

**IMPACT OF SMALL-SCALE IRRIGATION ON FARM
HOUSEHOLDS' FOOD SECURITY: THE CASE OF GIRANA
IRRIGATION SCHEME IN KOBO DISTRICT, NORTH WOLLO
ZONE OF AMHARA REGION, ETHIOPIA**

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**Impact of Small Scale Irrigation on Farm Households' Food Security:
The Case of Girana Irrigation Scheme in Kobo District, North Wollo
Zone of Amhara Region, Ethiopia**

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MASTER OF SCIENCE IN AGRICULTURAL ECONOMICS**

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ACRONYMS AND ABBREVIATIONS

ADLI	Agricultural Development Led Industrialization
AE	Adult Equivalent
ATT	Average Treatment on Treated
CSA	Central Statistical Agency
GFSI	Global Food Security Index
HH	Household Head
MoA	Ministry of Agriculture
MoFED	Ministry of Finance and Economic Development
MoWE	Ministry of Water and Energy
MoWR	Ministry of Water resource
MSI	Medium Scale Irrigation
OKARD	Office of Kobo Agricultural and Rural Development
OKGV	Office of Kobo-Girana Valley
PSM	Propensity Score Matching
RD	Regression Discontinuity
RWH	Rain Water Harvesting
SSI	Small-Scale Irrigation
WFP	World Food Program
WSDP	Water Sector Development Program

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**Impacts of Small Scale Irrigation on Farm Households' Food Security:
The Case of Girana Irrigation Scheme in Kobo District, North Wollo
Zone of Amhara, Ethiopia.**

ABSTRACT

In Ethiopia, small scale irrigation is thought to be one of the most useful irrigation systems which has a profound impact on food security through increasing income and production. Therefore, the study focused on the impact of small scale irrigation on farm household food security with specific reference to Kobo District of Amhara Regional State. The specific objectives of the study were to identify factors affecting households' participation in small scale irrigation and its impact on farm households' food security. A multi-stage random sampling technique was employed to select sample households. The primary cross sectional data were collected from 180 sample households' and analysis was carried out with the help of descriptive statistics and econometric models. The study used PSM model to analyze impacts of small scale irrigation on food security while Logit model was used to identify factors affecting household participation decision in small scale irrigation. In the logit regression model a total of twelve explanatory variables were included in the model of which seven were significant. The significant variables that are found to determine households' participation in small scale irrigation were age of household head, dependency ratio, distance from irrigation water source, distance to the nearest market, cultivated land size, livestock holding and off/non –farm income. The intervention in small scale irrigation revealed significant mean difference between two groups in terms of daily calorie intake and household consumption expenditure per adult equivalent. Using PSM (kernel matching with band width of 0.25) it was found that participation in small scale irrigation increased daily caloric intake and household consumption expenditure by 907.07kcal and 2593.92birr, respectively, over non-participant households. The sensitivity analysis result showed that the impact estimates on significant outcome variables were insensitive to unobserved selection bias. Thus, creating awareness on family planning, strengthening crop-livestock production, construction of irrigation schemes, arranging training and experience sharing to elder farmers, provision of market information and infrastructure and promoting off/non-farm income should be a policy priority and concern to enhance farm households' participation decision in small-scale irrigation for improving food security.

Key words: Small scale irrigation, Kobo-Girana, PSM, Food security, ATT, Amhara

1. INTRODUCTION

1.1. Background of the Study

Ethiopia's economy (more than 85%) has remained heavily dependent upon agriculture followed by industry (5%), and service (10%). The sector currently contributes 48.6% of GDP and underpins the livelihoods of 84% of the population (WFI, 2015). Ethiopia's agriculture, however, remained in its rudimentary stage because of soil degradation due to over use, drought, low subsidies, poor infrastructure, high rate of urbanization, fragmented small landholdings, limited use of irrigation and agricultural technologies (MoA, 2015;).

According to Asayehegn (2012) irrigation contributes to livelihood improvement through increased income, food security, employment opportunity, social needs fulfillment and poverty reduction. Moreover, increase in agricultural production through diversification and intensification of crops grown, increased household income because of on/off/non-farm employment, source of animal feed, improving human health due to balanced diet and easy access and utilization for medication, soil and ecology degradation prevention and asset ownership are contributions of irrigation.

Ethiopia is endowed with ample water resources with 12 river basins with an annual runoff volume of 122 billion m³ of water and an estimated 2.6-2.65 billion m³ of groundwater potential (Makombe *et al.*, 2011; MoA, 2011a). As a result, the economic actors of the country gave attention and designed a national strategic plan in 1991, ADLI gives more emphasis to small-scale irrigation to enhance irrigated agriculture, cooperative societies and agricultural technologies to answer the food demand of the country and bring socioeconomic development in the country. The successful history of Asian countries such as China, India, Singapore, Vietnam and Taiwan in the 1960s and 1970s through irrigated agriculture motivated the Ethiopian government to give more weight to the development of irrigation schemes (Bacha *et al.*, 2011). The development of irrigation practices was the main pillar in the Five-Year Growth and Transformation Plan (2011-2015) of Ethiopia as a means of achieving food self-sufficiency. Since then, the government of Ethiopia has allocated about 17% of its annual national budget to the agricultural sector (MoFED, 2012).

Although the country has estimated potential of 4.5 million ha of irrigable land, irrigation covers only 274,612 ha or about 6.1 percent of the total irrigable land. The reliance of most of the farmers on rain-fed agriculture has made the country's agricultural economy awfully fragile and exposed to the impacts of weather conditions and climatic variability leading to partial or total crop failure, which in turn resulted in food shortages (MoWE, 2016). Due to this reason, the yield and efficiency of the agricultural sector remains stumpy, which in turn, lead to the rampant food insecurity problem and poverty in the country and inability to meet the domestic need of the population with the country's per capital income of \$590 is substantially lower. This justify that the sector does not enable the country to meet the food requirement of the people and the country remains among one of the food aid recipient countries in the world (World Bank, 2016).

Agriculture is the main stay of the population in Amhara region and hence it contributes almost the largest share of livelihood of the population with insufficient, unreliable and erratic rainfall pattern which leads to poor yield of crops, recurrent drought, environmental degradation and poverty. Amhara Region had a total population of 20 million, making it the second mostly populated region in Ethiopia (CSA, 2012). According to the region's BoARD (2014) in the Amhara regional state, approximately 0.7million ha of land is estimated to be suitable for irrigation, of which the potential for small scale to large-scale irrigation is about 0.45million ha and also approximately 0.17million ha of land in the region was under irrigation. The remaining 0.25million ha holds great potential for future irrigation development in the region. Kobo district had ground and surface water resources in great amount and it is suitable for the development of small scale irrigation schemes. With this background, in this study impact of small scale irrigation on farm household food security in Kobo-Girana irrigation scheme, Kobo District of North Wollo Zone was conducted.

1.2. Statement of the Problem

For a country facing recurrent drought, with severe consequences for development, the need for irrigated agriculture cannot be over-looked. Ethiopia has many international rivers, high groundwater potential and natural lakes, which have high potential for irrigation. Despite the

large catalog of the river network, irrigated area only forms 10% of the total cultivated land and the area under agriculture is also unpretentious 15% of the cultivable area (MoWE, 2012).

Food security exists when people have sustainable physical and economic access to enough, safe, nutritious, and socially acceptable food for an active, healthy and productive life. The condition food security include food availability through domestic production or imports and economic capacity to access food, which in itself must be adequate in terms of quantity and quality to provide enough calories, proteins and minerals adequate for sustained health and productive performance (WFS, 1996). Ethiopia has been come in away achieving food security and reducing poverty, even though they persist the major problem in the country. Food insecurity mainly caused by rain deficit or total failure occurs in the country, it is most frequent and severe in the dry lowlands and to a limited extent in the sub moist mid altitude areas. Therefore, infrastructure development mainly in the form of water resources development (small-scale irrigation through river damming or diversion and the construction on of ponds) and the construction of rural roads as well as market centers and job creation through public and private enterprises helps in accessing food items by reducing food insecurity both at national and household levels (EPCC, 2015).

Even if Ethiopia has a huge potential in terms of surface and ground water availability and land which are in most cases suitable for irrigation development, it is in its infant stage and the country is not benefiting from the sub-sector. The major constraints that slow down the development of the sub- sector among others are predominantly primitive nature of the overall existing production system, shortage of agricultural inputs, population growth and low level of users' participation in the development and management of irrigated agriculture, limited trained manpower and inadequate extension services which can reduce agricultural productivity, which in turn worsens food insecurity and poverty (MoARD, 2011).

Irrigation increases agricultural productivity and farm income per hectare, according to previous studies like Berhanu and Peden (2002), Nhundu *et al.*(2010), it insulates the national agricultural economic sector against weather-related shocks and provides a more stable basis for economic growth and poverty reduction. According to Awulachew *et al.* (2010) Ethiopia had an estimated total area of 161,000 ha of irrigated agriculture, of which

64,000 ha was in small-scale schemes, 97,000 ha was in medium-and large-scale schemes. Currently, the countries irrigable land had grown to 397,492.16 ha with the total production capacity of 6.9 million tons (CSA, 2016). The Ethiopian government gives more emphasis to small-scale irrigation as a means of achieving food self-sufficiency (MoFED, 2014).

Amhara Region is endowed with river basins with net potential area of 0.57 million ha and irrigated agriculture is expanding since recent years. More than 6,200 small scale irrigation schemes of which 95% are traditional exist in the region (Birhanu *et al.* 2014). According to Melisew (2012) Amhara region enjoys a considerable potential for surface water harvesting by small-scale dams and river diversions and also underground water resources. However, the total area under irrigation is very low (average irrigated land holding of 0.2 ha) in the region due to absence of well-understanding of economics of small-scale irrigation, difficulty in the provision of inputs services and technical advice, lack of efficient utilization of water resources, lack of viable product markets and marketing institutions were some of the reasons for low level of efficiency and lack of sustainability in small- scale irrigation schemes. In addition to that researches on factors impeding participation decision of smallholder rural farm households in small-scale irrigation and its effect on food security were scant in the Region.

North Wollo zone is one of drought prone area like other areas of in Amhara Region. However, this area has surface and ground water resources which are not being accessed to full potential for production purposes. More importantly Kobo district is one of drought and erratic rainfall area, but with significant reserved ground and surface water sources. Yet, the district has not used its resources to full potential due to socio-economic and institutional factors. Kobo-Girana irrigation contributes to farm households in increasing crop yields and quality in semi-arid area of Kobo especially during period of erratic rain fall and drought even though the current irrigated area is very small (Adane, 2014).

To date, there are no studies on factors determining farm households' participation on small scale irrigation and its impact on households' food security in northern Ethiopia, particular in the studied district. Moreover, previous studies was focused on the availability and potential of water resources, optimum utilization of water and its management issues. To fill this knowledge gap this study focused on factors affecting smallholder farmer's participation

decision in irrigation agriculture and impacts of small-scale irrigation schemes on farm households' food security.

1.3. Research Questions

This study tried to answer the following research questions:

1. What factors are affecting households' participation in irrigation agriculture?
2. Does use of small scale irrigation have any impact on food security of the household?

1.4. Objectives of the Study

The general objective of the study is to analyze the impact of small-scale irrigation on farm household food security in Kobo District, North Wollo Zone. The specific objectives of the study are:

1. to identify factors affecting households participation in small scale irrigation in Kobo District
2. to analyze impact of small scale irrigation on farm households food security in Kobo District

1.5. Scope and Limitations of the Study

The research was undertaken in one district and in Kobo Girana small scale irrigation. Hence, confinement of the study to one woreda limits the generalization of the results. The study was limited to a cross sectional data.

1.6. Significance of the Study

Development practitioners need to know evaluation result of their efforts of irrigation intervention made in impacting the households' livelihood. This study give them some clue to revisit their program and to design better future development programs targeted at poor farm households. Small scale irrigation development is one of the many components in the agricultural sector that has been promoted in drought prone highland and vast lowland areas of

the country in order to increase and diversify agricultural production, to generate income, asset creation and improving the living standard of the rural households.

Generally, the study was an attempt to provide realistic information on the benefit of small-scale irrigation development in the study area, formulating future strategies and a baseline for further research on smallholder irrigation investment in the zone or/and the region. Therefore, from this study policy makers, researchers and smallholder farmers can benefit from the intervention to be made and other governmental and NGOs who have a stake in irrigated agricultural development. Moreover, the impact evaluation technique applied in this study can offer important reference for impact evaluation studies in other sectors.

2. LITERATURE REVIEW

In this chapter concepts and definition of irrigation, food security, small scale irrigation and its classification, linkage of small scale irrigation and food security, empirical finding on impact of small scale irrigation, empirical literatures, methods to impact assessment area and conceptual framework were reviewed

2.1. Concepts and Definition of Food Security

Food security is a broad and flexible concept, encompassing issues related to the nature, quality and security of the food supply, causes, coping strategies as well as issues of food access. Concepts concern food security can be traced back to the Hot Springs Conference of Food and Agriculture, since which time the issue has undergone several redefinitions and food security concern evolutions which were food surplus disposal (1940-1950), food for development (1960), food assurance (1970), broadened food security (1980) and freedom from hunger and malnutrition (1990). The issue of food security came really to the fore in 1970s and at the 1974 World Food Conference in Rome in the whole mankind. Since the 1974 the whole concept of food security has evolved, developed, multiplied and diversified at the global, national, household and individual level (Maxwell, 1996).

Food security thought to be there are over two hundred definitions penciled by scholars and institutions which is a clear indication of different views and approaches to the problem; however, the definition that has acquired the broadest acceptance is that of: food security is defined as a situation when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life (WFS, 1996). According to this definition, food security depends on four main interlinked pillars: availability, access, utilization and stability.

Food availability means that food is physically or sufficient food is available (production and imports). 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.

Food access: refers to social and economic access to food to obtain a nutritious diet. Normally, food access may include: home production, use of left-over stocks, purchase, barter, borrowing, sharing, gifts from relatives, and provisions by food aid.

Food utilization: is the way in which people use food or safe and nutritious food can be utilized. 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

Stability: it is a combination of availability, access and utilization which means all people at all times. This can refer to short-term instability or medium term instability, often stemming from climatic, economic, social and/or political factors that may threaten an otherwise food secure situation.

2.2. Household Food Security and Measurement

Household food security can be measured using either supply-side approach or demand side approach. The food supply equation deals with the food availability issues, for example, food production index, per capita output, food aid delivery, livestock index, crop index and others. The food demand equation, on the other hand, studies about the accessibility mainly focusing on income, anthropometrics index, consumption expenditure, nutrition index, dietscore, calorie intake index, hunger index and other derived indicators (Norton *et al.*, 2014).

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

2.3. Concepts and Definition of Irrigation

Water is a basic need for human beings and animals. It is essential for their metabolic processes. It is used to build healthy workforce, ensuring food security, provision of clean

energy for agriculture, recreation, transportation, hedge against climate change and variability catalyst. The most essential use of water in agriculture is for irrigation to produce enough food (MoWE, 2013).

Irrigation is a very old practice in the world and it has formed the foundation of civilization in numerous regions for millennia. Historically, civilizations have been dependent on development of irrigated agriculture to provide agrarian basis of a society and to augment the security of people. For example, the Nile's valley in Egypt and plain of Tigris and Euphrates in Iraq were under irrigation for 4000 years on a large scale. Mesopotamia, the land between the Tigris and Euphrates, was the bread basket for the Sumerian Empire. This civilization managed a highly developed, centrally controlled irrigation system. In that same time frame, irrigation apparently developed in China and in Indus basin (Schilfgaarde, 1994).

Irrigation refers to the purposive, organized, controlled, and artificial supply of water to a cropped area in order to complement rainfall and to overcome drought, and to reach a given crop production objective (Tlou *et al.*, 2006). 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 is one means by which agricultural production can be increased to meet the growing demands in Ethiopia. Irrigation is defined as artificially supplying and systematically dividing of water for agriculture to overcome deficiencies in rainfall for growing crops (Cantor, 1967)). This is an intentional action made by human to apply water for growing crops, especially during dry seasons where there is a shortage of rainfall.

2.3.1. Definition and Overview of Small Scale Irrigation in Ethiopia

Defining small scale irrigation is highly variable from place to place as the definition differs. Small-scale irrigation can be defined as irrigation on small plots, in which small farmers have the controlling influence and using a level of technology they can operate and maintain effectively and its systems are controlled and managed by single farmers or farmers' groups and (Smout and Shaw, 1999).

According to De Lange *et al.* (1997) SSI is defined as the development of traditional irrigation systems, which are used as complement to rain-fed crop production involving predominantly horticultural crops. In similar fashion, 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. MoA (2011) stated that, small-scale irrigation schemes are commonly taken as irrigated areas having an area of about 200ha. Accordingly, some features of the categories of SSI are described by different scholars and organizations as follows:

Traditional irrigation schemes: are usually initiated, built and managed by local knowledge of the community and these schemes are being managed by the beneficiary farmers through their own water users' association and initiatives. These schemes do not have permanent structure for water acquisition and flow control (MoA, 2011; Amede, 2014).

Modern diversion schemes: These are usually built on perennial rivers or springs with adequate base flow. Modern schemes are those equipped with permanent irrigation infrastructure such as water diversion (headwork's) and flow control structures and conveyance and distribution systems (FDRE, 2014)

Modern schemes with storage (Micro to medium dams): In view of the erratic nature of the rainfall, flow regulation is quite important for supplementary irrigation as well as increased intensity of irrigation. To irrigate a sizable area 100-200 ha, construction of small- to medium-scale dams is being practiced, particularly in the mid- and highlands where the population pressure and food insecurity are severe (MoA, 2011).

Pumped schemes: These are schemes with pumping arrangement for lifting water mainly from surface sources where diversion by gravity may not be feasible. As operation and maintenance of these schemes is costly, they are successful mainly in areas with good market access, better service delivery and growing of high value crops.

Micro-irrigation: these are recent introductions in the area of SSI that refers to individualized small-scale irrigation technologies for lifting, conveying and applying irrigation water. It therefore, includes treadle and small- power pumps to lift water and a variety of irrigation water application technologies such as smallholder drip systems and micro- sprinklers. These technologies are more affordable to be used by smallholders in their small plots.

Rain water harvesting (RWH): The principles of water harvesting are capturing the runoff, collecting, storing and utilizing the stored water for the intended use. Rainwater harvesting for crop production purpose can be done using different storage structures and the water can be conveyed to the field through different systems. Rainwater harvesting in any area depends on the factors like area of catchment, rainwater harvesting, (runoff) coefficient and average annual rainfall (WAID, 2011).

Shallow ground water harvesting: This is commonly used for domestic water supply. However, in areas where shallow ground water resources are available, it is possible to use existing appropriate water lifting technologies like treadle pumps to extend its use for irrigation. These are suitable for individual holding due to availability of affordable technologies and the wells are constructed generally less than 10m deep (Bank, 2008).

2.3.2. Irrigation Development and Food Security Situation in Sub Saharan Africa

Irrigation farming plays an important role in food production and food security in the world. About 30% of the world's food production comes from about 18% of the total cultivated land under irrigation. There are wide variations in the proportion of irrigated agricultural land in the developing world, with 37% in Asia, 15% in Latin America, 6% in Africa and 4% in Sub-Saharan Africa. Irrigation, therefore, plays a less significant role in African agriculture compared to other regions as Africa's irrigated cultivated land is why lower than the world average (FAO, 2012). Low levels of irrigation in Africa are as a result of high irrigation investment costs, declining world food prices, perceived failures of many past irrigation projects, limited government commitment, rugged topography and poor rural infrastructure,

heterogeneous and fragmented farmers, low population densities; and diets tied to crops with low water requirements (Inocencio *et al.*, 2007; You *et al.*, 2010).

Moreover, You *et al.* (2010) also stated that, Africa's specially SSA agricultural productivity is the lowest in the world, in part because of the underuse of irrigation in agricultural production almost entirely rain-fed despite that rainfall is highly variable and insufficient in many cases. Therefore, there is a need to prioritize irrigation development in SSA not only because of the existence of water resources, but also because of the high value of irrigated agriculture on the continent and the large number of rural poor that could benefit from productivity enhancement as a result of irrigation investment. In Africa, irrigated agriculture accounts for nearly 38% or 13 million ha are irrigated the value of all agricultural output. The average rate of expansion of irrigated area over the past 30 years was 2.3% in both Sub-Saharan Africa and all of Africa. According to FAO (2012) total irrigated land in Africa is estimated to be about 12.2 million hectares and six countries, namely Egypt, Madagascar, Morocco, Nigeria, South Africa and Sudan account for nearly 75% of this total irrigated land.

As a result of low use of irrigation many African specially SSA countries becomes food insecure and leads their economy deteriorated over a period. According to FAO (2014) Sub-Saharan Africa (SSA) (214 million people) remains the most food-insecure region by 26.6 % of the regional share. In general, Africa is making slow progress in achieving international hunger targets, with the sub-Saharan region especially lagging behind global trends. The region has been afflicted by conflict and natural disasters, and one in four people remain undernourished in sub-Saharan Africa – the highest prevalence of all the regions.

SSA's food security is projected to deteriorate over the next decade, at the aggregate level, as the number of food-insecure people is projected to rise nearly 37 percent, reaching 347 million in 2025. This projected increase outpaces the growth in total population for the region, so the share of food insecure people is rise, from 28.4 percent in 2015 to 30.4 percent in 2025. As a result the distribution gap (the amount of food needed to raise consumption in each food deficit income group to the nutritional target is 2,200 calories per person per day) is projected to rise at a slightly higher rate, 38.4 percent, than the food-insecure population, meaning negligible change in the intensity of food insecurity in the region (Rosen *et al.*, 2015).

Moreover, According to USDA (2014) 258 million food insecure people in SSA in 2014 projected to rise 346 million insecure people by 2024. This rate is very high as compared to other developing regions like Asia (220million) and Latin America (31 million).

2.4. Water Resources , Irrigation Development and Food Security Situation in Ethiopia

2.4.1. Water Resources and Use

Ethiopia is considered as the “water tower” of Africa as many rivers flow out of the country. In addition to the relatively high rainfall, particularly in the western part, the country is endowed with a significant amount of water resources from lakes, rivers and ground water. It is estimated that the country’s irrigation potential is close to 5.3 million ha of which 3.7million ha can be developed using surface water sources, 1.6 million ha using ground water and rain water management (Awulachew and Mekonnen, 2011)

According to MoWR (2010), it is estimated that Ethiopia has a total volume of 123 and 5.6 billion m³ of surface and ground water respectively. The Western half of the country receives sustainable amounts of precipitation and has many perennial rivers and streams while the precipitation is marginal in the Eastern half of the country. The country possesses twelve major river basins, which form four major drainage systems these are the Nile basin, the Rift Valley, the Shebelle -Juba basin and the Indian Ocean.

Agriculture is the main water-consuming sector and based on the total irrigated area, cropping pattern and calendar, annual agricultural water use is estimated to be 5.2 km³, while domestic and industrial water withdrawals are estimated to be about 0.33 and 0.02 km³ respectively. There is growing concern about water use because of the conflict between the environment and agriculture particularly in lowland rural areas, where total base flows are diverted for irrigation without releasing water for ecological conservation. Groundwater has not yet been considered for irrigation development, mainly due to high investment and running costs (Yokwe, 2009). The water resources of the country’s irrigation potential (Awulachew *et al.* (2010) are:

Surface water: Ethiopia has 12 river basins that provide an estimated annual runoff of about 125 km³, with the Abbay basins (in central and northwest Ethiopia) accounting for about 45 percent of this amount. While much of this run-off could be used for irrigation or other purposes, Ethiopia has limited water infrastructure to use this surface water. For example, current per capita water storage capacity is just 160 m³.

Groundwater: As a country with 84% of its population living in a much dispersed rural villages, Ethiopia should have given attention to its groundwater resources to supply potable water, irrigation and other purposes. Estimates show that almost 70% of the existing rural water supply to be from the groundwater. This implies that although water is physically available, the country lacks the infrastructures to use it properly.

Rainwater management: while Ethiopia has abundant annual rainfall, it varies spatially (different part of the country), temporally (different time of year) and inter annually (year cycles). Consequently, increasing rain water storage capacity and improving water control and rain water management techniques, especially rainwater harvesting (RWH), are critical to ensure that Ethiopia gets maximum use of its rainfall.

2.4.2. Irrigation Development and Food Security in Ethiopia

Irrigation use in Ethiopia dates back several centuries, and continues to be an integral part of Ethiopian agriculture. In Ethiopia, modern irrigation began in the 1950s through private and government-owned schemes in the middle Awash Valley by diverting water from rivers in the dry season with the objective of producing industrial crops where big sugar, fruit and cotton on large-scale basis and for the production of subsistence food crops as traditional irrigation. The experience in modern SSI development and management started in the 1970s by the Ministry of Agriculture, in response to major droughts, which caused wide spread crop failures and consequent starvation (Kidane *et al*, 2014).

Irrigation infrastructures in Ethiopia are increasing year after year which shows positive implications of in the development of SSI and LSI schemes through river diversion, constructing micro dams and water harvesting structures (Hagos *et al.*, 2009). According to MoWE (2016) irrigation development is very important in stimulating sustainable economic

growth and creating rural employment opportunity and is the corner stone of food security and poverty reduction. In recognition to this irrigation development is one of the major components of water sources and development program. Total are developed during 2002-2016 were 274,612ha (127138 ha was from SSI and 147474ha was from large and medium irrigation schemes).

Ethiopia with total population more than 90 million; agriculture is the foundation of its economic growth. Poverty is still a big obstacle to overcome in Ethiopia. Consequently, chronic and acute food insecurity is prevalent. About 10% of Ethiopia's citizens are chronically food insecure and this figure rises to more than 15% during frequent drought years. The deteriorating situation of food security in Ethiopia is caused by population pressure, drought, poor farming technologies, weak extension services, high labor wastage and pre and post-harvest crop loss (Endalew *et al.*, 2015).

According to FDRE (2015) Ethiopia's economy has been growing at an average rate of 10.8 % per year from 2004-2014, and the country growth driven by large public investment and growing services , has contributed to impressive progress in poverty reduction, measured as a change in the share of the population living below the poverty line. In this regard, Ethiopia has outperformed most SSA countries, even those with more fiscal space and with higher GDP per capital. Moreover, according to The Economist (2015) Ethiopia is the second biggest mover in food quality and safety next to Mali from 2012 -2015. Of the 109 countries in the GFSI, 60 have seen score increases in quality and safety since 2012. The top five most-improved countries were Mali (+16.4), Ethiopia (+13.2), Singapore (+12.9), Venezuela (+12.5) and Saudi Arabia (+11.7).

2.4.3. Irrigation Policies and Strategies in Ethiopia

More recently, the policies and strategies of Ethiopia strongly supports the irrigation developments especially the small scale irrigation (SSI) through the Water Sector Development Programs (WSDP) and Ethiopian Irrigation Development Plan (IDP). This irrigation development is mainly expressed in the development of small scale irrigation (SSI)

schemes by governments, donors and NGOs. Irrigation is believed as a key for food security and poverty reduction in Ethiopia (Gebremedhin, 2015).

According to FDRE water sector policy of MoWR (2001), the irrigation policy ensures the full integration of irrigation with the overall framework of the country's socio-economic development plans, and more particularly with the Agricultural Development Led Industrialization (ADLI) Strategy. The policy intention was gave the recognition that irrigation is an integral part of the water sector and consequently develop irrigation within the domain and framework of overall water resources management, promotes decentralization and users-based-management of irrigation systems taking account of the special needs of rural women. Moreover, it support and enhance traditional irrigation schemes by improving water abstraction, transport systems and water use efficiency, ensure the prevention and mitigation of degradation of irrigated water and maintain acceptable water quality standards for irrigation and enhances greater participation in the development of large scale irrigated farms in high water potential basins but with low population density.

2.4. Classification of Irrigation Development in Ethiopia

Around the world, scholars use different standards for classification of irrigation schemes. Irrigation schemes vary widely in size and structure, from micro irrigation (RWH), to river diversion, pumping, and small or large dams, etc. Irrigation schemes in Ethiopia can be grouped into three based on command area: large-scale schemes, which irrigate above 3000 ha of land normally constructed and managed by the state. LSIs include the Wonji-shoa, Methara, Nura Era and Fincha irrigation schemes. Medium-scale schemes possibly irrigating an area of 200-3000 ha of land and managed by state farms and enterprises. MSIs include Silile, Hare and Ziway irrigation schemes. The third category is SSI up to 200 ha of land mainly owned and managed by organized community or water-use associations .SSIs include household based RWH, hand-dug wells, shallow wells, flooding (spate), individual household-based river diversions and other traditional methods(Fuad, 2002; MoWR, 2002and Hagos *et al*, 2009).

Makombe *et al.* (2011) is also classified the irrigation development in Ethiopia based on the uses of a mix of the history of establishment, management system and the nature of the structures as follows:

Traditional schemes: These are SSI systems which usually use diversion weirs made from local material which need annual reconstruction or from small dams. The canals are usually earthen and the schemes are managed by the community and some were recently constructed with the aid of NGOs and government.

Modern schemes: These are SSI systems with more permanent diversion weirs made from concrete and small dams. The primary and sometimes secondary canals are made of concrete. They are community managed and have recently been constructed by government.

Public: These are large scale operations constructed and managed by government .Sometimes, public schemes operations are partially supported by the large scheme.

Private: These are privately owned systems that are usually highly intensive operations.

2.5. Small Scale Irrigation and Food Security

The expansion of small-scale irrigation schemes was taken as the main development strategy in order to reduce crop failure due to drought and erratic rainfall conditions in Ethiopia .Both irrigated and rain-fed agriculture is important in the Ethiopian economy by reducing poverty and promoting food security. Virtually all food crops in Ethiopia come from rain-fed agriculture with the irrigation sub-sector accounting for only about 3 percent of the food crops. Export crops such as coffee, oilseed and pulses are also mostly rain-fed, but industrial crops such as sugar cane, cotton and fruit are irrigated. Other important irrigated crops include vegetables and fruit trees in medium- and large-scale schemes and maize, wheat, vegetables, potatoes, sweet potatoes and bananas in small-scale schemes. There is a marked value added in irrigated agriculture (Getaneh, 2011).

Moreover, irrigation development in Ethiopia is considered to be an important investment for improving rural household food security status through increased agricultural production and for reducing the pressure on currently cultivated land by bringing unused land under cultivation. The rapidly rising food needs due to increasing population and progressively shrinking per capita agricultural land availability, warrants the intensification of cropping systems in the country. To cope with both population growth and limitation of agricultural

production, irrigation development is identified as a vital strategy for food security and alleviating rural poverty. In this regard most small-scale irrigation systems involve effective management and institutional support from the local government are likely to be successful in contributing to poverty reduction and household food security (Deressa *et al*, 2011).

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

2.6. Empirical Literature Review

Desta and Balta (2015) using a logistic regression model found small scale irrigation investment has appositive impacts on household food security by reducing rainfall risk, farm household's decision on irrigation enabled households to diversify production to new types of marketable crops like fruits, cash crops and vegetables, increased crops yield and marketing, reduced unemployment, reduced inequality and poverty. According to Abera (2015) binary logistic regression model result distance of the irrigation scheme , number of livestock holding, total annual income, access to market information, dependency ratio, age and sex of household head were found to be determine use of small scale irrigation scheme. Accordingly the empirical result confirmed that the development of small scale irrigation had appositive impact on food security of beneficiary households.

Derje *et al.* (2009) Heckman two stage empirical evidence from Ambo district revealed presence of significant welfare differences between irrigators and non-irrigators, and that irrigation has undoubtedly played a part in those observed differences. After receiving access to irrigation, farmers started to produce more than one crop by rotation per year, increased their income and consumption levels, and diversified their cropping systems.

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

not adopt micro irrigation technologies. In terms of income, in 2014 harvest season, which showed from the ATT result the average annual income of adopters was significantly higher which was birr 13341.78 over that of non-adopters mean annual income of birr 8270. On the other hand, Solomone (2015) using PSM model found irrigation user households per capital consumption expenditure were increased by 21% than non-user households.

Tesfaye (2008) using PSM showed that access to irrigation has a significant effect in increasing the consumption expenditure per adult (welfare level) of beneficiary household and observed a significant welfare differences between irrigators and non-irrigators, and concluded that access to irrigation had playing a part in those observed differences. The study found that about 70% of the irrigation users were food secure while only 20% of the non-users were food secure. Jema *et al.* (2013) using logit model result found that dependency ratio, family size, size of land holding and education of household head were significantly affected household participation decision in small scale irrigation scheme. PSM result showed that small scale irrigation scheme has profound effect on households' consumption expenditure in particular for smallholders. Based on the model result the per capital consumption expenditure of scheme users were increased by Birr 605.56 or by 25% than non-irrigation users.

Agerie (2013) using probit model found that distance from the nearest market, education level of household head, total livestock holding, distance to water sources, access to information, family labour, access to credit and gender of household head were significantly affected participating in small scale irrigation scheme. Based on the model result irrigation user households mean income were increased about 29154.16 birr per year over non-irrigating households. The use of small scale irrigation) is the major power for agricultural growth and food insecurity reduction (Norton *et al.*, 2014). This indicates that investment in irrigation can increase farmers' independence on rainfall, increase irrigated farm land, generate employment and promotes farmers to produce two or three times in a year.

Elemo (2014) the logit model results indicated that age of household heads, total size of cultivable farmland, farm insect and pest infection and distance of irrigated farm land from the main road were found negatively and significantly affected utilization of small-scale irrigation water while, education level of household heads, access to improved technology, number

of oxen owned and total active family labors were positively and significantly related with utilization of small-scale irrigation water.

2.7. Impact Assessment Methods

There are several methods/ approaches by which impacts can be evaluated. These include Randomized Selection Methods, Propensity Score Matching, Regression Discontinuity Design and Difference-in-Difference (Abadie *et al.*, 2004).

Randomized Selection Methods refers to a process of selection of both treatment and control group from well-defined a set of population randomly in order to evaluate the outcome of an intervention so that the comparison group is as similar as the treatment group except for the enrolment in the program. It can do ex-post matching and this leads matching on variables that change due to participation. Moreover, randomization does not require the untestable assumption of independence conditional on observables (Abadie *et al.*, 2004).

Difference-in-Difference (DID) Methods is a quasi-experimental design that makes use of longitudinal data from treatment and control groups to obtain an appropriate counterfactual to estimate a causal effect. It can be used when baseline and time series information on both participants and non-participants is available. However, such a panel based impact assessment can be expensive, time consuming, and logistically challenging to collect baseline and follow-up data that straddle the implementation of a program and the design assumes that the potential selection bias is linear and time invariant such that it can be subtracted off in the first differencing (Stern *et al.*, 2012).

Regression Discontinuity (RD) Design Methods this method allows observed as well as unobserved heterogeneity to be accounted for. Although the cut off or eligibility threshold can be defined non-parametrically, the cut off has in practice traditionally been defined through an instrument. Concerns with the RD approach include the possibility that eligibility rules will not be adhered to consistently, as well as the potential for eligibility rules to change over time. It initially assigns scores role for the intervention unit and then compares the outcome of individuals just above the cut-off point for eligibility with a group of individuals just below it. Individuals around the cut-off point are similar (Buddelmeyer and Emmanuel, 2004).

Propensity Scores Matching (PSM)

Propensity Score Matching (PSM) is a statistical matching technique that attempts to estimate the effect of a treatment or other interventions by accounting for the covariates. It allows finding a comparison group from a sample of non-participants closest to the treatment group in terms of observable characteristics so that both groups are matched on the basis of the propensity score, which is a predicted probability of participation given observed characteristics (Ravallion, 2009). Propensity value is estimated based on a statistical model logit or probit, thereby estimate the average treatment effect of the outcome difference between the two groups in absence of baseline data using observable variables (Abadie *et al.*, 2004). From the above-described impact assessment approaches, the study used PSM because of no baseline data of households before and after participation in small scale irrigation.

2.8. Conceptual Framework: Small Scale Irrigation-Food Security Linkage

This study adopted a conceptual framework that shows participation in irrigation schemes can relieve farmers from high dependence on rainfall and then ensures their food security status. Studies show that small scale irrigation in developing countries was counted on to increase production, reduce the dependence effects of unpredictable rainfall and provide jobs to the poor (Chazovachii 2012).

In order to enhance small scale irrigation to improve households food security, many factors must be considered: demographic factors (Sex of household head, age of household head, education level of household head, labor availability and dependency ratio), socio-economic factors (cultivated land size, livestock holding and off/non-farm income) and institutional factors (distance to the nearest market, distance from water sources, frequency to extension contact and access to credit) are all very essential.

Small scale irrigation has direct and indirect benefit to farm households to achieve livelihood development in rural areas. Accordingly, investment in small-scale irrigation creates employment opportunities, increases consumption expenditure and accumulating assets. Thus, irrigation lowers food prices so that the poor can afford and get access to the required food at fair prices (Torell and Ward, 2010). The following diagram shows the relation of

determining factors and the impact pathways of small scale irrigation participation on farm household food security in the study area.

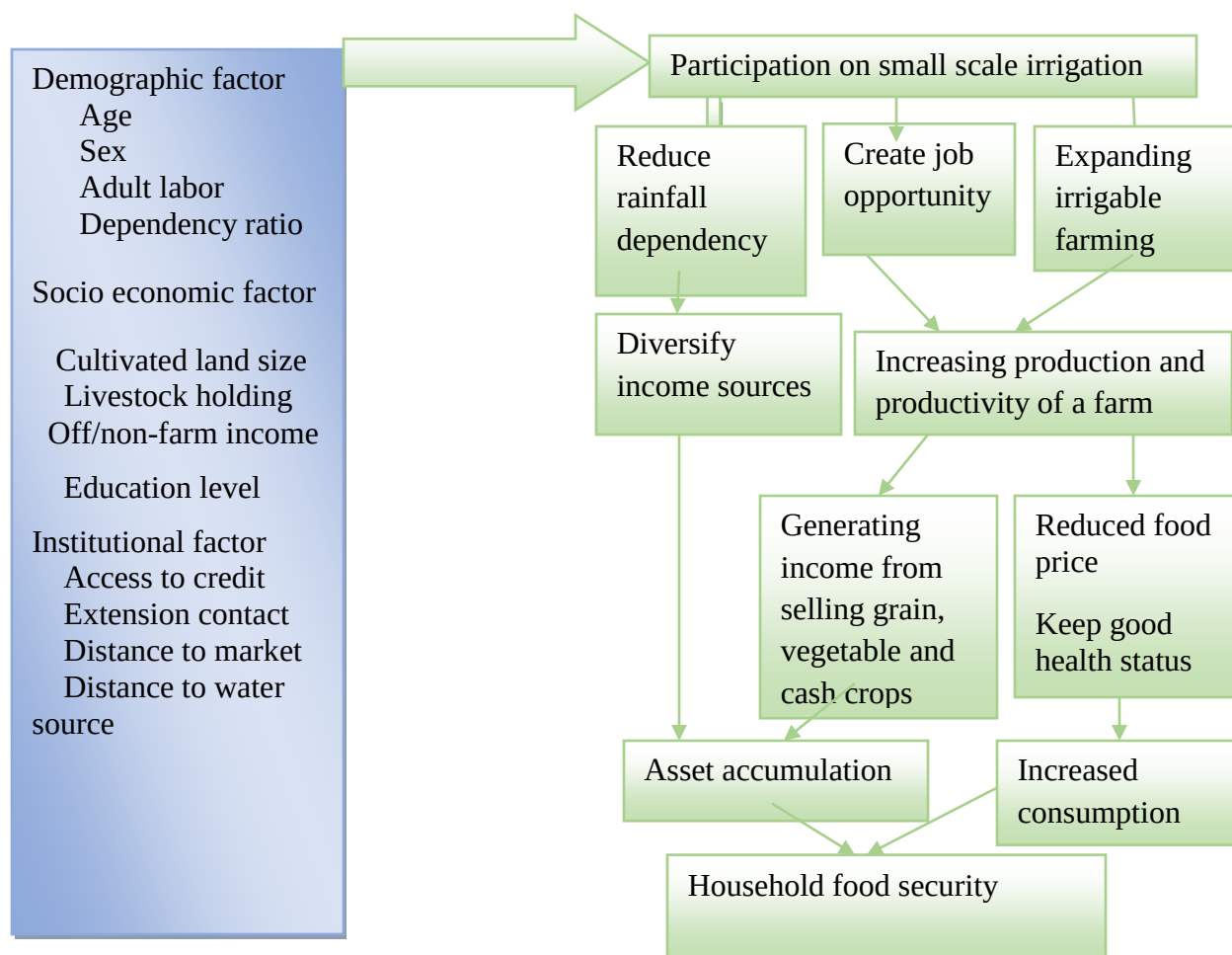


Figure 1. Conceptual framework of the study
Sources: Adapted from Adam (2013) and modified

3. RESEARCH METHODOLOGY

3.1. Descriptions of the Study Area

3.1.1. Location

Kobo District is one of the 11 Districts in North Wollo Zone of Amhara Regional State and is located in the North Eastern escarpment of Amhara about 54 km from North Woldia town, Addis Ababa –Adigrat high way, 189 km South of Mekele and 570 km from Addis Ababa. The District has 34 rural and 6 urban *kebeles*. The urban *kebele* administrations are located in Kobo, Robit and Gobiye towns. The District bounded in the North by Tigray Region, in the South by Gubalafto and Habru District, in the East by Afar Region and in the West Gidan District. The geographical coordinate of the area is lying between 11°54'04'' and 12°20'56'' N latitude and between 39°25'56'' and 39°49'04'' E longitude. The District has an attitude that ranges from 1400-3100m above sea level (CSA, 2011; OKARD, 2015).

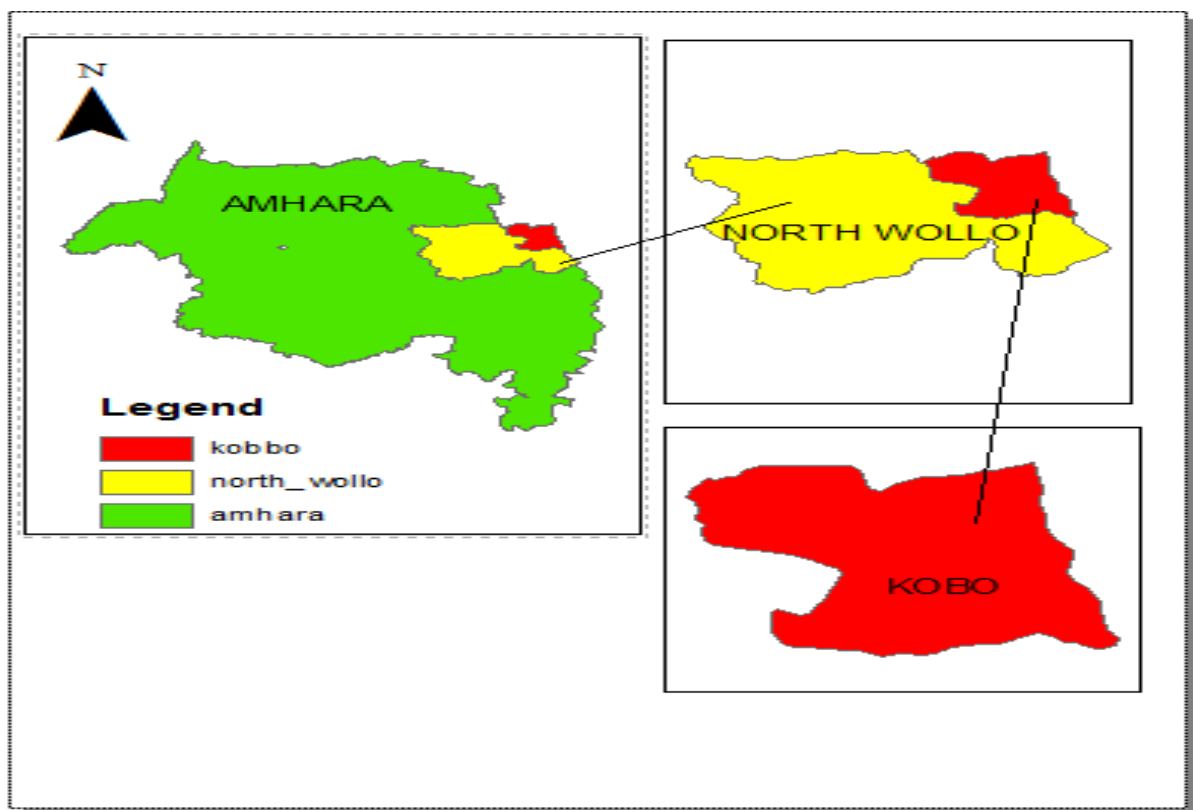


Figure 2. Location of the study area (Kobo District)

3.1.2. Climatic and Topographic Feature

The agro climatic feature of the district is tropical as 7.9, 37.2 and 54.9 % are *Dega*, *Weyna dega* and *Kola* respectively. The topography of the district consists of 65 % plain and the rest 20, 6, 5, and 4% are mountainous, rugged, gorges and swampy. The principal feature of rainfall in the area is bimodal and characterized by seasonal, poor distribution and erratic with a mean annual rain fall of 670mm that ranges from 500-850mm. The rainfall distribution of the area is categorized as short season (*Belg*) and long rain season (*Meher*) that occurs from February- April and July- October, respectively. The landscape of the district is characterized by a broad fertile plain which is separated from lowlands of the Afar region by the *Zobil* Mountains which are over 2000m high. The temperature varies from a minimum of 19°C to a maximum of 33°C annually. Compared to other districts of the zone, Kobo district has relatively hot climate and it has a mean annual temperature of 23.1°C (OKARD, 2015).

3.1.3. Population and Area Coverage

In Kobo district, there are 34 rural and 6 urban *kebele* administrations. According to CSA (2012) and OKARD (2015), the total human population in Kobo district was estimated to be 221,958 (49,841 households), an increase of 11.2% over the 2007 census (a total of 44,841 rural households and 9,398 urban households were counted in this woreda), of whom 111,605 were males and 110,353 were females. The religion of majority of the population in the district practiced Ethiopian Orthodox 82.88% and about 16.5% of the populations were Muslim. With an area of 2,001.57 square kilometers, Kobo has a population density of 119.7, which is less than the Zone average of 132.3 persons per square kilometer (CSA, 2011).

3.1.4. Agriculture

Agriculture is the mainstay of the population in the district and hence it contributes almost the largest share of the livelihood of the population. However, it is characterized by high incidence of food insecurity, recurrent drought and famine and dependency on rainfed agriculture. Hence, the sector remained subsistence in its nature. Mixed farming is the common practice prevailing in the district. As a result, the livelihood of the majority of the rural population depends on both crop farming and livestock production as an integral part.

Major crops grown in the area are sorghum, teff, maize and pea under rainfed farming and onion tomato, pepper, cabbage and maize under irrigation. Under livestock production, goats and cattle dominate the sub-sector (OKARD, 2015).

3.1.5. Kobo-Girana Small Scale Irrigation

Kobo-Girana small scale irrigation which comprises Kobo, Girana and some part of the Raya valley and was established in 2005 located in the North Eastern Amhara regional state, North Wollo Administrative Zone and has an elongation in north-south direction with a geographical zone of 11°56' to 12°18'N and 39°23' to 39°47'E. It is bounded by Zobil Mountain in the East, by Guba ridge in the South and Alamata District in the North. The sub basin is divided into Waja –Golesha, Hormat-Golina and Kobo –Gerbi ground water basin

Kobo District has a range of water sources which are suitable for irrigation practice and shares 43.74% of the total irrigable land of North Wollo Zone. Currently, the total irrigable land of the district is 7900ha. Kobo-Girana small scale irrigation is the only modern pressurized (drip and sprinkler) irrigation project which uses ground water in the District particularly and in Amhara Region generally. The Kobo- Girana small scale irrigation scheme has the capacity irrigating 6000ha of land; at this time only 2440.7 ha of land are irrigated for the three sub basins. Six of the 34 rural *kebeles* of the district are benefited from the project (OKARD, 2015; OKGV, 2016).

The main cereal crops produced in kobo Girana irrigation project are *Teff*, Sorghum and Maize. In addition to the above cereals, cultivation of the most commercial crops in the country such as tomato, onion, Chickpea and pepper are also produced in the area. Considering the effectiveness of the project, farmers and regional governments are drilling more deep well to cover the whole land in irrigation (OKARD, 2015; OKGV, 2016).

3.2. Data type, Sources and Method of Collection

Both primary and secondary data were employed in this study. Primary data was collected from 180 sample households. The questionnaire was pre-tested and amended based on feedbacks from the pre-test. Secondary data was collected from the different records of

district's office of agriculture, Kobo-Girana office, journals, websites and other relevant sources.

Trained enumerators collected the data under close supervision of the principal researcher. Enumerators were trained by the researcher on data collection, and interviewing techniques and how to approach respondents.

3.3. Sampling Technique and Sample Size

The sample households were selected by utilizing multi-stage sampling procedure. First, the six *kebeles* of Kobo district, where the program has been operating were purposively chosen. At the second stage, three representative *kebeles* were selected randomly from six project target *kebeles*'. Then, the households were stratified in to users and non-users. Irrigation users defined as those who used any irrigation system during production year. Non-user households are defined as farmers who have not participated in any irrigation activities within the same period while they are located in the same *kebele*; and the latter group served as a control group in the study in relation to impact assessments against irrigation user households.

In the third stage, 100 irrigation non-users and 80 irrigation user households were selected randomly based on probability proportion to sample size. Due to heterogeneous group of the population (irrigation users and non-users), 180 sample farm household respondents were determined using Cochran (1977) formula considering 95% of the confidence level ($z=1.96$), 36% estimated proportion of an attribute in the population (p) and 7% level of precision (e) from 11,570 total households. The formula is:

$$n_0 = \frac{z^2 pq}{e^2} = \frac{(1.96)^2 (0.36)(0.64)}{(0.07)^2} = 180 \quad (1)$$

Where, n_0 is the sample size, z is the selected critical value of desired confidence level, p is degree of variability in the population, $q = 1-p$ and e is the desired level of precision.

Table 1: Distribution of sample households for each kebele

Name of kebele	Total HH	Irrigation users	Sample HH (users)	non-irrigation users	Sample HH (non- users)
Aradom	2800	1300	39	1500	45
Abuare	1720	755	23	965	29
Jarota	1500	620	18	880	26
Total	6020	2675	80	3345	100

3.4. Methods of Data Analysis

Both descriptive statistics and econometric model (PSM) were employed to analyze the data. The descriptive statistics such as mean, standard deviation, percentage, t-test and chi-square test were used to compare the change in parameter of the treatment and control groups. Descriptive statistics provide a clear picture of socio-economic and demographic situation of the respondents.

Model Specification

The objective of the study is to investigate the impact of small-scale irrigation on farm household food security. Therefore, irrespective of its shortcomings, propensity score matching (PSM) method was used to measure the impact of small scale irrigation on households' food security. It is chosen among other non-experimental methods because it does not require baseline data, matching estimators highlight the problem of common support, since treatment effects can only be estimated within the common support (where there is poor overlap in support between the treated and the non-treated this raises questions about the robustness of traditional methods relying on functional form to extrapolate outside the common support) and matching does not require functional form assumptions for the outcome equation (that is, it is non-parametric) (Dehejia and Wahba, 2002).

Furthermore, the propensity score matching approach aims to only compare households that lie in the common support and exclude others from the analysis. Unlike econometric regressions methods, PSM compares observations and does not rely on parametric assumptions to identify impacts on projects. Even though PSM has many advantage, it has limitations such as it requires large samples, group overlap and hidden bias may remain because it matching only controls for observed variables. It attempt to estimate the average

impact of treatment on treated/ATT (Haile, 2008). According to Caliendo and Kopeinig (2005) there are five steps in implementing PSM include: estimation of the propensity scores, choosing a matching algorithm, checking on common support condition, testing the matching quality and sensitivity analysis

Estimation of the propensity scores:

The first step in PSM method is to estimate the propensity scores. As described by Rosenbaum and Rubin (1983) matching can be performed conditioning on $P(X)$ alone rather than on X , where $P(X) = \text{Prob}(D=1|X)$ is the probability of participating in irrigation conditional on X . If outcomes without the intervention are independent of participation given X , then they are also independent of participation given $P(X)$. This reduces a multi-dimensional matching problem to a single dimensional problem.

A logit model was used to estimate propensity scores using a composite of pre-intervention characteristics of the sampled households (Rosenbaum and Robin, 1983) and matching performed using propensity scores of each observation. In estimating the logit model, the dependent variable was irrigation participation that is users of irrigation, which takes the value of 1 and 0 otherwise. The mathematical formulation of logit model is as follows:

$$P_i = \frac{e^{z_i}}{1 + e^{z_i}} \quad \text{Where, } P_i \text{ is the probability of participation in irrigation} \quad (2)$$

$$Z_i = a_0 + \sum_{i=1}^n a_i X_i + U_i$$

Where, a_0 = Intercept, a_i = Regression coefficients

U_i = Disturbance term, and X_i = Pre-intervention characteristics.

$$\text{The probability that a household belongs to non-participant is: } 1 - P_i = \frac{1}{1 + e^{z_i}} \quad (3)$$

The odds ratio is $\frac{P_i}{1-P_i} = e^{Z_i}$ Taking the natural logarithm, then

$$Z_i = a_0 + \sum_{i=1}^n a_i X_i + U_i \quad (4)$$

Choosing a Matching Algorithm/ matching estimators

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

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

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

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

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

Checking on common support condition

Imposing a common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group. The common support region is the area which contains the minimum and maximum propensity scores of treatment and control group households, respectively. The basic criterion of this approach is to delete all observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group. Observations which lie outside this region are discarded from analysis (Caliendo and Kopeinig, 2005). No matches can be made to estimate the average treatment effects on the ATT parameter when there is no overlap between the treatment and non-treatment groups.

Testing the matching quality

One important concern that should be taken care of while doing PSM is balancing test to balance the distribution of the relevant variables in both the control and treatment groups. One suitable indicator to assess the distance in marginal distributions of the X variables is the standardized bias (SB) suggested by Rosenbaum and Rubin (1985). It is used to quantify the bias between treated and control groups. For each variable and propensity score, the standardized bias is computed before and after matching as:

$$SB(X) = 100 * \frac{\bar{X}_1 - \bar{X}_0}{\sqrt{0.5((V_1(X) + V_0(X)))}} \quad (5)$$

Where $\bar{X}_1$ and $\bar{X}_0$ are the sample means for the treatment and control groups, $V_1(X)$ and $V_0(X)$ are the corresponding variances. The bias reduction (BR) also can be computed as:

$$BR = 100(1 - \frac{B(X)_{after}}{B(X)_{before}}) \quad (6)$$

Treatment effect on the treated

To estimate the effect of small scale irrigation to a given outcome (Y) is specified as:

$$\tau_{ATT} = Y_i(D_i = 1) - (D_i = 0) \quad (7)$$

Where τ_i is treatment effect (effect due to participation in irrigation), Y_i is the outcome on household i , D_i is whether household i has got the treatment or not (i.e., whether a household participated in irrigation or not).

However, $Y_i(D_i=1)$ and $Y_i(D_i=0)$ cannot be observed for the same household at the same time. Depending on the position of the household in the treatment (Participation in small scale irrigation), either $Y_i(D_i=1)$ or $Y_i(D_i=0)$ is unobserved outcome (counterfactual outcome). Due to this fact, estimating individual treatment effect τ_i is not possible and one has to shift to estimate the average treatment effects of the population than the individual one. Two treatment effects are most frequently estimated in empirical studies (Caliendo and Kopeinig, 2005). The first one is the (population) Average Treatment Effect (ATE) which is simply the difference of the expected outcomes.

$$\Delta Y_{ATE} = E(\Delta Y) = E(Y_1) - E(Y_0) \quad (8)$$

This measure answers the question what would be the effect if households in the population were randomly assigned to treatment. But this estimate might not be of importance to policy makers because it includes the effect for which the intervention was never intended. Therefore, the most important evaluation parameter is the so called Average Treatment Effect on the Treated (ATT), which concentrates solely on the effects on those for whom the

program/interventions are actually introduced. In the sense that this parameter focuses directly on those households who participated, it determines the realized impact of small scale irrigation usage and helping to decide whether participation on irrigation is successful or not. It is given by:

$$\tau_{ATT} = E(\tau / D = 1) = E(Y_1 / D = 1) - E(Y_0 / D = 1) \quad (9)$$

This answers the question, how much did households participating in irrigation benefit compared to what they would have experienced without participating. Data on $E(Y_1/D=1)$ are available from irrigation users. An evaluator's classic problem is to find $E(Y_0/D=1)$. So the difference between $E(Y_1/D=1) - E(Y_0/D=1)$ cannot be observed for the same household. The possible solution is to use the mean outcome of the comparison individuals, $E(Y_0/D=0)$, as a substitute to the counterfactual mean for those being treated, $E(Y_0/D=1)$ after correcting the difference between treated and untreated households arising from selection effect. Thus, by rearranging, and subtracting $E(Y_0/D=0)$ from both sides of equation (8), one can get the following specification for ATT.

$$E(Y_1 / D = 1) - E(Y_0 / D = 0) = \tau_{ATT} + E(Y_0 / D = 1) - E(Y_0 / D = 0) \quad (10)$$

Both terms in the left hand side are observables and ATT can be identified, if and only if $E(Y_0/D=1) - E(Y_0/D=0) = 0$. i.e., when there is no self-selection bias. This condition can be ensured only in social experiments where treatments are assigned to units randomly (i.e., when there is no self-selection bias) (Caliendo and Kopeinig, 2005). In non-experimental studies one has to introduce some identifying assumptions to solve the selection problem. The following are two assumptions to solve the selection problem.

A. Conditional Independence Assumption (CIA):

Given a set of observable covariates (X) which are not affected by treatment, potential outcomes are independent of treatment assignment. This assumption implies that the selection is solely based on observable characteristics, and variables that influence treatment assignment and potential outcomes are simultaneously observed (Caliendo and Kopeinig, 2005). CIA is given as: $y_o \perp D / x$

Where $\perp$ indicates independence, X is observable characteristics and Y_0 is non-users.

B. Common support:

This assumption rules out perfect predictability of D given X . That is: $0 < P(D = 1 | X) < 1$

This assumption ensures that with the same X values have apposite probability of being both participants and non-participants. Give the above two assumptions, the PSM estimators of ATT can written as:

$$\tau_{ATT} = E(Y_1 - Y_0 / D = 0, P(X)) = E(Y_1 / D = 1, P(X)) - E(Y_0 / D = 0, P(X)) \quad (11)$$

Where $P(X)$ is the propensity score computed on the covariates X . Equation (10) is explained as; the PSM estimator is the mean difference in outcomes over the common support, appropriately weighted by the propensity score distribution of participants.

Estimation of standard error testing: the statistical significance of treatment effects and computing their standard errors is not a straightforward thing to do. The problem is that the estimated variance of the treatment effect should also include the variance due to the estimation of the propensity score, the imputation of the common support, and possibly also the order in which treated individuals are matched.

Bootstrapping: this method is a popular way to estimate standard errors in case analytical estimates are biased or unavailable. Each bootstrap draw includes the re-estimation of the results, including the first steps of the estimation (propensity score, common support). Bootstrap standard errors attempted to incorporate all sources of error that could influence the estimates. Bootstrapping estimate of standard errors is invalid for nearest neighbor matching selection. Thus, calculating analytical standard error is applicable here. Bootstrapping standard errors for kernel matching estimators is not subject to this criticism because the number of observations used in the match increases with the sample size.

Sensitivity Analysis

Here hidden bias i.e. the sensitivity of estimated treatment effects with respect to un-Observed covariates and Rosenbaum-bounds were tested and calculated. If results are very sensitive

reconsider identifying assumption and consider alternative estimators. Common support i.e. the sensitivity of estimated treatment effects with respect to the common support problem was tested and Lechner-bounds calculated (Caliendo and Kopeinig, 2005).

3.5. Definition of Variables and Working Hypothesis

Participation in Small scale Irrigation (PRTIR): This was a dummy dependent variable of the model and assumes a value of 1 for irrigation user households and 0 non-user households.

Outcome variables

Household consumption expenditure per adult equivalent: This refers to household expenses on food and non-food items per adult equivalent per year. Consumption expenditure measured by annual household consumption expenditure on food and non-food items measured in birr. Constructing measures of consumption food and non-food expenditures: the quantities monthly consumed /spend of different foods (food and non-food) were converted to values (Birr) using household self-reports of purchases as well as food prices reported in CSA and this figure converted in to year and then divided by Adult equivalent. The hypothesis is that participants in irrigation improves households' diet and are less vulnerable to food shortage than the non-users.

Daily caloric intake per adult equivalent: Daily calorie intake per adult equivalent is an important indicator of food security status at household level. In order to measure the food security, household information concerning type and amount of food item consumed by their families in the last seven days preceding the survey were collected from both irrigation user and non-user households. The food items was calculated using calorie conversion factor and household members were also converted to their adult equivalent. Then, the amount of total calories (kcal) consumed by each sample household was computed and divided by seven days to get daily calories consumed by the household. This figure was divided by the Adult Equivalent (AE) of respective households and which finally gave the amount of calorie available per AE for each sampled household and then compared with recommended kcal per AE per day (2200Kcal) which is set by the Ethiopia Government (FDRE, 2014). Thus, those households beyond this threshold level will be seemed to be food secure otherwise not food

secure. The hypothesis was that small scale irrigation users can increase their income and they have the capacity to secure their wellbeing than non-users.

Explanatory variables: The dependent variable which is participation in in small scale irrigation was assumed to be influenced by following independent variables. Each variables were defined with their hypothesis based on economic theory.

Sex of household head (SEX): This is a dummy variable, which takes 1 if sex of respondent is male, 0 otherwise. Since the participation of women on farming activities are by far limited due to cultural impediments than male, female headed households are expected to be less participated in small scale irrigation than male headed households. Jema *et al.* (2013) and Hadush (2014) revealed that irrigation users household heads were significantly male headed relative to non-users. Therefore, males were hypothesized to be better than the female farmers in participation in small scale irrigation.

Age of household head (AGE): It is a continuous variable measured in years. Age of a household head can generate or erode confidence on technologies. In other words, with age a farmer can become more risk averse to new technologies. Haile (2008) found that there was significant differences in the age of the households between irrigating and non-irrigating household heads. As age advances household head becomes much reluctant to accept new technologies. So, it was hypothesized that younger farmers have more probability of participating in irrigation practice while elder farmers are less likely to participate.

Labor availability (ADLAB): It is a continuous variable measured in terms of Adult-Equivalent (AE). It is one of the determinant factors for households' participation in small scale irrigation. Households with more labor have the probability of participating in irrigation practice. The findings of Hadush (2014) found that there was a significance difference in availability of adult labor between irrigation users and non-users and households, with irrigation have owned better labor input than non-irrigating households. Sikhulumile (2013) also found that irrigators were found to have bigger families (both in numbers and adult equivalents) compared to non-irrigators, indicating a high labor demand for irrigation farming.

Education level of the household head (EDUC): It is a categorical variable. Level of education was assumed to increase farmers' ability to obtain and use information relevant to the use of technology. Education is therefore expected to increase the probability of participation in irrigation technology. Getaneh (2011) and Kifle *et al* (2011) found education level of household heads was higher for irrigating households than non-irrigating households.

Frequency of extension contact (EXTF): It is continuous variable measured by number of contacts or visits made by the extension agents to sample households per year. The number of contact with development agents are more likely to be aware of new practices as they are easily exposed to information (Habtemariam, 2004). In a study in South Africa by Sikhulumile (2013) access to extension services improved the likelihood of irrigation participation, and extension officers are more visible in irrigation projects. Extension contact was hypothesized, to influence the farmers' decision to participate in irrigation positively.

Access to credit (ACT): It is dummy variable which takes a value of 1, if the household head uses credit, 0 otherwise. Credit is essential for procurement of inputs and payment of casual labor that help in the farm work. Credit access minimizes liquidity problems that household could face while intending to purchase agricultural inputs; and hence paves the way for timely application of inputs thereby increase the room for households participation in irrigation farming. Those households who have access to credit became capable of using irrigation than those who have no access to credit. Hence, it was expected to increase the probability of participation in irrigation farming.

Distance from the nearest market (MDTS): it is a continuous variable measured in Kilometers. Distance to the nearest market influences the probability of participation in irrigation technology. Kifle (2012) reported that the probability of participation in irrigation for a household, with a reasonably good access to market information would be nearly twice the households who do not have access to market information. Therefore, in this study it was hypothesized that distance from market is negatively related to participation in irrigation.

Off/non-farm income (OFIN): It is treated as continuous variable expressed in terms of birr. Off/non-farm income is the income generated other than on-farm activities. Hadush (2014)

found that household heads who were engaged in nonfarm activities were 25.12% more likely to participate and adopt a micro irrigation system than those household heads that had not participated in nonfarm activities. It is, therefore, expected to affect the use of irrigation technology positively

Dependency ratio (DEPR): This variable is measured as the ratio of household member not in the labor force, child or old, to those household members in the labor force. The dependency ratio reflects the pressure and responsibility on household member in the labor force. Hence, this variable was hypothesized to have a negative relationship with participation in the small-scale irrigation scheme that is, as dependency ratio increase, the participation in irrigation scheme decreases and vice versa.

Cultivated land size (LSZ): It is a continuous variable measured in hectare (ha) and represents the total owned cultivated land size (both irrigated and rain fed) of a household. The study of Abraham *et al.* (2015) identified that, size of cultivated land has positive affect household participation in small scale irrigation. Households who have large cultivated land size can have a better option to diversify production and a better position to use irrigation. Hence, this variable was hypothesized to have positive effect on consumption per adult equivalent which have effect on food security as well as participation in the irrigation scheme.

Distance from irrigation water source (WSD): It is a continuous variable measured in kilometer. Distance of households to water source was expected to determine both household's participation in irrigation and improving household income. Sikhulumile (2013) found that distance of farmer's homestead from the irrigation scheme had a negative influence on the farmer being an irrigator. Nearness to the scheme implies less time taken to the scheme, and ensures ease of management. Since the bulk of the farmers walk to the scheme, then the closer the farmer to the scheme, the higher his/her chance of being an irrigator.

Number of livestock holding (TLU): It is a continuous variable measured in terms of Tropical Livestock Units (TLU). Agerie (2013) reported that households who have a better livestock holding were participating in irrigation farming as compared to households with less livestock holding. Similarly, Hadush (2014) also reported livestock holding had appositive and

significant influence for participating in micro irrigation. Hence, for this study livestock ownership was hypothesized to be positively related to irrigation participation decision.

Table 2: Definitions of hypothesized explanatory variables

Variable Definition	Symbol	Expected sign	Types
Age of household head	AGE	-	Continuous
Sex of household head	SEX	+	Dummy
Education level of household head	EDUC	+	Categorical
Labor availability	ADLAB	+	Continuous
Number of Livestock holding	TLU	+	Continuous
Dependency ratio	DEPR	-	Continuous
Cultivated land size	LSZ	+	Continuous
Distance from irrigation water sources	WSD	-	Continuous
Frequency of extension contact	EXTF	+	Continuous
Access to credit	ACT	+	Dummy
Distance from the nearest market	MTDS	-	Continuous
Off/non-farm income	OFIN	+	Continuous

Outcome Variables		
Household consumption expenditure Per adult equivalent	TEPAE	Continuous
Daily caloric intake per adult equivalent	FEAE	Continuous

Source: Own definition, 2016

4. RESULT AND DISCUSSION

In this chapter the findings from descriptive and econometric analyses were presented and discussed.

4.1 Descriptive Statistical Results

Sex of household head: The sample households were composed of 80 irrigation user and 100 irrigation non-user households. The survey result showed that out of the total 180 sampled households, 77.22 % and 22.78 % were male headed and female headed respectively. The result also indicated that 82.5 % and 17.5 % of irrigation user households and 73 % and 27 % of irrigation non-user households were male headed and female headed households respectively. The Chi-square test was found to be no statistically significant difference in the sex of the household head between treatment and control household heads (Table 3).

Education level of household head: Education help farmers to acquire and understand information and to calculate appropriate input quantities in a modernizing or rapidly changing environment. Improved attitudes, beliefs and habits may lead to greater willingness to accept risk, adopt innovations, save for investment and generally to embrace productive practices. As shown in Table 3, the education level of household heads was categorized in to five groups: illiterate, read and write, elementary, high school completed and preparatory and above. According to the result the respondents' education level revealed that 29.44%, 29.44%, 31.67%, 8.33 % and 1.12% were illiterate ,read and write, elementary school completed, high school completed , and preparatory and above respectively. The survey also indicates that 23.75%, 76.25% and 29.44%, 71.54% of the respondent households were illiterate and literate of treated and control households respectively.

Access to credit: The study result in Table 3 showed that 45.56 % of the sample households used credit services while 54.44 % had not use credit. The majority of the sampled households did not obtained credit services. The survey result also described that 60 % of users and 52.5% non-users had not access to credit service. This result indicated that most of the respondents had not obtained credit service due to collateral problem, high interest rate and some due to

not needed the services at all. The chi square test indicated that there was no significant relationship between irrigation participation and access to credit services

Table 3: Definitions of hypothesized explanatory variables

Variables	PRTIR	Irrigation user Freq	%	non-user of irrigation Freq	%	Total freq	%	χ^2
Sex	Male	66	82.5	73	73	139	77.22	2.28
	Female	14	17.5	27	27	41	22.78	
	Total	80	100	100	100	180	100	
Education level	Illiterate	19	23.75	34	34	53	29.44	3.29
	Literate							
	Read and write	24	30	29	29	53	29.44	
	Elementary	27	33.75	30	30	57	31.67	
	High school	9	11.25	6	6	15	8.33	
	Preparatory and above	1	1.25	1	1	2	1.12	
	Total	80	100	100	100	180	100	
Access to credit use	credit user	38	47.5	40	40	82	45.56	1.02
	credit non-user	42	52.5	60	60	98	54.44	
	Total	80	100	100	100	180	100	

Sources: own survey result, 2016

Age of the household head: Age of the household head influences whether the household benefits from the experience of an older person, or has to base its decisions on the risk-taking attitude of a younger farmer. The average age of the sample household heads in the study area was between 42 and 45 with standard deviation of 8 and 9.69 for irrigation user and non-users respectively. The mean age of the sample household heads was 43.64 years with standard deviation of 9.03. According to the results in Table 4, there was no significant difference in the mean age of the household heads between treated and control groups.

Labor availability: The sample households had mean family labor size of 2.29 persons per household in terms of adult equivalent with standard deviation of 0.88. The mean labor for

treated and control sampled household groups in adult equivalent were 2.31 and 2.27 persons per household head with standard deviation of 0.97 and 0.81 respectively. The t-test result revealed that there was no significant difference in the mean between the irrigation users and non-user in terms of adult labor availability (Table 4).

Dependency ratio: Dependency ratio is defined as population that is not of working age (<15 and >64) divided by total number of working age persons (15-64years) per 100persons. The value is then multiplied by 100 to express it in percent. As shown in Table 4, the average dependency ratio of the sample households was 1.06 with standard deviation of 0.703. This means, on average, more than one dependent (young or elderly person) in the household for each working age member to support, feed and educate. The mean dependency ratio of treated and control sample households were 0.98 and 1.13 with standard deviation of 0.66 and 0.73 respectively. This result revealed that irrigation user sample households have less dependency ratio than the control households. The mean difference between groups in terms of dependency ratio was statistically insignificant.

Livestock holding: Livestock are the most important productive assets in the household. In the study area, livestock are important sources of draft power for ploughing, transportation and riding. Livestock also consolidate the social organizations as they serve in payment for blood compensation (as compensation when committing death crime) and gift for relatives. They play a role in religious and cultural ceremonies and serve as a source of prestige. It is also considered as a saved asset used during period of food shortage. In the study area, the main livestock species owned by the sample households were cattle, sheep, goat, donkey, camel and chickens. The average livestock holding for sample households was 3.48 in TLU with standard deviation of 1.60. Irrigation user households possess a large average number of (4.01 in TLU) than non-user households (3.05 in TLU). The t-test result showed that the mean comparison of the two groups with regard to livestock holding is statistically significant at 1% probability level.

Cultivated land size: Land is the major productive asset in agrarian countries like Ethiopia. Cultivable land is the most important scarce factor of production. In the study area, the average land holding size of the sample households was 0.65 ha with standard deviation of 0.4. The mean land holding size of irrigating households and non-irrigating households was 0.74 ha and

0.57 ha with standard deviation of 0.32 and 0.45 respectively. The mean difference between the irrigation user and non-users with respect to land holding size was significant at 1% probability level (Table 4).

Distance from irrigation water source: The survey result in Table 4 described that the average distance of the sample household from the irrigation water source in kilometer was found to be 3km with standard deviation of 1.48. The average distance for irrigation user households was 2.78km, the corresponding figure for non-users was 3.78 km. There was significant difference between irrigation user households and non-user households at 10% probability level in terms of distance from irrigation water sources.

Off/non-farm income: The types of off/non –farm activities in the study area are petty trade, remittance, selling local drinks (*tella, tejj...*), selling charcoal and wood, weaving and others. The t-test result in Table 4 showed that the average annual off/non-farm income for the sample households was 4862.22 birr. The irrigation user households earned birr 5507.13 per year and non-irrigation user households earned birr 4346.3 per year. The mean difference in non/off-farm income between irrigation users and non-users was significant at 10% probability level.

Frequency of extension contact: This refers to the number of contacts per year that the respondent made with extension agents. Frequent visit of agricultural extension agent's increases awareness among farmers about new farm activities through demonstrations and discussions. According to the study result in Table 4 showed that the mean frequency of extension contact of the sample households in the study area was 7.23 with standard deviation of 4.51. The mean contact of irrigating and non-irrigating households were 7.79 and 6.78 per year with standard deviation of 4.68 and 4.33 respectively. This shows that the treated group had one more contact than the control group with respect to extension contact but the t-value result showed that it had no statistically significant difference between irrigation users and non-users.

Distance from the nearest market: Markets have clearly played a role in determining the economic viability of irrigation development. With regard to the distance from the nearest market, the average distance of the sample household from the nearest market was 9.94km with standard deviation of 3.098. The mean distance of the treated and control group from the

nearest market was 9.52km and 10.27km with standard deviation of 3.27 and 2.93 respectively which was statistically significant between groups at 10% probability level.

Table 4: Descriptive statistics of sample households (for continuous variables)

Variables	Irrigation user HH		Non-irrigation user HH		Combined		t-value
	Mean	SD	Mean	SD	Mean	SD	
Age of HH head	42.43	8.00	44.62	9.697	43.64	9.03	-1.63
Labor availability	2.31	0.97	2.27	0.808	2.29	0.88	0.26
Dependency ratio	0.98	0.66	1.13	0.73	1.06	.703	-1.38
Livestock holding	4.01	1.40	3.05	1.63	3.48	1.60	4.15***
Cultivated land size	0.74	0.32	0.57	0.45	0.65	0.40	2.77***
Distance from water sources	2.78	1.56	3.18	1.39	3.00	1.48	-1.85**
Off/non-farm income	5507.125	5287.79	4346.3	4630.09	4862.22	4952.92	1.76*
Extension contact	7.79	4.68	6.78	4.33	7.23	4.51	1.49
Distance from the nearest market	9.52	3.27	10.27	2.93	9.94	3.098	-1.72*

***, * means significant at 1%, and 10% probability level respectively

Sources: own survey result, 2016

4.2. Descriptive results of outcome variables

Household consumption expenditure per AE: The combined mean of annual consumption expenditure (food and non-food) per adult equivalent of the sampled households was birr 11033.56 .The average annual consumption expenditure per adult equivalent of the participant and non-participant households was birr 13363.05 and 9169.97 respectively. The mean difference of the participant and non-participant households in consumption expenditure per adult equivalent was birr 4193.08. The households' consumption expenditures per adult equivalent per year between the participant and non-participant was significantly different at 1% probability level (Table 5).

Daily caloric intake per AE (kcal): The result of the study revealed that the average daily calorie intake per adult equivalent of sample respondents was 2518.33kcal with the standard deviation of 1181.21. The result in Table 5 also showed that the average calorie intake for

participant households and non-participant households was 3088.77 kcal and 2061.98 kcal with standard deviation of 1461.37 and 587.966 respectively. The result of this study showed that the mean difference of the calorie intake between the irrigation user households and the non-user households was 1026.78 kcal and statistically significant at 1% probability level.

Table 5: Mean calorie intake and expenditure per adult equivalent of sample households

Variables	Irrigation user HH	Irrigation non-user	Combined Mean	Mean Differences	t-value
Household consumption expenditure per AE	13363.05	9169.97	11033.56	4193.08	4.09***
Daily caloric intake per AE	3088.77	2061.98	2518.33	1026.78	6.41***

*** means significant at 1% probability level

Sources: own survey result, 2016

However, the above results cannot tell us whether the observed difference is exclusively because of the program or not. Therefore further analysis must be performed using propensity score matching techniques to address this issue.

4.3. Econometric Model Results

In this part propensity score matching model was used to analyze the impact of small scale irrigation on farm households' food security. The estimation of propensity scores, matching methods, common support region, matching quality/treatment effect and sensitivity analysis of the sample household are presented and discussed.

4.3.1 Estimation of Propensity Scores

According to Ravallion (2009) Propensity Score Matching is a tool that creates a comparison group with the treatment group based on factors that affect people's propensity to participate in the program. And also it allows finding of a comparison group from a sample of non-participants closest to the treatment group in terms of observable characteristics, so that both groups are matched on the basis of the propensity score, which is a predicted probability of participation given observed characteristics. For this study the logistic regression model was

used to estimate propensity score matching for treatment and control households. As stated earlier, the dependent variable is binary that indicate households participation in the small scale irrigation which takes value of 1 if the household is irrigation user and 0 otherwise.

Results presented in Table 6 below showed that the estimated model appears to perform well for the intended matching exercise. The likelihood ratio chi-square value, 53.73, revealed that the overall fitness of the model was found significant at 1% probability level. Moreover, the small value of Pseudo- R^2 (0.22) showed that irrigation user households do not have much distinct characteristics over non-user households and as such finding a good match between irrigation user and non-user households becomes easier. After matching there should be no systematic differences in the distribution of covariates between both groups and therefore, the pseudo R^2 should be fairly low (Caliendo and Kopeining, 2008).

Looking into the logit regression model (Table 6), the results indicated that seven explanatory variables from the twelve proposed variables were statistically significant. These significant variables were age of the household head, dependency ratio, livestock holding in TLU, cultivated land size, distance from irrigation water sources, off/non-farm income and distance from nearest market. Out of those seven significant variables, four variables which are age of the household head, dependency ratio, distance from water sources and distance from nearest market showed negative coefficients while livestock holding, cultivated land size and off/non-farm income revealed positive signs at their respective probability level.

Table 6: Logit model results of covariates

Variables	Coefficients	Standard error	Z value
Constant	2.232	1.524	1.46
Sex of the household head	0.494	0.462	1.07
Age of the household head	-0.0527**	0.0246	-2.14
Education level			
Read and write	0.165	0.495	0.33
Elementary	0.126	0.514	0.25
High school	1.039	0.757	1.37
Preparatory and above	0.731	2.083	0.35
Labor availability	0.249	0.228	1.09
Dependency ratio	-0.895***	0.283	-3.16
Livestock holding (TLU)	0.5944 ***	0.1456	4.08
Cultivated land size	0.935 **	0.457	2.05
Distance from irrigation water sources	-0.323 ***	0.130	-2.48
Off /non-farm income	0.078 *	0.0437	1.78
Frequency of extension contact	0.056	0.042	1.33
Distance from the nearest market	-0.1862***	0.0707	-2.63
Access to credit use	0.135	0.410	0.33
Number of observation	180		
LRchi2 (12)	53.73		
Prob >chi2	0.00***		
Log likelihood	-96.78		
Pseudo R ²	0.22		

*, **, *** means significant at 10%, 5% and 1% probability level respectively

Sources: own survey result, 2016

Moreover, p-score graph was used to show distribution of the household with respect to the estimated propensity scores. Figure 1 below portrays the distribution of treatment households, the control households and sample households with respect to the estimated propensity scores.

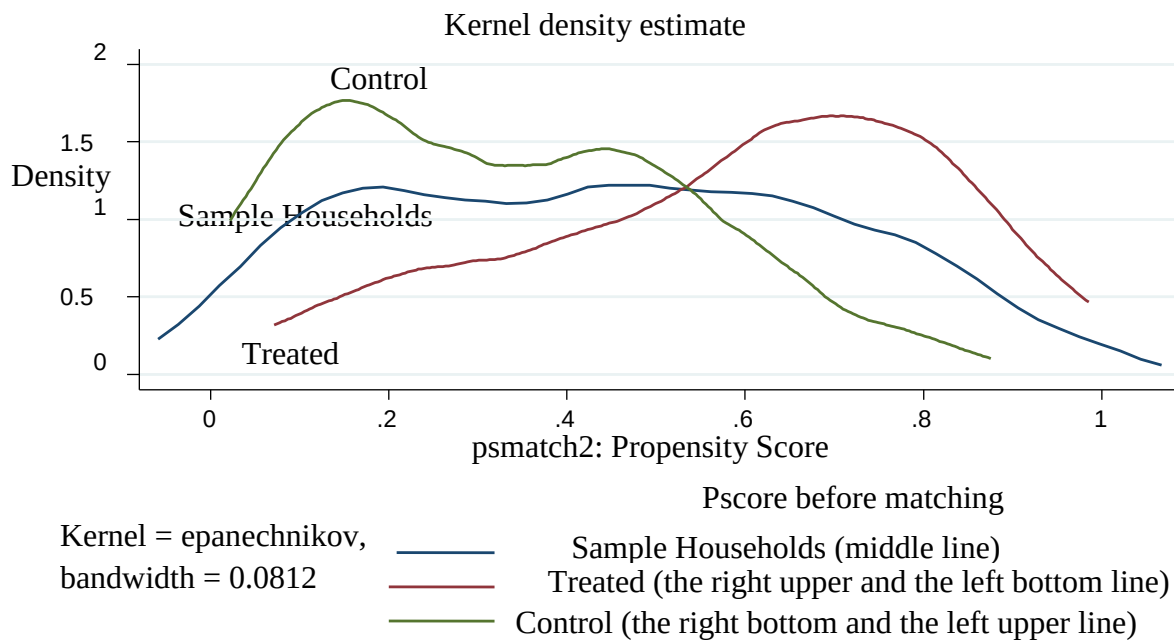


Figure 3. Kernel density of propensity score distribution

4.3.2. Matching Participant and Comparison Households

In this part, four main tasks were accomplished. First, distribution of sample households in estimated propensity score matching should be executed. Second, a common support condition should be imposed on the propensity score distributions of household and then discard observations whose predicted propensity scores fall outside the range of the common support region. Third, treatment effect on treated household should be analyzed. And finally sensitivity analysis should be done in order to check the robustness of the estimation.

As shown in Table 7, the estimated propensity scores vary between 0.071 and 0.875 of the total household. For this study the common support region would then lie between 0.071 and 0.875. In other words, households whose estimated propensity scores are less than 0.071 and larger than 0.875 are discarded from the analysis. As a results of this restriction 19 households (11 non-irrigation user and 8 irrigation users) were discarded from the exercise.

Table 7: Distribution of sample households in estimated propensity score matching

Group	Observation	Mean	SD	Min	Max
Treated	80	0.59	0.23	0.071	0.986
Control	100	0.33	0.21	0.022	0.875
Total HH	180	0.46	0.22	0.071	0.875

Source: Own survey result, 2016

4.3.3. Choice of Matching Algorithm

Alternative matching estimators were tried in matching the treatment and control groups in the common support region. These matching methods were nearest neighbor matching, radius matching, caliper matching and the kernel matching. According to Sianesi *et al* (2004) a good matching estimator is that provides low pseudo- R^2 value and statistically insignificant likelihood ratio test of all regress after matching (a matching estimator which balances all explanatory variables between both groups). Final choice of a matching estimator was guided by different criteria such as equal means test referred to as the balancing test (Dehejia and Wahba, 2002), Pseudo- R^2 and matched sample size. Accordingly a matching estimator which balances all explanatory variables (that is, results in insignificant mean differences between the two groups), bears a low pseudo R^2 value and large matched sample size is preferable.

According to Table 8 below shows that the estimated results of tests of matching quality based on the above mentioned performance criteria. After looking into the results, it has been found that kernel matching with a band width of 0.25 was found to be the best estimator for the data with low pseudo R^2 value of 0.015 and larger matched sample size as compared to other alternative matching estimators. As such, in what follows estimation results and discussion are the direct outcomes of the kernel matching algorithm based on a band width of 0.25.

Kernel matching associates the outcome of the treated household with the matched outcome that is given by a kernel-weighted average of all control groups for market development. Since the weighted averages of all market development interventions in the control group are used to construct the counterfactual outcome, kernel matching has an advantage of lower variance because more information is used (Heckman *et al.*, 1998).

Table 8: Performance criterion of different matching algorithm

Matching estimator	Balancing test	Performance criteria	
		Pseudo R ²	Matching sample size
Kernel matching			
Band width 0.01	12	0.024	122
Band width 0.1	12	0.019	161
Band width 0.25	12	0.015	161
Band width 0.5	12	0.050	161
Calipers			
Band width 0.01	10	0.060	122
Band width 0.1	11	0.032	161
Band width 0.25	11	0.032	161
Band width 0.5	11	0.032	161
Radius calipers			
Band width 0.01	12	0.200	122
Band width 0.1	12	0.017	161
Band width 0.25	12	0.021	161
Band width 0.5	12	0.083	161
Nearest neighbor matching			
NN(1)	11	0.032	161
NN(2)	12	0.022	161
NN(3)	11	0.033	161
NN(4)	12	0.031	161
NN(5)	12	0.026	161

Source: own survey result, 2016

4.3.4. Testing the Balance of Propensity Score and Covariates

The main purpose of the propensity score estimation is not to obtain a precise prediction of selection into treatment, but rather to balance the distributions of relevant variables in both groups. Balancing of propensity score and covariates by applying the selected matching algorithm is determined by considering different test methods such as the reduction in the mean standardized bias between the matched and unmatched households, equality of means using t-test significance for the variables used.

According to Table 9, the standard bias before matching lies in the range between 10.7% and 80%. After matching the standard difference of covariates lies between 4.1% and 14.1% which is below the critical level of 20% suggested by Rosenbaum and Rubin (1985). There were some variables which were significantly different for the two groups of respondents before

matching but after matching these significant covariate became insignificant which indicates that the differences in covariates mean between the treated and control groups eliminated and balanced. These creates a high degree of covariate balance between the treatment and control samples that are ready to use in the estimation procedure of treatment effect. Similarly, t-values in Table 9 showed that before matching some of chosen variables exhibited statistically significant differences while after matching all of the covariates were balanced.

Table 9: Propensity score and covariate balancing

Variable	Sample	Mean		Standard Bias %	Reduction Bias %	Test	
		Treated	Control			t-value	P > t
SEX	Unmatched	0.83	0.73	15.63		1.5	0.13
	Matched	0.85	0.82	5.70	63.5	0.38	0.71
AGE	Unmatched	42.43	44.62	-24.64		1.63	0.11
	Matched	42.86	43.36	-5.70	76.87	-0.36	0.72
EDU	Unmatched	2.36	2.11	25.13		1.69*	0.09
	Matched	2.31	2.24	6.40	74.5	0.39	0.69
ADLAB	Unmatched	2.31	2.27	48.94		0.26	0.79
	Matched	2.33	2.25	8.70	82.2	0.53	0.59
DEPR	Unmatched	0.98	1.13	-25.55		-1.38	0.17
	Matched	1.03	0.99	-2.50	90.22	0.33	0.74
TLU	Unmatched	4.01	3.05	63.19		4.15***	0.00
	Matched	3.87	3.71	11.00	82.59	0.71	0.48
LSZ	Unmatched	0.74	0.57	27.42		2.77***	0.006
	Matched	0.73	0.75	4.80	82.5	-0.21	0.83
WSD	Unmatched	2.78	3.18	-27.08		-1.85*	0.07
	Matched	2.87	3.01	-9.96	63.22	-0.65	0.52
OFFIN	Unmatched	5.31	5.12	23.36		1.76*	0.06
	Matched	5.39	5.2	4.20	82.02	0.25	0.80
EXTF	Unmatched	7.79	6.78	22.40		1.49	0.14
	Matched	7.35	6.89	10.5	53.13	0.66	0.51
MTDS	Unmatched	9.52	10.27	-24.13		-1.62*	0.10
	Matched	9.73	9.96	-7.40	69.33	-0.44	0.66
ACT	Unmatched	0.48	0.40	10.71		1.01	0.32
	Matched	0.46	0.44	14.10	61.7	0.24	0.81

***, * means significant at 1%, and 10% probability level respectively

Sources: own survey result, 2016

The χ^2 test for joint significance for kernel 0.25 band width matching algorithm is shown in Table 10. According to results, the low pseudo R^2 value and the insignificant likelihood ratio tests evident that both groups have the same distribution in all covariates after matching. These

result clearly showed that the matching procedure is able to balance the characteristics in the treated and the matched comparison groups. Therefore, these results used to evaluate the effect of small scale irrigation project among groups of households having similar observed characteristics. This allowed to compare observed outcomes for participants with those of a comparison groups sharing a common support.

Table 10: Chi-square for the joint significance of variables

Sample	Pseudo R ²	LR Chi ²	P > Chi2
Unmatched	0.22	53.73	0.00
Matched	0.015	2.92	0.996

Sources: own survey result, 2016

All of the above tests suggested that the chosen matching algorithm was relatively best with the data at hand. Thus, the next task is to estimate ATT for treated sampled households.

4.3.5. Estimation of Average Treatment Effect on the Treated

In this section, the impact of small scale irrigation on the outcome variables (total calorie intake and annual consumption expenditure per adult equivalent of households) was evaluated using PSM model, after the pre-intervention differences were controlled. The estimation result presented in Table 11 provides a supportive evidence of statistically significant effect of irrigation on outcome variable (calorie intake and consumption expenditure per adult equivalent). Average treatment effect on the treated (ATT) indicates that the households' calorie intake and annual consumption expenditure per adult equivalent improved as a result of irrigation intervention.

Results in Table 11 showed that, on average, the participant households increased the total calorie intake and consumption expenditure per adult equivalent by 907.07 kcal and 2593.92 birr respectively which were significant at 1% and 5% probability level. In other words, the participation in small scale irrigation has increased households caloric intake per adult equivalent of beneficiary households by 17.6% per day and consumption expenditure per adult equivalent by 11.3% per year

Table 11: ATT for total kcal intake and annual consumption expenditure due to participation

Outcome variable	Treated	Control	Difference	S.E. ^a	t-value
Daily caloric intake per AE	3037.78	2130.71	907.07	185.37	4.89***
Household consumption expenditure per AE	12770.65	10176.73	2593.92	1213.48	2.14**

The bootstrapped SE is obtained after 100 replications

, * means significant at 5% and 1% probability level respectively

Sources: own survey result, 2016

4.3.6. Sensitivity Analysis

In order to control unobservable biases, sensitivity analysis is used to address the impact of small scale irrigation on different significant outcome variables with respect to the choice of the balancing scores. Sensitivity analysis for insignificant effects is not meaningful and is therefore not considered. The first column of Table 12 shows those outcome variables which bears statistical difference between treated and control households while the rest of the values which corresponds to each row of the significant outcome variables are p-critical values (or the upper bound of Wilcoxon significance level -Sig+) at different critical value of e^y .

Results in Table 12 showed that the inference for the impact of small scale participation interventions is not changing though the participants and non-participant households have been allowed to differ up to 200% (3). That means for all outcome variables estimated, at various level of critical value of e^y , the p- critical values are significant which means there are important covariates that affected both participation and outcome variables. It is impossible to get the critical value e^y where the estimated ATT is questioned even if set the critical value largely up to 3, which is larger value compared to the value set in different literatures which is usually 2 (100%). Thus, the sensitivity analysis in Table 12 conclude that impact estimates (ATT) are insensitive to unobserved selection bias and are a pure impact of small scale interventions.

Table 12: Result of sensitivity analysis using Rosenbaum bounding approach

Outcome variables	$e^y = 1$	$e^y = 1.25$	$e^y = 1.5$	$e^y = 1.75$	$e^y = 2$	$e^y = 2.25$	$e^y = 2.5$	$e^y = 2.75$	$e^y = 3$
Daily caloric intake per AE	p<0.00	p<0.00	p<0.00	p<0.00	1.1E-16	4.3E-15	9.3E-14	1.1E-12	9.2E-12
Household consumption expenditure per AE	p<0.00	p<0.00	p<0.00	p<0.00	1.1E-16	4.3E-15	9.2E-14	1.1E-12	9.2E-12

e^y (Gamma) – log odds of differential assignment due to unobserved factors where Wilcoxon significance level for each significant outcome variables is calculated

Sources: own estimation, 2016

5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1. Summary and Conclusions

Small scale irrigation is an important driving tool in development efforts as a means of bringing household food security, reduce dependence on food aid and for economic growth. So that this study was initiated to analyze impact of small-scale irrigation on farm households' food security in Kobo District, Northern Ethiopia. The specific objective of the study are: identifying factors affecting household participation in small scale irrigation and to analyze impact of small scale irrigation on farm households' food security.

Using cross-sectional data from three selected *kebeles* of the District, the impact of small-scale irrigation on farm households' food security were analyzed. Both primary and secondary data were used for the study. The primary data were collected from a total of 180 randomly selected sample households in three *kebeles* from irrigation user and non-user households using semi-structured questionnaire. Multi-stage sampling procedure was employed in the study to determine the sample households. The data were analyzed using both descriptive statistics and PSM mode. Descriptive statistics was used to describe demographic, socio-economic and institutional factors of the households. PSM was used to extract comparable pair of treatment-comparison households in the absence of baseline data.

Descriptive results indicated that irrigation user and non-user households showed a statistically significant mean difference in terms of age of household heads, dependency ration, cultivated land size, livestock holding, distance from irrigation water sources and distance to the nearest market. However, the two groups have showed a statistically insignificant variation in terms of sex, education level and access to credit use of the household. In addition, mean difference of the outcome variables, household daily caloric intake and consumption expenditure per adult equivalent, were statically significant between groups.

The result of the logit model result showed that participation in small scale irrigation was significantly influenced by seven explanatory variables. These variables were age of the household head, dependency ratio, livestock holding in TLU, cultivated land size, distance

from water sources, off/non-farm income and distance to the nearest market. Households far from market and water sources are less likely to be included in the program than household living nearer to market and water sources. Similarly, households who have relatively large dependency ratio are less likely to participate in the program than those who have small dependency ratio. By contrast, size of owned cultivated land, livestock holding and off/non-farm income positively affected households' participation in the program.

In the PSM result, 72 irrigation user households were matched with 89 non-user households after discarding 19 households whose values were out of the common support region by using kernel matching estimator with 0.25 band width. The resulted matching passed on many process of matching quality tests such as t-test, reduction in standard bias and chi-square test. Moreover, the computed standard error was bootstrapped in order to capture all sources of errors in the estimates and finally sensitivity analysis was made.

The impact estimation results then indicated significant differences in daily calorie intake per adult equivalent and households' consumption expenditure per adult equivalent between treatment and control households. On average, the effect of the program on household calorie intake per adult equivalent per day and household consumption expenditure per adult equivalent per year were higher for irrigation user as compared to non-users by 17.6% and 11.3% respectively. The result of Rosenbaum bounding procedure showed that estimated ATT for all significant outcome variables were insensitive which clearly indicate its robustness. Therefore, it is possible to conclude that households' participation in small scale irrigation has significant relationship with food security.

5.2. Recommendations

Based on the empirical findings reported in this study, the following recommendations are forwarded:

This study found an evidence that irrigation user households have more total daily calorie intake per adult equivalent and annual consumption expenditure per adult equivalent of 907.07kcal and 2593.92birr than those who are non-user households respectively. This result calls for a closer integration of policies and more strategic investment targeted for promoting

small scale irrigation schemes in the study area and scale up to all areas of the country, specially to those areas where rain fall is erratic to achieve the intended goal of household food security.

According to the finding, age of household head has negative and significant effect on participation in small scale irrigation. So that the district development agents in the study area need to give awareness to the elders about the benefit of new technology through practical demonstration and arrange training for them to experience sharing from younger farmers.

Distance from irrigation water sources and market place were also negatively related to households' participation in small scale irrigation. Therefore, construction of irrigation schemes should consider the distance between irrigation water sources and village of household.

Similarly the responsible bodies in the district need to strengthen infrastructural development and farmer cooperatives to orchestrate farmers access to market at the right place and time to sell their irrigated produce , provision of inputs and ensures evenly dissemination of market information.

Off/non-farm-income positively influenced irrigation participation of households. From a policy perspective, the findings suggest that, although most rural households participate in the farm sector, rural development policies should focus equally on both the farm and the off/non-farm sectors. In addition, supporting and promoting off/non-farm sector and overcoming potential constraints regarding the diversification of off/non-farm activities in the study area is needed.

Cultivated land size positively and significantly affected households' participation in small scale irrigation. This indicating households who have large cultivable farm size being most likely to participate in irrigation. This result calls farmers should intensify their farm lands, consequently, agricultural production has increased remarkably, and the productivity of inputs has improved.

The study found that livestock holding affected significantly and positively participation in irrigation farming. This result calls a need from the stakeholders in governmental and non-governmental organizations to strengthen mixed crop-livestock farming system through research and development effort to enhance their complementary benefit by increasing demand capacity of disseminating promising technology based on farmers' endogenous knowledge and practice.

The study also showed that dependency ratio significantly and negatively affected farmers' participation in irrigation farming. The economic implication of a higher dependency ratio is likely to increase the burden of government while providing the provision of basic services like social security and health services. The health institution of the district through health extension workers need to strengthen awareness creation on family planning which can also tackle other related problems caused by high dependency ratio.

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7. APPENDICES

Appendix I: Tables

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

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

Source: Storck, *et al.*, 1991

Appendix Table 2. Conversion factor for Adult –Equivalents

Age group (years)	Male	Female
<10	0.6	0.6
10-13	0.9	0.8
14-16	1.00	0.75
17-50	1.00	0.75
>50	1.00	0.75

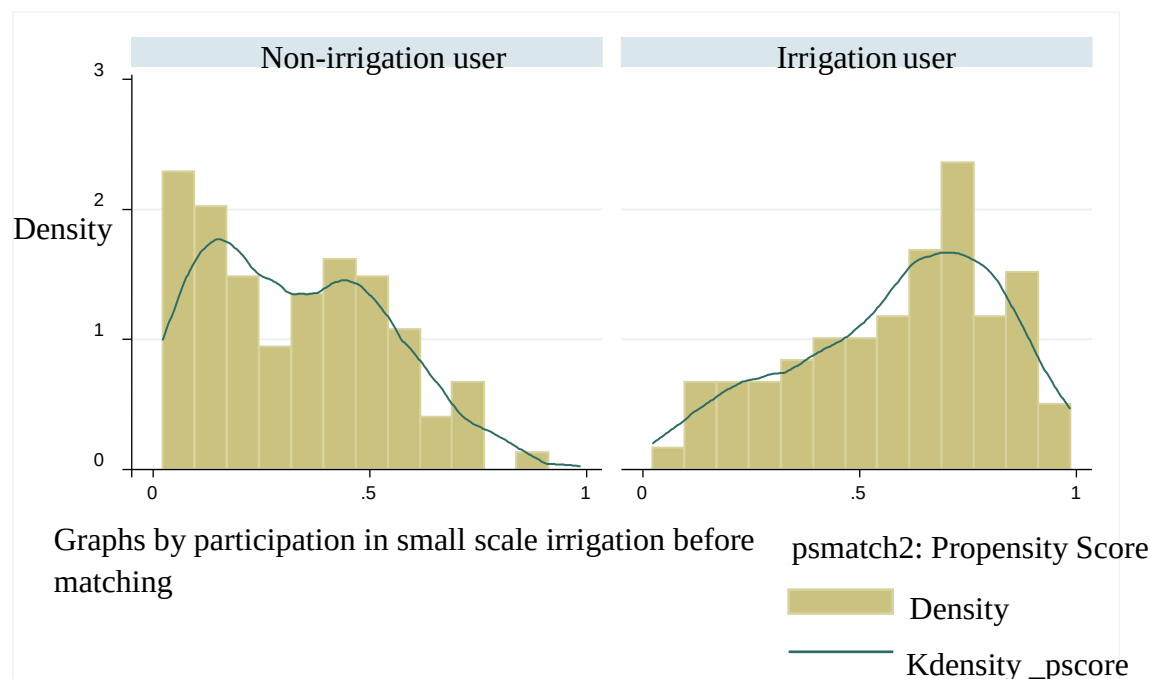
Source: Storck, *et al.*, 1991

Appendix Table 3. Conversion factors of food items consumed by sample household

Food items	Unit	kilocalorie (kcal)
Barley	kg	3723
Maize	Kg	3751
Sorghum	Kg	3805
Teff	Kg	3589
Wheat	Kg	3623
Irish potato	Kg	1037
Sweet potato	Kg	1360
Lentil	Kg	3522
Beans	Kg	3514
Peas	Kg	3553
Onion	Kg	713
Pepper	Kg	933
Beef	Kg	1148
Milk	Kg	737
Egg	Liter	61
Sugar	Unit	3850
Butter	Kg	7364
Edible oil	Kg	8964
Vetch	Lit	3470
Coffee	Kg	1103

Sources: EHNRI, 1997

Appendix II: Figure



Appendix Figure 1. Histogram of propensity score for kernel density participation

Appendix III. Survey Questionnaire

1. Household Characteristics

- 1.1. Kebele of household head _____ Name of household head _____
- 1.2. Types of respondents: 0. Non-users 1. Irrigation users
- 1.3. Sex of the household 0. Female 1. Male
- 1.4. Age of the household head _____ years old
- 1.5. Marital status: 1. single 2. Married 3. Divorced 4. Widowed
- 1.6. Family size: M, _____ F, _____, Total, _____
 1. Children < 10 years; M _____, F _____
 2. Children from 10-13 years; M _____, F _____
 3. Children from 14-16 years; M _____, F _____
 4. Number of adult from 17-50 years; M _____, F _____
 5. Elderly from 50-60 years; M _____, F _____
 6. Elderly above 60 years; M _____, F _____ (M=Male, F=Female)
- 1.7. Did your household members participate in farming work? 0. No 1. Yes
- 1.8. If yes, how many of them participated _____ (in number)?

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

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

1.11. Education level of the respondent: 0. Illiterate 1. Read and write 2. Elementary 3. High school 4. Preparatory and above

1.12. Religion: 1. Orthodox 2. Muslim 3. Protestant 4. Others (specify) _____

2. Cultivated land holding

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

2.2 If yes, its total land size _____ ha; Area under irrigation _____, area under rain fed _____

4.1.6. Total area of land cultivated during the last one year (2008 E.C) _____ (In ha).

2.3. Do you shared out your cultivated land in 2015/16 cropping year? 0. No 1. Yes

2.4. If you say yes, write your reasons _____

3. Number of livestock holding in 2008 E.C.

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

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

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

3.3. The total expected income of your livestock in 2015/16? _____ birr

4. Household activities and income from farming

4.1. How many years since you started farming (Farming experiences) _____ years?

4.2. How much total farm income do you obtained from both rain fed and irrigation farming in 2008 E.C? _____ birr.

4.3. Do you produce crop by rain fed in last cropping year (2008 E.C)? 0. No 1. Yes

4.4. What are major crop produced by rain fed in 2008 E.C.? Indicate crops you got from rain fed in 2008 E.C in the table below by using the code of crops given above the table.

5. Farming inputs and activities

5.1. Have you used farming inputs in 2008 E.C. production year? 0. No 1. Yes

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

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

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

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

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

6. Household non/ off- farm income in 2008 E.C

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

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

Pity trade =1, Sale of firewood /charcoal =2, Weaving =4, Handcraft =5, Sale of local drinks =6, Food aid =7, Remittance =8, Bee keeping =10, Renting land=11, others (specify) =12

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

7. Extension contact, distance to nearest market, and access to credit

7.1. Extension contact

1. Is there farmers training center (FTC) in your kebele? 0. No 1. Yes

2. How far is the FTC from your home _____ in Km?
3. Do you contact with DA's? 0. No 1. Yes
4. If yes, how many times do you contact with them _____ times per year?
5. What supports are you get from DA's? 1. Advice 2. Training 3. Demonstration of fields
4. Conflict resolution 5. Others (specify) _____

7.2. Distance to the nearest market

- 7.2.1. How far is your village from market place _____ in (Km)?
- 7.2.2. What are problems in marketing of your produce? 1. Transportation problem 2. Low price 3. Low bargaining power 4. Too far from market place 5. Others (specify) _____
- 7.2.3. Where do you sell your farm products? 1. On farm (local assembler) 2. Through cooperative services 3. Taking to the local market 4. Others (specify) _____
- 7.2.4. Do you get reasonable price for your produce in 2008 E.C? 0. No 1. Yes
- 7.2.5. If no, what are the reasons? 1. No demand for the produce 2. More supply of the produce 3. Others (specify) _____

7.3. Credit issues

- 7.3.1. Do you have access to credit for your agricultural activities? 0. No 1. Yes
- 7.3.2. If yes, where do you get the sources? 1. Commercial banks 2. Service cooperatives 3 Neighbors and relatives 4. Micro finance institutes 5. Other (specify) _____
- 7.3.3. For what purpose do you take credit? 1. Purchase of seeds 2. Purchase of fertilizer 3. Purchase of oxen 4. For family consumption 5. Others (specify) _____
- 7.3.4. If you say Yes #1, what are your reasons? 1. Collateral problem 2. No access to credit supply 3. No need 4. High interest rate 5. Others (specify) _____

8. Household expenditure in 2008 E.C

8.2. Non-food items expenditure (2008 E.C)

Item	Expenses
Education	
Clothes	
Water	
Transportation and communication	
House rent	
Health care (animal and human)	
Government tax	
Religious and cultural expense	

8.2. Consumption expenditure

Food type	consumption from own production			consumption from purchased		
	quantity	unit price	total expend	quantity	unit price	total expend
1. Cereals						
Teff						
Maize						
Sorghum						
Wheat						
Others						
2.Fruit &vegetable						
Onion						
Tomato						
Bean						
Pea						
Banana						
Others						
3.Animal product						
Egg						
Milk						
Meat						
Butter						
Others						
4.other products						
Salt						
Sugar						
Oil						
Soup						
Others(specify)						

8.3. Mention types of food items consumed in the household by recalling seven days back.

Food type	Consumed food items with its measurement (in Kg)						
	Enjera	Kitta	Bread	Porridge	Mengele	Roasted (Nifro)	Total
Cereals							
Teff							
Maize							
Sorghum							
Wheat							
Others							
Fruit & vegetables	Unit	Amount					
Tomato	kg(satara)						
Banana	kg						
Onion	kg						
Orang	kg						
Others							
Animal product							
Egg	No						
Butter	liter						
Cheese	liter						
Meat	kg						
Others							
Salt	kg						
Sugar	kg						
Oil	liter						
Pulses & oil crops							
Bean	kg						
Pea	kg						
Others							

9. General opinion of respondents

1. Please list all problems associated with irrigation development activities in your area.

a. _____

b. _____

3. What interventions must be made for better implementation of modern irrigation?

a. _____

b. _____

Thanks you for your cooperation and confidential response!!!

