



THE IMPACT OF SMALL SCALE IRRIGATION ON HOUSEHOLD FOOD SECURITY: THE CASE OF BURE WOREDRA, AMHARA REGIONAL STATE

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**The Impact of Small Scale Irrigation on Household Food Security: The Case of
Bure Woreda, Amhara Regional State**

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Science in Food Security and Developmental Studies.**

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Acronyms and Abbreviations

AE	Adult Equivalent
AGP	Agricultural Growth Program
AGRA	Alliance for Green Revolution in Africa
ANRS	Amhara National Regional State
BoARD	Bureau of Agriculture and Rural Development
CSA	Central Statistics Agency
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GoE	Government of Ethiopia
GTP	Growth and Transformation Plan
IFPRI	International Food Policy Research Institute
IPMS	Improving Productivity and Market Success
Masl	Meters above sea level
MoFED	Ministry of Finance and Economic Development
MoRAD	Ministry of Rural and Agriculture Development
MoWE	Ministry of Water and Energy
NGO	Non-Governmental Organization
NMTIP	National Medium-Term Investment Program
PA	Peasant Association
PSM	Propensity Score Matching
PSNP	Productive Safety Net program
SSI	Small Scale Irrigation
TLU	Tropical Livestock Unit
WBCSD	World Business Council for Sustainable Development
WFP	World Food Program
WSDP	Water Sector Development Program

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Abstract

Small scale irrigation is one of the technology that can increase agricultural productivity by reducing water scarcity in enhancing continuous and sustainable year to year cultivation and livestock production, which in turn improve household food security. Therefore, assessing the impact of small-scale irrigation on household food security will assist decision makers by providing reliable information. This study analysed the impact of small scale irrigation on household food security and identified the factors that induce households' participation in a small scale irrigations in Bure woreda. A multi-stage random sampling technique was employed to select 128 sample household heads for data collection to be analysed with the help of descriptive and econometric methods. Logit model and propensity matching score method was used to analyse the variable that affect household participation in small-scale irrigation. The outcome of the research revealed that, frequency of agriculture extension workers contact, household heads education status and distance from local market are positive factors to enhance the participation of households in a small-scale irrigation. On the other hand, household participation in a small scale irrigation is negatively influenced by household livestock holding, distance from irrigation water source, ratio of dependency and non-farm income generation capacity of a household. Household participation in a small scale irrigation has positive and statically significant mean difference compared to household not participate in a small scale irrigation on the daily calorie intake and annual caloric consumption expenditure per adult equivalent. Average treatment effect on treated (ATT) result shows that both the daily calorie intake and annual caloric consumption expenditure increase approximately by 28 percent or 908.29 and 628.94 ETB respectively because of participation in irrigation. There are negative factors that deter a household on the use of irrigation water in the study area. Therefore, the woreda administration is recommended to establish local farmers association, to build the capacity of farmers and Agriculture extension workers. It is also recommended to develop a bylaw and local regulations in the equitable use of available irrigation water.

Key words:-*Household food security, Small-scale irrigation, bylaws.*

Chapter One

Introduction

1.1 Background of the Study

Agriculture is the largest sector in the Ethiopian economy, accounting for over 50% of GDP and employing over 85% of the labour force and earns over 90% of the foreign exchange (Welteji, 2018). Therefore, it is a vital sector for the achievement of food security and employment creation and economic growth of the world (AGRA, 2013). Agriculture sector is also the backbone of economic growth especially for most of African countries where it generates about 25% of the Gross Domestic Product (GDP) in Sub-Saharan African Countries (Schaffnit, 2014).

The Government of Ethiopia (GoE) is currently implementing the Growth and Transformation Plan (GTP) which sets a long-term goal of becoming a middle-income country by 2025. According to official statistics, over the past 15 years the average agricultural growth rate has been close to 7% per annum. (AGP II, 2015).

The agriculture sector in Ethiopia is mostly relied on rain-fed, low farm production and productivity, use of old technology, recurrent drought and climate change which results in low productivity and in turn has great impact on food security. Most importantly the agriculture sector is challenged by the exceeding population growth rate over the production capacity of the sector (Gebissa, 2021)

Smallholder agricultural production in Ethiopia is depend on rain-fed agriculture waiting the summer rain per year with low diversification of farming systems. Moreover, production is highly subject to uncertainties of flood and drought. Consequently, it might be difficult to attain the agricultural development of the GTP of the uncertainties. Improved water control, usage and proper management of irrigation may help to cope these uncertainties (Zeweld, 2018).

Irrigation might be a vital input to increase agricultural productivity of land. Irrigation as an input may have immense influence on the productivity of agriculture and may increase the intensity of cropping in an irrigated area. Irrigation has a great contribution for building resilience to climate change and to reduce the effects of climatic conditions. The issue also includes lack of infrastructure and weak capacity in water management and proper water use. To cope up the challenges related to water management and proper water use, it is good to develop effective water management and irrigation practices though

creating connections between farmers and stakeholders. It is also important to improve the understanding of marketing issues after the anticipated production is realized.

The development of small-scale irrigation help farmers to overcome rainfall constraint by providing a sustainable supply of water for cultivation and livestock production (FAO, 2003). Irrigation in Ethiopia contributes to increase farmer income, household resilience and buffering livelihoods against shocks and stresses by producing higher value crops for sale at market and to harvest more than once per year.

The government of Ethiopia designed national strategic plan since the past three decades that focus on irrigation and agricultural technologies to answer the food demand of the country in both agrarian and pastoralist area (Bacha et al., 2011). For instance, the national Growth and Transformation Plan (GTP I) (2010/11-2014/15) addressed the issue of ensuring food security at the family, regional and national levels through focusing on the expansion of modern irrigation development especially in pastoralist area (MoFED, 2010 and FAO, 2012).

The Government of Ethiopia in collaboration with other development partners is working in transforming the agriculture sector in such a way that can able to increase productivity to fill the short fall of food through small scale irrigation. According to the AGP II (2015) program document small scale irrigation is the third component of the AGP II with two sub-components, small scale irrigation infrastructure development and improvement and improve irrigated agricultural productivity and management of selected SSI systems and enhance institutional capacity for integrated irrigation water and crop management through the introduction of improved on-farm irrigation water management, agronomic practices and capacity building interventions for smallholder irrigation systems.

Hence, this study tried to assess the impact of small-scale irrigation on household food security and to identify the major factors that affect household irrigation water use in Bure woreda, Amhara regional state.

1.2 Statement of the Problem

World food program indicates that nearly 200 million children under five in the developing world are stunted or chronically under-nourished and about 130 million are underweight. Meanwhile, 3.5 million children under five die every year, largely as a result of under-nutrition, attributed to lack of access to the food produced (Austin et al, 2011). Rural households are far from basic services infrastructures and the size of their farm is limited and constrained by seasonal on annual agriculture productivity. There is a problem of access to market after production. In all farming systems, livestock are the single most important household asset and there is a strong correlation between lack of livestock ownership and poverty, particularly among woman-headed households (WFP, 2010).

Food insecure households faces challenges including poor health, which inturn results to a decline in productivity. These challenges can create a vicious circle where households are unable to produce enough food, even in good year, because they are battling chronic health issues and unable to work to their full potential. The gravity of food insecurity, and its many rippling effects leads much of the development agenda to search for specific areas for intervention given limited resources and growing populations in many developing countries (IFPRI, 2009).

The 2011 Ethiopian demography health survey estimated the national prevalence of stunting among children at 44.4 percent, the prevalence of underweight at 28.7 percent and wasting at 9.7 percent which undoubtedly affects their cognitive development. The survey also revealed that the level of chronic malnutrition among women in Ethiopia is relatively high with 27 percent of women either thin or undernourished (MOH, 2013).

Ethiopia is one of the most food-insecure and famine affected countries. A large portion of the country's population has been affected by chronic and transitory food insecurity. recurring food shortage and famine are mostly linked to food security problem of the country associated with recurrent drought. More than 41 percent of the Ethiopian population were under the standard poverty level and around 31 million people were under nourished (FAO, 2010, P. 57,). As per the standard of 2,550 kilocalories (Kcal) per adult equivalent per day, around 40 percent of households in the country reside in rural area were food insecure (WFP and CSA, 2014)

Food insecurity is a critical challenge for over 80 percent of Ethiopian population live in rural areas and are heavily dependent on rain-fed agriculture; this makes them extremely vulnerable to changes in

weather conditions (Andersson, et al, 2009). At the time of El Niño, the estimated number of food insecure people was 4.5 million in August, 2015 and by the end of the same year this figure had more than doubled. According to a Government-led multi agency assessment, 10.2 million Ethiopians are considered to be food insecure in 2015/16 (FAO, 2015).

The country has faced three major famines and other similar situations in the past three decades. The recurrence of famine in the 1970s,1980s and 1990s has significantly affected the country's food production (FAO, 2015). However, during the past 20 years, the deficit in calorie intake in Ethiopia has been significantly reduced from 623 to 314 Kcal/cap/day accompanied by a 33 % decline in poverty rate from 1999 to 2010. Although these results are recorded as good progress in poverty reduction in Ethiopia, food insecurity is still a threat to the households of the country (Nagothu et al, 2015)

Studies conducted at small scale level in different parts of Ethiopia showed that almost 50 % of the study populations were food insecure. According to the crosssectional study done in Farta district in 2012, from the total study participants about 70.70 % were food insecure (Ali et al. 2013). Similarly, a study done in Addis Ababa city showed 58.16 % of the total households were below the food security cutoff point that classified food secure and insecure households and expressed this in terms of caloric requirements (Chinnakali, et al. 2014). Another study result from Sidama, Southern Ethiopia, showed 54.10 % of the households were food insecure (Birhane et al. 2014). A longitudinal study done in Ethiopia on adolescents' food security status has shown that different or fluctuating levels of food insecurity were registered in different rounds of the study period. Overall, 20.50 % of adolescents were food insecure in the first round survey, while the proportion of adolescents with food insecurity increased to 48.40 % one year later. During the one year follow up period, more than half (54.80 %) of the youth encountered transient food insecurity (Belachew, et al. 2012).

As the primary way out food insecurity problem of the country and Amhara region, irrigation development is taken as main strategy. In this program, government organizations, international and local NGOs, micro-finance institutions, private sectors and farmers are involved at different levels with different tasks. But, such interventions are encountering various social and technical problems that have challenged the strategy and implementation approaches (MoA & ATA, 2017).

Agriculture sector has primitive nature for overall existing production system, shortage of agricultural inputs and low level of user's participation in the development and management of irrigated agriculture, limited trained manpower and inadequate extension services, traditional farm tools, unimproved seeds

and fertilizers and poor animal breeds are the major constraints to agricultural development in Ethiopia. The country's ability to support agriculture through development of irrigation has been weak (Mengistu, 2000).

Irrigation development particularly small-scale irrigation is one of the major programs to improve agricultural production in the rural households of a country. It helps households to overcome shortage of rainfall by giving optimal water for irrigation agriculture and livestock, strengthen the base for sustainable agriculture, provide increased food security to poor communities through irrigated agriculture and contribute to the improvement of human nutrition (FAO, 2003).

A study conducted in West and Eastern Gojjam shows that, the total prevalence of food insecurity was 55.3 % (95 % CI: 53.8, 56.8). To compare food insecurity levels between the two zones, nearly sixty percent, 59.2 % (95 % CI: 57 %, 61.4 %) of the East Gojjam and 51.3 % (95 % CI: 49.1 %, 53.5) of West Gojjam households were food insecure (Achenef et al, 2016).

The study area, Bure woreda has a total area of 58,795 ha. the larger portion of the district 52.2% (30,677 ha) is allocated to arable land, 14.1% (8,280 ha) bush and shrubs, 10.3% (6,066 ha) forest and 5.2% (3,081 ha) grazing land. As computed from total farm household size and area of cultivated land the average size of a household cultivated land holding is about 1.6 ha.(Molla, et al, 2011 p.7)

Bure Woreda has strong potential of ground water as well as river water, therefore the government of Amhara Regional State and the administration of the Woreda gave special attention for irrigation to increase agricultural production of the rural households. However small-scale irrigation policy is a new and recently introduced and lacks in-depth studies on its factors that influence on irrigation participation in policy approaches. This program is not well supported by complete research which is able to examine the impact of small scale irrigation on household food security and the determinants of irrigation participation.

A research done to analyse the impact of small scale irrigation on household income in the study area focuses on the infrastructure feature of irrigation technology and highly limited on the socio-economic variables of household irrigation participation. There are other studies conducted in the region that only gives emphasis on the food security status of the small scale irrigation users and agricultural productivity with little attention of the factors that influence farmers to participate in the small scale irrigation. All this studies do not recognize farmers as a key factor in decision making rather it considers a top –down

approach of decision making. In addition to this, most of the previous studies on the impact of small scale irrigation have been descriptive in nature and have not included any systematic quantitative evaluations. (Lemlem (2015), Getaneh (2011), Getinet (2011) Zewdu (2016), Ayana (2016). Although these evaluations are relevant measurements for the impacts of smallholder irrigation on food security they are not complete, as they do not evaluate the socio economic factors of small scale irrigation on the participation of farmers on this practice and their impact on food security and dietary diversification.

Irrigation is assumed to improve agricultural production and food security. It is not well known to what extent the households using irrigation are better off than those who depend on rainfall in the study area. The knowledge regarding the contribution of irrigation to household food security is insufficient in the study area. More importantly, in Bure Woreda, where this study has been conducted comparative analysis studies are scarce on factors that determine rural household's participation in small-scale irrigation.

Therefore, this study reveals the factors that determine household participation in a small scale irrigation and the impact of small-scale irrigation on rural household food security.

1.3 Objective of the Study

The overall purpose of this study is to assess the impact of small-scale irrigation on rural household food security of Bure woreda, West Gojjam Zone of Amhara Regional State.

1.3.1 Specific Objectives of the Study

- To compare the food security status of rural households who participate in small scale irrigation and rural households who do not participate in small scale irrigation
- To ascertain the main determinant factors that may affect rural households' participation in a small-scale irrigation.

1.4 Research Questions

This research is designed to answer the following two research questions

- Do participation of small scale irrigation will have an impact on household food security status
- Which determinant factors will have strong effect on household participation to small scale irrigation

1.5 Scope and Limitation of the Study

This study is scoped with and limited to Bure woreda of Amhara Regional State of two kebeles (Jibegedel and Wundigie) and 128 respondents. Cross-sectional, data collected at one time was used for the analysis to come up to the conclusion. The study is subject to some limitations. For example, many data might be highly dependent on the memory of the respondents. Accordingly, some data particularly quantitative data might be short of accuracies. Some respondents were also unwilling to give the correct response for some sensitive variables. In this case, the study might have less confidence to conclude that the data has been accurate. Some secondary data at the woreda level might not be clear and well documented. However, maximum effort were made to gather reliable information by convincing farm households to address the objectives of the study. In addition to this, the study will try to use different data collection method, random sampling and the respondent consents in order to minimize the limitation and ensure the reliability of the data to produce valid results.

1.6 Significance of the Study

This study is significant for households to increase understanding regarding the factors that influence participation in small-scale irrigation and its effect on food security. This is because determining the role of small-scale irrigation on household food security status is immense for policy decision and implementation. The study gives a clue for policy makers and planners towards major blockage of farm household participation in small-scale irrigation and its effect on household food security of the study area. To sum up this, it was tried to attempt to provide realistic information on the overall issues of rural community participation in a small-scale irrigation in the study area and for formulation of future strategies on the investment of small scale irrigation. This research is also important for future reference to researchers and other individuals in their future study and career.

1.7 Organization of the Thesis

The thesis is composed of five chapters and organized as follows

Chapter 1: Introduction, encompassing the background, statement of the problem, objective, study scope and limitation and significance of the study.

Chapter 2: provides an overview of the literature review on the subject matter and explained empirical studies.

Chapters 3: provide a description of the study area and the methodology approach used in the study.

Chapter 4: presents results and discussion of the study and

Chapter 5: present summary, conclusion and recommendations.

Chapter Two

Literature review

2.1 Theoretical Literature Review

2.1.1 Definition and Concept of Food Security

Food security is defined in different ways by different organizations around the world. For example in 1996, the definition of food security was agreed and accepted at the World Food Summit in Rome and it was defined as a full access by all people at all times to sufficient, safe and nutritious food to meet their dietary needs (Todaro and Smith, 2015). This definition contains different features, such as food availability, accessibility, utilization and stability.

The physical availability of food for households remains constant as it is grown, processed, produced, and imported into our country and beyond. The food exists in the market, in shops and at the household level, as it is made by farmhouses on local farms as gardens in the domestic or international market. Due to population growth and climate change, the pressure on existing natural resources, i.e. land and water, is increasing. The effects of climate change often lead to soil degradation, lack of irrigation water, reduced soil moisture and therefore damage economic viability. This could be dangerous in the long run, with increasing opposition to the use of water resources (crop use for food consumption versus crop use for food, use by other sectors such as drinking water, industry and the environment); this may be a threat for long-term food security (USAID, 1992; Jacobs, 2009)

Food access concerns about having sufficient resources to obtain appropriate foods for a nutritious diet through a combination of home production, stocks, purchase, and gifts, borrowing or food aid. Food access is guaranteed when households and all individuals within them have adequate resources, such as own production, stocks, purchases, gifts, borrowing or aid. Household's wealth is an important determinant for food access when regular livelihood strategies are compromised by poor agro-climatic conditions, high prices, loss of employment, or illness (Todaro and Smith, 2015).

Food utilization is the method that the body requiring a diet for providing sufficient energy and various essential nutrients in the food. Food intake by individuals results in to the good care and feeding practices, food preparation, and variety of the diet and household distribution of food. It is combined with good biological utilization of food consumed, this determines the nutritional status of individuals (Todaro and Smith, 2015).

Food Stability complements the previous factors by stressing that food must be available, accessible, affordable and properly utilized on a continuous, long-term basis. It refers to the level of resilience to shocks and other crises (Todaro and Smith, 2015).

2.1.2 Household Food Security and Measurement

Food security is a broad concept and the meaning and the measurement is not obvious as it may seem. Food security is multidimensional in nature. Accurate measurement and policy targeting, therefore remains a challenge due to many dimensions involved (Hart et al., 2009). According to Jacobs (2009, p.411), *“A food security target depends heavily on indicators and the measurement of food (in) security”*.

Three categories of food security indicators exist with their respective strengths and limitations: food availability indicators focus on national food supply with slight attention to individual nutritional status; food expenditure and access indicators measure the monetary value of food as a proxy for food consumption, but often exclude individual nutritional status (or other anthropometric measurements); composite indexes incorporate all the available dimensions of food security into a single index, but the weights attached to components of the index might misrepresent their values in practice.

The measurement of food security can be done using the supply-side approach which covers the food availability aspect of food security or demand-side approach which encompasses the accessibility aspect of food security. The supply side approach can be used to calculate the food production index, per capita output, food aid delivery, livestock index, crop index and etc.). The demand side approach used to measure food accessibility focusing on income, consumption expenditure, nutrition index and diet diversity score, calorie intake index, hunger index and others (Norton et al., 2010).

Depending on the objectives and methodology of a research, researchers opt to use supply side approach and others preferred the food distribution. The supply-side approach measures food availability but the demand side approach measures accessibility. Therefore, demand side approach mostly preferred by most researchers (G/egziabher, 2008). Hence, in this study the demand side approach has been employed to assess the impact of small scale irrigation on rural household food security.

2.1.3 Definitions and Concepts of Irrigation

Water is a basic need for human beings as it is essential for their metabolic processes. It is used to build healthy workforce, ensuring food security, provision of clean energy for agriculture, industry & service maintenance of healthy ecosystem, recreation (aesthetic value), Transportation, hedge against climate change and variability catalyst (MOWE, 2013). The most essential use of water in agriculture is for irrigation to produce enough food. Agriculture is the largest user of water in all regions of the world except Europe and North America (FAO, 2002b). About 90% of water withdrawn is taken by irrigation in some developing countries and significant proportions in more economically developed countries (WBCSD, 2010). But about one fifth of the world (about 1.2 billion people) live in areas of water scarcity, which is not enough water available to meet their daily needs (World Development Report, 2010).

According to FAO, (1996 a), irrigated agriculture can be defined as the supply of water increased by artificial means, involving the use of water controls technology and including drainage to arrange excess water. Irrigation has been practiced in Egypt, China, India and other parts of Asia for a long period of time. Ethiopia also has a long history of traditional irrigation system (mainly diversion schemes).

Irrigation enables farmers to increase crop production and achieve higher yields, food availability and affordability for non-irrigators and reduces the risk of crop failure if rain fails (Hussein and Hanjra, 2004). It contributes the increase of yields per area, which results in a reduction in food price. Irrigation contributes to high yield of agricultural productivity through solving the rainfall shortage, motivates farmers to use more of modern inputs and harvest throughout the year and creates employment to members of the households (FAO, 2011). According to Fuad (2002), irrigation in Ethiopia can be classified in to small-scale irrigation, medium scale irrigation and large scale irrigation.

2.1.4 Definition and Concepts of Small-Scale Irrigation

Irrigation is the supply of water to agricultural crops by artificial means to offset the effect of drought (FAO, 1997). Irrigated agriculture is being practiced under smallholders, medium and large scale farming. Many authors such as Awlachev et al. (2007), Makomb et al., (2007), Hagos et al. (2009), Bacha et al. (2011) were used government based irrigation schemes classification systems for their description during their studies. According to Ministry of Water Resources of Ethiopia (MoWR, 2002), irrigation development in Ethiopia is classified based on the size of the command area, in three types: Small-scale irrigation systems (<200 hectares ha), Medium-scale irrigation systems (200-3,000 ha) and Large-scale irrigation systems (>3,000 ha). This classification system is the most common in Ethiopia.

Small-scale irrigations are type of irrigations that defined as schemes that are controlled and managed by the users. Small-scale schemes developed, operated and maintained by individuals, families, communities, or local rules and landowners, independently of government (W. Bart, 1996).

Similarly, to the above definitions in this study, small-scale irrigation is a type of irrigation practiced by smallholder households in small plot of land that is controlled and managed by the user's household.

2.1.5 Small-Scale Irrigation and Food Security

Irrigation investment enables household to increase crop variations, use of chemicals and improved seed varieties (Bhattarai et al., 2007) which help them to shift from lower subsistence agricultural farm production to high level agricultural production.

Farmers commonly suffered from continuous food insecurity as a result of climatic changes such as erratic weather caused by variable rainfall in turn will have low agricultural productivity. As a result of low productivity in rural area there is continuous and persistent poverty. On the other hand population increase creates additional pressure which resulted in a vicious circle of environmental depletion and food insecurity (Von Braun, 2008). As many of the low productivity areas did not use water resources, irrigation development is recognized as a backbone of agricultural productivity, enhancing food security, earning higher incomes and increasing crop diversification (Smith, 2004). In many developing countries, small scale irrigation schemes were considered as a means to increase production, reduce the risk of unpredictable rainfall and provide food security and employment to poor farmers (Burrow, 1987).

One of the policy priority of Ethiopia is the development of small-scale irrigation as a means of decreasing food insecurity and poverty. It enables households to generate more income, increase their resilience, and in some cases transform their livelihoods (MOFED, 2006). Small-scale irrigation in Ethiopia has a significant role in diversification of production of cash crops (Eshetu, 2010).

2.1.6 Irrigation Development in Ethiopia

Evidence also shows irrigation has been practiced in Egypt, China, India and other parts of Asia for a long period of time. Irrigation is the foundation of civilization in many regions. For instance, Egyptians have depended on Nile flooding for irrigation continuously for a long period of time on a large scale (Zewdie et al., 2007).

Irrigated agriculture is not an entirely new phenomenon in Ethiopia. As some literatures indicated, Small-scale traditional irrigation has been practiced for decades throughout the highlands where small farmers could be diverted seasonally for limited dry season cropping (FAO, 1994). According MoWE, (2012) modern irrigation was documented in the 1960s where the government designed large irrigation projects in the Awash Valley to produce food crops for domestic consumption and industrial crops for exports and it was strongly believed that rain fed agriculture should be supplemented by irrigation in order to achieve national food self-sufficiency and ensure household food security.

2.2 Empirical Literature Review

Number of studies conducted in various settings and countries show that cropping intensity, crop productivity and per hectare employment are higher in irrigated than in rain-fed settings. Hussain and Hanjar (2004) stated that cropping intensity is higher in the irrigated setting than the rain-fed setting. Cropping intensity ranges between 111 and 242% in irrigated and 100 and 168% in the rain-fed setting. The availability of irrigation facilities has therefore enabled farmers to raise nearly an extra crop a year, with consequent implications for household food security (Hussain and Hanjar, 2004).

Irrigation has also contributed to increase land productivity of major crops, including rice and wheat, the main staple foods of Asian rich and poor alike. For example, rice yields fall in the vicinity of 3.0–5.5 t ha¹ in irrigated settings, while the upper bound corresponding figure in rain-fed settings is around 4.0 t ha¹, implying that farmers can harvest an extra tone per hectare of rice due to access to good irrigation water. Similarly, wheat yields are higher in the irrigated than the rain-fed setting (Hussain and Hanjar, 2004). Likewise, labour employment per hectare, and wage rates, are higher in irrigated than non-irrigated settings. Further, the former serves as an employer of surplus labour of adjoining non-irrigated areas (Hussain and Hanjar, 2004).

Hussain et al. (2004) confirms that, improvement in the adoption of new mechanisms of production leads to high productivity of framers. This in turn creates on farm and off farm employment opportunities. These opportunities might improve household income, livelihood and quality of life in rural areas.

Similarly, there is a body of empirical studies that show that household income is higher in the irrigated than the rain-fed setting, and poverty is lower. For instance, study by Hussain and Hanjar (2004) indicated that income in irrigated settings is higher than in the rain-fed, and a 50% point gap is common; also income inequality is lower in irrigated than rain-fed settings, at least for these studies.

Irrigation has tremendous impact on income of a household. Crop production for those farmer using irrigation scheme is much higher than those farmers using rain-fed (FAO, 1995). Moreover, FAO (2007) and Mein Zen-Dick et al (1993) stated that, 72% of farmers could secure better food production/self-sufficiency and ensured source of livelihood income through the use of irrigated land in Zimbabwe. Similarly, another study conducted in Ethiopia by Awulachew et al (2005) stated that, it is estimated that in Amhara Region farmers earn up to about Birr 15,000.00 (about \$1,800.00) from farm products, mainly horticultural crops from modern small scale irrigation schemes.

K. Nhundu et al. (2010) stated that, among the farmers using irrigation in Mopane irrigation scheme in Zvishavane (Zimbabwe) , the majority (72%) were found to be food secure and had stable incomes. The study also showed that the gross margins of irrigation schemes were significantly greater than those not using irrigation. As a result, they had more crop output compared to the non-irrigators. This ensures availability of food for them. More income implies a much better security position for irrigators giving them the opportunity to purchase more nutritious foods.

Some empirical studies confirm Irrigation schemes can play a significant role in improving household food security. For instance, a study conducted in South Africa by S.S. Tekana and O. I. Oladele (2011), confirms that 84% of respondents acknowledged that irrigation contributes to food security. The same study showed that irrigation is one suitable means of ensuring household food security and for sustainable rural development within South Africa's largest semi-arid zone. Hence, it increases gross income and household food security.

The study by Ngigi (2002) disclosed that for the two decades in Kenya the percentage increase in crop production is not proportional to the rate of population increase. These challenges can be minimized through the development of irrigation. The study also help farmers in the diversification of crop production, increasing of food security, creating employment opportunities and income in rural areas of the Country.

In Ethiopia a study conducted by Woldeab (2003), proves that irrigation has provided an opportunity to increase production through an increase of the number of production seasons in a year, in addition to this a study conducted in Fogera District, in Ethiopia showed that the total mean annual cropping income of irrigating households was substantially higher than that for non-irrigating households (Getaneh, 2011).

(Lemma, 2004) studies in two irrigation schemes around Doni Kumbi and Bato Degaga peasant associations in East Shewa showed that average income obtained from irrigation agriculture for three consecutive years accounts for 69 %, 76 %, 76 % in Doni Kumbi and 0, 75 %, 61 % in Bato Degaga. The study has shown the importance of smallholder irrigation development as a drought mitigation measure and improvement of household food security.

A study conducted by Desta (2004) showed that household's income for those rural areas in which adequate small scale irrigation infrastructure exists is about 10% more than for those areas with low small scale irrigation infrastructure. In addition to this, the total aggregate income generated from agriculture is higher in highly irrigated areas by 30% compared to those with low irrigated areas taking in to account the low landownership and cultivated holdings. The share of agricultural income (in terms of both owned and cultivated land) is also found to increase with the increase in irrigation intensity of the village.

2.2.1 An Overview of Ethiopia's Food Security Situation and Irrigation

According Seleshi et al, (2005), agricultural production in Ethiopia was affected by increasing population, deforestation and land distribution. This reflected in a decrease in household production, grazing land. Hence, it has become a common phenomenon to ask for emergency food assistance for acutely food insecure people in Ethiopia.

According WFP (2010), due to the situations of people in Ethiopia, who do not have the capacity to produce or buy enough to meet their annual food needs even under normal weather and market conditions. The Productive Safety Net Program (PSNP) reach to support over 7.23 million people in 347 Woredas for seven regions (Tigray, Amhara, Oromiya, SNNPR, Afar, Harar and Dire Dawa) who are facing chronic food insecurity situation starting 2005 (Ministry of Agriculture, 2016). Hence, the expansion of small-scale irrigation schemes was taken as the main development strategy in order to reduce low crop productivity because of climate changes in Ethiopia by developing a National Medium-Term Investment Program (NMTIP).

In Amhara region, farmers produce insufficient amount of produces because of inconsistent rain fall and inadequate capacity in the region, strong attention is given to small-scale irrigation as a way out to reduce food insecurity and poverty. The development of agricultural technologies might be the main and powerful mechanism for the growth of agricultural productivity (Norton et al., 2010).

The development of irrigation may ensure farmers’ independence from waiting annual rainfall as it enables them to produce two or three rounds in a year. It also increase the size of farmland, use of chemicals and improved seeds to increase the amount of annual production. This in turn will reduce health and food security problems and it also improves household’s diet and annual income (Torell and Ward, 2010). Therefore, small scale irrigation is vital to increase land productivity, food security capacity higher and consistent income through repeated crop production and diversification (Smith, 2004).

2.3 Conceptual Framework

Different studies have been conducted to look into the direction and magnitude of the influence of different factors on farmers’ decision of participation in technology (irrigation participation). Demographic, Scio-economic and Institutional factors determined participation in irrigation turns to affect the impact of irrigation on household food security. Irrigation increases the intensity of cultivation of land per year and generates income source.

Irrigation increases productivity by mitigating vulnerability of rainfall and promote the rural dynamic economy (Seleshi et al., 2007). Reliable small-scale irrigation increases productivity and crop yields intensity per year (Samson et al., 2010) in turn enhance food security and dietary status of farm households (Torell and Ward, 2010). Policy environment and poverty level of the household are also factors that influence participation in irrigation. The following diagram shows the relation of determining factors and the impact pathways of irrigation participation of study area.

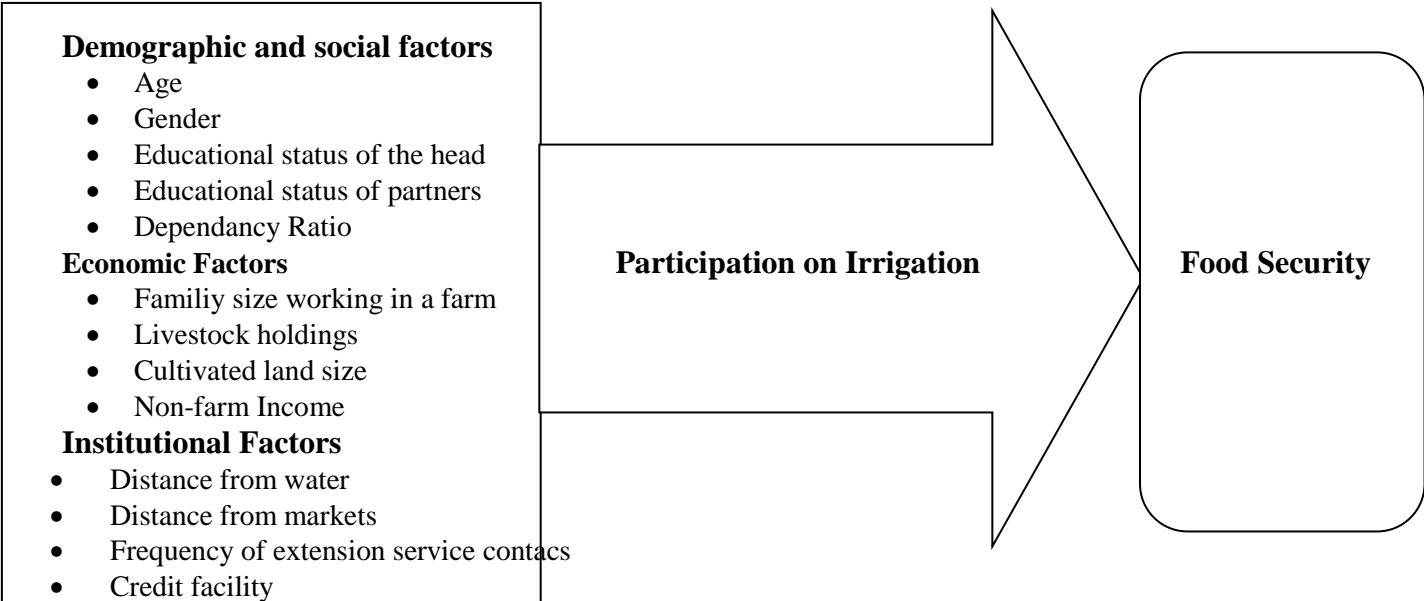


Figure 1 Conceptual Framework (Adopted & Modified from Tizita, 2017)

2.4 Variables Choice, Definition and Measurement

2.4.1 Con-founders

In this study participation in small-scale irrigation is a Co-founder variable in which it is explained by different variables. Food security status of a household is dependent variable. Participation in a small scale irrigation is a dummy variable with values of 1 for household use small scale irrigation and 0 for household who do not participate in a small scale irrigation.

Irrigation user is a rural household who owns irrigated land for farming purpose in different ways and non-irrigation users are those household who don't have access to the irrigated land in whatever way.

2.4.2 The Outcome Variables

Daily calorie intake and total annual caloric consumption expenditure per adult equivalent are the outcome of the study. Daily calorie intake per adult equivalent is an important indicator of food security status at the household level. To measure food security status of a household in the study area information concerning the type and amount food item consumed by each households in the seven days has been collected from both participant and non-participant household. Then the calorie content of food items consumed by sample households' is calculated using calorie conversion factor per adult equivalent. Finally, the amount of total calories intake of each sample household has been divided to seven days and to Adult Equivalent (AE) of respective households. This helps to calculate the amount of calorie consumption per AE for each sampled household per day. The calculated calorie consumption will be compared to the Kcal per adult equivalent per day (2200Kcal) established by the Ethiopian Public Health Institute. This value of minimum subsistence requirement used as a cut-off point between food secure and insecure households. Thus, those households beyond this threshold level seemed to be food secure otherwise insecure.

Total annual caloric consumption expenditure per adult equivalent is also outcome variable of this study. It refers to the total annual household caloric intake consumption expenditure on food items. It is measured in ETB. To do this expenditure of each household (irrigation user and non-user household) on food item has been collected. Then their significance has been tested by using t-test to compare the two group (irrigation user and non-user household).

2.4.3 Independent Variables

The following are factors that may affect household small scale irrigation participation combined with other factors.

Age of the household head: This variable is continuous and can be measured in year. In Ethiopia, household head is the decision maker for farming activities. Age is one of the factors that determine decision making of a person. Younger household heads are easy to adopt and accept new technology and production styles than aged household. Thus, the age of household head was hypothesized negatively to have affected on irrigation participation.

Sex of the household head: The variable represents the biological characteristics of being male or female. It is dummy variable with values of 1 if the household head is male and 0 otherwise. It has been hypothesized that male-headed households are in a better position to pull labour force than the female headed. Accordingly, this study was hypothesized that sex of the household head affect participation in irrigation positively.

Education status of the household head: This has been a dummy variable measured education status of the household head with values of 1 if the household head is literate (read and write) and 0 otherwise. Education creates awareness and helps farmers to develop positive attitude towards participation in new technology (irrigation), which helps farmers relatively ready to take risk of new farming practices. This study was hypothesized education status of the household head positively affect household irrigation participation.

Education status of the family members: This is a continuous variable to be measured with the number of family members with better education status within the household. Education of the household members help the farmers to develop positive attitudes towards the adoption of new technology (irrigation). This study will hypothesize that, the higher the number of family members with higher educational level the higher the probability of the household to adopt irrigation.

Dependency ratio: It refers to the proportion of economically inactive labour force (less than 15 and above 65 years old) to the active labour force (Between 15 and 65 years old) within a household and it is continuous variable. The dependency ratio negatively affect the participation of a household in irrigation practice, because burden of supporting family members fall in active labour within the household. It is

hypothesized that the more the dependency ratio in a household, the less food secure and participation in irrigation i.e. dependency ratio is negatively related to household irrigation participation.

Livestock holding: This variable is continuous variable referring to the number of livestock holding of the household measured in Tropical Livestock Unit (TLU). Livestock is an important source of income, food and draft power and represents an asset, which indicates the wealth and social status of the household and eases financial constraints. A household having more livestock adopt agricultural technology than less livestock holding. Therefore, this study will hypothesize that, livestock holding will be positively affect participation in irrigation.

Family size working in the farm: It refers to the labour in the household measured in number as it is a continuous variable. Households those have more labour adopt agricultural technologies (participation in irrigation) than less labour, since improved agricultural technologies requires more labour. Tadesse et al. (2013) indicate that, the availability of active family labour positively affects the adoption of small scale irrigation technologies. This is because the availability of a higher number of active family members working on the farm reduces the farms' external labour requirements. The study has been hypothesized that, as labour availability increases participation in irrigation might also increase and correlated positively.

Non-farm income source: This variable is a dummy variable that takes a value of 1 if a household participate in the non-farm activity and 0, otherwise. It represents the activities other than the farm activities (crops, and livestock), and off farm activity (agricultural wage). In this regard, households engage in non-farm activities better endowed than that of without any non-farm income sources. Therefore, this study hypothesize the participation of irrigation is positively affected by the involvement of a household in a non-farm income generating activities.

The frequency of extension contacts: It is a continuous variable measured in month. This refers to the number of contacts per month that the respondent made with extension agents. The effort to disseminate new agricultural technology (irrigation) is within the field of communication between the change agent (extension agent) and the farmers at the grassroots level. The frequency of contact between the extension agent and the farmer has been hypothesized to be the potential force, which accelerates the effective dissemination of adequate agricultural information to the farmers, thereby enhancing farmers' decision to participate in technology (irrigation). Hence, this variable has been hypothesized that, it has a positive effect on irrigation participation.

Distance from the local market: It refers to the distance between the household's home and the nearest market measured in kilometres as it is a continuous variable. The study of Abraham et al. (2015) shows that distance to the market negatively affects participation in irrigation. When a household is far from the market income get from farm product is low due to lack of market opportunity and transportation facility the farmer is less to participate in irrigation activity (Muez, 2014). This study has been hypothesized that, distance from the local market affect household participation in irrigation activities negatively.

Distance from irrigation water source: This variable is a continuous variable measured in kilometres. The distance of the households to the water source expected to determine the household's participation in irrigation. The nearer the household to irrigation water source, the higher the probability he /she will participate in irrigation activities, due to the fact that the operation cost of time lost in travelling is reduced. Hence, study will expect that the distance to irrigation water source affects participation in irrigation negatively.

Cultivated land size of the household : It is a continuous variable, as the cultivated land size increases provided other associated production factors remain constant, the likelihood that the holder gets more output is high. This variable represents the total cultivated land size (both irrigated and rain fed) of a household measured in hectare. Farmland is the major input for agricultural production in rural households. Total cultivated land should have a positive relationship with household's food security.

Access to Credit: This variable is a dummy variable that takes the value 1 when the household takes loan and 0 when the household has no credit. Credit can be used for the purchase of agricultural inputs to increase the productivity of farming and for the purchase of foods. Therefore, households who have access to credit may have a positive effect on improving households' food security status.

Chapter Three

Research Methodology

3.1 Description of the Study Area

Bure is one of the 106 woredas of Amhara National Regional State (ANRS) and part of West Gojjam Zone. It is one of the consistently surplus producer woredas of the Region. The main city of the woreda, Bure, is found 400 km northwest of Addis Ababa and 148km southwest of Bahirdar.

The woreda is connected with East Wollega Zone of Oromia Regional State and Metekel Zone of the Benishangul Gumez Regional State. The main road travel from Addis Ababa to Bahirdar, Gonder and Sudan is crossing Bure. Therefore, Bure has good opportunity to sell its agricultural products in different directions. This is good opportunity to easily transport agricultural inputs and products to and from Peasant Associations (PA) and market places.

As indicated under Table 1, human population of the Woreda is 169,609 of which 143,854 (85%) live in rural areas and the male population is relatively lower than female population of the Woreda, however, male-headed households are around 6 times higher than female-headed households. The number of agricultural households, 21,793, is about eight times higher than the households in the urban areas. This indicates that the livelihood of most of the Woreda population is dependent on agriculture.

Table 1. Population and households by sex in urban and rural areas of Bure woreda

	Total Population			Number of Household		
	Male	Female	Total	Male	Female	Total
Rural	72,033	71,821	143,854	19,226	2,567	21,793
Urban	11,633	13,122	25,755	1,699	1,087	2,786
Total	83,666	85,943	169,609	20,925	3,654	24,579

Source: Bure woreda, OoARD (2006)

The total area of the woreda is 72,739 ha of which 46.6% is cultivated and average household cultivated land holding is about 1.6 ha. At present the woreda is divided into 22 rural peasant associations (PAs) and two town associations. Bure and Kuchie are the two major towns in the woreda.

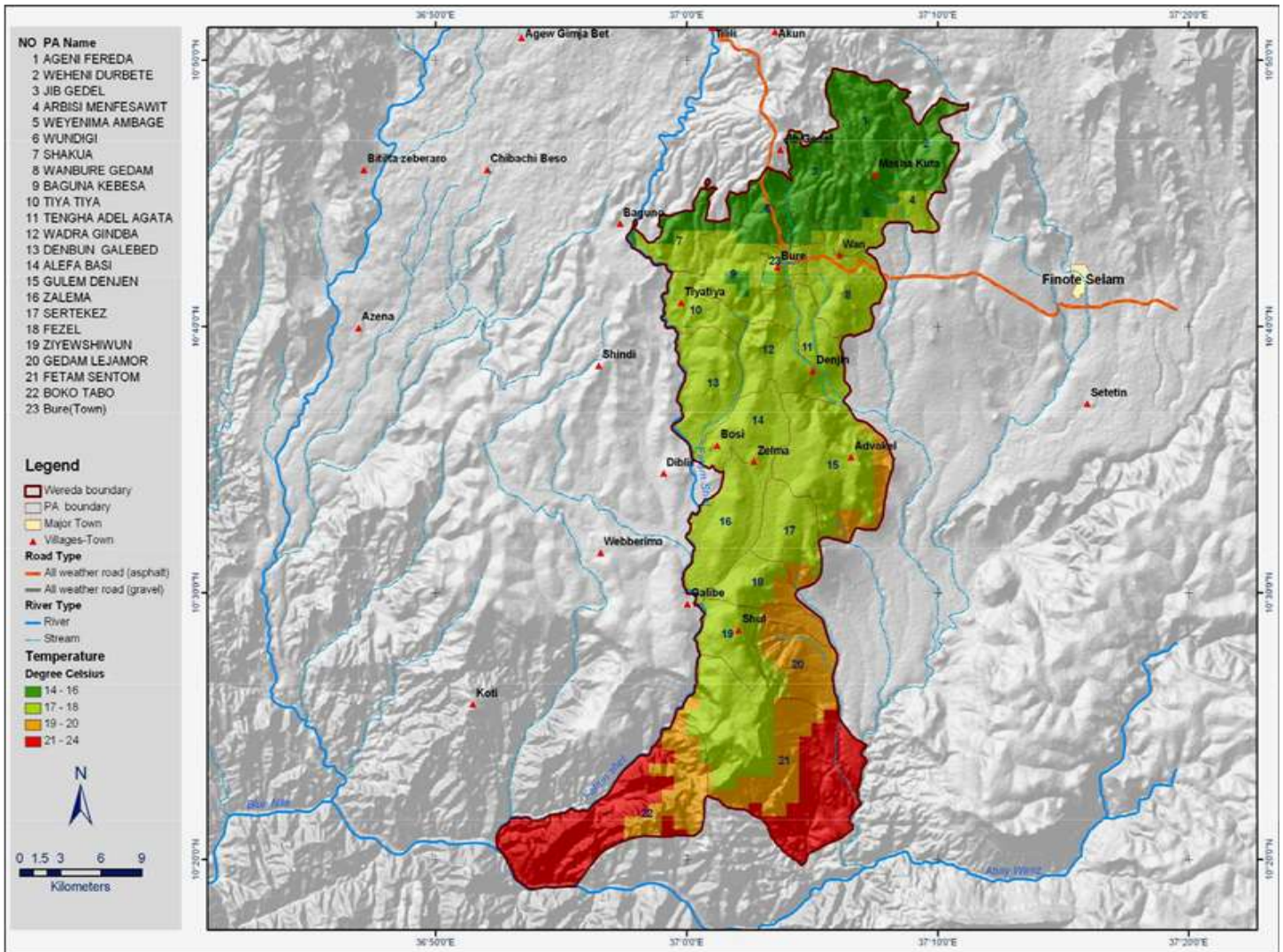


Figure 2. Map of Bure Woreda, Amhara Region (Source: IPMS ATLAS 2007)

Bure woreda receives relatively high amount of rainfall with balanced distribution pattern. According to available digital data the mean annual rainfall ranges from 1386 to 1757 mm. The western and northern parts of the woreda receive relatively higher annual rainfall compared to other parts of the woreda. It has mono-modal rainfall distribution and extends from May to September. Bure is different from the other parts of Amhara National Regional State (ANRS) in terms of amount and distribution of annual rainfall. Farmers practice irrigation to grow crops in the woreda. However, majority of the annual grain is produced during the rainy season (Meher) under rain-fed condition.

Agro-ecologically, Bure is classified into moist and wet lowland (10%), Woina-Dega (82%) and Dega (8%). The altitude of the woreda ranges from 713 to 2,604 meters above sea level (masl). The altitude

drops from 2,604 to 713 masl as one travels from north to south part of the woreda, while the opposite holds true for temperature. Long term annual mean temperature of Bure ranges from 14 oC to 24 oC. Ecological differences in the woreda gives opportunities to grow diverse crop types and rear different livestock types.

3.2 Research Design

A community based cross sectional studies was conducted. The data for this research has been collected at one time from the total sample size of 128 households of the selected two kebeles of the woreda. The two kebeles has been selected purposively based on the irrigation facility and other factors like easy of accessibility and cost factors.

3.3 Data Collection

Data has been collected through focus group discussion and household survey. The structured questions was clarified to the data collectors to make the respondents to capture the memories and viewpoints. The questions for the survey and group discussions was conducted using Amharic language.

Data collection from households has been carried out by two enumerators (12 grades complete) and the researcher as supervisor. The selection of enumerators depending on the knowledge of the study area, their local language, educational level and personal willingness to take part in the survey. After the selection process completed, one day orientation and discussion about the objectives of the survey, discussions on each question was undertaken. This helps the data collectors in creating a common understanding through avoiding misconception and increasing clarity. A support letter written by the Woreda Administration to each kebele was handed over to the enumerators. This helped them to complete the survey smoothly. Finally, the collected data has been coded, and entered in to excel and imported to STATA statistics software for further analysis. Descriptive statistics and econometric model used to analyse the collected data. The non-response rate is expected to be zero as the data collection is done through filling of the questionnaires by the hired data collectors.

Group discussions with 5-10 villagers has been conducted with women and men. Participants for focus group discussions was selected based on their familiarity with the discussion topics and suggestion from the agricultural extension service.

3.4 Inclusion and Exclusion Criteria

3.4.1. Inclusion Criteria

All households living in the two kebeles (Jibe Gedel and wundgie) were include.

3.4.2. Exclusion Criteria

Those households who are living both in the selected two kebeles and two town administrations (Bure and Kuchie) were excluded as they are economically strong with multiple sources of income.

3.5 Sampling Technique

A two- stage random sampling technique has been employed to select sample households. In the first stage of sampling procedure, out of 22 rural *kebeles* in Bure *woreda*, two rural *kebeles* (*Jib-Gedel and Wundgi*) has been purposively selected based on irrigation facility, distance from Bure, transportation and other costs. In the second stage representative respondents from each of the two *kebele* households has been selected and grouped in irrigation users and non-irrigation users.

To calculate the sample size of the study, the researcher used the formula developed by Yamane (1967) at 95% confidence level and 8.8% margin of errors as there was some constraints to manage large sample size.

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

Where, n= sample size for the study, N= total number of household head, e= margin of errors at 8.8%. Then out of 21,793 rural household heads, approximately a total of 128 households (64 users and 64 non users) respondents has been selected for household survey.

Then 64 sample respondents from irrigation users and 64 from non-users group has been selected randomly through simple random sampling technique. The reason for taking equal size of respondents from each stratum is that, the effect of irrigation on food security might be wrongly concluded if the number of participants taken from each group is not equal. Similarly to this study, Jema et al. (2013) and Zaman (2001) also used equal sample size to evaluate impact of small scale irrigation on house poverty alleviation in Grogutu kebele of East Showa Zone of Oromia region. Finally, 128 household heads has been interviewed from both irrigation users and non-users household.

3.6 Types of Data and Data Sources

Both quantitative and qualitative data type has been collected from primary and secondary data sources to obtain the necessary information for the purpose of this study. Primary data has been collected from respondents while, relevant secondary data has been organized and documented from published and unpublished sources.

The primary data collected from the respondents demographic, socio-economic and institutional related variable relevant to the study such as age of household head, sex of household head, education status of household head and family members, dependency ratio in household, non-farm income sources of household, cultivated land size of the household, frequency of household with extension contact, availability of credit facility, labour availability in household, distance of household from irrigation water source and local market.

In addition, secondary data such as background information of the study area has been collected from different journal, articles, paper and report of regional and district offices.

3.7 Methods of Data Analysis and Specification of the Empirical Model

The quantitative data is analysed using descriptive and inferential statistical tools. Means, percentages and standard deviation has been used to analyse descriptive statistics, while chi-square and t-test has been applied to test the statistical significance of the dummy and continuous variables respectively. A t-test has been used to inspect the mean difference of continuous variables of household who participate in and non-participants.

Qualitative data that has been collected from focus group discussion is analysed by narrative explanation with supported by quantitative data. An index score ranking method has also been used to analyse quantitative data collected from respondents regarding to constraint of irrigation water use. Finally, the analysis has been done with the help of STATA version 13.1 and Excel.

The two groups of the household has been compared to examine the effect of small-scale irrigation on household food security. These groups are irrigation user households and non- irrigation user households. The non-user households has been used as a comparison group to examine the impact of small-scale irrigation on user's households.

3.8 Matching Between Participants and Non-Participants

Propensity Score Matching (PSM) probability model has been applied to create a matching between household who participate in a small scale irrigation and households not participate in a small scale irrigation. The logic behind propensity score methods is that balance on observed covariates through careful matching on a single score. This study will use propensity score matching techniques in order to build the matching pair for participants that have similar observable characteristics between irrigation user and non-user households based on p-score in the absence of baseline data. The propensity score is the probability of receiving treatment based on measured Covariates:

$$E(x) = P(D=1 | X)$$

Where $E(x)$ is the abbreviation for propensity score, P a probability, $D=1$ a treatment indicator with values 0 for control and 1 for treatment, the "|" symbol stands for conditional and X is a set of observable covariates. In other words, propensity score expresses how likely a person is to select the treatment condition on a given observed covariates. This score is useful to match participants from treatment condition to participants from control condition who have a very similar estimated propensity score. This matching process creates a balance between treated and untreated participants. It is also expected to create balance on covariates that has been used to estimate the propensity score. This balance property is a key aspect of propensity score method because; a balanced pre-test covariate cannot be a confounder anymore, each that cannot bias the treatment effect estimate (Thoemmes, 2012).

According to Caliendo and Kopeinig (2008), there are steps of predicting the propensity scores, choosing matching algorithm, restrict common support area, testing matching quality or balancing test and sensitivity analysis to apply PSM

Step 1: Propensity scores A Logit model has been used to estimate Propensity Scores for each observation. The advantage of this model is that the probabilities are bounded between zero and one. The dependent variable is dichotomous, taking two values, 1 if an individual participates in small-scale irrigation and 0 otherwise. The covariates used to predict treatment assignment using logistic regression, specified as:-

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

where L_i is log of the odds ratio in favor of participation in small scale irrigation?

z_i = participation

β_0 = intercept

β_j = regression coefficient to be estimated

x_j = explanatory variable (like age, sex, education status etc.)

u_i = error term

Step 2: Choosing matching algorithm: the next stage is to choose the matching algorithm which best estimates the p-score. These include the nearest neighbour matching, radius matching and the kernel matching.

Nearest Neighbour matching: for each control unit this method assigns a weight equal to one for the nearest comparison unit in terms of the balancing score and zero to all the other comparison observations. So that, single comparison unit has been used as a matching for more than one control unit.

Radius Matching: Nearest neighbour, matching faces the risk of bad matches if the closest neighbour is far away. This can be reduced by a level on the maximum propensity score distance (calliper). By this matching, bad matches has been avoided and hence the matching quality rises. This is an alternative way of imposing the common support condition.

Kernel Matching: The matching algorithms discussed so far have in common that only a few observations from the comparison group used to construct the counterfactual outcome (unobservable outcome) of a treated individual. Kernel matching (KM) is non-parametric matching estimators that will use weighted averages of all individuals in the control group to construct the counterfactual outcome. In general, the most important question in using PSM is on how and which method to select these estimators. Clearly, as (Bryson et al., 2002) reported there is no single answer to this question. The choice of a given matching estimator depends on the nature of the available data set. However, according to Dehejia and Wahba (2002), a good matching estimator is that provides low pseudo-R2

value, statistically insignificant likelihood ratio test of all regresses after matching and to retain relatively larger observations to assess the impact of a participation.

Step 3: Common support: The common support region (overlap condition) is the area, which contains the minimum and maximum propensity scores of treatment and control group. Hence, the study used common support condition for any combination of characteristics observed in the treatment and control group.

Step 4: Testing matching quality or balancing test is one important concern that should be taken care of while doing PSM is balancing test or checked if the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment groups. The matching quality depends on the ability of the matching procedure to balance the relevant covariates. The standardized bias proposed by Rosenbaum and Rubin (1985) is the commonly used method to quantify the bias between treated and control groups. The study of Sianesi (2004) also proposed a comparison of the pseudo-R2 before and after matching. After matching, the pseudo-R2 should be low because of the matching use those households that have similar characteristics which mean that no significant difference of covariate of treated and the control group. To do so, the balancing test employed to check the matching quality.

Step 5: Sensitivity Analysis: - the basic question to be answered in sensitivity analysis is that, how strongly an unmeasured variable must influence the selection process in order to undermine the implication of matching analysis (Caliendo et al., 2005). This might be important to determine the strength of excluded variables influence on the selection process in order to undermine the implications of matching analysis. Hence, sensitivity analysis has been undertaken to detect the identification of CIA (conditional independency assumption) is satisfactory or affected by the dummy confounder.

Finally, Average Treatment on Treated (ATT): It has been used to assess the effect of small scale irrigation on the food security. It is the difference between the outcome of treated and not been treated will be computed as:

$$ATT = E(Y_i^T - Y_i^C | D = 1) = E(Y_i^T | D = 1) - E(Y_i^C | D = 1)$$

where D is treatment sample respondents

3.9 Measurement of Household Food Security Status

The overall adequacy of food supply in the study area has been analysed by using Calories intake model. More recently, a research conducted by Messay (2009) conveyed that, this analytical tool has been used by many scientific studies to assess household food security situation and to measure the contribution of projects to food availability mainly in agriculture sector.

Daily calorie intake and total annual caloric consumption expenditure per adult equivalent are the outcome of the study. Daily calorie intake per adult equivalent is an important indicator of Food security status at the household level. To measure food security status of household in the study area information concerning type and amount food item consumed by each households in the seven days preceding the survey were collected from both participant and non-participant household. Then the calorie content of food items consumed by sample households' was calculated using calorie conversion factor per adult equivalent.

Finally, the amount of total calories consummation of each sample household computed and divided to seven days and to Adult Equivalent (AE) of respective households, which is gave the amount of calorie consumption per AE for each sampled household per day and then compared with recommended Kcal per adult equivalent per day (2200Kcal) set by the Ethiopia Government (FSS, 2002), this value of minimum subsistence requirement was used as cut off point between food secure and insecure households. Thus, those households beyond this threshold level seemed to be food secure otherwise insecure. Total annual caloric consumption expenditure per adult equivalent is also outcome variable of this study. It refers to the total annual household caloric intake consumption expenditure on food items. It measured by ETB. To do this expenditure of each household (irrigation user and non-user household) on food item was collected. Than their significance was tested by using t-test to camper the two group (irrigation user and non-user household).

The existing documents indicates that, the Logit model is most common mathematical model in studies that encompasses food security. As mentioned by Hosmer and Lemeshow (1989), there are two basic explanations for the use of this model. The first is that, it is highly flexible and easy to apply the function and secondly it provides a meaningful explanation and interpretation. Therefore, in this study the logit model has been used for the analysis of the factors that affect household food security status.

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).

3.10 Data quality control

After reviewing the literature, the questionnaire was prepared first in English and then translated to the local language (Amharic). Data collectors were given orientation on filling response of the respondents and pre-test of the questions were done to check the completeness of each questionnaire. The Advisor was rechecked for the completeness of the questionnaire before the pre-test and orientation. Data is collected by 12 complete students in collaboration with the local Agricultural extension worker with the supervision of the researcher.

3.11 Ethical Consideration

The study adopted the research ethical standards, before proceeding with the research, an official letter from Addis Ababa University was obtained to provide for woreda agricultural office and obtained approval, while the respondents were contacted, the purpose of the study was explained at the beginning of the discussion. Their full consent was first checked before starting data collection. They also informed that, their information will be kept confidential and will be used only for the purpose of learning.

Chapter Four

Result and Discussion

4.1 Descriptive Statistics Result and Analysis

4.1.1 Socio - Economic and Demographic Data Analysis

As indicated in the below table 2, sex and non-farm income sources of a household do not show any significant difference between the two groups but the below depicts that education level has a significant difference for participant and non-participant to small scale irrigation.

Table 2. Descriptive statistics of for dummy variables

Variables	Participant In irrigation (M-57,F-7)	Non- participant in irrigation (M-56, F-8)	Total	χ^2 value
	Percentage	Percentage	Percentage	
Sex	male	90.00	88.80	0.65
	female	10.00	11.30	
	total	100.00	100.00	
Education status	literate	57.75	80.25	9.54
	illiterate	42.25	19.75	
	total	100.00	100.00	
Off farm income	yes	10.00	12.75	0.52
	no	90.00	87.25	
	total	100.00	100.00	

Education status: The result shows that 19.75% non-irrigation user household heads were illiterate and 42.25% of irrigation users were found literate household heads. This clearly implies that educated household heads were better participating in irrigation farming than that of uneducated household heads. The chi-square test indicates that education level of the two groups was statistically significant difference at 1% level of significance.

4.1.2 Scio - Economic Data Analysis

The below table summarizes that dependency ratio, total livestock holding, distance from irrigation water source, distance from local market, and frequency of extension worker contact has a significant difference among participant and non-participant.

Table 3: Descriptive statistics of continuous variables

Variables	Participant HH		non- participant HH		t-value
	Mean	SD	Mean	SD	
Age (in year)	37.13	19.36	38.90	9.83	1.04
Dependency ratio in the household (%)	85.45	62.53	103.11	75.21	2.60
Livestock holding in TLU	6.18	4.19	8.63	6.66	2.75
Distance from irrigation water source in (km).	1.50	0.71	1.82	0.878	5.13
Distance from nearest market in(km)	27.56	6.01	24.07	5.80	1.75
Labour availability	1.52	0.87	2.55	0.97	0.63
Frequency of extension contact with	1.84	1.85	1.13	1.19	3.38

As indicated in the table above the test statistical analysis shows that there is statistically significant difference in dependency ratio between participation and non-participate household at less than 1% level of probability and Livestock holding has less than 1% level of probability among the irrigation users and non-users.

The mean distance of household farm from irrigation water source is 1.50 km for irrigation user households and 1.82 km for non-irrigation user households. The result of the test statistics indicates that, there is statistically at less than 1% level of probability significant difference among the irrigation users and non-irrigation users. In addition, the average distance from nearest market for irrigation participant and non-irrigation participant were 27.56 and 24.07 km respectively. The test result indicate that there is significant difference in distance from nearest market between irrigation participant and non-participant at less than 10% probability level.

The mean frequency of extension contact for irrigation user households is 1.84 and for non-participant households is 1.13. These results show that there is difference between participant households and non-participant households in contact with extension. The t-test result showed that extension contact is statistically significant at 1 % level of probability.

4.1.3 Descriptive Results of Outcome Variables

The total caloric consumption of each sample household per adult equivalent per day measured in kilo caloric (kcl). As indicated in the descriptive statistics of participant and non-participant groups, the average Calorie intake per adult equivalent of household who participate in a small scale irrigation is 3,201.57 and households not participate in small scale irrigation is 1,987.35. As indicated the mean difference in Calorie intake per adult equivalent between the participant and the non-participant households is 1,214.35 kcl. This result showed that there is a significant difference between participant and non-participant households. The result of the t-test shows that there is statistically a significant difference of 1% level of probability.

Total caloric consumption expenditure per adult equivalent per year refers to the household expenditures paid for food item. As indicated in the below table, there is a difference between participant and non-participant groups. The mean caloric intake of consumption expenditure per adult equivalent per year of participant household is 2,184.12 ETB which is more than that of the non-participant 1,464.07 ETB. The mean difference in caloric intake consumption expenditure per adult equivalent per year between the participant and the non-participant households is 720.05 ETB. It is statistically significant difference at 1% probability level.

Table 4: caloric consumption expenditure per adult equivalent

Variables	Combined Mean	Participant Households	Non-Participant Households	Mean difference	T-test
Calorie intake/adult equiv.	2594.46	3201.57	1987.35	1214.35	7.51
Total Caloric consumption Expenditure per Year in ETB	1824.10	2184.12	1464.07	720.05	4.37

However, the above result cannot tell us whether the observed difference is exclusive because of the program or not. In fact, it is not possible to attribute the difference in calorie intake and Calorie intake consumption expenditure/adult equivalent of the two groups exclusively to the program. As stated earlier, a further analysis must be performed using propensity score matching techniques to address this issue.

4.1.4 Econometric Results

4.1.4.1 Multi-Collinearity Tests for Continuous Explanatory Variables

Multi collinearity can be checked by using Variance Inflation Factor (VIF). As indicated in the Appendix Table 4, there is no sign of multi-collinearity among the explanatory variables included in the model as the VIF value exceeds 10% and R^2 exceeds 90% as indicated by Gujarati (2004).

4.1.4.2 Logit Results of Participation in Irrigation

The logistic regression model indicates that only three of the ten explanatory variables has no significant influence on the participation of small-scale irrigation. These explanatory variables that significantly influence the participation of a household in a small scale irrigation includes education status, family dependency ratio, distance from water source, livestock holding, nonfarm income source, the frequency of extension contact and distance to local market. Of these seven variables, four had negative signs and the remaining three had positive signs.

Table 5. Logit results of participation in irrigation

Variables	Coefficients	Standard errors	odds ratio
Sexhh	-0.488	0.378	0.605
Agehh	0.010	0.017	1.010
Edustatushh	1.034	1.356	2.861
Dependratio	-0.003	0.0012	0.897
Laborav	-0.108	0.198	0.879
Distirrgwater	-1.014	0.101	0.353
Livstockhold	-0.088	0.029	0.913
Nonfarm	-1.368	0.167	0.217
Freqextncont.	0.433	0.204	1.565
Distlocmrkt	0.067	0.040	1.090
Constant	0.125	1.654	1.129
N	128		
LRchi2 (10)	56.40		
Prob >chi ²	0.000		
Log likelihood	-82.602		
Pseudo R ²	0.254		

Education status:-This variable significantly affect participation in irrigation positively at 5% level of significance. The odds ratio of the variable indicates that other factors constant as education status of household increase by one unit, participation in small-scale irrigation will increase by a factor of 2.861. It is probably due to those households who educated better chance to adopt agricultural technology than illiterate.

Dependency ratio of household: -This variable affects participation in irrigation negatively at 10% level of probability. The odds ratio of this variable indicate that other factors being constant, the increase of dependency ratio by one unit results in a decrease of household participation in irrigation by a factor of 0.897.

Distance from irrigation water sources:-This variable has significant negative effect on the participation to irrigation at 1% level of probability, keep other variables constant. The odds ratio of the variable is 0.353 which indicates that, as a unit increase in the distance of irrigation water from the household decrease the participation of a household in irrigation by 0.353.

Livestock holding:-This variable significantly affects household participation in irrigation at 10% level of probability, other variables being constant. As indicated in the above table, household participation in irrigation is negatively affected by livestock holdings of a household. The odds ratio revealed that at a unit increasing in livestock holding participation in irrigation decrease by 0.913.

Non-farm income source:-This variable positively affect participation in irrigation at 5% level of significance, other factors being constant. The odd ratio indicates that, a unit increase in non-farm income sources of a household, decrease participation in irrigation by the 0.217.

The frequency of extension contact:-This variable has a positive effect of household participation in irrigation at 10% level of probability, other factors being constant. The result of the odds ratio of 1.565 indicates that, a unit contact of household with extension agent, increase participation in irrigation by 1.565.

Distance from local market:-This variable has a positive effect on household participation at 5% level of probability, other variables being constant. The odds ratio of 1.090 reveals that, as a unit increasing of distance of local market increase, participation in irrigation increase by odds of 1.090.

4.1.4.3 Generation Propensity Score Matching

4.1.4.3.1 Estimation of Propensity Scores

To estimate the propensity score matching, logistic regression model is used for participant and non-participant households. The model used ten matching variable that have chosen as an explanatory variable. In doing so, the dependent variable was a binary variable taking a value of 1 for household participate in irrigation or 0 otherwise. The pseudo-R² value is 0.254. A low pseudo-R² value shows that program households do not have many distinct characteristics between explanatory covariate which easier a match between participant and non-participant household.

4.1.4.3.2 Matching Participant and Comparison Households

As stated before, four main tasks accomplished before one launches the matching task itself. First, predicted values of program participation (propensity scores) should be estimated for all households in the program and outside the program. Second, a common support condition imposed on the propensity score distributions of household with and without the program. Third, discard observations whose predicted propensity scores fall outside the range of the common support region. Fourth, sensitivity analysis approved to evaluate how strongly unobserved variables must influence selection into the result of sensitivity of participation on small-scale effects on outcome variables. Finally, estimation of treatment effect on the treated done by using selected matching algorithm.

As shown in Table 6, the estimated propensity scores vary between 0.066 and 0.995 (mean =0.657) for participant households and between 0.122 and 0.938 (mean = 0.340) for non- program (control) households. The common support region would then lie between 0.066 and 0.938. In other words, households whose estimated propensity scores are less than 0.066 and larger than 0.938 not considered for the matching exercise. Because of this restriction, 15 households (9 participants and 6 control households) discarded from the analysis.

Table 6. Distribution of estimated propensity scores

Group	Observation	Mean	STD	Min	Max
Total household	128	0.499	0.283	0.012	0.995
Participant	64	0.657	0.228	0.066	0.995
Non participant	64	0.340	0.241	0.122	0.938

4.1.4.3.3 Choice of Matching Algorithm

Alternative matching estimators used in matching the treatment and control households in the common support region. The final choice of a matching estimator guided by different criteria such as equal means test(balancing test), Low pseudo-R2 and greater number of matched sample size are some of the criteria to select matching algorithm (Dehejia and Wahba, 2002). Balancing test refers number of explanatory variables with no statistically significant mean differences between the matched groups of treatment and control households. Table 7 below shows that the estimated results of tests of matching quality based on the above-mentioned performance criteria. When look into the results, nearest neighbour matching bond width (1) is the best estimator for the data at hand based on

the above criteria. As a result, this study used to estimate the average treatment effect on the treated (ATT) of outcome variable or objective of this study based on the results obtained from the nearest neighbour matching.

Table 7: Performance of different matching estimator

Matching estimator	Performance	Matched sample size
	criteria Pseudo R ²	
Kernel matching		
Band width 0.01	0.017	96
Band width 0.1	0.041	128
Band width 0.25	0.036	128
Band width 0.5	0.065	128
Radius callipers		
0.01	0.192	128
0.1	0.192	128
0.25	0.192	128
0.5	0.192	128
Nearest neighbour matching		
NN(1)	0.035	128
NN(2)	0.037	128
NN(3)	0.038	128
NN(4)	0.046	128

4.1.4.3.4 Testing the Balance of Propensity Score and Covariates

The main purpose of the propensity score estimation is to balance the distributions of relevant variables in both groups. The balancing powers of the estimations determine by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched households, equality of means using t-test significance for the variables used (Table 8). Accordingly, the mean standardized bias before and after matching, shown in the fifth columns of Table 8. In the present matching models, the standardized difference in X (a set of observable covariates) before matching is in the range of 4% and 53% in absolute value. After matching, the remaining standardized

difference of X for almost all covariates lies between 3.8% and 19.4% in absolute value, which below the critical level of 20% suggested by Rosenbaum and Rubin (1985). These show evident that, sample differences in the unmatched data significantly exceed those in the samples of matched cases. T-values in Table 8 show that before matching half of chosen variables exhibited statistically significant differences while after matching all of the covariates are balanced.

Table 8 . Propensity score and covariate balancing

Variable	Sample	mean		Standard bias%	Reduction bias%	t-test
		treated	control			
Sexhh	Unmatched	0.90	0.88	4.0	-22.77	-0.25
	Matched	0.89	0.87	4.4		0.26
Agehh	Unmatched	38.13	39.91	-16.37	1.75	1.05
	Matched	38.70	39.10	-3.8		0.24
Edustatuhh	Unmatched	0.41	0.18	50.3	-20.27	-3.18
	Matched	0.37	0.40	-6.0		-0.33
Depratio	Unmatched	106.46	140.14	-44.5	29.97	2.81
	Matched	112.39	117.47	-6.7		-0.45
Laborav	Unmatched	2.52	2,61	-9.8	26.67	0.62
	Matched	2.58	2.40	19.4		1.25
Disirrgwater	Unmatched	1.30	1.91	-81.3	2.03	5.14
	Matched	1.36	1.48	-16.3		-1.05
Livstokhold	Unmatched	6.19	8.62	-43.8	8.34	2.76
	Matched	6.32	5.75	10.4		0.80
NonfarmSOR	Unmatched	0.10	0.13	-11.5	0.11	0.00
	Matched	0.09	0.04	16.6		1.31
Fregexcont	Unmatched	1.95	1.12	53.3	-2.32	3.37
	Matched	1.82	1.59	14.8		0.91
Dislocmkt	Unmatched	26.57	25.06	27.8	-42.50	1.76
	Matched	26.37	27.21	-15.4		-0.91

4.1.4.3.5 Estimation Treatment Effect on the Treated

This section assess the impact of participation on small scale irrigation on the outcome variables after the pre-intervention differences were controlled. The two outcome variable are calorie intake and caloric consumption expenditure per adult equivalent.

A positive difference between the outcome variables, households' calorie intake and annual consumption expenditure per adult equivalent of the treated and the control indicates that there has been improved because of participation irrigation intervention in the study area.

Table 9. ATT of outcome variable

Outcome variables	Participant	Non-participant	Difference	SE	t-value
Kilo calorie intake per adult equivalent per day	3183.91	2275.61	908.29	227.50	3.99
Total Caloric consumption Expenditure per Year in ETB	2246.33	1617.39	628.94	256.17	2.46

As can be seen from Table 9, the study provides evidence as to whether or not the participation in small-scale irrigation has brought significant changes on household's food security or calorie intake. The estimation result presented in Table 9 provides a supportive evidence of significant effect of the program on household calorie intake and annual consumption expenditure per adult equivalent. In other words, the participation in small-scale irrigation has increased the kilocalorie intake per adult equivalent for participant households on average by 28.52% per day and increase caloric consumption expenditure per AE per year by 28%.

4.2 Factors Affecting Irrigation Water Use in the Study Area

Even though, irrigation has positive impact on the food security households of the study area have faced a number of irrigation water use related constraints. Hence, this study find some of the major constraint of irrigation water use based on data obtained from survey and FGD. Accordingly, irrigation water scarcity, damage or breakdown of irrigation structure, deficiency of water allocation, limited experience of Households on irrigation activity, manpower (increasing of labor wage), present of crop pest and disease and conflict over irrigation water are the major constraints of irrigation water use in the study area. Among this problem based on overall index score ranking result; irrigation water

scarcity, damage or breakdown of irrigation structure, deficiency of proper water allocation and financial constraint are the top four constraints of irrigation water use in the study area as shown in the Table 10.

Table 10. Constraints of irrigation water use in the study area

No.	Constraints	Overall scores	Index score	Rank based on score
1	Deficiency of proper water allocation	258.3	0.148	3
2	Breakdown of irrigation infrastructure	306.90	0.176	2
3	Irrigation water scarcity	359.80	0.206	1
4	Financial constraints	248.70	0.142	4
5	Limited experience on irrigation	219.40	0.126	5
6	Limited manpower	138.80	0.079	6
7	Crop pest and disease	108.60	0.062	7
8	Conflict over irrigation water use	99.60	0.057	8

According to discussion held with FG and the survey result, irrigation water scarcity is the first challenge in the study area. The major reason is unfair irrigation water user, siltation of irrigation canal, breakdown of underground water pipe, division box and main canal. Due to this problem, water is lost without giving any use to the farm households.

The second constraint of irrigation water use in the study area is breakdown of irrigation structure. According to the focus group discussion and survey result. The main reason for breakdown of irrigation structure in the area is lack of maintenance over the year and unfair irrigation water use in the area.

The third constraint focus group discussion and survey result revealed is the deficiency of water allocation problem on irrigation water use. The cause is weakness of rule and regulation on irrigation water use and un-functionality of water use association in the area regarding irrigation water use. Due to this reason in the study area unfair resources use was observed among irrigation water user households.

The fourth and fifth constraint of irrigation water use in the study area is financial constraint and limited experience of Households on irrigation farm. According to the FGDs results, the major crop grown in the area is vegetable crop next to maize. Households of the area had an interest to produce vegetable crop to fill the immediate need of income but do not produce because of financial constraint and limited experience in crop production. This also hampered Households to use irrigation by their own in the study area.

The other problem that FGD results revealed is lack of effective marketing system or market structure in the study area. It means that due to inelastic of price vegetable crops and perishable nature of the crop farmers do not get fair price. In addition to this problem, market broker of vegetable crop is also impeded price decision of the vegetable crop in the study area. All these reasons leads farmers of the area to be less benefited from the crop they produced (Appendix Table 5). According to FGD result lack of experience of Households on post-harvest handling of vegetable crop and lack of linkage of vegetable producer Households with agro-processing industries is reason for households are unable to get a reasonable price from the sale of vegetable crop in the area.

Generally, even though the food security status of the household is improved in the study area, lack of sufficient water allocation, breakdown of irrigation structure (canals, water pipe, division box), lack of experience in irrigation activity, insufficient marketing system are among the reason hampering or reducing the benefit of irrigation to Households in the area.

Chapter Five

Summary, Conclusion and Recommendation

5.1 Summary and Conclusion

This study is conducted in Bure Woreda, which is one of the 106 woredas of Amhara National Regional State (ANRS) and part of West Gojjam Zone. It is one of the consistently surplus producer woredas of the Region. The main city of the woreda, Bure, is found 400 km northwest of Addis Ababa and 148km southwest of Bahirdar.

The human population of the Woreda is 169,609 of which 143,854 (85%) live in rural areas and the male population is relatively lower than female population of the Woreda, however, male-headed households are around 6 times higher than female-headed households. The number of agricultural households are more than the households in the urban areas. Therefore, it can be concluded that the livelihood of most of the Woreda population is dependent on agriculture.

The total area of the woreda is 72,739 ha of which 46.6% is cultivated and average household cultivated land holding is about 1.6 ha and the woreda is divided into rural peasant associations (PAs) two town associations. Bure and Kuchie are the two major towns in the woreda.

Agro-ecologically, Bure is classified into moist and wet lowland (10%), Woina-Dega (82%) and Dega (8%). The altitude of the woreda ranges from 713 to 2,604 meters above sea level (masl). The altitude drops from 2,604 to 713 masl as one travels from north to south part of the woreda, while the opposite holds true for temperature. Ecological differences in the woreda gives opportunities to grow diverse crop types and rear different livestock types.

A two- stage random sampling technique has been employed to select sample households. In the first stage of sampling procedure, out of 22 rural kebeles in Bure woreda, two rural kebeles has been purposively selected based on irrigation facility, distance from Bure, transportation and other costs. In the second stage to select the representative respondents from each of the two kebele households has been identified and stratified in to two strata: irrigation users and non- users.

Then a total of 128 sample respondents were selected from the two strata randomly through simple random sampling technique. Finally, equal same size 64 from irrigation use and 64 from non-irrigation user household was selected for the study. It is conducted using primary data collected through questionnaires directly from the selected sampled households, focus group discussion and secondary data collected from documents.

Mean, percentage and standard deviation of the two groups are analysed through descriptive statistics. Chi-square and t-test has been applied to test the significance of the two groups. Accordingly, some variations observed between users and non-users in terms of household characteristics and institutional factors. The two groups differ to some extent in terms educational status, distance from irrigation water source, dependency ratio and the frequency of extension contact user better than non-user. With regard to econometric model, logit is used. The result of logit shows education status, frequency of extension contact, and distance from local market affect household participation in irrigation positively. While, dependency ratio, livestock holding, distance from irrigation water source and non-farm income source affect household participation in irrigation negatively.

Further based on the criteria of selecting matching algorithm the ATT is calculated. The result confirm that participation in small-scale irrigation has a positive impact on food security and annual caloric consumption expenditure. Moreover, the study has also identified some irrigation water use related constraints. Accordingly, irrigation water scarcity, damage or breakdown of irrigation structure, deficiency of proper water allocation and financial constraint are the top four challenge of irrigation water use in the study area.

Lack of effective marketing system is other constraint for irrigation water use and reason for Households to share out their land. According to the FGD result, Households of the area less benefited from the crop they produce. The major cause is price inelastic and perishable nature of the crop, interference of market broker on price decision, limitation of experience on post-harvest and handling, limited to agro-processing industries on vegetable, lack of linkage of vegetable producer agro-processing industries are among the constraint of the households in the study area.

Generally, even though participation in small-scale irrigation improves the food security status and annual caloric consumption expenditure by 28.52 and 28 percent respectively, there are also many irrigation related constraints, that hampered or reduce the benefit of irrigation in the study area.

5.2 Recommendations

Based on the result of the study, the researcher recommended the below demographic and socio economic related factors

Household participation in a small scale irrigation is positively affected by Education level of a household head. Therefore, enhancing education level of the woreda through capacity building and experience sharing will improve the participation of households in a small scale irrigations.

There is a direct relationship between use of irrigation farming and availability of labour force in a household. The more labour forces exist in a household the probability of participating in irrigation farming increases. Therefore, it is recommended to increase the technology that increase the level of labour forces in a household. This can be done through the introduction of Agricultural technologies and improving the working habit of the household's through clustering of farmers and supporting of 'Debo'

As distance from irrigation water source increases the participation of a household in a small scale irrigation reduced. Thus expansion of irrigation infrastructure in the woreda through farmers association and developing by laws for the use of irrigation infrastructure will improve the participation of households in a small scale irrigation.

Non-farm income source of household, affect household irrigation participation negatively. Thus, it is recommended to enhance the capacity of households in developing entrepreneurial skill and using of saving scheme for hard time.

Frequency of extension contact has a positive impact for household participation in irrigation. This is justified by the idea that extension workers provide technical support, promote small scale irrigation and its importance. Therefore, the woreda Agriculture office better to increase the number of extension workers assigned in the area to increase contacts. It is also important to provide incentives to extension workers by giving short and long-term trainings.

Water distribution and damages of the irrigation infrastructure are the main constraint identified in the study area. This study recommended to encourage the establishment of cooperative Associations and

the development of by laws in using and protecting of irrigation infrastructures for better use and by-laws, awareness may bring sense of ownership.

Finally, marketing is one of the major constraints of irrigation users in the study area that makes household to depend on Brokers and marketing mediators. This study recommend the woreda administration to look into the development of marketing facilities and establishment of farmers' cooperatives.

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Appendix 1. Conversion Factor of Tropical Livestock Unit (TLU)

Livestock Category	TLU	Livestock Category	TLU
Ox	1	Horse	1.1
Cow	1	Sheep (adult)	0.13
Woyefen	0.34	Sheep (young)	0.06
Heifer	0.75	Goat (adult)	0.13
Calf	0.25	Goat (young)	0.06
Donkey (adult)	0.7	Hen	0.013
Donkey (young)	0.35		

Appendix 2. Conversion Factor for Adult Equivalent (AE)

Age group	Male	Female
0-1	0.33	0.33
1-2	0.46	0.46
2-3	0.54	0.54
3-5	0.62	0.62
5-7	0.74	0.7
7-10	0.84	0.72
10-12	0.88	0.78
12-14	0.96	0.84
14-16	1.06	0.86
16-18	1.14	0.86
18-30	1.04	0.8
30-60	1	0.82
+60	0.84	0.74

Appendix 3. Conversion of Food Items Consumed by Sample Household

Food type	Kcl/kg	Food type	Kcl/kg
Maize	0.33	Sugar	0.88
Wheat	0.46	Tomato	0.96
Teff	0.54	Cabbage	1.06
Bean	0.62	Onion	1.14
Potato	0.74	Milk	1.04
Tea	0.84	Butter	1
Coffee		Oil	0.84

Appendix 4. Multi-Collinearity Test for Continuous Explanatory Variables

Variable	VIF
Labor / man equiv.	1.16
Age	1.12
Depend ratio	1.12
Distlocalmrkt	1.10
Distirrigation	1.06
Fergextncontact	1.05
Livstokhold	1.05
Mean VIF	1.09

Appendix 5. Major Reason of Households Shard out Cultivate Land in the Study Area

Constraints	Overall	index score	Rank
Labour shortage	103.20	0.117	4
Lack of experience	262.91	0.298	2
Marketing(Fear of loss due to price of vegetable	301.08	0.342	1
Lack of working capital	212.89	0.241	3

Appendix 6. Sensitivity Analysis

No	Outcomes	$e^{\gamma}=1$	$e^{\gamma} = 1.25$	$e^{\gamma} = 1.5$	$=1.75$	$e^{\gamma} = 2$
1	Kcl/ad.eq/day	P<0.000	P<0.000	P<0.000	P<0.000	P<0.000
2	Conexp./ad.eq/year	P<0.000	P<0.000	P<0.000	P<0.000	P<0.000

Appendix Table 7. Household questioner (English Version)



Addis Ababa University

Faculty of Developmental Studies

Department of Food Security and Developmental Studies

The main aim of this questionnaire is to collect data as input for the study entitled “**Impact of small scale irrigation on household’s food security in Bure District Western Gojjam Zone of Amhara Regional State, Ethiopia**”, whose sole purpose is to contribute some effort in conducting research on the subject matter so that policy makers can use the information to improve the service so as to contribute its part in improvement of the livelihood of the society and economic growth of the country. Therefore, extending thanking in advance for your co-operation, each pieces of information collected going to be used.

PART, I. Household Characteristics, Demographic and Socio-Economic

1. Household characteristics

1.1 Household Category 1. Irrigation user 2. Non-irrigation user

1.2 Sex of household head 1.Male 2. Female,

1.3. Age of household head----- years

1.4. Education status of household head 1.literate, 2 . Illiterate

1.5. Family member size?

Family member age	1. Male,	2.Female
0-14		
15-65		
Above 66		

2. Cultivated Land holding

Description	Land size in Hectare
2.1 your own cultivated land	
2.2 Rented cultivated land cropping year	
2.3 Shared in cultivated land	
2.4 Provided to other family member as gift	
Total cultivated land	

2.5 If yes, what is the reason of shard out your own land?

Reason of shred out	Response		Rank
	1,yes	2,no	
1. Is lack of working capital			
2. Is lack of experience			
3. Is fear of losses			
4. Other specify			

2.6 How much total cultivated land do you produce crop for cropping year? -----

1. Produced using irrigation ----- Quintal

2. Produced by rain fed ----- Quintal

2.7 What are major crops you produce in by rain fed?

Crop type	Response		Area in ha	Yield / ha kg	Sales in Kg	Last year market price/100kg	Total crop income
	1. Yes,	0. no					
Maize							
Teff							
Leguminous							
pepper							
others							
Total annual income from rain fed crop production in last year							

2.8 What are major crop produced by irrigation in (Only for irrigated farm)

Crop Type	Response.		Area (ha)	Production per hectare	Sales in Kg	Price per (Qt.)birr	Total income Birr
	1. Yes,	2.no					
Maize							
Onion							
Tomato							
Wheat							
Pepper							
Others							
Total annual income from irrigated crop production in last year							

2.9 using irrigation how many seasons do you produce within a year? -----

2.10 Do you face any problem on irrigation water use? 1. Yes 2 . No

2.11 If yes, what are the major constraints on irrigation water use? Ranking them

Major constraints of irrigation water use	Rank
Water allocation	
Damage of irrigation structure	
water scarcity	
Financial constraint	
Experience in irrigation	
man power	
Crop disease	
conflict over irrigation water use	
Others	

3. Type of livestock holding

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

3.2. If yes, indicate current number of livestock you have?

	Oxen	Cow	Calf	Heifer	Sheep	Goat	Donkey	Horse	Camel	Chicken	others
Currently available											
Sales last year											
Total income											

4. Extension contact

4.1. How many times do you contact with agricultural extension worker? -----

5. Agricultural Input use

8.1. Do you use any agricultural input in the last year? 1. = Yes 2. = No

8.2. If **yes**, what are the source of agricultural input?

No	Source agricultural input used	Amount of Agricultural input in Kg
1	Research	
2	farmer cooperative	
3	Traders.	
4	Others	

6. Distance to nearest local market and marketing

6.1 Did you get nearest market to sale/ buy agricultural output/input? 1. Yes 2. No

6.2 Did you face any problem on marketing vegetable crop in cropping year?

1. Yes. 2. No

6.3 If yes, what are the major reason not get reasonable price

Reason	Response	
	1.yes	2. no
Less demand for the product		
More supply of the product		
Lack of access to potential market		
Price fluctuation due to market broker		
others		

6.4 How far the nearest local market from you home? -----

7. Household consumption expenditures

7.1 How much amount expenditure used for food for Household consumption from crop production in last year?

Type of crop used for consumption	Consumption from own production			Consumption from purchased		
	Quantity In (Qt)	Unity price	Total expend	quantity	Unity price	Total expend
Maize						
Sorghum						
Teff						
Wheat						
Common Bean						
Bean						
others						
Total						

7.2 How much amount of expenditure used for food for the Household Consumption from animal production and their by product in last year?

livestock & their products	Consumption expenditure							
	Consumption from own production				Consumption from purchased			
	unit (No or kg)	Quantity in No	Unity price	Total price	Unit(No or kg)	Quantity (No)	Unity price	Total price
Sheep								
Goat								
Milk								
Butter								
others								
total								

7.3 How much amount of expenditure used for the household consumption for the following non-agricultural products/industrial products in the last year?

Type of Product	Unit	Quantity	Unit cost	Total value
Salt				
Sugar				
Oil				
Soap				
Others (specify)				

7.4 How much amount of expenditures used for the following Non Food items?

Item	Expenses/year
Clothing (dress and foot wear)	
Family Education	
Family Health care	
Animal health expense	
Power(electricity) expense	
Dry cell	
Government tax	
others	
total	

7.5 How much amount of expenditures spent for the following beverage last year?

Item	Expenses/year
Soft drink	
Cigarette	
Tea and coffee	
Others specify	

7.6 What are type food item your family consume in last 7(seven) day? List them accordingly

Did your household consume	food type	unit	Amount from production	Amount from purchased	Total consumption
Cereals?					
	maize	kg			
	sorghum	kg			
	Teff	kg			
	wheat	kg			
	barley	kg			
	millet	kg			
	rice	kg			
Pulses and oil crops?	'Boloqee'	kg			
	beans	kg			
	Chick pea	kg			
Animal product?	Cow milk	liter			
	Camel milk	liter			
	Cattle meat	kg			
	Camel meat	kg			
	Goat milk	kg			
	Sheep milk	kg			
	butter	kg			
	egg	no			
Beverage	Tea	orcap			
	coffee				
	chat	-			
	cigarette	bucket			
	Soft drink	liter			

"matafcha"	sugar	kg			
	Edible oil	liter			
	salt	kg			
Fruits vegetables and root crops	potato	kg			
	Sugar potato	kg			
	onion	kg			
	carrot	kg			
	tomato	kg			
	Others specify				

Appendix 8: Household Questionnaires (Amharic Version)



**አዲስ አበባ ዩኒቨርሲቲ
የሀገር ልማት ጥናት ኮሌጅ**

የምግብ ዋስትና እና የሀገር ልማት ጥናት ዲፓርትመንት

የዚህ ቃለ መጠይቅ ዋና አላማ አነስተኛ የቤተሰብ መስኖ ግብርና በቡሬ ወረዳ ምዕራብ ጎጃም ዞን በምግብ ዋስትና ላይ የሚያመጣውን ለውጥ ለማጥናት ሲሆን ለፖሊሲ አውጭዎች የአገሪቱን የህብረተሰብ ኑሮ እና የአገሪቱን የኢኮኖሚ እድገት እንዲሁም አገልግሎቱን ለማሻሻል እንዲችሉ በዚህ ርዕሰ ጉዳይ ላይ ምርምር ለማድረግ ሲሆን ለቃለ መጠይቁ በቅድሚያ ስለትብብርዎ ምስጋና እናቀርባለን።

ክፍል 1 : የቤተሰብ ዲሞግራፊና ሶሻዮ-ኢኮኖሚ ሁኔታ

1. የቤተሰብ ሁኔታ

- 1.1. ምድብ 1. መስኖ ተጠቃሚ 2. መስኖ የማይጠቀም
- 1.2. የቤተሰብ መሪ ጾታ 1. ወንድ 2. ሴት
- 1.3. የቤተሰብ መሪ እድሜ _____ አመት
- 1.4. የቤተሰቡ አባላት የትምህርት ደረጃ 1. የተማረ 2. ያልተማረ
- 1.5. የቤተሰብ አባላት ብዛት በእድሜ

የቤተሰብ አባል እድሜ	ብዛት	
	ወንድ	ሴት
0-14 አመት		
ከ15-65 አመት		
ከ66 አመት በላይ		
ድምር		

2. ቤተሰቡ የተያዘ የሚታረክ መሬት በሄክታር

መግለጫ	ስፋት በሄክታር
2.1. የቤተሰቡ ይዘታ	
2.2. በኪራይ የተያዘ ይዘታ	
2.3. ከሌላ ቤተሰብ ጋር በጋራ የተያዘ	
2.4. ለሌሎች ቤተሰብ ለጋራ የተሰጠ	
ጠቅላላ ስፋት	

2.5. ከሌላ ቤተሰብ ለጋራ የተሰጠ መሬት ካለ ምክንያቱ ምንድን ነው

ምክንያት	በቅደም ተከተል ከከፍተኛ ወደ ዝቅተኛ
1. የመስሪያ ካፒታል እጥረት	
2. የልምድ ማነስ	
3. የኪሳራ ፍራቻ	
4. ሌላ	

2.6. ያለፈው አመት የምርት መጠን

1. በመስኖው የተመረተ _____ ኩንታል
2. በዝናብ የተመረተ _____ ኩንታል

2.7. ከመስኖ ውጭ (በዝናብ) ባለፈው አመት ያመረቱት የምርት አይነት

የሰብል አይነት	አመርታለው		ስፋት በሄክታር	ምርት በሄክታር በኪ.ግ	ጠቅላ ላ ምርት	የተሸጠ በኪ.ግ	ያለፈው አመት የአንድ ኩንታል ዋጋ	አጠቃላ ይገቢ
	አዎ	አይደለም						
በቆሎ								
ጤፍ								
ጥራጥሬ /አተር ባቄላ ሌሎችም/								
በርበሬ								
ሌላ								
ድምር								

2.8. ባለፈው አመት በመስኖ የሚያመርቷቸው የምርት አይነቶች

የሰብል አይነት	አመርታለው		ስፋት በሄክታር	ምርት በሄክታር በኪ.ግራም	ጠቅላላ ምርት	የተሸጠ በኪ.ግራም	የአንድ ኩንታል ዋጋ	ጠቅላላ ገቢ
	አዎ	አይደለም						
በቆሎ								
ሽንኩርት								
ቲማቲም								
ስንዴ/ገብስ								
በርበሬ								
ሌላ								
ድምር								

2.9. መስኖ በመጠቀም በአመት ምን ያህል ጊዜ ያመርታሉ _____

2.10. መስኖ በሚጠቀሙበት ጊዜ ከውሃ አጠቃቀም ጋር ተያያዥ የሆነ ችግር አጋጥሞት ያውቃል?

1/ አዎ 2/ የለም

2.11. ለጥያቄ 2.10 አዎ ከሆነ ችግሮቹ ምንድን ናቸው በደረጃ ያስቀምጡ

ዋና ዋና ችግሮች	ደረጃ
የውሃ ክፍፍል	
የመስኖ መሰረት ልማት መፍረስ (መጎዳት)	
የውሃ እጥረት	
የገንዘብ እጥረት	
በመስኖ ሙያ ልምድ አለመኖር	
የአዝርት በሽታ	
በውሃ አጠቃቀም አለመግባባት	
ሌሎች	

3. የቀንድና የጋማ ከብቶች ይዘታ

3.1. የቀንድና የጋማ ከብቶች አለዎት? 1. አለ 2. የለም

3.2. ለጥያቄ 3.1. መልስ አለ ከሆነ የጋማና የቀንድ ከብቶች

	በሬ	ላም	ጥጃ	ጊደር	በግ	ፍየል	አህያ	ፈረስ	ዶሮ	ሌላ
አሁን ያለዎት ብዛት										
በአለፈው አመት የተሸጡ										
የተገኘ ገቢ										

4. ከግብርና ኤክስቴንሽን ሰራተኛ ጋር ያለ ግንኙነት

4.1. በአካባቢ ካለ የግብርና ኤክስቴንሽን ሰራተኛ ጋር ምን ያህል ይገናኛሉ -----

5. የግብርና ግባት አጠቃቀም

- 5.1. የግብርና ግባቶችን ይጠቀማሉ 1. እጠቀማለሁ 2. አልጠቀምም
- 5.2. የግብርና ግባቶችን የሚጠቀሙ ከሆነ

ተ.ቁ	የግብርና ግብአቶች ምንጭ	የምርት ግብአት አይነትና መጠን በኪ.ግ
1.	የምርምር ተቋማት	
2.	ከማህበራት	
3.	ከነጋዴዎች	
4.	ሌላ	

6. የቤተሰቡ መኖሪያ ከገበያ ያለው ርቀት

- 6.1. የግብርና ግብአቶችን ለመግዛት ወይም ምርት ለመሸጥ በአካባቢ ገበያ ይገኛል
 - 1. ይገኛል
 - 2. አይገኝም
- 6.2. የአትክልት ምርቶችን ለመሸጥ ችግር አጋጥሞት ያውቃል?
 - 1. አዎ
 - 2. አያውቅም
- 6.3. ለለጠጥየዎቹ 6.2 አዎ ከሆነ ምክንያቶች ምንድን ናቸው?

ምክንያት	ምላሽ	
	አዎ	አይደለም
የምርት ፍላጎት ማነስ		
ብዙ ምርት ስለተመረተ		
ገበያ በአካባቢ ያለመኖር		
የምርት መሸጫ ዋጋ ወጣ ገባ መሆን በደላሎች ምክንያት		
ሌላ ምክንያት		

6.4. የገበያ ርቀት ከመኖሪያ ምን ያህል ይርቃል _____ ኪ.ሜ

7. የቤተሰብ የምግብ ወጪ

7.1. በአለፈው አመት የቤተሰብ የምግብ ወጪዎ ____ ብር ያህል ይሆናል ?

ለምግብነት የተጠቀሙት ምርት	ከተመረተው ምርት			በግዢ የተጠቀሙት		
	መጠን	የአንድ ዋጋ	ጠቅላላ ዋጋ	መጠን	የአንድ ዋጋ	ጠቅላላ ዋጋ
በቆሎ						
ገብስ						
ጤፍ						
ስንዴ						
አተር						
ባቄላ						
ሌሎች						
ድምር						

7.2. የቤተሰብ የምግብ ወጪ ከእንስሳት ተጽእኖ ምን ያህል ይሆናል ?

የእንስሳት አይነት	ከቤተሰብ ምርት የተጠቀሙት			በግዢ የተጠቀሙት		
	መጠን	የአንድ ዋጋ	ጠቅላላ ዋጋ	መጠን	የአንድ ዋጋ	ጠቅላላ ዋጋ
በግ						
ፍየል						
ወተት						
ቅቤ						
ሌላ						
ድምር						

7.3. በአመት ለምግብ ወጪ ከግብርና ምርቶች ውጪ ምን ያህል ይሆናል ?

የምርት አይነት	መለኪያ	ብዛት	የአንዱ ዋጋ	ጠቅላላ ዋጋ
ጨው				
ስኳር				
ዘይት				
ሳሙና				
ሌሎች				

7.4. ምግብ ነክ ያልሆኑ የፍጆታ ወጪዎች በአመት ምን ያህል ይሆናል ?

አይነት	የአመት ወጪ
ልብስና ጫማ	
የትምህርት	
ለእንስሳት ጤና	
ለቤተሰብ የጤና	
ለሀይል (ኤሌክትሪክ)	
ለባትሪ ድንጋይ	
ግብር ለመንግስት	
ሌላ	
ድምር	

7.5. በአመት አልኮል ነክ ላልሆኑ መጠጦች ምን ያህል ይሆናል ?

አይነት	ወጪ
ለስላሳ መጠጦች	
ለሲጋራ	
ሻይ ቡና	
ሌላ	
ድምር	

7.6. ባለፉት ሰባት ቀናት ውስጥ ቤተሰቡ የተጠቀመው የምግብ አይነት

የቤተሰቡ ምግብ መጠሪያ	የምግብ አይነት	መለኪያ	መጠን	ከቤተሰቡ ምርት	ከግዥ	ጠቅላላ ድምር
እህል	በቆሎ					
	ማሽለ					
	ጤፍ					
	ስንዴ					
	ገብስ					
	ነጭ ማሽለ					
	ሩዝ					
ቅባትና የቅባት እህሎች እና ጥራጥሬዎች	ቦሎቄ					
	ባቄላ					
	ሽንብራ					
	አተር					
	ጓያ					
	ሌሎች					
የእንስሳት ተዋጽኦ	የላም ወተት					
	የግመል ወተት					
	የከብት ሥጋ					
	የግመል ሥጋ					
	የፍየል ሥጋ					
	የበግ ሥጋ					
	ቅቤ					
	እንቁላል					
ከአልካል ነጻ የሆኑ መጠጦች	ሻይና ቡና					
	ጫት					
	ሲጋራ					
	ለሥላሳ መጠጦች					
	ሌሎች					
ማጣፈጫ	ስኳር					
	ዘይት					

	ጨው					
	ሌሎች					
ፍራፍሬና አትክልት	ድንች					
	ስኳር ድንች					
	ሸንኩርት					
	ካሮት					
	ቲማቲም					
	ማንጎ					
	ሙዝ					
	ብርቱካን					
	ሌሎች					

Appendix 9: Checklist for Focus Group Discussion

1. Do you face any problem or continent of related to irrigation water use in your area? 1. Yes 0. No

2. If yes, what are the major problems or continents of irrigation water use in you of the area?

What are the main causes of continents of irrigation water use?

- A. Water scarcity
- B. Damage of irrigation structure
- C. Financial problem
- D. Lack of experience of water management
- E. Other specify

3. In your opinion, how this problem solved in the future? Explain -----

4. Is there any irrigation water use association in your area? 1. Yes 0. No is their functional? 1. Yes 0. No 4.1. If yes, how it work on irrigation water use, distribution, management and so on? Explain -----

4.1.1. If no, how they affect irrigation water use of the area? Explain -----

4.2. Is their rule and regulation of irrigation of use in your area? 1. Yes 0. No

4.2.1. If yes, how it work on irrigation water use, distribution, management and so on? Explain -----

4.2.2. If no, how they affect irrigation water use of the area? Explain -----

5. What are the major crops produced in the area? What problem you face regarding to crop produced in the area?

Explain-----

5.1. In your opinion, what are the causes of the problem regarding to crop produce in the area? Explain -----

5.2. How problem related to crop produce affect the benefit of irrigation? Explain -----

6. What possible solution or recommend you suggest to solve problem problems or continents of irrigation water use, irrigation water use association, rule and regulation of irrigation water use and problem regarding to crop produced in the area? Explain -----

Appendix 10. Respondent Consent Form (English Version)

Respondent Consent Form

I decided to be a participant in this study by clearly understand the purpose of the study, procedures and conditions and confirming my right to withdraw my consent from the study at any stage.

I confirm with my signature that, I participant in the study. When I make this decision, I fully understand the risks that may occur due to the study and I believe that all of this information has been explained to me in a language that I understand well.

Respondent name ----- signature -----

Researcher name ----- signature -----

Witness name ----- signature -----

If you have any questions regarding this study or any emergency related to it, please use the following address.

Telephone - +251989818958

E-mail - biraraesubalew@gmail.com

Appendix 11. Respondent Consent form

ስለ ስምምነቱ ማረጋገጫ ፊርማ

እኔ ስሜ ከታች የተገለጸው የጥናቱ ተሳታፊ ለመሆን ስወስን የጥናቱን አላማዎች አሰራሮችና ቅድመ ሁኔታዎች በግልጽ በመረዳትና ከጥናቱ ተሳታፊነት ፈቃደኛነቴን በማንኛውም ደረጃ የማንሳት መብቴን በማረጋገጥ ነዉ።
እኔ ----- በጥናቱ ተሳታፊ መሆኔን በፊርማዬ እያረጋገጥሁ ይህንን ስወስን በጥናቱ ሳቢያ ሊከሰቱ የሚችሉ አደጋዎችን በሚገባ የተረዳሁና ከጥናቱ በማንኛውም ደረጃ በማመን ነዉ እነዚህ መረጃዎች ሁሉ በሚገባ በምረዳዉ ቋንቋ የተገለጸልኝ መሆኔን በፊርማዬ አረጋግጣለሁ ።

የተሳታፊው ሙሉ ስም-----ፊርማ-----

የተመራማሪው ሙሉ ስም -----ፊርማ-----

የምስክር ሙሉ ስም -----ፊርማ-----

ይህን ጥናት በተመለከተ ጥያቄ ቢኖርዎት ወይም ከዚህ ጋራ በተዛመደ መልኩ ስለሚያጋጥመዎት ድንገተኛ ችግር በሚከተለዉ አድራሻ ይጠቀሙ።

ሞባይል+251989818958