, by 0.03% on food security.

The marginal effect of livestock owner shipe who those household use irrigation (Table 4.11) implies that as the rural household were more own of livestock, their probability of affecting the food security have been increased, on average, by 0.18% they became secure.

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

This chapter accordingly summarizes the findings in line with the objectives, draws conclusions and makes the necessary recommendations. Areas of further study that may enrich the study area are also suggested.

5.1. Conclusion

The objective of this study was to assess the effect of small-scale irrigation on household income and food security. Small scale irrigation has played a key role in enabling sustainable food production where it is well managed by lowering the risk of crop failure. Irrigation also helps to prolong the effective crop growing period in areas with dry seasons by permitting multiple cropping per year.

Food security was measured using a commonly known measure of food security status known as household food insecurity and access scale. The results based on this measurement revealed that 61.67% of the households in the study area were food secure while 38.33 % were food insecure. From total irrigation user 98.33% households were food secure and 25% of irrigation non-user households were food secure. Diet diversity and food consumption score between irrigators and non-irrigators had significant mean difference at 1% significant level.

The result indicated that, irrigation user households were more food secure than non-users households in the study area. Thus, the food insecurity occurrence households with no irrigation practice are greater than households practicing irrigation. This suggests that small-scale irrigation has an important influence on rural household food security. And it is observed that small scale irrigation is one of the viable solutions to secure household food needs in the study area.

The results of the determinants of food security indicate that age of household, cultivated land holding, access to irrigation, active family labor, family labor, health status, livestock ownership and meal per day were the major factors that significantly influence on households household food security. cultivated land holding, access to irrigation, family labor, health status. Meal per day and livestock ownership affected the household food security in the study area.

Finally the results of this study indicate, the main constraints for irrigation use and performance of irrigation in the study area found in group discussion were long distance between their farm, lack of

irrigable farm land (lack of suitable land that can be for used irrigation), market problem, irrigation tool, and presence of pests and disease.

5.2. Recommendations

Based on the findings of the study the following recommendations are forwarded in order to improve household food security in the study area.

The finding reveals that irrigation and income, food security are positively and significantly related in the study area. Participation in irrigation helps the households to generate additional income and diversification of household food consumption. Therefore, development strategies and programs related with food security through agricultural production should think about the importance of irrigation. Hence, the governmental and non- governmental organization should expand access of small scale irrigation to households in poverty reduction and to improve their food security. Strong regulatory mechanism should be designed to overcome problems related to irrigation use to provide incentives to committed and disciplined farmers.

The finding of the study showed that user in small-scale irrigation has significant and positive effect on income of rural households and food security. So the government and other concerned body should work in expansion and technical development of small-scale irrigation to increase their user in small-scale irrigation. Small-scale irrigation has a potential to improve the income of rural households, but potential users face several problems that hinder them to use efficiently in small-scale irrigation in the study area. Therefore, government and other concerned stake holder should be try to solve or at least to mitigate the problems faced in small-scale irrigation by providing training in irrigation water management and crop production., provision of necessary input for irrigated agriculture to enhance farmers users into small-scale irrigation.

Educational level of the rural household has positive and significantly affect farmer's user into small-scale irrigation. Therefore, for effective user in to small-scale irrigated activities, government policy makers and other responsible bodies should be enhance the educational status of the rural households through adult education, proper utilization of farmers training center for improvement of educational status of the households.

Active family labor was positively and significantly affects the user in to small scale irrigation. Therefore, introducing labor saving technology (tractor and herbicide chemical) and improving the working habit of the household's should be advisable to reduce labor shortage in the households

Livestock ownership has positively affected user in to small- scale irrigation. So the government and any other stakeholder should be focus on improving the existing traditionalmixed farming system in the study area.

The health statusand meal per day have significant positive effect onimplementation of small scale irrigation activities in the district. Thus, all concernedstakeholders should improve the health centers in providing health servives and giving training on food diettothe farmers for better small scale irrigation activities implementation and sustainable incomegeneration and achieving food security.

Agricultural extension service and rural credit access have significant positive effect onimplementation of small scale irrigation activities in the district. Thus, all concernedstakeholders should improve agricultural extension services and rural credit accessibility tothe farmers for better small scale irrigation activities implementation and sustainable incomegeneration.

Small scale irrigation farming requires less technical and capital investments, and it has lessor no significant environmental impacts than medium and large scale irrigation. Therefore,governmental and non – governmental organizations should give due attention forinvestments on small scale irrigation schemes and run-off water harvesting structuresconstructions so as to increase irrigation potential and numbers of irrigation users in all ruralareas of the district.

Accessing improved agricultural inputs and markets information for perishable agriculturalproducts are most challenging factors for irrigation users. Therefore, all concerned bodiesshould give prior focuses for improved agricultural inputs, favorable irrigation technologiesand market linkages for farmer products.

Reference

- ✓ Alemkiros(2008).OpportunitiesandChallengesofVegetableMarketinginKilte-AwlaeloWoreda, MSC Theseis, Mekelle University.
- ✓ Asfaw D. (2007). Scaling up Agricultural Water Development in Africa, the Case of Ethiopia:Minister of Water Resources, Federal Republic of Ethiopia.
- ✓ AWULACHEW, S. B. (2006) Improved Agricultural Water Management: Assessment of Constraints and Opportunities for Agricultural Development in Ethiopia. Symposium and Exhibition on Best Practices and Technologies for small Scale Agricultural Water Management in Ethiopia. Addis Ababa, Ethiopia.
- ✓ Awulachew SB, Merrey D, Van Koopen B, and Kamara A. 2010. Roles, Constraints and Opportunities of Small-Scale Irrigation and Water Harvesting in Ethiopian agricultural Development: Assessment of Existing Situation. ILRI workshop; 2010 March 14-16; Addis Ababa, Ethiopia: International Water Management Institute (IWMI).
- ✓ AzemerBirhanu (2006). Food Security and Economic Impacts of Small Scale Irrigated Agriculture in Ethiopia, A Case Study of Telltale Irrigation Project in North Shoa Zone, Oromia Region. Unpublished MastersThesis , Addis Ababa University, Ethiopia.
- ✓ Babbie,E.(2003).ThePracticeofSocialResearch.Victoriaetc.,Wadsworth.
- ✓ BerhanuGebremedhin and Pendon. D.(2000). Policies and Institutions to enhance the Impact of Irrigation Development in Mixed Crop- Livestock System: Policies for Sustainable land Management in the highlands of Ethiopia: Summery of Papers and Proceedings of a Seminar, Addis Ababa Ethiopia: ILRI
- ✓ Bert Huizinga (1996). Course Model: RuralExtension, the Netherlands, Wageningen University Press.
- ✓ CSA (Central Statistics Agency). 2007. Summery and statistical report of 2007 population and housing census of Ethiopia.
- ✓ DegafaTolossa (2005). Rural Livelihoods, Poverty and Food Insecurity in Ethiopia. A Case Study at Erenssa and Garbi Communities in Oromia Zone, Amhara National Regional State. Doctor W Thesis Norwegian University of Science and Technology.

- ✓ DessalegnRahmato (1999). Water Resources Development in Ethiopia: Issues of Sustainability and Participation, Addis Ababa.
- ✓ Dhawan, B. D. (1992). Irrigation in India's Agricultural Development: Productivity, Stability, Equity. New Delhi, India: Sage Publications India.
- ✓ DIAO, X. & NIN PRATT, A. (2007) Growth options and poverty reduction in Ethiopia – An economy-wide model analysis. Food Policy 32.
- ✓ FAO(1987).IrrigationandWaterResourcesPotentialinAfrica.

- ✓ FAO (1996). Irrigation Water Management Training Manual Irrigation Scheme Operationand Maintenance No.10 Rome: FAO
- ✓ FAO (1997) Farm Management for Asia: A Systems Approach, Department of Agricultural and Resource Economics, University of New England, Australia.
- ✓ FAO. (1997). Irrigation technology transfer in support of food security proceeding of a sub regional workshop; 1997 April 14-17; Harare, Zimbabwe: water report 14.
- ✓ FAO (1998). Institutional and Technical Options in the Development and Management ofSmall– scale Irrigation Water Report No.17 Rome: FAO
- ✓ FAO (2003). Agriculture , Food and Water a Contribution to the World Water Development Report Rome: FAO
- ✓ GEBREMEDHIN, B. & PEDON, D. (2002) Policies and institutions to enhance the impact of irrigation development in mixed crop-livestock systems, In: Integrated water and land management research and capacity building priorities for Ethiopia.
- ✓ Proceedings of MoWR/EARO/IMWI/ILRI international workshop. Addis Ababa, Ethiopia,ILRI.
- ✓ GirmayTesfaye, MitkuHaile, BerhanuGebremdhin, Pender,J. andEyasuYazew(2000). Small– Scale Irrigation in Tigray: Management and Institutional Considerations, Policies for sustainable Land Management in the High Land of Ethiopia, Socioeconomics and Policy Research Working Summary of Papers and Proceedings of a Seminar Paper 30, Addis Ababa, University, Ethiopia.
- ✓ HABTAMU,G.(1990)ProblemsandConstraintsintheStudy,ConstructionandManagementof Small-Scale IrrigationProjects. PresentedattheNationalIrrigationPolicyand Strategy Workshop. Addis Ababa.
- ✓ Haile Tesfay,(2008). Impact of Irrigation Development on Poverty Reduction in Northern

Ethiopia A Thesis Presented to the Department of Food Business and Development, National University of Ireland, Cork, in Fulfillment of the Requirement for the Degree of Doctor of Philosophy.

- ✓ Hussain I, Biltonen E. (2001). Irrigation against Rural Poverty: An Overview of Issues and Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia; Proceedings of National Workshops on Pro-Poor Intervention Strategies in Irrigated Agriculture in Asia Bangladesh, China, India, Indonesia, Pakistan, and Vietnam. 2001 August; International Water Management Institute; Colombo, Sri Lanka.
- ✓ Hussain, Lutizar and Munir, Hanjar (2004). Irrigation and poverty Alleviation: Review of the Empirical Evidence, Irrigation and Drainage.
- ✓ IMF (International Monetary Fund). 2011. World Economic Outlook Database [Internet].
- ✓ International Monetary Fund Available from: <http://www.imf.org>.
- ✓ Kampen J. and Schwart L. (1992). Agricultural Extension in East Africa, World Bank Technical Paper No. 164, The World Bank, Washington D. C.
- ✓ Mark W. Rosegrant, Ximing Cai and Sarah A. Cline (2002). World Water and Food to 2025, Dealing With Scarcity, International Food Policy Research Institute, Washington DC.
- ✓ Maxwell, S and Smith, M. (1992). Household Food Security Concepts Indicators, Measurements. A Technical Review: IFAD/UNICE.
- ✓ Awulachew SB, Merrey D, Van Koopen B, and Kamara A. 2010. Roles, Constraints and Opportunities of Small-Scale Irrigation and Water Harvesting in Ethiopian agricultural Development: Assessment of Existing Situation. ILRI workshop; 2010 March 14-16; Addis Ababa, Ethiopia: International Water Management Institute (IWMI).
- ✓ Melkamu Amare (2001). Small-Scale Irrigation in Ethiopia; Experience, Constraints and Development Perspectives. EACE Bulletin Vol. 3, No. 1, September 2001.
- ✓ Mereba Abera (2002). Kechine Abeba, North Wollo, Amhara Region, Small-Scale Irrigation Project Results.
- ✓ MOFED. 2010. The Federal Democratic Republic of Ethiopia, Growth and Transformation Plan (GTP) 2010/11-2014/15, Draft. 2010 September, Addis Ababa.
- ✓ MOFED. (2010). Trends and prospects for meeting MDGs by 2015, millennium development goal report.
- ✓ MOWR (2002) Ethiopian water sector Development program 2002-2016.
- ✓ Nhundu, K, Gwata, C, Mushunje, A. 2010. Impacts of Zimbabwe European Union micro-

- project programme (Zim/Eu MPP) in funding smallholder irrigation projects on food security and income levels: A case study of Mopane irrigation scheme in Zvishavane, Midlands province, Zimbabwe. African Journal of Agricultural Research Vol. 5(14).
- ✓ Ray Debraj (1998). Development Economics, USA: Princeton University Press.
 - ✓ Regassa E. Nemara, Goodwill Makobe, Fitsum Hagos, Seleshi B. Wlachew, (2007). Rural Poverty and Inequality in Ethiopia: Does Access to Small-Scale Irrigation Make a Difference? International Water Management Institute.
 - ✓ ROSE R. (1993). "Some Sustainability and Resource Policy Issues in ILCA'S Livestock Research in Sub-Saharan Africa", Proceeding of the Research Planning Workshop Held at ILCA, Addis Ababa.
 - ✓ Saleth, RM, Samad, M, Molden, D and Hussain, I. 2003. Water, poverty and gender: an overview of issues and policies, Water policy, Vol 5: No 5/6.
 - ✓ Seid Yassin (2002). Small – Scale Irrigation and Household Food Security: a case study of Three Irrigation Schemes in Gubalfto Wereda of North – Wollo Zone Amhara Region. MSC Thesis. Addis Ababa University, Ethiopia.
 - ✓ SMITH, M. (1998). The Role of Small-Scale Irrigation in Food Security: Institutional and Technical Options in the Development and Management of Small-Scale Irrigation. Proceedings of the Third Session of the Multilateral Cooperation Workshops for Sustainable Agriculture, Forestry and Fisheries Development. Tokyo, Japan.
 - ✓ Solomon, H. (2005). Socio-economic Infrastructure of the Tigray Region, Department of Geography, Mekelle University (Unpublished).
 - ✓ TESHOME, A. (2006) Irrigation Policies, Strategies and Institutional Support Conditions in Ethiopia. Proceedings of Symposium on Best Practices and Technologies for Agricultural Water Management in Ethiopia. Addis Ababa Ethiopia.
 - ✓ UNDP. (2007). Globalization, Agriculture and the Least Developed Countries [Internet]. Issues Paper, Istanbul. 9-11 July 2007. Available from: <http://www.unohrrls.org>.
 - ✓ Van Den Ban A.W. and Hawkins HIS. (1988). Agricultural Extension. New York: John Wiley and Sons Inc.
 - ✓ Wagne Ayalneh (2004). Socio economic and Environmental Impact Assessment of Community based Small- Scale Irrigation in the Upper Awash Basin. A case study of Four Community based irrigation schemes. Msc Thesis ,Addis Ababa University, Ethiopia.

- ✓ WoldeabTeshome (2003).Irrigation Practices, State Intervention and Farmers‘ Life-Worlds in Drought-Prone Tigray, Ethioia, Ph.D. Thesis, Wageningen University.
- ✓ World Bank (1986). The Challenge of Hunger in Africa: Acall to Action World Bank Washington D.C.
- ✓ World Bank (1986). Poverty and Hunger: Issues and Options for Food Security in Developing Countries; World Bank Policy Study Washington D.C.
- ✓ Zhou Y, Zhang Y, Abbaspour CK, Yang H, Mosler JH. 2008. Economic impacts on farm households due to waterreallocation inChina“sChaobai Watershed

APPENDEXES

Sample Questionnaire Sections

Section 1: Household Demographics

1. How many people currently live in your household?
2. Please specify the number of males and females in the household.
3. What is the age of the household head?
4. What is the gender of the household head? (Male / Female)
5. What is the highest level of education attained by the household head?
 - Illiterate. -Read and Write Only
 - Elementary 1-4. - Elementary 5-8
 - High School 9-12. - Above High School

Section 2: Landholding and Irrigation Practices

1. What is your total landholding size (in hectares)?
2. How much of your land is irrigable?
3. How much land do you currently irrigate (in hectares)?
4. Do you practice small-scale irrigation? (Yes / No)

5. If yes, what type of irrigation system do you use? (e.g., canal, pump, rainwater harvesting)
6. How many cropping seasons do you cultivate with irrigation per year?
7. What are your major crops cultivated under irrigation? (List all)
8. What are your major crops cultivated under rain-fed agriculture? (List all)

Section 3: Crop Production and Inputs

1. What is the average yield per crop from irrigated land (in quintals or kg)?
- 2..What is the average yield per crop from rainfed land?
3. Do you use chemical fertilizer? (Yes / No)
4. If yes, specify types and quantity applied per season.
5. Do you apply organic manure? (Yes / No)
6. Have you used improved seeds? (Yes / No)
7. Do you use pesticides? (Yes / No)
8. If no to any inputs, please specify reasons (e.g., cost, not available, not knowledgeable).

Section 4: Household Income

1. What was your total household income in the last year? (Birr)
2. What portion of your income was from crops under irrigation? (Birr)
3. What portion of your income was from rain-fed crops? (Birr)
4. How much income did you earn from livestock and livestock products? (Birr)
5. Do you engage in off-farm activities for income? (Yes / No)
6. If yes, please describe activities and average annual income from them.

Section 5: Food Security

1. How many months within the past year was your household food secure (had enough food from own production)?

Less than 6 months

6-8 months

9-11 months

12 months

More than 12 months (excess)

2. Did you experience food shortages in the last year? (Yes / No)

3. If yes, what were your main coping strategies? (e.g., borrowing, selling assets, reducing meals)
4. How many meals do household members typically eat per day?

Section 6: Perceptions and Constraints on Irrigation

1. What motivated you to adopt small-scale irrigation? (Select all that apply)

- Household food demand.
- Appropriate climate conditions
- Ease of irrigation application.
- Income generation
- Other (specify)

2. What benefits have you observed from irrigation? (e.g., increased income, food security, employment)

3. What are the main challenges you face in practicing small-scale irrigation?

- Water shortage.
- Lack of inputs (fertilizer, seeds)
- Market access problems.
- Lack of skill/training
- High cost of inputs.
- Others (specify)

4. Have you received any agricultural extension services or training on irrigation? (Yes / No)

5. If yes, how frequently?

Certainly! Below are specific question prompts to facilitate focused and rich discussions during your FGDs on small-scale irrigation:

1. What motivated you to adopt small-scale irrigation in your farming activities?

2. How do you decide which crops to grow under irrigation, and why?

3. What benefits have you observed in your household income since you started using irrigation?

4. In what ways has irrigation affected your household's food security?

5. Have you noticed changes in employment opportunities in your community during irrigation seasons?

6. What are the main challenges or constraints you face related to irrigation practices? (e.g., water shortages, input availability, access to markets)

7. Have you received training or support from agricultural extension services on irrigation management? How helpful has it been?

8. How do community groups or irrigation associations support farmers like you?

9. What improvements do you think are needed to maximize the benefits of small-scale irrigation in your area?

10. Is there any thing else you would like to share about your experience with irrigation?

These prompts are designed to encourage open dialogue and capture valuable qualitative insights complementing your quantitative data.

