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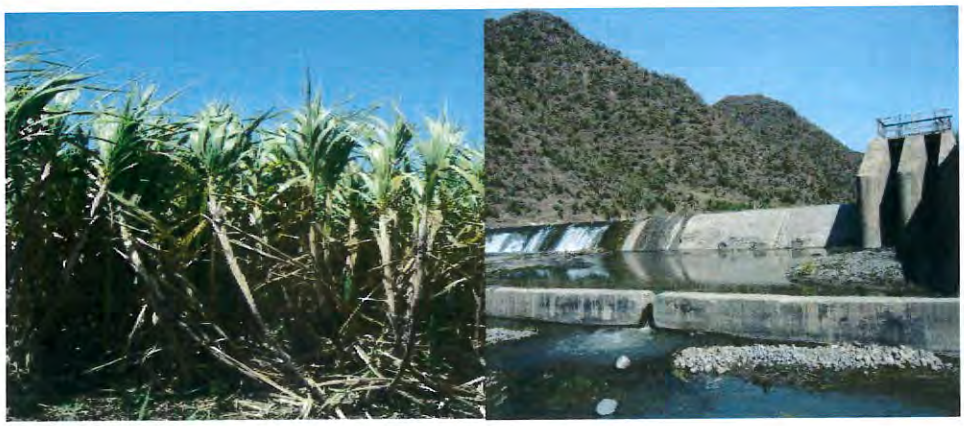

LINKING SMALL-SCALE IRRIGATION AND HOUSEHOLD FOOD SECURITY IN DROUGHT PRONE AREA OF NORTH EAST ETHIOPIA: A CASE STUDY OF ALAWUHA IRRIGATION SCHEME IN GUBALAFTO WOREDA, NORTH WOLLO ZONE.

BY

GETINET KEBEDE AYALEW

JUNE, 2011

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A Thesis submitted to the School of Graduates Studies of Addis Ababa University In Partial Fulfillment of the Requirements for the Degree of Master of Science in Food Security Studies.

MSc THESIS

BY

GETINET KEBEDE AYALEW

ADVISOR: - DEREJE HAILU (PhD)

ADDIS ABABA, ETHIOPIA

JUNE 2011

ADDIS ABABA UNIVERSITY
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Title

Linkage Small-Scale Irrigation and Household Food Security in Drought Prone Area of North East Ethiopia: A Case Study of Alawuha Irrigation Scheme in Gubalafto Woreda, North Wollo Zone.

By
Getinet Kebede

Food Security

APPROVED BY THE BOARD OF EXAMINERS: SIGNATURE

Dr. Ali Hassen _____
CENTER HEAD

Dr. Dereje Hailu _____
ADVISOR

Dr. Mulugeta Feseha _____
INTERNAL EXAMINER

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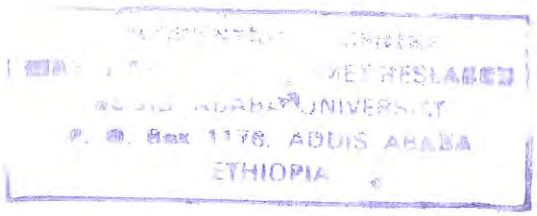
DEDICATION

I dedicate this thesis to my lovely family.



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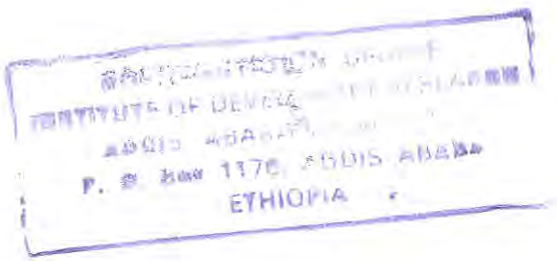

LIST OF ABBREVATIONS

ADLI	Agricultural Development Led Industrialization
AAU	Addis Ababa University
ACSI	Amhara Credit and Saving Institution
AER	Adult Equivalent Ratio
ANRS	Amhara National Regional National State
CAADP	Comprehensive Africa Agriculture Development Program
CSA	Central Statistical Authority
DAs	Development Agents
EDRI	Ethiopian Development Research Institute
EHNRI	Ethiopian Health and Nutrition Research Institute
FAO	Food and Agriculture Organization
FEZs	Food Economy Zones
FGDs	Focus Group discussions
FSP	Food Security Programme
FTCs	Farmers Training Centers
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
IFPRI	International Food Policy and Research Institute
HFBM	Household Food Balance Model
HHs	Households
KAs	Kebele Administrations
LPM	Linear Probability Model
MDR	Minimum Daily Requirement
MoFED	Ministry of Finance, Economic and Development
MoWRD	Ministry of Water Resource Development
MoARD	Ministry of Agriculture and Rural Development
MoARDFSCD	Ministry of Agricultural and Rural Development Food Security Coordination Directorate
NCFSE	New Coalition on Food Security in Ethiopia

NGO	Non- Governmental Organizations
PAs	Peasant Associations
PASDEP	Plan for Accelerated and Sustained Development to Eradicate Poverty
PSNP	Productive Safety Net Programme
SEARAR	Sustainable Environmental & Agricultural Rehabilitation for Amhara Region
SNNPR	South Nation, Nationalities and Peoples Region States
SSA	Sub-Saharan Africa
SPSS	Statistical Package for Social Scientist
SSI	Small-Scale Irrigation
UNDP	United Nation Development Program
WAO	Woreda Agriculture Office
WFP	World Food Programme
WUAs	Water Use Associations

LIST OF UNITS

g	gram
ha	hectare
Kcal	Kilo calorie
Kg	Kilo gram
Km	Kilometer
masl	meter above sea level
mm	millimeter
MT	Metric tone
Q/q	quintal
TLU	Tropical Livestock Unit

ABSTRACT

In north eastern part of Ethiopia, drought induced food insecurity has been a long-lasting problem. In this thesis, an attempt made to identify household food security status and its determinants in one of drought prone area- Gubalafto Woreda. Moreover, the linkages between Small Scale Irrigation and household food security in provision of food energy assessed. A multi- stage stratified sampling procedure was used to select 115 sample households from both irrigation users and non-users living within the targeted kebeles. A combination of quantitative analysis like descriptive statistics, Household Food Balance Model, binary logit model and qualitative study were used to reach at reliable results by using data gathered from both primary and secondary sources. The survey result revealed that 29 % of sample households were food insecure and 71 % food secure. There is huge gap in food calorie availability ranging from 788- 8405Kca in the study area. Food insecure households were found to have an average of 24% food gap in terms of dietary energy, which is needed to fulfill the national minimum requirements. The average per capita calorie supply for irrigation users was found substantially increased by 889 Kcal, which is about 42 % percent of the minimum requirement of food calorie requires by an individual. The use of SSI was found significantly related to household food security situation in provision of household dietary energy and taking a lion share in the proportion of study areas major consumable from food crops production. The logit model revealed that household size, educational status of household head, number of farm oxen, cultivated land size, engagement in non-farming, access to irrigation and credit service were found significant determinants. Correspondingly, the study disclosed that the long distance between irrigated land to farmers residence, lack of cleaning and maintenance of scheme, free grazing , poor irrigation methods and crop selection were the major constraints in the irrigation farm. SSI is one of the viable solutions to household food supplement and hence promoting of smallholders to produce directly consumable food grains is advantageous. It is important to address those food security determinants and farmers' views in planning and executing of development policies and programs by all stakeholders to tackle the problem of household food insecurity in the study area.

1. INTRODUCTION

1.1. Background of the study

Ethiopia is one of the poorest countries in the world, ranked at 171st out of 182 countries on the UNDP Human Development Index results made in 2009 (Demese et al., 2009). According to (WFP, 2010), over 7.5 million chronically food insecure households living in 300 Woredas has been targeted in Productive Safety Net program (PSNP) to get a food support for the coming five years at national level. Likewise, about 2,519,829 households in Amhara National Regional State (ANRS) have been planned to supply to 88738.065 MT food commodities under the ongoing program (MoARD, 2010). This food insecurity situation is because of natural and manmade factors mainly drought, land degradation, population pressure and lack of infrastructure facilities (FAO/WF, 2010).

According to (Demese, Getinet, Goshu, & Yaddesa, 2009) the current yield levels by rural smallholders is not able to produce to fulfill their minimum food requirements since one-third of the rural household owns less than 0.5 ha of farming land that are dependent on rainfed agriculture system. Similarly, a research made by Selesh (2005) confirmed that the food production status of the country has to be doubled till 2025 as compared with the current level of production so as to meet the food demands of the growing population of Ethiopia concurrently. Otherwise, continuing with the production momentum, supplying the required amount of food for the population will be a challenge at large.

Hence, resolution of both the short and long term food shortage situation of the country brings to apply modern agricultural mechanisms so as to boost production and improve the overall economic, social and institutional contexts of the country (Mekuria, 2003).To this end, the large food deficit situation of the country both at national and household level cannot be resolved on rainfed agriculture alone (Desta, 2004). Due to this fact, the Ethiopian government has been involved in irrigation development works to improve the situation of agricultural production level mainly focusing in drought-prone affected areas of the country since the mid of 1980s (Woledeab, 2003).

A priority is given for irrigation by the current government to promote multiple cropping of food and cash farming systems in order to cope up with the problem of climate variability and ensure food security at household and national level (MoFED, 2010). As stated in the Growth and Transformation Plan (GTP) document the lessons learnt from the past two ten years national development programs has given a direction to be considered in areas mainly encountered with delaying in entrance of rainy seasons, early withdrawal and mal-distribution problems. Clearly, the principles and strategies declared in this document is an extension of MoWRD (2002) which is planned to utilize the available water resources in expansion of small, medium and large scale irrigation schemes focusing on promotion of market oriented farming system by small holders.

In relation with farming system by farmers, some scholars argued that Ethiopia has to learn the experiences of Ghana and other Asia countries on utilization of irrigated lands in production of consumable bundle of food crops rather than encouraging them to cultivate vegetable and/or industrial crops, which have an indirect and limited effect on household food security situation (Tsegaye & Tamene, 2005). Taking in to account the two dichotomies, an empirical research at grass root level is needed for verifying either encouraging of cash or food crop production to contribute in ensuring household food security. So far, studies on analyzing contribution of irrigation on food security improvement have been focused on large-scale irrigation schemes which were established and managed by the state (Selesh et al., 2005). Moreover, the studies were carried out too quickly to fulfill government and donor requirements only as reported by the same authors.

To this effect, studies done on assessing the contribution of Small-Scale Irrigation (SSI) by measuring food availability at household level is limited though the national coverage reaches over 40 % of the irrigated land in such scheme within the country (Dessalegne, 1999). Furthermore, Selesh (2005) recommends as to the need to undertake assessment in use of SSI considering its status in supplying crop production for rural households'. Thus, this study intends to explore the link of small scale irrigation and household food security improvement in one of drought prone area of North East Ethiopia Gubalafto Woreda.

1.2. Statement of the problem

North eastern part of the ANRS has been marked with the worst famine event history of the nation, which is mainly attributed by erratic rainfall occurrences. Actually, the study area, North Wello, is known in its food insecurity situation due to the incidence of recurrent drought problem for the past so many decades. According to (Ramakrishna & Assefa, 2002), even in normal production season, it is realized that the situation of food production cannot be exceed more than 59% of consumption needs fulfillment in the study area. The same study asserts that there is evidence shown as a food demand is increasing by 1.78% but the food availability situation is decreasing by 4.41% per year. As a result, large number of people has become a food aid dependent to fulfill their immediate food demands.

The study Woreda, Gubalafto, particularly share the food deficit situation due to the erratic, unpredictable and low amount of rainfall situation. To this end, as the PSNP implementation plan document of (MoARD, 2009) describes a total of 51,775 people (37% of the Woreda population) targeted to supply 3261.825 MT of food transfers in the year's period 2010-2014. As the study made by Rockstorm (2002) revealed the dry spells period, which occurs frequently, causes 70% of yield reduction and sometimes a total of crop failure in arid and semi-arid rain fed agriculture. In effect, the problem of recurrent drought coupled with the existing small land size holding will be an illusion for ensuring of food security (Hussian & Bhattarai, 2003).

Cognizant to this fact, a lot of effort has been made by government, development partners and communities to improve the food security situation of smallholders through creating access to irrigated agriculture. Among those, Alawuha Small-Scale Irrigation (SSI) is one of the constructed schemes by the regional government state of Amhara in collaboration with Sustainable Environmental and Agricultural Rehabilitation for Amhara Region (SEARAR) in 1998, which is found in the eastern low land part of Gubalafto targeted to serve the two accessible kebeles named as Lay-Alawuha and Lasetegerado.

But, according to the assessment made by the regional concerned bodies who verified that most of the constructed irrigation schemes is found at zero level of practices and the overall land coverage is below 50% of its planned capacity although expansion efforts is ongoing by regional government until now (Muluken, 2005). Similarly, an assessment made on 13 constructed irrigation schemes around the study area confirms that only 970 ha of land is irrigated out of the expected 3400 ha, which is ⅓ of their capacities. Likewise, a preliminary assessment made by the researcher in September 2010 and his past working experience observed that the irrigation water utilization condition has not shown progress, which has an effect on agricultural production and subsequently the food security situation of the area.

Due to this fact, it is important to assess the extent of food availability by using Alawuha SSI from the point of contributing to ensure household food security and challenges faced by the community in utilizing the constructed scheme at grass root level. Therefore, this study examines the link between use of small scale irrigation and household food security status in drought prone area of North East Ethiopia. It helps to explore important actions and knowledge will be used in planning and targeting of development programs, research and extension and policy issues in particular for the study area and the country in general.

1.3. Objectives of the Study

The main objective of the study is to analyze the linkage between use of small-scale irrigation and household food security. The research focuses on the following four specific objectives:-

1. To measure household food security status of farm households in the study area.
2. To identify factors influencing food security status at household level in the study area.
3. To assess contribution of use of small scale irrigation to household food security status.
4. To identify farmers view's and challenges in small scale irrigation water use system.

1.4. Research Questions

The study addresses the following research questions:-

1. What is the current status of household food security in the study area?
2. What are the major demographic, socioeconomic and institutional factors that influence household food security status in the study area?
3. To what extent does the small scale irrigation contributes to the attainment of household food security through supplying of directly consumable food grains?
4. How do farmers perceive their ways of irrigation water utilization and the challenges encountered in management of the small scale irrigation scheme?

1.5. Significance of the study

In Ethiopia, numerous public and civil society funded food security and irrigation programs have been implemented at national and local levels to ameliorate food insecurity and hunger. Hence, assessing the household food security situation can help to identify and understand this basic aspect of well-being of the population and to inform groups or areas with severe conditions so as to take solution by concerned bodies. Particularly, this study can help public officials, policy makers, service providers, and the local community at large to assess the changing needs for assistance and the effectiveness of existing programs in the study area. Moreover, at grass root level, determining the food security status of the households comprising the community can provide an indispensable tool for assessment and planning. The result can be also used as an input for researchers involved in similar thematic area to further knowledge generation in concepts related to irrigation development and food security in drought prone areas of Ethiopia.

1.6. Scope and limitation of the Study

Government policies increasingly recognize the importance of small scale irrigation to commercialization of agriculture and expansion of agriculture productivity. Linking of subsistence farmers to the global market is usually addressed in two ways: through improved marketing extension and by improving physical infrastructure. This paper

focuses primarily on assessing the contribution of use of small scale irrigation in increasing grain production and ensuring food security at household level. Hence, the study focuses on identifying factors influencing household food security and challenges to small scale irrigation to intensify crop production. This study is done in one modern small scale irrigation scheme serving two drought affected kebeles in North Eastern part of the Amhara Region. Due to budget and time constraints the study has limitation of only using current year crop production information rather than time series data of the area.

1.7 Organization of the study

This research is structured into six chapters. Chapter One introduces the background and objectives of the study. In chapter 2, a literature review concerning concepts and issues on small scale irrigation and food security, its impacts on global, national and household food security is discussed. Chapter 3 describes the methods of data collection and analysis of the study. The description of the study is highlighted in chapter 4. Chapter 5 presents the findings on the socio-cultural and demographic situation, the current food security status of the study area, the irrigation water management and its economic contribution to food security and farmers perception in their crop management practices. Finally, the conclusions and policy implications are given in chapter 6.

2. REVIEW OF LITERATURE

This part attempts to present related literature reviewed in relation with SSI mall-scale and household food security concepts and definitions, and measuring of it. Subsequently, it tries to discourse the major theoretical perspectives on food security and small-scale irrigation giving particular emphasis on linkages and contribution of small-scale irrigation to household food security. Synthesis of few relevant and related empirical studies undertaken on irrigation and food security is also highlighted in this chapter. Finally, the conceptual framework for this study, which is drawn from the theoretical perspectives, is explained at the last section of this chapter.

2.1. Definitions and Concepts of Food Security and Small Scale Irrigation

This section mainly aims at reviewing major definitions and concepts of food security and small-scale irrigation in general and then state the adopted working definition of food security and small-scale irrigation at household level for this study.

2.1.1 Definitions and Concepts of Food Security

It is more than half a century the concept of food security has become a global issue, and evolved through a sequence of definitions and paradigms. After the first conference of FAO held in 1943, the concept of food security passes over many accepted definitions and evolutionary phases were promoted by concerned international concerned bodies (George et al, 2009). These food security centered concern has evolved five main chronological approaches are: (1) the food surplus disposal in between 1940-50 (2) the means to promote food for development in 1960' (3) the idea of food assurance in 1970' (4) broaden food security issues in 1980' and (5) the shift to freedom from hunger and malnutrition since 1990' has been acknowledged by international and bilateral donor organizations to help in improving the food insecurity situation existing in poor countries including our nation.

Hence, for the purpose of this study, it is adopted that of the most common and accepted definition given by World Food Summit held in 1996 as a working definition: Food Security' is achieved when it is ensured as "all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food which meets their dietary needs and food preferences for an active and healthy life." (WB, 1996)

According to Annie(2009) food security is generally assessed in terms of four component concepts: namely Food Availability, Food Access, Food Utilization and Food Stability (*versus* Vulnerability) which are explained very briefly in the succeeding paragraphs.

Food Availability means that food is physically present because it has been grown, processed, manufactured, and/or imported. For example, food is available because it can be found in markets and shops; it has been produced on local farms or in home gardens; or it has arrived as part of food aid. This refers to all available food in the area, and includes fresh, as well as packaged, food.

Many factors can affect availability of food directly or indirectly. For instance, food availability can be affected by disruptions to the food transport and production systems, due to blocked roads, failed crops or a switch from food crops to cash crops, changes in import and export tariffs, amongst other factors. Such occurrences can influence the amount of food coming into an area. In addition, food availability is dependent upon seasonal patterns in food production and trading.

Food Access: refers to the way in which different people obtain available food. Normally, the way of accessing food is through a combination of means. This may include: home production, use of left-over stocks, purchase, barter, borrowing, sharing, gifts from relatives, and provisions by welfare systems or food aid. Food access is ensured when everyone within a community has adequate financial or other resources to obtain the food necessary for a nutritious diet.

Similar to availability, access also depends on various factors like household's available income and its distribution within the household, as well as on the price of food. It also depends on markets. Food access can be negatively influenced by unemployment, physical insecurity (e.g. during conflicts), loss of coping options (e.g. border closures preventing seasonal job migration), or the collapse of safety-net institutions which once protected people on low incomes.

Food Utilization: is the way in which people use food. It is dependent upon a number of interrelated factors: the quality of the food and its method of preparation, storage facilities, and the nutritional knowledge and health status of the individual consuming the food. For example, some diseases do not allow for optimal absorption of nutrients, whereas growth requires increased intake of certain nutrients.

Food utilization is often reduced by factors such as endemic disease, poor sanitation, lack of appropriate nutritional knowledge, or culturally-prescribed taboos (often related to age or gender) that affect a certain group's or family member's access to nutritious food. Food utilization may also be adversely affected if people have limited resources for preparing food, for example due to a lack of fuel or cooking utensils.

Food Stability: To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks (e.g. an economic or climatic crisis) or cyclical events (e.g. seasonal food insecurity). The concept of stability can therefore refer to both the availability and access dimensions of food security.

2.1.2 Household Food Security

Studies on assessment of food security can take different level of unit of analysis, at national, regional, community, household and individual levels. Since collecting precise information for each individual might be impossible or too costly, especially in poor country like Ethiopia, there is an option which is widely practiced in food security research. This is a study starts at household level analysis by applying a weight (Adult

equivalent scale or ratio) to adjust to its composition and drives weighted per capita estimate (Jacobs, 2009). Hence, it is worthwhile to look at the concept of household food security since this study's center of attention is at household level.

The concept of household food security is a more recent development and the bulk of literature dated from 1980s equating national food security with food self-sufficiency is a problem that needs to be clearly understood. Many countries those used to be considered as self sufficient in food were found to be food insecure due to the fact that they either lack an efficient food system or the capacity to the level of food entitlement. This indicates that attaining macro-level food self sufficiency does not ensure the achievement of household food security (Getahun, 2003)

Therefore, food security strategy has to address household-level food production and investment in food production and storage. These, however, are essential but not sufficient vehicles for solving household-level malnutrition and household food insecurity problems (Rukuni, 2002). Debebe (1995) as cited in Ayalew (2003) indicates that household food security mainly conditioned by factors, which are related to the process of acquisition, household procurement strategies and socio economic condition of the society. With regard to this, the key elements that are critical to household food security are availability and access. The former is further influenced by the different source of food and handling patterns which facilitate the time dimension of food availability in the household.

Besides, household is identified as food secured if entitlements of demand for food security is greater than food needs, which is defined as the aggregation of individual requirements. At individual level, the definition is much more straightforward. An individual is food secure if his or her food consumption is determined by claim the individual has on household food source.

Entitlements is Sen (1981) defined as a set of alternative commodity bundles that a person can commend in a society using rights and opportunities that he or she faces. This

means, what can a person produce, buy or borrow, given what they own and what socially and state regulations allow them to do with that. He identified four main categories of entitlement, namely, trade based entitlement, which describes what an individual can buy with the commodities and cash they own; production based entitlement, which describes the right to own what one produces with one own resource; inheritance or transfer entitlement which refers to the right to own what is willingly given by others as remittance, bequest, as well as transfer from state such as social security, pensions and food distribution. All these entitlements give an individual control over resource which they can use.

2.1.3 Measuring Household Food Security

There is no single indicator to measure food security. Many different indicators are needed to capture the various dimensions at country, household and individual levels (Hoddinnot, 1999). Since food security is influenced by different interrelated socio economic, physical, institutional and political factors, it requires understanding of multidimensional contexts of the target area. Hence, combining both qualitative and quantitative household data sources in studying of food security activities allows knowing holistic nature of the study area comprehensively as argued by (Degefa T. , 2006) since some indicators only appropriate for assessing the process while others monitoring of the outcomes of certain project goals. It is up to the researcher to select a combination of indicators that suit the objectives of the investigation, the level of aggregation and specific circumstance of the study and study area ((Carletto & Morris, 1999).

Generally, the most common indicators to household food security are food availability, food consumption or access and composite food security. Measuring food security in terms of food availability focuses on national or household agro food output or supply (Jacobs, 2009). In the table below it was illustrated these three common indicators.

Indicator/Measure	Focus	Examples
Food availability	National/household agro-food output	Food balance sheets/models
Food composition/access	Food demand or consumption at household level	Household expenditures models, food expenditures ratio, income elasticity
Composite food security	Simultaneously captures each dimensions in a single indicator	Poverty Hunger Index, Food security Gap Index

Sources: Jacobs, 2009.

The Food Balance Sheet is a widely used tool for analyzing the overall food supply situation and estimating import requirements of a country or region. The original Food Balance Sheet was introduced by FAO under its Global Information and Early Warning System for Food and Agriculture based in Zimbabwe in 1994 ((SADC, 2009).

The Household Food Balance Model (HFBM) is developed by Degefa in 1996, which is adopted from FAO, to simplify the method of gathering data in food security research nationally as explained by (Messay, The Food Security attainment role of urban agriculture: A case of Adama town,Central Ethiopia, 2009). The same author conveyed that the food balance sheet tool has been used by many scientific studies to measure the contribution of development projects mainly in agriculture sector. Hence, this research is used HFBM analytical tool to assess the household food security status of the proposed area of study.

2.1.4 Concept and Definition of Small Scale Irrigation

According to FAO (1994) irrigation is defined as the artificial application of water to the crop for the purpose of food and fiber production overcoming deficiencies in rainfall and help in creating stabilized agriculture. Irrigation development could also be defined as a case of agricultural development in which technology intervenes to provide control for the soil moisture regimes in the crop root zone in order to achieve a high standard of continuous cropping (EVDSA, 1996). A working definition of irrigation for this paper is

therefore as defined by Uphoff (1986) "Irrigation is the practice of applying water to soil to supplement the natural rainfall and provide moisture for plant growth."

Before embarking on defining small-scale irrigation, it is useful to come across at different criteria used to categorize and classify different types of irrigation. Around the world, scholars use different standards for classification of irrigation schemes. Regarding the ways of supplying water, flood irrigation, furrow irrigation, sprinkling or spray irrigation and drip irrigation are identified (Nigussie, 2002). Irrigation may also be categorized using other criteria such as ownership, economic objective and modernity. Turner (1994) also points out that irrigation systems can be classified according to size, source of water, management style, degree of water control, source of innovation and type of technology. Most authors, however, agree that concepts of local management and simple technology should be combined with size.

According to Fuad (2002), irrigation schemes in Ethiopia can be grouped into three: large-scale schemes, which irrigate 3000 hectares of land normally constructed and managed by the state; medium-scale schemes possibly irrigating an area of 200-3000 hectares of land and mostly managed by state farms and enterprise. The third category is small-scale schemes irrigating up to 200 hectares of land mainly owned and managed by organized community or water-use associations.

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

Small-Scale Irrigation is, therefore, farmer managed: farmers must be involved in the design process and, in particular, with decisions about boundaries, the layout of the

canals, and the position of outlets and bridges Yusuf (2004) as cited by Tafesse 2007). In similar fashion, W. Bart (1996) defined SSI as: Farmer-managed irrigation schemes of a few hundred square meters to a several thousand hectares, developed, operated and maintained by individuals, families, communities, or local rulers and landowners, independently of government, and generally for the production of basic food or fiber crops and vegetables for local markets. Indeed, small-scale schemes are defined as schemes that are controlled and managed by the users themselves.

2.2 Theoretical Perspectives in Irrigation use and Household Food Security

As Africa lags behind other regions in adoption of technologies, particularly, irrigation, fertilizer and improved seed verities, as a result the numbers of food insecure people will be rise by 2020, and those of malnourished children will increase correspondingly (Rukuni, 2002). As one of the reasons access and efficient utilization of land is indicated. Not only that land has not been used as source of resource in much of Africa but also land enhancement has not been a priority for African farmers (Maxwell, 2001). At country level, irrigation with higher yields can allow countries to grow more of their own food and be less dependent upon imports especially in view of the common occurrence of droughts in the region.

Development of agricultural water resources brings significant changes at various levels, from farm to national levels. These are changes in production patterns, land and property values, expansion in the use of improved agricultural inputs (such as high yielding variety seeds, fertilizers, pesticides, etc.) and expansion in overall economic activities through backward and forward linkages. The impacts of these changes vary greatly from one level to another. Some of the impacts are confined to only farm level, while others spread to the whole project command and others spread to wider region and province/state or national level (Hussain & Bhattarai, 2003). Where conditions are favorable use of irrigation can raise the incomes of smallholder farm households by reducing production risk and farm output diversification, thereby encouraging farmers to gain the benefits of greater specialization and commercialization at the same time enabling farmers to adapt production concerned on market demand and higher prices (Hasnip et al., 2001).

In areas where communities and households depend to a great extent on agriculture for their livelihoods, access to irrigation is a necessary, but not a sufficient condition for poverty alleviation. For instance, access to other production inputs and services by the poor and marginal farmers is also important to enhance benefits of irrigation for poverty alleviation (Hussian, 2004). In line with this, Birhanu (2003) also indicated the need for policy and institutional interventions to boost the impacts of irrigation so as to enhance its contribution to sustainable livelihoods of rural people. According to these writers, this could be achieved through household asset building by strengthening market access, by promoting high-value crops, and improving farming systems by providing extension and technical support to smallholder irrigation.

Therefore, the challenge that Ethiopia faces in terms of food insecurity is associated with both inadequate food production even during good rain years and natural failures due to erratic rainfall. Therefore, one means by which agricultural production can be increased to meet the growing food demands is through increasing agricultural yield and increasing cropping intensity. Increasing yields in both rain-fed and irrigated agriculture and cropping intensity in irrigated areas through various methods and technologies are the most viable options for achieving food security in Ethiopia (Mekuria, 2003).

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

Population increase, deforestation and frequent land distribution has affected agricultural production in Ethiopia. This is reflected in a decrease in household production, a decrease in grazing land and scarcity of manure. That is why in most occasions; food insecurity quickly turns into famine when there are some climatic irregularities (Seleshi et al, 2005). Thus, it has become a common phenomenon to appeal for emergency food assistance for acutely food insecure people in Ethiopia.

According to FAO/WFP, (2010), a total of 5.23 million people would need emergency food assistance from January to June 2010. In addition, starting from 2006, the Productive Safety Net Programme (PSNP) reach to support over 7.23 million people in 300 Woredas for seven regions (Tigray, Amhara, Oromiya, SNNPR, Afar, Harar and

Dire Dawa) who are facing chronic food insecurity situation as the same report disclosed by FAO/WFP explained. This is due to the circumstances of people who do not have the capacity to produce or buy enough to meet their annual food needs even under normal weather and market conditions.

To reduce the risk of crop failure due to drought and erratic rain fall conditions in Ethiopia, the MoWR prepared a National Medium-Term Investment Program (NMTIP) for Water Sector Development Program (WSDP) for 15 years (2002-2016) through expansion of SSI schemes as a main development strategy to support the existing subsistence production system. According to a research result made by Awulachew (2007), there are 310 irrigation schemes developed in Amhara region so far. These irrigation schemes covered an irrigated area of 8,469.26 hectares with 17,443 people beneficiaries. Out of these total irrigated areas, 5,718.68 hectares is from small-scale and 2,750.58 are from medium-scale irrigation schemes. The same report disclosed that the total irrigated area in Ethiopia is reached about 250,000 ha, which is estimated at 5 – 6 % of the developable potential of 3.7 million ha found within the country.

Appropriate technologies have been introduced depending on the socio-economic conditions of chronically food-insecure households and different menus of technological packages have been prepared and disseminated to these households through the extension services. The packages include provision of improved inputs to increase livestock and crop production and productivity, moisture conservation and utilization, credit, training, support for additional income-generating activities, and provision of market information. The core objective of the food security program is to increase food availability and access at household level through increased crop production and productivity, increased livestock production and productivity and increased access to other non-farm income through agricultural and non- agricultural activities (MoFED, 2010).

Therefore, achieving improved food security at country level can be met through efficient food production and distribution system throughout the country. To overcome national food insecurity, the economic policy of a country has to give due emphasis to tackling

household food insecurity at grass root level through increased production as much as possible. The emphasis on agricultural production is, however, one aspect of approaching food insecurity at household level; it is an urgent action to be taken to ensure the right to food for Ethiopian citizen. Hence, agricultural development policies should encourage farmers to adopt packages of new agricultural technologies with focusing in using of SSI majorly for food crop production system to maximize household food security (Tsegaye & Tamene, 2005).

2.4 Empirical Studies in Irrigation and Food Security

2.4.1 Determinants of Household Food Security

Different scientific studies were conducted to identify determinants of food security in developing countries including Ethiopia. In this section, some of the empirical evidence was mentioned. For example, in Ghana, the calorie gap (the difference between the recommended and reported calorie intake) at household level is influenced by a set of demographic and household characteristics (Keyreme and Thorbecke, 1991; cited in (Tegegne et al, 1999). In particular, the study showed that, *ceterius paribus*, the calorie gap declines with age of household head, educational level of household head, income and the value assets owned by the family. Lower calorie gaps also associated with male-headed households and maturity index, a variable that measures a contribution of older children relative to adults. On the other hand, calorie gap widened with dependency ratio.

The static, non-separable agricultural household model was employed to examine the effect of changing in key exogenous factors on food security and consumption pattern of rural households covered five districts in rural Sindh based on household level data collected from the cross section survey from August 2004 to September 2006. The evidence suggested that household full income, food prices, and women specific variables such as age and time allocation were found significant variables to influence household food security (Faiz, 2006).

Shiferaw et al (2004) in their analysis of household food security determinants in Southern Ethiopia, they concluded that the supply-side variables were more to determine the household food security than the demand-side variables. In their study adopting of improved technology, having better farm size and land quality were found an important role in ensuring household food security in the study area.

Epherm (2008) studied determinants of household food security in Sekota Woreda using logit model. The study found that poverty household food security in the north eastern part of Ethiopia were strongly associated with various socio-economic and bio-physical factors that influence the food security status of households were age of household head, dependency ratio, size of cultivated land, total number of livestock owned (excluding oxen), number of oxen, manure application, land quality index and farmer's knowledge on the effect of land degradation on food security.

2.4.2 Contribution of Irrigation to Household Food Security

Even though land augmenting impact of use of irrigation has been studied in terms of increases in crop yield, income, diversification and generating off-farm activities by different scholars, specific empirical studies on the contribution of irrigation to household food security measured in terms of calorie acquisition is very scant or almost nil. Therefore, this empirical review is bounded only to these studies.

In terms of income, irrigation has a strong land augmenting impact. The value of per hectare crop production under irrigated settings is about twice that of under rain-fed settings. Household income and consumption are much higher in irrigated settings than in rain-fed settings, and a 50 percent point gap is common (FAO, 1995). 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 SSI schemes (Awulachew et al, 2005.) Besides, the study concluded that irrigation investments can have broader food security and poverty reduction impacts, if efforts are geared towards revitalizing and up-grading existing traditional SSI schemes, with support to enhance access to input supply, output marketing and extension to facilitate access to information and innovations (ibid).

An Impact study by Desta (2004) revealed that contribution of irrigated agriculture to income is about 70 % in the highly irrigated villages as compared to 60 % in two other low irrigated areas. At the same time, the absolute size of agricultural income is also the highest in the highly irrigated village despite the lower landownership size and cultivated holding by more than 30 % over the low irrigated village. 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. The highly irrigated village has higher per hectare agricultural income by over 50% over the low irrigated village.

Fuad (2002) findings verified that that cash crop economy with important cash flow offers a wide range of off-farm income possibilities as compared to subsistence farming. He shows that about 45% of farmers involved in cash crop production are engaged in income generating off-farm activities while 13 % are from the non-cash crop producers. Moreover, (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 69 %, 76 %, 76 % in Doni Kumbi and 0, 75 %, 61 % in Bato Degage. The study has shown the importance of smallholder irrigation development as a drought mitigation measure and improvement of household food security.

A study made in socio-economic assessment of two small-scale irrigation schemes in Adami Tullu Jido Kombolcha Woreda, Central Rift Valley of Ethiopia, result showed that irrigation schemes increased households' income compared to situation before implementation of the schemes and thus contributed to improvement of household food security status (Mengistu, 2007). He also found that households had grown mixed crops such as onions, maize and green beans though the net revenue gained by the two irrigation schemes were significantly different. This is a means of reducing risks from temporary food shortage by rural households using diversification strategy in their irrigation land.

An econometric analysis of the link between irrigation, markets and poverty by smallholder vegetable and Fruit Production in the North Omo Zone, SNNPR findings suggested that promoting small scale, low cost and labor-intensive irrigation projects and building the capacity of farmers are very important for reducing poverty in the cash growing rural areas of Ethiopia (Tadel & Debel, 2006).

2.5 Conceptual Framework of the Study

In household food security, irrigated agriculture plays a crucial role in the sustainable livelihoods of rural communities. Improvement in access to irrigation water serves as a powerful tool to diversify livelihoods and reduce vulnerability for smallholder producers (Birhanu & Pedy, 2003). There are five key dimensions how irrigated agriculture contributes to socioeconomic uplift of rural communities. These are production, income, consumption, employment, food security, and other social impacts contributing to overall improved welfare (Hussian, 2004).

The same author in the same year notes that irrigation can benefit the poor through raising yields and production, lowering the risk of crop failure, and generating higher and year-round farm and nonfarm employment. It can enable smallholders to adopt more diversified cropping patterns and to shift from low-value subsistence production to high-value market-oriented production, which increase income of household. Furthermore, (Abebaw, 2003) explains use of irrigation will enable farm households to produce high value crops, in most cases vegetables, which eventually increase crop income. Increased income creates consumption stability since the farmers will have access to purchase enough food for household.

On the other hand, farm households who participate in irrigated agriculture would able to increase crop production through increased use of complementary inputs (such as high yielding variety seeds, fertilizers, pesticides, etc.), which enables them to produce more and retain food for household consumption i.e. availability of food in household will be enhanced. Access to irrigation also creates an opportunity for rural farm households to produce crop throughout a year since water will be available for crop to grow whenever needed, that means risk of crop failure is reduced. Hence, the household will not face consumption shortfall, as production of crops are possible during off periods where food stocks are depleted.

The point is that it is impossible to generalize that only accessing irrigation water by rural poor solves the problems of food insecurity. There are factors like, institution, policies, market situations and rural household characteristics that affect directly or indirectly the food security and income situation of rural household. The following conceptual framework is developed to show the linkage between household food security and access to irrigation water.

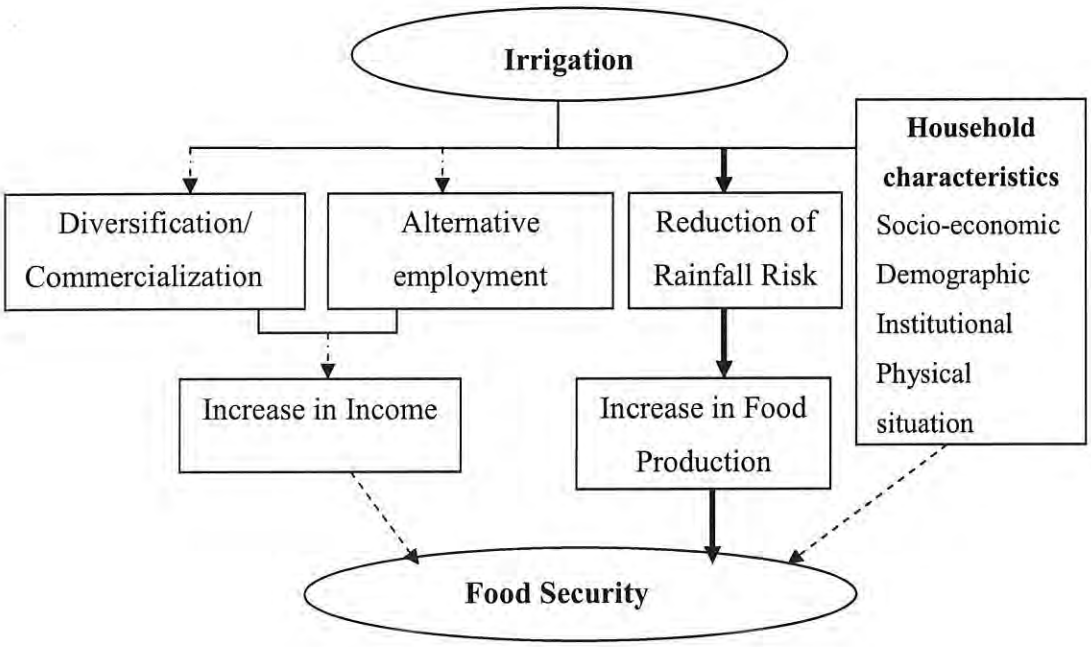

Figure 1 Schematic Representation of Irrigation and Food Security Linkage.

Source: The researcher adapted from the work of Tsegaye & Tamene (2005).

3. DESCRIPTION OF STUDY AREA

This chapter gives an overview of physical, demographic and socio-economic situation of the Zone in general and the study Woreda in particular. It briefly explains the population, land use, soil type and the farming characteristics of the study area.

3.1 Overview of North Wollo Zone

North Wollo zone is one of eleven administrative zones of the Amhara National Regional State (ANRS). It is situated in Northeastern highland plateaus of Ethiopia with an area of size 12,706 km^2. It is bordered with Tigray region in the North and Afar region in the East. South Wollo and South Gondar are the bordering zones in the South and West, respectively.

According to the 2007 population and housing census results, about 1,503,283 peoples are living within the zone, of which 1,347,624 (89.64 percent) are rural dwellers while the remaining, 155,649 (10.36 percent) are urban peoples (CSA, 2008). The study zone is comprised of 256 rural & 12 local Kebele Administrations within 10 Woredas. Woldiya, the administrative center of the zone, is 520 kms far away from Addis Ababa along the main road passes to Mekelle and 360 kms from Bahir Dar town (capital city of the regional government state).

The mean annual rainfall lies within range of 600 to 1300 mm. The Eastern escarpment receives lowest rainfall and West parts of the Zone receive highest in average volume of amount. In Eastern part of the area, rainfall distribution is bimodal: with short rains during months of February to May while large volume of rainfall occurs during months of June to September. Principally, the zone is identified as one of drought prone areas with severely degraded natural resource basis confronted with chronic food insecurity and famine problems for the past so many decades. Like other parts of the region, mixed farming is predominantly practiced by small holders as a major source of livelihood.

3.2. Description of Gubalafto Woreda

3.2.1 Location and Topography

Gubalafto Woreda, where this research has been conducted is located in the northeast part of North Wollo Zone. It is one of ten Woredas found within the Zone located on surrounding the Zonal capital city, Woldiya. The Woreda is divided into 34 Peasant Associations (PAs) and 2 urban Kebele administrations (KAs). The topography of Woreda is made up of a chain of mountains, hills, valleys and cliffs exposed for severe natural resources degradation problem mainly soil erosion and deforestation.

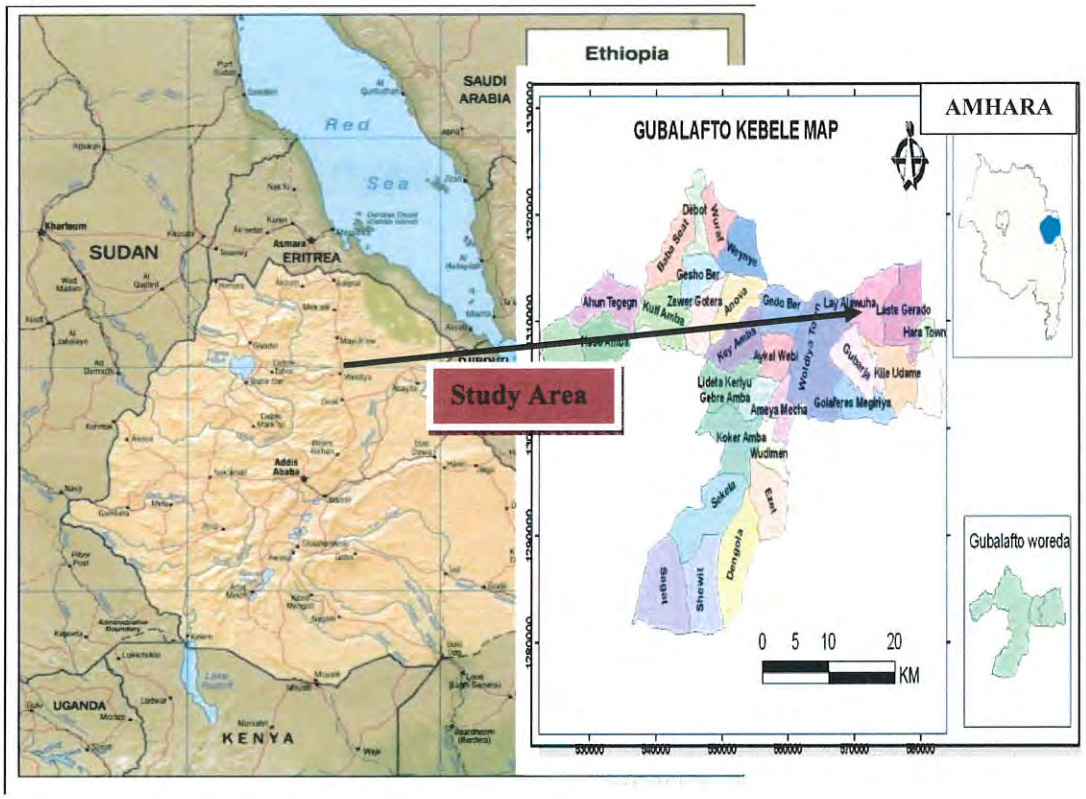

Figure 2 Map of the study area

Source: Own formulation data derived from GIS and http://www.maps of world.com

3.2.2 Population

The total population of Gubalafto Woreda is 139,800, of which 70,732(50.6%) are males and 69,068(49.4%) are females and among it, about 134,915(96.5%) of the population are living in rural and 4,885(3.5%) are urban areas in general (CSA, 2008).

3.2.3 Climate and Altitude

Based on the traditional agro-ecologies classification result made by SAVE (2004), Woreda topography is classified as 25 % highland, 61 % midland and 14 % as lowlands areas. The elevation varies from 1150 to 2800 masl and majority of landmass is under midland and lowland topography. The mid and highlands covers Western escarpment and lowland comprises all of Eastern and central part of the Woreda.

According Sirinka Agricultural Research meteorological data, the specific site of the study area, has an average altitude of 1250 masl, and gets annual rain fall between 500-800 mm ranges with minimum and maximum temperature of 15°c and 31°c respectively. Consequently, recurrent drought and frequent crop failure due to erratic and low amount of rainfall problems, the Woreda is known as chronically food shortage area in the region (Wondimu & Tewodros, 2005).

In a single term, the condition of rural livelihoods is exposed for drought hazards as it can understand from the basic data of the Woreda verified. To cope up with shocks may happen and to maximize income, rural households pursued a number of strategies. Specifically, to overcome problem of drought induced food insecurity, farmers have been participated long ago in using different agricultural water technologies like SSI.

3.2.4 Economic Situation

Agriculture is predominantly source of livelihood in the study area. It is characterized by both crop production and livestock rearing systems. According to study finding of SAVE (2004) Gubalafto Woreda categorized in to three Food Economy Zones (FEZs), i.e. *Belg*,

both *Belg* and *Meher* and *Meher* dependent zones. The highlands are primarily dependent on Belg rains for their main crop (barley), while mid highlands are both *Belg* and *Meher* rains, which enable them to harvest twice a year. The lowlands rely upon summer rains for their main harvest and to a lesser extent *Belg* rains for regeneration of pasture and planting of long maturing varieties. The main food crops grown are *tef,* sorghum, maize and chick pea. In addition, different vegetables and fruits such as tomato, onion, pepper, orange, mango, avocado, coffee, papaya and coffee are grows.

However, the production status of these crops is very much limited to areas which have access to irrigation. In moisture stress areas like Gubalafto, amount of crop harvested is strongly related to size of cultivated land and moisture availability. Accordingly, the intent to increase crop output by farm households largely relies on expanding farmlands and distribution of farm land for different crops. Besides, weakening of draft power, crop pests (such as *Yequela Wof,* bush crickets, stock borer), weeds (mainly congress weed, etc) and disease were listed as a major constraints in crop production system in the study area as the same report made by SAVE in 2004 disclosed.

Moreover, livestock production is one of vital livelihood sources in the study area. The major livestock includes cattle, sheep, goats, donkey, camel and poultry. Hence, they are considered as important assets and used as sources of food, income and draught power.

3.2.5 History of Alawuha Small-Scale Irrigation

Alawuha SSI scheme is located about 535km far away from the capital city of Ethiopia along the main road passes from Addis Ababa to Mekelle town cited in North-Eastern parts of the country. Alawuha River is streamed from different tributaries of North Wollo highlands from west and sheds to east low land plateau. Alawuha SSI is constructed by diverting Alawuha River in 1998 by the then organization known as Sustainable Environmental and Agricultural Rehabilitation for Amhara Region (SEARAR).

The secondary source documents from Gubalafto WAO shows that the irrigated land characterized as well-drained loam soil and the shortest distance of irrigated farm land

from the source is 0.5 km at Lay-Alawuha Kebele while the longest distance is 4.2 km sited at Lasetegerado Kebele, and it has a discharge rate of 720 liters per second.

The water is diverted from the main river by diversion weir and conveyed through primary canal that extends up to the end of irrigated land by divided in to six secondary canals having 1.5 km length from the primary canal. The diversion structure across the river till reaching to first nearest irrigated land is cemented. Lastly, water distributed from the main and secondary canals to each farm plots via tertiary with all earthed canals.

The total potential irrigated area by the scheme is 296 hectare (ha) of land serving about 1431 households living within two kebeles called Lay-Alawuha and Lasetegerado. The data disaggregation in terms of sex shows that the scheme is benefiting for 1264 male and 167 female households in the targeted community.

4. RESEARCH METHODOLOGY

This research methodology part tries to discuss the general research approach and design employed in this study to effectively achieve research objectives and adequately address research questions. Accordingly, it was followed mix of both qualitative and quantitative research approaches. Nevertheless, the methods of data collection and analysis employed were more of quantitative and the qualitative data was used to supplement analysis of quantitative data.

This chapter is organized into four sections. In the first section of this chapter, the sampling procedure and sampling techniques adopted with procedure of sample size determination is discussed followed by the second section that discusses about sources and methods of data collection. Section three and four focus on descriptions and discussions about methods of data analysis and detail description of the econometric binary logit model respectively. The model description is explained with its specifications and definition of both dependent and explanatory variables, which are used to identify determinant factors for household food security status.

4.1 Sampling Technique and Sample Size Determination

The sampling procedure followed for this study is a multi stage sampling procedure. Firstly, Gubalafto Woreda is selected as it is identified as one of drought induced food insecure Woreda in north eastern part of the country. Then, out of total 34 kebeles found within the Woreda 2 kebeles; namely Layealewuha and Lasetegerado were selected purposively considering factors of the presence of Alawuha SSI and its accessibility.

In the second stage of sampling procedure, a stratified random sampling technique was employed so as to determine sample frame of the study which is used to select sampled household heads within selected kebeles, list of household heads with a separate sheet of users of the constructed irrigation scheme was obtained from respective Kebele administrations and Agricultural Extension Offices. The stratification was mainly based

on an attributes of sample population being small-scale irrigation user or not followed. Then, in the third stage, sample household heads from both irrigation users and non-users were selected using proportionate random sampling technique considering the total sample determined for the survey. Accordingly, this procedure resulted in the following sampled households.

Table 1: Distribution of sampled households by their kebeles

Stratum	Name of sampled Kebele	Total Households per kebele	Sampled Households per kebele
Irrigation user	Lasetegerado/03	361	29
	Layealewuha/04	1070	46
	Sub total	**1431**	**75**
Non-user	Lasetegerado/03	740	31
	Layealewuha/04	169	9
	Sub total	**909**	**40**
Total Sum		**2340**	**115**

Field survey, 2011.

In inclusion of the above mentioned size of sample households, the study applied a simplified formula provided by Yamane (1967), statistically estimated at 95% confidence level, degree of variability = 0.05 and level of precision =90%.

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

Where n is the sample size, N is the population size (total household size), and e is the level of precision. Based on the number of the total households in the sampling frame, the formula equated and reached a minimum of 322 respondents. However, the study was carried out on 115 respondents by considering homogeneity characteristics of sample households.

4.2 Sources of Data and Methods of Data Collection

As highlighted in introducing of this chapter, using of combinations of both qualitative and quantitative data is valuable first and for most in food security research works to get a comprehensive and holistic understanding of the intended result. Accordingly, this study employed both quantitative and qualitative approaches to address issues raised appropriately and advance knowledge in relation to food security and irrigation development. Thus, both qualitative and quantitative data were collected from primary and secondary data sources. Methods and techniques of data collection employed to gather data from primary and secondary sources are discussed below.

4.2.1 Primary Data Sources

To generate the required primary data from different primary sources, research tools such as household survey, key informant interview, focus group discussions and field observations were employed. These techniques were used to collect data that belongs to household demographic and socio-economic characteristics, current household food security situation, farming operations and food crop production status, farmers' attitude in water management and utilization system. Consequently, to collect best quality data the following procedures were used in this survey.

4.2.1.1 Household survey

For the household survey, a semi-structured questionnaire that contained both open and close-ended questions was prepared to gather data from total 115 sampled household heads. Then, questionnaire was translated into vernacular language (Amharic). Prior to conducting actual process of data collection using this questionnaire, pre testing of questionnaire was done to ensure validity and reliability. Moreover, in order to minimize errors in data collection and properly administer the questionnaire two day trainings were given for five enumerators including pretesting work. Finally, minor modification was done on questionnaire based on the feedback gained and the final modified semi-structured questionnaire was administered on selected sampled households residing within the two PAs. The survey was conducted for a month in February, 2011.

4.2.1.2 Focus group discussion

Using a checklist comprising open ended questions specifically prepared for each groups of target community and overall situation of the study area have been asked to get various socio-economic facts. It enabled to triangulate or substantiate the secondary and household survey data generated on current situation of household food security, challenges that farmers have been faced irrigation activity and contribution of irrigation to food production supplement in the study area.

A total of three focus group discussions were conducted with selected participants. The first FGD was undertaken with community representative, whereas the second and third FGDs were held with irrigation users and non users respectively. On average 11 peoples participated for the group discussions. In selection of participants attempt was made to include different segments of population such as kebele leaders, Kebele Council members, elders, development agents, members from association of irrigation water users, women, irrigation users and non- users and youth farmers were included.

At Woreda level, eight key informant interviews were conducted with key stakeholders of irrigation development, food security, agricultural cooperative promotion and SAVE UK staffs as additional source to explore qualitative information using an interview schedule (See Annex 5, part three).

4.2.1.3 Field Observation

As one of research methods, filed observation was also employed. Specifically field observation was carried out to gather information about the irrigation and food security setting to link the peoples experience and current problems faced in the area. Since the researcher has a good memory and knowledge about the area in his past working experience, it was simple to seek information and observe what is going on the ground.

4.2 2 Secondary Data Sources

Secondary data was collected in order to analyze contribution of irrigation for household

food security. The secondary data includes data regarding total grain production and cropping intensity followed by farmers with irrigated land and rainfed farmers at community level. The secondary sources of information include Gubalafto Woreda and respective Zonal government annual reports, National and Regional official statistical abstracts, and researches undertaken in the area.

A visit was made to collect the necessary secondary information to Woreda Agricultural and Rural Development, Food Security Coordination, Finance and Economic Development, Transportation and Agricultural Marketing Promotion, Zonal Disaster Prevention and Preparedness Desk and NGOs involved in irrigation work. Moreover, the data published in different books, policy documents about agricultural development and food security and research journals were also use to accomplish the research.

4.3 Method of Data Analysis

After data was collected from both primary and secondary sources, it was analyzed using different methods of data analysis. Before analysis, quantitative data gathered using the survey was coded and entered into statistical software known as Statistical Package for Social Sciences (SPSS -16). The data was then cleaned.

For the quantitative data, both descriptive and inferential statistics techniques of data analysis were employed. Descriptive statistical techniques such as mean, percentage, standard deviation were used for presenting difference in socioeconomic variables in analysis of data. Specifically, SPSS soft ware was used to analyze most of quantitative data collected in the survey. The strength and direction of a linear relationship between two variables was analyzed using correlation coefficient.

The overall adequacy of food supply in the study area was analyzed by using household food balance model (HFBM). 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. The same author asserted that the model was initially

formulated by Degefa in 1996 adopted from the FAO Regional Food Balance Model. It is likely that the established food balance sheet equation tries to include all the available cereal and non-cereal food commodities as shown below.

Household Food Balance Model:-

NGA = (GP + GB + FA + GG) - (HL+ GU + GS +GV); Where,

NGA = Net grain available/year/household

GP = Total grain produced/year/household

GB = Total grain bought/year/household

FA = Quantity of food aid obtained/year/household

GG = Total grain obtained through gift or remittance/year/household

HL = Post harvest losses/year

GU =Quantity of grain reserved for seed/year/household

GS =Amount of grain sold/year/household

GV =Grain given to others within a year

Because of the survey was made immediately after main harvesting/production period of the area it is preferred to use HFBM than other food security measurement tools. From experience it is observed that local communities in the study area have been involved in performing culturally accepted social activities like wedding ceremony during this time. Hence, taking food consumption data using 24 hours recalls method or other techniques may not be appropriate and even lead to come up with counterfeit results. Accordingly, for measuring annual food availability status of sampled households HFBM tool was selected.

As mentioned above, the method has to derive separately the amount of grains available for domestic utilization (food use) and other secondary components (grain uses for other purpose/losses). Hence, the net quantity of food available was calculated and converted into dietary calorie equivalent based on Ethiopian Health and Nutrition Research Institute (EHNRI)'s food composition table. The calculated calorie was compared against the national average daily caloric requirement for a moderately active adult ($\leq$ 2100 kcal) to look into the dietary calorie status of the resettled households in the study area. Based on

this information, those households who the meet above estimated caloric requirement were categorized as food secure and otherwise as non- food secure.

After classifying sampled households based on their food security status as food insecure and food secure, the major food security determinants of the study area were identified using logit model. Similarly, the contribution of irrigation to household food security was analyzed using household kilo caloric acquisition method between irrigated and rain fed agriculture comparing the food commodities directly supplied from irrigated alone as dependant variable and expressing its influence on the probability of the household to be food secure or otherwise.

4.4 Model specification and variable definition

Dependent Variable

Household food security: Food security status at the household level was measured using HFBM tool and converted in food energy requirements based on the household's adult equivalent ratio and reached at figure of food calorie in kilo calorie/day/person. Thus, those households beyond the estimated calorie requirement level (≥ 2100 cal per person per day) were deemed to be food secure and otherwise food insecure (Refer Table 2).

The study applied a probability model specified as food security is a function of series of explanatory socioeconomic, demographic, institutional and farming characteristics of households as elaborated below. The dependent variable is a dummy variable, which takes a value of zero or one depending on whether or not a household is food secure or not (i.e. Food secure=1 and Food insecure=0).

Logit model is used to estimate dependent dichotomous variables. Although linear probability model is the simplest method, it is not logically attractive model, because it assumes the conditional probability increases linearly with the value of explanatory variables. Unlike linear probability model, logit model guarantees that the estimated probabilities increase but never step outside the 0 – 1 interval and the relationship between probability (Pi) and explanatory variable (X_i) is nonlinear.

Thus, a logistic model is used to identify the determinants of food security and to assess their relative importance in determining the probability of being in food secure situation. The functional form of logit model is specified as follows (Gujarati, 2003)

$$P_i = E(Y = 1/X_i) = \frac{1}{1 + e^{-(\beta_o + \beta_i X_i)}} \quad \text{---------- (1)}$$

For ease of exposition, we write (1) as:-

$$P_i = \frac{1}{1+e^{-Z_i}} \quad \text{---------- (2)}$$

The probability that a given household is food secure is expressed by (2) while, the probability for food insecure is:-

$$1 - P_i = \frac{1}{1 + e^{Z_i}} \quad \text{---------- (3)}$$

Therefore we can write:-

$$\frac{P_i}{1-P_i} = \frac{1+e^{Z_i}}{1+e^{-Z_i}} \quad \text{---------- (4)}$$

Finally, taking the natural log of equation (4) we obtain:-

$$L_i = \ln\left[\frac{P_i}{1-P}\right] = Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \quad \text{---------- (5)}$$

Where Pi = is a probability of being food secure ranges from 0 to 1

Zi = is a function of n explanatory variables (x) which is also expressed as:-

$$Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \quad \text{---------- (6)}$$

β_0 is an intercept

β_1, β_2 ------ β_n are slopes of the equation in the model

Li = is log of the odds ratio, which is not only linear in X_i but also linear in the parameters.

Xi = is vector of relevant household characteristics

If the disturbance term (U_i) is introduced, the Logit model becomes

$$Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + U_i \quad \text{---------- (7)}$$

Independent Variables (X's): this includes various socioeconomic characteristics expected to affect the food security situation of the household. Based on the available information from related literatures, previous food security studies and the researcher's personal knowledge about the area, twelve explanatory variables, which are anticipated to have significant impact on household food security were selected and hypothesized. The explanatory variables that are hypothesized to have positive or negative influence on household food secure security status are described below.

Age of household head (AGEHH): It measures age of household head in years. As age of household increases, they can acquire more knowledge and experience in farming and pre assume vulnerability and risk conditions of food insecurity. Mostly choice of crops to be grown is influenced by household heads; hence aged farmers will be perfect in terms of preference of decision making. Thus, age of household head is hypothesized to affect food security status positively.

Education level (EDULEVEL): It is the number of years of schooling attained by the sampled households' heads up to the time of the survey. Education is expected to have a positive effect on household food security status. Households with better education level are believed to have a chance to apply scientific knowledge and better manage their farm activities in good manner, hence boost domestic production to fulfil household consumption needs.

Household size (THHSIZE): Family labour plays an important role, particularly in rural families as a factor of production. Therefore, household with more agricultural labour results with more profitability in food grain production if available farming land can accommodate household productive labour force appropriately otherwise they will a burden to the family. Hence, increasing by one household labour has positive influence in increasing agricultural production and has positive contribution to household food security.

Dependency ratio (DEPRATIO): Household members aged below 15 and above 64 are considered as dependent and dividing it by household members whose age is between 15 - 64 resulted in dependency ratio. These groups are economically inactive and became burden to other member of household to fulfill their immediate food demands. It is hypothesized that dependency ratio and food insecurity are positively related.

Number of livestock owned excluding oxen (TOTALTLU): This refers to total number of livestock measured in tropical livestock unit (TLU). Livestock is important source of income, food and draught power for crop cultivation in Ethiopian agriculture. Household with more number of livestock have a chance to obtain more direct or indirect income sources to purchase foods commodities, particularly during food crisis. Livestock also used as the major employment

opportunities for rural household members. Therefore, higher livestock size would increase significantly the status of food security.

Number of oxen own (NUMBOXEN): The number of draught oxen owned household during the survey periods. Oxen are one of basic farm assets and are predominant source of traction power in the study area. Households who own more oxen have better chance to be food secure than others. This is because oxen possession allows undertaking farming activities on time and when required. The number of oxen available to household is, therefore, hypothesized to enhance probability of being food secure.

Cultivated Land size (CULTLAND): this refers to total cropping land cultivated by a household in the past one year production period. It has a direct relation with crop production. A larger size of cultivated land implies more production and availability of food grains. Hence, size of cultivated land was expected to have positive impact on household food security status.

Credit Service (CREDITSER): Credit is very much useful to purchase inputs such as improved seeds and other important inputs. Hence, farmers who have access to credit would have positive effect on crop production due to use of agricultural inputs which enhance food production and ultimately increase household food security status that indicates the direct relationship of credit and household food security.

Participation in training service (TRASER): Extension service play important role for rural farmers in terms of providing advice and information. Among these, training is one of useful service to introduced and develop practices of modern technologies (proper types and rates of fertilizer, improved varieties of seeds, agro-chemicals, etc.) Hence, those household's participated in training organized at FTC or farm demonstration is supposed to apply their knowledge to increase farm production. Thus, households would be in a better position of food security status.

Engagement in Non-farm activity (NONFARM): It is a measure of any household member participated in non farming activities and generated an income in Birr. It was assumed that farm

income earned by a household is primarily spent on food items such as on food grains, and non-food items required for household members. Therefore, in this study it was hypothesized in that non-farm income is positively associated with household food security status.

Food aid (FOODAID) - The food aid amount kilogram. The existing Productive Safety and other emergency program create access to food availability for vulnerable households. Therefore, households received food commodities would fulfill their food gap needs, hence, in this study, it was hypothesized that households who have been receiving food aid are expected to be food secure than those who did not targeted under PSNP.

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

5. RESULT AND DISCUSSION

This chapter gives details of the research findings divided into five sections. The first section describes household food security status of sampled households and the study area food availability situation, which is constructed by using household food balance model. The demographic, socioeconomic and institutional characteristics of sample households consorting with their identified level of food security are illustrated in the second section. In the third section, the contribution of irrigation to food energy supplement for target beneficiaries is discussed. The major determinants of household food security identified using econometric model, is elaborated in the fourth section. Finally, farmers' perception and their challenges in utilizing the constructed irrigation scheme are explained.

5.1 Measuring of Food Security Situation of the Study Area

In assessing food security situation of the study area, the following steps were followed. First all staple food sources of cereals and non-cereals grains available for sample households in the study area were collected. Secondly, the collected data was structured in to HFBM equation to determine the net food availability status of the household. Thirdly, the study fixed the past one year cropping period (January 2010 to December 2011) as frame of analysis. Finally, food energy requirement for each household member's was weighted by converting in to Adult Equivalent Ratio (AER).

5.1.1 Food Security status of sample households

In this study, food security status is measured as the extent of food available for human consumption, expressed in kilocalories per person per day needed of subsistence requirement for annually as elaborated in the previous chapter. To this end, an attempt was made to convert food grains available for sampled households into dietary calorie using EHNRI's food composition table (see Annex 4). Thus, households' who were found to fall above the national minimum recommended calorie requirement level, i.e. $\geq$ 2100 kcal were categorized as "food secure" and those found below the requirement as "food insecure".

Accordingly, the food security status of the total sampled households (115) using the computed HFBM result shows that 29 % (33 households) were found food insecure while 71 % (82 households) were food secure. The detail figure showing household food security status is attached under Appendix 4.

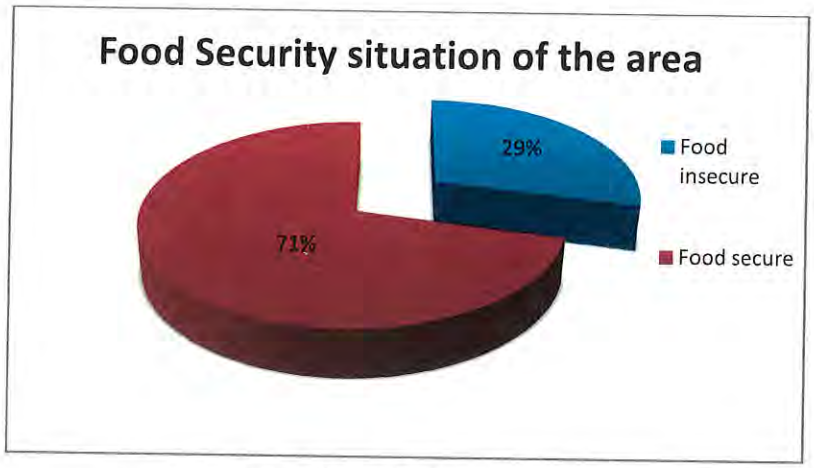

Figure 3 Study area's food security status

Source: Survey result, 2011

5.1.2 Description of food availability in the study area

Table 2 reveals that availability of food for the food insecure households and food secure households is 1605 Kcal or 1.72[1] quintal of food grain per person/year and 3411Kcal or 3.65 quintal of food grain per person/year respectively. This clearly indicates that there is deficiency in food energy to considerable proportion of the population in the area.

Nevertheless, the survey result shows that the overall average food energy is 2877 Kcal, which is higher than the national value (2100kcal). Moreover, the research denotes that household's food calorie availability was found within the range of 788 to 8405 Kcal. This implies that there is enormous gap in energy availability among the sampled households. For instance, food energy shortage by an average of 24% was found for food insecure households while comparing it with the national level of requirement to fulfill their food need.

[1] The national conversion factor for annual food energy requirement is 2.25 quintal per person per year.

Table 2: Construction of food balance sheet of the study area

Household dietary energy availability expressed in Kilo calories per person per day

No	Household Food balance Model attributes	Food secure Household	Food insecure Household	Data for study area			
				Min.	Ave.	Max.	Total
1	Food grain produced	4622	1931	769	3826	12762	439981
2	Food grain bought	286	176	72	253	1383	29126
3	Quantity of food aid obtained	220	224	0	222	598	25469
4	Food grain obtained through gift/remittance	12	0	0	8	451	932
	Subtotal 1 (1+2+3+4)	**5139**	**2331**	**841**	**4309**	**15194**	**495508**
5	Post harvest losses per year	8	2	20	6	488	680
6	Quantity of grain reserved for seeding purpose	181	112	33	161	443	18505
7	Amount of grain sold	1512	605	0	1244	5337	143088
8	Grain given to others within a year	27	7	0	21	521	2389
	Subtotal 2 (5+6+7+8)	**1728**	**726**	**53**	**1432**	**6789**	**164662**
9	**Net grain available (subtotal 1 - subtotal 2)**	**3411**	**1605**	**788**	**2877**	**8405**	**330846**

Source: Field survey, 2011

5.1.3 Food grain source forms in the study area

Figure 4 shows the major food grain sources in terms of energy amount for sample households. The survey data validates that an average of 89%, 6%, 5% and zero percent amount of calorie per capita was obtained from own production, domestic purchase food aid and remittance forms in their order of significance. It clearly depicts that domestic food grain production is the major source of food supply followed by local purchase. On the other hand, it substantiates the fact that variability in local agricultural production status largely affects the food availability situation of the area.

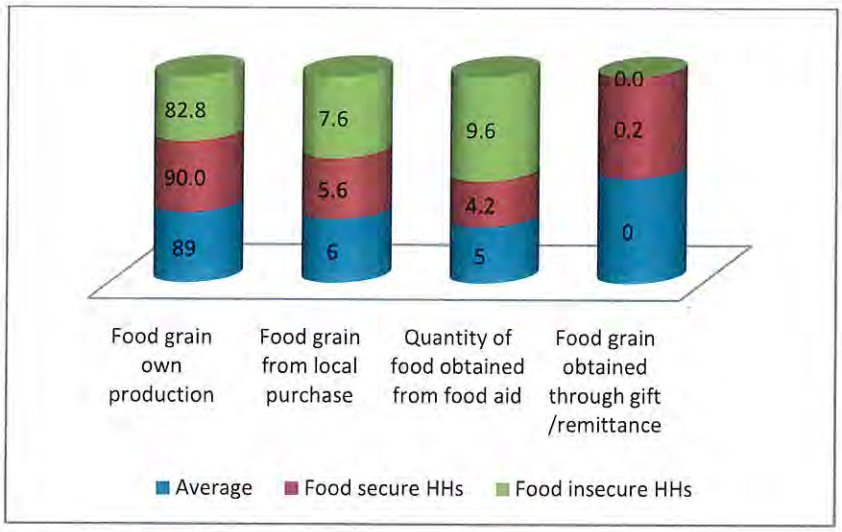

Figure 4 Study area's food sources distribution

Source: Field survey, 2011

As presented in figure 4, while comparing food grain sources for food secure, food insecure and the average of the total sampled households, the share from own production (90%) by food secure households is highest. On the contrary, the food grain available for the same food secure households obtained from local purchase (5.6%) and food aid (4.2%) constitutes the lowest amount compared with both the total areas' average (6 % and 5%) and food insecure households (7.6% and 9.6%) respectively. This shows that food secure households directly cover most of their food consumption needs from own production than other means of food source.

Quite the reverse, the share from food aid and purchase is high for food insecure households that outweigh the quantity supplied for food secure households. This implies that food insecure households were more dependent on purchasing of food commodities to meet the minimum household food consumption requirements than food secure ones. Remarkably, food aid was also received by food insecure households at twofold than the average supplied for the area. It reflects that food aid program is an important source for food insecure households, who are more vulnerable section of the community in the study area.

5.2 Demographic and Socio-economic Characteristics of sample households

It is important to describe household's demographic & socio-economic characteristics of sample households for validation of the study results explanations. Hence, in the next sections the characteristics of sample households' such as sex, age, marital status, household size, dependency ratio, educational status, livestock ownership and cultivated land size (irrigable and rain fed land area) is described in relation to sample households food security status.

5.2.1. Sex and Marital status

Out of the sampled households, 78.3% (90 households) were male-headed and 21.3% (25 households) were female-headed. Regarding their marital status, about 78.3 % of sample households were married while 13 % and 8.7 % were divorced and widowed respectively. Among food secure households, 92.6% were male-headed and 7.4% were female-headed. Likewise, within food insecure households 61.8% and 38.2% were male and female-headed respectively.

Table 3: Household food security by sex and marital status of household head

	Status of Food security						
	Food insecure (33)		**Food secure (82)**		**Total (115)**		**χ2 Statistics**
	N	**%**	**N**	**%**	**N**	**%**	
Sex of the household head							
Male	21	63.6	75	91.5	96	83.5	**13.211*** **
Female	12	36.4	7	8.5	19	16.5	
Total	**33**	**100**	**82**	**100**	**115**	**100**	
Marital Status of household head							
Married	21	63.6	75	91.5	96	83.5	
Divorced	6	18.2	7	8.5	13	11.3	**19.028*** **
Widowed	6	18.2	0	0	6	5.2	
Total	**33**	**100**	**82**	**100**	**115**	**100**	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

As it was hypothesized in this research, the chi-square test approved there is a systematic association between sex of the household head and household food security status at a significant level of 1%. This can be explained in a way that in the study area, division of labor by and large is governed by gender, which allows men as responsible for crop production including livestock rearing, while women for domestic tasks (food preparation and processing, cleaning, marketing, fetching firewood and water). This means the tasks in which women participate are strictly defined customarily inclined to nonproductive activities. Likewise, plowing of land is delimited as men's work since women are believed too weak to carry out farming operation that oblige them to provide their lands for sharecropping which in turn substantially decrease their food availability at household level.

The chi-square test also ratified that those divorced and widowed households have systematic association with food security status, at a significant level of 1%. Similarly, for the case of divorced women, the husband generally keeps the land, while the wife often leaves the area in addition with other assets, such as livestock and food grain due to traditional practice of male dominance; hence women might remain with low assets to produce enough for their households.

5.2.2. Household size and Agricultural Labour Availability

Labor is one of the major resource on which the farming activities of the study communities are established like any other part of Ethiopia. An average household size of the study area was 5. Specifically, the age distribution shows that 44.3%, 52.7% and 3% of the sampled household members lies within the age categories between "0-1", "15-59" and '60 and above' years of age, respectively.

The t-test analysis revealed that mean difference in household size, productive work force and male members of the household between the ages of 15 to 64 has a significant difference between food secure versus food insecure households at 10%, 5% and 5% level of significance, respectively. It is expected that the number of agriculture labourers will significantly increase among food secured household. This might due to the presence of such distinctive characteristics to utilize their capital (mainly land and labor) efficiently in production in which the share of labor utilized in their productive capital they have. Hence, they get time to enter into definite

connections and relations to other farmers like renting in land from relatively resource poor farmers and hence produce food crops, which is enough to feed their household. In addition, the type of land contract might be in fixed rent and this minimizes the presence of inefficiency in labour wage within the household farming activity.

Table 4: Household food security by age, size and labor force distribution

	Status of Food security						
	Food insecure (33)		**Food secure (82)**		**Total (115)**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**t-statistics**
Household size	4.78	1.49	5.58	1.68	5.01	1.58	2.495**
Productive labor force	2.44	1.06	2.93	1.36	1.05	0.92	2.069 **
Dependency ratio	1.74	0.88	1.47	0.92	2.59	1.17	0.839(NS)

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

5.2.3. Age of Household Head and Dependency Ratio

The mean age of the sample household heads was found 46.15 with standard deviation of 7.99. The maximum age observed was 67 while the minimum was 29 years. The mean age of food insecure households was 44.59 years and that of food secure households was 46.80 years. The statistical analysis revealed that there is no significant difference in the mean age of the household head between food secure and food insecure households.

Over all dependency ratio, defined as the ratio of people aged in between 0 to 14 and above 64 over those aged in between 15 to 64. The survey result indicated 2.59 average dependency ratios for the total sampled households. However, the study result show that, similar to the age of household head, dependency ratio has no significant mean difference between the two groups (see table 5 below).

Table 5: Household food security by age distribution

	Status of Food security						
	Food insecure (33)		Food secure (82)		Total (115)		
	Mean	SD	Mean	SD	Mean	SD	t-statistics
Age of household head	44.59	9.88	46.80	7.03	46.15	7.99	-1.579 (NS)
Male ≤ 10 years of age	0.74	0.67	0.56	0.82	0.61	0.78	1.034(NS)
Female ≤ 10 years of age	0.56	0.56	0.43	0.59	0.47	0.58	1.244 (NS)
Male b/n 11 to 14 years	0.65	0.77	0.53	0.61	0.56	0.67	0.727(NS)
Female b/n 11 to 14 years	0.50	0.51	0.51	0.61	0.49	0.58	0.126 (NS)
Male b/n 15 to 59 years	1.76	0.85	1.42	0.76	1.52	0.79	2.147**
Female b/n 15 to 59 years	1.56	0.93	1.31	0.56	1.38	0.70	1.603 (NS)
Male ≥ 60 years of age	0.00	0.00	0.24	0.16	0.02	0.13	0.900 (NS)
Female ≥ 60 years of age	0.03	0.17	0.12	0.11	0.02	0.13	0.667b(NS)

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

5.2.4. Educational status of household head

The summary result presented in table 6 offers majority of household heads (48.73%) were able to read and write, followed by illiterate and primary education level consisting of 22.6 % and 13.04 %, respectively. It means that majority of them (70.4%) were under low level of education.

Table 6: Household food security by educational status

Educational status	Food secure (81)		Food insecure(34)		Total (115)		$\chi 2$ test
	N	%	N	%	N	%	
Illiterate	18	22.2	8	23.5	26	22.6	2.237 (NS)
Read and write	36	44.4	19	55.9	55	47.8	
Primary (1 to 4 grade)	12	14.8	3	8.8	15	13.0	
Primary (5 to 8 grade)	9	11.1	3	8.8	12	10.4	
Secondary (9 to 12 grade)	6	7.4	1	2.9	7	6.1	
Diploma and above	-	-	-	-	-	-	
Total	**81**	**100**	**34**	**100**	**115**	**100**	
Categorization of educational level							

Illiterate (including read &write)	54	66.7	27	79.4	81	70.4	1.868 (NS)
Literate (grade 1 to higher level)	27	33.3	7	29.6	34	29.6	
Total	**81**	**100**	**34**	**100**	**115**	**100**	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

It was hypothesized that household food security and education status of the household head has positive relationship. In contrast to this, the survey result shows that there is no systematic relationship between educational status of household head and food security status.

5.2.5. Tropical Livestock Unit (TLU)

Next to land, livestock is the second most important asset for households living in the study area. As described in table 7, the survey result signifies that 11.3% of the sample households do not have livestock while the majority (88.7 %) of sample households were found having different types of livestock consisting of cattle, small ruminants, back animals (camel and donkey) and poultry with a typical household maintained an average of 4.51 cattle, 2.10 small ruminants, 0.99 back animals, and 3.17 poultries.

Comparably, in the study area, an average livestock holding, excluding poultry is 3.48 Tropical Livestock Unit (TLU) and the minimum and maximum number of livestock holds were 0 and 15.58 TLU respectively. (Table7). The survey result shows that food secure households possessed relatively high number of livestock than food insecure households and the mean difference between the two groups due to owning of livestock was significant at 5% level.

Table 7: Livestock ownership of household head

Livestock type	Food secure (82)		Food insecure (33)		Total (115)		t-test
	M	SD	M	SD	M	SD	
Farm oxen	1.90	0.58	1.44	0.99	1.77	0.75	- 4.048***
Large ruminants/cattle	4.91	3.76	3.59	3.59	4.51	3.79	-2.060 (NS)
Small ruminants	2.16	3.79	2.5	3.63	2.1	3.73	0.418 (NS)
Back animals	1.07	1.5	0.85	1.07	0.99	1.4	-0.371 (NS)
Chickens	3.32	3.29	2.82	3.25	3.17	3.27	-0.801(NS)
TLU (excluding hens)	3.76	2.03	2.80	2.19	3.48	2.11	-2.248**
Do you have livestock?							
	N	%	N	%	N	%	
Yes	77	93.9	25	75.8	102	88.7	7.727**
No	5	6.1	8	24.2	13	11.3	
Total	82	100	33	100	115	100	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

It might be because of the reason that owning livestock have a direct impact on annual food production status of the household mainly in performing farming operation as a draught power and fertilizer (manure). Moreover, it is the fact that livestock used as source of capital accumulation, prestige and means of coping during food shortage in the study area as participants explained during FGDs. As a whole, the increase in food will make to supply enough crop residues for keeping more number of livestock which contributes to ensure food security at household level.

5.2.6 Access to farm oxen

Like most parts of Ethiopia, oxen are the engines for agricultural works in the study area. As disclosed in table 8, nearly one-fourth of the sampled households (75.7%) owned a team of farm oxen and some (5.2%) had three and above oxen. Of course, in contrast to this, some (13)

(11.3%) reported that they do not have a single ox to accomplish their farming activity. In general, the survey result manifest that majority (88.7%) have at least one ox to plow their land with appropriate cropping time. It might also used as a means to get additional benefits either in food or cash.

Table 8: Farm oxen owned by households

Number of oxen owned	**Food secure (82)**		**Food insecure (33)**		**Total (115)**		
	N	**%**	**N**	**%**	**N**	**%**	**$\chi 2$ test**
Zero (No oxen)	5	6.1	8	24.2	13	11.3	
One ox	3	3.7	6	18.2	9	7.8	16.345^{***}
Two oxen	69	84.1	18	54.5	87	75.7	
Three and above oxen	5	6.1	1	3.0	6	5.2	
Total	**82**	**100**	**33**	**100**	**115**	**100**	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

Furthermore, the survey result reveals that there is a systematic association between food security status and oxen ownership at 1% level. It is possibly the fact that ownership of a better number of oxen (at least a pair of oxen) may allows a farmer to prepare personal farming land on time and rent-in the land of other households on a contractual basis in return gets additional production of food grains, which supplement their household sufficiently. On the other hand, it signifies that the loss of oxen makes critical for households holding though there is a traditional practice of sharing and/or renting.

5.3 Institutional Characteristics

Major institutional characteristics of the sampled households, which are important to explain the food security status of households is discussed hereunder.

5.3.1 Extension and Farmers' Training Service

The ongoing extension service is delivered to interested farmers mainly via Development Agents (DAs) through sharing of modern agricultural knowledge and information to improve farmers' lives in a better way. DAs are frontline workers in day-to-day contact with farmers. Thus, they provide technical advices by organizing trainings at Farmers Training Center (FTC) and conducting visits to farmers' fields.

Table 9: Extension service for sample households

	Food secure (82)		Food insecure (33)		Total (115)		$\chi 2$ test
	N	%	N	%	N	%	
Have you participated in the training organized at FTC last year?							
Yes	53	64.6	14	42.4	67	58.3	
No	29	35.8	19	57.6	48	41.7	**4.773****
Did the DAs visit and advise you in 2009/10 production season?							
Yes	64	78	10	30.3	74	64.3	
No	18	22	23	69.7	41	35.7	**23.382*****

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

As presented in the above table 9, 58.3% of the sampled households reported that they are benefiting from the training organized at FTC and 64.3 % responded that they got advice by DAs at farm level. The survey result revealed that households who have got a training and extension service have systematic association with their food security status at 5% and 1% significance level, respectively. It might due to the better follow up and backup to encourage farmers to adopt

improved seed of maize utilization and increased food production so as to supply sufficient amount of food for households.

According to the information collected from key-informants, the major trainings given for selected farmers include utilization and management of modern agricultural extension packages, irrigation water and marketing of their products. Moreover, the information gathered from the FGDs response strengthened that the existing extension service has a crucial role to aware them in their problems and opportunities to increase agricultural production.

5.3.2 Agricultural Credit and Input supply services

Various studies made in Ethiopia have recognized that an appropriate application of modern farm inputs such as chemical fertilizers, improved seeds and herbicides would increase crop yield and productivity in smallholder farming system Degefa (2006). Therefore, the importance of inputs is certain for highly degraded environmental context such as Gubalafto Woreda so as to improve land productivity and make better agricultural production. The availability of agricultural credit to subsistence farmers is a key indicator in assessing the food security situation of certain target community. Hence, it was tried to examine the credit service and modern input utilization system of the study area in relation to food security status.

Regarding the availability of credit, the survey result shows that credit activities were limited especially in crop farming sector. Only 30% of the households' stated that they have received credit to purchase improved agricultural inputs in last year production season. Among those households who have got a credit, 10% reported that they utilized it to buy improved seeds and fertilizer while the majority used it to purchase livestock, which comprises as 60% invested the money for buying of farm oxen, 23.3% for acquiring of small ruminants and 6.7% were for camel procurement (Table 10).

The study result disclosed that there is a significant systematic association in terms of food security status among respondents due to they have got access to agricultural inputs or not at 5% level of chi-square test. This can be related to the fact that farmers who got credit make use of it for purchasing of improved seeds, fertilizer and farm oxen to increase crop production.

The sources of credit for farmers in the study area were Amhara Credit and Saving Institution (ASCI), Farmers cooperatives, NGOs and traditional institutions. All of sample households as described to an inquiry on why they did not take credit. According to them, the reasons were absence of credit service (67.06%), high rate of interest (22.35%), fear of inability to pay back their loan on time (7.06%) and not have shortage of capital (3.53%). This response suggests that the credit flow was distributed and provided last year at a very low intensity though majority of farmers were interested to take it. One of the reason for low input utilization in crop farming might be due lack of an institution responsible in provision of the inputs (mainly improved seeds of vegetables, maize and *Tef* crops) as participants explained during the FGDs.

Table 10: Households access to credit and agricultural inputs

	Food secure (82)		**Food insecure (33)**		**Total (115)**		**$\chi 2$ test**
	N	**%**	**N**	**%**	**N**	**%**	
Have you got credit in last year production season?							
Yes	26	31.7	4	12.1	30	26.1	
No	56	68.3	29	87.9	85	73.9	**4.681 ****
Did you use improved seed and fertilizer in last year production?							
Yes	57	69.5	12	36.4	69	33.0	
No	25	30.5	21	63.6	46	67.0	**4.620 ****
If you got credit, for what purpose you used it?							
To purchase improved seeds, pesticides etc…					3	10.0	
To purchase oxen					18	60.0	
To purchase small ruminant animals					7	23.3	
To purchase camel					2	6.7	
Why you did not interested to took credit last year?							
There is no credit available in the area					57	67.06	
High rate of interest					19	22.35	
Fear of inability to pay back					6	7.06	
No shortage of capital					3	3.53	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

5.3.3 Access to Marketing and Road Facility

Using the survey an investigation was made on how farmers run marketing activities in their locality. Consequently, the result imparts that majority of sample households (78.3%) sold their produce for two nearby market centers only whereas some of respondents (21.3%) did not sell farm products totally. In addition, it is observed that all of them retailed individually to *Hara* and *Woldiya* locally known open markets as disclosed by 42.6% and 72.2% of sampled households respectively (table 11).

In this regard, farmers reported that since they have little choice to sell farm products, they are forced to dump agricultural products to consumers and/or traders at the above mentioned market areas. Besides, they testified that because of lack of getting reliable market information and absence of links with local buyers and sellers in their vicinity they are not in a position to get better benefit in trading of agricultural commodities.

Especially, as explained by key informants, due to absences of marketing outlets and group marketing system around the area, farmers were limited in producing of marketable crops mainly pepper and Tef . Moreover, as it can be seen in the table below, all farmers responded that there is no market information center, which means that there is no institution involved in provision of and accessing of marketing information in the study area. With regard to transportation, as illustrated in table 11, around 36% of sampled households were forced to walk on foot to deliver products to market areas, which respondents dominantly used for mobility. The second most important transport mode was using pack animals (34%) and the last was track transportation (27%) as households responded.

Though it was hypothesized, the significance test verifies that there is no systematic relation between food security status of household and access to market and road infrastructures in the study area. It is probably, due to lack of effective extension support, transforming of beneficiaries in to producer cooperatives and advocating of group marketing, they could not able to specialized in production quality products by using the constructed irrigation scheme. As the result, they were not successful to attract regular buyers coming to their farm gates though there

is better road facility adjacent with the irrigated area.

Table 11: Households access to marketing and road facility

	Food secure (82)		Food insecure (33)		Total (115)		
	N	%	N	%	N	%	$\chi 2$ test
Did you supply your production to market?							
Yes	61	75.3	29	85.3	90	78.3	
No	20	24.7	5	14.7	25	21.7	NS
What was your market place?							
Hara	34	42	15	44.1	49	42.6	NS
Woldiya	58	71.6	25	73.5	83	72.2	
	M	**SD**	**M**	**SD**	**M**	**SD**	**t-test**
How far your home from the following places							
Hara	7.91	3.46	8.09	3.69			
Woldiya	12.87	3.57	12.72	3.56			NS
Main road	1.95	1.32	2.39	1.10			
What are your means of transportation to market centers?							
Human power					32	36	
Animal power					31	34	
Truck					27	30	
Is there market information center in your vicinity?							
Yes					115	100	
No					0	0	
What type of marketing you follow while you sold the products?							
Individually					115	100	
Collective marketing					0	0	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

5.3.4 Access to Social Protection Program

As indicated earlier in the HFBM, food aid is one of the attributes contributing to household food availability. Accordingly, it is meaningful to discover the contribution of food aid programs in food energy acquisition status of the study area community. In the study area, the Productive

Safety Net Program (PSNP) is the major food aid source. It has been functional for the past ten years as discussed in section 5.1.3. To this effect, the sample respondents were asked with regard to food aid donation during the last one year. As can be seen from table 12, majority of sample households (60%) were beneficiaries of either the PSNP or emergency program food commodities donated by external aid sources for six months of duration during last year. They were encountered with food shortage problem due to short and unreliable *Belg* rains fall between the months of March to May (2009/10) though it was common for most of them in their life experience as reported by key informants at kebele level.

Table 12: Contribution of food aid to household food supply

	Food secure (82)		**Food insecure (33)**		**Total (115)**		
	N	**%**	**N**	**%**	**N**	**%**	**χ2 test**
Have you got food commodities last year in PSNP or/and emergency program?							
Yes	47	57.3	22	64.7	69	60	**0.857(NS)**
No	34	42.7	12	35.3	46	40	
	M	**SD**	**M**	**SD**	**M**	**SD**	**t- test**
Total Food available from food aid program/donation							
Food aid quantity(Q)	0.23	0.22	0.25	0.21	0.24	0.22	**0.980 (NS)**

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

Moreover, as a secondary data collected from Gubalafto Woreda Food Security and Early Warning case team certified that out of the total population living in the two study kebeles, *Layealewuha* and *Lasetegerado*, there are 532 and 924 households embraced under PSNP for the next five years period. Out of this number, 361 and 187 households were irrigation users living both in *Layealewuha* and *Lasetegerado* kebeles respectively. According to this information, from the total irrigation users, 49% and from the total household population, 64% of households living in both kebeles were found to be dependent on food aid to meet their food demand needs. However, the chi-square test confirmed that there is no systematic association between food aid and the food security status.

5.3.5 Household Engagement non-farming activities

It is clearly introduced in chapter four as the area belongs to one of the north eastern part of Ethiopia with low agro-ecological potential and natural resource assets, participation in non-farming activities might be alternative options for farmers' to support their food demands at household. With this fact, the study found that households' engagement in non-farm income sector was low. Only 27% of sample respondents declared that they were involved in non-farming activities. However, as respondents explained such income help households in meeting critical cash and food deficits and also enables them not reduced in grain or livestock thereby preventing undesirable leakages in their household resources.

The survey result confirms that the percentage of households engaged in non farming by food secure households was higher than food insecure ones though the chi-square test shows no significant relation between the two variables. As to the types of non-farm activities, the top three activities farming households participated are livestock trading, petty trading and preparation of local drinks which could be suggested as that of alternative areas of intervention to diversify their livelihood sources (see Table 13).

As to the types of non-farm activities, the top three activities they have been participating were livestock trading, petty trading and preparation of local drinks which could be suggested as that of alternative areas of intervention to diversify their livelihood sources. In light of this, greater emphasis has to be given to the enhancement access to non-agricultural activities especially that of households found with lack of farming oxen and female headed households.

Table 13: Engagement of household members in non-farming activity

	Food secure (82)		Food insecure (33)		Total (115)		$\chi 2$ test
	N	%	N	%	N	%	
Did any one of your household member participated in non farming activity?							
Yes	24	29.3	7	21.2	31	27	NS
No	58	70.7	26	78.8	84	73	(0.776)
What type of non farming activities your household engaged?							
Weaving	1	1.2	0	0	1	0.9	
Handcrafts	1	1.2	1	2.9	2	1.7	
Hair dressing	0	0	1	2.9	1	0.9	
Preparation of local drinks	5	6.2	0	0	5	4.3	
Livestock trading	7	8.6	1	2.9	8	7.0	
Petty trading	3	3.6	2	5.8	5	4.3	
Sell of fire wood	4	4.9	0	0	4	3.5	
Wage laborer/urban areas	1	1.2	0	0	1	0.9	
Employment as monthly paid	2	5.8	2	2.4	4	3.6	
Transportation of pack animals	2	2.5	0	0	2	1.7	

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

5.4 The Link between Irrigation and Food Security

Scientists from the international agricultural community have developed various indicators which facilitate consideration of all-important aspects of irrigation water management and overall progress of it comprehensively in SSA (Mark, Mandy, & Siwa, 2009). The indicators are institutional framework, water resource use, irrigation area, irrigation technology, agricultural productivity and poverty level of improvement observations. Hence, by taking into account some of the limitations of this research, essentially focused in micro- level analysis, which is difficult to apply all these indicators, the research intends to use these indicators with a bit of amendments pertinent to explore the current status of the irrigation scheme and its contribution to household food availability.

To show linkages between food security and use of SSI, assessment in terms of four major dimensions is undertaken. The first way that this study tries to link the use of small-scale irrigation to household food security is through calculating and comparing the shares of food grain produced by rainfed and SSI farming systems. The total share is grouped into two major categories. In one hand food grain produced from rainfed was summed up for each crop type and on the other hand food grain produced from both rainfed and SSI was summed for each crop type. Then the proportion of each category in relation to the total food grain produced in the study area for these two categories was analyzed to show by how much SSI contributed to the total amount of food available to the households.

In line with this, the second attempt focuses on the contribution of SSI in terms of amount of energy it has provided for the households in the study area. This is calculated by computing the net food amount supplied from irrigation only ((Kg/person/ day). Then dietary food calorie amount (Kcal/capita/day) obtained from SSI is found by multiplying the net food amount supplied from irrigation ((Kg/person/ day) by the conversion scale (Kcal/100gram) of each crop type. Finally, the total food energy obtained from each food crop cultivated using SSI was compared to the average dietary food calorie amount (Kcal/capita/day).

Thirdly, the total sampled households were categorized into SSI users and nonusers and the household food energy amount in Kcal of these groups were compared using t-test to check

whether there is any significant mean difference between users and nonusers which will clearly show any significant contribution of the scheme.

Finally yet importantly, using chi-square test, food security status of households and use of irrigation was tested to see if there is any significant association between the two variables as a basis to include it in logit model to crosscheck whether it is one of the determinant factors of food security when of course taken and run with other variables too. The analyses of these four ways adopted to link SSI to food security are discussed in the next consecutive sections.

5.4.1 Food grain availability from rainfed and SSI in the study area

An evaluation findings like FAO shows that the use of small-scale irrigation has a general increase in the availability of food and earning capacity of poor households in developing countries (FAO, Emergency and Rehabilitation Programme in Southern Africa Regional Intergency Coordination Support Office,Johannseburg,South Africa, 2006). Hence, in assessing the contribution of irrigation to household food security, measuring of a caloric intake per capita was applied in this paper by using the adopted HFBM. To this end, an attempt was made to apply combination of these techniques and estimated food energy supplied from irrigated agriculture in the study area.

All consumable food crops grown by farmers in the study area were collected in which households depend on for fulfilling their food demand. In doing so, the food crops grown from the irrigated agriculture and rain-fed were gathered separately to compare the difference. After that, the food energy obtained from each food crop was converted into household calorie requirements. Hence, it is simple to compare the food energy obtained by irrigation users and non-users in the study area. By following this procedure, the tabulated data in Table 14 well underpin the findings of the survey.

Table 14: Food grain available for the study area

Types of food grain	Total food grain production (q)			Food production distribution (%)		
	Rain fed agriculture	Rainfed + Irrigation agriculture	Total	Rainfed	Rainfed+ Irrigation	Total
Tef	112.25	289	401.25	27.98	72.02	100.00
Sorghum	382	700	1082	35.30	64.70	100.00
Maize	5	398	403	1.24	98.76	100.00
Wheat	0	0	0	0.00	0.00	0.00
Chickpea	0	6	6	0.00	100.00	100.00
Lentil	0	0	0	0.00	0.00	0.00
Fababeans	0	0	0	0.00	0.00	0.00
Total	**499.25**	**1393**	**1892.25**	**26.38**	**73.62**	**100.00**

Source: Survey result, 2011

As can be seen from the above table, the share distribution from total grain food produced by both Rainfed and Irrigated agriculture, and Rainfed farming is 73.62 % (1393 q) and 26.38% (499.25q) respectively. The staple food crops grown include *Tef,* sorghum, maize and chickpea comprising of 72.02%, 64.70%, 98.76% and 100% was supplied by irrigated and rainfed farming system, whereas the rain fed agriculture comprising 27.98%, 35.30%, 1.24% and 0% for Tef, sorghum, maize and chickpea respectively. When comparing these respective proportions with the proportion supplied by a combination of irrigated and rainfed farming, it is obviously clear that that the greater proportion of food crops produced is supplied by irrigated agriculture for the study area in particular and the Woreda in general.

5.4.2 Net Food Grain Supply from Irrigated Agriculture

The irrigated agriculture contribution in terms of households energy supply is found very large (.i.e. 1931.35 (Kcal/capita/day). This is because of the net food crops produced by using the irrigation is much larger and these crops are the principal staple food sources around the study area. This figure (1931.35) is worked out following these steps. First as indicated above, since

the food crops grown from the irrigated agriculture and rain-fed were gathered separately, the irrigation scheme is found to be the source for three main food grains namely maize, *Tef* and chickpea for household consumption. Then food energy available from these three crop types used in the SSI scheme was calculated by multiplying the net food supplied from use of irrigation of each crop type by the conversion scale to get the household calorie requirements

Table 15: Contribution of irrigated agriculture for household energy supply

Types of food grain	Food supplied from irrigated agriculture (Quintal)	Net Food Supplied from irrigation (Kg/person/ day	Conversion scale (Kcal/100gram)	Dietary food calorie amount (Kcal/capita/day)
Tef	176.75	0.5802	358	569.05
Sorghum	0	0	359.2	0
Maize	398	1.3064	375	1342.21
Wheat	0	0	362.3	0
Chickpea	6	0.0197	372.3	20.09
Lentil	0	0	532.2	0
Faba bean	0	0	351.4	0
Total	**580.75**	**1.9063**		**1931.35**

Source: Survey result, 2011

5.4.3 Comparison of energy acquisition by irrigation users and nonusers groups

Another way of assessing contribution of SSI is through comparison of sampled households grouped into irrigation users and non-users in terms of their food energy obtained by their respective food source. Clearly, the survey indicates that there is better food energy availability for irrigation users than non users. That means an average of 3186 kcal was supplied for irrigation users while it was 2297 kcal for the non-users. In terms of food energy availability, the average per capita calorie supply for irrigation users was found substantially increased by 889 Kcal, which is about 42 % percent of the minimum requirement needed by an individual nationally (table 16). The t- test verified that there is a significance mean difference in mean food energy acquisition between users and nonusers at 1% significance level.

In connection with the food availability, the survey result shows that 73.2 % of food secure households were found to be users of SSI whereas 26.8% were non-users. Parallel to this

concerning food insecure household, 45.5% were users and 54.5% were non users. The chi-square result confirmed also a significance association between use of irrigation and food security status at 5% significance level. This finding is so important since it shows that access to irrigation is one of factor that influences household's food security in the study area. This might be clearly shows that an irrigation user can cultivate either a range of crops or increase in volume of production of crops in the irrigated agriculture; hence it contributes to ensure household food security especially in areas, which are vulnerable to drought. But it is hard to believe that they are consistently food secure since the survey shows that some of irrigation users were food insecure.

Table 16: Sample households in category of irrigation use

	Food secure (82)		**Food insecure (33)**		**Total (115)**		**$\chi 2$ test**
	N	**%**	**N**	**%**	**N**	**%**	
Are you irrigation user							**7.968****
Yes	60	73.2	15	45.5	75	65.2	
No	22	26.8	18	54.5	40	34.8	
Household food energy amount in Kcal							
			M	**SD**	**t-test**		
Irrigation user			3186	1402			
Non user			2297	847	3.664***		

5.4.4 Major crops cultivated in irrigation

As depicted in table 17, the production pattern in the scheme differs considerably by types of crops grown among irrigation users, most of the farmers (59%) cultivate food crops, while very few cultivates vegetables (33%) and fruits (8%). Furthermore, a widely grown crops from the irrigated agriculture where food crops like maize and Tef and cash crops of pepper and onion with a proportion of 32 %, 26%, 18% and 13% of areas during last year production season, respectively.

Table 17: Cropping pattern in the irrigated agriculture

Crop type	Number of farmers Grown the crop	Farmers' irrigated land coverage (%)	Subtotal Coverage (%)
Maize	62	32.1	
Tef	50	25.9	59
Chickpea	2	1.0	
Pepper	35	18.1	
Onion	26	13.5	33
Tomato	4	2.1	
Sugar cane	4	2.1	
Banana	3	1.6	8
coffee	4	2.1	
Avocado	1	0.5	
Papaya	1	0.5	

Source: Survey result, 2011

In regarding with management of irrigated agriculture, as data collected from the FGD reveals that farmer grows two times a year using improved varieties of seeds mainly maize and vegetables. They responded that because of the absence of agricultural inputs delivery organization and the poor germination of improved maize, farmers preferred to use local variety seeds onwards.

According to their explanations, the reason for their preference for pepper and onion production is due to the fact that these are the best of all vegetables not affected by pests and diseases. Recently, onion has also attacked by pests and disease according to the explanation given by sampled respondents. Moreover, the land preparation work has not done till this survey was made. The researcher also observed that only one farmer families were acting in planting of pepper during this survey was made though the time is appropriate for planting of vegetables.

Figure 5 Household family members planting of pepper in their farm land

In addition, as to the crops diversification the study investigates categorizing the crops grown in to four groups. In this study, the concepts of diversification is a farmer intends growing of a single crop in to mixing of any type of food and/or cash crops together targeted to incur a better yield or/and risk management that has been faced in their local context as outlined in table 18.

The finding of the survey confirms that there was an emphasis given by smallholders on cultivation of staple food crops (34.8%) in their farming system. The second, 32.2% of sample households was adopting mixing of food and commercial crops in their land and the third and fourth method of crop diversification adopted by farmers were growing of commercial crops only and combination of all food, vegetables and fruits together comprises about 19.1 % and 11.3 % respectively.

Table 18: Major crops diversification

Cluster of crop diversifications	Food secure (82)		Food insecure (33)		Total (115)		$\chi 2$ test
	N	%	N	%	N	%	
Growing of staple food crops only	24	29.3	19	57.6	43	34.8	
Growing of food crops & commercial crops	24	41.5	3	9.1	37	32.2	**12.839****
Growing of commercial value crops only	14	17.1	8	24.2	22	19.1	
Growing of food crops, vegetables & fruits	10	12.2	3	9.1	13	11.3	
Total	**82**	**100**	**33**	**100**	**115**	**100**	

Source: Survey result, 2011

*Note: ** indicates that the coefficients are statistically significant at 5%.*

The study result verifies that vegetable and fruit productions are limited as compared to food crops production using the scheme. Hence, this case study approves that the strategy flowed by smallholders was focusing on production of food crops and it may also helps smallholders in the future to tackle the problem observed food insecurity in the area. As can be seen from the table above, chi-square test showed that there is a significant association between farmer's type of diversification and their food security status at 5% level of test.

5.4.5 Irrigated Area and Allocation among Users

A small holder in the area hold an average size of 0.06 ha of total cultivable crop land and an irrigation user has an average of 0.13 ha of irrigated land as reported by sample farmers. Furthermore, as shown in table 18 , the irrigated farm size between food secure and food insecure households varies with an average size of 0.15 ha and 0.08 ha, and the distance from their residence to their plots is also varied significantly in average of 2.97 km and 4.16 km respectively. To this effect, the t-test tests show that there is significant difference between the two groups at 10% level of significance. It means that there is high probability for irrigation users who have a characteristics of having relatively large total cultivable land and irrigated size and who have their plots of land near to the irrigation water source to be food insecure than food insecure and the reverse also holds true (Table 18).

Table 19: Households' irrigated land size distribution

Cultivated land characteristics	Food secure (82)		Food insecure (33)		Total (115)		t-test
	M	SD	M	SD	M	SD	
Size of total cultivated crop land	0.65	0.21	0.49	0.16	0.60	0.21	**-3.546*** **
Size of irrigable land	0.14	0.13	0.08	0.10	0.13	0.12	**-2.811** **
How far your irrigated plot from the source of irrigation water (Km)?	0.50	0.86	1.16	1.22	0.98	1.16	**NS**
How far your irrigated plot from your home/residence (Km)?	2.97	3.48	4.16	2.18	3.80	3.05	**-2.365** **

Source: Survey result, 2011

*Note: *, **, *** indicates that the coefficients are statistically significant at 10%, 5% and 1% respectively.*

NS: - Not Significant

It might be that those farmers who have relative large size of land and farmers living to nearest place will have more time to spend in their farm plots the necessary management practices day to day (supply of water, watching of growing plants and others) as a result they obtained high crop yield which is enough to fed their family members.

This figure indicates that from the total population of two kebeles about 65% are who have an access from the irrigation scheme. And, among the total beneficiaries, the proportion of male and female households is 58 % and 7% respectively. It means that the irrigation scheme is serving majority of dwellers and it can be considered as a virtual source of food sources for the study area.

5.4.6 Irrigation methods of the area

Various methods can be used to supply water to crops grown in the irrigation farm. A particular irrigation method is chosen to attain a better crop and a higher yield at farm level. According to sample households' responses, farmers have been practicing two types of irrigation methods in their field. A substantial number of farmers (57.4%) practice flooding and 7.8% used furrowing to irrigate the field. It means that flooding type of surface irrigation is the most widely adapted

method of irrigation in the study area. As to the reasons for their preference to the above mentioned irrigation methods, they noted that since flooding method is simple and it does not requires much labor they adopt it as first and most important method in their farm as can be seen in table 20 below.

Table 20: Irrigation methods and reasons for selection

Question	Responses	
	N	%
What type of irrigation methods you use?		
Flooding	66	88
Furrow	9	12
Total	**75**	**100**
Why you practiced the above mentioned irrigation method?		
Due to topography of the land	8	11
To use the water properly	9	12
since the method is simple	36	48
since I have labor shortage	22	29
Total	**75**	**100**

Source: Survey result, 2011

5.4.7 Present Status of Water Use Management

Irrigation scheme management involves quite a wide range of tasks like distribution of water, follow up of the day-to-day operation and maintenance and the likes at the ground. In view of these issues, the survey explored some aspects of water management. For this reason, the study used in-depth interviews' with WUA members, kebele representatives, extension agents, experts and farmers to investigate the subject in a better way.

5.4.7.1 Organization and Regulation Arrangements

The WUA is the lowest organizational structure established in the area. The secondary data sources from WAO verified that a WUA was organized initially when the irrigation scheme construction started in 1999. The WUA has seven members comprising of irrigation users from both kebeles. The WUA have regular meeting schedules to discuss every two weeks but it usually performed as required according to the explanation given by executive committee

members. The WUA meets with all the team leaders every month. The major tasks of the WUA are to decide on the schedule for water distribution, to plan and organize canal clearance, and to solve problems arising from the scheme. Hence during peak irrigation time, two WUA members will be assigned to visit the irrigation site to oversee the distribution and to deal with problems that might arise.

Under WUA there are '*Yewuha abats*', can be called team leaders, in each block principally working on managing of secondary and tertiary canals. In the study area, there are 42 teams, consisting of between 25 and 40 irrigation users each. It was observed that the scheme is mainly administered by '*Yewuha abats'* but, organizationally, team leaders informed by the WUC about the schedule for water distribution and canal clearance. Then, team leaders inform water users about the time of distribution and canal clearance. Most information channeled between team leaders and team members through informally, for example when they meet at the irrigation site. Irrigation users do not have their own meetings, but rather use the monthly general assembly of the kebele as a forum to share urgent information concerning irrigation. They have written bylaws accepted by beneficiaries which have been worked before the irrigation transformed in to modern scheme.

The kebele administration does not play a significant role in the management of the scheme, but they have various indirect roles in relation to assigning non-irrigation users for canal clearance in campaign days and handling cases of breaches of WUC rules before the Social Court. They also plays a role in chairing the kebele assembly meetings, where the field technician, DA or WUA have common forum about irrigation-related issues, and often where officials from the Woreda level came to pass information down to the communities.

5.4.7.2 Irrigation water use system

Worldwide experience shows that irrigation will perform better when the services provided by the scheme are financed by the fees collected from the farmers themselves. Hence, various methods are applied for charging of users such as using irrigation volume, the size of irrigated area and by a share of the harvested crop. To this end, in Alawuha SSI scheme, in principle they charged a fixed amount of money by the size of land irrigated an individual owned at the

irrigation scheme. An individual user is expected to pay a water fee of 2.50 birr per year for 0.125 hectare of irrigated land, which is very small in terms of the money should be collected and needed to cover its operational cost in the future. It can argue due to the fact that the researcher did not see enough capital collected by the irrigation association which is ready to cover such operation cost of the scheme.

The basic principle they follows in distributing the water is that each beneficiary will receives for 12 hours a day on round base until their crops reached to be harvested. Thus, farmers can cultivate the entire irrigable land and can receive till they satisfied if the water capacity is enough during the production seasons. A team typically has the right to use water in a group of four to seven farmers irrigate at the same time. Water is also allocated during the night, when farmers use torches or moonlights. It means that during shortage of water, they did not have a mechanism either to share it equally or give priority for vulnerable crops grown in the area. Hence, it affects the cultivation of vegetable crops like onions and others, crops which are past the flowering stage if the water is not applied at their appropriate time.

Table 21: Condition in water usage and conflict

Question	**Response**	
	Frequency	**%**
Do you get enough water for irrigation during all periods?		
Yes	30	40
No	45	60
Total	**75**	**100**
Have you ever faced any conflict in irrigation water?		
Yes	61	81
No	14	19
Total	**75**	**100**

Source: Survey result, 2011

Insufficient water is considered a common problem in Alawuha SSI, which is reflected by the fact that 30% of farmers in the survey reported that over the last one year they had not received

sufficient water (table 20). The farmers also reported that the scheme has maintenance and flooding problems. Moreover, due to fragility of the main canal, there is a leakage from the damaged main canal. Yet there is not maintenance work done once it was constructed in 1999. The fact that some of sample farmers were satisfied with water availability and did not see any problems in the scheme reflects that although parts of the scheme do not have any operational problems, other parts do. This impression is also confirmed by the discussions made with WUAs.

As a result it was reported that there was conflict among 61 irrigation users (81%) and they also explained that were dissatisfied with the WUA handling of the matters. Their dissatisfaction was by the fact that the WUA was not able to enforce the rules and ensure a fair distribution of water. The kebele officials and DAs also confirm that the ability to handle conflicts and enforcing the rules has been less marked by the committee in general.

According to the explanation made by WUA during our FGD, the payment is too small as compared with the benefits generated by the scheme. The main problem is that farmers feel that water is free and believe they can get it without paying since it is a common resource as elaborated by WUA committee members. The source of this attitude might be because of lack of an agreement and/or awareness made during the construction phase among all relevant actors on responsibility to take over in managing of the developed modern irrigation scheme altogether.

5.4.7.3 Community Participation

The public participation has been reflected mainly on labor contribution and small amount of money as a water fee. Particularly, canal clearance is done both by irrigation users and other community members through community campaigns. In the study area, PSNP has a large share in maintenance work of the scheme since it used as a source for food for work supplement for the entire community under the irrigation scheme. The WUA asks kebele administration to allocate community labor to assist the canal clearance from sediments and grass. The involvement of non-irrigation users caused dissatisfaction as they arguing that why they should contribute their labor since the number of irrigation users are enough to do so. Rather, their efforts shall be allocated in other natural resources works as underlined by respondents. The logic is that it

creates dependency and laziness to accomplish their work on time though they are benefiting from the irrigation.

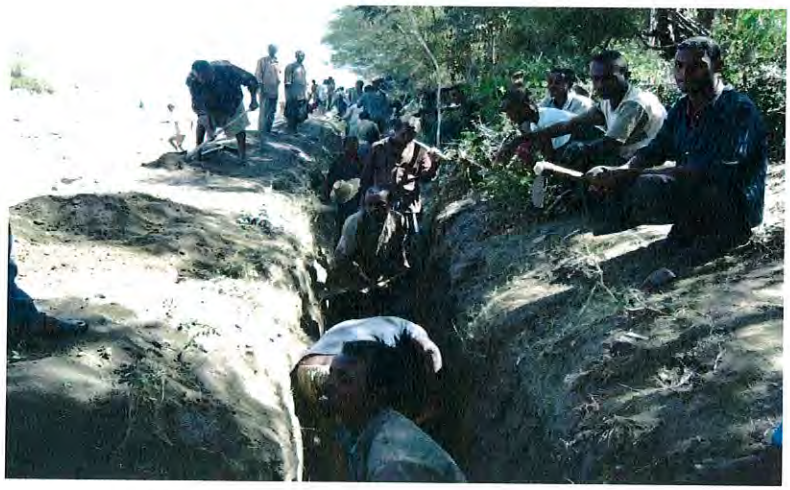

Figure 6 Community members participating in canal cleaning

In fact, it is unclear why irrigation users did not show motivation to clean the canals so far though they are the primary stakeholder and they set up well developed bylaws circulated by each team declared as every individual should have a responsibility to clean his/her part. Over all, the local community has as asset in traditional irrigation, and therefore it could be considered as a base for management of the irrigation development works in the area. But, although they have long history in irrigation, the current management system is not as such satisfactory and could not be consider as sufficient way of water management system.

5.4.8 Challenges of Small holders in Irrigated Agriculture

The survey attempted to identify major constraints of irrigation practice to contribute household food security requesting sample HH to respond based on their perceptions and experiences. Furthermore, the sample respondents were asked to rank the problems in order of importance. The results of the subjective assessment of the sample farmers are summarized in table 20.

The result of the descriptive statistics indicated that 38.67%, 36%, 13.33% and 6.67% of the sample farmers reported that the long distance between irrigation land and their residence, free

grazing, poor irrigation method practices and poor canal management problems were the first and the most important problems in the study area, respectively. Similarly, the result of descriptive statistics showed that very small proportion of the sample framers, 2.6% and 1.33%, reported that pest infestation, lack of improved seeds and high cost of agricultural inputs were their first problems, respectively.

In addition, the result of the descriptive statistics showed that poor irrigation methods practices, the long distance between irrigation land and their residence and poor canal management system were the second upper most problems to be considered in their irrigation activities as reported by 30.67%, 25.33% and 16 % respectively, sampled drawn from the study area. Likewise, the result of the assessment on challenges by target beneficiaries has shown that 18.67%, 13.33% and 12% of farmers perceived that poor canal management, poor irrigation methods and free grazing respectively were considered as the top problems ranked as the third important constraints in their priority setting.

In general, the summary result of the survey shows that the irrigated land distant from their home, obeying of poor irrigation methods, practicing of unsatisfactory ways of canal maintenance and cleaning, free grazing and poor crop selection in their farming were the five most important challenges that the community largely faces in their irrigated agriculture at 19.47%, 15.73%, 14.13%, 13.33% and 6.93% as reported by interviewed households in their order of priority respectively.

Table 22: Constraints in smallholder irrigation practices

	Ranking Responses											
	1st		2nd		3rd		4th		5th		Summary	
Challenges for irrigation	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**	**No**	**%**
Poor irrigation method practice	10	13.33	23	30.67	10	13.33	7	9.33	9	12.00	59	**15.73**
Weed problem	0	0.00	4	5.33	5	6.67	4	5.33	5	6.67	18	4.80
The distance form irrigable land to home is very far for proper management	29	38.67	19	25.33	9	12.00	11	14.67	5	6.67	73	**19.47**
Pest and disease occurrence	2	2.67	3	4.00	6	8.00	7	9.33	6	8.00	24	6.40
Poor canal management and cleaning	5	6.67	12	16.00	14	18.67	8	10.67	14	18.67	53	**14.13**
Poor crop selection	0	0.00	1	1.33	4	5.33	12	16.00	9	12.00	26	**6.93**
Lack of efficient extension support	0	0.00	1	1.33	2	2.67	3	4.00	3	4.00	9	2.40
Lack of provision of improved seeds	1	1.33	1	1.33	4	5.33	7	9.33	7	9.33	20	5.33
High cost for purchasing of agricultural inputs	1	1.33	3	4.00	7	9.33	5	6.67	9	12.00	25	6.67
Transportation problem	0	0.00	0	0.00	2	2.67	2	2.67	2	2.67	6	1.60
Marketing problem	0	0.00	2	2.67	2	2.67	5	6.67	3	4.00	12	3.20
Free grazing	27	36.00	6	8.00	10	13.33	4	5.33	3	4.00	50	**13.33**
Total sum	**75**	**100**	**75**	**100**	**75**	**100**	**75**	**100**	**75**	**100**	**375**	**100**

Source: Survey result, 2011

The above identified problems were also aired by the community, individual households, development agents and officials at Kebele level at the discussion made during the field survey. Discussion with the Woreda agricultural, mainly irrigation development experts revealed that among the challenges, shortage of improved seed provision, lack of self motivation, poor irrigation methods, flooding and the scheme's structural defect at the diversion wear (head work) were taken as the most pressing problems. In general, according to the explanation given by local community and quantitative data collected during the survey, one can conclude that majority of farmers are doing the same agricultural practices on irrigated land as that of rain-fed land, which limits to use the full potential of the scheme.

5.5 Econometric Result

This section presents food security determinants in the study area which is pulled out from econometric analysis results (i.e. binary logistic regression model). The section is sub-divided into three parts. In the first part, brief summary of bivariate analysis results of demographic, socio-economic and farming variables will be presented. Secondly, model specification and estimation procedure in addition with the hypothesized variables expectation and definitions will be explained. The third section will provide discussion on identified determinants of household food security situation of the study area.

5.5.1 Summary of Major Variables

In chapter four, bivariate statistical methods of analysis mainly t-test and chi-square were used to investigate the difference and association of various sets of continuous and discrete variables in relation to sample households' food security situation. In this regard, food secure households and food insecure households differ with respect to some demographic, socio-economic and farming characteristics. The detailed result of the means of the continuous variables and scores of discrete variables are given from Table 3 to Table 12 as you discovered previously.

Chi-square and t-tests were used to investigate presence or absence of difference between food secure and food insecure households regarding the values of each variable. Accordingly, household size, labor, size of cultivated land, size of irrigated land, irrigated plot distance from the head of water source, livestock ownership (excluding oxen), number of oxen were found having significant difference between food secure and food insecure households. On the other hand, sex, marital status, access to extension services, access to credit, application of improved agricultural inputs, farmers adopted cropping pattern and access to irrigation scheme has a systematic association to their food security situation.

From the results of the bivariate analysis one may consider two major points: First, food secure households in the area are peoples of more resource endowed and educated (who have better size of cultivable land, owns irrigable farming and livestock asset mainly oxen farming).Second, food secure households are who have supported from local institution like credit and so as to diversify their income source from non farming activities. However, such tests may put out of sight the

confounding effects of other variables that need to be disentangled. Thus econometric analysis is fundamental to clearly set out the major variables that determine the food security situation of the study area. In the next section, the results of analysis will be explained in detailed.

5.5.2 Determinants of Household's Food security

Before using the logit model for hypothesized variables, it is necessary to test the problem of multicollinearity or association among the potential independent variables. There are two measures that are often suggested to test the existence of multicollinearity. These are: Variance Inflation Factor (VIF) for association among continuous variables and contingency coefficients for dummy variables. VIF shows how the variance of an estimator is inflated by the presence of multicollinearity (Gujarati, 2003).

A statistical package known as SPSS was employed to compute the VIF values. As a rule of thumb, if the VIF of a variable exceeds 10, there is multicollinearity. To avoid serious problems of multicollinearity, it is quite essential to omit the variable with value 10 and more from the logit analysis (ibid). Thus, the variance inflation factor (VIF) was employed to test the degree of multicollinearity among the continuous variables.

As shown in the annexed table 6, the values of the VIF for seven continuous variables were found to be small (i.e. VIF values less than 2), indicating the data have no serious problem of multicollinearity. Similarly, the contingency coefficient, which measures the association between various categorical variables based on the Chi square, were computed in order to check the degree of association or the existence of multicollinearity problem among the categorical explanatory variables. The decision rule for contingency coefficients states that when its value approaches 1, there is a problem of association between the dummy or categorical variables, i.e., the values of contingency coefficients ranges between 0 and 1, with zero indicating no association between the variables and values close to 1, indicating a high degree of association.

Based on the correlation coefficient results, the computation reveals that there was no problem of association among the dummy / categorical and explanatory variables. Hence, after screening of the best variables among the hypothesized variables multicollinearity problems were checked for continuous and dummy variables respectively. Accordingly there was no multicollinearity

problem in both cases. After checking of it, model analysis was conducted.

In this study, the dependent variable is either being food secure or food insecure. In order to explain this binary variable, it is necessary to construct a model that relates the dependent variable to a vector of independent variables. The logit model was employed in this study to estimate the effects of the hypothesized independent variables on food security status of farmers.

Twelve independent variables which are found to be significant in the descriptive statistics were included in the model. These variables were selected by testing the existence of multicollinearity using Variance Inflation Factor (VIF) and contingency coefficients, in addition to their significance in the descriptive statistics. Hence, the various goodness of fit was checked and validate that the model fits the data. The likelihood ratio test statistics exceeds the Chi-square critical value at less than 1 probability level. This implies that the hypothesis, which says all coefficients except the intercept is zero, was rejected. The value of Pearson Chi-square test shows the overall goodness of fit of the model at less than 1% probability level.

Another measure of goodness of fit of the model is based on a scheme that classifies the predicted value of events as one if the estimated probability of an event is equal or greater than 0.5 and 0 otherwise. From all sample farmers, 93 were correctly predicted in to food secure and food insecure categories by the model. The correctly predicted food secure (sensitivity) and correctly predicted food insecure (specificity) of the model were 95.1 and 87.9 respectively. Thus the model estimated groups of food secure and food insecure accurately. The maximum likelihood estimate of the parameters and the effect of independent variables on the food security status of sampled households were analyzed and presented in Table 23.

The binary logit model identified seven significant variables out of the hypothesized twelve variables that determine household food security status in the study area. Among the factors considered in the model, six variables are found to have a positive influence on food security status of households and one factor, household size, was found to have a negative influence on household food security status (Table 23).

Table 23: The maximum likelihood estimates of the binary Logit model

Variable	B	Sig.	Exp(β)
Access to irrigation	1.324**	0.039	3.760
Age of household head	0.031	0.475	1.031
Household size	-0.797***	0.001	0.451
Dependency ratio	-0.164	0.748	0.849
Cultivated land	6.084**	0.013	438.597
Number of farm oxen	1.314**	0.018	3.720
Total livestock size	-0.027	0.898	0.973
Food aid	0.002	0.210	1.002
Education status	0.554*	0.095	1.739
Access to credit	1.437*	0.098	4.207
Nonfarm activity engagement	1.264*	0.089	3.541
Training participation	0.006	0.992	1.006
Constant	3.628	0.036	
-2Log likelihood	104.027		
Model chi-square	92.73	0.000	
Correctly predicted food insecure	87.9		
Correctly predicted food secure	95.1		
Over all cases correctly predicted	93		

Note:*significant at 10%, **significant at 5%, ***significant at 1%

Source: Model output

These determinant factors are number of oxen own (NUMBOXEN), total cultivable land size (TOTCULAN), household labor availability (HHLABOR), educational status of household head (EDUSTHH), access to irrigation (IRRACC), access to credit (CREDITACC), and participation in non-farming (NONFARM) activities. In light of the summarized model results possible explanation for each significant independent variable are given as follows:

Total cultivable land size: In this study it was expected that a larger size of cultivated land will have more chance of being food secure at household level. The logit result shows that the

variable has a significant difference in respect of household food security status. It is found that one of powerful variables which has a positive relationship with the food security status of the household at 5% level of significance. This means that those households which have larger cultivated land size are food secure than those having smaller land size are food insecure. The cultivated land size in the study area is not large (the minimum is 0.125 and the maximum is 1.25 and the mean is 0.60 hectares). Though it is small, the result shows that it largely influences household food security by an additional unit of cultivated through any means of arrangements in the study. It is due to the fact that in drought prone area like Gubalafto an increase in the size of cultivated land plays a significant role to increase food grains production which is needed to cover household food demand per year.

Access to irrigation: The model measures the relation between the use of irrigation users and non-user and status of food security. This variable positively influenced the food security status of the household. The results suggest that becoming an irrigation user on the household farm improves the status of household food security at 5% level of significance level. This can be justified by the fact that in moisture stressed areas like Gubalafto; getting moisture through irrigation farmers will improve agricultural production condition. Especially, smallholders can enable to grow food crops a minimum of twice a year, hence increased consumable food source of the household. So, it overcomes insufficiency of food availability mainly in drought or food shortage circumstance at large. Here, the coefficient of the variable confirms that they will get higher food energy by a factor of 3.076 being a farmer get irrigation access.

Number of Oxen Owned: Oxen are among the most important factors of production and as it was expected it determine household food security status of the study area. It is the fact that an ox is the sole input of draft power for land preparation in their crop farming system. Hence, it has significant contribution in supplying of food grain for the household member. In agreement with prior expectation, number of oxen owned by the household affects household's food security positively at a probability level of 5%. The more the number of oxen available to households the larger is the probability of being food secure. The positive sign of this variable indicates that the contribution of oxen ownership towards ensuring food security.

Household size: This variable was significant at 1% level of test and a negatively related to household food security status in the study area. This implies that, other things remaining constant, as family size increases by one person, the likely probability to become food secure decreases by a factor of 0.451. It is probably due to an increase in household size decrease cultivated land per capita and in return decrease the availability of enough food for a household. It also exerts influence on demand of non-food items, which has an impact on household food security status.

Educational status of household head: This variable has positive impacts on food security status of households and was significant at 10% level. Holding other variable constant, a change in household head education level by one unit, say one grade, will increase a probability of being more food secure by a factor of 1.267. The possible justification for this finding was that educated farmers tend to use adequate knowledge in their agriculture; especially farmers could have an ability to operate and manage irrigation systems in modern way, which can propel production and yield to meet the household food demands than illiterate ones. Thus, being literate reduces the chance of becoming food insecure, which makes them to be sufficient in food than uneducated ones. This result is in agreement with findings of Abebaw (2003) as stated that education has positive and significant effect on household food security.

Household access to credit: This is one of institutional factor that determine food security situation of farm households .The logit model analysis revealed that credit has a significant positive association with food security status (at a probability level of 10%). This is in agreement with the prior expectations about the impact of the differential access to credit service. This is because a farmer who has access to credit can overcome his/her financial constraints and can purchase various agricultural inputs (mainly oxen farming, improved seed and chemicals) required for his/her farm production to produce more through purchasing of agricultural inputs. The households with more access to farm credit have possibility to reduce the probability of being vulnerable to food insecurity. The odds ratio in favor of food security increases; other things remain constant, by a factor of 4.207 as farm households get access to farm credit.

Off-farm/non-farm income (OFFNONFI): This variable represents the involvement of an individual from the household members in off/non- farm activities and utilized the generated income in cash or in kind mainly for household food consumption purpose during the year. Empirical findings indicate that off-farm/non-farm income have effect on food security. In the areas like Gubalafto, where the farmers face crop failure, the benefit earned from off-farm activities is an important means of acquiring food. The result suggests that households engaged in off-farm activities are endowed with additional income and less likely to be food insecure. Consistent with the hypothesis, off-farm income is positively and significantly associated with farm households' food security status (at probability level of 10%).

Hence, the econometric result gives a clue in the variables should be considered during interventions in order to overcome the problem of food insecurity in the study area.

6. CONCLUSION AND IMPLICATION

6.1 Conclusion

Given the significance of ensuring food security at household level in Ethiopia, micro-level analysis on identification of household food security determinants and the link between food security and utilization system of small scale irrigation must get due emphasis and considerations in policy, research and development works. This chapter presents what has been learned from the study as a conclusion and forwards possible implications for concerned stakeholders to address the problem of food insecurity. The study was conducted in North Eastern Ethiopia, where majority of smallholders living in a situation for food gap of 3 to 6 months of period annually to meet their minimum food requirements due to erratic rainfall patterns accustomed in the area.

The study shows that average annual food availability of the study area is 2877 Kcal per capita per day, which is better than the national value (2100kcal). On the contrary, the food insecurity problem is observed at 29 % of sample households, about 1605 kcal per capita of food energy of per individual. There is an average of 24% calorie insufficiency to fulfill the minimum national requirement by small holders. On the contrary, the household's food energy acquisition for those households having irrigated agriculture is found to be higher than rain-fed dependent households. In general, in the study area, food security situation is found with high variation situation (highly food insecure to generally food secure status among the sample respondents) but it has good crop farming potential resources for ensuring household food supplement. And it is observed that SSI is one of the viable solutions to secure household food needs in the study area, hence promoting of smallholders in production of directly consumable food grains is advantageous. The question that may come is that why such gaps among smallholders? Is it due to lack of addressing the structural food insecurity causes of the area?

To this end, the attribute to the difference in household food security status were not because of differences in irrigation access alone. On top of this, the study result disclosed that determinants of household's food security are characterized by distinctive socio-economic and biophysical features of sampled households. In other words, those households that maintain greater number

of oxen, better household size, haves relatively large size of cultivable land, educated household heads, who have access to credit, irrigation land and participated in non farming activities could play an important role in improving food security situation of the area.

From crop farming/agronomic point of view, it can conclude that there is good potential resource suitable for intensive agriculture in the study area like irrigation water, land, oxen and labor. In the study area, it is observed that irrigation water is crucial and contributed to improve the food security situation at household level. The analysis proves that irrigation has a significant effect on average calorie supplement at the household level. The result shows that there are about 889 kcal differences among irrigation users and non users. And the test verified that the higher amount of food sources by irrigation user households are not due to chance. It is because of the marginal differences in food crops cultivated from irrigated agriculture.

Hence, it is viable to advocate a farming system focused on production of directly consumable food crops centered approach through improved supply of institutional credit, assured irrigation facilities and better extension support services in the study area. Apparently, food availability can be assured by mainly boosting of food grain production strategies. However, the recurrent drought problem of the area which is accompanied by an additional pressure on the already inefficient irrigation water application system leads to serious food shortage conditions. So, without improving the existing irrigation water use system the long-term sustainability of food security is uncertain.

The farmers practice under using the constructed SSI scheme is mainly on but not as such in satisfactory way and it can be said that it is managed similar to the rainfed agriculture system. The attitude of farmers in using improved agricultural inputs is promising but needs further encouragement. Moreover, the local community indigenous water use system is remarkable but requires additional technical and management support by relevant stakeholders. In the future there is a need to make further scientific studies on cropping pattern and selection.

To this end, significant problems that are challenging sample households in irrigation agriculture such as the long distance between their farm and home, practicing of poor irrigation methods, lack of on time canal maintenance and cleaning, free grazing and poor crop selection have to be

considered and addressed in order to use it efficiently, and hence, improves the life of small holders around the study area. Therefore, based on the assessments of the existing scenario on food security and irrigation development about the area, it is intended to forward appropriate strategies and ranges of intervention options, in the following section.

6.2 Implications

This study has some implications for policy making to improve situation of household food security and to enhance its linkage with irrigation farming system. Hence, some of the options that should be taken in to consideration are suggested below.

Education is very important determining factor that show positive and significant impact to determine food security status of households in the study area. The more household head educated, the higher will be the probability of educating family member and familiar with modern technology. And it is central to adopt and use modern agricultural technologies and practices, agricultural information and institutional accessibilities which in turn increase and improve farm household's food production. Thus government has to give due attention for training farmers through strengthen and establishing both formal and informal type of education, farmers' training centers, technical and vocational schools.

The result of econometric analysis also revealed that households with oxen holdings are more likely to be food secure. An ox is the main draft power source for crop land preparation that directly contributes to betterment of food security status of the area. Therefore it is imperative that development strategy should able to give due attention for livestock sector in availing of oxen farming through credit and overall management of livestock production that aimed at improving food security status of people living at Alawuha area.

The results of the study showed that concentration of cultivated land size was 0.60. These results revealed that distribution of land size is equitable and very small. Therefore, further redistribution of land will not solve the problem of food security in the study area since there is limited land. Hence, other options should be looked into in order to improve food security status of the households like improving the quality of land through improved soil and nutrient

management, promotion of effective utilization of the constructed irrigation scheme and creation of rural employment opportunities. On the other hand, it needs to intensify small holder farming system. In order to intensify the farm, farmers should be supported in provision of modern agricultural technologies and inputs focusing to boost production status on their piece of cultivated land to be able to get more yields per unit area.

Moreover, the study result disclosed that it is important to stress on non-farming activities to supplement the agriculture sector so as to develop sustain way of livelihood system in the study area. Since the area has also potential livestock asset (like camel and donkey) which is used for transportation purpose and other alternative income-generating activities. It might stabilize the problem of excessive productive labor and rainfall variability faced in the area.

Sustainable food security intervention must not exclude the improvement of production and productivity of agricultural sector through use of irrigation. As the findings of this study assured, irrigation and food security are positively and significantly related in the study area. Therefore, development strategies and programs related with food security through agricultural production should think about the importance of irrigation. Hence, the development of small scale irrigation activities should be further strengthened. However, in the irrigated agriculture the following points have to be considered to utilize the full capacity of the irrigation scheme:-

- Developing basic irrigation scheduling methods for farmers.
- Organize capacity-building activities to advance the farmers' participation in irrigation water management to upgrade their existing indigenous way of management system.
- The stakeholders in irrigation are important and concern the provision of services in the form of agricultural extension advice, input supply, and possibly for technical and financial support in repairing and maintaining of the scheme.
- Expansion and promotion of family planning programs/services since household size affect negatively their food security situation.
- Development of social infrastructures around SSI scheme so as to attract smallholders to settle near to their farm so as to utilize the constructed irrigation scheme efficiently.
- Conduct studies and advice in cropping pattern, crop-water-yield function and market opportunities for crops produced around the area.

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APPENDICES

Annex 1 Food Composition Table for Use in Ethiopia –Part III:

No	Food and Description	Local name	Food energy
1	Tef, Eragrostis tef (Zucc.)Trott.	T'yef,dibilliq	358.90
2	Corn (maize) , Zea mays L. :white, whole grain	Beqqollo, nech	375.00
3	Sorghum, Sorghum spp.: white, whole grain	Mashyilla, nech	359.20
4	Wheat, Triticum vulgare vill.: white ,whole grain	Sindye, nech	362.30
5	Broad beans, Vicia faba L. :,whole, dried	Baqyela,difin	351.40
6	Chickpeas,Cicer arietinum L.: whole, dried	Shimbera, difin	372.30
7	Lentils, Lenss culinaris Med.:, whole, dried	Missir, difin	352.20
8	Peas.field,Pisum sativum L.: whole, dried	Ater, difin	355.30
9	Vetch,Lathyrus sativus L.: dried	Gwayya,dereq	347.00

Source: Ethiopian Health and Nutrition Research Institute (EHRI)

Annex 2 Adult Equivalent Conversion Factor

Age Category	Adult equivalent Ratio
Male less than 10	0.6
Male 10 to 13	0.9
Male 14 to 16	1
Male 17 to 50	1
Male greater than 50	1
Female less than 10	0.6
Female 10 to 13	0.8
Female 14 to 16	0.75
Female Male 17 to 50	0.75
Female greater than 50	0.75

Source: Source: Institute Pan African Pour le Development (1981); cited in Strock et al. 199

Annex 3 Total livestock unit conversion factor

Livestock	Average Biomass (Kg)	TLU Equivalent
Camels	250	1
Cattle	175	0.7
Sheep/Goat	25	0.1
Horses/Mules	200	0.8
Donkeys	125	0.5

Source: Source: Storck, et al. (1991)

Annex 4 Dietary energy availability of sampled HHs in Kcal /person/day

ID NO	GP	GB	GG	FA	Sub total	HL	GU	GS	GV	Sub total	NGA
1	3925	204	0	415	4545	0	208	1581	0	1789	2755
2	7150	467	0	93	7710	0	205	3550	186	3942	3768
3	1243	178	0	0	1421	0	184	242	0	427	995
4	1400	104	0	319	1824	0	53	213	0	267	1557
5	2708	488	0	0	3196	0	190	770	0	961	2236
6	3875	416	0	271	4562	0	204	1102	0	1306	3256
7	7305	482	0	0	7787	0	341	5237	0	5578	2209
8	4966	147	0	598	5711	0	225	1651	0	1876	3835
9	3854	229	0	178	4262	0	179	1253	0	1431	2831
10	2999	218	0	0	3217	0	143	1000	143	1285	1932
11	2667	209	0	0	2876	0	213	1067	0	1280	1596
12	1201	385	0	449	2034	0	90	300	0	390	1644
13	5904	1224	0	0	7128	0	443	1771	0	2214	4914
14	1387	221	0	425	2033	0	107	640	0	747	1287
15	1305	239	0	0	1544	0	93	373	0	466	1078
16	1150	267	0	344	1760	0	115	460	0	575	1185
17	2134	157	0	531	2822	0	160	854	0	1014	1808
18	2824	224	0	0	3049	0	153	763	0	916	2133
19	3493	489	0	373	4354	0	187	499	0	686	3668
20	4484	124	0	378	4985	0	158	1282	0	1440	3545
21	6042	122	0	0	6164	0	249	1757	0	2006	4158
22	1757	72	0	437	2266	0	110	512	0	622	1643
23	2952	80	0	408	3441	0	123	984	0	1107	2334
24	3157	86	0	437	3679	0	132	1228	0	1359	2320
25	2990	169	0	458	3617	0	115	920	0	1035	2582
26	2051	182	0	464	2697	0	93	746	0	839	1858
27	2638	277	0	375	3290	0	283	1130	0	1413	1877
28	4554	124	0	0	4678	0	379	1012	0	1392	3286
29	3238	140	0	379	3757	0	143	1333	0	1476	2281
30	2725	133	0	407	3266	0	136	545	0	681	2584
31	3243	183	0	373	3799	0	187	748	0	935	2863
32	1990	195	0	396	2581	0	149	597	0	746	1835
33	1951	110	0	449	2510	0	150	450	0	600	1910
34	3267	168	0	343	3778	0	172	860	0	1032	2746
35	3689	154	0	368	4211	0	123	1230	0	1353	2858
36	3339	336	0	434	4109	0	145	1016	0	1161	2948
37	4598	167	0	0	4764	0	170	1703	0	1873	2891
38	3542	612	0	0	4154	0	295	1180	0	1476	2678

ID NO	GP	GB	GG	FA	Sub total	HL	GU	GS	GV	Sub total	NGA
39	2872	282	0	397	3552	0	120	957	0	1077	2475
40	2362	168	0	392	2922	0	82	656	0	738	2184
41	3406	349	0	271	4027	0	204	1090	0	1294	2732
42	4722	144	0	588	5455	0	295	1180	0	1476	3979
43	12177	245	0	0	12422	0	334	5071	0	5405	7017
44	3652	146	0	396	4195	0	149	1311	0	1460	2734
45	7996	369	0	0	8365	0	377	3031	0	3408	4957
46	3614	152	0	387	4153	0	155	1574	0	1729	2424
47	5695	255	0	339	6289	0	170	2244	0	2414	3875
48	3875	179	0	455	4508	0	183	1286	0	1469	3039
49	7725	200	0	0	7925	0	272	2761	0	3033	4892
50	3338	160	0	436	3934	0	109	1341	0	1450	2484
51	2379	115	0	390	2884	0	118	791	0	908	1976
52	4135	267	0	407	4809	0	204	1374	0	1579	3230
53	4588	277	0	375	5240	0	283	1524	0	1806	3434
54	6546	144	0	0	6690	0	295	1771	0	2066	4624
55	8307	267	0	0	8573	0	204	3318	0	3522	5051
56	2373	175	0	356	2904	0	134	374	0	508	2397
57	6219	214	0	327	6760	0	164	2235	0	2399	4361
58	4715	219	0	356	5290	0	134	1626	0	1760	3530
59	4232	186	0	379	4798	0	143	1342	0	1484	3313
60	6043	267	0	0	6309	0	204	2192	0	2396	3913
61	996	138	0	560	1694	0	0	281	0	281	1413
62	6231	167	0	0	6398	0	170	1960	0	2131	4267
63	6488	95	0	0	6583	0	245	2158	146	2549	4035
64	3649	119	0	0	3768	121	121	1213	61	1516	2252
65	2728	106	0	0	2834	56	108	1094	0	1258	1575
66	3302	373	188	375	4239	0	188	582	0	770	3469
67	3422	75	0	0	3497	0	154	1399	0	1553	1944
68	5129	95	0	0	5224	0	195	1981	0	2175	3049
69	5055	122	0	0	5177	249	249	884	125	1507	3669
70	3619	93	0	0	3712	0	143	286	190	619	3093
71	3674	104	0	531	4310	0	107	1522	160	1788	2522
72	5357	78	0	0	5435	0	120	1798	0	1917	3518
73	10296	371	0	0	10667	253	253	2794	0	3300	7367
74	8387	294	0	0	8680	0	225	1985	150	2360	6321
75	2108	278	0	280	2666	0	70	562	0	633	2034
76	1077	1197	0	449	2723	0	53	0	0	53	2670
77	885	588	0	0	1473	0	89	0	0	89	1385

ID NO	GP	GB	GG	FA	Sub total	HL	GU	GS	GV	Sub total	NGA
78	2383	135	0	0	2518	0	69	421	69	560	1958
79	2275	101	0	513	2888	0	103	618	0	721	2167
80	1171	143	0	292	1606	0	73	439	0	512	1093
81	1747	557	451	538	3293	0	108	216	0	324	2969
82	1789	88	0	0	1876	0	89	716	0	805	1071
83	2415	110	0	299	2824	0	113	900	0	1013	1811
84	2175	95	0	0	2270	0	97	592	0	690	1581
85	3154	275	0	0	3429	0	105	1149	0	1255	2175
86	2067	91	0	25	2183	0	93	559	0	652	1530
87	4195	369	0	0	4563	0	188	1524	0	1712	2851
88	1500	91	0	186	1777	0	93	0	0	93	1683
89	759	124	0	0	883	0	95	0	0	95	788
90	3480	202	0	0	3681	0	103	851	0	954	2727
91	1929	93	0	474	2497	0	76	770	29	875	1622
92	4041	93	0	0	4134	0	143	1341	0	1484	2650
93	6466	327	0	0	6793	0	251	1715	0	1965	4828
94	12762	495	0	0	13257	0	253	4599	0	4852	8405
95	4008	177	0	180	4364	0	181	1273	0	1454	2911
96	3333	186	0	504	4023	0	152	1023	0	1175	2848
97	1608	1383	0	259	3251	0	33	272	0	304	2947
98	6218	214	0	0	6432	0	164	1798	219	2180	4252
99	4071	206	0	315	4593	0	158	1274	0	1433	3160
100	8065	93	0	0	8158	0	190	2873	190	3254	4905
101	7204	267	0	0	7471	0	272	3330	421	4023	3448
102	2864	231	0	118	3213	0	118	1180	0	1298	1915
103	2013	246	0	301	2560	0	80	604	0	684	1875
104	4055	221	0	450	4726	0	90	1297	0	1387	3339
105	4534	244	0	0	4778	0	162	748	0	911	3867
106	1735	950	293	365	3342	0	55	598	0	653	2689
107	3028	147	0	0	3175	0	150	600	300	1051	2124
108	3422	151	0	384	3956	0	92	1085	0	1177	2779
109	3202	182	0	371	3756	0	93	940	0	1033	2722
110	1850	922	0	395	3168	0	132	529	0	661	2507
111	4048	248	0	252	4548	0	190	1518	0	1708	2840
112	1441	93	0	190	1724	0	71	286	0	357	1367
113	4605	369	0	188	5161	0	141	1164	0	1305	3856
114	1920	104	0	319	2344	0	107	640	0	747	1597
115	5380	248	0	0	5627	0	190	1540	0	1730	3898

Source: Own computation, field survey 2011.

Annex 5 Contingency Coefficients for Discrete Explanatory Variables

	Constant	ACCIRR	EDUSTAU	ACCCRE	NONFARM	TRAIN	FOODAID
Constant	1.000	-0.526	-0.387	-0.142	-0.245	-0.258	-0.638
ACCIRR		1.000	-0.090	-0.047	0.186	-0.083	0.270
EDUSTAU			1.000	0.023	-0.157	-0.111	0.132
ACCCRE				1.000	0.005	-0.074	0.034
NONFARM					1.000	-0.066	0.093
TRAIN						1.000	-0.019
FOODAID							1.000

Source: Model output

Annex 6 Variance Inflation Factors (VIF) of Continuous variables

Variables	**Tolerance**	**VIF**
HHAGE	0.581	1.720
HHSIZE	0.730	1.369
DEPRAT	0.813	1.230
CULLAND	0.647	1.483
OXENSIZE	0.487	1.052
TLU	0.478	1.092

Source: Model output

Annex 7 Research questionnaires

Questionnaire for the household survey

Part one: General information

1. Questionnaire identification number _____
2. Date of interview (Ethiopian calendar) _____
3. Name of respondent's Kebele: 1) Derogeber 2) Lasetegerado
4. Name of respondent's village/Got/ _____
5. Sex of household head : (1) Male (2) female
6. Religion of household : 1) Muslim 2) Orthodox 3) other(specify)_____
7. Marital status of household: (1)Married (2) Single (3) Divorced (4) Widowed
8. Are you an irrigation user/Alawuha SSI : (1) yes (2) No
9. Educational level of household head: (1) illiterate (2) Literate (read and write only) (3) Grade 1 to 4 (4) Grade 5 to 8 (5) Grade 9 to12 (6) Other (specify)_____
10. Social status or responsibility in your community : (1) Kebele Administration (2) Religious leader (3) Local institution/CBOs (4) Traditional healer 5) Elder (6) Agricultural cooperatives administration (7) Water committee (8) others (specify)_____
11. Age of household head/farming experience: _____
12. Total household size _____
13. Could you list out the age category of your household members?

Age category (years)	**Sex**		**Total**
	Male	**Female**	
Individuals who are less than and equals to 10			
Individuals who are 11-14			
Individuals who are 15-64			
Elders who are over 64			

1. Did all your household members participate in farming work? (1) Yes (2) No
2. If your answer is yes, how many of them engaged, who are under the age of 15 to 64? __
3. Could you tell the total land size you have owned (hectare)?

Land category	Cultivated land (rainfed agriculture)	Cultivated land (irrigable land)	Grazing land	Total
Own				

Part two: Food production and/or Agricultural productivity status

4. How many of food grain was **AVILABLE** for your family consumption purpose during the past one year production time (in Quintal)?

Name of grain/crop	**How Many grain Produced?**	**How many grain Bought?**	**How many grain obtained via gift or Remittance?**	**How many grain reserved for seeding?**	**How Many grain Sold?**	**How many grains given to others?**	**How many grain lost after post harvest?**	**How many grain gains as food aid?**
Tef								
Sorghum								
Maize								
Wheat								
Chick peas								
Lentil								
Beans								
others								

5. Have you got **food aid** as PSNP beneficiary or any emergency program to supplement your consumption gap? 1) Yes 2) no
6. If yes, for how long you received food aid for the past one year? 1) 3 months 2) 4 months 3) 5 months 4) 6 months 5) other (specify) _____months
7. Do you have livestock? 1) Yes 2) No
8. If yes, indicate the number of livestock you have last year:-

	Type of livestock										
Livestock number	Oxen	Local cows	Bull	Heifers	Calves	Goats	Sheep	Camel	Donkey	Bees	Hens

9. How did you operate your farming activity last year? 1) Using own oxen 2) Coupling with other

farmers 3) Borrow from friend and/or relatives 4) By contributing labor to a person who has oxen 5) By sharing the land 6) 0thers (specify)_____

10. Had you faced unable to cover land under crop due to shortage of oxen? 1) yes 2) No
11. If yes, how much of land size not covered by crops _____? (hectare)

Part three: Agricultural Extension, Credit, Marketing and other institutional support services

12. Did you use improved seed varieties in past production time? 1) Yes 2)No
13. If your answer is yes for # 12, did you face a problem in using the improved seeds? 1) yes 2) No
14. If you faced a problem in using of improved seeds, what are those? _____
15. Did you use inorganic fertilizer in past production time? 1) Yes 2)No
16. Did you use chemicals to kill pests if you had a problem? 1) Yes 2)No
17. Had you get an extension support by development agents during 2009/10? 1) Yes 2) No
18. If yes for the above question, for how many time they visited your farm?___ (no of contacts)
19. What were the purpose of the DAs' visits?_____(multiple answers possible) 1) To give an advice on crop production 2) To give an advice on animal production 3)To give an advice on irrigation 4) To give an advice on soil conservation 4) To collect taxes 5) Others(specify)_____
20. Is there Farmers training center (FTC) in your locality? 1) yes 2) No
21. How far is the FTC distance from your residence _____ in Km
22. If there is FTC, have you participated in the training organized last year? 1) yes 2) No
23. If yes, in which topics you had been trained from the lists mentioned in the table below?

Training topics	**How many rounds you have been trained (numbers)**	**For how long you have taken (days)**
Agronomy		
Livestock production		
Irrigation technology		
Natural resource management		
Soil and water conservation		
Agricultural Marketing		
Agricultural inputs		
Agricultural Credit		
Post harvest crop management		
Others (specify)		

24. Had you got any type of credit (in cash or kind) in 2009/10? _____1) Yes 2) No
25. If your answer is yes for the above question, for what purpose you take the credit? 1) Purchase of improved seeds 2) Purchase of fertilizer 3) Purchase of chemicals 4) Purchase of oxen 5) Purchase of small ruminant animals 6) Others (specify) _____
26. What were your sources of credit?

Name of credit source	**Response**	
	Yes	**No**
Agricultural service cooperatives		
Local government banks		
Traditional association (Iddir etc.)		
Local institution (Shelf help groups)		

6. What are the sources of irrigation water?
7. What is the role and number of irrigation scheme water use association?
8. What are the rules and regulation (bylaws) practiced by the irrigation scheme water association?
9. What are the major constraints or draw backs of to use irrigation water in order of importance?
10. What is the nature of conflict related to irrigation water and measures taken to resolve conflicts? Is the irrigation water available throughout the year?
11. How is water distribution handled for all beneficiaries? Who is more favored and who is not? Why?

Checklist for Woreda level discussion

1. Could you describe please the role of your institution in the existing irrigation scheme management system at Alawuha site?
2. How do you see the importance the irrigation scheme to the economic well being and in particular growing crops needed to improve the food supply?
3. What are the constraints observed in utilization of irrigation water and the possible solution needed to upgrade the potential of the scheme capacity such as changes in irrigation method, delivery and storage systems, adjustments in crops and irrigated acreages, or improved scheduling in the delivery system? How do you see the current condition of the scheme canals and structures and its maintenance work?
4. Is the water available throughout the season and how is it determined to distribute for irrigation users?
5. Are there existing water users organizations? Are they effective in distributing water equitably and efficiently? Are they capable of maintaining the irrigation systems and collecting fees for canal maintenance? What can be done to improve existing organizations?
6. How do you see the cooperation between all users involved in the operation, maintenance, and improvement of the irrigation system?
7. What are the water laws of the region and the community bylaws established to secure fair utilization system among users?
8. What are the marketing activates given for small holders like availability of price and marketing information and tackling the marketing bottlenecks and problems in transportation?
9. Could you mention please an updated information you have about your Woreda such as:- Soils, crops and climate (rainfall) situation of the area, Seasonal or weekly water delivery schedules; Data on the actual irrigated area and beneficiaries; Sources of income and distribution of income in the community or group, alternative sources of income, who are the poorest people, Topography, water resources, local soils, climate, rainfall, forestry resources, existing irrigation infrastructure and condition, Crops grown and cropping practices, Fertilizer used, source of seed and reliability of seed sources, Irrigation present and potential size of farms in the area and distribution, Cash crops and subsistence crops diversification, Livestock present and distribution in the community, feed and fodder for livestock, vaccinations, small animals raised, local breeding practices, limiting resources of crop and livestock production.

Thank you!!!

DECARATION

I, the undersigned, declare that the thesis is my original work, has not been presented for a degree in any University and that all sources and that all sources of material used for the thesis have been duly acknowledge.

Declared by:

Name: Getinet Kesede

Signature: _____

Date: 28 June, 2011

Place: AA

This thesis has been submitted for examination with my approval as a University advisor

Name: _____

Signature: _____

Date: _____

Place: _____