PARTICIPATION IN SMALL-SCALE IRRIGATION VEGETABLE FARMING AND ITS IMPACT ON FARM HOUSEHOLD'S INCOME IN DEDO DISTRICT, JIMMA ZONE, OROMIA REGION, SOUTH WESTERN ETHIOPIA

M.Sc. THESIS

GUDINA BAJURA GEMECHU

JUNE, 2020

JIMMA, ETHIOPIA

Participation in Small-scale Irrigation Vegetable Farming And Its Impact on Farm Household's Income in Dedo District, Jimma Zone, Oromia Region, South Western Ethiopia.

By: Gudina Bajura Gemechu

A Thesis Submitted to

Jimma University College of Agriculture and Veterinary Medicine in Pa rtial Fulfillment of the Requirements for the Degree of Master of Science in Rural Development and Agricultural Extension

(Agricultural Communication and Innovation)

Major Advisor: Akalu Dafisa (Msc, Assistant Professor)

Co-Advisor: Biruk Fikadu (Msc, Assistant professor)

June, 2020

Jimma, Ethiopia

DEDICATION

This thesis dedicated to my brother *Bogale Bajura Gemechu(BOGGEE)* who have been always wishes my success and contributed much to bring me up to this level, but not lucky to see the final fruits of his effort.

STATEMENT OF AUTHOR

I the undersigned, hereby declare that the thesis- Participation in Small-scale Irrigation Vegetable Farming and its Impact on Household's Income in Dedo District, Jimma Zone, Oromia Region, South Western Ethiopia is the outcome of my own work and all sources of materials used for this thesis have been duly acknowledged. This thesis has been submitted in partial fulfillment of the requirements for M.Sc. degree at Jimma University and is deposited at the University Library to be available to borrowers under rules of the library. I solemnly declare that this thesis is not submitted to any other institution anywhere for the award of any academic degree, diploma, or certificate.

Brief quotations from this thesis are allowed without special permission provided that accurate acknowledgement of source is being made. Requests for permission for extended quotation or reproduction of this manuscript in whole or in part may be granted by the head of the department of Rural Development and Agricultural Extension or the Dean of the School of Graduate Studies when in his or her judgment the proposed use of the material is in the interest of scholarship. In all other instances, However, permissions must be obtained from the author.

Name: Gudina Bajura Gemechu Signature: _____________

Place: Jimma University, Jimma

Date of submission: ______________________

BIOGRAPHICAL SKETCH

The Author was born on June, 1990 in Oromia National Regional State, West Wollega zone, Genji District Lalisa Dibe village. He attended his elementary school at lalisa Dibe elementary school, attended his secondary school at Gimbi comprehensive High school.

Then he joined Jimma University in 2010 GC and graduated with B.Sc. Degree in Rural Development and Agricultural Extension in June, 2012 GC. After his graduation, he was employed in Jimma Zone, Dedo woreda Cooperative Promotion Office, from 2013 to 2018. Then he rejoins Jimma University in October 2018 to pursue his M.Sc. study in Rural Development and Agricultural Extension, specialization in Agricultural Communication and innovation.

ACKNOWLEDGMENTS

First and foremost I praise and honor my Lord Jesus Christ for the opportunity and capacity given to me to realize my aspiration and who always let the bulk of unfinished work to be completed at a moment.

Secondly my particular appreciation and deepest gratitude goes to Mr. Akalu Dafisa (Asst. Prof.), my major advisor, and as well Mr. Biruk Fikadu (Asst. Prof.) my Co-advisor, without them, the accomplishment of this research would have been difficult. Besides, their gentle advisor ship from the early designs of the work to the final write-up of the thesis by adding valuable, constructive and ever teaching comments, frequent assistant, subsequent and unreserved technical support are commendable.

Thirdly, I would like to express my special thanks to Mr. Zamach Aba Gojem, Vice-head of Dedo District agricultural development Office; Mr. Tasfaye Hailu, an expert at Dedo district Cooperative promotion office, Mr. Tesfaye Tajeba, co-ordinator of irrigation extension department of the district Agricultural Development Office, for their heart-felt cooperation in facilitating the necessary processes and for their unreserved willingness in providing the required secondary data for the study.

Finally, I would like to appreciate those households who were interviewed for taking their time to bring information to my research needs and to enumerators those who help me in collecting primary data for this research work.

ABBREVIATION AND ACRONOMYS

AGP	Agricultural Growth Program
ATA	Agricultural Transformation Agency
CSA	Central Statistical Agency
DWPEC	Dedo Woreda Planning and Economic Cooperation
DWAO	Dedo Woreda Agricultural Office
EEA	Ethiopian Economic Association
ETB	Ethiopian birr
FAO	Food and Agricultural Organization
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GTP	Growth and Transformation Plan
Ha	Hectare
ILO	International Labor Organization
IWMI	International Water Management Institute
LSI	Large Scale Irrigation
Mha	Million Ha
MoARD	Ministry Of Agriculture and Rural Development
MoFED	Ministry of Finance and Economic Development
MoWIE	Ministry of Water, Irrigation and Electricity
MSI	Medium Scale Irrigation
NGO	Non-Government Organization
NPC	National Plan Commission
OECD	Organization for Economic Co-operation and Development
PSM	Propensity Score Matching
RWH	Rain Water Harvesting
SNNP	South Nation, Nationalities and People
SPSS	Statistical Package for Social Sciences
SSI	Small-scale Irrigation
TLU	Tropical Livestock Unit
UNDP	United Nation Development program
WUAS	Water Users Association

TABLE OF CONTENTS

Page

LIST OF TABLES

Page

LIST OF FIGURES

Page

LIST OF TABLES IN THE APPENDIX

Page

ABSTRACT

Ethiopian economy is highly dominated by traditional small-scale farming Agriculture. The government has working on irrigation development as the potential available was not utilized intensively. There was no adequate study on the impact of using small-scale irrigation vegetable farming on household income. So, the main objective of this study was to analyze determinants of households' participation in small-scale irrigation vegetable farming and its impact on household's income in Dedo District of Jimma zone by using a cross-sectional survey data. Multistage sampling was used to select 250 sample respondents. The primary data were collected using interview schedule, focus group discussion and key informant interview. Various documents were reviewed to collect the secondary data. Descriptive statistics and econometric model like binary logistic regression and Propensity Score Matching were used to analyze data. It was found out that more than 80% of respondents were using traditional way of water diversion and more than 50 percent of respondents were producing only once a time in a year by using irrigation. Potato was the major vegetable crop cultivated by irrigation followed by cabbage and tomato. The mean cultivated land holding was 0.08hac per household and from the available potential, it was estimated that half of it was currently not irrigated. With this regard the status of participation in small-scale irrigation farming was found to be very low in the study area. The study result also indicated; education, family size, credit use and contact with development agent influence participation in small-scale irrigation positively, whereas land size, market distance, farm distance from water and off/non-farm activities have negative influence. The result of propensity score matching also indicated that participation in irrigated vegetable farming had a significant and positive influence on household's income. It was concluded that irrigated vegetable farming has positive and significant impact on household annual income. Therefore, small-scale irrigation vegetable farming practice is needs to be encouraged and the status of participation in small-scale irrigation must be improved. To do this government and other development actors like NGOs should work more jointly at all level.

Keywords: Impact, Small-Scale Irrigation, vegetable, Household Income, Participation, Propensity Score Matching, Dedo, Ethiopia

1. INTRODUCTION

1.1. Background of the Study

Ethiopia is predominantly an Agrarian Country in which 73% of its population directly or indirectly involved in agriculture (International labor organization, 2017). Due to the existence of diversified topography, soil, weather and climatic conditions that favor agricultural activities the majority of the Ethiopian population have been engaged in and generate their income from the sector. The sector approximately contributing about 37% of Gross Domestic product (World Bank/OECD, 2016 in Passarelli *et al.*, 2018), and supplies raw materials for 70% of the country's Agro-industries (Ethiopian Economic Association EEA, 2012). About 70 % of the foreign exchange is derived from the sector. However, agriculture in Ethiopia is mainly characterized by the use of backward and traditional farm implements and subsistence farming system (Food and Agricultural organization, 2015). Agricultural production is still characterized by low levels of modern inputs in remote parts of the country, including virtually no mechanization, limited animal draft power, and under-application of fertilizers, pesticides, and improved seeds (Sheahan and Barrett, 2017).

Ethiopian agricultural practice has been traditionally dominated for centuries by small-scale farmers and its performance has long been adversely affected by shortage of rain and water that left many to sustain their lives on famine relief support (Alemu *et al*. 2011). From the total production, about 97 percent of Ethiopia's food crops are produced by rain-fed agriculture, whereas only 3% is from irrigated agriculture (FAO, 2015). Due to high dependency on rain-fed agriculture and other topographic and low adaptive capacity and other related factors, Ethiopia ranks the ninth most susceptible country in the world to natural disasters and weather-related shocks (Tongul and Hobson, 2013).

In Ethiopia, development strategies in the last decade have largely focused on the expansion of irrigated agriculture. The implementation of irrigation development schemes is one of the most effective ways to reduce poverty and promote economic growth. These schemes raise crop production through enhanced yield, acreage and number of cropping cycles per year, as well as decrease the risk of crop failure. Increased availability of irrigation and the lowered dependency on rain-fed agriculture is an effective means to increase food production and enhance the self-sufficiency of the rapidly increasing human population (Jaleta *et al.*, 2013 cited in Kedir, *et al*., 2016).

Irrigation in Ethiopia contributes to increase the farmers' income, household resilience and buffering livelihoods against shocks and stresses by producing higher value crops for sale at market and to harvest more than once per year. In turn, this provided them to build up their assets, buy more food and non-food household items, educate their children, and reinvest in further increasing their production by buying farm inputs or livestock. However, the benefits are very unevenly distributed among households (Eshetu *et al*., 2010). 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.

Ethiopia is believed to have the potential of 5.3 million hectares of land that can be developed for irrigation through pump, gravity, pressure, underground water, water harvesting and other mechanisms (Ministry of Finance and Economic Development, 2010). However, evidences show that less than 5% of the potentially irrigable lands are currently under irrigation (Worqlul *et al.*, 2017). The irrigation potential in Oromia region is the highest from the country which share about 1.7 Million hectares (Mha) out of 5.3 Mha at national level (cited in Hirko *et al*., 2018).

Jimma Zone is one of the wettest zones from the region even though its farming system is highly dependent on rain-fed agriculture. Dedo woreda is one of the 21 woredas of jimma zone which has high irrigation potential and small-scale irrigation has a history of more than 50 years. Rivers like Waro, Gibe, Unta, Offole are used as a major source of water for irrigation in the woreda. Farmers have been practicing irrigation farming through water diversion and recently small-scale irrigation dam is being constructed by government under a project implemented by AGP-II in some kebeles (Dedo Woreda Agricultural Office, 2019).

Small-scale irrigation in the Dedo district is vegetable based and the major vegetable crops produced by small-scale irrigation are potato, cabbage, tomatoes, turnip, carrot, garlic, onion and green papers. Potato, Cabbage and tomato are the dominant irrigation crop. Dedo district stands first in vegetable production in general and potato production is the dominant one particularly (Faris *et al.,* 2018). But in the study area majority of the farmers are using traditional irrigation practice which is based on water diversion to farm land manually and there are a few numbers of farmers who owned motor pump. In the year 2016 and 2017, the number of farmers engaged in small-scale irrigation was 6,000 and 6700, respectively. In the same year, area irrigated in hectare was 1, 479 and 1, 500 in two consecutive years from the 6150ha of total irrigable farm land potential. Again in the year 2018 and 2019 the number of farmers engaged in irrigation farming were 1,969 and 2,069, respectively. The size of land irrigated in the same years was 1592ha and 1634 ha from the same available potential (DWAO, 2019). Even though there was a progressive improvement in these consecutive years, with relation to the available potential the extent to which farmers are participating is very low. This implies that there is a limitation on the participation and utilization of the small-scale irrigation in the study area. So far, there is no adequate stand that explains why farmers in the district are not using the existing opportunity to increase their production and enhance their standard of living. Therefore, with this background, this study was conducted to find out the determinants of participation in small-scale irrigation vegetable farming and to investigate the income difference between irrigated vegetable farming participants and non-participants.

1.2. Statement of the problem

Agriculture, the main source of livelihood in Ethiopian economy is mainly rain-fed and it depends on erratic and often insufficient rainfall. The country has 4.5 million ha of irrigable land (Ministry of Water and Energy, MoWE, 2011). However, in Ethiopia from the existing cultivated area, it is estimated that currently only about 4 to 5 percent is irrigated, with existing equipped irrigation schemes covering about 640,000 ha (Seleshi *et al.*, 2014). As a result, there are frequent failures of agricultural production and this forced many of the societies to lead their live dependent on assistance from different organizations for food (Abebaw *et al*., 2015). Evidence shows that, there is a huge gap between the potential and the level of irrigation applied in the country due to technical, physical and economic challenges (ATA, 2016).

Different authors have conducted studies on irrigation farming, especially regarding small-scale irrigation farming and confirmed that, both directly and indirectly it has a significant impact on enhancing smallholder farmer's livelihood in different parts of our country (Kinfe *et al*., 2012; Agerie, 2013; Tulu, 2014; Dereje and Desale, 2016; Kedir, *et al.*, 2016; Leta *et al*., 2018).

However, the work of these authors has its own limitations. For instance Kedir *et al*. (2016) focused on the general impact of irrigation on food security and the determinants of irrigation water use. In this study even though the attempt to address the food security issues was good, it has own limitation on the determinant part. Factors those affect irrigation water use may not determine the probability of participation as a whole, because there are other determining factors of participation probability beyond those determine water utilization. Again the study by Leta *et al*. (2018) focused on the impact of small-scale irrigation on farm income and asset holding. But Leta has not focused on the specific crop and his work is general. The work of Agerie (2013) and Kinfe *et al*. (2012) also focused on the investigation of factors affecting farmer's decision to participate in small-scale irrigation and the effect of participation in irrigation on rural farm Household's income by using Heckman's two-stage estimation which has a methodological gap similar to Tulu (2014) employed Tobit model to analyze marginal effect of small-scale irrigation on income level of rural household. These authors used models that may not estimate the clear impact of irrigation, as self-selectivity biasness matters. Because, income of farmers may be different even in the absent of participation, estimating a clear impact of participation requires appropriate matching of both groups based on their propensity score, rather than on their individual characteristics. To make such matching method the best model is propensity score matching. The work of Dereje and Desale (2016) in other word focused on the livelihood improvement dimension of small-scale irrigation. Livelihood improvement by itself is a broad concept, which comprises; income improvement, food and nutrition security, health, and the like. So, these authors lack the specificity of the concept of investigation, because, when it is general the clear visibility of the irrigation impact may become biased.

Irrigation farm by itself is a broad concept, so it needs to be specific in terms of crop type. This because, in the area where there is sufficient rain, irrigated agricultures are mainly vegetable crops, rather than other crop types cultivated by rain fed. For example the irrigation farming practice which is practiced in the arid and semi-arid parts may not be feasible in humid area, where there is a sufficient rainy season.

In the study area, despite there is a huge potential for irrigation farming and the area has a favorable condition for vegetable production, farmers are not well utilizing the available potential and there is no sufficient scientific evidence that shows the reason behind this problem.

From the view of the above research gaps, the researcher has motivated to rigorously examine the determinants of participation in small-scale irrigation vegetable farming and its impacts' on farm household's income in the study area, by using appropriate impact analysis model.

1.3. Objectives

1.3.1. General objective

The general objective of this study is to analyze the determinants of farmers' participation in small-scale irrigation farming and its impact on farm household's income in the study area.

1.3.2. Specific objectives

1. To assess status of farmers' participation in small-scale irrigation farming in the study area;
2. To analyze determinants of participation in small-scale irrigation farming in the study area and
3. To analyze the impact of small-scale irrigation vegetable farming on household's income in the study area.

1.4. Research Question

1. What is the extent to which farmers in the study area have participating in irrigation farming?
2. What are the factors determining farmers' participation in small-scale irrigation vegetable farming?
3. What impact small-scale irrigation farming has on household's income in the study area?

1.5. Significance of the study

The findings of this study could expect to support agricultural development offices and development planers of the study area in terms of improving the knowledge base on the issues under investigation for the purpose of ongoing development activities and the plan in the future. Understanding the participation level and factors that hinder households to participate in irrigation help local development planner to make an appropriate plan that address with households' need. Such information about decisions on matters of agricultural technologies is important for development planers, researchers and extension workers engaged in development and diffusion of irrigation technologies. This is because they can utilize the results of this study in setting research and extension agenda. Furthermore, information on farmers' characteristics will give a feedback and enable researchers to modify and redirect research activities towards the most important problems. Over all the findings of this study can help interested researchers and students to further investigate this thematic area in other place.

1.6. Scope of the study

This study was conducted in the scope of one administration Woreda, three Kebeles and 250 sample farmer households. The objective of this study was to assess the status of participation in small-scale irrigation vegetable farming and to analyze the determinants of farmers' participation in small-scale irrigation vegetable farming and its impact on rural farm household's income using a cross-sectional survey data from households. Besides, the study focused on the application of propensity score matching method to assess the impact of small-scale irrigation vegetable farming on household's income.

1.7. Limitations of the Study

Different studies are aimed at establishing factors determining or affecting participation in irrigation and its impacts on livelihood aspects of the society; like income, poverty, asset holding and food security. As such, several factors have been found to affect participation in irrigation farming practice. These include government policies, environmental factors, demographic factors, institutional factors and socioeconomic factors. However, this study is concerned only with socioeconomic factors, demographic factors, institutional factors and physical factors to analysis factors that affect farmer's decisions to participate in small-scale irrigation vegetable farming. In addition, this study was undertaken by using cross-sectional data. But, impact analysis can also be conducted by use of panel data and time series data which give more detailed information than cross-sectional data. However, because of problem of availability of data as well as resources and time constraint these data types could not be used. The study also limited on the contents of the investigation, because it focused only on vegetable based irrigation farming. So it may applicable only for the area which have similar characteristics with the study woreda.

1.8. Organization of Thesis

The thesis contains five main parts. It starts with an introduction, encompassing the background, statement of the problem, objective, scope, limitation, significance of the study and this section as well. Part two is a review of literature (empirical and theoretical). Part three presents the methodology used in this study; while the fourth part is about the results and discussion. The last part, part five, presents summary, conclusion and recommendations.

2. LITERATURE REVIEW

2.1. Conceptual and Theoretical Review

2.1.1. Basic concepts and definition

Irrigation- Irrigation is defined as artificial application of water to the living plants for the purpose of food production and overcoming shortage of rainfall and help to stabilize agricultural production and productivity (FAO, 1994). Reddy (2010) also defined irrigation as an artificial application of water to soil for the purpose of supplying the moisture essential in the plant root-zone to prevent stress that may reduce yield and/or cause poor quality of crop products. This is an on purposive action made by human beings to apply water for growing crops, especially when there is a shortage of rainfall and during dry seasons.

Small-scale irrigation- can be defined based on the area of land irrigated and it differs from country to country. Small-scale irrigation is the type of irrigations that defined as schemes that are operated and maintained by individuals, families, communities, or local rules or the schemes which practice independently by rural farm households in a small plot of land (Abraham *et al*., 2015). It is often community-based and traditional methods, covering less than 200 ha.

Participation in small-scale irrigation- Participation in a certain technology defined in different ways by various authors. However, Hirko *et al*.(2018) after citing the definition of adoption by Rogers, 1983 and Loevinsohn *et al.,* 2013 define participation in small-scale irrigation as “the use of an innovation (new way) of crop production by applying water in artificial way to crop land purposively”.

Similarly, to the above definition in this study, participation in small-scale irrigation vegetable farming is a practice that smallholder farm households are involving in a types of irrigation practiced in small plot of land for the purpose of producing at least one vegetable crop types by applying irrigation water and that controlled and managed by the user's household.

Definition and concept of vegetables -The term vegetable is used to describe the caring edible shoot, leaves, fruits and root of plants and spices that are consumed whole or in part, raw or cooked as a supplement to starchy foods and meats as cited by Haile (2014). Vegetables are also described as those plants, which are consumed in relatively small quantities as a side dish with the staple food. However, vegetables are important food varieties within the human diet because they provide nutrients like vitamins and minerals and also the bulk of roughage the body desires and which are usually lacking in most traditional staple foods.

In the context of this paper, vegetables are defined in culinary terms to include vegetables that have fruit and leafy herbaceous parts eaten raw or cooked (i.e., lettuce, head cabbage, Ethiopian cabbage, tomatoes, green and red peppers, green beans, etc.), root and tubers which include beetroot/turnip, carrot, potatoes, sweet potatoes, and bulb crops (onion, garlic).

Status of participation: status of participation in this research is to explain the extent to which farmers are practicing small-scale irrigation which is measured in terms of year of experience in irrigation activity, type of irrigation they practicing, technology utilization, size of cultivated irrigation farm land, frequency of cultivation within a year and types of crops produced.

2.1.1. Overview of Irrigation Development

Irrigation has long played a key role in feeding expanding populations and is undoubtedly destined to play a still greater role in the future. It not only raises the yields of specific crops, but also prolongs the effective crop growing period in area with dry seasons, thus permitting multiple cropping (two or three and sometimes four crops per year) where only a single crop could be grown. Irrigation can bring about increased agricultural production thereby improve the economic and social wellbeing 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. In addition, the role of irrigation development is increasing food sufficiency level of households (helps to produce sufficient amount of food consumption), increasing income level, asset building such as house construction for rent, saving account and creation of employment opportunity(Kedir *et al.*, 2016). Thus it is an important indicator of economic development and brings sustainable agriculture development (Tolera, 2019).

Moreover, with the security provided by irrigation, additional inputs needed to intensify production such as pest control, fertilizer; improved varieties and better tillage become economically feasible. Irrigation reduces the risk of these expensive inputs being wasted by crop failure resulting from lack of water (FAO, 1997). Therefore, water resource is the special resource in agriculture without which no agricultural commodity is produced, since agricultural production and productivity are especially sensitive to spatial and inter-temporal variations in natural factors of production (Pardey *et al*., 2012).

2.1.1.1.Irrigation Development in Africa

Small-scale irrigation is critically important as an innovative practice in smallholder agriculture in Africa. This is because it improves farm productivity, farming systems adaptation to climate variability and change and achievement of household food security and national developmental goals. There is a lot of heterogeneity in what small-scale irrigation farming entails in Africa. It is characterized by the use of simple technologies to access water for irrigation (Kamwamba *et al*., 2016). Trends in irrigated land expansion over the last 30 years show that, on the average, irrigation in Africa increased at a rate of 1.2 percent per year; this rate began to fall in the mid-1980s and is now below 1 percent per year, but varies widely from country to country. The total irrigated land of Africa is estimated to be 124 million ha. This figure includes all the land where water is supplied for the purpose of crop production. It represents an average of 7.5 percent of arable land (FAO, 1995). There have been improvements in irrigation as the sector is gradually being transformed from subsistence-oriented to high value marketed crops. Since smallholder agriculture is not capital intensive, it is promoted as an adaptation strategy for the recurrent droughts that are attributed to climate variability and change in the region. Most of the streams in the region are seasonal with torrential flows during the short wet season of 3–4 months. The greater part of the year has low flows. The ground and large river/lake basin water are considerable but has not been tapped for irrigation use. The main challenge in developing small-scale irrigation has been the insufficient institutional capacity at both national and local levels (Tesfaye *et al.,* 2008)

2.1.1.2.Irrigation Development in Ethiopia

In Ethiopia, irrigated agriculture is expanding and widespread, but its contribution to the overall economic development of the country is not as required, due to little utilization of the technology, and other factors. Consequently, the Ethiopian government has given top priority to development and utilization in the irrigation sub-sector, towards enhancing agricultural production and thereby improving the food security situation (Yalew 2010).

In Ethiopia, irrigation development is a policy priority for agricultural transformation, but poor practices of irrigation management discourage efforts to improve livelihoods, and expose people and the environment to risks (Asmamaw, 2015). Irrigation projects have been failing mainly because of insufficient participation by beneficiaries and insecurity of land tenure. Socioeconomic, cultural, religious and gender-related issues pose a problem to full and equal participation by beneficiaries (Mekonnen *et al*., 2017). Moreover, the poor performance of irrigation in the country, systematic and holistic evaluation of irrigation management in general and of small-scale irrigation in particular is lacking (Awulachew *et al*., 2010).

Small-scale irrigation development is one of the components of water resource development. Ethiopia has large water potentials that could be used for a wide range of irrigation development programs. It has 12 major river basins with an annual water runoff volume of more than 122 billion cubic meters (Asmamaw, 2015). In addition, the groundwater potential is estimated to be more than 2.6 billion cubic meters (Awulachew *et al*., 2010).

Currently, less than 5% of the irrigable land is irrigated while the irrigation potential has been estimated to be about 4.3 million ha of arable land (Worqlul *et al.*, 2017). Irrigated agriculture is becoming increasingly important in meeting the demands of food security, employment, rural transformation and poverty reduction. For Ethiopia, increasing agricultural productivity, enabling households to generate more income, increasing their resilience as well as transforming their livelihoods stands out as the most pressing agenda now and for the coming decades. SSI is a policy priority in Ethiopia for rural poverty alleviation, climate change adaptation and growth (Kidane, 2016).

2.1.1.3.Classification of irrigation development in Ethiopia

According to the Ministry of Water Resource (2002), irrigation development in Ethiopia is classified using two systems. The first classification system (the most common in Ethiopia) uses the size of command area irrigated in to three types: Small-scale irrigation systems (<200 ha), Medium-scale irrigation systems (200-3,000 ha) and Large-scale irrigation systems (>3,000 ha).

Small-scale irrigation schemes are the responsibility of the Ministry of agriculture and rural development and regions, while Medium-scale irrigation and Large-scale irrigation are the responsibility of the Ministry of water resource. Small-scale irrigation is widespread and has a vital role to play in Ethiopia. The success of small-scale systems is due to the fact that they are self-managed and dedicated to the felt needs of local communities. Indeed, small-scale schemes are defined as schemes that are controlled and managed by users themselves (Agerie, 2013). Examples of small-scale irrigations include household-based Rain water harvest, hand-dug wells, and shallow wells, flooding (spate), individual household-based river diversions, pumping and other traditional methods.

According to the Ministry of Water Resource (2002), management system and nature of the structures as follows:

- Traditional schemes: These are SSI systems which usually use diversion weirs made from local material which need annual reconstruction or from small dams. The canals are usually earthen and the schemes are managed by the community. Many are constructed by local community effort and have been functional for very long periods of time; some were recently constructed with the aid of NGOs and government.

- Modern schemes: These are SSI systems with more permanent diversion weirs made from concrete hence no need for annual reconstruction and small dams. The primary and sometimes secondary canals are made of concrete. They are community managed and have recently been constructed by government.
- Public: These are large scale operations constructed and managed by government. Sometimes, public schemes have out growers whose operations are partially supported by the large scheme.
- Private: These are privately owned systems that are usually highly intensive operations.

2.1.1.4.Irrigation Potential and status of Participation in Ethiopia

Ethiopia is a rich country in water resource and most of the time it is termed as a water tower of Africa because of its abundant water resource availability (Adunga 2014). It has a huge potential of water resource which accounts 122 billion meter cube annual surface runoff and 2.9 billion meter cube groundwater, though it is characterized by uneven spatial and temporal distributions (Tesfa and Tripathi, 2015). But Ethiopia is using a very little of its abundant water resource potential for irrigated agriculture (ATA, 2016). The estimated total irrigable land potential in Ethiopia is 5.3 Mha assuming use of existing technologies, including 1.6 Mha through rain water harvesting and ground water (Awulachew *et al*., 2010). This indicates that there are potential opportunities to vastly increase the area of irrigated land.

Recent source indicates that, the total area of irrigated land in Ethiopia increased from 885,000 ha to 2.4 million ha 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 (National plan commission, 2015). Evidence also shows that, in Ethiopia, farm size per household is 0.5 ha and the irrigated land per households' ranges from 0.25 - 0.5 ha on average (MoA, 2011). However, irrigated agriculture in Ethiopia comprises merely 3% of the total national food production (Bacha *et al.*, 2011). Belay and Bewket (2013) argues that irrigation practice is critical to poverty alleviation through increased production in rural areas; so as to improve food security and rural livelihoods status and also contribute to national economy.

2.1.1.5.Vegetable Production and Its Status in Ethiopia

Ethiopia is well known for its diversity of indigenous food plants, including vegetables, spice and herbs, medicinal plant, root and tubers. Vegetables are grown in different parts of the country both in commercial quantity as well as small volumes by private farmers and other operators engaged in the business. Small-scale production is concentrated in Harerghe (eastern highland parts) and the central highlands, whilst large commercialized cultivations are widely spread in the low land zones, mainly following the Awash and Gibe/Omo rivers (Nimona 2017).

Vegetable production is an important economic activity in Ethiopia. The production system ranges from home gardening, smallholder farming to commercial farms owned both by public parasternal and private enterprises (Aklilu, 2000). Vegetables serve as suitable crops for farming systems diversification and land intensification, particularly with recent increases in the establishment of small and medium scale irrigation schemes in the country. In fact, it can generate high income for the farmers because of high market value and profitability. The country has favorable climatic conditions for vegetable production of various crops ranging from temperate to tropical vegetables (Shimeles, 2010).

The cultivated vegetables are mainly grown by traditional farmers in home gardens, although some are grown in fields and along fled margins. About 27% of the crop species cultivated in home gardens in Ethiopia, many of them indigenous, are used as vegetables (Gelmesa, 2010 cited in Nimona 2017). The same source also indicates that traditional vegetables do not figure very prominently in modern crop research and conservation programmers rather marginalized in modern agriculture and receive no special attention. The vegetable resources of Ethiopia can be developed through a strategy of complementing and augmenting traditional practices with modern scientific approaches.

2.1.1.6.Irrigation Potential and Participation status in Oromia Region

In Oromia evidences show that there are 63 river systems and 688 tributary streams which annually generate 58 billion cubic meters of surface water. In Oromia region, out of the estimated 1.7 million ha of potential irrigable land, only 85,400 ha have been developed so far, which is about 5% of the potential, which is about 2.14 percent of the total cultivated land (MoARD, 2013).

2.1.2. Theoretical Framework for Participation Decision in Irrigation Practice

Irrigation water is a common-pool resource, which can take the form of communal, private or state property, or not be subject to any form of ownership. Common pool resources are used in common when the appropriation is difficult and monitoring the use and exclusion of non-members is difficult and costly (Bosa, 2015). Therefore, irrigation water resource is used in either of the above mentioned property regime and it is not necessarily governed by the common property right regime.

The participation in a certain technology depends on the advantage it will bring to the participant. The advantages can be seen in different ways either the increase in the physical outcome or in the satisfaction of the participant. Therefore, the participation decision of the farmers in irrigated farming is based on the utility difference they obtain between the use of irrigated farming and not using irrigated farming. The utility theory will be used in the formulation of participation decision of households in irrigation (Hirko *et al.,* 2018).

In this particular study, the decision whether to participate in irrigation practice or not, depends on the expected utility of participating and not participating in irrigated farming. The farmers participate in irrigated farming when they expect that the utility from participating in irrigation is greater than not participating in it. Otherwise if the expected utility from using irrigated farming is lower than the expected utility from not using it, the decision of the farmers will be non-participation in irrigated farming. Utility is assumed to depend on income, but also takes into account other factors such as socio economic, demographic and institutional factors that affect income of the farmer (ibid). The objective of producer is profit maximization but profit is used to purchase goods and services that maximize the utility of the owner of the firm (Debertin, 2012). Therefore, utility theory based on production choice was used as a theoretical basis for the participation decision of the farmers in small-scale irrigation comparing the utility of non-participation (status quo) with participation (the new state) (cited in Hirko *et al.,* 2018).

We could denote utility for the two states as follows:

Utility for the status quo would be:

$$U_{0j} = u(Y_j, Z_j, q^o, \varepsilon_{oj})$$

And utility for the final state would be:

$$U_{1j} = u(Y_j, Z_j, q^1, \varepsilon_{1j})$$

Based on this model, respondent j adopts irrigation practice, if the utility with the participation in irrigated farming exceeds utility of the status quo.

$U_1(Y_j, Z_j, q^1, \varepsilon_{1j}) > U_{0j}(Y_j, Z_j, q^o, \varepsilon_{oj})$

where U_0 denotes the utility function from the status quo, U_1 denotes the utility from participation in irrigation, Y is income, q^o and q^1 are the alternative levels of the good indexes with and without irrigation practice, respectively, (with $q^1 > q^o$, indicating that q^1 refers to the improved total output of the farmer after participating in irrigation). Z_j is a vector of individual characteristics.

Assuming that farmers maximize utility, the decision by farm household j to participate in irrigation practice (IRRIG =1) or not participating in irrigation practice (IRRIG= 0) is based on a comparison of expected utilities of both situations. Using the difference in expected utilities gives the following decision rule:

$$IRRIG = \begin{cases} 1, if\ E\left[U_{1j} - U_{0j}\middle|Z_j\right] > 0 \\ 0, if\ E\left[U_{1j} - U_{0j}\middle|Z_j\right] \leq 0 \end{cases}$$

Where E is the expectation operator, U_1 and U_0 are the same as mentioned earlier. Farmers differ in the way they form expectations on the utility levels of both choices. These differences are due to characteristics of the farmer. The vector Z_j accounts for variables that are assumed to have an impact on the utilities of both choices and the way expectations are formed on these utilities.

2.2.Empirical Review

2.2.1. Empirical studies on Determinants of participation in irrigation farming practice

There are various determining factors that are affecting farmer's decision to participate in small-scale irrigation farming practice. Based on this some of the demographic, socio economic and institutional factors that are determining irrigation farming practice are discussed below by reviewing different empirical works in the literatures.

2.2.1.1.Demographic factors

The demographic factor such as sex of a respondent is mostly used as one of determinant factors of participation in irrigation and found that male headed households are the most likely participant in small-scale irrigation practice (Kinfe *et al*., 2012; Muhammad *et al*., 2013; Gebrehaweria *et al*., 2014). Age is another demographic factor that shows negative significant influence on participation in irrigation (Beyan *et al*., 2014; Edo, 2014; Gebrehaweria *et al*., 2014; Sithole *et al*., 2014). These findings indicate that, younger household heads are more innovative in terms of technology adoption and are more likely to take risk than older household heads. As evidences has depicted, this findings by different scholars, implies that the older the farmers, the more reluctant they may be in participating in irrigated farming due to tiredness on one hand or the wealth they have accumulated during their adulthood on the other. Other findings shown that family size of households positively and significantly influence the farmer household decision to participate in irrigation farming practice. This indicated that the households use the family members as a labor force and they can easily undertake the irrigation activity than lower family size households (Tewodros *et al*., 2013; Hailu, 2014). Further studies conducted by different scholars revealed that Year of schooling of the household head had a positive significant influence on the irrigation practice decision of farmers (Tewodros *et al*., 2013; Muhammad *et al*., 2013; Edo, 2014; Nhundu *et al*., 2015; Kedir *et al*., 2016). From these studies it indicates that education is the very important variable that influences the irrigation practice by farmers and needing policy action in different setup of different countries.

2.2.1.2.Socioeconomic factors

There are different socio economic factors that determine farmer's decision to participate in small-scale irrigation. These factors include, land holding size, number of oxen, number of livestock, non-farm and off farm activities and income. Concerning land holding size, Edo (2014), found that there is negative association between land holding size and households' decision of participating in small-scale irrigation practice. This was resulted because the farmers with larger land size were found allocating their land for rain-fed agriculture and animal husbandry. Other studies indicate that farm size is found positively affecting participation decision in irrigation practice by smallholder farmers (Beyan *et al*., 2014; Sithole *et al*., 2014; Abebaw *et al*., 2015). These sources found as it has a positive significant effect on the participation decision of the households. Thus farmers with large farm size were found participating in irrigated farming than their counterparts.

Oxen ownership and number of livestock also influences the small-scale irrigated farming decision positively (Beyan *et al*., 2014; Gebrehaweria *et al*., 2014; Kedir *et al*., 2016). It is revealed that oxen among farmer household in our country are the main source of draft power and thus farmers who had more oxen used them in preparing the land for irrigated farming easily and the households with lower number of oxen may face difficulty in land preparation and may not be able to participate in irrigated farming.

The total livestock owned by the households also shown positive significant effect on the irrigation participation decision of the households (Hailu, 2014). Farmers with higher TLU were found with higher probability of participating in the irrigation practice. Authors like Hailu *et al*. (2014) and Legesse *et al*. (2018) revealed that there is a positive significant association between irrigation use and livestock ownership. The possible reason indicated here is that in rural economy livestock is a means of income besides their other benefits that helps farmers to purchase farm implements for irrigation use. However, Kedir *et al*. (2016) found that farmers with higher number of TLU were less irrigation participant and this variable show that there is negative significant association between livestock holding and decision of participation in small-scale farming.

Non-farm income also has positive and significant influence on households' decision to participate in irrigation. This indicated that households who get access to income from non-farm activity have a chance to pay for purchase of inputs for irrigation farming than their counterpart (Beyan *et al*., 2014; Hailu, 2014). So participating in non-farm activities can influence the farmers' participation in small-scale irrigation.

2.2.1.3.Institutional factors

The institutional factor such as access to market information is found to be a positive significant influence on participation in irrigation practice (Kinfe *et al*., 2012; Sinyolo *et al*., 2014). This implies that the farmers who have access to market information were found to have higher irrigation participation probability than those that does not have market information. Farmers that have market information on input and output price would be attracted by the benefit of irrigated farming and then enhanced to participate in irrigation farming. Thus, having more access to up-to-date market information on prices of inputs and outputs would encourage households to participate in irrigation activities (Abebaw *et al*., 2015).

Access to credit is also an institutional factor positively affecting participation in irrigation practice by smallholder farmers (Muhammad *et al*., 2013; Sithole *et al*., 2014; Nhundu *et al*., 2015). Access to credit enables farmers to overcome their financial constraints associated with production and participation in irrigation and also encourages group formation and learning. Another explanatory variable frequency of extension contact has shown positive significant effect on participation in irrigation practice (Kedir *et al*., 2016). This implies that farmers who make frequent contact with extension contact get information and knowledge about the new technology and the benefit gained from irrigation farming and as a result they are more initiated to participate in irrigation farming practice more than their counter parts.

2.2.1.4.Physical factors

The distance of farmland (farm plot) from irrigation water source (Kinfe *et al*., 2012; Beyan *et al*., 2014; Sithole *et al*., 2014, Abebaw *et al*., 2015), and market distance (Kedir *et al*., 2016) have a significant negative effect on participating in irrigated farming. Based on the findings of these scholars, concerning water source distance, long distance plot of farm land from water source lead farmers for extra cost when compared to nearest farmers to water source in many ways such as opportunity cost of time, cost of irrigation water access. This has forced the distant farmers from the water source to practice irrigated farming less than their counterparts.

Again concerning market distance farmers those are found at more distance from local market are exposed to more marketing cost and they are less benefitted from their product. This is most probably due to the perishable nature of irrigation farming agricultural product and since it may perished and quality reduced before reaching the market for sell (Kinfe *et al*., 2012).

2.2.2. Impact Studies on Participation in Irrigation

In the irrigation impact evaluated with the help of propensity score matching indicates a positive significant effect of participation in small-scale irrigation on rural household income (Hailu, 2014; Shiferaw and Mengistu, 2015). Woldegebrial *et al*. (2015) reported a significant difference in income, overall expenditure and asset accumulation between irrigation participants and non-participants by using PSM in their investigation.

Apam (2012) applied the “with and without” approach to assess the impact of irrigation and found that irrigation affected farmers living conditions by increasing yields, employment, asset holding and reducing hunger, food prices and migration. However, the use of the “with and without” could be problematic because the levels and changes in these factors could also be due to other factors and not necessarily irrigation. Thus, the study would have benefited a lot from the use of regression or other econometric techniques that will help in dealing with the issue of attribution. Peprah *et al*. (2015) found in Sankana that irrigation had direct effects on output and income of farmers.

Banson *et al*. (2014) investigated the impact of small-scale irrigation technology on poverty reduction among peri-urban and urban farmers in Kwabenya in the Greater Accra region of Ghana. The study used descriptive statistics in the analysis and showed that use of small-scale irrigation increased yields and savings levels of farmers and consequently contributed to reducing poverty gap among these farmers.

2.2.2.1.Contribution of Irrigation to Household Income

Irrigation has high contributions to asset ownership and income of rural households (Tedros, 2014). Increased in agricultural production through diversification and intensification of crops grown, increased household income because of on/off/non-farm employment, source of animal feed, improving human health due to balanced diet and easy access and utilization for medication, soil and ecology degradation prevention and asset ownership are a few to mentioned (Kalkidan *et al*., 2017). Irrigation users invest the additional income gained from irrigation in different activities. Some irrigation users provide in community services, while others in educating their children. Besides, increasing income from irrigation made them to access materials for their children and replaced the labor of their children engaged on-farm by hired labor (Kinfe, 2012).

From Heckman two step treatment effect model, participation in small-scale irrigation was found to have positive and significant effect on income of farm households (Kinfe *et al*., 2012; Belay and Beyene, 2013; Abraham *et al*., 2015). Peprah *et al*. (2015) found that irrigation had direct effects on output and income of farmers. It also provides auxiliary employment in terms of fishing and offer indirect benefits supporting households' basic necessities and income for reinvestment.

Irrigation user households are in a better position when compared to those that are non-users. For example, users 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 nonusers. Accordingly, access to small-scale irrigation can significantly improve income level of beneficiary households. Access to irrigation increases the opportunity for crop intensity and diversification which increase cropping income. Therefore, access to irrigation has got a significant and positive contribution to income (Kedir, *et al.*, 2016).

Some of the major results identified in relation to the contribution of small-scale irrigation to livelihood improvement include increased agricultural production and better food security, getting additional income, access to improved nutritional values (vegetables and fruits), improved feeding habit, improved access of water for drinking livestock development and sanitation, purchase of oxen and cows, pay credit and save money, purchase of household goods, building of houses in towns, cover educational cost for children and the likes. These all indicates that small-scale irrigation activities are improving rural households living condition and promoting the livelihood of the farmers (Nahusenay and Madhu, 2015).

2.3. Methodological Review

2.3.1. Participation decision analysis method

Based on the dependent variables in this study, participation decision of the farmers in small-scale irrigation vegetable farming practice, there are various models that can be used. Binary logit model, binary Probit model, Tobit model, and Double hurdle model are the models suited to analyze the factors determining the probability of participation under different underlying assumptions.

As indicated in Gujarati (1995), logit or probit models are widely applied to analysis of determinant studies for a limited dependent variable and their result is similar. Contrary to this, Green (2003) suggests that although both model results with similar outputs, the logit model is easier in estimation, even though this is not the problem nowadays, since it is the work of the computer software within the couple of seconds. Tobit model is an improvement to probit model and it can be used to analyze both the participation decision of the farmers in small-scale irrigation (probability of participation) and the intensity of participation in irrigation practice by the farm households by the use of single non-linear least square estimation using maximum likelihood method(Gujarati, 2004). If the scope of this study was to deal with both the probability of participation and the intensity of participation the suited model for such analysis is binary probit model. Different scholars use different models for the purpose of analyzing the determinants of participation decision and some of them are reviewed below.

Kinfe et al. (2012) and Abraham et al. (2015) applied descriptive statistics to analysis the factors that determine households' participation in irrigation in their study of Effect of small-scale irrigation on the income of rural farm households. Beyan et al. (2014) use Logit model to analysis the factors that affect households' participation in irrigation practice in his study of Impact of small-scale irrigation on farm income generation and food security status.

Jema et al. (2013) applied Probit to analyze factors that determine households' participation in irrigation in his study of Impact of small-scale irrigation scheme on household poverty alleviation. Similarly Sinyolo et al. (2014) and Agerie (2013) applied Probit model to analyze the determinants of participation in small-scale irrigation practice. The study of Hirko et al., 2018 employed probit model to analyze the determinants of participation and the intensity of participation in small-scale irrigation farming. Kedir et al., 2016 applied logit model to analysis factors that determine farmers' participation in irrigation practice.

2.3.2. Impact analysis methods

There are several methods by which impacts can be evaluated under non-experimental or quasi-experimental approaches. These include randomized selection methods, propensity score matching, regression discontinuity design, difference-in-difference and instrumental variable estimation methods (Khandker et al., 2010). Different scholars employed different impact analysis approach in their study. Some of the models used for impact evaluation by some investigators summarized as follows:

Kinfe et al. (2012) and Abraham et al. (2015) applied Heckman's two stage to estimation effect of small-scale irrigation on the income of rural farm households. Beyan et al. (2014) and kedir et al. (2016) used PSM model to analysis impact of small-scale irrigation on farm income generation and food security status and impact of small-scale irrigation on household food security, respectively. Another Author, Jema et al. (2013) also applied PSM to analyze the impact of small-scale irrigation scheme on household poverty alleviation. Similarly study of Sinyolo et al. (2014) also used PSM model to analyze the impact of smallholder irrigation on household welfare. Leta *et al*. (2018) employed Propensity Score Matching (PSM) model to examine the impact of small-scale irrigation on farm income and asset holding. Agerie, 2013 in other word used Hackman two stage to estimate the effect of small-scale irrigation participation on income. In the first stage, estimate the selection or participation equation (the probability of participating in small-scale irrigation) using probit model and derives maximum likelihood estimates with data from both participants and nonparticipants, using the estimation result constructed "Inverse Mills ratio" which is the tool for controlling bias due to sample selection (Heckman1979). On the second stage including the Inverse Mills ratio as an additional explanatory variable to the household income equation or outcome equation and estimated the equation using OLS model by using data from the participant households only. Dereje and Desale (2016) used descriptive statistics to conduct assessment on the impact of small-scale irrigation on household livelihood improvement. Following majority of the impact evaluation approach reviewed above PSM was applied in this study to analysis the impact of small-scale irrigation vegetable farming on farm, household's income.

Propensity score matching (PSM) has two key underlying assumptions (Baum, 2013). The first one is conditional independence; there exists a set X of observable covariates such that after controlling for these covariates, the potential outcomes are independent of treatment status. The other one is common support, for each value of X, there is a positive probability of being both treated and untreated. It is used when it is possible to create a comparison group from a sample of non-participants closest to the treated group using observable variables. Both groups are matched on the basis of propensity scores, predicted probabilities of participation given some observed variables (Caliendo and Kopeinig. 2005).

The interest of impact analysis in this study is estimating the average treatment effect on the treated (ATT) of irrigated vegetable farming practice. But the estimation of this effect may be impossible based on the before and after because in the 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. For such a problem, PSM provides an appropriate solution (Rosenbaum and Rubin, 1985). It accounts for sample selection bias due to observable differences between treatment and comparison groups. It controls for self-selection by creating a statistical comparison group by matching every individual observation of the treatment group with individual observations from the control group with similar observable characteristics. Therefore, propensity score matching was used in this study to estimate ATT to solve such problem.

2.4.Conceptual frame work

According to the findings of study conducted on participation in irrigation at different areas of the country there are different factors that influence participation in small-scale irrigation. Accordingly we can classify those factors that affect farmers' participation in irrigation practice in to different categories of demographic, socio-economic, physical, and institutional variables. Previous studies show household income increased following the adoption of small-scale irrigation technologies (Xie *et al*., 2014).

By reviewing different conceptual and empirical literature on small-scale irrigation farming practice, a conceptual framework has been formulated by taking into consideration household demographic, socio-economic, institutional, and social factors that could affect farmers' participation in small-scale-irrigation farming practice in the study area. The diagram of the conceptual Framework is shown in Figure 1 below

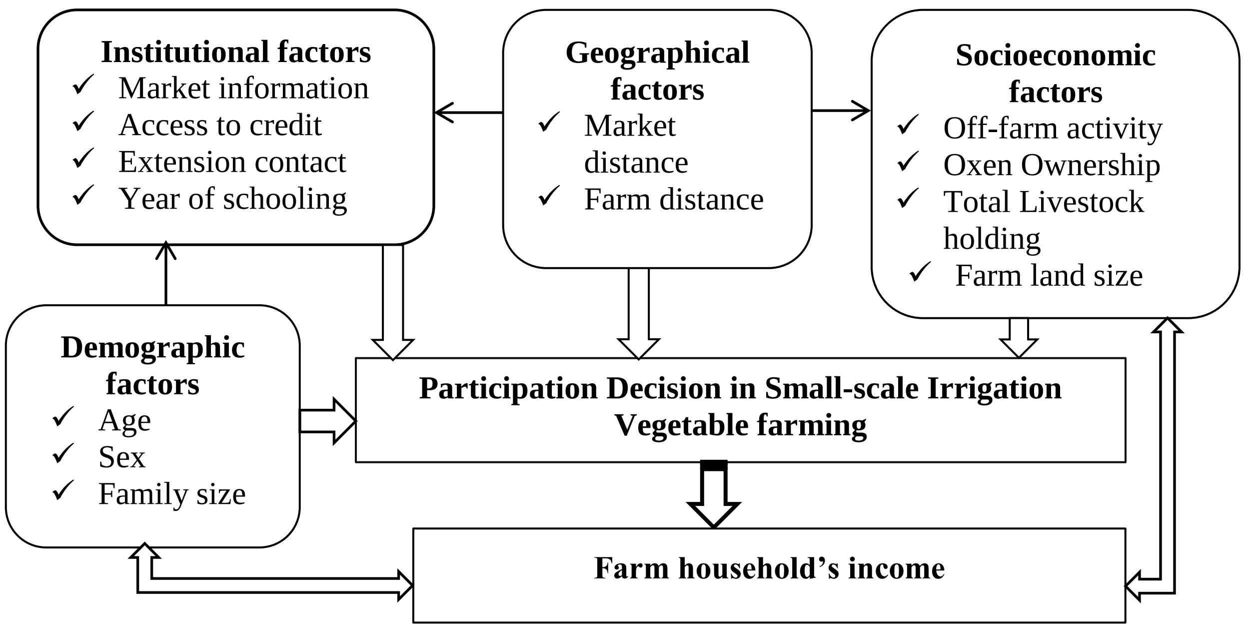

Figure 1 Conceptual Framework of the Study

Source: Own design based on Empirical Review (2020).

3. METHODOLOGY

3.1. Description of the Study Area

Dedo district is among the 21 woredas of Jimma zone extends and astronomically located between 7^{o}13'-7^{o}39' north latitudes and 36^{0}43'-37^{0}12' east longitudes. Total area of the district is 797.8 square kilometer or 79,780 ha. The district has 33 rural kebeles and 3 urban kebeles, total of 36 kebeles. The total populations of the district are counted as 227,592 (110,746 male and 116846 female which is 48.66% and 51.34%, respectively). From this population figure 214,658 (94.32%) are rural dwellers and the rest 12,934 (5.68%) of the population are urban dwellers. Dedo is bordered with Kersa district in the north, Mancho district in the east, Southern nation and nationalities peoples Regional state in the south and Seka Chokorsa district in the west(Dedo Woreda Administration office, 2019).

The climate condition of the district consists of 32.6% dega, 49.2% woinadega and 18.2% Kolla agro-climates. The most widely produced products in the district are cereal crops like maize, teff, wheat, barley, Vegetables, fruits and Coffees are common. A Small-Scale Irrigation practice in the Woreda has a long history. In the area the most commonly cultivated crops by small-scale irrigation are vegetable crops like cabbage, potato, tomatoes, and green papers and to the rare case onions and garlics, where other crops like maize, teff, sorghum, and other field crops are cultivated by rain-fed agriculture(Dedo Woreda planning and economic cooperation, 2019).

The district has three different altitudes: - the northern part that lies with elevation between 1,500 meters above sea level and 2,000 meters above sea 1evel is characterized by flat plain which covers 24.8% of the district area. The vast central part lies with altitude between 2,000 and 3,000 meters above sea level and act as a watershed for Gojeb and Gibe Rivers that covers 57% of the district area. The southern portion along the Valley of Gojeb River lies between 1,000 meters above sea level and 1,500 meters above sea level. This covers 18.2% of the district's area (ibid).

The rainfall of the district is weakly bi-modal with spring a small rainy season during the months of March and April while summer long rainy season during the months of June, July, August and September. The vast area of the district annual rainfall varies between 1,200mm and 1,700mm. Precipitation of the district is characterized by seasonality, it mostly occurs in summer with slight extension back to spring and forward to autumn. So, volume of discharge is subject to high fluctuation a sporadic flash of flood as a result of torrential tropical rains in summer and dry channels for some rivers in dry seasons. The total area of the district's surface drainage pattern is fallen in the Omo River Basin. Unta, Waro and Offole are the major perennial river that drains to Gibe River (ibid).

The major soil categories of Dedo district are Orthic Acrsoils and Orthic vertisoils. Orthic Acrisoils covers 80 % of the district and orthic vertisoils covers 20% of the district. Orthic Acrisocls cover the largest part of the district particularly in the Gojob River. OrthicVertisoils do confine the southern portion of the district particularly in the Gojeb River Valley. Because of plain land formation, the soil of the district is eroding by rainfall. All the soil types have good agricultural potentialities (DWAO 2019).

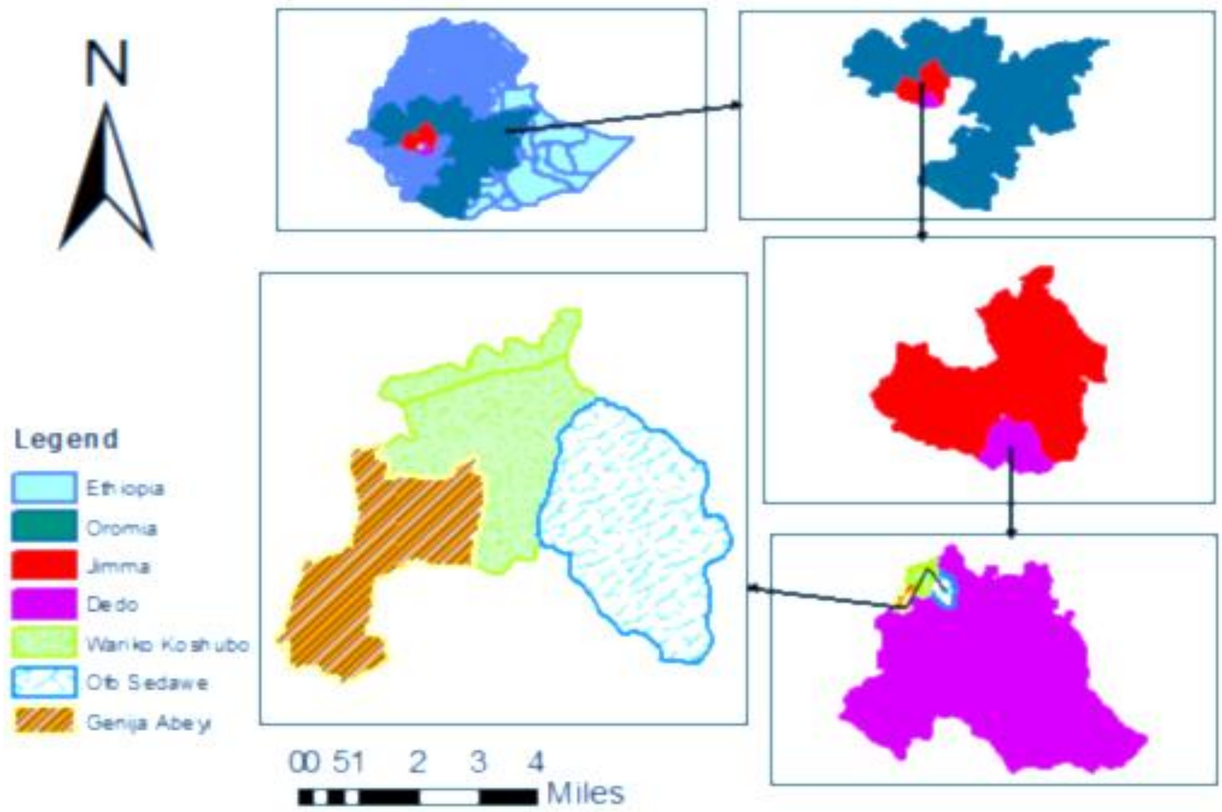

Figure 2 Map of the study area

Source: Ethio GIS, 2020

3.2. Research Design

This study employed mixed approach that involves collecting of both quantitative and qualitative data, analyzing and integrating the two forms of data. The study employed cross-sectional household survey to collect data at specific point in time from farmers, about their household information, farm and farm level characteristics during the 2020.

3.3.Sampling Procedure and Sample Size

Multi- stage sampling procedures were employed to select sample households. On the first stage, out of 11 irrigation potential kebeles of Dedo woreda, 3(three) kebeles were purposively selected by considering their similar characteristics in terms of availability of irrigated vegetable production potential to clearly identify the impact of irrigated vegetable farming. On the second stage households in the selected kebeles were identified and stratified in to two strata which were small-scale irrigation vegetable farming participants and non- participants, using stratified sampling technique. The stratum of irrigation participant includes those who own, rented/shared in or gifted in land for direct irrigated vegetable farming practice and produce at least one vegetable crop. The second stratum referred to here after as non-participant were irrigation non-participant households who neither own, rented/shared in or gifted in irrigation land for direct irrigation farming nor involved in irrigation farming by any means. In this case a few number of farmers who partially apply irrigation practice for maize production, but not vegetable crop were considered as non- participants.

On the third stage, simple random sampling technique was applied by taking into account probability proportional to size of the identified households in each of the 3(three) selected kebeles after determination of sample size. Yemane’s sample size determination formula with 6% error margin was applied to determine sample size for this study. The reason why this formula with 6% error margin was applied is because it is impossible to collect data from total population due to time and financial limitation as well as, difficulty to manage large sample size. Suggested by Yamane (1967), Yemanes’ sample size determination formula is given as,

$$n = \frac{N}{1+N(e^{2})} \quad \text{--} \quad (3.1)$$

Where n is the sample size, N is the population size of selected kebeles which is (2536) households and e is the level of precision and assumed as e = 6% when this applied to equation (3.1) it gives (250.355 ~ 250), Therefore, the sample size for this specific study was 250 households.

Table 1 Distribution of sample selected from the three kebeles

Name of Kebeles	Total households (non-participant/ participant)	Sampled Households (non-participant/participant)
Ofole Dawe	916 (442/474)	90 (42/48)
Waro Kolobo	813 (492/321)	80 (47/33)
Ganjo Abayi	807 (372/435)	80 (36/44)
Total	2536 (1306/1230)	250(125/125)

The reason why used equal sample size from both stratum was that because the impact analysis is a key objective in this study and the impact of the irrigation may be over or under estimated if the number of irrigation participants are more or less than non-participants. Similarly to this study, Tulu (2014), Abrham *et al.* (2015) and Kedir, *et al.* (2016) also used equal sample size to evaluate the effect of small-scale irrigation on rural households' income, impact of small-scale irrigation on income of rural farm households, and impact of small-scale irrigation on household's food security, respectively. Supporting this, Alvi (2016) suggests proportional and equal sample allocation techniques from strata. Therefore, the researcher was employed a probability type of sampling techniques which is equal sample allocation stratified sampling method.

3.4.Types of Data, Data Sources and methods of data collection

3.4.1. Data types and data sources

For this specific study both quantitative and qualitative data types were collected from primary and secondary sources to obtain the necessary information.

The sources for primary data were the sample households in the study kebeles; whereas the source for secondary data was woreda and zonal governmental offices, different published and unpublished documents and reports that are relevant for the study.

3.4.2. Methods of data collection

For the purpose of collecting primary data various data collection techniques such as household's survey through interview schedule to collect qualitative information from sample respondents; and qualitative primary data were collected by using focus group discussion, key informant interview and direct field observation.

Household survey

To generate quantitative information at household level, household survey was undertaken by using interview schedule. The household survey covered personal data, household resources, production, household income, and different factors related to small-scale irrigation farming. Prior to actual survey pre-test was conducted on 12 households. Three enumerators, one for each kebele, were assigned based on their familiarity with study kebeles and experiences on data collection. Training was provided to the enumerators on the procedure to follow while conducting interview with respondents and deep discussion was also held to make the questionnaire clear. Guidance and follow up was given throughout survey.

Focus Group Discussions

The focus group discussions (FGD) were held to generate qualitative information that supplements the individual respondent's interview. One focus group discussions at each study kebeles were conducted and each focus group comprised eight individuals. Participants of focus group discussion were farmers representatives purposively selected from both groups based on their familiarity with the information and experience to make effective discussion on the issues under consideration. Guiding questions (check list) was prepared and used as a guide for the purpose of data collection. The output of the discussion was used to get additional supporting qualitative evidence on situation of small-scale irrigation farming and farmers participation status.

Key Informant Interview

The primary quantitative data collected from sample households were further enriched by additional qualitative information gathered from key informants through intensive interview conducted with key informants. For the purpose of collecting information from key informants unstructured guiding questioner was prepared and utilized during interview. The numbers of interviewed key informants were limited to 7 key informants, composed of woreda agricultural office and development agents of study kebeles'. These numbers of key informants were limited based on the principle of data saturation assumption.

3.5.Methods of Data Analysis

The collected quantitative data were analyzed by using descriptive statistics, inferential statistics and econometric models. Binary logistic regression and propensity score matching were employed to analyze the determinants of participation in small-scale irrigation and impact analysis, respectively. Qualitative data collected from focus group discussion was analyzed by narrative explanation. Finally, the analysis was done with the help of (SPSS ver.20, STATA version 13 and Excel).

3.5.1. Descriptive analysis

Descriptive statistics like mean, standard deviation, frequency distribution, minimum and maximum were used for describing the data.

3.5.2. Inferential analysis

Inferential statistics like chi-square and t-test were used to test statistical significance of dummy and continuous explanatory variables, respectively on treatment and control groups.

3.5.3. Econometric Model Specification

A. Binary logistic model

The dependent variable in this study is the participation decision of the farmers in small-scale irrigation vegetable farming practice. Since this dependent variable is dichotomous (binary), it takes a value of 1 if the household is small-scale irrigation participant and 0 otherwise. As indicated in Gujarati (1995), logit or probit models are widely applied to analyze determinant studies for a limited dependent variable and their result is similar. Contrary to this, Green (2003) suggests that although both model results with similar outputs, the logit model is easier in estimation. Thus, in this particular study a binary logistic regression model, where dependent variable is Y and independent one is X is employed. In order to explain the model, the following logistic distribution function was used (Gujarati, 1995).

$$Pi = \in(Y=1/Xi) = \frac{1}{1+e^{-(\beta 1+\beta 2xi)}} \quad \text{……………………………………………..…..…(1)}$$

In the logistic distribution equation, Pi is the independent variable; Xi is the data that is the possibility of participation of an individual (option of having 1 or 0 values). When β 1+β2Xi in Equation 1 is replaced by Zi, Equation 2 is obtained:

$$Pi = \frac{1}{1+e^{-Zi}} \quad \text{………………………………………………………………………….……..…..…… (2)}$$

Z i is between - ∞ and + ∞, and P i is between 1 and 0. When Pi shows the possibility of the household being participant, the possibility of being non-participant is 1- Pi. Then, the possibility of non-participant can be explained as in Equation 3 as follows:

$$1-\mathrm{P}i = \frac{1}{1+e^{Zi}} \quad \text{………………………………………..…………………………….…………… (3)}$$

Equation 4 is obtained by dividing the participants by non-participants:

$$\frac{Pi}{1-Pi} = \frac{1+e^{Zi}}{1+e^{-Zi}} = e^{Zi} \quad \text{…………………………….…………………...……………………….…. (4)}$$

When the natural logarithm of both sides of the equation is written, Equation 5 is obtained

$$Li = \ln\left(\frac{Pi}{1-Pi}\right) = Zi = \beta 1+\beta 2Xi \quad \text{……………………….……………………………….……….……..… (5)}$$

Thus, non-linear logistic regression model is liberalized based on both of its parameters and variables. “L” is called “logit” and models such as this called “logit models” (Gujarati, 2003). In this situation, Equation 6 is used for proper transformations:

$Pi = \in(Y = \frac{1}{Xi}) = \frac{1}{1+e-(\beta 1+\beta 2X1+\beta 3X2+\cdots+\beta kXk)}$……………………………………..……………..

(6)

Odds and odds ratio are significant terms in logit model. Odds are defined as the ratio of the number of events that occurred to number of events that did not occur. “Odds ratio” on the other hand, is the ratio of two odds, in other words, the ratio of likelihood to another. In Equation 4, two probabilities, irrigation participant and non- participant probability of an event are proportioned and this is the odds of proportion. It is important to understand that possibility, odds, and logit concepts, are three different ways of explaining the same thing (Menard, 2002).

$Zi = \beta o + \varepsilon \beta iX + Ui$……………………………………………...………………………….. (7)

Where, I. is a function of explanatory variables, i=1,2,3,…,n

βo = intercept

βi = regression coefficient to be estimated or logit parameter

U = a disturbance term,

Xi = a vector of household characteristics

B. Propensity Scores Matching (PSM)

To analyze the impact of small-scale irrigation vegetable farming on household income, this study applied a propensity score matching (PSM) non-experimental technique, which is a widely applied among other non-experimental methods because it does not require baseline data, the treatment assignment is not random and considered as second- best alternative to experimental design in minimizing selection biases. The main challenge in undertaking a reliable impact evaluation is the construction of the counterfactual outcome, that is, what would have been happened to income of participants in absence of participation in irrigation. Constructing the counterfactual outcome using propensity score matching technique (PSM) is becoming an increasingly employed approach when the outcome is never observed. PSM uses information from a pool of units that do not participate in the intervention to identify what would have happened to participating units in the absence of the intervention. Accordingly, PSM is used when it is possible to create a comparison group from a sample of non-participants in irrigation closest to the treated group using observable variables. Both groups will be matched on the basis of propensity scores, predicted probabilities of participation given some observed variables.

According to Caliendo and Kopeinig (2008), there are steps that apply in PSM. These steps are predicted propensity scores, choosing matching algorism, restrict common support area, testing matching quality or balancing test and sensitivity analysis. These described as follows:

Step 1: *Propensity scores*- A Logit were model used to estimate Propensity Scores for each observation. The advantage of this model is that the probabilities are bounded between zero and one (Staurt, 2010). The dependent variable is dichotomous, taking two values, 1 if an individual participates in small-scale irrigation vegetable farming and 0 otherwise. The covariates used to predict treatment assignment using logistic regression, specified as:-

$$L_i = l_n\left(\frac{p_i}{1-p_i}\right) = \ln\left(e^{\beta_\circ} + \sum_{j=1}^{n} \beta_j X_{ji}\right) = Z_i = \beta_\circ + \sum_{j=1}^{n} \beta_j X_{ji}$$

Where L_i= a log of the odds ratio in favor of participation in small-scale irrigation

Z_i = participation

$\beta_\circ$ = intercept

β_j = regression coefficient to be estimated

X_i = Explanatory variables (like Age, Sex, Year of schooling etc.)

Step 2: *Choosing matching algorism*: The next stage is to choose matching algorithm which best estimates the p-score. There are different matching algorithms that can be used to determine the treatment effect on the treated in PSM. But the most common matching algorithms used in PSM include: nearest neighbor matching, radius matching, caliper matching and kernel matching. These matching methods use different means of matching the treated to the control group to determine the average effect of a given program participation or intervention (Dehejia and Wahba, 2002).

The above four matching algorithms was tested to estimate the impact of participation in small-scale irrigation and the best of the four was selected.

Step 3: *Common support*: The common support region (overlap condition) is the area, which contains the minimum and maximum propensity scores of treated and control group, respectively. Implementing the common support condition ensures that any combination of characteristics observed in the treatment group can also be observed among the control group (Cameron and Trivedi, 2005). Hence, the study used common support condition for any combination of characteristics that to be observed in the treatment and control group.

Step 4: *Testing matching quality or balancing test*: One important concern that should be taken care of while doing PSM is balancing test or checked if the matching procedure is able to balance the distribution of the relevant variables in both the control and treatment groups. The matching quality depends on the ability of the matching procedure to balance the relevant covariates. The standardized bias proposed by Rosenbaum and Rubin (1985) is the commonly used method to quantify the bias between treated and control groups. The study of Sianesi (2004) also proposed a comparison of the pseudo-R^2 before and after matching. After matching, the pseudo-R^2 should be low because of the matching use those households that have similar characteristics which mean that no significant difference of covariate of treated and the control group. In other word, the t-test value of all covariate after matching is insignificant. To do so, the balancing test is proposed to be employed to check the matching quality.

Step 5: *Sensitivity analysis*: The basic question to be answered in sensitivity analysis is that, how strongly an unmeasured variable must influence the selection process in order to undermine the implication of matching analysis (Caliendo *et al*., 2005). Hence, sensitivity analysis was undertaken to detect weather the identification of CIA (conditional independency assumption) is satisfactory or affected by the dummy confounder.

Average Treatment on Treated (ATT): It used to evaluate the impact of irrigation farming practice on the participant group. It is the difference between the outcome of treated and the outcome of treated observations if they had not been treated (counterfactual) computed as:

$$\tau_{ATT} = \mathrm{E}(Y(1)/D = 1) - E(Y(0)/D = 1)$$

Where D is treatment of sample respondents

Here the Data on$\mathrm{E}(Y(1)/D = 1$, are available from irrigation farming participants. However, $E(Y(0)|D = 1)$, the outcome of participating households if they had not participated is not observed. So $\mathrm{E}(Y(1)/D = 1 - E(Y(0)/D = 1)$ cannot be observed for the same household. Due to this problem, one has to choose a proper substitute for it in order to estimate ATT. The possible solution for this is to use the mean outcome of the comparison individuals, E(Y (0)/D=0), as a substitute to the counterfactual mean for those being treated, E(Y (0)/D=1) after correcting the difference between treated and untreated households arising from selection effect. Thus by rearranging, and subtracting E(Y(0)/D=0) from both sides of equation one can get the following specification for ATT

$$\mathrm{E}(Y(1)/D = 1) = E\ (Y(0)/D = 1) - E(Y(0)/D = 0) = \tau_{ATT} +\ E\ (Y(0)/D = 1) - E(Y(0)/D = 0)$$

In this case, Both terms in the left side are observables and ATT can be determined if and only if E(Y(0)/D=1)- E(Y(0)/D=0) zero which occurs when there is no self-selection bias. This condition can be ensured only in social experiments where treatments are assigned to units randomly i.e., when there is no self-selection bias (Caliendo and Kopeinig, 2008; Dillon, 2008). In order to resolve the selection matter in non-experimental (PSM) impact studies the following two assumptions are required.

Conditional independence assumption: It indicates the outcomes are independent of treatment and conditional on (Xi). This assumption shows that the selection is only depend on observable characteristics that affect both participation decision of households and the outcome variables simultaneously (Caliendo and Kopeinig, 2008).

Common support: Is refers to the area in which both participant and non-participant households have propensity score values in common. In other words, it is the area which contains the minimum and maximum propensity score of treated and control groups, respectively. Those observations whose propensity score is smaller than the minimum and larger than the maximum are discarded from the treatment and control groups (Caliendo and Kopeinig, 2008). That is 0<P (D=1)/X<1.

Given these two assumptions, the propensity score matching algorithm to estimate ATT can be described as:

$$\tau_{ATT} = \mathrm{E}(\mathrm{Y}(1) - Y(0)\ /D = \ 0, P(X)) = E\big(Y(1)\ /D = 1, P(X)\big) - E\big(Y(0)\ /D = 0, P(X)\big)$$

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

3.6.Methods of data presentation

The data collected from respondents through various procedures and techniques were presented by tables, graphs, charts, and narration after analyzed by an appropriate descriptive and econometric model analyzing methods.

3.7.Description of Variables and Hypothesis

3.7.1. Dependent Variables

In this study, participation decision of farmers in small-scale irrigation vegetable farming practice is the dependent variable. It is dummy variable and takes value of 1 if the farmers are participant in irrigation farming or 0 otherwise.

3.7.2. Outcome variable

In this study household gross income derived from agricultural (crop and livestock) sales and value of crops and livestock products retained for household consumption, and as well income generated from off/non-farm activities was an outcome variable and it measured in Ethiopian birr.

3.7.3. Explanatory/independent variables

These are variables that affecting dependent variable, farmer participation decision in small-scale irrigation and its combined effects of various factors such as demographic, socio-economic and institutional factors. Based on economic theory and empirical studies conducted previously to know which independent variables influence individual participation in small-scale irrigation practice at farm household level the regressors found most commonly affecting irrigation practice are defined below.

Age of household head: This variable is a year age of the household head and it is continuous variable measured in years. From the findings of different studies age of household head is found negatively affected the participation in irrigation practice by farmers (Beyan *et al*., 2014; Nhundu *et al*., 2015; Wang *et al*., 2015). Therefore, this variable was hypothesized as influencing participation in the small-scale irrigation practice negatively.

Sex of household head: This variable represents the biological characteristics of being male or female and it is a dummy variable taking value of 1 if the sex of the household head is male or 0 if female. As the previous empirical studies indicate this variable is found that the probability of participating in irrigation practice will be higher for male headed household as compared to female headed households (Asayehegn *et al*., 2011; Muhammad *et al*., 2013; Gebrehaweria *et al*., 2014). In most cases the small-scale irrigation farm land in our country is found at far from households' home and it requires high effort to farm and the effort required may be hard to female headed households to participate in small-scale irrigated farming (Kinfe *et al*., 2012). Therefore, this variable was hypothesized as; if the household head is female there will be low probability of participating in small-scale irrigation practice.

Year of schooling of household: This variable is a completed grade school of household head and it is a continuous variable measured in terms of years of schooling, taking zero if household head haven't any formal education and some value greater than zero if has formal education. This variable is found by different researchers as the educated households most probably participate in small-scale irrigation farming than their counterpart ones, due to the knowledge on the economic feasibility of irrigation practice they can get from extension service or by reading (Muhammad *et al*., 2013; Abebaw *et al*., 2015). Based on this reason, this variable was hypothesized as if the household is educated there is a high probability of being participated in irrigation farming.

Family size: this variable represents the family member of the households. It is a continuous variable measured in Adult equivalent (AE). Evidences show that the farmers with higher family size were found participating in small-scale irrigation practice more than those with lower family size (Tewodros *et al*., 2013; Hailu, 2014). This may be the case when the family members are used as the labor force in irrigated farming. This will reduce the cost incurred in hiring external labor. Therefore, this variable was hypothesized to influence participation in small-scale irrigated farming positively.

Oxen owner Ship: This variable shows weather the household has ox or not. This variable is a dummy variable that takes a value of 1 if the household own at least one ox or 0 otherwise. As the sources indicate the farmers own their own oxen or with higher number of oxen were found to participate in irrigation practice than those either haven’t ox or owned lower number of oxen, due to the fact that oxen in most part of our country, as well in the study area used as draft power for land preparation and farmers with no oxen or lower number of oxen face difficulty in land preparation and found to be in low probability of participating in irrigation farming (Sithole *et al*., 2014; Gebrehaweria *et al*., 2014). Therefore, this variable was hypothesized as positively affecting participation decision of household’s in small-scale irrigation farming.

Farm Land holding size: This refers to the total area of farmland that a farm household cultivated in hectares. This variable is a continuous variable measured in terms of land size in ha. From pervious empirical studies it is found that farmers having larger area of cultivable land were participate more in irrigation farming than their counterpart. Because large size of cultivated land is sometimes seen as social status among smallholder farmers; the status they have in the society may encourage those farmers to participate in irrigated farming to maintain their status in the society (Beyan *et al*., 2013; Abebaw *et al*., 2015). Therefore, in this specific study this variable was hypothesized as influencing farmer’s participation decision in small-scale irrigation positively.

Total livestock owned: This variable referring to the number of livestock owned by the household. It is a continuous variable measured in Tropical Livestock Unit (TLU). The higher the total livestock owned by the household the higher the probability of participating in small-scale irrigation practice (Hailu, 2014; Abera, 2015). This result could be related with the possibility of using the livestock sale at the time of irrigated farming as a source of income that can be used for expending on irrigated farming input. But in contradiction to this finding (Kedir *et al*., 2016) found that this variable has negative association with the probability of participation in irrigation farming. This could be due to the fact that households owned large number of livestock may use their land for grazing for livestock rather than making it for irrigation farming. In this study this variable was hypothesized to influence probability of participating in irrigation positively.

Access to market information: This represents the availability of information concerning the input, and price and demand for product. It is dummy variable taking value of 1 if the household access information on the market concerning the input, and demand and price issue of the product, or 0 if they not access. From the previous studies, this variable is found to be positively and significantly affected the participation decision of the farmers in small-scale irrigation, because farmers who do not access to market information like price of product and input get fair price and can be benefitted from selling of product and vice versa (Kinfe *et al*., 2012; Abebaw *et al*., 2015; Pokhrel *et al*., 2016). Therefore, this variable was hypothesized to influence the irrigation participation decision of the households positively.

Participate in non/off -farm activity: This variable represents the activities other than the farm activities (crops, and livestock), and off farm activity (agricultural wage). It is dummy variable taking on 1 if the respondent participates in non/off-farm activity or 0 otherwise. The related evidences show that the farmers having access to non-farm activities were found participating in irrigation practice than those not having access to non-farm activities (Beyan *et al*., 2014; Hailu, 2014). This may be due to the reason that the farmers having access to non-farm activities may use extra income generated from off-farm activities on the expenditures required in irrigated farming. But in contradictory to this (Kedir *et al*., 2016) found that farmers those are access to more non-farm income are less probably participate in small-scale irrigation, because households who get access to non-farm income are do not need to practice farming activity because they can replace the income generated from farm by income they get from non-farm source. Therefore, based on these reasons the variable was hypothesized to influence participation in irrigated farming negatively.

Credit use: this represents weather the household use credit for agricultural purpose or not. This variable is dummy variable taking value of 1 if the household is credit user or 0 if not credit user. Access to credit (use) by different researchers was found affecting the irrigation practice decision of the farmers positively, because farmers who have access and use credit are able to buy required irrigated farming inputs on time than those who do not have access and do not use credit (Muhammad *et al*., 2013; Sithole *et al*., 2014). Therefore, this variable was hypothesized to affect participation decision in irrigation positively.

Distance from the nearest market: This is the distance between farm household's irrigation plot and the nearest market place measured in walking minutes on foot it takes the farmer to arrive. It is a continuous variable measured in minutes. Different sources indicate that the farther the distance of the market from the farmer's farm land, the lower the probability of the farmers' participation in small-scale irrigation practice. This could be because, when farmer's farm plot is far from the market, the transaction cost for acquiring input and sale of output will be high and this will, in turn, reduce the relative advantage of participating in small-scale irrigation. Especially for perishable commodities if the market place is located far away from the farm, the commodity may perish before arriving the market (Kinfe *et al*., 2012, Agerie, 2013, Hirko *et al*., 2018). Therefore, this variable was hypothesized as influencing the participation decision of the farmers in irrigation farming negatively.

Distance of plot of land from irrigation water source: This variable refers to the distance between the nearest farm plot of the household and the irrigation water source in minute. It is a continuous variable measured in terms of walking minutes on foot. It is found by different scholars as it hampers participation in irrigation practice, because it could be leads the cost of bringing water to the plot of land to be high (Beyan *et al*., 2014; Kedir *et al*., 2016). Therefore, this variable was hypothesized to influence participation in small-scale irrigation negatively.

The frequency of contact with Development agent: - This refers to the number of days per month that agricultural development agents make visit the household for the purpose of giving extension service. It is a continuous variable measured in number of days. It takes a value of 0 if a farmer does not make contact at all and taking a number 1 or greater if make contact in a month. Evidences showed that farmers who made more frequent contact with extension agents were get more information regarding benefit of irrigation and the likelihood that they participate in irrigation farming is more than that of their counter parts (Kedir *et al.*, 2016; Agerie, 2013). Hence this variable was hypothesized to positively influence participation in irrigation farming.

Table 2 Summary of explanatory variables' definition and their hypothesis

List of variables	Types/Nature of variables	Measurement of variables	Expected sign	Supporting evidences
Dependent Variable				
Participation decision to irrigation	Dummy	1=participant 0=otherwise		
Outcome Variable				
Annual Household Income	Continuous	Ethiopian Birr		
Independent Variable				
Age of household head	Continuous	Years	+	Beyan *et al*., 2014; Nhundu *et al*., 2015; Wang *et al*., 2015
Sex of household head	Dummy	1 if male, 0 otherwise	-	Asayehegn *et al*., 2011; Muhammad *et al*., 2013; Gebrehaweria *et al*., 2014 Kinfe *et al*., 2012
Year of schooling	Continuous	class year	+	Muhammad *et al*., 2013; Abebaw *et al*., 2015
Family size	Continuous	Adult Equivalent	+	Tewodros *et al*., 2013; Hailu, 2014
Total Livestock owned	Continuous	Tropical Livestock Unit	+	Hailu, 2014; Abera, 2015
Oxen ownership	Dummy	Own =1, 0 otherwise	+	Sithole *et al*., 2014; Gebrehaweria *et al*., 2014
Farm Land holding size	Continuous	Hectare	+	Beyan *et al*., 2013; Abebaw *et al*., 2015
Distance from nearest market	Continuous	Minute	-	Kinfe *et al*., 2012, Agerie, 2013, Hirko *et al*., 2018
Access to Market Information	Dummy	Access=1, 0 otherwise	+	Kinfe *et al*., 2012; Abebaw *et al*., 2015; Pokhrel *et al*., 2016
Distance of plot of land from water source	Continuous	Minute	-	Beyan *et al*., 2014; Kedir *et al*., 2016
Participation in off/non-farm activity	Dummy	1 if participate, 0 other wise	-	Beyan *et al*., 2014; Hailu, 2014
Credit use	Dummy	1 if used, 0 if not	+	Muhammad *et al*., 2013; Sithole *et al*., 2014
Frequency of contact with DA	Continuous	Frequency in no	+	Kedir *et al*., 2016; Agerie, 2013

4. RESULTS AND DISCUSSIONS

This part deals with the analysis of the survey data and secondary data from both qualitative and quantitative analysis. It includes the descriptive analysis of the farm household's demographic, socioeconomic, institutional and geographic related characteristics in the study area, and the status of farmers' participation in small-scale irrigation in the study area. Lastly econometric analysis and interpretation of determinants of household's participation in small-scale irrigated vegetable farming and its' impact on household income is presented in this part.

4.1.Characteristics of Sample Respondents

In this section, sample households' demographic and socioeconomic characteristics (economic, social capital and geographic characteristics) were presented to give insight about, characteristics of the sample households in the study area. The distribution of the dummy variables related with irrigation participants and non-participants was given on Table (3). The proportion of the respondents falling into these categories was given and the association of these categorical variables with decision to participate in small-scale irrigation vegetable farming practice was tested by using chi-square test. The summary of socioeconomic characteristics of the farmers along with the mean difference test (t-test) of continuous variables was presented in Table 4. After estimating the mean values, the significance of mean difference test was undertaken by two-group mean comparison test for the continuous variables. The detailed discussion of both dummy and continuous variables was presented under different conceptual groups.

4.1.1. Demographic characteristics

Age of Respondents- The survey result indicates that the overall mean age of total respondents was 43.68, with the minimum and maximum age of 24 and 66 years, respectively. However, the mean age of irrigation participant respondents' was 44.37 years with SD of 8.8 and non-participant respondents' was 42.99 years with SD of 10.14. The minimum and maximum age of participant was 24 and 65 whereas it was 25 and 65 for non-participant, respectively (table 4). The t test analysis result of this variable ($t=1.15$; $p=0.253$; $\alpha=0.05$), shows that there was no significant mean difference in age of household heads between irrigation participants and non-participants.

Sex of household head: From the survey result it was found that out of the total household heads about 239 (95.6%) of them were male, whereas the proportion of the male headed households for participants and non-participants were about 120 (96%) and 103 (95.2%), respectively (Table 3). The chi-square test result on this variable shows that there was no significant association between sex of household head and decision to participate in small-scale irrigation ($\chi 2$ =0.095; P=0.758). This shows that being male headed or female headed household has no association with decision to participate in irrigation farming.

Family size- The mean family size of the total sampled households' in Adult equivalent were 5.10 with the standard deviation of 1.15. The minimum and maximum family size in AE for total respondents was 2.55 and 8.75, respectively. However, the minimum and maximum family size was 2.65 and 8.75 for participants and 2.55 and 8.15 for non-participant, respectively. The result indicated that the mean family size of the irrigation participants and non-participants households was 5.31 and 4.89, respectively and the standard deviation of the participants and non-participants was 1.35 and 1.15, respectively (table 4). The t- test statistic result shows that, there is significant mean difference between participants and non-participants group at less than 1% significant level in terms of their family size in Adult equivalent (t =2.633; p=0.009; α=0.05).

4.1.2. Economic characteristics/Asset holding/

Farm Land holding Size- Result from Table 4 shows; the mean size of farm land holding for total respondents was 1.38 ha with minimum and maximum holding of 0 and 3.5ha, respectively. But the mean land holding size of irrigation participant was 1.24 ha with SD of 0.71, while it was about 1.51 ha with SD of 0.71 for non-participants. The minimum and maximum holding for participant and nonparticipant was 0 and 3.5 and, 0.13 and 3ha, respectively. The t-test result (t = -2.989; p =0.003; α=0.05), shows that there was significant mean difference in the size of farm land between irrigation participant and non-participant households.

Total Livestock Holding- The survey results in Table 4 shows the mean total livestock holding in TLU for all respondents was 2.43, whereas the minimum and maximum holding is 0 and 9.7, respectively. However, the mean TLU for participants and non-participants was 2.35 with SD of 1.64 and 2.506 with SD of 1.315, respectively. The TLU for participants was 0 and 9.67, respectively, whereas the minimum and maximum TLU for non-participant was 0 and 7.1, respectively. The t-value, (t =-0.83; p=0.410; α=0.05), shows there was no significant mean difference in livestock holding in TLU between participant and non-participant.

Oxen ownership- the result shows that out of the total respondents 157(62.8 %) have their own oxen. The proportion of participants and non-participants who have owned their own oxen was 75(60%) and 82(65.6%), respectively (table 3). The Chi-square result for this variable shows that there was no statistically significant association between oxen owner ship and households participation in small-scale irrigation in the study area ($\chi 2$=0.839; P=0.360). This shows that owing oxen has no significant influence on the household's decision to participate in irrigation farming. The possible reason is that because small-scale vegetable farming has been practicing on the small plot of land, land preparation can be manually performed.

Participation in off- farm/non-farm activity- The survey results in Table 3 below shows that out of the total respondents, about 175 (70%) participate in non/off-farm activity. The proportion of participants and non-participants who participate in non-farm/off-farm activities was 57.6% and 82.4%, respectively. The Chi-square result of this variable ($\chi 2$=18.305; P=0.000), shows that there was statistically significant association between participation in non-farm activities and households' decision to participate in small-scale irrigation farming at 1% significant level. The possible reason is that those households who practice or have access to non-farm activity were replace the utility that would be gained from being participating in irrigation farming by utility they gain from practicing non-farm activity. From the key informant interview it is revealed that farmers in the study area participate in nonfarm activities like petty trade and self-employment like mining activities, and especially youngsters are participate in mining activities and petty trading during dry season.

4.1.3. Institutional characteristics/social & human capital/

Year of schooling- Education equips the individual to obtain, process, and utilize information from different sources. It enhances farmer's ability to acquire process and use information relevant to use irrigation technologies. As the results in table 4 shows, the mean years of schooling for the total households was 1.59 with minimum and maximum grade 0 and 10, respectively. However, the mean year of schooling for irrigation participant and non-participant households was 1.94 with SD of 2.689 and 1.250 with SD of 2.292, respectively. The minimum and maximum school attainment was 0 and 10 for both groups, respectively. The t-test result of this variable (t =2.202; p=0.029; α=0.05), shows that there was significant mean deference in the education level of respondents between two groups at 5% significant level.

Frequency of Contact with Development Agent-The mean frequency of contact with development agent in a month for all respondents was 1.39 with minimum and maximum of 0 and 4 contacts per month, respectively. But the mean contact in a month for irrigation participants and non-participants was 1.67 and 1.11, respectively (Table 4). The t-test result (t =4.463; p =0.000; α=0.05), indicated that, there was a significant mean difference in frequency of contact with development agent in a month between irrigation participant and non-participant households at 1% significant level. From FGD it was confirmed that there is an improvement in participation of irrigation practice from year to year as farmers are getting understanding about economic feasibility of small-scale irrigation from development agent from time to time.

Access to market information- the result from table 3, shows out of the total respondents 173 (69%) of them have access to market information, whereas the proportion of participants and non-participants who have access to market information about input and output prices and as well market demand for their product were 89(71.2%) and 84(67.2%), respectively. The chi-square result of this variable ($\chi2$=0.469; P=0.493), indicates that there was no significant association between household's accessibility to market information and decision to participate in small-scale irrigation in the study area. Possibly this is due to all most all farmers were get market information sufficiently from different sources including mobile phone, Development Agents, other farmers, radios and etc.

Credit Use - The survey results in Table 3 shows that out of the total respondents, about 112 (44.8%) were used credit and 138 (55.2%) were not used credit. The proportion of participant and non-participant households those use credit were 64(51.2 %) and 48(38.4%), respectively. The Chi-square result of this variable ($\chi2$=4.141; P=0.042), shows there was a significant association between credit use and households' decision to participate in small-scale irrigation at 5% significant level. This is possibly due to households, who use credit, have better possibility to cover the cost of agricultural input like purchasing of fertilizer, improved seed, and pest/herb sides and also farm machinery like motor pump. From the interview made for key informant it is revealed that farmers, mainly those who organized under WUA, use credit for motor pump, fertilizer and seed purchase. Participants of focus group discussion also revealed farmers take credit from their farmer cooperatives to buy chemical fertilizer and pay service fee and cost of fuels for motor pump during irrigation farm. But they also add that there is a challenge on credit accessibility.

4.1.4. Geographical characteristics

Market distance: From the descriptive analysis, the mean distance in walking minute on foot of the market for the total sample households was about 89.22 minute, with minimum and maximum market distance of about 25 minute and 150 minute, respectively. But the mean walking minute of market distance for participants was about 84.08 minute with minimum and maximum market distance of about 25 minutes and 145 minute, respectively, where as that of non-participants was about 94.36 minute, with minimum and maximum distance of about 30 minutes and 150 minute, respectively (table 4). The t-test statistical analysis (t = -2.669; p =

0.008; α= 0.05), revealed that there was significant mean difference in the distance of the market in walking minute on foot from households' farm plot between irrigation farming participants and non-participants at 1% significance level. Participants of FGD also reflected that farmers are not motivated to produce vegetable crops by irrigation as there is no nearest market place on which they can sell their products and not getting reasonable price because the quality of the product is get under question on the trip due to the perishability nature of the product.

Farm Distance from River- The mean distance in walking minute of the farm plot from the irrigation water source for the overall sample household was 4.33 minutes with minimum and maximum walking minute of 0 and 30. The mean distance in walking minute for participant household is 3.62 minutes with minimum 0 and maximum 15 minute and it is 5.04 minutes for non-participants with minimum 0 and maximum 30 minute (Table 4). t-test result (t = -2.387; p = 0.018; α= 0.05), shows that there is a significant mean difference in distance of farm plot from water source between participant and non-participant households at 5% significant level. From the key informant interview it was revealed that farmers those whom their farm plot is far from river not practice irrigation as it needs high labor cost to get water or divert water to their land.

Table 3: Descriptive and inferential statistics of dummy variables

Variable		**SSI participant**		**Non partic ipant**		**Total**		**Ch^2**	**P-value**
		N	**%**	**N**	**%**	**N**	**%**		
Sex	Male	120	96	119	95.2	239	95.6	0.095	0.758
	Female	5	4	6	4.8	11	4.4		
Oxen	Owned	75	60	82	65.6	157	63	0.839	0.360
Ownership	Not owned	50	40	43	34.4	93	37		
Market	Access	89	71.2	84	67.2	173	69	0.469	0.493
information	Not access	36	28.8	41	32.8	77	31		
Credit use	Use	64	51.2	48	38.4	112	44.8	4.141	0.042**
	Not use	61	48.8	77	42.6	138	55.2		
Off/non-farm	Participate	72	57.6	103	82.4	175	70	18.305	0.000***
activity	Not participate	53	42.4	22	17.6	75	30		

**** and *** means significant at 10% and 5% significant levels, respectively**

Table 4: Descriptive and inferential statistics of Continuous Variable

Variables	Participant (125)				Non-participant (125)				Total respondents (250)				Sig	t-value
	Min	Max	Mean	SD	Min	Max	Mean	SD	Min	Max	Mean	SD		
Age	24	65	44.37	8.80	25	65	42.99	10.14	24	66	43.68	9.50	0.253	1.15
Education level	0	10	1.94	2.69	0	10	1.25	2.29	0	10	1.60	2.52	0.029	2.202**
Family size	2.65	8.75	5.31	1.35	2.55	8.15	4.89	1.15	2.55	8.75	5.10	1.27	0.009	2.633***
Farm land size	0	3.5	1.24	0.70	0.13	3	1.51	0.71	0	3.5	1.38	0.71	0.003	-2.989***
Total livestock	0	9.67	2.35	1.64	0	7.1	2.51	1.32	0	9.7	2.43	1.49	0.410	-0.83
market distance	25	145	84.08	29.58	30	150	94.36	31.28	25	150	89.22	30.82	0.008	-2.669***
Farm distance	0	15	3.62	2.97	0	30	5.04	5.97	0	30	4.33	4.76	0.018	-2.387**
Contact with DA	0	4	1.67	1.03	1	4	1.11	0.95	0	4	1.39	1.03	0.000	4.463***

*, ** and *** means significant at 10%, 5% and 1% significant levels, respectively

4.1.5. Descriptive statistic result of annual household income (Outcome variable)

In this specific study household annual income in ETB is the outcome variable and it was analyzed as characterizing the farm households in the study area. The result from table (5) below shows that the mean annual income of the sample households in the study area was Birr 23541.56, with minimum and maximum annual income of Birr 2300 and 61300, respectively. But the mean annual income of the participants is Birr 26006.30, with minimum and maximum annual income of Birr 2300 and 61300, respectively, whereas the mean annual income of the non-participants was Birr 21076.82 with minimum and maximum annual income of Birr 4200 and 56900, respectively. The descriptive analysis revealed that there was significant difference in the annual income of households between irrigated vegetable farming participants and non-participants. The mean difference between the non-participants and participants was significant at 5% significance level. This implies that the income of the participants was higher as compared to non-participants because farmers who were participating in small-scale irrigation farming could get more income from the selling of vegetable products in addition to the regular rain fed farming practice.

Table 5: Descriptive statistics of outcome variable

Variables	Total HH		Participant		Nonparticipant		Mean Difference	Sig	t-test
	Mean	SD	Mean	SD	Mean	SD			
HH Mean annual income	23541.56	10363.279	26006.3	10518.28	21076.82	9632.19	4929.48	0.000	3.864***

***** indicates significant at 1%, probability levels**

However, the above result cannot tell us whether the observed difference is exclusive because of the irrigation farming or not. In fact, it is not possible to attribute the difference in annual household income of the two groups exclusively to the program, as comparisons are not yet restricted to households who have similar characteristics. As stated in methodology part, a further analysis must be performed using propensity score matching techniques to address this issue.

4.2. Status of farmers' participation in small-scale irrigation

Status of participation in this specific study is to explain the extent to which farmers are practicing small-scale irrigation which is measured in terms of year of experience in irrigation farming practice, type of irrigation they practicing, technology utilization, size of cultivated irrigation farm land, frequency of production within a year and variety of crops produced.

4.2.1. Available irrigable land and the status of cultivated irrigation land size

From the total of 6150ha of irrigable land size in the year 2018/19 only 1634 ha (26.56%) were irrigated (DWAO 2020). The survey result in table 6 below shows that from the total irrigable farm land for the total respondents only 10.024(33.86%) ha was cultivated by irrigation farming during the study year and the rest is being cultivated by traditional rain fed practice. The mean irrigable land size for the total population was 0.118 ha, where as it was about 0.162 ha and 0.074 ha for participants and non-participant respectively. During the 2018/19 production season the mean irrigated land size for the study area for the whole respondent was found to be 0.04 ha for the total respondents with minimum and maximum cultivated land size of 0 and 0.25 ha. The standard deviation for size of cultivation is 0.063. This figure is found less than the national average that has been previously estimated to lie between 0.25 to 0.5ha per household (MoA, 2011). But the mean irrigated/cultivated land size for participant was found to be 0.08 with the SD of 0.68. The t-test statistical analysis result of these variables shows that, there was statistically significant mean difference between participant and non-participants in terms of both, irrigable land size and cultivated irrigation farm size, both at 1% significant level. From focus group discussion it was confirmed that, small-scale irrigation practice in the study area was still merely traditional and the production pattern is limited on small varieties of vegetable crop production in traditional means.

A 29 years old male key informant interviewee from Ofole kebele mentioned, the problem is not only due to the problem of farmer's attitude on irrigation practice, but also the topography of the land that requires high cost to bring water from its source to the plot of land. Because of this, farmers are experienced to produce only small amount of vegetable crops on small plot, by diverting river water manually and there was only insignificant maize production among a little number of farmers. Therefore, despite of its' long history, the status of farmers' participation in small-scale irrigation in terms of crop types and amount of production was found to be very low.

Regarding this a 45 years old male household head from Ofole Dawe kebele was explain as;

"My farm plot is not appropriate to apply water through traditional water diversion method. So the option I have is using motor pump on rent. For example during the last production season I was used rental motorized pump by paying 100 ETB for one liter of fuel. But there is a probability when income I earned from the irrigation production is not enough to cover the cost I incurred for the production. So this problem of not easily access to irrigation water was mainly limits me not to produce more on more land".

Table 6: The status of irrigable and cultivated irrigation land size

Variable	Size holding									
	Participant			Non-participant			All respondents		Sig	t-value
	Total	Mean	SD	Total	Mean	SD	Total	Mean		
Irrigable land size	20.294	0.162	0.181	9.284	0.074	0.105	29.578	0.118	0.000	4.683***
Cultivated/irrigated land size	10.024	0.08	0.665	0	0	0.00	10.024	0.04	0.000	14.043***

'***' indicates significant at 1% significant level.

4.2.2. The status of major vegetable crop type produced in the study area

According to data obtained from Dedo woreda Agriculture Office, the major crops being produced by using irrigation in the study area includes potato, cabbage, tomato, green peppers, onion, and garlic. In the year 2018/19 the irrigation land allocated for potato were 715ha, land allocated for cabbage were 475ha, land allocated for tomato were 175ha, land allocated for green pepper were 103ha and land allocated for other vegetable types were 166ha. The amounts of production during the same year were 121,550 quintal potato, 71,250 quintal cabbage, 14000 quintal tomato, 5562 quintal green pepper and 11980 quintal of other vegetable types, respectively (DWAO 2019). Similarly, the survey result also reveals that in the study area, vegetable crops produced under irrigation farming are potato, cabbage, tomato, green peppers, onion, garlic, carrot and turnip. From these the first three are the major crops that are being produced by farm households and the majority of available cultivated irrigation farm plot was allocated for these crops in the study year, for the sample households (Fig. 3). Similar result is reported by Petros and Woldegabrel (2017), who found that the farmers' cropping practices changed from depending on production of field crops in to mostly depending on production of vegetables especially cabbage, potato, tomato and pepper. In the study area the mostly produced crop is potato, which holds about 3.724 ha and the least produced crop is carrot, which holds about 0.15ha of land from the total cultivated farm plot. The finding of Faris *et al*. (2018), supports this result that confirmed, potato production is particularly a dominant among other vegetable crops in Dedo woreda.

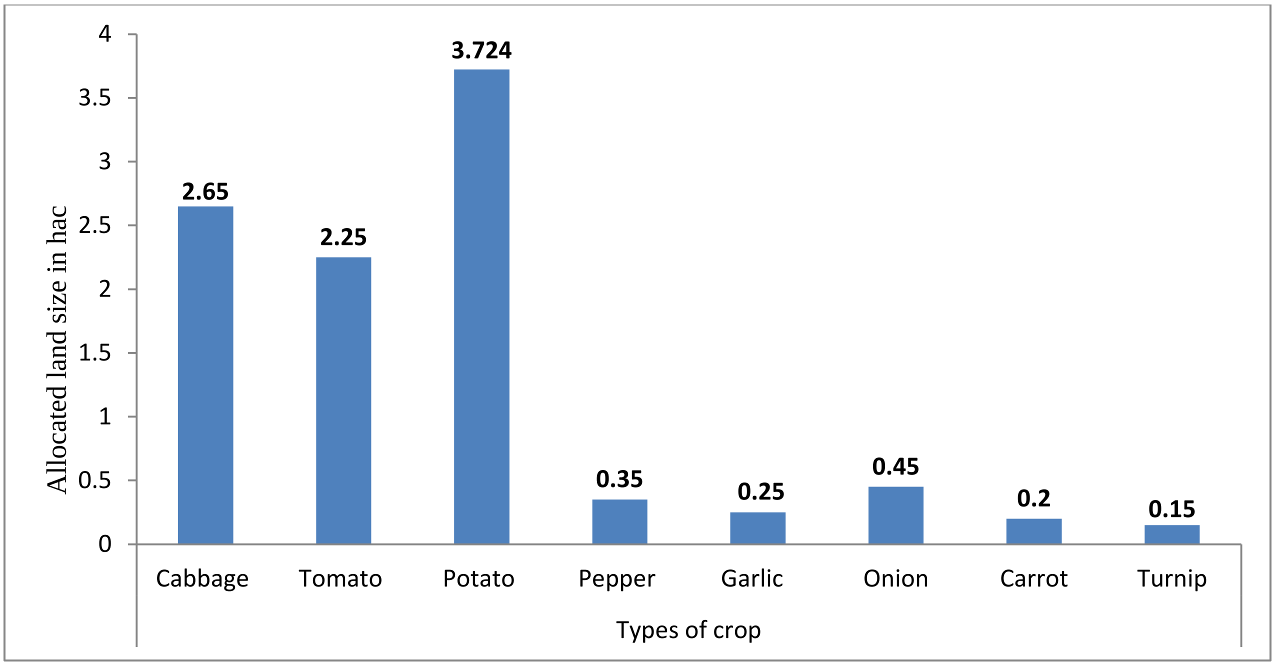

Figure 3 Types of crop cultivatiod with allocated irrigated land size

4.2.3. Farmers' experience on irrigation practice

Small-scale irrigation practice in the District has a long history of more than 50 years. From the survey result in (table 7), it is found that the mean irrigation experience of the sample respondents was 9.38 years with minimum and maximum experience 0 and 40 years, respectively; whereas the mean irrigation experience for participants was 18.76 with SD of 9.056. The minimum and maximum experience for participants was 3 and 40 years, respectively. This indicates small-scale irrigation has old history in the study area. Dedo woreda is endowed with irrigation potential; and small-scale irrigation has a history of more than 50 years (DWAO, 2019).

Table 7 Irrigation experience of sample respondents

Variable	Total respondents				Participant				Non participant			
	Mean	SD	Mini	Max	Mean	SD	Mini	Max.	Mean	SD	Mini	Max
Irrigation experience	9.38	11.36	0	40	18.76	9.056	3	40	0	0	0	0

4.2.4. Frequency of cultivation in a year

The major objective of irrigation farming practice is to increase production and productivity by increasing the frequency of cultivation in a year. The expansions of small-scale Irrigation practice increase farmers' cropping frequencies; use of improved farm inputs (improved seeds and chemical fertilizer) and also increased farm productivity (Petros and woldegabrel 2017). In the study area, it was found out that from the total irrigation participant households 61 (48.8%) of them produce only once within a year and 64(51.2%) of them produce two times within a year where as no one of respondents was produce more than two times (Fig 4). This result shows that in the study area farmers are not intensively used their opportunity of irrigation practice and the intervention is not well supported by farmer extension linkage. By its nature vegetable crops can be cultivated more than two times in a year, but in the study area farmers are not experienced to utilize their irrigation farmland intensively, rather they produce once and wait for rain fed to cultivate again. This may be arising from different natural and manmade challenges of irrigation farming in addition to farmers' attitude towards technology adoption.

Focus group discussion confirmed that, farmers who have farm plot near to the river were forced to produce only once during the dry season and then they produce either some flood tolerant crops, like maize or they wait for another dry season to cultivate again that plot of land. This occurrence was because, the river is over flowed and damages the crop on the farm during the heavy rainy season. So, introducing the flood controlling system may give an opportunity to frequent production in a year.

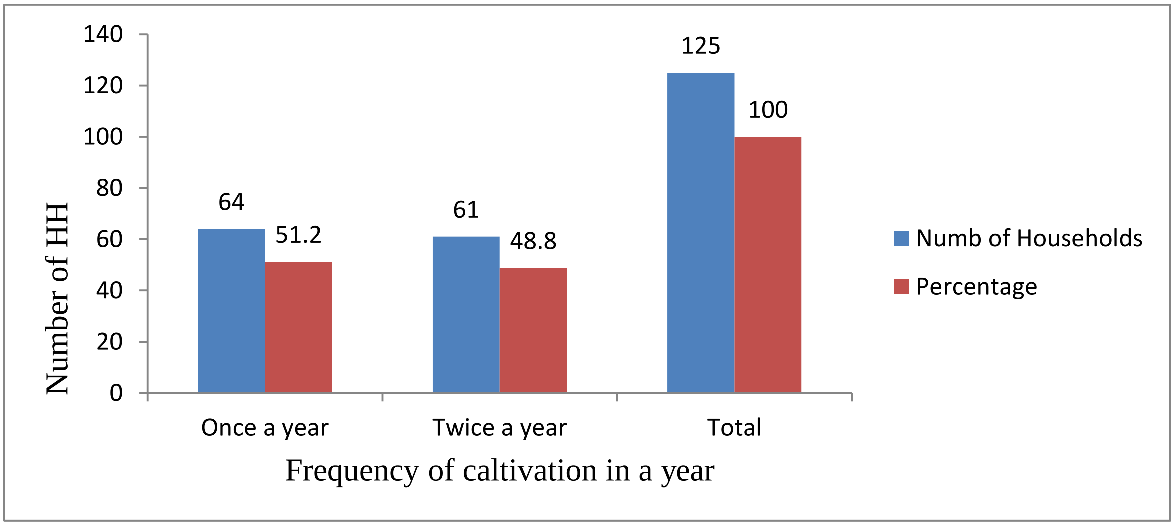

Figure 4 : Frequency of cultivation within a year

4.2.5. Types of Irrigation Use and technology utilization

According to information obtained from Dedo Woreda Agricultural Office, irrigation user farmers utilizes river water by three water diversion methods; such as traditional water diversion from river, concrete water diversion from river and using motorized pumps water diversion from river. Recently, the number of farmers producing by the use of traditional water diversion, were 9495, whereas, about 1300 and 614 produce by use of motorized pump and modern concrete water diversion respectively (DWAO 2019). The survey result also revealed that from the total participant sample households, the majority 100(80%) uses traditional river diversion, 14 (11%)

uses motorized pump and 11 (9%) uses the combination of two (Fig 5). Petros and woldegabrel (2017) revealed that farmers are using small-scale irrigation by using three types of water diversion method like traditional, concrete and motorized, because most of water harvesting technologies are not functional due to problem of farmers attitude especially on water harvesting technology which was very low.

A 38 years old key informant interviewee named Getachew, Development agent of waro kolobo kebele, confirmed that in the study area other types of irrigation; like treadle pump or other modern form of irrigation technologies were not adopted, because water harvesting technologies are not functional due to the problem of farmers' attitude on water harvesting technology, inability to cover cost of fuel and financial constraint to purchase motorized pump, lack of well supported intervention by farm extension linkage and lack of modern irrigation constructed in the study area.

From the FGD discussion, it was confirmed that, even though there is immense water resource in the study area, like Waro, offole and Gibe; they are not well utilized, because it cannot be diverted by traditional means. Farmers are still producing by means of traditional water diversion, which they inherited from their family. So to improve water utilization and promote irrigation practice, government need to encourage the construction of modern scheme, that escalates the status of participation by reducing the cost of production for farmers. However, in terms of other agricultural technology utilization, it is found out that farmers are utilizing fertilizer, improved seed, and pest/herb sides and also they apply row cropping system to increase yield.

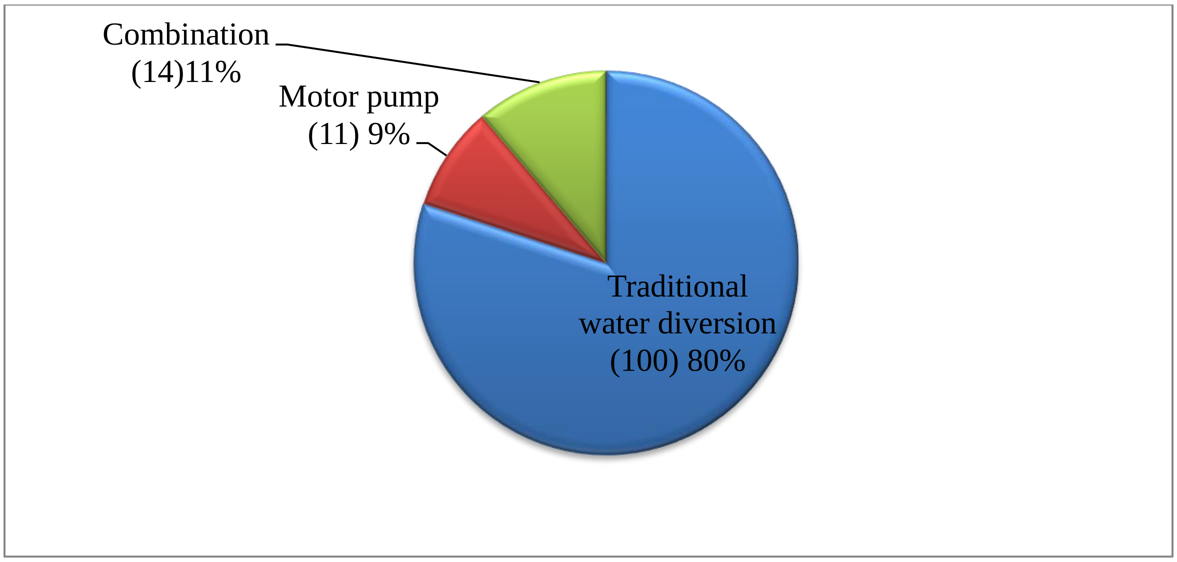

Figure 5 Types of Irrigation used by households

4.3.Determinants of Participation in small-scale Irrigation farming

Binary logistic regression model was employed for the analysis of determinant of participation in irrigation farming. Before performing the econometric estimation, different econometric assumptions were tested using appropriate techniques. Therefore, for binary logistic regression, first, the presence of strong multicollinarity among continuous explanatory variables was tested using variance inflation factors (VIF). The values of VIF for variables were found to be small (i.e. VIF values less than 10). Based on the VIF result (ranges between 1.03 and 1.13), it can be concluded that the data set had no serious problem of multicollinearity (Appendix table 3). Second, for the dummy variables contingence coefficient (CC) was used to check the existence of multicollinerty (Appendix table 4). There was no any continuous or dummy explanatory variable dropped from the estimated model since no serious problem of multicollinearity were detected from both the VIF and contingency coefficient results. As a result, all the explanatory variables were retained and moved to the analysis.

The dependent variable is participation in small-scale irrigation farming. The various test of goodness- of-fit indicate that the selected covariates provide good estimate of the probability of participation in small-scale irrigation farming from the household survey data. Pseudo- *R*2 indicates how well the independent variables explain the probability of participation (Caliendo and Kopeinig, 2008). Pseudo- R^2 value (0.1916), which is fairly low, indicates that households participated in small-scale irrigation vegetable farming does not have many distinct characteristics. In addition, the LR chi2 test statistic (66.41) indicates that explanatory variables are jointly highly statistically significant (1%) and this confirms that there is a relationship between the dependent and explanatory variables included in the model used.

From the result of binary logistic regression model, among thirteen variables assumed to have association with small-scale irrigation farming practice in the study area, eight of them (year of schooling of the households, family size, size of farm land, market distance, farm plot distance from water source, access to credit, participation in off-farm activity and frequency of extension contact) were found to have statistically significant effect. However, from those variables, farm land size, market distance, farm distance and participation in off farm activities were negatively influence, whereas year of schooling of the household head, family size, credit use and frequency of contact with development agent were influence positively participation in small-scale irrigation vegetable farming in the study area, (table 8).

Year of Schooling (EDUCAT): This variable was hypothesized to affect the probability of participation in small-scale irrigation farming positively. As a prior hypothesis, this variable has a positive influence on households' participation decision in small-scale irrigation vegetable farming and it is significant at 5% significant level. Other factors held constant, the odds ratio in favor of participating in small-scale irrigation vegetable farming increases by a factor of 1.17 for a unit increase in year of schooling. The possible implication for this is that educated households can utilize knowledge and information on the economic feasibility of irrigation practice they get from extension agents, radio or by reading from different sources, and then they initiated to participate in irrigated vegetable farming more. This finding is consistence with the finding of Kedir *et al*. (2016) who found that households who are able to read and write has a better chance to adopt agricultural technology than non-educated (unable to read and write) farmers.

Family Size (FMLSIZE) - It was hypothesized that family size of the household would influence farmers' decision to participate in small-scale irrigation vegetable farming positively. As prior hypothesized this variable influences farmer's decision to participate in small-scale irrigation vegetable farming positively and significantly at 5% significant level. The odds ratio in favor of participating in small-scale irrigation vegetable farming increases by a factor of 1.31 for a unit increase in adult equivalent. This implies that the larger the family size of the household the more they can participate in small-scale irrigation vegetable farming as they have possibility of getting family labor available for farming activity. Irrigation farming requires intensive labor utilization and, as a result a household with larger family size has cheaper labor that encourages them to participate in small-scale irrigation. This finding is consistent with study of Abraham *et al*. (2016) revealed, households with large family size are motivated to participate in small-scale irrigation farming more likely than households with small family size.

Farm land size (LANDSIZE): Farm size was hypothesized to be positively influence participation in small-scale irrigation vegetable farming. But from the survey result, it was found to be influencing farmers' decision to participate in small-scale irrigation vegetable farming negatively at 5% significant level. The odds ratio in favor of participating in small-scale irrigation vegetable farming decreases by a factor of 0.61 for a unit increase in size of farmland. The study result is in line with the work of Hailu (2014), stated that farmers who have small size of land have high probability to participate in small-scale irrigation. In other word, this finding is in contradictory with the finding of Abiyu *et al*. (2015), stated that farmers who have large farm size could more likely involved in irrigation water use. The possible explanation for this result is that farmers who have large farmland size could get more yields and in turn more income from production of different crops on the large size of land by other land use pattern. From the focus group discussion it is indicated that, in the study area small land holders have no other option rather than intensively cultivating their small plot, whereas large land size holders have utilize their land for other land use pattern.

Market Distance (MRKTDIST): This variable was found negatively and significantly affected the farmers' decision to participate in small-scale irrigation vegetable farming at 5% significance level. Other factors held constant, the odds ratio in favor of participating in small-scale irrigation vegetable farming decreases by a factor of 0.99 as the market distance increases by one walking minute on foot. The possible explanation for this finding is that the farther the farmer from the market center, the more they face the problem of taking their product to the market easily and as a result, their products become perished on the trip. This found to be leads farmers not to participate in small-scale irrigated vegetable farming. This result was in line with the work of Abrham *et al*. (2015) and Kinfe *et al*. (2012) who revealed that the far the nearest market place from farmers farm plot, the less probability they decide to participate in irrigation farm and contradictory with the finding of Kedir *et al*. (2016), indicated that the far the farm from local market the less the probability to involve in other activities and the more probability to invest in irrigation.

Credit Use (CREDIT): Credit use was one of the variables that affect the participation decision of farmers in small-scale irrigation and hypothesized to have positive association. As hypothesized this variable was found to be significantly and positively influencing the participation decision of the farmers in small-scale irrigated vegetable farming at 10% significant level. Other variables held constant, the odds ratio in favor of participating in small-scale irrigation for credit user is 1.659 times than that credit non-user. The possible explanation for this finding is that farmers, who use credit, have better possibility to cover the cost of agricultural input for irrigation by the cash they get on credit. This finding is in line with the work of Leta *et al*. (2018) and Nhundu *et al*. (2015) who found that farmers who access to credit are able to acquire all the necessary inputs in right quantities and qualities for the irrigation practices at the right time.

Distance of plot of land from water source (FARMDIST): This variable has a negative association with farmer's decision to participate in small-scale irrigation vegetable farming and statistically significant at 5% level of significance. It indicates that as distance of plot of land from irrigation water source increases by one walking minute on foot, the probability of participating in small-scale irrigated farming decreases by a factor of 0.921, all other factors kept constant. The possible explanation behind this finding is that as farmers in the study area are small holders, the more the plot of land far from the water the more it requires advanced technology to divert water from river, then the less they decide to participate in irrigation. This result is in-line with the finding of Kedir *et al*. (2016) and Sithole *et al.* (2014), who found that distance of farmer's homestead from the irrigation scheme had a negative influence on the farmer being participate in irrigation farming.

Participation in Off/non-farm income (OFFFARM): this variable was one of the variables hypothesized to influence farmer's decision to participate in small-scale irrigation vegetable farming negatively. As prior hypothesized, in this study it was found to be influence farmers decision to participate in small-scale irrigation vegetable farming negatively at 1% significant level. The odds ratio in favor of participating in small-scale irrigation vegetable farming for participants of off-farm activity is 0.25 times less than those who do not participate in off-farm activity, other variables held at their mean level. The possible explanation behind this finding is that farmers who participate in non /off-farm activities are not get a time to invest on irrigation farming as irrigation needs intensive follow up or they invest their time on other non-farm and off farm activities. This finding is in line with the work of Kedir *et al*. (2016) and Abraham *et al*. (2015) who found that farmers those are access to more non-farm income has a less probability to participate in small-scale irrigation. But it is contradictory with Beyan *et al*. (2014) and Hailu (2014) who revealed that non-farm participation increases the probability of participation and adoption of micro irrigation technologies.

Frequency of Contact with development agent (CONTACTDA): This variable was significantly and positively related to household participation decision on small-scale irrigation at 1% significance level and the odds ratio in favor of participating in small-scale irrigation increases by a factor of 1.547 for a unit increase of contact with development agent in a month. The possible reason for this finding is that farmers who made frequent contact with agricultural development agent are more access to information on technology utilization and farm advice which in turn influence them to decide to participate in small-scale irrigation farming practice. This finding is in line with the work of Abiyu *et al*. (2015) who found that the more farmers access to farm advice and training the more they utilize the small-scale irrigation.

Table 8: Binary logistic regression model output

DEPVAR	Coef.	Odds Ratio	Z	P>z
SEX	0.433	1.542	0.650	0.516
AGE	0.004	1.004	0.270	0.787
EDUCAT	0.157	1.170	2.490	0.013**
FMLSIZE	0.271	1.311	2.250	0.025**
LANDSIZE	-0.495	0.610	-2.260	0.024**
OXEN	0.215	1.240	0.540	0.586
TOTLIVST	-0.038	0.963	-0.320	0.748
MARKTINFO	0.123	1.131	0.380	0.705
MRKTDIST	-0.010	0.990	-1.980	0.047**
CREDIT	0.506	1.659	1.720	0.085*
FARMDIST	-0.083	0.921	-2.120	0.034**
OFFFARM	-1.386	0.250	-3.800	0.000***
CONTACTDA	0.437	1.547	2.840	0.004***
_cons	-0.296	0.743	-0.220	0.827

Number of obs = 250
LR chi2(13) = 66.41 Prob > chi^2 =0.0000
Log likelihood = -140.081 Pseudo R^2 =0.1916

*, **and*** are the significance level at 10, 5 and 1 % respectively;

4.4. Impact of small-scale irrigation vegetable farming on farm household's income

4.4.1. Econometric model analysis of impact of small-scale irrigation vegetable farming on household's income

Propensity score matching (PSM) method of impact evaluation was used to perform impact analysis in this study mainly because of the absence of baseline data. PSM consists of four phases: estimating the probability of participation, i.e. the propensity score, for each unit in the sample; selecting a matching algorithm that is used to match participants with non-participants in order to construct a comparison group; checking for balance in the characteristics of the treatment and comparison groups; and estimating the effect and interpreting the results (Staurt, 2010).

Estimation of Propensity Score

As Propensity scores can be constructed using a logit or probit regression to estimate the probability of a unit's exposure or assignment to the program, the probability of participating in small-scale irrigation, conditional on a set of observable characteristics that may affect participation in small-scale irrigation vegetable farming practice, in this specific study the propensity scores are constructed using the logit regression, because it is the most common model for propensity score estimation as stated in Staurt (2010). The results of the estimated propensity score distribution of all observable covariates by logit model are reported in Appendix table (5).

Choice of matching algorithm

Different matching algorisms were tried in matching treated (irrigation participant) with control (non-participant households) in common support region. The final choice of matching algorism was guided by three criteria: namely equal mean test (balancing test), pseudo R^2 and size of matched sample. Matching algorism which balances all explanatory variables of groups (result in insignificant mean differences between both groups), bear low pseudo R^2 value and results in large sample size is preferable (Dehejia and Wahba, 2002). Based on these criteria, Kernel Matching with band width of (0.1) was found to be best estimator for this study and impact analysis procedure was followed and discussed by using this matching algorism (Table 9).

Kernel Matching is a non-parametric matching estimator that use weighted averages of (nearly) all-depending on the choice of the kernel function- individuals in the control group to construct the counterfactual outcome (Caliendo and Kopeinig, 2008). Kernel weights the contribution of each comparison group member so that more importance is attached to those comparators providing a better match. The difference from caliper matching; however, is that those who are included are weighted according to their proximity with respect to the propensity score. The most common approach is to use the normal distribution (with a mean of zero) as a kernel, where the weight attached to a particular comparator is proportional to the frequency of the distribution for the difference in scores observed (Bryson *et al*., 2002). According to Caliendo and Kopeinig (2008), a drawback of this method is that possibly bad matches are used as the estimator includes comparator observations for all treatment observation. Hence, the proper imposition of the common support condition is of major importance for kernel matching method. A practical objection to its use is that it will often not be obvious how to set the tolerance. The question remains on how and which method to select. Clearly, there is no single answer to this question. The choice of a given matching estimator depends on the nature of the available data set (Bryson *et al*., 2002).

Table 9: Performance criteria of matching algorisms

Matching Algorisms	Performance criteria		
	Balancing test*	Pseudo-R^2 after matching	Matched sample size
Nearest Neighbor (NN)			
Neighbor(1)	12	0.043	245
Neighbor(2)	12	0.028	245
Neighbor(3)	13	0.021	245
Neighbor(4)	12	0.023	245
Neighbor(5)	13	0.021	245
Caliper Matching (CM)			
0.01	8	0.048	210
0.1	12	0.043	245
0.25	12	0.043	245
0.5	12	0.043	245
Kernel Matching (KM)			
With band width of (0.01)	13	0.026	210
With band width of (0.1)	13	0.018	245
With band width of (0.25)	13	0.019	245
With band width of (0.5)	11	0.067	245
Radius Matching (RM)			
With band width of (0.01)	7	0.175	245
With band width of (0.1)	7	0.175	245
With band width of (0.25)	7	0.175	245
With band width of (0.5)	7	0.175	245

Identifying common support region

According to Table (10) below, the propensity scores vary between 0.099 and 0.969 for irrigation participants with the mean of 0.62; whereas the score vary between 0.011 and 0.936 for non-participant households with the mean of 0.38. Then, the common support lies between 0.099 and 0.936. This means that household whose propensity score less than minimum (0.099) and larger than maximum (0.936) are not considered for matching purpose. Based on this procedure, 5 households all from small-scale irrigation participant group (Treated group) were discarded from the study in impact analysis procedure.

Table 10: Distribution of estimated propensity score of households

Group	Observation	Mean	STD	Min	Max
All households	250.000	0.500	0.245	0.011	0.969
Treated households	125.000	0.620	0.221	0.099	0.969
Control households	125.000	0.380	0.206	0.011	0.936

Verifying the Common Support Condition

Figure (6), below shows the distribution of propensity score and common support region. The bottom halves of the histogram shows the propensity score distribution of irrigation non participant households and the upper halves shows the propensity score distribution of irrigation participant households. The red colored (treated on support) and the blue colored (untreated on support) indicates the observations in the small-scale irrigation vegetable farming participant group and non-participant group that have a suitable comparison, respectively, whereas the green colored (treated off support) indicates the observations in the participant group (treated) that do not have a suitable comparison.

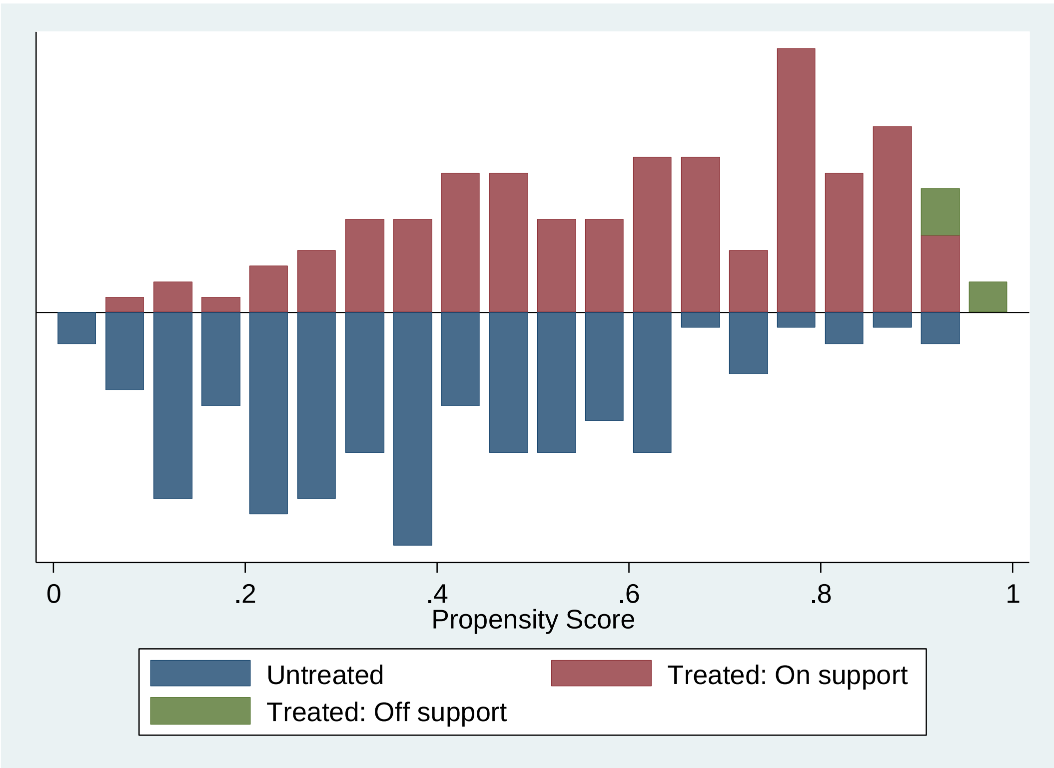

Figure 6: Propensity score distribution and common support for propensity score estimation.

Testing of balance of propensity score

After selecting best matching algorism which satisfies prior identified performance criteria, balance of propensity score and explanatory variables was checked by the selected matching algorism (Kernel Matching With band width of (0.1)). The result from (Table 11) shows, the standard bias difference between explanatory variables before matching was in the range of 3.9% and 56.5% in absolute value. But after matching, the remaining standardized bias differences between explanatory variables lay between 0.1 % and 17.4% in absolute value which is below the critical level of 20% suggested by Rosenbaum and Rubin (1983). It is clear that the main intention of estimating propensity score is not to get a precise prediction of selection into treatment, rather to balance the distributions of relevant variables in both groups (Caliendo and Kopeinig, 2008). Therefore, Kernel Matching With band width of (0.1) has created a covariate balance between two groups, which is important to conduct impact analysis (Table 11).

Table 11: Propensity score and covariate balance test

Variables	Unmatched	Mean		%reduct		t-test	
	Matched	Treated	Control	%bias	bias	t-value	p-value
_pscore	U	0.620	0.380	112.800		8.910	0.000
	M	0.607	0.600	3.300	97.100	0.250	0.801
SEX	U	0.960	0.952	3.900		0.310	0.759
	M	0.958	0.968	-4.600	-18.100	-0.390	0.699
AGE	U	44.368	42.992	14.500		1.150	0.253
	M	44.442	44.980	-5.700	60.900	-0.450	0.651
EDUCAT	U	1.944	1.248	27.900		2.200	0.029
	M	1.825	2.035	-8.400	69.800	-0.600	0.549
FMLSIZE	U	5.310	4.892	33.300		2.630	0.009
	M	5.313	5.314	-0.100	99.800	0.000	0.997
LANDSIZE	U	1.242	1.508	-37.800		-2.990	0.003
	M	1.273	1.275	-0.300	99.100	-0.030	0.980
OXEN	U	0.600	0.656	-11.600		-0.910	0.362
	M	0.600	0.590	2.100	81.800	0.160	0.873
TOTLIVST	U	2.351	2.506	-10.400		-0.830	0.410
	M	2.369	2.628	-17.400	-66.900	-1.300	0.196
MARKTINFO	U	0.712	0.672	8.600		0.680	0.495
	M	0.700	0.735	-7.500	13.000	-0.600	0.551
MRKTDIST	U	84.080	94.360	-33.800		-2.670	0.008
	M	85.042	84.450	1.900	94.200	0.160	0.875
CREDIT	U	0.512	0.384	25.900		2.040	0.042
	M	0.500	0.553	-10.800	58.400	-0.820	0.411
FARMDIST	U	3.616	5.040	-30.200		-2.390	0.018
	M	3.583	3.604	-0.400	98.600	-0.050	0.961
OFFFARM	U	0.576	0.824	-56.000		-4.430	0.000
	M	0.592	0.650	-13.200	76.400	-0.930	0.352
EXTCONTACT	U	1.672	1.112	56.500		4.460	0.000
	M	1.608	1.592	1.600	97.200	0.120	0.902

Table (12), below present's; results from covariate balancing tests before and after matching using household survey data. The standardized mean difference (Caliendo and Kopeinig, 2008) for overall covariates used in the propensity score (around 33.1% before matching) is reduced to about 5.5% after matching. The bias substantially reduced, in the range of 22 to 33% through matching. The p-values of the likelihood ratio tests indicate that the joint significance of covariates was always rejected after matching; whereas it was never rejected before matching. The pseudo- R^2 also dropped significantly from 19.3% before matching to about 1.8% after matching. The low pseudo-R^2, low mean standardized bias, high total bias reduction, and the insignificant p-values of the likelihood ratio test after matching suggest that the proposed specification of the propensity score is fairly successful in terms of balancing the distribution of covariates between the two groups. Hence, these results can be used to assess the impact of irrigated vegetable farming practice among groups of households having similar observed characteristics. This enables to compare observed outcomes for irrigated vegetable participant and those of a non-participant group sharing a common support.

Table 12: Propensity Score Matching Quality test

Sample	Ps R2	LR chi2	p>chi2	Mean Bias	MedBias	B	R	%Var
Unmatched	0.193	66.87	0.000	33.1	28.5	112.2*	1.10	22
Matched	0.018	6.01	0.966	5.5	3.9	31.8*	1.62	33

4.4.2. Estimating Average Treatment Effect on Treated (ATT)

The estimation of the impact of a certain technology intervention is based on the above mentioned steps of propensity score matching when we do not have the baseline data. Following the estimation of propensity scores, the implementation of a matching algorithm, and the achievement of balance, the small-scale irrigation vegetable farming impact estimated by averaging the differences in outcome between each treated unit and its neighbor or neighbors from the constructed comparison group. The difference in mean of the income who participated in the small-scale irrigation vegetable farming and those who did not can then be interpreted as the impact of the irrigated vegetable farming. Table 13 shows the impact of participation in small-scale irrigated vegetable farming on household income.

Table 13: Average treatment effect on the treated (ATT) estimation results

Outcome Variable	Sample	Treated	Controls	Difference	S.E.	T-stat
HH mean Annual Income in ETB	Unmatched	26726.30	21076.82	5649.48	1456.77	3.88
	ATT	26951.81	21726.81	5225.00	1865.54	2.80**

* *indicates significant at 5% significance level, ATT- Average treatment effect on the treated

Sensitivity analysis

In order to check for problem of unobservable biases, sensitivity analysis was performed on the computed outcome variables using Rosenbaum Bounding approach with respect to deviation from the conditional independence assumption. The basic question to be answered here is whether inference about treatment effects may be affected by unobserved factors (hidden bias). Result show that the inference for the impact of irrigation intervention is not changing, though the participants and non-participant households has been allowed to differ in their odds of being treated up to 100% at critical sigma 2 in terms of unobserved covariates (Table 14).

Table 14: Result of sensitivity analysis using Rosenbaum bounding approach

Outcome variable	e^{γ} =1	e^{γ} =1.25	e^{γ} =1.5	e^{γ} =1.75	e^{γ} =2
HH Annual income in ETB	0.000	0.000	0.000	0.000	0.000

Thus, it is possible to conclude that impact estimates (ATT) of this study for outcome variable was insensitive to unobserved selection bias; and is a pure effect of participation in small-scale irrigation vegetable farming.

From table (13) the average treatment effect on the treated is about ETB 5225.00 and it is significant at 5% significance level. This result implies that participation in small-scale irrigation vegetable farming increases income of participant households significantly; or in other words, farmers who have practice small-scale irrigation vegetable farming were found to be better off than their counterparts when compered on the basis of their annual income. This finding is consistent with certain studies conducted on impact of participation in irrigated farming on household income using propensity score matching (Woldegebriel, 2015; Dereje and Desale, 2016; Leta *et al*., 2018). Participants of focus group discussion also confirmed that, without any doubt, small-scale irrigation vegetable farming has positive impact on household’s income, if one can practice intensively. They mentioned that, participants were generate extra income from selling of vegetable crops produced by the use of irrigation, that mainly practiced during dry season in addition to income they get from the regular production by rain fed. Farmers those are participating in small scale-irrigation farming were not only benefitted only from direct selling and consumption expense replacement, but also they benefitted by utilizing income they get from selling for agricultural input purchase for rain fed agriculture. Because they get income during the time of purchasing agricultural input, like seed and chemical fertilizer, they able to purchase sufficient quantity and quality at a right time. As a result their production and productivity increased, which in turn increase their annual income. Therefore, irrigated vegetable farming has positive impact on household’s annual income in the study area, so top priority must be given to the improvement of the status of farmers’ participation in irrigation practice.

5. SUMMARY OF MAJOR FINDINGS, CONCLUSION AND RECOMMENDATION

5.1. Summary

This study was conducted in Dedo District of Jimma Zone which is located in the southwestern part of Ethiopia, Oromia National Regional State. In this study the factors determining participation in small-scale irrigation by the farm households and the impact of participation in small-scale irrigation vegetable farming on farm household's income was analyzed. In addition, the status of farmers' participation was assessed. The analysis was made by using data collected from 250 sample households of three rural kebeles by using multi-stage sampling procedure. The study design was cross-sectional survey design. Descriptive statistics and econometric model was used to analysis the result of the study.

Descriptive statistics like percentage, frequency distribution, mean and standard deviation were used. In addition, inferential statistics like chi-square and t-test were used to see associations and differences in characteristics between small-scale irrigation participant and non-participant, respectively. There was an association between participation in small-scale irrigation and factors like credit use and participation in non-farm or off farm activities. The two groups differ to some extent in terms Year of schooling, distance from irrigation water source, and distance from market, family size, cultivable land size and the frequency of extension contact. The study used binary logistic regression model to analyze the determinants of participation in small-scale irrigation and it also used propensity score matching to analyze the impact of small-scale irrigation on household's income in the study area.

The status of irrigation farming practice in the study area is found at its infant stage. The vegetable crops produced by irrigation in the study area were found potato, cabbage, tomato, onion, garlic, green pepper, carrot and turnip where the first three are dominant. The mean cultivated irrigation land holding size was found about 0.04ha per households which is less than the country standard.

The result of binary logistic regression model analysis reveals that Year of schooling of the household head, family size, access to credit and frequency of contact with development agent influence participation in small-scale irrigation positively, whereas cultivable land size, distance of farm plot from water source, market distance and participation in off/non-farm activities influence participation in small-scale irrigation negatively.

The impact analysis of participation in small-scale irrigation vegetable farming on household income by propensity score matching shows significant difference in the income of farm households between participants and non-participants. The average treatment effect on the treated, (impact of intervention on income), was ETB 5225.00 and it was significant at 5% significance level.

5.2. Conclusion

Small-scale irrigation development is important strategy and a policy priority for improving livelihoods of farmers and ensures food security. The general objective of this study was to assess the impacts of small-scale irrigation vegetable farming on household annual income and determinants of participation in small-scale irrigation in Dedo district of Jimma zone, Southwestern Ethiopia. Based on the findings of the study, the conclusions are set as the following.

The result revealed that farmers who have more year of schooling have participated in small-scale irrigation farming more than their counterparts. This implies that educated households apply their knowledge and skill gained from various sources on irrigation participation than non-educated households. Households who have large family size also have more probability to participate in small-scale irrigation than those who have small family size. This indicates that large family size gives an opportunity to get high labor force to invest on irrigation farming. The result further revealed that holding small size of farm land positively influence irrigation participation, because households holding small size of farm land has no option to increase their production and productivity rather than utilizing their small plot intensively, and irrigation farming is the good strategy to do that. Farmers who have plot of land nearest to irrigation water source and who are nearest to local market found having more probability to participate in small-scale irrigation. This because having farm plot near to water reduces the challenges and cost of diverting water to their farm and being nearest to local market is reduce the transaction cost of purchasing input and selling their irrigation output. The result again revealed that households those participate in off farm/non-farm activities have less probability of participating in irrigation as they divert their livelihood pattern more from farming activities to non-farm/off-farm activities because they earn immediate income from those activities. Further, the result revealed that credit use and frequent contact with development agent increases the probability of participation in irrigation farming. This implies farmers who access to credit have an option to cover cost of production input like fertilizer, improved seed, etc. in other way farmers who have frequent contact with development agent were get the information and farm advisory service from development agents that motivate them to use improved technology like irrigation.

The impact analysis result from PSM model indicates that farmers who have participating in small-scale irrigation vegetable farming were earning more income than their counter parts. Therefore, it is observed that small-scale irrigation vegetable farming is an important intervention to improve rural farm household's income.

Despite its important contribution in improving household's income, the status of participation in terms of size of land under cultivation, improved technology utilization especially motorized pump, frequency of production and also the type of crops produced was very poor and needs a comprehensive intervention.

5.3. Recommendation

In view of the major findings and the above conclusions, the following recommendations were forwarded.

As it is found educated household heads are in the better position to participate in irrigation farming, enhancing the Year of schooling of the farm households through formal and informal means is recommended.

The study result revealed that having large family size had positive influence on the irrigation farming as it gives the opportunity to get high labor force. This implies that household with less family members' faces labor shortage and less to practice irrigation farming, because irrigation use more labor forces. Therefore, introducing and ensuring the supply of labor saving technology (like motorized pump and herbicide/pesticide chemicals) is recommended.

Size of farm land found influencing participation in small-scale irrigation farming negatively. This revealed that households who hold small farm land are more participating in small-scale irrigation. This implies participation in irrigation farming is mainly considered as only the means to solve the land shortage. This should be the reason why, households holding large land size are not adopting irrigation as improved farm technology. Therefore, development actors in the study area must work more on creating awareness on importance of small-scale irrigation technology.

Market place especially that appropriate for vegetable products must be constructed on the nearest market to solve the problem of market distance and problem arising with it. Market linkage between producers and small traders must exist thus to facilitate the possibility of selling their products on their farm at fair price, and as well linkage to other markets should be created through farmer cooperative, because it is expected to solve the problem of hindrance to participate in irrigation farming due to market distance. In doing that the active participation of NGOs and other development actors is highly recommended.

The study also revealed that farm distance from irrigation water source was found to be hindrance for participation in irrigation. Therefore, Regional Development actors and development planners; and specifically agricultural development office in the study woreda, including NGOs must work more on ground water development and concrete water diversion scheme development. Water harvesting technology, which is still not practicing in the study area should be considered and encouraged to create an opportunity for those who do not access to river can irrigate their farm land.

The credit system and utilization means need to be facilitated more in the study area to enable farmers to use credit because it was one of the significant variables that determine participation in irrigation practice in the study area.

The provision of extension service for farm households by development agents must be encouraged and updated knowledge and information on farm technology adoption must be diffused through frequent visit; since frequency of contact made with development agent was found influence participation in small-scale irrigation positively.

Generally, small-scale irrigation is a top policy priority as a whole. Similarly irrigated vegetable farming was found to be influence farm household’s income significantly and positively. Therefore, small-scale irrigation vegetable farming must get the first priority in the area to improve farmer’s livelihood.

Finally, the study considers a few concepts of small-scale irrigation vegetable farming from broad aspects that needs further study. So, further studies must be conducted by incorporating other important variables like market problem, access to seed, pest infestation, product perishability and etc. that didn’t considered in this study, but important to be assessed.

REFERANCES

Abebaw Abiyu, Mesfin Tebeje and Ermias Mekonnen. 2015. Determinants of small-scale irrigation utilization by smallholder farmers' in rift valley basin, Wolaita zone, Ethiopia. *Journal of Natural Sciences Research.* 5(21), pp.2224-3186.

Abera Ifa. 2015. Determinants of use of Small-Scale Irrigation and its Effects on Household Food Security: in Bako Tibe district, West Shoa Zone of Oromiya Region. MSc. Thesis, Haramaya University, Haramaya, Ethiopia.

Abiyu, A., Tebeje, M. and Mekonnen, E., 2015. Determinants of small-scale irrigation utilization by smallholder farmers' in rift valley basin, Wolaita zone, Ethiopia. *Journal of Natural Sciences Research*, *5*(21), pp.2224-3186.

Abraham Gebrehiwot Yihdego, Addis Adera Gebru and Mesfin Tilahun Gelaye. 2015. The impact of small–scale irrigation on income of rural farm households: Evidence from Ahferom Woreda in Tigray, Ethiopia. *International Journal of Business and Economics Research*, 4(4), pp. 217-228.

ADF (African Development Fund). 2005. Rural water supply and sanitation program in Ethiopia: AppraisalReport, Infrastructure Department North East and South Onin.

Adugna Eneyew. 2014. Five key constraints to small-scale irrigation development in Ethiopia, socioeconomic view: Review paper. *Global Advanced Research Journal of Management and Business Studies,* 3(10), pp.441-444

Agerie, N.W., 2013. Determinants of smallholder rural farm households' participation in small-scale irrigation and its effect on income in North Gondar zone: *a cross-sectional approach (evidence from Dembia Woreda)* (Doctoral dissertation, Mekelle University).

Alamerie, K., Ketema, M. and Gelaw, F., 2013. Risk management strategies and pesticides use in vegetable production: The case of smallholder farmers in Kombolcha Woreda, East Hararge Zone, Oromia national regional state, Ethiopia. *Risk Management*, *4*(7).

Alemu, A.E., Kassa, B. and Yihdego, G., 2011. Determinants of Land Allocation to Irrigation and Its Wealth Effect: Evidence from Northern Ethiopia. *Journal of the Drylands,* 4(2), pp.310-319.

Alvi, M., 2016. A manual for selecting sampling techniques in research. Available: https://mpra.ub.uni-muenchen.de/70218/: Date Accessed 20th Dec 2019.

Apam, L. S., 2012. *An Assessment of the impact of small-scale irrigation schemes on livelihoods and poverty reduction in the Upper East Region.* An MSc thesis submitted to the of Planning, Kwame Nkrumah University of Science and Technology.

Asayehegn, K., Yirga, C. and Rajan, S., 2011. Effect of small-scale irrigation on the income of rural farm households: The case of Laelay Maichew District, Central Tigray, Ethiopia. *Journal of Stored Products and Postharvest Research,* 2(10), pp.208-215.

Asmamaw, D.K., 2015. A critical review of integrated river basin management in the upper Blue Nile river basin: the case of Ethiopia. *International Journal of River Basin Management*, *13*(4), pp.429-442.

ATA (Ethiopian Agricultural Transformation Agency). 2016. Annual Report, Addis Ababa, Ethiopia. Cross reference.

Awulachew, S.B.; Merrey, D.; van Koopen, B.; Kamara, A. Roles, constraints and opportunities of small-scale irrigation and water harvesting in Ethiopian agricultural development: Assessment of existing situation. In Proceedings of the ILRIWorkshop, Colombo, Srilanka, 14–16 March 2010; International Water Management Institute (IWMI): Addis Ababa, Ethiopia, 2010.

Bacha, D., Namara, R., Bogale, A. and Tesfaye, A., 2011. Impact of small‐scale irrigation on household poverty: empirical evidence from the Ambo district in Ethiopia. *Irrigation and Drainage*, *60*(1), pp.1-10.

Banson, K. E., Asare, D., Heng, L., Cobbinah, J. F. and Adu-Sarkodieh, A. (2014). Impact of small-scale irrigation technologies on poverty alleviation among peri-urban and urban farmers. *Journal of Life Sciences*, 8 (2), pp. 142-151.

Baum, C.F. 2013. Propensity Score Matching, Regression Discontinuity, Limited Dependent Variables. Applied Econometrics, Boston College, Massachusett, USA.

Belay, M. and Bewket, W., 2013. Traditional irrigation and water management practices in highland Ethiopia: Case study in Dangila woreda. *Irrigation and Drainage*, *62*(4), pp.435-448.

Belay, S. and Beyene, F., 2013. Small-scale irrigation and household income linkage: Evidence from Deder district, Ethiopia. *African Journal of Agricultural Research*, *8*(34), pp.4441-4451.

Beyan Ahmed, Jema Haji and Adem Kedir. 2014. Effect of small-scale irrigation on the farm households' income of rural farmers: The case of Girawa district, east Hararghe, Oromia, Ethiopia. *Asian Journal of Agriculture and Rural Development*, 4(3), pp.257-266

Bosa, M. S. 2015. Water institution and management in Cape Verde. *Water journal*, 7(6),pp.2641-2655.

Bryson, A., Dorsett, R. and Purdon, S., 2002. The Use of Propensity Score Matching in the Evaluation of Labour Market Policies. Working Paper No. 4, Department for Work and Pensions

Caliendo, M. and Kopeinig, S. 2005. *Some Practical Guidance for the Implementation of Propensity Score Matching*. Discussion Paper No. 1588.

Caliendo, M. and Kopeinig, S. 2008. Some Practical Guidance for the Implementation of Propensity Score Matching. *Journal of Economic Surveys*, 22(1), pp.31-72.

Cameron, A. and Trivedi, P. 2005. Micro-Econometrics Methods and Applications. Cambridge University, New York.

Clarke, K.A., 2006. Practical Sensitivity Analysis. *Unpublished manuscript, University of Rochester*.

Debertin, D.L. 2012. *Agricultural Production Economics*. 2nd Edition. University on Kentucky. Upper Saddle River, N.J. USA.

Dedo Woreda Agaricultural office, 2018. Annual report. Dedo, Sheki

Dedo Woreda Agaricultural office, 2019. Annual report. Dedo, Sheki

Dedo Woreda Planning and Development Cooperation, 2019. Dedo Woreda Socio economic profile.Dedo, Sheki

Dehejia, R. and Wahba, S., 2002. Propensity Score Matching Methods for Non- Experimental Causal Studies. *The Review of Economics and Statistics*, 84(1), pp.151–161.

Dereje Mengistie and Desale Kidane, 2016. Assessment of the Impact of Small-Scale Irrigation on Household Livelihood Improvement at Gubalafto District, North Wollo, Ethiopia

EEA (Ethiopian Economic Association). 2012. Annual Report on Ethiopian Economy. Addis Ababa, Ethiopia.

Eshetu S, Belete B, Goshu D, Kassa B, Tamiru D, Worku E, Lema Z, Delelegn A, Tucker J., 2010. *Income diversification through improved irrigation schemes*: Evidence from Gorogutu district, eastern Ethiopia.

FAO (Food and Agricultural Organization). 2015. Ethiopia Country Highlights on Irrigation Market Brief. UNFAO,, Rome, Itally. Prepared under Food and Agricultural Organization of United Nations(UNFAO,)/International Finance Corporation(IFC) cooperation.

FAO (Food and Agricultural Organization). 2001. The state sof food and agriculture. World Review Part I. Rome. Italy. 18-20p.

FAO (Food and Agricultural Organization). 1995. Irrigation in Africa in Figures. Water Reports. Rome, Italy farmers managed small-scale irrigation development.

FAO(Food and Agricultural Organization). 1997. Irrigation potential in Africa: A basin approach. FAO Land and Water Bulletin 4.Cross reference

FAO (Food and Agricultural Organization). 1994. Irrigation, drainage and salinity. An international source book FAO/ UNESCO.

Faris, A., Shumeta, Z. and Muche, M., 2018. Determinants of Marketed Surplus of Potato Producers in Dedo District of Jimma Zone, Ethiopia. *World Journal of Agricultural Sciences*, *14*(2), pp.74-80.

Food and Agriculture Organization (FAO). (2011). AQUASTAT online database. Available: http://www.fao.org/nr/aquastat. Date Accessed 5th Dec 2019.

Gebrehaweria Gebregziabher, Meredith A. Gardiano, Simon Langan J. and Regassa Namara. 2014. Economic analysis of factors affecting motor pump irrigation adoption in Ethiopia. Academic Journal, Journal of Development and Agricultural Economics. 4(3), pp. 257-266

Gebrehiwot, N.T. and Rao, P.M.S., 2015. Opportunities and Challenges of Small-Scale Irrigation and Its Implications for Livelihood Improvement :(The Case of Tigray Regional State, Northern Ethiopia).

Gebremedhin, B. and Peden, D., 2002. Policies and institutions to enhance the impact of irrigation development in mixed crop–livestock systems. *Integrated water and land management research and capacity building priorities for Ethiopia*, p.168.

Gelmesa D, 2010. Shifting to alternative food source: Potential to overcome Ethiopians' malnutrition and poverty problems. Haramaya University, Local seedbusiness project, Dire Dawa, Ethiopia.

Green, W. 2003. *Econometric Analysis*. 5th ed. Prentice Hall. Inc, New York.

Gujarati M. 2004. Basic Econometrics, 4th Ed. Publisher: McGraw Hill Companies. United State Military academy, West point, New York.

Gujarati, D.N. 1995. *Basic Econometrics*, McGraw-Hill International Editions, (3rd Edition). Heckman, J. 1979. Sample selection bias as a specification error. *Econometrica*, 47(-), pp 153–161.

Hailu, B.K., Abrha, B.K. and Weldegiorgis, K.A., 2014. Adoption and impact of agricultural technologies on farm income: Evidence from Southern Tigray, Northern Ethiopia. *International Journal of Food and Agricultural Economics (IJFAEC)*, *2*(1128-2016-92058), pp.91-106.

Hirko, T., Ketema, M. and Beyene, F., 2018. Participation in Small-Scale Irrigation Practice: The Case of Abay Chomen District of Oromia National Regional State, Ethiopia. International Journal of Agricultural Economics, 3(6), pp.135.

International Labour Organization, 2017. ILOSTAT database. http://www.ilo.org/ilostat/faces/wcnav_defaultSelection: Accessed 1 Nov. 2019.

Jaleta, K.T., Hill, S.R., Seyoum, E., Balkew, M., Gebre-Michael, T., Ignell, R. and Tekie, H., 2013. Agro-ecosystems impact malaria prevalence: large-scale irrigation drives vector population in western Ethiopia. *Malaria journal*, *12*(1), pp.350.

Jema Haji, Mohammed Aman and Tewodros Hailu. 2013. Impact Analysis of Mede Telila Small-scale Irrigation Scheme on House Poverty Alleviation: Case of Goro gutu District in Eastern Hararghe Oromia National Regional State Ethiopia. *International Journal of Development and Economic Sustainability*, 1(1), pp.15-30.

Kalkidan, F.,Yemiru, T. and Ephrem, T. 2017.Challenges in women-managed small-scale irrigation practices: the case of Lume district, central rift valley of Ethiopia. World Research Journal of Agricultural Sciences, 3(1), pp. 054-059.

Kamwamba-Mtethiwa, J.;Weatherhead, K.; Knox, J., 2016. Assessing Performance of Small-Scale Pumped Irrigation Systems in Sub-Saharan Africa: Evidence from a Systematic Review. Irrig. Drain. 65, pp.308–318.

Kassie, A.E., Tesema, T.A. and Amencho, N.W., 2020. Evaluation of stream flow under land use land cover change: A case study of Chemoga Catchment, Abay Basin, Ethiopia. *African Journal of Environmental Science and Technology*, *14*(1), pp.26-39.

Kedir Hamda, A., Beyen, D. and Teshome, D., 2016. *Impact of small-scale irrigation on household's food security in Fentale District East Showa Zone of Oromia National Regional State, Ethiopia* (Doctoral dissertation, Haramaya University).

Khandker, S. R., Koolwal, G. B. and Samad, H. A. 2010. Handbook on Impact Evaluation: quantitative methods and practices. The World Bank, Washington DC., USA.Cameron, A. and Trivedi, pp. 2005. Micro-Econometrics Methods and Applications. Cambridge University, New York.

Kinfe, A., Chilot, Y. and Sundar, R., 2012. Effect of small-scale irrigation on the income of rural farm households: the case of Laelay Maichew district, central Tigray, Ethiopia. Journal of Agricultural Sciences (Sri Lanka), 7(1), pp.43-57.

Legesse, L., Sidama, H., Hawassa, E., Ayele, A., Tasewu, W. and Alemu, A., 2018. Impact of Small-scale Irrigation on Household Farm Income and Asset Holding: Evidence from Shebedino District, Southern Ethiopia.

Leta L., Abayneh A., Workalemahu T. Abera A., 2018. Impact of Small-scale Irrigation on Household Farm Income and Asset Holding: Evidence from Shebedino District, Southern Ethiopia. *Journal of Resources Development and Management. Vol.43, ISSN 2422-8397*

Lipton,M., Litchfield, J., & Faurès, J. M., 2003. The effects of irrigation on poverty: A framework for analysis. Water Policy, 5, p. 413–427.

Loevinsohn M., Sumberg J. and Diagne A. 2013. Under what circumstances and conditions does adoption of technology result in increased agricultural productivity? A Systematic Review.

Mekonnen, A., Kidane, D. and Teketay, D., 2017. 1. Adaptations of Pastoralists to Climate Change and Variability in the Dry Land Areas of Afar, Ethiopia. Of El Niño on Biodiversity, Agriculture, and Food Security 23-24 February 2017 Haramaya University, Ethiopia, p.121.

Menard, S., 2002. *Applied logistic regression analysis* (Vol. 106).

Mihretu, F.B., 2019. Challenges and Opportunities of Vegetable Quality Seed Production and Seed System in Ethiopia. *International Journal of Research Studies in Agricultural Sciences (IJRSAS)* Volume 5*:* pp.15-25

MoA. Natural resources management directorates. Small-Scale Irrigation Situation Analysis and Capacity Needs Assessment, Addis Ababa, Ethiopia; 2011a.

MoA (Ministry of Agriculture). Natural Resources Sector Small-Scale Irrigation Capacity Building Strategy for Ethiopia, Addis Ababa, Ethiopia; 2011b.

MoFED.(Ministry of Finance and Economic Development), 2010.Performance Evaluation of the First Five Years Development Plan (2006-2010) and Growth and Transformation Planning the next Five Years (2011-2015).

MoWR (Ministry of Water Resources). 2002. Water sector development program 2002-2016, Volume II: Main Report. Ministry of Water Resources, Federal Democratic Republic of Ethiopia, Addis Ababa, October 2002.

Muhammad-Lawal A., Adenuga, A. H. and Jimoh, O. 2013. Determinants of adoption of irrigation technology by small-holder farmers in selected local government areas in Kwara state, Nigeria. *Taraba journal of Agricultural Research*, 1(1), pp.21-27.

Nahusenay , T. and P.Madhu S. 2015. Opportunities and Challenges of Small-Scale Irrigation and Its Implications for Livelihood Improvement: The Case Of Tigray Regional State, Northern Ethiopia. Addis Ababa, Ethiopia.

Namara, R. E., Upadhyay, B. and Nagar, R. K., 2005. *Adoption and Impacts of Microirrigation Technologies: Empirical Results from Selected Localities of Maharashtra and Gujarat States of India*. IWMI Research Report 93. Colombo, Sri Lanka: International Water Management Institute.

Nhundu, K., Mushunje, A., Zhou, L. and Aghdasi, F.. 2015. Institutional determinants of farmer participation in irrigation development post "fast-track" land reform program in Zimbabwe. *Journal of Agricultural Biotechnology and Sustainable Development.* 7(2): 9-18

Nimona Fufa Hunde .2017. Opportunity, Problems and Production Status of Vegetables in Ethiopia: A Review. Journal of Plant Science & Research .4(2):1-13 No 7:163-171.Sri Lanka.

NPC (National Planning Commission)., 2015. Ethiopian second five year (2015/16-2019/20) Growth and Transformation plan, Addis Ababa, Ethiopia

Pardey, P.G., Alston, J.M. and Kang C.C. 2012. Agricultural Production, Productivity and R&D over the Past Half Century: An Emerging New World Order. Invited plenary paper presented at the International Association of Agricultural Economists (IAAE). Triennial Conference, Foz do Iguaçu, Brazil, 18-24 August, 2012.

Passarelli, S., Mekonnen, D., Bryan, E. and Ringler, C., 2018. Evaluating the pathways from small-scale irrigation to dietary diversity: evidence from Ethiopia and Tanzania. *Food Security*, *10*(4), pp.981-997.

Peprah, K., Amoah, S. T. and Achana, G. T. W., 2015. The reticulation irrigation scheme at Sankana, Upper West Region, Ghana: Current usage, productivity and incomes. *Ghana Journal of Geography*, 7 (1), pp. 25-46.

Pokhrel, B., Krishna, P. and Eduardo, S., 2016, January. Factors Affecting the Choice, Intensity, and Allocation of Irrigation Technologies by US Cotton Farmers. In *2016 Annual Meeting, February 6-9, 2016, San Antonio, Texas*(No. 230199). Southern Agricultural Economics Association.

Reddy, R.N. 2010. *Irrigation Engineering*, Gene-Tech Books, New Delhi - 110 002.

Regassa E. Namara, Gebrehawaria Gebregziabher, Meredith Giordano & Charlotte De Fraiture 2013 Small pumps and poor farmers in Sub-Saharan Africa: an assessment of current extent of use and poverty outreach, Water International, 38:6, pp.827-839, DOI: 10.1080/02508060.2014.847777

Rogers, E.M. 1983. *Diffusion of Innovations*. 3rd edition. New York: Macmillan Publishing Co.Inc.

Rosenbaum, P. and Rubin, D., 1983. The Central Role of the Propensity Score in Observational Studies for Causal effects. Biometrika, 70(1), PP. 41-55.

Rosenbaum, P.R. and Rubin, D.B., 1985. Constructing a control group using multivariate matched sampling methods that incorporate the propensity score. *The American Statistician*, *39*(1), pp.33-38.

Seleshi, B.A., Erkossa, T. and Namara, R.E., 2010. Irrigation Potential in Ethiopia Constraints and Opportunities for Enhancing the System. *Colombo, Sri Lanka: International Water Management Institute. 59p*.

Sheahan, M., & Barrett, C. B., 2017. Ten striking facts about agricultural input use in sub-Saharan Africa.Food Policy, 67, 12–25. https://doi.org/10.1016/j.foodpol.2016.09.010.

Shiferaw Solomon and Mengistu Ketema, 2015. Impact of irrigation technologies on rural households' poverty status: the Case of Fogera District, North-Western Ethiopia. *Agris on-line Papers in Economics and Informatics*,7(1): pp.59-67.

Shimeles Aklilu, .2010. Research Achievement on Variety Development and Seed Production of Vegetable Crops in Ethiopia. Varietal Evaluation and Seed Production of Vegetable Crops held at AVRDC Africa Regional Program.

Sianesi, B., 2004. An evaluation of the Swedish system of active labor market programs in the 1990s. *Review of Economics and statistics*, *86*(1), pp.133-155.

Sinyolo, S., Mudhara, M. and Wale, E., 2014. The impact of smallholder irrigation on household welfare: The case of Tugela Ferry irrigation scheme in KwaZulu-Natal, South Africa. *Water SA*, *40*(1), pp.145-156.

Sithole, N.L., Lagat, J.K. and Masuku, M.B., 2014. Factors influencing farmer's participation in smallholder irrigation schemes: The case of Ntfonjeni rural development area. Journal of Economics and Sustainable Development, 5(22), pp.157-167.

Tedros, T. 2014. Contribution of Small-holders' Irrigation to Households Income and Food Security: A Case Study of Gum-selasa and Shilena Irrigation Schemes, Hintalowejerat, South-Eastern Zone of Tigray, Ethiopia. M.Sc Thesis, Mekelle University, Ethiopia. 88p.

Tesfa W, and Tripathi SK., 2015. Watershed management in highlands of Ethiopia: A Review. Open Access Library Journal 2(06):1.file.scirp.org

Tesfaye, A.; Bogale, A.; Namara, R.E.; Bacha, D. The impact of small-scale irrigation on household food security: The case of Filtino and Godino irrigation schemes in Ethiopia. Irrig. Drain. Syst. 2008, 22, pp.145–158.

Tolera, T., (2019). The Problems, Opportunities and Implications of Small-scale Irrigation for Livelihood Improvement in Ethiopia-A Review. Journal of Civil and Environmental Research, 9(12)

Tongul, H. and Hobson, M., 2013. Scaling up an integrated watershed management approach through social protection programmes in Ethiopia: the MERET and PSNP schemes. A New Dialogue: Putting People at the Heart of Global Development, 1516.

Tulu, H., 2014. *The Effects of Small-scale Irrigation on Rural Households' Income: The Case of Adami Tulu Jido Kombolcha District, Oromia National Regional State. A M.*

Sc (Doctoral dissertation, thesis Submitted to Department of Agricultural Economics School of Graduate Studies Haramaya University (HU)).

Wang, J., Klein, K.K., Henning Bjornlund, Lijuan Zhang & Wencui Zhang., 2015. Adoption of improved irrigation scheduling methods in Alberta: An empirical analysis. *Canadian Water Resources Journal/Revue canadienne des ressources hydriques*, 40(1), pp47-61

Woldegebrial Zeweld, Guido Van Huylenbroeck, Assefa Hidgot, M. G. Chandrakanth and Stijn Speelman, 2015. Adoption of Small-Scale Irrigation and Its Livelihood Impacts in Northern Ethiopia

Woldemariam, P. and Gecho, Y., 2017. Determinants of Small-Scale Irrigation Use: The Case of Boloso Sore District, Wolaita Zone, Southern Ethiopia. *American Journal of Agriculture and Forestry*, *5*(3), pp.49-59.

World Bank/OECD., 2016. World Bank national accounts data, and OECD national accounts data files. https://data.worldbank.org/. Accessed 10 Oct. 2019.

Worqlul, A.W.; Jeong, J.; Dile, Y.T.; Osorio, J.; Schmitter, P.; Gerik, T.; Srinivasan, R.; Clark, N. Assessing potential land suitable for surface irrigation using groundwater in Ethiopia. Appl. Geogr. 2017, 85, 1–13. [CrossRef]

Xie, H., You, L., Wielgosz, B., & Ringler, C., 2014. Estimating the potential for expanding smallholder irrigation in sub-Saharan Africa. Agricultural Water Management, 131, 183–193. https://doi.org/10.1016/j.agwat.2013.08.011.

Yalew Adane, 2010. *Integrated Watershed Development from Sustainable Livelihood Perspective*; The case of Terri Watershed in Delanta Woreda, Ethiopia, M.Sc Thesis, Addis Ababa, Ethiopia,2010.

Yamane, T. 1967. Statistics: An Introductory Analysis, 2nd Edution. New York: Harper and Row.

APPENDIX

HOUSEHOLD SURVEY QUESTIONNAIRE

The objective of this questionnaire is to collect data as input for the study entitled "**Participation in and Impact of Small-scale Irrigation Vegetable Farming on Household's Income in Dedo District Jimma Zone of Oromia National Regional State, South Western Ethiopia"**, with the sole purpose of contributing some effort in conducting research on the subject matter. Dear respondent, the result of this study will help rural development actors and policy makers to improve the small-scale irrigation practice so as to contribute its part in improvement of the livelihood of the rural society and economic growth of the country. Your responses are confidential. Therefore, you are kindly requested to provide genuine responses. Thank you for your time and cooperation!

General Identification information

Research site: Region: **Oromia** Zone: **Jimma** District______ Kebele ____________________

Name and code of Enumerator /Interviewer: ______________________ Mob: ________________

Date of interview: _______________________

Sample respondents' identification number: _______________________

Part 1. Demographic/Background information of the Household Head

1.1. Sex of the Household head: 1. Male 2.Female

1.2. Age: ________________years

1.3. Marital status: 1. Married 2. Unmarried

1.4. Can you read and write? 1. Yes 0. No

1.5 If you say "yes" what type of education do you have? 1. Formal 2. Informal

1.5.1. If you have formal education what is your Education level? _________ (grade)

1.5.2. If informal what type of informal education do you have? 1. Religious education 2. Adult education

1.6. Religion of the respondent 1. Muslim 2. Christian 3. Waaqeffata 4. Other (specify)

1.7. How many family members do you have including you? _____________

1.7.1. Could you please tell me their age characteristics?

No	Name of household member	Sex		Total
		Male	Female	
1	<10 years			
2	10-13 years			
3	14-16 years			
4	17-50 years			
5	>50 years			
	Total			

Part 2. Socio-Economic information of the household

2.1. For how many years you participate in farming activity? ___________years

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

2.3. If yes what is the size in ha? _______ha.

2.4. Do you have rented in/out your farm land? 1. Yes 0. No

2.5. If "yes" what is the size in ha? Rented in ______ha , Rented out _______ha.

2.6. Do you have your own oxen? 1. Yes 0. No, if yes how many oxen do you have? ______

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

2.8. If yes, can you tell me information on **livestock** in the following table?

Types of Livestock		**Number of Livestock you owned**
Cattle	Oxen	
	Cows	
	Bull	
	Heifer	
	Calves	
Sheep and Goat	Goat	
	Sheep	
Equines	Horse	
	Donkey	
Poultry	Chickens	

Part 3. Participation in irrigation practice and the extent of participation

3.1. Do you participate in small-scale irrigation farming practice? 1. Yes 0. No

3.2. If "yes" for how many years did you practice irrigation farming? ____________ (years)

3.3. Do you have access to irrigation water? 1. Yes 0. No

3.3.1. If yes, what is the main source of your irrigation water? 1. Hole 2. River 3. Well 4. Others

3.4. Do you have your own irrigable farm land? 1. Yes 0. No

3.5. If yes, please how many total ha of irrigable land do you have_________Hec? From this what amount of it did you cultivated in last crop season__________Hec?

3.6. Which small-scale irrigation type did you use? 1. Modern micro dam 2.Traditional river diversion 3. Motor pump 4.Treadle pump 5.Others specify (if any)

3.7. Did you use agricultural technology for your irrigation farming? 1. Yes 0.No

3.8. If your answer for the question above is "yes" what type of technology did you use? (More than one answer is possible) 1) Fertilizer 2) Improved seed 3) Row cropping 4) Motor pump 5) Pest/herb sides

3.9. How many times you produce per year on irrigable land? 1. Once 2.Twice 3. Three times 4.four times

3.10. How far on average is your farm plot from irrigation water source? _______ (walking minute).

3.11. How far is on average your farm plot from main road? _______ (walking minute on foot).

3.12. Please can you tell me information about vegetable crops you produce by using irrigation during 2018/2019 cropping season? (For SSI participant only)

S/N	Description of vegetable crop	How many times do you produce within a year?	Size of land cultivated in	
			Local measurement	Hectare
1	Cabbage			
2	Tomato			
3	Potato			
4	Carrot			
5	Turnip			
6	Pepper			
7	Garlic			
8	Onion			
9	Lettuce			
10	Beets			
	Other (please specify)			

3.13. If you are not using small-scale irrigation schemes, what are the main reasons for not using?

1. Shortage of land for irrigation 2. Lack of awareness about irrigation
3. Production input problems 4. Lack of oxen 5. Problem of sufficient irrigation water

Part 4: Institutional factors

4.1. Is there formal/informal social organization in your area? 1. Yes 0. No

4.2. Did you participate in formal or informal farmer organization/association? 1. Yes 0. No

4.2.1. If yes in which of the following you are member? (more than one answer is possible)

1. Farmer cooperative 2. Youth association 3. Religious association 4. Ikub 5 . Idir 6.WUA 7. others

4.3. what is your role in the association(s) in which you have membership?

1. Chair man 2. Member of board committee 3. Member

4.4. Could you indicate any benefits you gained by being the member of association:___

____

4.5. Do you get market information? 1. Yes 0. No

4.6. If yes, what is the source of information? 1. Intermediaries 2.Radio 3.From mobile 4.From development agents 5. From other farmers

4.7. Where do you sell your products? 1. Local market 2.On-farm 3. Regional market

4.8. How far on average is the nearest market from your irrigation farmland? _____ (hours on foot)

4.9. Do you face market problem for your irrigation product? 1. Yes 0. No

4.10.If yes, please specify ____

____

4.11. Do you get contact with development agent for farm advice? 1. Yes 0. No

4.12. If "yes" For how many times within a month do you get contact with DA? ________days per month?

4.13. What sort of extension services you get from them_______________________________

____

4.14. Did you use credit for your agricultural production? 1. Yes 0. No

4.15. If yes, did you have access to credit? 1. Yes 0. No

Part: 5 Income of the household

5.1. Would you give information about your crop production and income for 2018/19 production season **(December 2018- December 2019)**?

Type of Agricultural activity	Type of crop	Area cultiva ted (Hec)	Total production cost in ETB	Total production				
				Unit	Consumed		Sold	
					Amount	Price in ETB	Amount	Price in ETB
Irrigation	Cabbage							
	Tomato							
	Potato							
	Carrots							
	Turnip							
	Peppers							
	Garlic							
	Onion							
	Lettuce							
	Beets							
	Others							
	Others							
Rain-fed	Vegetables							
	Cabbage							
	Tomato							
	Potato							
	Carrots							
	Turnip							
	Peppers							
	Garlic							
	Onion							
	Lettuce							
	Beets							
	Others							
	Others							
	Cereals							
	Maize							
	Teff							
	Niger seed							
	Wheat							
	Bean							
	Pea							
	Sorghum							
	Others							
	Cash crops							
	Chat							
	Coffee							
	Fruits							
	Avocado							
	Papaya							
	Banana							
	Others							

5.2. Income generated from Livestock sell (December 2018- December 2019)

Types of Livestock		**Sold**		**Currently owned**	
		Quantity	**price**	**Quantity**	**Average price**
Cattle	Oxen				
	Cows				
	Bull				
	Heifer				
	Calves				
Sheep and Goat	Goat				
	Sheep				
Equines	Horse				
	Donkey				
Poultry	Chickens				

5.3. Income generated from Livestock output (December 2018- December 2019)

No	Commodity type	Unit	Amount produced	Consumed		Sold	
				Qt	Estimated price	Qt	Price in ETB
1.	**Dairy output**						
1.1	Milk						
1.2	Butter						
1.4	Cheese						
2.	**Poultry**						
2.1	Egg						
3.	**Honey bee**						
3.1	Honey						
3.2	Bees wax						
3.3	Bee colony						
4.	**Animal by-products**						
	Hide and skin						

5.4. Non-farm/off-farm income (December **2018-** December **2019)**

5.4.1. Do you participate in non-farm/off-farm activities? 1. Yes 2. No

5.4.2. If you say "yes" for above question please can you tell me the type of activity you practice and income you get from it?

No	Types of Non-farm/off-farm activities	Income Per day in ETB	Income Per month in ETB	Total income in a Year
1	Hire out labor			
2	Remittance income			
3	Self-employment			
4	Sale of Firewood/charcoal			
5	Sale of Handicraft			
6	Sale of beverages			
7	Chat trading			
8	Other petty trade			
9	Village shop			
10	Others			

GUIDING QUESTIONS FOR FOCUS GROUP DISCUSSION

1. How do you see the irrigation practice in your locality?
2. Is there any problem in participating in small-scale irrigation farming in your locality? So what will be the solution?
3. What do you think that the most important solution for the problems?
4. What do you think about the role of government and NGO in improving the current irrigation practice?
5. What type of irrigation water source do you think is more advantageous for the community in the area?
6. What is the extent of use of agricultural technologies in your locality? Is there access to agricultural inputs? How about farmer’s utilization for irrigation farming?
7. What are non-farm activities available in your area and how do you view its advantage related to irrigate farming?
8. What type of vegetable crop you think very important to generate income?
9. Is there credit access to use for agricultural input? How about its utilization?
10. Do you think that there is difference in annual income between irrigation user farmers and non-users in your area?

INTERVIEW GUIDE FOR KEY INFORMANTS

1. How do you see the status of irrigation practice in you district? What are the problem existed and what will be its solution?
2. What is the problem related with irrigated vegetable production in this district?
3. Do you think that irrigation vegetable farming is more profitable than other crop production?
4. What types of vegetable crops are produced in this district?
5. What is the trend of irrigation activity in the past years in the district?
6. What are the existing strategies in relation to agriculture in general and irrigation in particular and how do you view them?
7. How do you view the role played by Ethiopian government in irrigation development in the district?
8. What are important strategies for irrigation development in the area?
9. What are non-farm activities available in the district and in which farmers are more participate?
10. What do you recommend to improve the current performance of irrigation farming in the area?

Appendix Table 1: Conversion factors used to compute tropical livestock units

S/N	Animal Category	Tropical Livestock Unit
1	Oxen	1.1
2	Cow	1
3	Heifer	0.5
4	Bull	0.6
5	Calves	0.2
6	Sheep	0.01
7	Goat	0.09
8	Donkey	0.5
9	Horse	0.8
10	Mule	0.7
11	Poultry	0.01

Source: Stork *et al*., 1991

Appendix Table 2: Conversion factors used to compute adult-equivalent (AE)

Age Group (years)	Male	Female
< 10	0.6	0.6
10 – 13	0.9	0.8
14 – 16	1	0.75
17 – 50	1	0.75
> 50	1	0.75

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

Appendix Table 3: Multicollinearity test for continuous variables included in binary logit model

Variable	VIF
TOTLIVST	1.13
AGE	1.09
LANDSIZE	1.06
FARMDIST	1.05
EXTCONTACT	1.04
FMLSIZE	1.03
EDUCAT	1.03
MRKTDIST	1.03
Mean VIF	1.06

Source: survey result (2020)

Appendix Table 4: Contingency coefficient for discrete variables

	SEX	OXEN	MARKTI~O	CREDIT	OFFFARM
SEX	1.0000				
OXEN	-0.0844	1.0000			
MARKTINFO	0.0681	0.0602	1.0000		
CREDIT	0.0364	0.0111	-0.0088	1.0000	
OFFFARM	-0.0553	0.3991	0.0359	0.0281	1.0000

Source: survey result (2020)

Appendix Table 5: Propensity score distribution of covariates

DEPVAR	Coef.	Std. Err.	Z	P>z
SEX	.4329881	.6668777	0.65	0.516
AGE	.0043353	.0160082	0.27	0.787
EDUCAT	.156871	.063075	2.49	0.013**
FMLSIZE	.2706484	.1204984	2.25	0.025**
LANDSIZE	-.4946661	.2191908	-2.26	0.024**
OXEN	.2151805	.3956092	0.54	0.586
TOTLIVST	-.0377113	.1174809	-0.32	0.748
MARKTINFO	.1227477	.324344	0.38	0.705
MRKTDIST	-.0099285	.0050051	-1.98	0.047**
CREDIT	.5062023	.2942456	1.72	0.085*
FARMDIST	-.0826443	.0389404	-2.12	0.034**
OFFFARM	-1.38613	.3643751	-3.80	0.000***
EXTCONTACT	.4366206	.1536328	2.84	0.004***
_cons	-.2964784	1.356045	-0.22	0.827

Number of obs = 250
LR chi2(13) = 66.41 Prob > chi2 =0.0000
Log likelihood = -140.08181 Pseudo R2 =0.1916

Source: survey result (2020)

Appendix Table 6: Result of sensitivity analysis using Rosenbaum bounding approach
rbounds delta , gamma(1(.25)2)

Rosenbaum bounds for HHAINCOME (N = 250 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	22965	22965	21700	24240
1.25	0	0	21985	23950	20750	25275
1.5	0	0	21210	24750	19950	26160
1.75	0	0	20570	25475	19290	26920
2	0	0	20005	26080	18750	27600

Source: Field Survey (2020)

* 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 (a= .95)

CI- - lower bound confidence interval (a= .95) vif

Variable	VIF	1/VIF
LANDSIZE	1.13	0.885360
EXTCONTACT	1.09	0.921587
FARMDIST	1.06	0.943604
AGE	1.05	0.948878
MRKTDIST	1.04	0.965099
EDUCAT	1.03	0.968179
TOTLIVST	1.03	0.969779
FMLSIZE	1.03	0.970235
Mean VIF	1.06	

. pwcorr SEX OXEN MARKTINFO CREDIT OFFFARM

	SEX	OXEN	MARKTI~O	CREDIT	OFFFARM
SEX	1.0000				
OXEN	-0.0844	1.0000			
MARKTINFO	0.0681	0.0602	1.0000		
CREDIT	0.0364	0.0111	-0.0088	1.0000	
OFFFARM	-0.0553	0.3991	0.0359	0.0281	1.0000

. rbounds HHAINCOME , gamma(1(.25)2)

Rosenbaum bounds for HHAINCOME (N = 250 matched pairs)

Gamma	sig+	sig-	t-hat+	t-hat-	CI+	CI-
1	0	0	22965	22965	21700	24240
1.25	0	0	21985	23950	20750	25275
1.5	0	0	21210	24750	19950	26160
1.75	0	0	20570	25475	19290	26920
2	0	0	20005	26080	18750	27600

```
* 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 (a=  .95)
  CI-    - lower bound confidence interval (a=  .95)
```