

**IMPACT OF SMALL-SCALE IRRIGATION SCHEME ON HOUSEHOLD  
FARM INCOME IN JARDEGA JARTE DISTRICT, OROMIA NATIONAL  
REGIONAL STATE, ETHIOPIA**

**M.Sc. THESIS**

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**Impact of Small-Scale Irrigation Scheme on Household Farm Income in  
Jardega Jarte District, Oromia National Regional State, Ethiopia**

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As thesis research advisor, I hereby certify that I have read and evaluated this thesis prepared, under my guidance, by Bikila Abdisa, entitled “Impact of Small-Scale Irrigation Scheme on Household Farm Income in Jardega Jarte District, Oromia National Regional State, Ethiopia “and I recommended that it be accepted as fulfilling the thesis requirement.

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## **DEDICATION**

This manuscript is dedicated to memory of my father Abdisa Geleta Tolera who always wishes to see my academic achievement but passed away without seeing my victory.

## STATEMENT OF THE AUTHOR

By my signature below, I declare that this Thesis is my own work. I have followed all the ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of this Thesis. Any scholarly matter that is included in the Thesis has been given recognition through citation.

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## **BIOGRAPHICAL SKETCH**

The author was born on January 4, 1994 from his father Abdisa Geleta and his mother Bel'ise Geleta in Jardega Jarte District of Horro Guduru Wollega Zone of Oromia Region. He attended his Elementary School at Harolago Primary School and Alibo Primary School and his Secondary and Preparatory School at Alibo Secondary School and Alibo Preparatory School, respectively. After successfully passing University Entrance National Examination in 2014, he joined Haramaya University on October 2014 and graduated with Bachelor of Science Degree in Agribusiness and Value Chain Management on July 9, 2016. After graduation, the author was employed in Cooperative Bank of Oromia and worked there for one year. On November 2017, he joined Haramaya University to pursue his M.Sc. Degree in Collaborative Masters in Agricultural and Applied Economics in specialization of Environmental and Natural Resource Economics at University of Pretoria, South Africa. On August 2018, the author was employed in Haramaya University as Graduate Assistant.

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## **ACRONYMS AND ABBREVIATIONS**

|       |                                               |
|-------|-----------------------------------------------|
| ATT   | Average Treatment effect on Treated           |
| DID   | Difference in Diffence                        |
| FAO   | Food and Agricultural Organization of the UN  |
| GDP   | Gross Domestic Product                        |
| IWMI  | International Water Management Institute      |
| JJDAO | Jardegga Jarte District Administrative Office |
| MoA   | Ministry of Agriculture and Natural Resource  |
| MSI   | Medium Scale Irrigation                       |
| MoARD | Ministry of Agriculture and Rural Development |
| MoWIE | Ministry of Water Irrigation and Energy       |
| MoWR  | Ministry of Water Resource                    |
| NPC   | National Planning Commission                  |
| LSI   | Large Scale Irrigation                        |
| ODI   | Overseas Development Institute                |
| OIDA  | Oromia Irrigation Development Authority       |
| PSM   | Propensity Score Matching                     |
| RD    | Regression Discontinuity                      |
| SSI   | Small Scale Irrigation                        |
| RWH   | Rain Water Harvesting                         |

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# **Impact of Small-Scale irrigation Scheme on Household Farm Income in Jardega Jarte District, Oromia National Regional State, Ethiopia**

## **ABSTRACT**

*Irrigation increases productivity by reducing crop losses that is created due to limited water supply, enable cultivation during the lean season, and making crop production possible on lands where rain fed agriculture is infeasible. The geographical location of the Jardega Jarte district is favorable for small-scale irrigation practices but most smallholder farmers are not participating in small-scale irrigation scheme. Possible reasons for non-participation have not been systematically studied in the study area. This study was conducted to identify factors affecting participation decision on small-scale irrigation practices and to estimate the impact of small-scale irrigation scheme on household farm-income. Primary data were obtained directly through interview, Focus Group Discussion, key informant interview and direct personal observation and secondary data source were collected from the published and unpublished documents. Multi-stage purposive and random sampling procedures were applied to select 210 sample households (100 participants and 110 non-participants) from four randomly selected kebeles out of 21 kebeles of the district. Both descriptive statistics and econometric model (Propensity Score Matching) were employed to analyze the data. The result revealed that participation in the small-scale irrigation scheme was significantly and positively affected by educational level of the household head, active labor force, non-farm income and tropical livestock holding, but significantly and negatively affected by distance to the nearest market, and distance from water source. The finding of the study showed that the average income of participants and non-participants were 15394.68birr/year, 10813.83birr/year respectively. This indicates that participation in small-scale irrigation scheme has increased the household's farm-income by 4580.85birr on average, which is 42.4% higher than that of non-participants. So the study recommends that government and other concerned body of the district and zone should work in expansion and technological development of small-scale irrigation and attempt must made to solve or at least to mitigate the problems faced by smallholder farmers and has to enhance the educational status of the farmers and they to enhance their participation in small-scale irrigation.*

**Keywords:** Household's farm-income, Participation, Propensity Score Matching, Small-scale irrigation

# 1. INTRODUCTION

## 1.1. Background of the Study

In Ethiopia, agriculture is the mainstay of the economy but, its production is still characterized by low levels of modern inputs in remote parts of the country, including virtually no mechanization, lack of infrastructures market institutions and under-application of fertilizers, pesticides, improved seeds and extremely vulnerable to rainfall variability (Sheahan and Barrett, 2017). The economy of the country is mainly based on low productive, rain-fed agriculture. Agriculture has been traditionally dominated by smallholder farmers and its performance has long been adversely affected by shortage of rainfall and water that left many to sustain their lives on famine relief support (Abebe *et al.*, 2011). From the total production, about 97% of Ethiopia's food crops are produced by rain fed agriculture, where as only 3% is from irrigated agriculture (FAO, 2015).

In many parts of the world, farming using irrigation has been necessitated by the growing land shortage and the need to maximize on the limited land available to grow crops (Moyo, 2015). Irrigation, being one of necessary measures, is most successful way of fighting against drought because it controls soil water balance, which creates favorable conditions for high, stable and economically justified plant production (Kljajicet *al*, 2013). This benefits the poor farmers through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low value staple production to high-value market-oriented production (Kinfе *et al*, 2011).

Irrigation plays a dominant role in increasing agricultural productivity and contributes to livelihood improvement through, food security, social needs fulfillment and poverty reduction (Yenesew, 2015). It contributes to poverty alleviation by enhancing productivity which leads to an increase in income and promoting employment and economic growth. A rapid increase in the area covered by irrigation, especially small-scale water use, provides farmers with opportunities to raise output on a sustainable basis and contribute to the reliability of food supplies (FAO, 2012). Modern irrigation system plays a very limited role in Sub-Saharan Africa's including

Ethiopia to agricultural sector. Food production in the region remains entirely rain-fed and only two percent of the total cultivated area is irrigated (FAO, 2013). However, in some parts of the continent this situation is changing. This indicates that there should be new means of production through irrigation water application by smallholder farmers rather than strongly relying on rain-fed agriculture. Hence increasing the opportunity of using small-scale irrigation and reducing the hindrance to irrigation participation needs to be made. Because irrigation is one means by which agricultural production can be increased to meet the growing food demands (Tongul and Hobson, 2013).

In Ethiopia, Irrigation plans give priority to high-value horticultural crops, so that farmers can maximize their return on irrigation. The target is to expand coverage of small-scale irrigation schemes from current government-estimated 2.3 million hectares to 4.1 million hectares, and to expand medium and large-scale schemes from approximately 658,000 ha to 954,000 over the same period (FDRE, 2016).

The irrigation potential in Oromia is the highest in the country, but, its level of utilization is not as per its potential and the regions agricultural sector is almost entirely dependent on rain-fed farming. Irrigated agriculture constitutes just less than 5 percent of the potential and about 2.14 percent of the total cultivated land and it is said that out of the estimated 1.7 million ha of potential irrigable land, only 85,400 ha has been irrigated so far. The implication of these figures is that irrigated agriculture has to go a long way before it can make a significant contribution towards regional food security (OIDA, 2016).

Horro Guduru Wollega is one of the wettest zones from the region and potential area in small-scale irrigation, but the farming system is highly rain-fed (Temesgen, 2017). Although Jardega Jarte is the district found in this zone consisting of high irrigation potential, the potential available for irrigated farming is not intensively used (JJDOoARD, 2018). There was no sufficient scientific evidence why the farmers in the district are not utilizing this potential to increase their production and improve their farm-income. Therefore, this study was mainly concerned identifying the factors that determine the farmers' decision participation in small-scale irrigation practice and its impact on farm-income of participants.

## 1.2. Statements of the Problem

Agriculture in Ethiopia is mostly small- scale, rain-fed, traditional and subsistence with limited access to technology and institutional support services (Adugna, 2014). Consequently, rainfall variability and moisture stress is constraining the development of the rural sector. The population of Ethiopia is increasing rapidly and to feed the increasing population, extensive system of the agricultural production may not be sufficient due to constant supply of land (Moyo, 2015). Despite the rapid population growth and food demand, the production of agricultural outputs using modern technology at smallholder level is at its minimal stage (FAO, 2015). The traditional system of production and rain-fed agriculture alone could not guarantee to feed this rapidly increasing population and it needs supplementation from irrigated agriculture.

Irrigation plays a fundamental role in world food provision, but, it has performed below expectations in Sub-Saharan Africa (Garcia-Bolanos *et al.* 2011). Ethiopia is a country that is most susceptible to natural disasters and weather-related shocks in the world due to high dependence on rain-fed agriculture and other topographic and low adaptive capacity (Tongul and Hobson, 2013). The use of supplementary irrigation from either traditional or modern water harvesting structures is considered as the primary measure to be taken against the problem (Garcia Bolanos *et al.*, 2011). The improvement of the livelihood of smallholder farmers through irrigated farming can be achieved only, if small-scale irrigation schemes are designed, constructed and managed properly, according to specific set of key management objectives. This can be achieved within the context of effective organizational coordination and farmer's participation (OIDA, 2018). Small-scale irrigation has the potential to meet the demand for food security, agricultural diversity and for increasing production and productivity on a fixed land.

In Ethiopia, there is growing interest on investment on cereals and horticultural crops seed multiplication, marketing and distribution by smallholder farmers, cooperatives and unions. This helps to improve the efforts made to satisfy irrigation input demand, but there is poor economic background of users for irrigation infrastructure development, to access irrigation technologies and agricultural inputs, where the price increment is not affordable to farmers (Gebremariam and Ghosal, 2016).

The previous studies on small-scale irrigation are mainly concerned with the relationship between irrigation and food security and importance of irrigation practices but the relationship between small-scale irrigation and household income is limited. Major problems faced by farmers that hinder them to participate in small-scale irrigation and the reasons of low and inadequate community involvement in planning, construction and implementation of irrigation development and diversified irrigation agronomic practices, has not studied well and this research fill this gap of knowledge.

The geographical location of the study area is favorable for small-scale irrigation practices, but most smallholder farmers are not participating in the small-scale irrigation and utilizing these opportunities. Agricultural production in the study area is primarily rain-fed and mainly depends on erratic and often insufficient rainfall (JJDOoARD, 2018). Consequently, there is a frequent failure of agricultural production which reduces the farm-income of the household and irrigation has the potential to stabilize the agricultural production and minimize the negative impacts of the variability and insufficient rainfall. Given these facts, this study tries to provide explicit empirical evidences about the impact of small-scale irrigation on the income of the households and factors determining participation in to small-scale irrigation schemes.

### **1.3. Research Questions**

Owing to the above mentioned problems and knowledge gaps, this study is proposed to answer the following questions.

- What are the factors affecting smallholder farmers to participate in to small-scale irrigation practices?
- What is the relationship between small-scale irrigation participation and household income?
- What are the problems associated with the performance and management of small-scale irrigation.

#### **1.4. Objectives of the study**

The main objective of this study is to examine the impact of small - scale irrigation interventions on the farm-income of smallholder farmers in the study area and the specific objectives are:

- to identify factors that affect households participation decision in small-scale irrigation scheme; and
- to estimate the impact of small-scale irrigation scheme participation on household farm-income.

#### **1.5. Significance of the Study**

The finding of this research provides information as to how effective measures will be made to implement appropriate strategies and enhance livelihood of small-holder farmers through improvement of the existing and expansion of appropriate technology on small-scale irrigation practices. The study was attempt to provide a realistic information on the benefits of small-scale irrigation development in the study area, formulating future strategies and baseline for further research on smallholder irrigation investment in the zone or region. It helps to add to the empirical literature that uses the combination of both quantitative and qualitative approach in assessing the impact of irrigation technology interventions on agricultural production and hence income.

#### **1.6. Scope and Limitations of the Study**

This study is limited only Jardega Jarte district due to constraint of data and objectives of the study. Even if Panel and time series data can give more information for such study than cross-sectional data, because of unavailability of these data in the study area these types of data could not be used and cross-sectional has been used. In addition the, study is limited to one district of the zone and the findings of the study can be generalized for more than one districts having similar physical and socioeconomic settings.

### **1.7. Organization of the Thesis**

The thesis consists of five chapters including this chapter, which provides general information and objectives of the study. Chapter two presents a review of related literature and chapter three presents the methodology used in the study, while, results are discussed in chapter four. Chapter five summarizes the finding of the study and concludes by drawing recommendations.

## 2. REVIEW OF LITERATURE

### 2.1. Basic Concepts of Irrigation

Irrigation is defined as the artificial application of water to cropland for the purpose of satisfying the water requirement necessary for growing different crops and it plays key role in stabilizing food production in number of countries by either supplementing or replacing the need for natural precipitation for the purpose of food production (FAO, 1997). Irrigation water is applied to ensure that the water available in the soil is sufficient to meet crop water needs (FAO, 2015). This is an on purpose action made by human beings to apply water for growing crops, especially when there is a shortage of rainfall and during dry seasons.

Wichelns (2000) defines irrigation as “human intervention to modify the spatial or temporal distribution of water and to manipulate all or part of this water for production of agricultural crops”. The primary goal of irrigation, from farmer’s perspective is to deliver the volume and quality of water required by plants, throughout season, to optimize plant growth and crop production. Chamber (1988) suggested that from farmer’s perspective, good irrigation service involves the delivery of “an adequate, convenient, predictable and timely water supply for preferred farming practices”.

Irrigation success considers the degree to which water volume, quality and time of irrigation events match the requirements of plant throughout the season. Perfect success occurs when the volume, quality and timing of water deliveries would generate maximum crop yield, given that irrigation inputs are not limiting (FAO, 2015). Actual yield will be less than maximum yield when irrigation success is less than perfect. Farmers attempting to maximize net revenue, subject to resource constraints, will select irrigation inputs to achieve a desired level of irrigation success (Wichelns, 2000).

Irrigation can be categorized as small-scale, medium-scale and large-scale depending on the area of irrigated, scale of operation, and type of control or management. But criteria for this category may vary from country to country. For example, in India the irrigation scheme of 10000 ha is classified as small-scale irrigation, while in Ghana

the largest irrigation scheme is 300 ha. A single definition for SSI is not easy to drive or globally applicable. In the Ethiopian context, SSI is generally considered to command areas of about 200 ha or less (Gebremariam and Ghosal, 2016). Examples of SSIs include household based rain water harvesting (RWH), hand-dug wells, flooding (spate), shallow wells, individual household-based river diversions and other traditional methods. Medium- scale (MSI) schemes cover an area of 200-3000 hectares. Examples: Hare irrigation scheme in Southern Nations Nationalities and People's Region. Large-scale irrigation (LSI) schemes cover an area greater than 3000 hectares. Examples of LSIs in Ethiopia include the Wonji-shoa, Methara, Nura Hera, and Fincha irrigation schemes. SSI schemes are the responsibility of the MoARD and regions, while MSI and LSI are the responsibility of the MoWR (Awulachew, 2010).

Globally, irrigation has been found to be the largest consumer of water, accounting for about 70% of the total diverted water (FAO, 2013). Irrigated land recently accounts for about 20% of the world's farmed area and takes care for 55% of global food production. Consequently, agriculture sector faces in fact a complex series of challenges to produce more food of better quality while using less water per unit of output, to produce sustainable diets and to reduce malnutrition, to apply clean technologies that ensure environmental sustainability, to cope with possible impacts of climate change and to contribute in a productive way to the local and national economy, from producer to consumer. Thus, improving water management practices in agriculture is crucial for maintaining global food security and alleviating rural poverty (FAO, 2012). Reducing irrigation water use by increasing irrigation water productivity is crucial to meet the ever increasing water demand for agriculture (Yenesew, 2015).

## **2.2. Economic Importance of Irrigation Development**

Irrigation expansion has been regarded as promising approach to ensure food security and livelihood security in the face of climate change and population growth (FAO, 2012). While only 4% of cultivated area in sub-Saharan Africa is irrigated, the potential for the expansion of irrigation in the region is large and investments are accelerating (Giordano *et al*, 2012).

Previous investments in irrigation by donors and governments have focused on developing large scale irrigation schemes, but evidence suggests that the greatest gain in terms of profitability and sustainability will come from investments in small-scale irrigation (Xie *et al.* 2014; You *et al.* 2011). These studies also reveal that increased in yield and income comes from the adoption of small-scale irrigation technologies and they also found that small-scale irrigation has the potential to increase agricultural yields by at least 50%, with the majority of the income benefits accruing to the smallholders themselves.

Irrigation increases productivity by reducing crop losses that were created due to limited water supply, enabling cultivation during the lean season, and making crop production possible on lands where rain-fed agriculture is infeasible (Moyo, 2015). As a result of a project that introduced 50000 tube wells in Nigeria, farmers experienced increasing returns per hectare from 65 to 500% with an average rate of return on investment close to 40% (Burney and Naylor, 2012). Irrigation enables farmers to participate in market oriented-production, thereby increasing income from agriculture. A study from Kenya and Tanzania found that 73 and 83% of irrigated crops grown were commercialized (Nkonya *et al.* 2011). In addition to the overall economic benefits, irrigation also improves food security and nutrition outcomes (Azzarri, 2016).

The dependence on the unreliable rainfall is a limiting factor for agricultural productivity. The Government of Ethiopia has identified small-scale irrigation as an important component of adaptation (MoARD, 2010). A study by (Kaur, 2010) assessed the effectiveness of small-scale irrigation as a climate adaptation intervention in Ethiopia. The study found that small-scale irrigation is a potentially valuable component of adaptation strategies as it increases agricultural productivity and households' ability to cope with climate variability. However, accompanying measures are required to ensure that water sources themselves are resilient to a variable climate and the design is proofed against extreme events.

Irrigation has a multifaceted role in contributing towards food security, self sufficiency, food production and export (Yenesew, 2015). Irrigation can bring about increased agricultural production thereby improve the economic and social well being of the farmers. For meeting the growing demand for food in the short run and long run

food security, small-scale irrigation has immense contribution in achieving the objective. It is one of the options which increase yield, facilitate diversification, reduce rainfall risk, and create employment opportunities.

The role of irrigation development is increasing food sufficiency level of households (helps to produce sufficient amount of food consumption), increasing income level, and asset building such as house construction for rent, saving account and creation of employment opportunity. Thus, it is an important indicator of economic development and brings sustainable agriculture development (Tesfa, 2011).

Belay and Bewket (2013) explained that irrigation water is critical to poverty alleviation through increased production in rural areas so as to improve food security and rural livelihoods. Smallholder irrigation users have also received significant focus from local governments to enable farmers to cultivate crops twice or more per year. Irrigation improves household income and contributes to poverty reduction. Irrigation user households are in a better position when compared to those that are non-users and they have high crop income, higher level of education of the household head, large size of livestock holding, better labor man-day equivalent and all these contributed significantly to high total income for users than non-users (Temesgen, 2017). As a result, access to irrigation increases the opportunity for crop intensity and diversification which increase income generated from crops.

Smallholder irrigation user had proven to be a viable and attractive alternative for poor farmers especially in the rural areas. In addition, they asserted that returns from intensive irrigated agriculture even on tiny plots could greatly exceed returns from rain-fed cereal production. As a result, in many developing countries such as Ethiopia, small-scale irrigation schemes were counted on to increase production, reduce risk related to unpredictable rainfall and provide food security and employment to poor farmers (OIDA, 2016).

### 2.3. Irrigation Potential and Development in Ethiopia

Ethiopia is endowed with ample water resources with 12 river basins and 22 natural and artificial lakes with an annual runoff volume of 122 billion m<sup>3</sup> of water and an estimated 2.6-2.65 billion m<sup>3</sup> of groundwater potential, which makes an average of water available 1557.5 m<sup>3</sup> per person per year (Makombe., 2011; MoA, 2013 ; Adugna, 2014). Due to this Ethiopia is considered to be the water tower of Africa. The largest four river basins of the country namely: Abay, Baro Akobo, Tekeze and Omo-Ghibe account for 80%-90% of the country's water resource. Even if the potential and actual irrigated area is not precisely investigated (Belay and Bewket, 2013), estimates of irrigable land in Ethiopia vary between 1.5 and 4.3 Million hectares (Mha), averaged about 3.5Mha. On the other hand, there is a difference in irrigation potentials and actually irrigated lands. For example 3.7Million ha and 197,000 ha are indicated differences in this regard. MoA (2013) also reported that about 10 - 12% of the total irrigable potential is used in traditional and modern irrigation schemes.

In Ethiopia modern irrigation system was started at the Awash River basin with bilateral collaboration of Ethiopia and Dutch company during the 1950s for the productions of commercial crops such as sugar cane and cotton (Gebremedhin and Asfaw, 2015). Source indicates that, the total area of irrigated land in Ethiopia increased from 885,000 ha to 2.4 million ha in from 2011 to 2015 with a plan of increasing irrigated land to 4 million by 2020 (ATA,2016), including the 658,340 ha of land developed with high and medium irrigation schemes (NPC, 2016). But there is a plan to expand the high and medium schemes to about 954,000 hectares by the end of the GTP-II (2019/20).

Irrigation development in Ethiopia can be considered as a cornerstone of food security and poverty reduction tool as it has a power to stimulate economic growth and rural developments (MoA, 2013). As a result, irrigation infrastructures are increasing year after year, which show country wide positive development implications and experiences in small and large scale irrigation schemes. In Ethiopia, farm size per household is 0.5 ha and the irrigated land per households' ranges from 0.25 ha - 0.5 ha in the Ethiopian context. As a result, individual landholdings per households are

too small to feed the household. With this limited land holdings, increasing food demands of the population depends on either one or a combination of increasing agricultural yield, increasing the area of arable land, and increasing cropping intensity by growing two or three crops per year using irrigation (Gebremedhin and Asfaw, 2015).

Regarding to the irrigation development in Ethiopia, different literatures reports differently regarding the amount of irrigation water resources as irrigation potentials, are irrigated. This implies that irrigation water resource potentials in Ethiopia are not well studied and documented (Gebremedhin, 2015). As a result of this irrigation development in Ethiopia is in its infancy stage (Adugna, 2014), and its contribution to the national economy as compared to its potential is limited (MoA, 2013). The Ethiopian government is therefore pursuing plans and programs to develop irrigation in an effort to substantially reduce poverty and create an atmosphere for social change (NPC, 2016).

### **2.3.1. Irrigation potential in Oromia Region**

Oromia region has 63 rivers and 688 tributary streams which annually generate 58 billion cubic meters of surface water, the equivalent of half the nation's surface water resources (OIDA,2016). Despite this large water resource potential, Oromia's agricultural sector is almost entirely dependent on rain-fed farming and irrigated agriculture constitutes just less than 5% of the potential. The land suitable for surface irrigation in Oromia is estimated to be 1.7 million hectares of which only 97,185ha (5.5%) has been developed so far. Out of these develop areas, the share of community irrigation constitute 66,224ha which 10,820ha were developed with the help of regional government, 6588 ha were developed by NGOs and 48,816ha were developed traditionally. The amount of water used for the purpose of irrigation is only 1.5 % of the total 58 billion cubic meters obtained from mean annual run off generated in the region and 2.1 billion cubic meters of ground water (MoWIE, 2013).

### **2.3.2. Irrigation potential in Horro Guduru Wollega**

Horro Guduru Wollega is one of the wettest zones of Oromia region which has a long rainy season which starts in spring and continues to autumn. The amount of rain-fall of the zone is dependent on altitude and the aspect of land in relation to rain bearing winds. The climate of rural areas of the zone is divided in to temperate (34.78%); sub-tropical (35.46%), and tropical (29.78%) (Monenus, 2016). This shows that the dominant climate of the zone is sub-tropical followed by temperate, and tropical. These climatic types are the best for the production of different weather crops. The presence of huge water potential as a result of long rainy season and higher altitude has given the zone great advantage to produce different types of crops and hence to increase food security of the zone (Temesgen, 2017). This zone is a place where large scale irrigation system is practiced, like Fincha irrigation schemes.

Despite its high water potential, Horro Guduru Wollega zone faces the problem of crop failure due to the climatic variability and drought spells because of the high dependency on rain-fed agriculture. For example it has faced a problem of decline in the production of crops on the year 2012 (MoARD, 2013). There are many opportunities in the zone that can enhance irrigated farming, because it has many rivers and streams that can be applied to agriculture. But its potential and level of utilization does not approach to each other.

## **2.4. Empirical Literature Review**

Different studies found that different factors affecting participation in to small-scale irrigation practices using different models and hypothesizing different explanatory variables that influence irrigation practices. Therefore, this section has been concerned with review of previous empirical studies to come up with convincing information with most commonly significant variables affecting participation in small-scale irrigation practice to use them as a basis of the hypothesis for this study.

The study by Edo (2014), using the logit model results indicated that age of household heads, total size of cultivable farmland, 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.

Some studies indicated that educational status of the household head had a positive and significant influence on the irrigation practice decision of farmers (Tewodros *et al.*, 2013; Edo, 2014; Abebaw *et al.*, 2015). These studies indicate that education is the very important variable that influences the irrigation practice by farmers and needing policy action in different setup of different countries.

A study by Beyan *et al.* (2014) and Hadush (2014), shows that the households participating in the non-farm activity were found to participate in irrigation practices more than those not participating in non-farm activities. These studies indicated that, the positive relationship between non-farm activity and irrigation practice by farmer was due to the reason that the income from non-farm activity was used to cover the irrigation costs such as inputs required and enable those farmers participate in irrigation easily as compared to their counter parts.

The longer distance from plot of farm land and water source lead farmers for extra cost when compared to farmers nearest to water source in many ways such as opportunity cost of time cost of irrigation water access. This distance from water source has forced the farmers to practice irrigated farming less than their counterparts (Kinfe *et al.*, 2012; Beyan *et al.* (2014); Sithole *et al.*, 2014),.

A study conducted by (Hadush, 2014) showed that the total livestock owned by the households has positive significant effect on the irrigation participation decision of the households. Farmers with higher TLU were found to be higher probability of participating in the irrigation practice. In general, this finding shows that farmers with larger value of the variable were found participating in irrigation practice more than those with lower values. The study further confirmed that presence of significant differences between farm households who adopt not adopt small-scale 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.

Bacha *et al.* (2011) in the study of the impact of small-scale irrigation on household poverty in central Ethiopia, reported that land productivity, asset ownership, credit utilization, extension support, resilience to poverty, mean off-farm income, and mean food consumption and expenditure on food and non-food assets were significantly higher for irrigators than non-irrigators.

Jema *et al.* (2013) using logit model result found that dependency ratio, family size, size of landholding 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 than non-irrigation users. They also indicated that the per capita consumption expenditure of irrigation users is 25% more than non-users of irrigation. In general their study concluded access to small-scale irrigation scheme improved the livelihood of households in the study district.

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, 2014). This indicates that involvement in small-scale 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 and hence it increases household income.

## **2.5. 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).

### **2.5.1. Randomized Selection Method**

This method refers to a process of selection of both treatment and control group from a well-defined 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). But this method has some limitations to apply for this study like unable to estimate entry effect, external validity (generalizability), difficult to extrapolate the results to a larger population.

### **2.5.2. Difference-in-Difference (DID) Methods**

It 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 differentiating (Stern *et al.*, 2012). This method is not applied for this study because it is difficult to get the baseline data of the respondents.

### **2.5.3. 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). This method is not used for this study because of its limitations

like: ATE obtained only for the ‘marginal’ individuals – those on either side of the edge, problem of external validity across entire sample and need to control for other characteristics that might be correlated with assignment and also affect outcome.

#### **2.5.4. Propensity Score 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).

Treatment and control households will be matched on propensity scores obtained from regressing participation in small-scale irrigation on pre-treatment observable household characteristics using the logit or probit model. These scores will be used to select comparison households through the best matching estimator. This study used PSM because it does not require baseline (pre intervention data) of households before and after participation in small-scale irrigation scheme. Moreover, PSM has advantage over other impact evaluation method models because of its simplicity in relaxing the assumptions of functional forms that are imposed by parametric regression models, such as ordinary least squares (OLS), and that it relaxes randomization.

## **2.6. Conceptual Framework of the Study**

Several factors including Physical, technical, socioeconomic, institutional and environmental factors influence participation in irrigation in collaboration with effectiveness of the farm household. That is, farm output from small-scale irrigation depends on physical input (land, labor, capital and water) and their productivity can also be influenced by non physical factors such as demographic, market, governmental policy, property rights, and environmental factors. Households,

participation of irrigation and their efficiency has an impact on farm productivity which in turn leads to high level of income. But, effectiveness and utilization of irrigation are also influenced by various factors which in turn influence farm-income and social welfare status of the household.

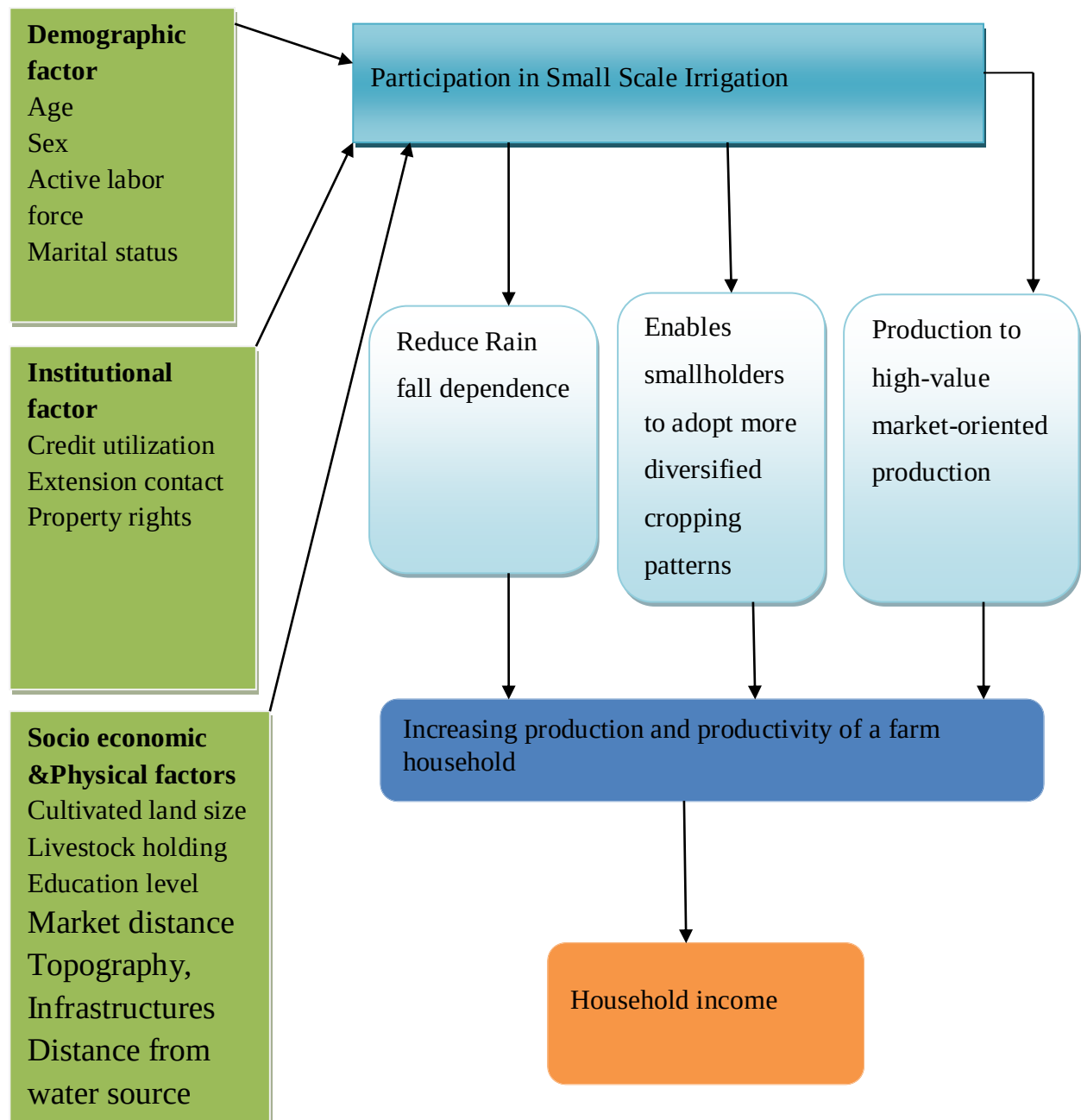


Figure 1. Conceptual Framework

Source: Own design from empirical literatures and theories

### 3. RESEARCH METHODOLOGY

This chapter provides details of the methodology used to address the objectives of the study. It includes description of the study area, sampling design, data type and collection method, methods of data analyses, and important variables selected for the study.

#### 3.1. Description of the Study Area

Jardega Jarte is one of the 9 districts in the Horro Guduru Wollega Zone of Oromia National Regional State of Ethiopia; located at 9° 45' 0'' to 10° 10' 0''N latitude and 36° 55' 0'' to 37° 20' 0''E longitudes and the capital of the district is Alibo. The district has 21 rural *kebeles* and 3 urban *kebeles*. The district is bordered in east by Abay Chomen, in south by Horo, in southwest by Abe Dongoro, in west by East Wollega Zone, in northwest by Amuru, in north by the Abay River which separates it from the Amhara Region. The 2007 national census reported a total population for this district is 48,943, of whom 24,475 were men and 24,468 were women; 4,757 or 9.72% of its population were urban dwellers. Topographically, it is characterized by plateaus, mountains, hills and plains. Altitude wise, the district lies between 1600 and 2880 meter above sea level. The area is endowed with the large rivers like Choggo River and Angar River which are major source of irrigation water for the farmers (JJDAO, 2018). The district has a long history of traditional irrigation practices and indigenous knowledge. Hence, it is possible to grab the opportunities and capitalize on. Mixed agriculture (crop and livestock) is the main stay of the farming communities on which their livelihood is fully dependent. Major crops grown in the zone include cereals (barley, wheat, teff, maize and oat), pulses (field bean and peas), oil crops (niger seed, rapeseed and sesame), root crops (potato) and vegetables (cabbage, onion and garlic) and fruit varieties. Maize, potato, onion, cabbage, garlic and sugar cane are the major crops and vegetables grown by irrigation in the district.

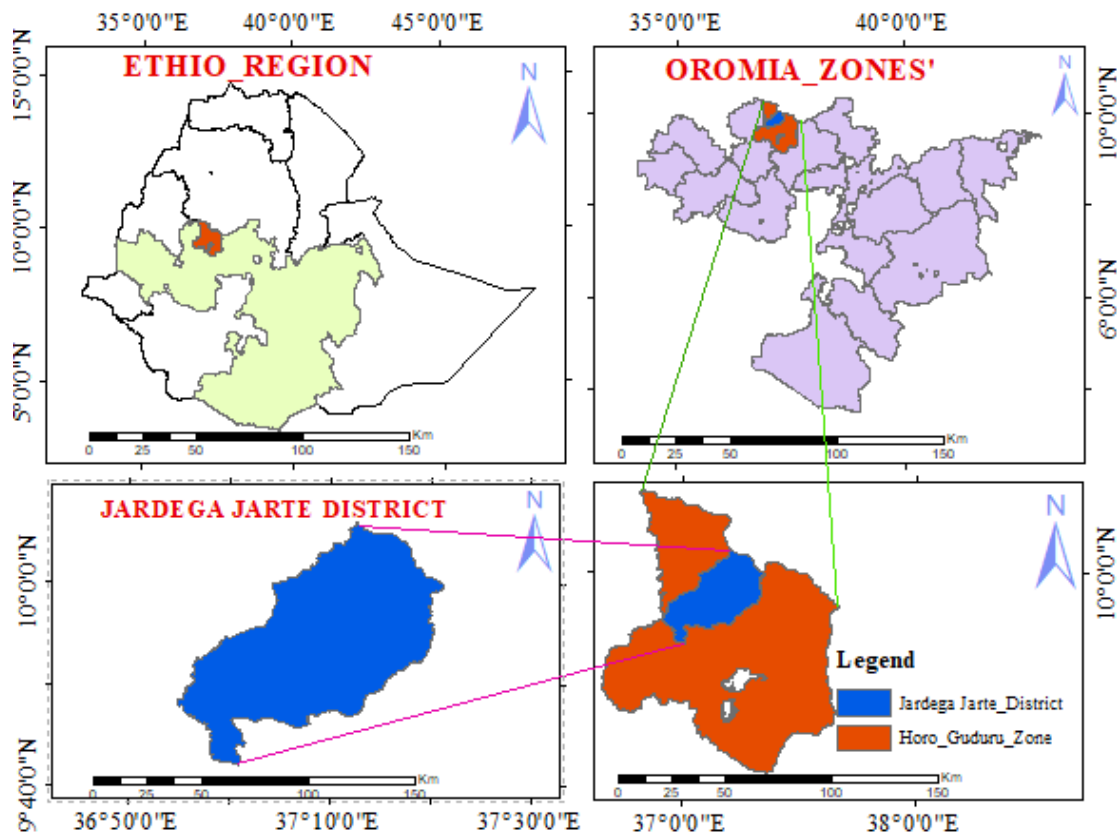


Figure 2. Description of the study area

Source: Own design with the help of GIS expert, (2019)

### 3.2. Data Type, Sources and Methods of Data collection

For this study both primary and secondary data sources were employed. Primary data were obtained through interview by using sample household heads as the unit of analysis. In addition, Focus Group Discussion, key informant interview and direct personal observation were used. The questionnaire was translated in to language spoken in the study area (Afaan Oromoo), to convey the questions effectively to the rural interviewees and it was pre-tested, administered and filled by the trained and experienced enumerators. Data were collected on various socio-economic, demographic and institutional factors affecting participation in irrigation and the outcome variables. To enrich the primary data, the secondary data source also collected from the published and unpublished documents of the District Administration Office, Agricultural Bureau of Oromia Region, Federal Government Organizations and from different publications and policy documents.

### 3.3. Sampling Techniques and Sample Size Determination

In this study, a multi-stage purposive and random sampling procedure was applied to select sample household. In first stage, Jardega Jarte district and 10 potential *kebeles* which are conducive for Small-scale irrigation practices were purposively selected from 21 rural *kebeles* in the district. The *kebeles* are selected depending on endowment with small-scale irrigation and because of the extensive practice of irrigated agriculture. In second stage, four representative *kebeles* were selected randomly. In the third stage, from four randomly selected *kebeles* a total 210 sample households, 110 irrigation non-users and 100 irrigation user households were selected randomly based on probability proportion to sample size. This sample size is assumed to represent the population, since the district is more homogeneous in terms of climate, resource endowment and other factors related to the issue of the study.

In this study due to heterogeneous group of the population in terms of participation in to small-scale irrigation (irrigation users and non-users), sample farm household respondents will be determined using Cochran (1977) formula considering 93% of the confidence level ( $z=1.81$  for 93 confidence level), 50% estimated proportion of the population participating in small-scale irrigation ( $p$ ) due to unknown variability and 7% level of precision ( $e$ ) from total households. The formula is:

$$n_0 = \frac{Z^2 pq}{e^2} \quad (1)$$

$$q = 1 - p = 0.5 \text{ (50\%)}$$

Proportional sampling technique has been used to select the sample from each of the four randomly selected *kebeles*. The sample selected from each selected *kebeles* was proportional to the sample population in each *kebele* and the formula for this purpose was determined by formula.

$$n_i = \frac{N_i(n)}{\sum N} \quad (2)$$

Where  $n_i$ - the sample to be selected from  $i$ 's *kebele*

$N_i$  - the total population living in selected  $i$ 's *kebele*.

$\sum$  - The summation sign

$\sum N$  The sum of total population in the selected three *kebeles*

n – total sample size

Table 1. Distribution of sample households selected from four *kebeles*

| Name of <i>kebele</i> | Total number of household head | Sample selected (Non-participant/participant) | Proportion |
|-----------------------|--------------------------------|-----------------------------------------------|------------|
| Haro Dadhi            | 582                            | 74(38/36)                                     | 33%        |
| Sombo Kumi            | 454                            | 58(31/27)                                     | 25.70%     |
| Irroo                 | 306                            | 34(18/16)                                     | 17.30%     |
| Tulu Nono             | 422                            | 44(23/21)                                     | 24%        |
| Total                 | 1764                           | 210                                           | 100%       |

Source: Own survey, (2019)

### 3.4. Methods of Data Analysis

#### 3.4.1. Descriptive statistics

The descriptive statistics was employed to summarize the demographic and socioeconomic behavior of household characteristics using mean, standard deviation. In addition, sub sample comparisons based on different explanatory variables was conducted using t-test and  $\chi^2$ -tests.

#### 3.4.2. Theoretical model specification

The theoretical benchmark of participating in small-scale irrigation is on the basis of utility derived. Therefore, rural households with higher utility derived from practicing of irrigation would prefer to engage in small-scale irrigation.

$$U_i = X_i\beta + \varepsilon_i \quad (3)$$

Where,  $U_i$  shows the utility derived from participation in small-scale irrigation,  $X_i$  represents all the explanatory variables which affect the probability of participation in small-scale irrigation,  $\varepsilon_i$  reveals the disturbance term which is unobservable factors for the farm household with zero mean and constant variance ( $\delta^2$ ).

### 3.4.3. Propensity score matching model specification

To estimate the impact of the small-scale irrigation scheme on household farm-income the PSM econometric model was applied. Propensity score matching (PSM) is one of the rigorous impact evaluation methods commonly used by researchers as it considers the issue of the counterfactual (What would have happened to those who had participated in small-scale irrigation, had they not been participated) and overcomes the selection bias and contamination problems (White *et al.*, 1999). PSM matches subjects based on propensity scores rather than on multiple variables as in traditional impact evaluation methods. According to Rosenbaum and Rubin (1983), under strong ignorability assumption (conditional independence assumption and common support), propensity score is a suitable single-index balancing score to identify matching partners.

PSM econometric model was applied based on two assumptions: first the Conditional Independence Assumption (CIA) that is the key assumption made in PSM is that selection into a program can be captured with observable data that are available to the evaluator,  $(Y_0, Y_1) \perp T \mid X$ , where  $Y_0$  shows the outcome of the control groups,  $Y_1$  shows the outcome of the treated group,  $T$  shows the participation into the program, and  $X$  shows the set of pre-treatment explanatory variables. Thus, based on Rosenbaum and Rubin (1985) using their assertion that treatment assignment is strongly ignorable, displayed that, for non-randomized observations, outcome and treatment are conditionally independent given the propensity score,  $P(x)$ ,  $(Y_0, Y_1) \perp T \mid P(x)$ . That is a balancing condition needs to be satisfied for propensity score matching,  $T \perp X \mid P(x)$ .

Secondly, the common support or overlap condition:  $0 < P(T_i = 1 \mid X_i) < 1$ . According to Heckman *et al.*, (1999) suggestion this assumption ensures that the treatment observations have comparison observations “nearby” in the propensity score distribution. Thus, in order to estimate the real impact of the irrigation participation on households’ farm-income propensity score matching is employed since OLS could not control the selection bias of the treatment and this model had this merit.

In practice, participation in small-scale irrigation cannot be random. According to Ravallion (2005), PSM allows the estimation of mean impacts without arbitrary assumptions about functional forms and error distributions. The basic idea behind this

approach is to find the group of households, those individual who are similar to participants in all relevant pre-treatment observable characteristics (Rosenbaum and Rubin, 1983). That is, to find control observations (i.e. non-participants) having initial observable characteristics similar to participants of small-scale irrigation households to serve as valid surrogates for the missing counterfactuals. This approach assumes that after controlling for all pre-participation in to small-scale irrigation observable household characteristics that are correlated with participation and the outcome variables, participant households have the same average outcomes as non-participant households would have had, had they also been not participated. Once this is accomplished, differences in outcome of this adequate control group and treatment group can be attributed to the participation only.

For this study, the outcome variable is annual farm-income and the treatment variable is participation in small-scale irrigation. Randomly selected participant household (treatment group) are matched to non-participants households (control group), and the difference in outcome indicator is evaluated statistically. According to Caliendo and Kopeinig (2008), PSM follows the following steps: estimating propensity scores, checking for overlap, choosing the best matching algorithm, assessing the matching quality, estimating the treatment effect and performing sensitivity analysis if significant differences are observed after matching.

#### **3.4.3.1. Estimation of the propensity scores**

The first step in PSM method is to estimate the propensity scores. Propensity score is the probability of a unit in target the group (treated and control units) to be treated given its observable characteristics  $X_i$ ; formally:  $\Pr(D_i=1|X_i)$ . The propensity score is a balancing score in the sense that, as demonstrated by Rosenbaum and Rubin (1983), if two units have similar propensity scores, and then they are also similar with respect the set of covariates  $X$  used for its estimation. Propensity score can be estimated using a binary choice models (logit or probit), in which treatment status is regressed on observed pre-intervention characteristics to create a counterfactual group. The predicted probability is the propensity score.

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

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

Where  $z_i = x_i\beta + \varepsilon_i$

Where,  $P_i$  is the probability of participation to irrigation

$X_i$  · Pre-intervention characteristics

$\varepsilon_i$  = error term

The probability non-participant household is;  $1 - P_i = \frac{1}{1 + e^{z_i}}$

$\ln(p_i/1-p_i) = z_i = x_i\beta + \varepsilon_i$  is the logs of odds ratio in favor of success.

### 3.4.3.2. Checking common support condition

Checking a common support is the second step in PSM because average treatment effect on treated and on control group will only define in the common support region (Caliendo and Kopeinig, 2008). To avoid comparing the incomparable only the subset of the comparison group that is comparable to the treatment group should be used in the analysis. The common support region is the area within the minimum and maximum propensity scores of treated and comparison groups, respectively and it is done by cutting off those observations whose propensity scores are smaller than the minimum and greater than the maximum of treated and comparison groups, respectively. Hence, an important step is to check if there is at least one treated unit and one non-treated unit for each value of the propensity score. Several methods are suggested in the literature, but the most straightforward one is a visual analysis of the density distribution of the propensity score in the two groups. Another possible method is based on comparing the minima and maxima of the propensity score in the

treated and in the non-treated group. Both approaches require deleting all the observations whose propensity score is smaller than the minimum and larger than the maximum in the opposite group.

#### 3.4.3.3. Choosing a Matching Algorithm

The next step consists of matching treated and non-treated units that have similar propensity scores using an appropriate algorithm. The matching algorithms differ not only in the way they measure the degree of similarity between treated and non-treated units but also with respect to the weight they assign to the matched units. Even though there is a little guidance on the selection of best matching algorithm, according to Baser (2006), the best matching algorithm is the one that reduces selection bias by increasing the balance between the treatment and control groups. In this study, the best matching algorithm was selected on the basis of the criteria suggested by different studies: large matched sample size, large number of insignificant variables after matching, small pseudo- $R^2$  after matching and small mean standardized bias (3-5%). The most widely used matching algorithms used in the literature are: nearest neighbour, Caliper and kernel matching used on the basis of the some criteria.

**Nearest Neighbor method:** It is one of the most straightforward matching procedures. The treated unit is matched with the unit in the comparison group that presents the closest estimated propensity score. Two variants are possible: matching with replacement (an untreated unit can be used more than once as a match) and matching without replacement (an untreated unit can be used only once as a match) (Caliendo and Kopeinig, 2008). Non-participants for which there are no participants with sufficiently similar score are discarded from the sample; the same is true for participants for which there is no similar non-participants. A variation of nearest neighbor matching matches multiple non-beneficiaries to one single beneficiary with different caliper distance. But matching on more distant neighbors can reduce the variance of the estimator at a cost of an increase in bias. Therefore, reasonable distance should be taken to reduce the bias.

**Caliper matching:** To avoid the risk of poor matches, radius specifies a “caliper” or maximum propensity score distance by which a match can be made. The basic idea of radius matching is that it uses not only the nearest neighbor within each caliper, but

all of the comparison group members within the caliper (Baser, 2006). In other words, it uses as many comparison cases as are available within the caliper, but not those that are poor matches (based on the specified distance). In ‘radius caliper’ matching a maximum propensity score radius, a ‘caliper’ is established, and all non-beneficiaries within the given radius of a beneficiary are matched to the beneficiary.

**Kernel matching:** is nonparametric matching estimator that uses weighted averages of all individuals in the control group to construct the counterfactual outcome. Weights depend on the distance between each individual from the control group and the unit exposed to the treatment for which the counterfactual is estimated (Caliendo and Kopeinig, 2008). The kernel function assigns higher weight to observations close in terms of propensity score to a treated individual and lower weight to more distant observations. The major advantage of this approach is the lower variance, which is achieved because more information is used. A drawback of this method is that some of the observations used may be poor matches. Hence, the proper imposition of the common support condition is of importance for this. When applying kernel matching, one also has to choose the kernel function and the bandwidth parameter.

#### **3.4.3.4. Testing the matching quality**

The quality of the matching procedure is evaluated on the basis of its capability in balancing the control and the treatment groups with respect to the covariates used for the propensity score estimation. There are several matching quality evaluation methods in the literature. Standardized bias (SB), pseudo- $R^2$  t-test and joint significance, are the most widely used and recommended by Rosenbaum and Rubin (1985), were used in this study. The basic idea of all approaches is to compare the distribution of these covariates in the two groups before and after matching on the propensity score. If there are significant differences after matching, then matching on the propensity score was not (completely) successful in making the groups comparable and remedial measures have to be taken (Caliendo and Kopeinig, 2008). For each covariate  $X$ , SB is defined as the difference of sample means in the treated and control subsamples as a percentage of the square root of the average of subsample variances:

$$SB = \frac{\bar{X}_T - X_C}{\sqrt{0.5(V_T(X) + V_C(X))}} \quad (5)$$

where  $X_T$  and  $X_C$  are sample means of the treated and control households and  $V_T$  and  $V_C$  are the corresponding sample variances. In this method, although there is no clear guidance on the tolerance level of the remaining bias after matching, Caliendo and Kopeinig (2008) recommend a 3-5% mean bias as sufficient in most empirical studies.

#### 3.4.3.5. Average Treatment effect on the treated

The interest of the impact part of this study was determining the average treatment effect on the treated (ATT) of irrigation practice. But the estimation of this effect is impossible based on the before and after because of absence of baseline data and it needs substituting the counterfactual mean of treated, by the mean outcome of untreated (Caliendo and Kopeinig, 2005). Even though it is possible based on with and without data it will be biased estimator under selectivity biasness. To solve this problem, PSM was used because it provides an appropriate solution (Rosenbaum and Rubin, 1985).

ATT is specified as:

$$ATT = E(Y_{1i} - Y_0 | T_i = 1) \quad (6)$$

Denoting participation in small-scale irrigation adoption by  $T_i$  where ( $T_i = 1$  treated and  $T_i = 0$ ) indicates none treated). Average Treatment effect on the Treated (ATT) for the population can be computed as:

This is similar with

$$ATT = [E(Y_{1i} | T_i = 1) - Y_{0i} | T_{i-1}]$$

Thus, sample equivalence is given by:

$$ATT = \frac{1}{n} \sum_{i=1}^n (Y_{1i} - Y_{0i} | T_i = 1) \quad (7)$$

Where  $Y_{1i} | T_i = 1$ ) indicates the amount of farm-income from participants of small-scale irrigation intervention.  $Y_{0i} | T_i = 1$ ) indicates what would have been the amount of income without participation in small-scale irrigation.

#### 3.4.3.6. Sensitivity Analysis

Based on the conditional independence or unconfoundedness assumption, matching has become a popular approach to estimate average treatment effects. Checking the sensitivity of the estimated results with respect to deviation from this identifying assumption has become an important topic in the applied evaluation literature. If there are unobservable variables that affect assignment in to treatment and outcome variable simultaneously, a hidden bias might arise to which matching estimators are not robust (Rosenbaum, 2002). If the study will be free of hidden bias, the effect of unobservable variable will be zero and the participation probability will solely be determined by observed characteristics. However, if there will be hidden bias, two individuals with the same observed covariates  $X$ , will have differing chances of receiving treatment.

### 3.5. Definition of Variables and Working Hypotheses

#### Dependent variable

The dependent variable for this study is participation in the small-scale irrigation farming with dummy values of 1 for households participating in irrigated farming and 0 for those not participating in irrigated farming in the study area.

#### Outcome variable

**Annual farm-income:** The outcome variable for this study is the total annual farm-income of the household measured in Birr.

## Independent Variables

Socio-economic, demographic, institutional and physical factors are expected to influence participation in irrigation farming. However, based on economic theories and empirical works the following explanatory variables, which are expected to have significant impacts in determining participation in small-scale irrigated farming in the study area are selected and hypothesized as follows.

**Sex of the household head (SEX):** This is a dummy variable, which takes a value of 1 if the household head is male and 0 otherwise. Sex of the household head was included to differentiate between male and female headed in their participation in irrigation activities. Different studies indicated that the probability of participating in irrigation practice will be higher for male headed household as compared to female headed households (Mohammadet *et al.*, 2013; Gebrehaweria *et al.*, 2014; Kinfe *et al.*, 2012). In this study, it is hypothesized that being male headed household positively affects the probability of participation in small-scale irrigation scheme farming.

**Age of the household head (AGE):** This is a continuous variable defined as the age of the household head at the time of interview measured in number of years. The older the household head, the lower the ability to work on irrigated farms which is naturally labor intensive. Also, older households may tend to be too traditional and less likely to invest on long-term agricultural production activities. Thus, as age increases the participation of farmers in irrigated farming will decrease. The findings of Beyan *et al.*, (2014); Edo, 2014) shows that the age of household head negatively affected the participation in irrigation practice by farmers. Therefore, it is hypothesized that age of household head has negative impact on participation and annual farm-income.

**Active labor force (ACTLF):** It is a continuous variable measured in number of healthy persons aged 15-65. It is one of the determinant factors for households' participation in small-scale irrigation. Households with more active labor force have the probability of participating in irrigation practice. The findings of Hadush (2014) found that there was a significance difference in availability of active labor force between irrigation users and non-users and 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. Therefore, for this study this variable was expected to affect the participation in small-scale irrigation and farm-income positively.

**Education of the household head (EDU):** This refers to the number of years of formal schooling a household head completed. Education increases farmer's ability to get process and make use of information on irrigation technology and new practices. Education may enable farmers to be more aware of irrigation importance. (Abebaw *et al.*, 2015; Edo, 2014) found that literacy of household has positive relationship with the probability of the participation of farmers to use irrigation water. In this study, this variable was expected to have positive relationship with household participation in irrigated farming and annual farm-income.

**Irrigation experience (IREXP):** This a continuous variable measured in number of years a sampled respondent is engaged in irrigated farming. Irrigation experiences enable farmers to install and maintain the irrigation systems and enable at operating different irrigation machineries. (Temesgen, 2017) found that experience of participant in to irrigation was higher than that of non-participants and irrigation experience enable the farmers to participate more in to the small-scale irrigation practices. Therefore, this variable was hypothesized to influence the probability of farmer's participation in irrigated farming and annual farm income positively.

**Distance from nearest market (DISTFM):** It is a continuous variable measured in kilometer. It refers to the distance between the farmer's residence and the nearest market centre. The further the market centre is the lesser the income from the selling of farm produce. If the market place is located far away from the farm, especially perishable commodities may perish before reaching the market. To avoid such incidences the farmer may sell his output for cheaper price thus reducing the income and hence having a negative impact on his participation in irrigated farming and hence, annual farm-income. The study by (Kinfu *et al.*, 2012) indicated that the farther the distance of the market from the farmer's residence area, the lower the probability of the farmer's participation in small-scale irrigation practice. Therefore, this variable is hypothesized to influence farmer's participation in irrigated farming and annual farm-income negatively.

**Livestock ownership (TLU):** This variable represents the total number of livestock in tropical livestock units owned per individual sample household. Animal rearing is one component of the farming systems in the study area. Sources indicate the farmers with higher number of livestock were found to participate in irrigation practice and with higher intensity of participation than those with lower number of oxen (Gebrehaweria *et al.*, 2014; Sithole *et al.*, 2014). Therefore, it is expected to affect the probability of participation in small-scale irrigation and annual farm-income positively.

**Land holding (LH):** This variable is continuous variable measured in hectare. Those farmers having larger area of cultivable land were found to participate more in irrigation practice than their counterpart as the evidences indicated by (Beyan *et al.*, 2013; Abebaw *et al.*, 2015). But it is found influencing the participation decision negatively by Edo (2014). This is mainly because farmers with small farm size do not have opportunities to increase production by increasing the size of cultivated land and the only option they are left with is to use intensively their farm land. For this study this variable was expected to have negative relation with the probability of participation in small-scale irrigation scheme but positive relation with annual farm-income.

**Credit utilization (CREDIT):** It is dummy variable which takes a value of 1, if the household head uses credit and 0 otherwise. Credit is essential for purchasing 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. (Sithole *et al.*, 2014) found that credit utilization affect the irrigation participation decision of the farmers positively. Hence, it was expected to increase the probability of participation in irrigation farming and annual farm-income.

**Frequency of extension contact (FREEC):** 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 is more likely to be aware of new

practices as they are easily exposed to information. 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. In this study this variable was hypothesized, to influence the farmers' decision to participate in irrigation and annual farm-income positively.

**Non-farm income (NONFI):** It is treated as continuous variable expressed in terms of birr. Non-farm income is the income generated other than on-farm activities. Hadush (2014) found that household heads who were engaged in non-farm activities were 25.12% more likely to participate and adopt a micro irrigation system than those household heads that had not participated in non-farm activities. It is, therefore, expected to affect the participation in to small-scale irrigation and annual farm-income positively.

**Distance of the farm from irrigation water sources (DISTFW):** It is a continuous variable measured in kms. It refers to the average distance from the nearest water source to the households' irrigation farm. As farm land gets closer to the water source, they can have access to sufficient water, which increase irrigation water use participation of the household (Agerie, 2013). Therefore, in this study, this variable was hypothesized to be negatively correlated with participation in irrigated farming and annual farm-income.

**Membership to Cooperative (MEMTC):** It is a dummy variable 1 represents if a household is a member of a certain farmers' association or cooperatives and 0 otherwise. Membership to an association let farmers to access inputs easily with an affordable price that is pertinent to increase in participation to the small-scale irrigation and thereby farm-income (Desta *et al.*, 2015). Therefore, this variable hypothesized to have positive relation with participation in small-scale irrigation and annual farm-income of the household.

Table 2. Summary of definition and hypotheses of explanatory variables

| Explanatory Variables                 | Measurement of Variables | Hypothesized direction of significance |
|---------------------------------------|--------------------------|----------------------------------------|
| Sex (SEX)                             | Dummy                    | Positive                               |
| Age (AGE)                             | Continuous               | Negative                               |
| Marital status (MSTATUS)              | Categorical              | Positive                               |
| Education (EDU)                       | Continuous               | Positive                               |
| Active Labor force (ACTLF)            | Continuous               | Positive                               |
| Irrigation Experience (IREXP)         | Continuous               | Positive                               |
| Distance from market (DISFM)          | Continuous               | Negative                               |
| Distance from water source (DISFW)    | Continuous               | Negative                               |
| Non-farm income (NONFI)               | Continuous               | Positive                               |
| Land holding (LH)                     | Continuous               | Negative                               |
| Frequency of extension contact(FREEC) | Continuous               | Positive                               |
| Credit (CREDIT)                       | Dummy                    | Positive                               |
| Membership to cooperative (MEMTC)     | Dummy                    | Positive                               |
| Livestock ownership (TLU)             | Continuous               | Positive                               |

Source: Own construction from related literatures, (2019)

## 4. RESULT AND DISCUSSIONS

This chapter presents the results and discusses the key findings of the study. Thus, it is organized in two sections. The first section provides descriptive analyses on the demographic, socio-economic and institutional characteristics of sample farm households and second section deals with the econometric model. The descriptive analysis further extended to discuss the sample households that are hypothesized to affect participation in to small-scale irrigation included in model.

### 4.1. Descriptive Statistical analysis

Demographic, socio-economic and institutional attributes of farm households which play crucial role in either promoting or impeding participation of small-scale irrigation or not are discussed here under.

**Age of the Household head:** The mean age of participant was about 36 years where as that of non-participant was 39.09 years. This shows that younger aged households participate more than older households in small-scale irrigation. The descriptive analysis revealed that there was a significant mean difference in age of household heads between participants and non-participants in small-scale irrigation scheme at 1% level of significance.

**Educational level of the household head:** The mean year of schooling for the sampled households was 3.28 in terms of years of schooling, whereas the participants and non-participants had a mean education level of 4.15 and 2.5 years of schooling, respectively. There was significant mean difference in the educational level between participants and non-participants household heads at 1% level of significance. The result indicates that, the education level of the participants was higher as compared to non-participants. This result further reveals that education enable smallholder farmers to participate in to small-scale irrigation.

**Active labor force:** It was one of the determinant factors for households' participation in small-scale irrigation. The mean total active labor force was 3.89 and the mean active labor force for participant and non-participant was 4.17 and 3.65 respectively. This shows that household with large number of active labor force

participate more in to small-scale irrigation. This maybe because of this family members are used as labor force in irrigated farming and this will reduce cost incurred in hiring external labor force. There was significant mean difference at 5% level of significance active labor of households between participants and non-participants.

**Total Livestock holding:** Livestock was one of the most productive asset of the farm household. In collaboration with crop production, livestock rearing is the main source of livelihood of the population in the study area. The mean total livestock holding of the total households was 14.02 TLU. The mean livestock holding for participant was 15.19 TLU while that of the non-participants was 12.97 TLU. There was significant mean difference at 1% level of significance in the livestock holding of households between participants and non-participants. The survey result shows that the livestock holding by participants was higher as compared to non-participants.

**Distance to the nearest market:** This variable is a proxy for transaction cost. From the descriptive analysis, the mean walking distance from the nearest market for the total sample households in the study area was 14.5 kilometers. The mean walking market distance of the participants was 11.78 kilometers, where as that of the non-participants was 17.04 kilometers. The descriptive analysis result shows that there was significant mean difference in the distance from the nearest market from household residence between participants and non-participants in irrigation practice at 1% significance level. The result also indicates that the distance from nearest market for the participants is lower as compared to that of non-participants. This result shows that as distance between farm household's residence and nearest market increases participation in to small-scale irrigation decreases.

**Distance from water source:** The survey result described in table reveals that the average distance of the sample households farm from the irrigation water source in kilometer was found to be 0.80 km. The mean distance from water source for irrigation user is 0.55 km and for non-users 1.02 km. The result shows that as distance between farmers plot of land and water source increases participation in to small-scale irrigation decreases. There was significant mean difference between irrigation user households and non-user households at 1% probability level in terms of distance from irrigation water sources.

**Irrigation experience:** The mean irrigation experience of the total households in the study area was 3.89 years, with minimum and maximum experience of 0 and 28 years, respectively. But the mean irrigation experience of the non-participants was 1.31, where as that of the participants was 7.82. The descriptive analysis revealed that there was significant mean difference in the year of experience of households between participants and non-participants in irrigation practice. The mean difference of irrigation experience between the non-participants and participants was significant at 1%. This implies that the experience of the participants was higher as compared to non-participants.

**Non-farm income:** The types of non-farm activities in the study area are petty trade, selling local drinks, selling charcoal and wood, weaving and others. The average annual non-farm income for the sample households was 1036 birr/per year. The irrigation user households earned birr 1550birr/per year and non-irrigation user households earned birr 568.72 birr/year. The mean difference in non-farm income between irrigation users and non-users was significant at 1% significance level.

Table 3. Summary statistics for continuous Variables

| Continuous Variables              | Participants<br>n=100 | Non-Participants<br>n=110 | Combined      | t-value  |
|-----------------------------------|-----------------------|---------------------------|---------------|----------|
|                                   | Mean/SD               | Mean/SD                   | Mean/SD       |          |
| Age (years)                       | 36.25(7.97)           | 39.09(8.616)              | 37.69(8.41)   | 2.40***  |
| Irrigation experience<br>(Years)  | 7.82(5.42)            | 1.31(2.82)                | 3.89(4.28)    | 2.51***  |
| Education (Year of<br>schooling)  | 4.15(4.11)            | 2.5(3.38)                 | 3.28(3.83)    | -3.18*** |
| Active labor force                | 4.17(1.98)            | 3.65(1.76)                | 3.89(1.88)    | -2.01**  |
| Livestock (TLU per<br>capita)     | 15.19(7.13)           | 12.97(6.23)               | 14.02(6.75)   | -2.40*** |
| Dist. from nearest<br>market (km) | 11.78(6.35)           | 17.04(9.15)               | 14.5(8.35)    | 4.79***  |
| Dist. from water source<br>(km)   | 0.55(.68)             | 1.02(0.85)                | 0.80(0.81)    | 4.37***  |
| Land holding (ha)                 | 1.77(1.55)            | 1.45(1.34)                | 1.60(1.45)    | -1.56    |
| Non-farm income (Birr)            | 1550(3010.43)         | 568.72(1482.9)            | 1036(2383.45) | -3.03*** |

Note: \*\* and \*\*\* indicates significance at 5 and 1 level of significance.

Source: Own survey result, (2019)

**Credit utilization:** The survey result shows that out of 210 sample household heads 42.37% of them used credit and the remaining 57.6% do not used credit services. The survey result describes that 23.80% of irrigation users and 33.80% non-users had not used credit service. As the survey result shows the majority of the sampled households did not obtained credit services. This is because of high interest rate, religious factors and the collection period of the loan provided to the farmers was when the price is very low and these disincentive farmers to use credit services. The chi-square test result indicates that there was significant relationship between irrigation participation and credit utilization at 5% level of significance because credit enables to buy irrigation inputs.

**Membership to cooperatives:** The study result in Table 4 shows that 39.57% of 210 household were membership to farmer's cooperative unions and other cooperatives and 60.43% of the household head are not member to any cooperative unions. Being

membership in any cooperative union helps farmers to access inputs like seed, pesticides and fertilizers. The chi-square test result indicated that there was significant relationship between irrigation participation membership to cooperative at 5% level of significance.

Table 4. Summary Statistics for dummy explanatory variables

| Dummy Variables            |        | Irrigation users |       | Non-users |       | $\chi^2$ |
|----------------------------|--------|------------------|-------|-----------|-------|----------|
|                            |        | Frequency        | %     | Frequency | %     |          |
| Sex                        | Male   | 87               | 41.42 | 92        | 43.8  | 0.47     |
|                            | Female | 13               | 6.2   | 18        | 8.57  |          |
| Membership to cooperatives | Yes    | 48               | 22.86 | 35        | 16.67 | 5.73**   |
|                            | No     | 52               | 24.76 | 75        | 35.71 |          |
| Credit utilization         | Yes    | 50               | 23.8  | 39        | 18.57 | 4.53**   |
|                            | No     | 50               | 23.8  | 71        | 33.8  |          |

Sources: own survey result, 2019

#### 4.1.1. Irrigated land size per participant households

The mean irrigated land size for the study area for the irrigation participants was found to be 0.382ha and it was within the range of national average. The minimum and maximum irrigated land size for the participants was found to be 0.12ha and 2.5ha with the standard deviation of 0.341ha which was greater than the mean value which indicates that it was high varied than that of for the whole sample.

Table 5. Distributions of irrigated land size

| Variable                                  | Observation | Mean  | Std.Dev | Min  | Max  |
|-------------------------------------------|-------------|-------|---------|------|------|
| Irrigated land size (ha) for participants | 100         | 0.382 | 0.341   | 0.12 | 2.25 |

Note: Max-maximum, Min-minimum, Std.Dev- Standard deviation

Sources: Own survey result, 2019

#### 4.1.2. Types of irrigation practices used

From the total participant sample households, the majority (82%) uses the traditional river diversion; Motor pump was the other irrigation type used by the farmers in the study area comprises about 6% of the participants. The lower number of the farmers use modern micro dam. This was the micro dam constructed by the Sustainable Land use and Management project and the farmers around this project use this modern micro dam irrigation. The other 8% of participant households use other means of irrigation such as hand dug bucket watering and flood plain and draining wet lands.

Table 6. Summary of the type of irrigation used by participants

| Irrigation type             | Frequency | Percentage | Cumulative |
|-----------------------------|-----------|------------|------------|
| Traditional river diversion | 82        | 82         | 82         |
| Motor pump                  | 6         | 6          | 88         |
| Modern micro dams           | 4         | 4          | 92         |
| Others                      | 8         | 8          | 100        |
| Total                       |           | 100        |            |

Sources: Own survey result, 2019

#### 4.1.3. Major problems encountered in use of small-scale irrigation practices

Small-scale irrigation has a potential to improve the income of rural households in developing countries like Ethiopia, but potential users face several problems and challenges in using irrigation, marketing and transporting of their products. In the study area a field survey with focus group discussion and key informant interviews indicates that small-scale irrigator's great benefit is accompanied with multidimensional problems. The major problems of small-scale irrigation in the study area are: Seasonality of water flows due to prolonged winter, failure of crops due to unknown reasons to the farmers, poor infrastructural developments, in adequacy of irrigation technologies and input supplies, shortage of basic technical knowledge on irrigation pumps, lack of well defined property rights and other several factors.

In the study area, other factors like design issue, cultural, institutional and environmental problems are also faced by smallholder farmers. These problems are more difficult because they affect the production and productivity mostly from time of

production to harvest and final marketing of their produce and most of these problems are beyond the control of farmers and this needs the interference of government sectors to tackle these problems.

Table 7. Summary of major problems in use of small-scale irrigation

| Major problems in use of<br>Small-scale irrigation        | Rank of problems by respondents |     |        |     |                 |     |
|-----------------------------------------------------------|---------------------------------|-----|--------|-----|-----------------|-----|
|                                                           | First                           | %   | Second | %   | Third and above | %   |
| Seasonality of Water                                      | 12                              | 12  | 14     | 14  | 21              | 21  |
| Failure of crops                                          | 7                               | 7   | 4      | 4   | 12              | 12  |
| Variability of weather and climate                        | 6                               | 6   | 8      | 8   | 7               | 7   |
| Crop diseases and pests                                   | 16                              | 16  | 24     | 24  | 8               | 8   |
| Poor infrastructural developments                         | 14                              | 14  | 18     | 18  | 2               | 2   |
| In adequacy of irrigation technologies and input supplies | 22                              | 22  | 12     | 12  | 6               | 6   |
| Shortage of basic technical knowledge on irrigation pumps | 21                              | 21  | 18     | 18  | 14              | 14  |
| Lack of well defined property rights                      | 0                               | 0   | 2      | 2   | 22              | 22  |
| Other                                                     | 2                               | 2   | 0      | 0   | 18              | 18  |
| Total                                                     | 100                             | 100 | 100    | 100 | 100             | 100 |

Sources: Own survey result, (2019)

## 4.2. Factors Affecting Participation in the Small-scale Irrigation scheme

Logit model was used to identify factors affecting participation in the small-scale irrigation scheme and to estimate propensity scores to be used for matching participants and non-participants in the small-scale irrigation. The result presented in Table 8 showed that the estimated model appears to perform well for the intended matching. The likelihood ratio has a chi-square distribution of 69.14 and is significant at 1% probability level, indicating the overall fitness of the model. Moreover, goodness of fit in logistic regression analysis is measured by smaller Pseudo-R<sup>2</sup> (0.23), the model result shows that the correctly predicted percent of sample households. The results further reveals that variables such as educational level of the

household head, active labor force, distance to the nearest market, distance from water source, non-farm income and tropical livestock unit are statistically significant factors affecting the probability of participation in small-scale irrigation. Conversely, sex, age, extension contact, credit utilization, membership to cooperative did not provide strong evidence in predicting the probability of participation in to small-scale irrigation practices.

**Educational level of the household head:** As hypothesized, the educational level of the household head significantly and positively affects participation in to the small-scale irrigation scheme at 1% significance level. The significant positive effect of education was because education improves the readiness of the household to accept new ideas, innovations and technologies, increases household heads' ability to obtain process and use information. Education also serves as the springboard for social and economic changes and enables one to easily adopt to new livelihood strategy, which in turn enhances his/her, willingness to participate in small-scale irrigation. This result is in accordance with (Wang *et al.* 2015).

**Active labor force:** The survey result showed that availability of active labor force was found to be positively and significantly influenced the participation in to small-scale irrigation scheme. This is due to the fact that households who have large number of healthy persons aged 15-65 were participated more in to small-scale irrigation. The result of marginal effect in the logit model showed that an increase in active labor by one person increases the probability of participation in to the small-scale irrigation scheme by 0.046.

**Distance to the nearest market:** The results of the logit model also indicated that the distance of the farmer's residence from the nearest market was found to be negatively and significantly influence the probability of participation in to small-scale irrigated farming. As the distance from farmer's residence and market place increases, the transaction cost for selling output and obtaining input will be high. This might, in turn, reduce farmers' participation in irrigated farming and their farm-income reduced. Moreover, irrigation users located nearby to the nearest market location have advantage to sell their farm produce at good price. The marginal effect of logit model shows that an increase in distance from market place by one kilometer leads to

decrease in probability of participation to small-scale irrigation farming by 0.015. This finding is consistent with previous result of Abebe *et al.* (2011).

**Distance from water source:** This variable found to be negatively related with the participation in small-scale irrigated farming. This implies that household that has farm-land far from irrigation scheme will leads to decrease in probability of participation in small-scale irrigation. The interpretation of the marginal effect also implies that an increase in distance from water source by one kilometer leads to decrease participation in small-scale irrigated farming by a factor of 0.166. This result is also evidenced results of Kinfel *et al.* (2012), Beyan *et al.* (2014).

**Non-farm income:** This variable was found to be positively and significantly affect the participation in to small-scale irrigation. This is due to the fact that households that get income from other than farm can alleviate or remove the credit constraints of rural households and may be used to finance irrigation investment. The result of marginal effect of logit showed that an increase in non-farm income by one birr increases the probability of participation in to small-scale irrigation by a factor of 0.001. This finding is consistent with the results of Hadush *et al.* (2014).

**Total Livestock holding:** Households who have larger number of livestock in tropical livestock unit were more likely to be participated in irrigated farming. These variables were found to influence the participation in to small-scale irrigation positively and significantly. The implication of the result was that livestock are an important source of cash in rural areas to allow purchase of farm inputs that can be used when irrigation is available. The marginal effect for tropical livestock unit indicates an increase in tropical livestock unit by one increase the probability of participation in to small-scale irrigation by a factor of 0.015. This finding is in line with the results of Temesgen (2017).

Table 8. Logit model for program selection and results of covariates

| Variable               | Coeff.    | Std.error | Z     | p>z   | Marginal effect |
|------------------------|-----------|-----------|-------|-------|-----------------|
| Sex                    | 0.234     | 0.490     | 0.48  | 0.632 | 0.057           |
| Age                    | -0.031    | 0.021     | -1.50 | 0.135 | -0.008          |
| Marital status         | 0.151     | 0.412     | 0.37  | 0.714 | 0.038           |
| Education              | 0.153***  | 0.046     | 3.31  | 0.001 | 0.038           |
| Active Labor force     | 0.186**   | 0.092     | 2.02  | 0.044 | 0.046           |
| Dist. from market      | -0.059**  | 0.025     | -2.39 | 0.017 | -0.015          |
| Dist from water source | -0.665*** | 0.248     | -2.68 | 0.007 | -0.166          |
| Non-farm income        | .00024 ** | .000098   | 2.48  | 0.012 | 0.001           |
| Land holding           | 0.098     | 0.125     | 0.78  | 0.434 | 0.024           |
| Freq. of ext. contact  | 0.124     | 0.263     | 0.47  | 0.637 | 0.031           |
| Credit                 | 0.261     | 0.357     | 0.73  | 0.464 | 0.065           |
| Memb. to cooperative   | 0.427     | 0.361     | 1.18  | 0.237 | 0.106           |
| TLU                    | 0.059**   | 0.027     | 2.19  | 0.029 | 0.015           |
| Constant               | -0.867    | 1.5       | -0.58 | 0.564 |                 |
| Number of observation  | 210       |           |       |       |                 |
| LR chi2(12)            | 69.14     |           |       |       |                 |
| Prob > chi2            | 0.00      |           |       |       |                 |
| Log likelihood         | -110.93   |           |       |       |                 |
| Pseudo-R2              | 0.23      |           |       |       |                 |

Source: Own survey result, (2019)

Note: \*\*\* and \*\* represent significance at 1%, and 5% probability levels, respectively.

### 4.3. Impact of Small-Scale Irrigation Scheme on Households Income

#### 4.3.1. Estimation of propensity score matching

Propensity Score Matching is a tool that creates a comparison group with the treatment group based on factors that affect household's probability to participate in the program (Ravallion, 2009). It also 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. Logistic regression model was used to estimate propensity scores for treatment and control households.

### 4.3.2. Matching quality and common support

Another important step in investigating the validity or performance of the PSM estimation is verification of the common support or overlap condition. It is assumed that the probability of participation in small-scale irrigation, conditional on observed characteristics, lies between 0 and 1 ( $0 < P(D = 1/X) < 1$ ). This assumption is critical to estimation, as it ensures that households with the same  $X$  values have a positive probability of being both participant and non-participant (Caliendo and Kopeinig, 2008). By choosing kernel matching, an area of common support which is defined by the bandwidth set to 0.1 of the standard deviation of the balancing score. The distribution of the estimated propensity scores and the overlap between participant and non-participant are shown in Figure 3. The figure illustrates the imbalanced distribution between treatment and control households and show the cases excluded from the analysis to avoid bad matches.

The overlap or region of common support between treatment and control groups can be verified with relatively straightforward strategies. One obvious approach is through visual inspection of the propensity score distributions for both groups. Simple graphs or density distribution plots of propensity scores for the two groups, together with a comparison of the minimum and maximum propensity score values in each distribution, can typically provide researchers a good, initial reading of the extent to which there is overlap in the propensity scores of the treatment and control units (Heinrich *et al.*, 2010). A visual inspection of the density distribution for participant and non-participant in Figure 3 indicates that the common support condition is satisfied as there is substantial overlap in the distribution of the estimated propensity scores for the two groups.

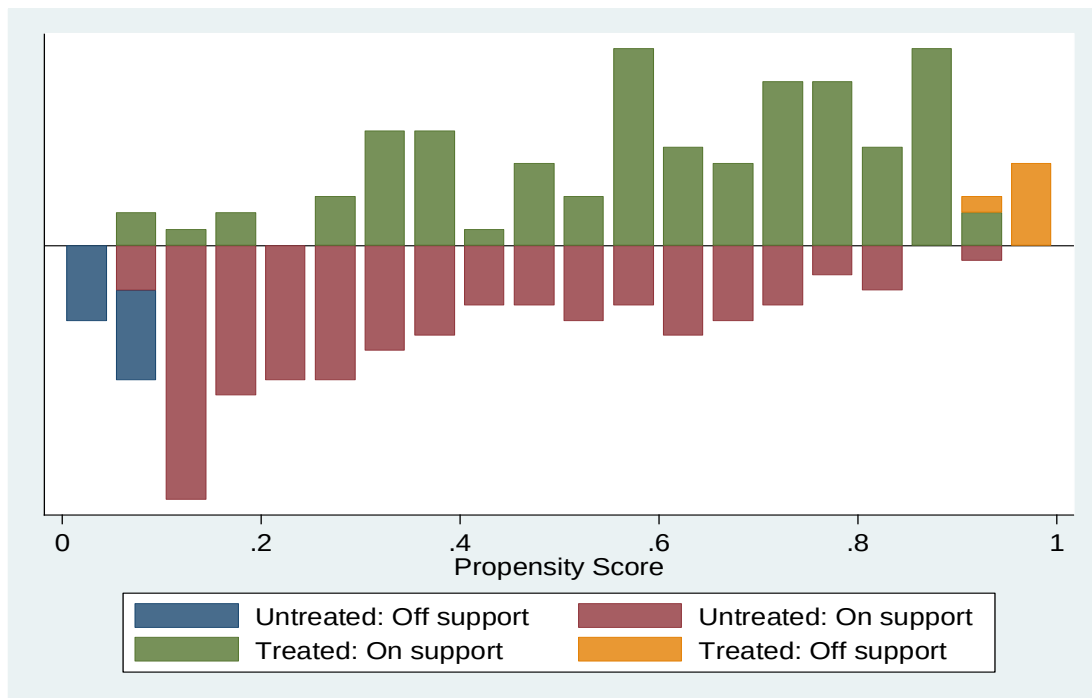


Figure 3. Common support area by comparison of participant and control groups  
Source: Survey data result, plotted using psgraph, (2019)

Moreover, kernel density score was used to show distribution of the household with respect to the estimated propensity scores. Figure in appendix part (Appendix figure 1) portrays the distribution of treatment households and the control households with the estimated propensity scores.

The estimated propensity scores vary between 0.0757 and 0.9124. Based on minima and maxima criterion the common support region would then lie between 0.0757 and 0.9124 and households whose estimated propensity scores are less than 0.0757 and larger than 0.9124 are discarded from the analysis. As a result of this restriction 6 households (irrigation users) and 11 households (irrigation non-users) were discarded from the matching exercise.

Table 9. Summary of propensity score for a common support

| Variable         |                   | Observation | Mean   | SD     | Min    | Max    |
|------------------|-------------------|-------------|--------|--------|--------|--------|
| Propensity score | Participants      | 100         | 0.6284 | 0.2240 | 0.0757 | 0.9967 |
|                  | Non –Participants | 110         | 0.3378 | 0.2329 | 0.0167 | 0.9124 |
|                  | Total             | 210         | 0.4762 | 0.2706 | 0.0167 | 0.9966 |

Source: Own survey result, (2019)

### 4.3.3. Choosing the matching algorithm

In this study, the best matching algorithm chosen is the one with large matched sample size, large number of insignificant variables after matching, small pseudo- $R^2$  after matching and small mean standardized bias. Result presented in (Table 10) indicates that kernel matching estimator with bandwidth of 0.1 is the best matching estimator satisfying all the four criteria listed above. After looking into the results, it has been found that kernel matching with a band width of 0.1 was found to be the best estimator for the data with low pseudo- $R^2$  value of 0.005 and smallest means standardized bias of 3.4 as compared to other alternative matching estimators. Heckman *et al.* (1998) argued that kernel matching performs better in reducing standardized mean bias between treated and control groups than other matching algorithms and this method uses more information and has a lower variance. Hence, kernel matching estimator with bandwidth of 0.1 was used to estimate the average treatment effect on the treated (ATT) of the participants of small-scale irrigation on the outcome variable.

Table 10. Performance criteria of different Matching algorithms

| Matching estimators                   | No. of insignificant variables after matching | Pseudo- $R^2$ after matching | Matched sample size | Mean SB    |
|---------------------------------------|-----------------------------------------------|------------------------------|---------------------|------------|
| <b>Nearest neighbour matching</b>     |                                               |                              |                     |            |
| Nearest neighbour with replacement    | 13                                            | 0.039                        | 193                 | 9.4        |
| Nearest neighbour without replacement | 13                                            | 0.018                        | 193                 | 5.8        |
| <b>Caliper matching</b>               |                                               |                              |                     |            |
| Radius 0.1                            | 13                                            | 0.039                        | 193                 | 9.4        |
| Radius 0.5                            | 13                                            | 0.039                        | 193                 | 9.4        |
| Radius 0.25                           | 13                                            | 0.039                        | 193                 | 9.4        |
| <b>Kernel matching</b>                |                                               |                              |                     |            |
| <b>Bandwidth 0.1</b>                  | <b>13</b>                                     | <b>0.005</b>                 | <b>193</b>          | <b>3.4</b> |
| Bandwidth 0.25                        | 13                                            | 0.013                        | 193                 | 5.9        |
| Bandwidth 0.5                         | 13                                            | 0.051                        | 193                 | 10.9       |

Source: Survey data result, using ptest, (2019)

#### **4.3.4. Testing the balance of propensity score and covariates**

The quality of the matching procedure is evaluated on the basis of its capability in balancing the control and the treatment groups with respect to the covariates used for the propensity score estimation. We call the process of matching creates a high degree of covariate balance between the participants and comparison groups if after matching some covariates, which were significant before matching become insignificant. This can be seen from the executed t-test in the balanced test. This test helps to check if there are significant differences in covariate means for both groups. Before matching, differences are expected, but after matching the covariates should be balanced in both groups and hence no significant differences should be found (Rosenbaum and Rubin, 1985). For this study t-value in (Table 11) showed that before matching some of chosen variables exhibited statistically significant differences while there were no significant mean and proportion difference between participant and non-participant in terms of all explanatory variables hypothesized to affect participation in to small-scale irrigation and outcome variable. These create 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, the standard bias before matching lies in the range between 0.5% and 66.8% but after matching, the standard bias of covariates lies between 0% and 9.4%. Rosenbaum and Rubin (1985) suggested the standardized bias difference of the covariates must be below the critical level of 20 percent.

Table 11. Propensity score and covariate balancing

| Variable | Unmatched<br>Matched | Mean    |         | %bias | %reduced<br>bias | t-test |        |
|----------|----------------------|---------|---------|-------|------------------|--------|--------|
|          |                      | Treated | Control |       |                  | T      | P>t    |
| _pscore  | U                    | 0.628   | 0.34    | 127.2 | 97.2             | 9.20   | 0.000  |
|          | M                    | 0.606   | 0.59    | 3.6   |                  | 0.27   | 0.790  |
| Sex      | U                    | 0.87    | 0.84    | 9.5   | 67               | 0.68   | 0.495  |
|          | M                    | 0.861   | 0.87    | -3.1  |                  | -0.22  | 0.824  |
| Age      | U                    | 36.25   | 39.01   | -33.2 | 99.9             | -0.01  | 0.017  |
|          | M                    | 36.51   | 36.55   | 0.0   |                  | -0.00  | 0.998  |
| M-status | U                    | 2.085   | 2.08    | -0.5  | -137.5           | -0.04  | 0.017  |
|          | M                    | 2.085   | 2.08    | -1.2  |                  | -0.00  | 0.998  |
| EDU      | U                    | 4.15    | 2.5     | 43.8  | 82.2             | 3.18   | 0.002  |
|          | M                    | 3.96    | 3.66    | 7.8   |                  | 0.50   | 0.617  |
| ACTLF    | U                    | 4.173   | 3.65    | 27.8  | 100              | 2.02   | 0.045  |
|          | M                    | 4.085   | 4.07    | 0.0   |                  | 0.02   | 0.983  |
| DISTFM   | U                    | 11.78   | 17.04   | -66.8 | 99.9             | -4.79  | 0.000  |
|          | M                    | 11.936  | 11.93   | -0.0  |                  | 0.00   | 0.997  |
| DISTFW   | U                    | 0.558   | 1.03    | -60.8 | 90.2             | -4.38  | 0.000  |
|          | M                    | 0.567   | 0.62    | -5.9  |                  | -0.48  | -0.633 |
| NONFI    | U                    | 1550    | 568.73  | 41.4  | 91.5             | 3.04   | 0.003  |
|          | M                    | 1138.3  | 1226    | -3.5  |                  | -0.23  | 0.816  |
| LH       | U                    | 1.806   | 1.46    | 24.1  | 62..9            | 1.75   | 0.082  |
|          | M                    | 1.706   | 1.83    | -8.9  |                  | -0.57  | 0.571  |
| FREEC    | U                    | 0.52    | 0.46    | 8.4   | 41.7             | 0.61   | 0.545  |
|          | M                    | 0.5106  | 0.55    | -5.3  |                  | -0.31  | 0.754  |
| CREDIT   | U                    | 0.5     | 0.35    | 29.6  | 93.3             | 2.14   | 0.033  |
|          | M                    | 0.468   | 0.47    | 2     |                  | 0.13   | 0.892  |
| MEMTC    | U                    | 0.48    | 0.32    | 33.3  | 91.6             | 2.42   | 0.016  |
|          | M                    | 0.468   | 0.48    | -2.8  |                  | -0.19  | 0.850  |
| TLU      | U                    | 15.192  | 12.97   | 33.1  | 89.1             | 2.41   | 0.017  |
|          | M                    | 15.084  | 14.86   | 3.6   |                  | 0.22   | 0.827  |

Note: U- Unmatched, M- Matched

Source: Own survey data result, (2019)

The joint significance test and the pseudo- $R^2$  are also good indicators; accordingly, the low pseudo- $R^2$  value and insignificant likelihood ratio tests evident that both groups have the same distribution in all covariates after matching. The pseudo- $R^2$  indicates how well the regressors  $X$  explain the participation probability (Caliendo and Kopeinig, 2008). After matching there should be no systematic differences in the distribution of covariates between both groups. Therefore, the pseudo- $R^2$  should be

fairly low and the insignificant likelihood ratio. Furthermore, a Chi-square test on the joint significance of all regressors and it should be insignificant after matching (indicated by p-value).

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 among groups of households having similar observable characteristics. This allowed comparing observed outcomes of participant with comparison groups sharing a common support.

Table 12. Overall balance indicators of covariates

| Sample    | Pseudo-R <sup>2</sup> | LR chi <sup>2</sup> | p>chi <sup>2</sup> | Mean Bias | Med Bias |
|-----------|-----------------------|---------------------|--------------------|-----------|----------|
| Unmatched | 0.239                 | 69.33               | 0.000              | 33.2      | 33.2     |
| Matched   | 0.005                 | 1.39                | 1.000              | 3.4       | 3.3      |

Source: Own survey result, (2019)

#### 4.3.5. Average treatment effect on the treated

According to Caliendo and Kopeinig (2008) an important decision which has to be made in the empirical analysis is when to measure the effects. The impact of small-scale irrigation scheme on the outcome variable (farm income) was evaluated using PSM model, after the pre-intervention differences were controlled. The estimation result presented shows that the average income reported by participants in small-scale irrigation scheme was 15430.5birr<sup>1</sup>/year, while that for non-participants was 11539.90birr/year which was 33.7% lower than that of participants. After controlling for other factors using PSM method, the average income of participant is 15394.68birr, while that of non-participants is birr 10813.83birr. This indicates that, participation in to small-scale irrigation scheme has significantly increased the household's income by 4580.85birr/year on average, which is 42.4% higher than that of non-participants. The impact evaluation of the average treatment effect on treated of participation in to small-scale irrigation for this result was conducted using kernel matching and bootstrap method was used to estimate standard errors for matching

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<sup>1</sup> 1 USD = 29.0499 ETB, Dollar to Ethiopian Birr exchange rate (USD ETB) as of 31 Jul 2019.

estimator to account for the fact that the propensity score is also estimated. This finding is consistent with studies (Hadush, 2014, Shiferaw and Mengistu, 2015, and Temesgen, 2017). Therefore expansion and technological development of small-scale irrigation should be encouraged and problems hindering smallholder farmers to participate in small-scale irrigation needs to be solved to enhance their participation.

Table 13. Average treatment effect on the treated (ATT)

| Outcome variable | Sample    | Treated  | Controls | Difference | S.E     | T-stat |
|------------------|-----------|----------|----------|------------|---------|--------|
| Farm-income      | Unmatched | 15430.5  | 11539.90 | 3890.59    | 1545.80 | 2.52   |
|                  | ATT       | 15394.68 | 10813.83 | 4580.85    | 2791.63 | 2.24** |

\*\* indicates significance at 5% significance level

Note: ATT- Average Treatment effect on treated, S.E- standard error

Source: Own survey result, (2019)

#### 4.3.6. Sensitivity analysis

Rosenbaum (2002) proposes using Rosenbaum bounding approach in order to check the sensitivity of the estimated ATT. Result on Appendix table 2 shows that the inference for the effect of the small-scale irrigation is not changing though the participant and non-participant households has been allowed to differ in their odds of being treated in terms of unobserved covariates. That means for outcome variables estimated, at various level of critical value of gamma, the p-critical values are significant (i.e., there is no hidden bias due to unobserved confounder) which further indicate that the study have considered important covariates that affected both participation in small-scale irrigated farming and outcome variable, annual farm-income. Thus, the study can conclude that the impact estimates (ATT) are not sensitive to unobserved selection bias and are a pure effect of participation into small-scale irrigated farming.

## 5. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

### 5.1. Summary and Conclusions

Small-Scale Irrigation is one of the most useful irrigation system which is designed to increase production and productivity and to reduce risks related to rainfall variability as well as increasing income of the rural households. Hence, this study was undertaken to identify factors affecting household's participation in to small-scale-irrigation scheme and to estimate its impact of on household farm-income in Jardega Jarte district of Oromia National Regional State.

The study used cross sectional data from four *kebeles* of the district. Both primary and secondary data were used for this study. The primary data were collected from a total of 210 randomly selected sample households from both irrigation users and non-user households using semi-structured questionnaire. Multi-stage purposive and random sampling procedure was employed in the study to select the sample households. The data were analyzed using both descriptive statistics (to describe demographic, socioeconomic and institutional factors of the households), and PSM econometric model was applied to estimate the impact of the small-scale irrigation scheme on household income.

Descriptive statistical result indicated that there is statistical mean difference between irrigation user and non-user households' in terms of age, educational level, active labor force, distance to the nearest market, distance from water source, non-farm income and total livestock holding. However, the two groups have a statistically insignificant mean variation in terms of sex and total cultivated land size.

The major problems faced by small-scale irrigation user in the study area are: Seasonality of water flows, failure of crops, poor infrastructural developments, in adequacy of irrigation technologies and input supplies, shortage of basic technical knowledge on irrigation pumps, lack of well defined property rights and other several factors in design issue, cultural, institutional and environmental problems are identified in the study area during the survey.

The result of logit model showed participation in to small-scale irrigation is significantly and positively affected by educational level of the household head, active labor force, non-farm income and tropical livestock holding, but significantly and negatively affected by distance to the nearest market, and distance from water source. Conversely, sex, age, extension contact, credit utilization, membership to cooperative did not provide strong evidence in predicting the probability that a household participates in small-scale irrigation practices.

PSM result showed that 94 irrigation user households were matched with 99 non-user households after discarding 17 households whose values were out of the common support region by using kernel matching estimator with 0.1 band width. The result of matching passed on many process of matching quality tests such as t-test, reduction in standard bias. The result of Rosenbaum bounding procedure showed that estimated ATT for all significant variables were insensitive to unobservable which clearly indicate its robustness. Therefore, it was concluded that households' participation in small-scale irrigation has significant and positive impact with household's income.

In conclusion, impact estimation result indicated significant differences in the average farm-income of participants of small-scale irrigation and control group. The result further indicated that the average annual farm-income of participant is 15394.68birr, while that of non-participants is birr 10813.83birr This indicates that participation in to small-scale irrigation scheme has significantly increased the household's income by 4580.85birr on average, which is 42.4% higher than that of non-participants.

## **5.2. Recommendations**

The finding of the study showed that participation in to small-scale irrigation scheme has significant and positive impact on farm-income of rural farm households. So the government and other concerned body should work in expansion and technological development of small-scale irrigation to increase their participation in small-scale irrigation.

Small-scale irrigation has a potential to improve the farm-income of rural households, but potential users face several problems that hinder them to participate efficiently in small-scale irrigation in the study area. An understanding of these problems will assist

in generating solutions leading to improved performance of smallholder in small-scale irrigation schemes. Therefore, government and other concerned body should try to solve or at least to mitigate the problems faced in small-scale irrigation by providing training in irrigation water management and crop production, by assigning extension worker to assist the farmers and effort should be made in rural road networks and there should be provision of necessary input for irrigated agriculture to enhance farmers participation in to small-scale irrigation.

The study showed that educational level of the household head had significantly and positively affects the probability of farmer's participation in to small-scale irrigation farming. Therefore, for effective participation in small-scale irrigated farming, government policy makers and other responsible bodies has to enhance the educational status of the farmers in the rural areas through adult education, proper utilization of farmers training on improvement in crop production technologies and crop management to increase crop yield.

Distance from the nearest market significantly and negatively affected the farmer's participation in to small-scale irrigated farming. Therefore, the government and policy makers should strengthen efforts of expanding infrastructural development like rural road networks to improve transportation facilities in order to enable farmers easily transport their produce and the provision of necessary input for irrigated agriculture that would ultimately increase farmer's participation and farmers need to be assisted in developing a reliable market network where they can sell produce and purchase inputs.

The study also revealed that distance of land from water source was significantly and negatively affected participation in to small-scale irrigated farming. Therefore, proper construction of irrigation canals and improving the existing scheme structures in the irrigated area should be in place and special attention should be given to increase the size of irrigated land by taking the water to long distances to cover large area using improved irrigation schemes.

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## **7. APPENDICES**

## Appendix I: Tables

Appendix Table 1. Conversion factors used to estimate tropical livestock unit (TLU)

| Livestock                 | C.F TLU | Livestock              | C.F TLU |
|---------------------------|---------|------------------------|---------|
| Oxen and cow              | 1       | Horse and mule         | 1.1     |
| Bull and Heifer           | 0.75    | Donkey (adult)         | 0.7     |
| Calf ( < 1 years)         | 0.25    | Donkey (young)         | 0.35    |
| Weaned calf (1-2.5 years) | 0.34    | poultry                | 0.013   |
| Sheep and Goat (adult)    | 0.13    | Sheep and Goat (young) | 0.06    |

Source: Storck,*et al.*,1991

Appendix Table 2.Sensitivity analysis for unobservable bias

| Gamma | sig+ | sig- | t-hat+  | t-hat- | CI+   | CI-     |
|-------|------|------|---------|--------|-------|---------|
| 1     | 0    | 0    | 11650   | 11650  | 10100 | 13400   |
| ..1   | 0    | 0    | 11150   | 12100  | 9650  | 14000   |
| ..2   | 0    | 0    | 10750   | 12600  | 9300  | 14500   |
| ..3   | 0    | 0    | 10350   | 13100  | 8975  | 15000   |
| ..4   | 0    | 0    | 10000   | 13500  | 8685  | 15500   |
| ..5   | 0    | 0    | 9700    | 13950  | 8425  | 15950   |
| ..6   | 0    | 0    | 9450    | 14300  | 8200  | 16350   |
| ..7   | 0    | 0    | 9200    | 14700  | 7950  | 16732.5 |
| ..8   | 0    | 0    | 8955    | 15000  | 7750  | 17150   |
| ..9   | 0    | 0    | 8750    | 15350  | 7550  | 17500   |
| 2     | 0    | 0    | 8573.75 | 15680  | 7400  | 17885   |

\* gamma - log odds of differential assignment due to unobserved factors

sig+ - upper bound significance level

sig- - lower bound significance level

t-hat+ - upper bound Hodges-Lehmann point estimate

t-hat- - lower bound Hodges-Lehmann point estimate

CI+ - upper bound confidence interval ( $\alpha = 0.95$ )

CI- - lower bound confidence interval ( $\alpha = 0.95$ )

Source: Survey result, 2019 using rbounds.

## Appendix II: Questionnaire

### **A research questionnaire on Impact of Small scale Irrigation on household income in Jardega Jarte District**

The purpose of this questionnaire is to gather reliable data and information on small scale irrigation practices on irrigation users and non-user household's socio-economic, access for services and other important information. Dear respondents, the result and the finding of the research help to produce scientific evidenced policy directions and recommendations. It will help different stakeholders and policy makers to make appropriate measures on irrigation development in the future.

**Thank you in advance for your cooperation!**

#### **Identification**

Date of data collection\_\_\_\_\_Code \_\_\_\_\_

Enumerators Name \_\_\_\_\_ Signature\_\_\_\_\_

#### **Household Characteristics**

1. Name of household head\_\_\_\_\_ Kebele of the HH\_\_\_\_\_
2. Sex of the HH 0.Female 1.Male
3. Education level of the respondent: 0. Illiterate 1.Read and write 2.Elementary 3. High school 4. Preparatory and above 5. Formal education \_\_\_\_\_grade
4. Age of the household head \_\_\_\_\_ Years old
5. Marital status: 1. single2. Married 3. Divorced 4. Widowed
6. Family size: M, \_\_\_\_\_ F, \_\_\_\_\_, Total, \_\_\_\_\_
7. Did your household members participate in farming work? 0. No 1. Yes  
If yes, how many of them participated?\_\_\_\_\_

#### **Land holding**

8. Do you have your own land? 0. No 1. Yes  
If yes, its total land size \_\_ha; Area under irrigation \_\_\_\_, area under rain fed \_\_\_\_ha  
Total area of land cultivated during the last one year \_\_\_\_\_ (In ha).
9. Are you irrigation user?0 = No 1 = Yes

a. If your answer is yes which type of irrigation you use?

A) Modern micro dams

B) Motor pump

C) River diversion

D) Others specify \_\_\_\_\_

c. If the answer is No, what was the reasons not using irrigation?

1 = No farmland in surface water access 2 = No awareness about it

3 = Sufficient rain and moisture 4 = others \_\_\_\_\_

If you are using irrigation how do you perceive the size of land holding you have under irrigation?

1. Very small 2. Small 3. Sufficient 4. Big/ large

10. Distance between your irrigable land and source of water \_\_\_\_\_KM

11. How long do you use irrigation farming? \_\_\_\_\_years

12. What are the major problems encountered in small-scale irrigation schemes you use per crop season. Please rank them.

A) Seasonality of Water

B) Variability of weather and climate

C) Crop diseases and pests

D) Poor infrastructural developments

E) In adequacy of irrigation technologies and input supplies

F) Shortage of basic technical knowledge on irrigation pumps

G) Lack of well defined property rights

H) Others \_\_\_\_\_

13. What help do you need from the government or any organization on your irrigation farming?

\_\_\_\_\_  
\_\_\_\_\_

14. Have you cultivated the total of your irrigable land during the last dry season?

0 = No 1 = Yes

If your answer to question No.15 is No, what are the reasons? (Circle the answers)

1 = Shortage of family labor 2 = Lack of quality seed 3 = shortage of water

4 = enough production rain fed 5 = Lack of credit

6 = others specify \_\_\_\_\_

15. Are you dissatisfied with the existing irrigation water supply system? 1. Yes 0. No  
 .If Yes for Q15, what kind of challenges and problems you have faced/observed in the existing irrigation schemes? Specify all bellow

1. Seasonality of irrigation water 2. Imbalance between the demand and the existing system of water supply 3. Distance from water source 4. Conflict

5) Others \_\_\_\_\_

### Number of livestock holding in 2011 E.C.

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

|                  | Type of livestock |      |      |        |      |       |     |        |     |
|------------------|-------------------|------|------|--------|------|-------|-----|--------|-----|
|                  | Bull              | Oxen | Cows | Heifer | Goat | Sheep | Hen | Donkey | Hen |
| Livestock number |                   |      |      |        |      |       |     |        |     |
| Livestock sold   |                   |      |      |        |      |       |     |        |     |
| Values in birr   |                   |      |      |        |      |       |     |        |     |

18.The total expected income of your livestock in 2018/19? \_\_\_\_\_birr

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

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

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

### Extension contact

20. Do you contact with DA's(extension contact)? 0. No 1. Yes

If yes, how many times do you contact with them \_\_\_\_\_times per year? What supports are you get from DA's? 1. Advice 2. Training 3. Demonstration of fields

4. Conflict resolution 5. Others (specify) \_\_\_\_\_

21.How much time does it take you to travel the nearest market to sell your agricultural products and buy the necessary items? \_\_\_\_\_ Hours(\_\_\_\_\_KM)

22. 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) \_\_\_\_\_

23. 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) \_\_\_\_\_

Do you get reasonable price for your produce in 2010 E.C? 0. No 1. Yes

If no, what are the reasons? 1. No demand for the produce 2. More supply of the

produce 3. Others (specify) \_\_\_\_\_

### **Credit issues**

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

If yes, where do you get the sources? 1. Banks 2. Service cooperatives

3. Neighbors and relatives 4. Micro finance institutes 5. Other

(specify) \_\_\_\_\_ 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) \_\_\_\_\_

If No to Q23, what was the reason?

a) No access b) high interest rate c) I have sufficient capital d) Collateral e) Others

(specify) \_\_\_\_\_

How much have you borrowed for agricultural production in the preceding

agricultural season? \_\_\_\_\_ Birr.

25. Are you membership to any cooperative in your area? 0. No 1. Yes

If your answer is yes what services do you get from the membership? 1. Loan service

2. Input supplies 3. Others (specify) \_\_\_\_\_

### **General opinion of respondents**

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

a. \_\_\_\_\_

b. \_\_\_\_\_

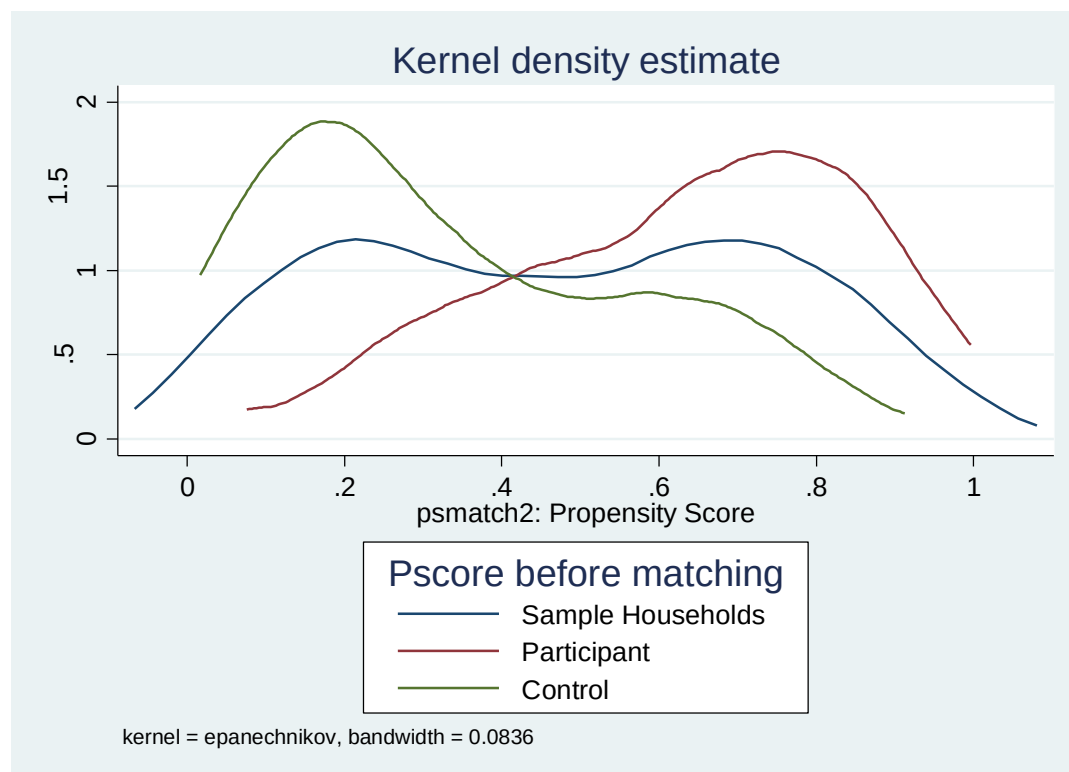
3. What interventions must be made for better implementation of modern irrigation?

a. \_\_\_\_\_

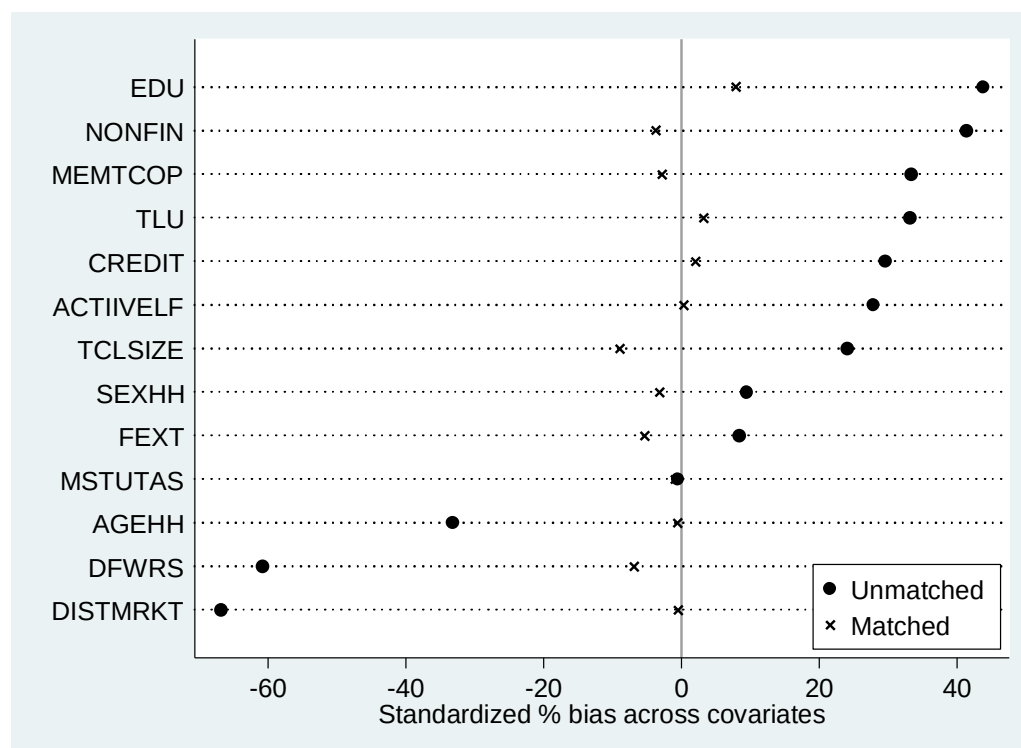
b. \_\_\_\_\_

**Thanks you for your cooperation and confidential response!**

### Appendix III: Figures



Appendix Figure 1. Kernel Density scores for participants and non-participants



Appendix Figure 2. Graphical representation of balance indicators of covariates

```
. logit Partirrrrigation SEXHH AGEHH MSTUTAS ACTIIVELF DFWRs DISTMRKT NONFIN TCLSIZE FEXT EDU MEMTCO
> P CREDIT TLU
```

```
Iteration 0:   log likelihood = -145.32272
Iteration 1:   log likelihood = -111.0716
Iteration 2:   log likelihood = -110.75661
Iteration 3:   log likelihood = -110.75507
Iteration 4:   log likelihood = -110.75507
```

```
Logistic regression               Number of obs   =       210
                                LR chi2(13)      =       69.14
                                Prob > chi2       =       0.0000
Log likelihood = -110.75507       Pseudo R2     =       0.2379
```

| Partirrrrigation | Coef.     | Std. Err. | z     | P> z  | [95% Conf. Interval] |           |
|------------------|-----------|-----------|-------|-------|----------------------|-----------|
| SEXHH            | .2346914  | .4902222  | 0.48  | 0.632 | -.7261264            | 1.195509  |
| AGEHH            | -.0310171 | .0207426  | -1.50 | 0.135 | -.0716719            | .0096377  |
| MSTUTAS          | .1519949  | .4110961  | 0.37  | 0.712 | -.6537386            | .9577284  |
| ACTIIVELF        | .187012   | .0922632  | 2.03  | 0.043 | .0061793             | .3678446  |
| DFWRs            | -.6611512 | .2480566  | -2.67 | 0.008 | -1.147333            | -.1749693 |
| DISTMRKT         | -.0586132 | .0246427  | -2.38 | 0.017 | -.106912             | -.0103144 |
| NONFIN           | .0002479  | .0000986  | 2.51  | 0.012 | .0000547             | .000441   |
| TCLSIZE          | .11635    | .1276932  | 0.91  | 0.362 | -.1339241            | .3666242  |
| FEXT             | .1269822  | .2634651  | 0.48  | 0.630 | -.3894               | .6433643  |
| EDU              | .1523702  | .0460361  | 3.31  | 0.001 | .0621411             | .2425992  |
| MEMTCOP          | .4173077  | .3608852  | 1.16  | 0.248 | -.2900142            | 1.12463   |
| CREDIT           | .2652458  | .3570712  | 0.74  | 0.458 | -.4346009            | .9650925  |
| TLU              | .0595813  | .026852   | 2.22  | 0.026 | .0069524             | .1122102  |
| _cons            | -.9439324 | 1.510784  | -0.62 | 0.532 | -3.905015            | 2.01715   |

```
. mfx
```

```
Marginal effects after logit
y = Pr(Partirrrrigation) (predict)
= .46745657
```

| variable | dy/dx     | Std. Err. | z     | P> z  | [ 95% C.I. ] |          | X       |
|----------|-----------|-----------|-------|-------|--------------|----------|---------|
| SEXHH*   | .0579478  | .1197     | 0.48  | 0.628 | -.176652     | .292547  | .852381 |
| AGEHH    | -.0077214 | .00516    | -1.50 | 0.135 | -.017843     | .002401  | 37.6952 |
| MSTUTAS  | .0378377  | .10232    | 0.37  | 0.712 | -.162708     | .238384  | 2.08095 |
| ACTIIV~F | .0465549  | .02298    | 2.03  | 0.043 | .00152       | .09159   | 3.899   |
| DFWRs    | -.1645876 | .06168    | -2.67 | 0.008 | -.285486     | -.043689 | .805419 |
| DISTMRKT | -.0145912 | .00612    | -2.39 | 0.017 | -.026577     | -.002606 | 14.5381 |
| NONFIN   | .0000617  | .00002    | 2.50  | 0.012 | .000013      | .00011   | 1036    |
| TCLSIZE  | .0289643  | .0318     | 0.91  | 0.362 | -.033356     | .091284  | 1.62429 |
| FEXT     | .0316111  | .06557    | 0.48  | 0.630 | -.096906     | .160128  | .490476 |
| EDU      | .0379312  | .01146    | 3.31  | 0.001 | .015465      | .060398  | 3.28571 |
| MEMTCOP* | .1037573  | .08923    | 1.16  | 0.245 | -.071125     | .278639  | .395238 |
| CREDIT*  | .0660149  | .08872    | 0.74  | 0.457 | -.107879     | .239909  | .42381  |
| TLU      | .0148322  | .00668    | 2.22  | 0.026 | .001732      | .027933  | 14.0288 |

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

## Appendix Figure 3. Logit model output and marginal effects

```
. bs "psmatch2 Partirrrrigation (SEXHH AGEHH MSTUTAS ACTIIVELF DFWRs DISTMRKT NONFIN TCLSIZE FEXT ED
> U MEMTCOP CREDIT TLU) ,outcome(Farmincome)" "r(att)",r(100)
```

```
command:      psmatch2 Partirrrrigation (SEXHH AGEHH MSTUTAS ACTIIVELF DFWRs DISTMRKT NONFIN TCLSIZE
> FEXT EDU MEMTCOP CREDIT TLU) , outcome(Farmincome)
statistic:    _bs_1      = r(att)
note: label truncated to 80 characters
```

```
Bootstrap statistics               Number of obs   =       210
                                Replications     =       100
```

| Variable | Reps | Observed | Bias     | Std. Err. | [95% Conf. Interval] |          |      |
|----------|------|----------|----------|-----------|----------------------|----------|------|
| _bs_1    | 100  | 4233.1   | 895.1253 | 2791.634  | -1306.108            | 9772.308 | (N)  |
|          |      |          |          |           | -386.7327            | 10431.48 | (P)  |
|          |      |          |          |           | -1194.561            | 8833.737 | (BC) |

```
Note:  N   = normal
       P   = percentile
       BC  = bias-corrected
```

## Appendix Figure 4. Bootstrap statistics