THE CONTRIBUTION OF SMALL-SCALE IRRIGATION ON THE LIVELIHOOD OF SMALLHOLDER FARMERS: THE CASE OF MEREB-LEKE WOREDA, CENTRAL TIGRAY, ETHIOPIA

MSc THESIS

BY

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APPROVAL SHEET 1

This is to certify that the thesis entitled "The contribution of small-scale irrigation in the livelihood of smallholder farmers, the case of Mereb-Leke woreda: Central Tigray, Ethiopia" is submitted in partial fulfillment of the requirement for the degree of Master of Sciences with specialization in climate smart agricultural landscape assessment.

It is a record of original research carried out by Goitom Gebrihet Fikade Id. No GP CSALR/007/11, under my supervision; and no part of the thesis has been submitted for any other degree or diploma.

The assistance and help received during the course of this investigation have been duly acknowledged. Therefore, I recommended it to be accepted as fulfilling the thesis.

Yemiru Tesfaye (PhD)		9/10/2020
Name of major advisor	Signature	Date
Name of Co-advisor	Signature	Date

Approval Sheet 2

We, the undersigned, member of the Board of the final open defense by Goitom Gebrihet Fikade have read and evaluate his thesis entitled "The contribution of small-scale irrigation in livelihood of smallholder farmers, the case of Mereb-Leke woreda, Central Tigray Ethiopia" and examined the candidate. This therefore is to certify that the thesis has been accepted in partial fulfillment of the requirement for the degree of Master of Science.

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Name of External Examiner	Signature	Date
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Name of Internal Examiner	Signature	Date
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SGS approval	Signature	Date

DEDICATION

I dedicated this thesis document to my Father, Mother, brothers, sisters and my wife for tending me with love and for their wholehearted partnership in the success of my life.

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LIST OF AVRIVATIONS

FDRE……..... Federal Democratic Republic of Ethiopia

FTC ……Farmers Training Center

GDP…….Gross Domestic Product

MoARD……Ministry of Agriculture and Rural Development

NMTIP…….National Medium-Term Investment Program

SSI……Small Scale Irrigation

WOoARD……Woreda Office of Agriculture and Rural Development

MoWIE……Ministry of Water, Irrigation and Electricity

WSDP……..Water Sector Development Program

Abstract

About 95% of Ethiopian agricultural product is mainly produced by rural smallholder farmers with low production. The low agricultural production and productivity in Ethiopia is due to backward agricultural technologies and limited access to improved inputs. Farmers of those do not participate in irrigation have less knowledge on the importance of small-scale irrigation, they produce once a year and they are dependent on rainfed crop. The objective of the study was to evaluate the contribution of small-scale irrigation in improving the livelihood of households. Three-stage sampling technique was used to select sample respondents. Firstly the woreda and the kebeles were purposely selected due to potential of irrigation schemes. Secondly, the sample households were stratified into two groups of irrigation participants and non-participants. Finally respondents were randomly selected. 95% level of confidence interval was used. To analyze data, descriptive and econometric models in STATA software were used. Family size, size and owner ship of cultivated land, access to irrigation water source, distance to FTC and frequency of attaining training had significant effect for participating. Small-scale irrigation contributes for the increment of crop yields, livestock yields, changes in cropping system, introduction of new crop varieties, increase the consumption level, and enhance employment generation. The main findings of the research indicates that irrigation access enabled the sample households to grow crops more than once a year; to insure increased stable production, income and consumption. The study concludes that small-scale irrigation is one of the feasible solutions to secure household food needs in the study area.

Key word: Small-scale irrigation, livelihood, smallholder farmers, Merb-Leke

1. Introduction

1.1.Background of the study

Agriculture is considered as a key sector in Sub Saharan Africa since almost all rural households depend directly or indirectly on agriculture (OECD/FAO, 2016). Agriculture is a backbone of Ethiopian economy (Makombe *et al*., 2011). Most of the population in Ethiopia lives in highland areas, with 85 percent being rural and dependent on agriculture with a low level of productivity (MoA, 2011a; Bekele *et al*., 2012). Despite its economic and social benefits, production and productivity of different agricultural crops in Ethiopia is mostly on a small scale and average crop yield is very low, as compared to other developing countries (Awulachew *et al.,* 2010; Kalkidan *et al.,* 2016).

The economic development is influenced dominantly by the prospects of the agricultural sector in most of sub Saharan African countries. Since it play a significant role through its high share of GDP and employment, the sector prioritized in various development agenda in most of the countries in the region (OECD/FAO, 2016). Even though agricultural sector is an important sector in terms of employment, supplying food and generating foreign earnings in most of sub Saharan economies, the rural poverty rates remain high (Dercon & Gollin 2014).

Ethiopia is the second populous country in Sub Saharan Africa in which the performance of the overall economy is highly correlated to the agricultural sector (FAO, 2014b). Moreover, 83 percent of the total population sustain their livelihood through the employment opportunity created by the sector (CSA, 2013).Growths of overall economy, improvement in food security and reduction in poverty in Ethiopia in recent years are due to the growth in agricultural sector. The largest share of the agricultural output is due to crop production. Therefore, crop

production contributes to the agricultural output in particular and to the national economy as a whole (FAO, 2014a). According to (Teshome and Lupi, 2018), the average national GDP share of agricultural sector is 47.40%, over the past twenty four years (from 1993-2016). Even though the country has three main resources opportunity such as labor, land, and water for production, the agriculture sector is mostly dependent on rainfall and mainly small-scale; with backward farming system, low access to improved technologies and institutional support services. The great challenge to Ethiopia's national economy is its difficulty to produce sufficient amount of agricultural food and to provide adequate food to population (Samuel, 2006).

The low agricultural production and productivity is due to backward agricultural technologies and limited access to improved inputs that enhances for the increment of production and productivity in rural smallholder farmers (FDRE, 2010; Samuel, 2006). Agreement has been reached by the government and donors that any solution that reduces rural poverty has to focus on increasing the production and productivity of smallholder agriculture (FDRE, 2010). Access to fertilizer, improved technologies, farm credit and then increasing the growth of crop production and productivity are the major concerns of national strategy (Samuel, 2006). Even though the use of improved technology is important, drought and precipitation variability issues are critically important. To address these challenges as critical resource in agriculture, the contribution of irrigation water plays an important role in productivity and livelihood activities of farmers.

Globally, irrigation practice is one of the possible means of feeding the rapidly growing population in the world (Kalkidan *et al.*, 2016). Ethiopia is endowed with ample water resources with 12 river basins with an annual runoff volume of 122 Billion m^3 of water and an

estimated 2.6 - 2.65 Billion m^3 of groundwater potential (Makombe *et al.*, 2011; MoA, 2011a). Due to this, Ethiopia is considered to be the water tower of Africa (Makombe *et al*., 2007). Moreover, Even if the potential and actual irrigated area is not precisely investigated (Belay and Bewket, 2013), estimates of irrigable land in Ethiopia vary between 1.5 and 4.3 Million hectares (Mha), averaged about 3.5 Mha (Makombe *et al*., 2011). MoA, (2011a) reported about 10 - 12% of the total irrigable potential are currently under production using traditional and modern irrigation schemes.

In Ethiopia, agriculture is primarily rain fed; it depends on erratic and often insufficient rainfall. As a result, there are frequent failures of crop production (Abonesh *et al.,* 2006; Kalkidan *et al.,* 2016). Therefore, irrigation agriculture has the potential to stabilize crop production and mitigate the negative impacts of variable or insufficient rainfall. The development of irrigation and agricultural water management holds significant potential to improve productivity and reduce vulnerability to climactic volatility in the country (MoFED, 2010; Kalkidan *et al*., 2017).

Many researchers underline the importance of irrigation as a viable strategy to increase crop yields and to achieve food security in developing nations including Ethiopia where there is sufficient irrigation potential (Abraham *et al.,* 2015).

Irrigation has high contributions to food security, 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). Most of the time, irrigation

utilization greatly supports the livelihood of the non-irrigation users through employment opportunity; the daily laborers work in the irrigation farms of the irrigation users fully or partly (FAO, 2000)

The government has given an attention for the development of agriculture by applying effective technologies to use its potentials (MoFED, 2010). In addition, the present irrigation farms are practicing at minimal levels and lots of the small-scale irrigation projects have been performing below the necessary economic efficiency (Getaneh, 2011). Irrigation creates job opportunities to the locality; and can increase livelihood and the living standard of the society (Getaneh, 2011; Oni *et al.*, 2011).

1.2. Statement of the problem

Irrigation has significant contribution to agricultural production and productivity by increasing crop yields, and helps the smallholder farmers to improve the producing capacity and to get high income (Zhou et al., 2008). Irrigation is among the programs that have the contribution in the increment of agricultural production in a given country. It also helps the poor households to overcome the impacts of shortage and irregularity of rainfall by applying optimal water for irrigation crop, strengthening the base for sustainable agriculture, provide increased food security to poor communities through irrigated agriculture and contribute to the intensification of human nutrition (FAO, 2003).

Mereb-Leke Woreda, the study area in Tigray Region, Ethiopia is one of the drought prone districts in the region. This Woreda suffered from rainfall variability and become more difficult for the cropping of long growing season crop varieties. However, Mereb-Leke woreda is one of the woredas in Tigray region with an irrigation potential area of 3200 hectares which is still implementing the program with 1683 hectares (WOoARD, 2019). According to 2019

report of Office of Agriculture, this woreda has rivers, ponds, diversions, dam and wells. Because of the potential of the woreda in ground water, river, pond and dam, the regional government, the administrative office and Agricultural office of the Woreda gave great attention on small-scale irrigation in the kebeles having irrigation potential to increase agricultural production of the rural smallholder households. However farmers of the woreda still don't develop knowledge towards the importance of irrigation. Therefore, the importance of studying the contribution of Small-scale irrigation in the livelihood of smallholder farmers in this study area is that, this woreda is not well supported by sufficient studies in the contribution of SSI in livelihood of smallholder farmers. In addition to this, irrigation practices in this woreda provide the best opportunity to the government in developing modern small-scale irrigation.

There is an assumption of irrigation in improving the income of smallholder farmers. But there are not enough studies that indicate how much of the practice makes the households those participate in small-scale irrigation are better than the non-participant in the study area.

Therefore, this initiates the researcher to choose the study area, and to make clear the problems and to fill the gaps by identifying and evaluating the contribution of small-scale irrigation for the improvement of household livelihood and living standard.

1.3.Objectives of the study

The general objective

The overall objective of the study was to evaluate the contribution of small-scale irrigation in income of farmers in the study area.

Specific objectives

- To identify factors that determine farmers' participation in small-scale irrigation.
- To evaluate the contribution of small-scale irrigation in improving the income of households.

1.4. Research questions

This research will try to answer the following three basic and major questions.

1) What are the main factors that determine households' participation in small-scale irrigation?
2) How is the situation of irrigation participants in terms of income improvement when compared with their non-irrigation counterparts?

1.5. Significance of the Study

Achievement of the objectives that have been already listed above is an important tool for small-scale irrigation agricultural development. The study would be significant that will increase households' understanding and would create opportunity of participation in small-scale irrigation. This is because determining the contribution of small-scale irrigation to household income of SSI is very important for policy implementation. The study would give a clue for policy makers and planners towards major barriers of farm household's participation in small-scale irrigation and its contribution in increasing of household income in the study area. Development agents and agricultural experts will benefit from this study in knowing the main problems and opportunities of farmers in participation of small-scale irrigations. Generally, the significance of this study is that, it helps to provide realistic information on the

overall issues of small-scale irrigation development in the study area and for formulating future strategies on smallholder irrigation investment.

1.6. Scope and limitations of the Study

This study was scoped to one administration woreda, three kebelles and 344 respondents. The objective of this study was to estimate the contribution of small-scale irrigation in the livelihood of smallholder farmers. The study is thus subject to some limitations. For example, many data were highly dependent on the memory of the respondents because of the underdeveloped recording system in the country. Accordingly, some data particular in the quantitative data might be short of accuracies. Some respondents were also unwilling to give the correct response for some sensitive variables. Some secondary data at the woreda level are not clear and well documented. However, the study used the different data collection method, random sampling and the respondent consents in order to minimize the limitation, and ensure the reliability of the data and produce valid results.

2. Literature Review

2.1. Definitions and Concepts of Irrigation

Water is among the basic need for both human beings and animals. It is vital for their metabolic processes. According to MoWE, (2013), water is used to build healthy labor force, ensuring food security, provision of clean energy for agriculture, industry & service maintenance of healthy ecosystem, aesthetic value, transportation, hedge against climate change and variability catalyst . The most vital use of water in agriculture is for irrigation to produce adequate food. About one fifth of the world (about 1.2 billion people) live in areas of water shortage, which is inadequate water available to meet their day-to-day, needs (World Development Report, 2010).

According to FAO (1996), irrigated agriculture can be defined as the supply of water increased by artificial means, involving the use of water controls technology and including drainage to arrange excess water. Irrigation has been practiced in Egypt, China, India and other parts of Asia for a long period of time. Ethiopia also has a long history of traditional irrigation system (mainly diversion schemes). It allows farmers to increase crop production and achieve higher yields, food availability and affordability for non-irrigators and reduces the risk of crop failure if rain fails (Hussein and Hanjra, 2004). According to Zewdie et al., (2007), India and Far East have grown rice using irrigation nearly for 5000 years. Analysis in Asia indicates that irrigation contributes to increase yields per area, for most crops by between 100%-400%. This has contributed to a reduction in food prices. Irrigation plays great role to agricultural productivity through solving the precipitation scarcity, inspires agriculturalists to practice more of up-to-date inputs and harvest all over the year and generates employment to members of the households especially to wife and children (FAO, 2011).

According to Fuad, (2002) irrigation in Ethiopia can be classified in to three:

1. Small-scale irrigation which is often community based and traditional methods covering less than 200 hectares,
2. Medium scale irrigation which is community based or publicly sponsored, covering 200-3000 hectares and
3. Large scale irrigation covering more than 3000 hectares, which is typically commercially or publicly sponsored.

2.2. Definition and Concept of small-scale irrigation

Small-scale irrigation is type of irrigation that defined as schemes that are controlled and managed by the users. According to W. Bart (1996), small-scale schemes developed, operated and maintained by individuals, families, communities, or local rules and landowners, independently of government. Small-scale irrigation is a form of irrigation defined as irrigation, on small plots, in which farmers have the controlling influence and must be involved in the design process and decisions about boundaries (Tafesse, 2007).

2.2.1. Small-scale Irrigation and livelihood improvement

As various scholars like Burrow (1987) stated, smallholder irrigated agriculture was confirmed to be a viable and attractive alternative for poor farmers especially in developing countries. This study reviewed the economic contribution of small-scale irrigation on rural household livelihood improvement. Bhattarai et al., (2007) stated that, irrigation investment in India empowered farmers to increase diversification of crops.

Farmers in rural areas suffered from persistent poverty and food insecurity due to climatic changes and dependent on variable rainfall. This leads to low agricultural productivity. As

many low productivity areas did not use water resources, irrigation development is known as a backbone of agricultural productivity, improving food security, receiving higher incomes and increasing crop diversification (Smith, 2004). In many developing countries, small-scale irrigation schemes were considered as a means to increase production, reduce the risk of unpredictable rainfall and provide food security and engagement to poor farmers (Burrow, 1987).

According to MOFED, (2006), small-scale irrigation is a policy priority in Ethiopia for rural poverty alleviation, food security and growth. It supports households to generate more income, increase their resilience, and to transform their livelihoods. Small-scale irrigation in Ethiopia had an important role in diversification of production to new types of marketable crops like fruits, cash crops and vegetables (Eshetu , 2010). According to G/egziabher (2008), farm production in irrigation and rainfall-based areas of Tigray has large difference in their productivity. He has found that, the farm production produced based on irrigation was high due to post-harvest storage facilities, and doubling or tripling effects of irrigation while the rain-fed areas produced subsistence crops and encountered a chronic food deficit. A study conducted by Hagos et al. (2009) also indicated that, irrigation in Ethiopia increased yields per hectare, income, consumption and food security.

2.3. Irrigation Development in Ethiopia

According MoWIE (2012), modern irrigation was documented in the 1960s where the government designed large irrigation projects in the Awash Valley to produce food crops for domestic consumption and industrial crops for exports and it was strongly believed that rain fed agriculture should be supported by irrigation in order to attain national food self-sufficiency and confirm household food security. According to MoFED (2012), the total

irrigation potential in Ethiopia is 3,798,782 hectare but currently irrigation schemes have covered only 368,160 hectare, 10% of the potential.

According to MoWE (2012), Tigray Region has 300,000 hectares irrigation potential which is 4% of its surface area. The region has used only 2% of its irrigation potential. Therefore, it has huge unused potential of irrigation resources. According to Awulachew *et al*. (2007), the reasons for the poor development of irrigation in the region are fragmented and small farmland, political instability, lack of technologies, government owned land policy, lack of financial resources, and weak institutional set up in the region.

2.4. Determinants of Households participation in small-scale irrigation

Different studies were conducted to identify factors of irrigation participation in many countries including Ethiopia. According to Dillon (2011), household head education level, gender of the head, age of household head, landholding, livestock units, access to credit from financial institutions, farmland size, distance to the roads, distance to markets, distance to rivers, household sizes, access to market information, type of peasant associations and training are important factors influenced to participate in irrigation farming. Similar studies found that rural associations, information access are crucial tools to bring attitudinal change and encourage respondents to adopt new technologies through informal education, panel discussion, public meetings and other demonstrations (Nugusse, 2013). According to Asayehegn *et al*. (2011), farmers who are members of the formal and informal institutions such as water user association, peasant associations and local leadership, education are factors influenced to participate in irrigation farming. According to Epherm (2008) household food security in the north eastern part of Ethiopia were strongly associated with various socio-economic and bio-physical factors that influence the food security status of households were

age of household head, dependency ratio, size of cultivated land, total number of livestock owned, manure application, land quality and farmer's knowledge on the effect of land degradation on food security.

2.5. Irrigation techniques/methods

Irrigation methods are the system how to get water for irrigation purposes from its sources. It depends on water resources, rain water, topography, plants cultivated and growing seasons (Dupriez and De Leener, 2002). There are only two general methods of applying irrigation water; surface irrigation and sub-surface irrigation

2.5.1. Surface irrigation

Surface irrigation is the ancient methods of irrigation, which convey water from the survey to the fields in lined or unlined channels. It is the introduction and distribution of water in a field by the gravity flow of water over the soil surface. According to Widtose (2001), the key methods of applying water are basin irrigation, boarder irrigation, flood irrigation and furrows irrigation. One can choose these irrigation techniques on basis of the nature of the soil, the form of the land, the head of the water stream, the quantity of water available and the nature of the crop.

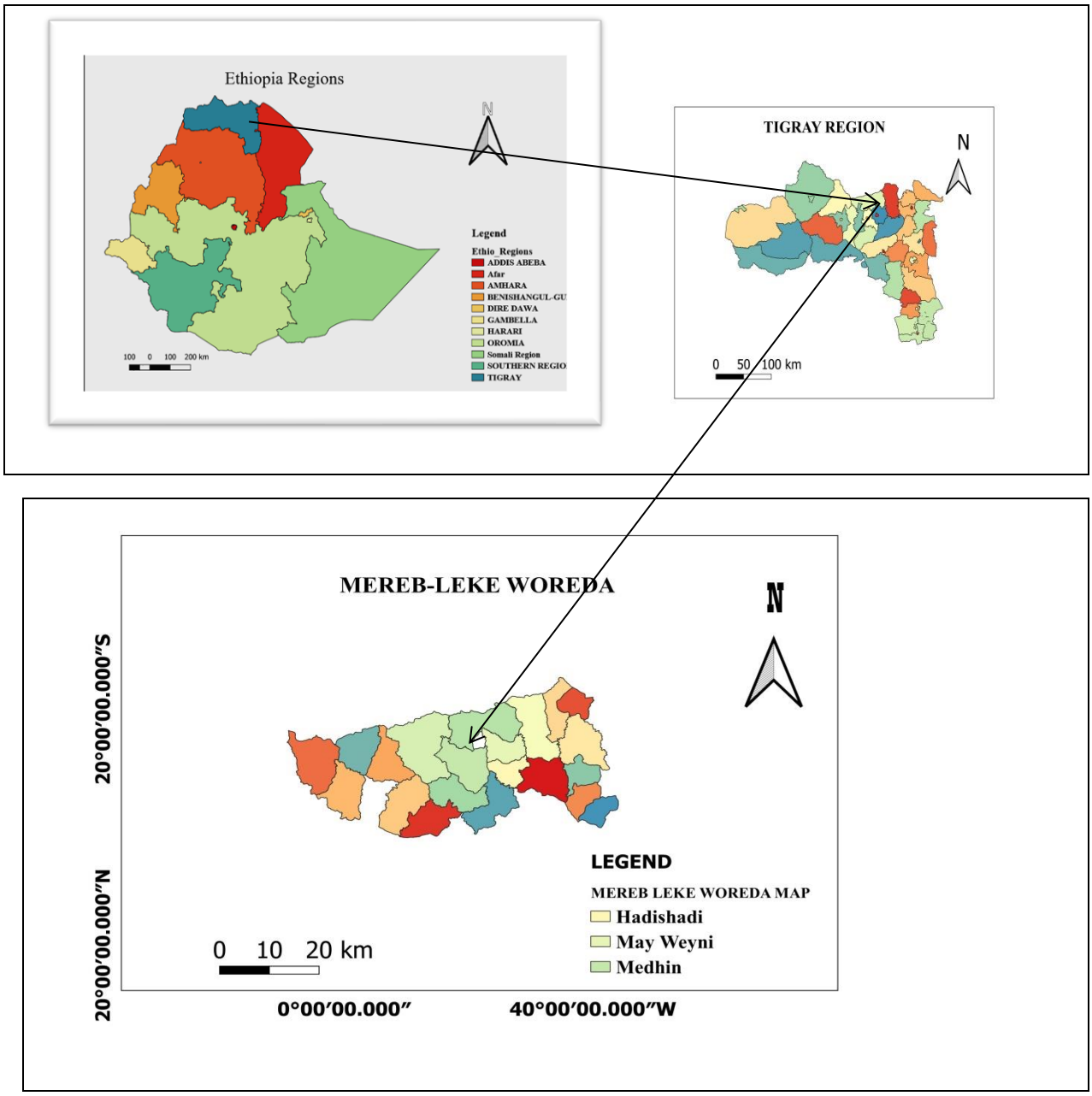
3. Materials and Methods

3.1.Description of the study area

The study area which is Mereb-Leke worda is one of the woredas in Tigray Region of Ethiopia part of the Central Zone that is bordered, Ahferom woreda to the East, , Tahtay Maychew woreda to the south west, Lailay Maychew woreda to the South west, Mereb River (which separates it from Eritrea) to the North, Adwa woreda to the South. Mereb-Leke woreda is located 14°24'48.0"N and 38°47'05.0"E .It is about 261 Km far from the capital city of Tigray Regional State, Mekelle. It has 21 rural and 4 urban Kebeles (Figure 1). According to Woreda Administration office (2019), Mereb-leke woreda is with a total population of 154,351.which is, Male 76,455 and 77,896 is Female. According to the Woreda Finance and Economic Development Office, the total house hold of the woreda in the year 2019 is 37,411(26827 male headed and 9927 are female headed). The Woreda has total 33,422 rural households with a total cultivate land of 30,283 hectares.

The study area (the woreda) has two agro-climatic zones - Mid Highland (Woyna Dega) and Low land (Kola). The main rainy season extends from late June to early September and distribution of the rainfall is however, with large variability, untimely and irregular in nature.

Figure 1 Location map of the study area



Source : Woreda Mereb_Leke office of Agriculture and Rural Development 2019

3.2. Sampling techniques and sample size

3.2.1. Selection of the study area

The study was in three kebeles of Mereb-leke woreda namely Medhn, Mayweyni and Hadush-Adi. These kebeles have relatively higher water potential and farmers in these kebeles have long history of traditional irrigation practices. Therefore, the kebeles have better irrigation activities that give opportunity to government in developing modern small-scale irrigation schemes and they are accessible in roads to market and thus better access to market

3.2.2. Sampling techniques

The three-stage sampling techniques were taken to select sample respondents. Firstly, Mereb-Leke Woreda was purposely selected mainly because of the area is relatively better for small-scale irrigation activities that gives opportunity to develop modern small-scale irrigation schemes. Out of the total 21 rural kebeles found within the Woreda; Medhn, May-weyni and Hadush-Adi was purposely selected mainly due to availability of irrigation schemes. Secondly, the sampling frame obtained from the kebeles office was stratified into two groups of small-scale irrigation participants and non-participants. For this study, participants are those households in the three Kebeles who use different irrigation sources such as, river diversion, dams and well. The non-participants are those households, in the same Kebeles, with no irrigation access from the scheme. Thirdly, 172 irrigation users and 172 non-users, 344 respondents were selected from 3295 total household in the selected kebeles randomly. Then the sample households were randomly selected from both groups.

3.2.3. Sample size

To determine the sample size (n), sample size determination formula was used as follows:

$n=\frac{z^2pq}{e^2}$, where, n=the sample size z= the value of the standard deviation at a given confidence level, q=1-p = statistical significance (acceptable error) p = the proportion in the target.

The researcher had used 95% level of confidence interval and 5% level of significance. Since the target population less 10,000, 50% is recommended to use in the target.

Thus, p = 50% = 0.5 and q = 1-p = 1-0.50 = 0.5(50%).

The total household of the selected 'kebeles' (N) is 3295 households.

Therefore, the sample size is given by:

$n= \frac{(1.96)^2\,(0.5)(0.5)}{(0.05)^2} = \frac{3.8416\ x\ 0.25}{0.0025} = \frac{0.9604}{0.0025} = 384.$ Then to find real sample size,

$n= \frac{n}{1+\frac{n}{N}} = \frac{384}{1+\frac{384}{3295}} = \frac{\frac{384}{3295+384}}{3295} = \frac{\frac{384}{3679}}{3295} = \frac{384X3295}{3679} = \frac{1{,}265{,}280}{3679} = 343.91 \approx 344$

Table 1 Proportional Sample Size Determination

Kebeles	No of HH	How to compute	Sample size		
			Users	Non-users	Total
Medhn	1524	1524*344/3295	80	80	160
May-weyni	932	932*344/3295	48	48	96
Hadish-adi	839	839*344/3295	44	44	88
Total	3295	$\frac{1524*344}{3295}+\frac{932*344}{3295}+\frac{839*344}{3295}$	172	172	344

Purposive selection of non-probability sampling technique was used in order to get further information from agricultural office, extension workers and local leaders since all do not have equal chance of selection to get main information from the key informants. At district level, agricultural office head, finance and economic development office head, cooperative process owner, crop and horticulture process owner, extension process owner food security process owner, water, mine and energy office head and horticulture expert were selected. At kebele level, Medhn kebele extension agents, May-weyni extension agents and Hadush-adi extension agents were selected purposely. For group discussion 15 model farmers 5 each kebele were selected.

3.3. Data collection methods

Primary data were collected from farmers through household survey. Formal survey data collection was conducted on the sample households with the structured questionnaires in each selected kebele. Information about small-scale irrigation and socio-economic aspects related to, farmers' management strategies of irrigation practices, family size, age, educational status, farm size, and labor requirements were collected. Secondary data such as , irrigation potential of the woreda, population, area of cultivated land and location of the study area were collected from annual, five year and ten year reports of relevant government offices, journals, and books relevant to the area of study.

3.4. Data analysis

The data was entered into STATA and SPSS software for investigation and both descriptive and econometric models were used to analyze the data. The categorical variables such as sex of households, educational level, accesses to farmland, accesses to water source, frequency of

training, use of credit and owner ship of farmland were analyzed using chi-square. Whereas the continuous variables such; age of households, family size, farmland size and distance to farmers training center (FTC) were analyzed using one-way ANOVA. It is important to measure additional incomes (factors) that influence the income of both irrigation users and non-users such as production of field crops per hectare and livestock obtained from field crop and irrigation.

The income and consumption level of both irrigation users and non-users was analyzed using one-way ANOVA. The change in crop production and livestock production was analyzed using paired t-test to know the production differences.

The contribution of small-scale irrigation in improving the livelihood of households using linear regression analysis can lead to biased estimation if the underlying process which governs selection into small-scale irrigation is not added in the empirical framework. The reason for this is that the effect of the program may be over or underestimated if the program participants are more or less able to derive benefits compared to non-participants (Zaman, 2001). Therefore, the Heckman two-stage estimation procedure, which assumes a probit in the first step and ordinary least square (OLS) in the second step, is recommended to detect and avoid sample selection biasness (Heckman, 1979). If its coefficient is statistically significant, the selection biasness's are confirmed (Heckman, 1979; Greene, 2000). Then the model was specified as the following:

Participation /probit equation $z_i^* = \sum_{k=1}^{k} yk\ wki + u_i$ ……. (1)

Where, z_i^* =participation decision which has dichotomous realization on unobserved *Zi*,

yk = unknown parameters of the *k* variables, *wki* = variables determining probability of participation in small-scale irrigation utilization u_i = disturbance term

Inverse miller's ratio/lambda is calculated as

Then after calculating the lambda it included in the outcome equation if it is significant, unless otherwise the model will be inappropriate or there is no selection bias. In this case OLS is appropriate model.

Outcome /selection equation $\gamma i = \sum_{s=1}^{s} \beta i \times si + \varepsilon\, i$ …….... (3)

Where, γ_i = the observed value of household income, χ_{si} = s variables determining household income, β_s = vector of unknown parameters of the household income and ε_i =error term

γ_i is observed only if $z_i^* > 0$ and the disturbances ε_i and u_i follows a normal distribution with zero means and constant variances and covariance's which is $\sigma_{u\varepsilon}$.

3.5. Operational Definition and Description of variables

Different variables are expected to affect rural households' decision participation in small-scale irrigation schemes and level of income from small-scale irrigation in the study area. The variables were hypothesized to influence participation decision in small-scale irrigation and livelihood improvement status is explained in this section.

3.5.1. Demographic and Socio-Economic Variables

Sex of the household head: Nokuphiwa L *et al*. (2014) stated that, sex of household head is a dummy variable 1 if male and 0 if female and is expected to determine the difference in decision to participate in smallholder irrigation schemes between male and female household

heads. According to Nokuphiwa L *et al*. (2014), males are expected to have a high probability of participating as compared to females because they make the final decisions in the households. On the other hand women are sometimes discriminated to access to land and are often occupied with other household's activities hence the probability of them to participate is very low. According to Bradshaw (2006) gender is an important determinant in technology adoption. Men often control household finances and decisions regarding purchases of agriculture technology and inputs (Bradshaw, 2006). According to Bradshaw (2006), male household heads are expected to have higher income compared to female household heads because of better labor inputs used and with regard to farming experience. Male headed farmers are also better than the female headed farmers since it is assumed that male household heads have more exposure and access to information and new interventions than female household heads, which might enable them to participate in the small scale irrigation as early as possible and their income is higher than their counterpart.

Age of a household head: According to Sithole *et al.* (2014), age is a continuous variable. Previous empirical studies found a two way relationship between age and participation in irrigation scheme as well as other agricultural technologies. Sithole *et al.* (2014) stated that, younger household heads are more dynamic with regards to adoption of innovations than older household head; however they are usually more occupied with other job opportunities as compared to farming. Age is a continuous variable measured in years. It is one of the factors that determine decision making of a person. Previous studies found a two way relationship between age and decision to participate in irrigation scheme and other agricultural technologies. Diederen *et al*. (2003) also found that younger farmers are more innovative and open to technological advances and be more willing to adopt a new technology. Therefore, this

study was hypothesized relationship between age of the household head and participation in irrigation scheme.

Education level of a household head: This is a continuous variable measured in formal schooling years completed by the household head. That is the number of years of schooling attained by the sampled households' heads up to the time of the survey. According to Feder *et al*. (1985), farmers with more education have been shown to adopt modern agricultural technologies sooner. Most previous studies indicated that the possibility to adopt and apply new methods of farming increased along with education level is suggested to have a positive effect on participation since it enables an individual to make independent choices and to act on the basis of the decision, as well as increase the tendency to co-operate with other people and participate in group activities (Etwire. *et al*., 2013).

Family size: is a continuous variable indicating the number of people who live and eat together. This variable is expected to positively influence farmers' participation. Household size serves as a form of family labor and complements the effort of the household heads on the farm (Martey. *et. al.*, 2013). The availability of family labor provides the household head the opportunity to share responsibility and save time for other development activities. Also, larger households spend more on food and other household needs and hence the need for external support. This is continuous variable measured in total number of the household members living under the same roof adjusted to adult equivalent. According to Shimelis, (2009) household with large labor force can participate in small-scale irrigation more than a household with small- number of labor force.

Cultivated land holding: This is a continuous variable measured in hectare and it refers to the total cultivated land size of the household heads. It was hypothesized the household's farm size and the probability of cultivated land size to adopt small-scale irrigation technology. Total cultivated land should have a positive relationship with income of a household (Kamara *et al*., 2001).

Distance to farmers training center: This is a continuous variable measured in kilometer. The necessary information can be gained from training, demonstration or workshop, and through mobile, TV and radio. Therefore this study was measured the influence of distance of farmers training center in participating of farmers in small-scale irrigation.

3.5.2. Institutional Factors

Frequency of getting extension service: frequency of getting extension service is categorical variable referred to the frequency of contact that households made with extension agent per year. The researcher will assess the frequency of contact with extension workers by separating into three-point scale. 1= none, 2 = twice a year, 3 = quarterly (every three months), 4 = every month. According to Tizita Damtew (2017), farmers contact more with development agent have better knowledge about extension packages including irrigation technology than the others .This enables them to enhance production, which is one of the condition of food security. Bacha et al. (2011) found significant difference between irrigators and non-irrigators in access to extension.

4. Result and discussion

4.1. Characteristics of Sample Households

In the first section, the sample households' demographic characteristics (Table 2) such as sex of the household heads, family size, age of the household head, educational level, access to cultivated land, cultivated land size and use of credit and frequency of getting training are discussed

Sex of HH: Based on the sample household collected, 172 of the households are irrigation users with 162 male headed and 10 female headed and 172 households are non-users with 153 male headed and 19 Female headed (Table 2). According to the analyses, sex of HH has not a significant effect on the probability of households to participate in small-scale irrigation.

Family size: According to the analyses the minimum and maximum family size of irrigation users are 1 and 11 respectively with an average family size of 6.337 whereas the minimum and maximum family size of non-users are 2 and 11, respectively, with an average family size of 6.906 (Table 3). The average family size of the total respondents was 6.6.22 with a minimum 1 and maximum of 11 in the study area (Table 3). Family size is useful for formulating various development plans and for monitoring and evaluating their implementation. The p-value shows that family size has significant effect on participation in small-scale irrigation at a 5% level of significance (Table 4).This study is similar with Gebrehiwot Yihdego, (2015) who states that, households with large family size are more likely to be motivated to participate than households with small family size. Participation in irrigation requires more labor force as a result households with larger family size has cheaper labor that encourage them to practice in small-scale irrigation.

Age of household head: In the study area the minimum age of the head of HH irrigation users is 26 and 68, respectively, with the average age of 46.92 whereas the minimum and maximum age of the non-users is 29 and 67, respectively, with the average age of 45.319 (Table 3). According to the finding, age of the household head has no significant effect for participating in small-scale irrigation at a 5% level of significance (Table 3).This finding match with Muez Haileleul Aregawi (2014) who stated that, the age difference between the two groups is found to be statistically insignificant suggesting age has no influence on the participation decision.

Educational level: In the study area the educational background of the total respondents users and non-users) shows that, 147(42.73%) are illiterate, 186 (54.07%) of the respondents are elementary completed and 11(3.20%) are secondary school (Table 2).The educational level of irrigation user households 70 (40.7%) are illiterate, 95(55.23%) are elementary, and 7(4.07%) are secondary school (Table 2).The educational level of non-user households 77(44.77%) are illiterate, 91(52.91%) are elementary, and 4 (2.33%) are secondary school (Table 2). According to the analyses, educational level of household has not significant effect for participating in small-scale irrigation at a 5% level of significance (Table 2)

Access to cultivated land: According to the analyses, 147 (85.47%) of the irrigation users have farmland, 25 (14.53%) have not, 25 (14.535) of the irrigation users rent farmland for the purpose of irrigation. 153(88.95%) of the non-users have farmland, 19 (11.05%) have not their own farmland, 15(8.72%) of non-users those who have not their own farmland share farmland for the purpose of rainfed crop production and 4 (2.33%) of them rent farmland for rainfed

crop production (Table 2). Access to cultivated land has no significant effect for households to participate in SSI at 5% significant level (Table 2).

Cultivated land size: According to the analyses, the maximum cultivated land size of the irrigation users is 1.5 hectare with an average cultivated land size of 0.678 hectare and the non-users have maximum cultivated land size of 1 hectare with an average land size of 0.784 hectare (Table 2). Size of cultivated land has a significant effect for smallholder farmers to participate in small-scale irrigation at 5% level of significance (Table 3). The result shows that, respondents with large cultivated land size have an opportunity to participate in small-scale irrigation. However farmers with small land size have less capacity to participate in small-scale irrigation due to the need of farmers to intensify crops in a parcel of land. This finding is similar with Woldemariam, (2017) which stated that, the variation in the land holding size between two groups has its own implications on the utilization of irrigation water; better land holder farmers have better chance to use irrigation.

Frequency of getting training: According to the analyses, the maximum frequency of training on the irrigation users is 5 and the minimum training frequency is 3 and the average training frequency is 4.738. While the frequency of training non-users is minimum of 2 times and maximum of 3 times a year with an average frequency of 0.982 (Table 3). 8(4.65%) of the irrigation users get a frequency of 3 times, 29(16.86%) of them 4 times, 135(78.49%) of them get 5 times. 3(1.74%) of the non-users get a frequency of 2 times, 169 (98.26%) of them get 3 times (Table 2). From the total respondents, 177(51.45%) of them get a training that is 3 times a year, 135(39.24%) of them get 5 times a year, 29(8.43%) of respondents get 4 times and 3 respondents get twice a year (Table 2). According to the analyses, frequency of getting

training has significant effect for smallholder farmers to participate in small-scale irrigation at 5% level of significance (Table 2). Farmers those who get high training frequency have higher capability to participate in small-scale irrigation than those who get less frequency.

Table 2. Categorical variables that determine Small-scale irrigation participation

Variables	Category	Irrigation users		Non-users		$\chi 2$
		Count	%	Count	%	
Sex of households	Female	10	5.81	19	11.04	0.081
	Male	162	94.18	153	88.95	
Accesses to farmland	No	25	14.5	19	11.04	0.51
	Yes	147	85.46	153	88.95	
Ownership of farmland	Own and cultivated	147	85.46	153	88.95	.000*
	others but cultivated and sharing the output	0	0	9	5.23	
	Others but cultivated by rent	25	14.53	5	2.90	
Access to irrigation water source	No	0	0	167	97.09	.000*
	Yes	172	100	5	2.90	
Frequency of production per year	Once	64	37.2	172	100	.000*
	Twice	107	62.2	0	0	
	Three times	1	0.58	0	0	
Educational level	Illiterate	70	40.69	77	44.76	0.539
	Elementary school	95	55.23	91	52.90	
	college/university graduate	7	4.06	4	2.32	

Ownership of cultivated land: This is a dummy variable that has a significant effect on participation in SSI at 5% significance level (Table3). According to the analyses, farmers who have their own farmland have higher opportunity to participate in small-scale irrigation. **Access to water source:** Availability of irrigation water determines the participation of smallholder farmers to small-scale irrigation. According to the results, access to irrigation water source has a significant effect on participation of smallholder farmers in SSI at 5% level of significance (Table 2). Farmers who have irrigation water source have opportunity of participating than those who don't have access. This result is similar with the finding of Adekunle, O. A.; et al (2015) which stated that, participation of farmers in irrigation is so much dependent on the availability of water.

Distance to farmers training center (FTC): In the study area, the maximum distance to the FTC is 15 km and the minimum distance is 0.3 km with the average distance of 9.139 km (Table 3). According to the analyses, distance to farmers training center has a significant effect to participate in SSI at 5% level of significance (Table 3). This analyses shows that, farmers near the FTC attains frequent training about irrigation and they have higher opportunity to participate in irrigation. In addition to the response of sample farmers, group discussion and key informants have supported the result.

Table 2. Continuous variables that determine participation in Small-scale Irrigation

Descriptive								
Continuous variables		Obs.	Mean	Std. Dev	Std. Error	Min	Max	Sig.
Age of households	Irrigation users	172	45.32	7.998	.6099	29	67	
	Non-users	172	46.92	10.11	.7713	26	68	.104
	Total	344	46.12	9.140	.4928	26	68	
Family size	Irrigation users	172	6.90	1.748	.1333	2	11	
	Non-users	172	6.33	1.991	.1519	1	11	.005
	Total	344	6.62	1.892	.1021	1	11	
Size of farmland	Irrigation users	172	.7848	.3401	.0259	0	1	
	Non-users	172	.6787	.3622	.0276	0	1.5	.005
	Total	344	.7318	.3548	.01913	0	1.5	
Frequency of getting training	Irrigation users	172	2.983	.1313	.0100	2	3	
	Non-users	172	4.738	.5365	.0409	3	5	.000
	Total	344	3.860	.9618	.0519	2.0	5.0	
Distance to farmers training center (Km)	Irrigation users	172	10.83	3.338	.2546	2.0	15.0	.000
	Non-users	172	7.447	3.767	.2873	0.3	15.0	
	Total	344	9.139	3.937	.2123	0.3	15.0	

Frequency of getting training: The result shows that, frequency of attaining training has a significant effect in participating in irrigation at 5% level of significance (Table 4). The highest the household gaining training the more participate in SSI. This finding is similar with Gebrehiwot Yihdego, (2015), stated that, extension service plays a great role in obtaining and getting of all the advices, training with all the agricultural activities performed by the farm households and households with more extension service are more likely to participate than with less extension service provision of their counterparts.

4.2. Contribution of SSI in improving the livelihood of smallholder households

In this objective the main contribution indicators of SSI for the improvement of livelihood of smallholder farmers are; crop yield before and after irrigation, production of livestock before and after irrigation, change of cropping system, introduction of new crop varieties, comparison between consumption of irrigation user and non-user households, comparison of irrigation users and non-users total income, comparison of market supply of irrigation users and non-users.

Rainfed crop production before and after irrigation: The average yield of irrigation user households before the starting of irrigation is 998.66 kg and the average crop yield of households after the starting of irrigation practice is 1144.55 kg (Table 4). The mean yield difference is 145.89 kg (Table 4). The result indicates that the change in yield after participating in irrigation was 145.89 kg. The paired t-test result shows that, the mean difference of rainfed crop before and after irrigation is significant at 5% level of significance (Table 4). This is due to the knowledge of applying different inputs such as commercial fertilizers, improved seed and chemicals and the capacity to buy these inputs.

Table 3 Change of Crop Production Comparison using paired t-test

Paired Samples Statistics

Yield comparison	Mean	Obs.	Std. Dev	Std. Error Mean
Yield of total rainfed crops before irrigation in kg	998.663	172	676.3271	51.5695
Yield of total rainfed crops after irrigation in kg	1144.558	172	726.2272	55.3743

Paired Samples Correlations

	Obs.	Correlation	Sig.
Yield of total rainfed crops before irrigation in kg & Yield of total rainfed crops after irrigation in kg	172	.636	.000

Paired Samples Test

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Yield of total rainfed crops before irrigation in kg - Yield of total rainfed crops after irrigation in kg	-145.89	599.66	45.724	-236.152	-55.6387	-3.191	171	.002

Production of livestock before and after irrigation: The average livestock holding before irrigation is 18.69 and the average livestock production after irrigation is 25.44 (Table 5).The mean difference of livestock before and after irrigation is 6.74 livestock per household. According to the paired t-test result, the mean difference of livestock holding before and after irrigation is significant at 5% level of significance. According to the focus group discussion, population of livestock increases due to availability of feed in the irrigation farm. Focus group also discussed that, after the starting of irrigation, smallholder farmers have been developed the ability of buying livestock through the income from irrigation.

Table 4 Change of Livestock Production Comparison using paired t-test

Paired Samples Statistics

	Mean	Obs.	Std. Dev	Std. Error Mean
Total Live stock before irrigation	18.698	172	18.4071	1.4035
Total Live stock After irrigation	25.442	172	18.2046	1.3881

Paired Samples Correlation

	Obs.	Correlation	Sig.
Total Live stock before irrigation & Total LS After irrigation	172	.338	.000

Paired Samples test

	Paired Differences					T	df	Sig. (2-tailed)
	Mean	Std. Dev	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Total Live stock before irrigation - Total Live stock After irrigation	-6.7442	21.0653	1.6062	-9.9147	-3.5736	-4.199	171	.000

Change of cropping system: Out of the total irrigation users (172), 171(99.42%) households produce new crops after the starting of irrigation (Table 6). From 172 irrigation user households, 171(99.42%) of the respondents change the late crops (Sorghum, Finger millet and Teff) to the improved variety crops especially irrigation crops such as onion, tomato, lettuce, Swiss chard, cabbage and fruits (Table 6). All the households that participate in irrigation have changed the cropping system from rainfed crops to market-oriented crops (vegetables and fruits) (Table 6). Irrigation use enables smallholder farmers to develop the custom of using different inputs to increase yield of commodities. Increasing yield increases income of households and thus improves their livelihood. The analyses shows that 172 i.e. all the households those participate in irrigation, have developed the custom of using different agricultural inputs. Small-scale irrigation enables smallholder farmers to produce twice a year and increases the profitability of agriculture. From the total respondents those who participated in irrigation, 139(80.81%) produces twice a year (Table 6). At the study area, small-scale irrigation has higher contribution for the introduction of high yielding crops since there is water availability. According to the analyses, 164 (95.35%) respondents from the total 172 irrigation have introduced high yielding crops (Table 6).

Table 5 Changes of irrigation users after the starting of irrigation

Changes	Category	Freq.	Percent
New crops production	No	1	0.58
	Yes	171	99.42
	Total	172	100
Crop ignorance	No	1	0.58
	Yes	171	99.42
	Total	172	100
Change of cropping system	No	0	0
	Yes	172	100
Practice of input application	No	0	0
	Yes	172	100
Production of crops twice a year	No	33	19.19
	Yes	139	80.81
	Total	172	100
Production of high yielding crops	No	8	4.65
	Yes	164	95.35
	Total	172	100

Household consumption comparison: Household consumption refers to the ability of the household to produce or buy a basket of goods containing the minimum quantity of calories and non-food commodities. Small-scale irrigation enables households to increase their consumption level since irrigation increase the income of individual households. The result shows that, the average annual food consumption level of irrigation users is 37,842.13 ETB. However the average annual food consumption of the non-irrigation users is 27,326.29 ETB (Table 8). The mean difference is 10,515.84 ETB per household. Therefore, irrigation user household consumption level is better than the non-user's by 10,515.84 ETB annually. However the result is insignificant, the irrigation users increase their consumption level due to the increase in income. The maximum expenditure for food is 98732 ETB while the non-users

expenditure is 66,947 ETB (Table 7). The difference is 31,785 ETB. However, the result shows that the mean difference is insignificant.

Consumptions other than food are clothes for adults and kids, access to energy for cooking food, soap, ornament, blanket & sheets, transport fee, house goods, school fee, tax, health care, fee for students, etc. The analyses show that, the average non-food consumption of the irrigation users is 12,296.15 ETB whereas the non-users mean consumption is 10,077.62 ETB (Table 7). The mean difference is 2,218.53 ETB. This result indicates that small-scale irrigation has a contribution of households to increase their expenditure towards the non-food consumption. Since small-scale irrigation increases the income of households, they develop their capacity to buy different non-food commodities. According to the result, the maximum consumption for irrigation users is 72,280 ETB while the maximum consumption level is 16,150 ETB (Table 7).

Table 6 Household Consumption Comparison

Descriptive								
		Obs.	Mean	Std. Dev	Std. Error	Min	Max	Sig.
Household food consumption in ETB	Non-users	172	27326.28	10061.63	767.19	15515	66947	.065
	Irrigation users	172	37842.13	73945.64	5638.30	11200	98732	
	Total	344	32584.21	52954.74	2855.12	11200	98732	
Household consumption other than food in ETB	Non-users	172	10077.62	14936.99	1138.93	2900	16150	.110
	Irrigation users	172	12296.15	10308.20	785.99	1730	72280	
	Total	344	11186.89	12862.35	693.49	1730	161500	

Source: Own computed from survey 2020

Irrigation enhanced employment opportunities: Among the many contribution of small-scale irrigation, employment generation is important. At the study area irrigation users employ more daily labor than that of non-users. The result shows that, 89 (25.9%) of the irrigation users hire daily labor (Table 8). However 164 (47.7%) of the non-users don't hire daily labor instead they use family labor and support friends (Table 8). The analysis shows that, irrigation users employ more labor than that of non-users and it is significant at 5% level of significance. This finding is similar to the result of Adugna et al., (2014) that they have stated that, the beneficiaries of irrigation have shifted from once a year (rainy season) to two and three harvests and labor use efficiency were improved due to irrigation.

Table 7 Labor Employment

		Non-users		Irrigation users		Chi-square
		Count	%	Count	%	
Labor employment	Use own family labor	12	3.5%	4	1.2%	.000*
	Hire labor	8	2.3%	89	25.9%	
	Support with friends	152	44.2%	79	23.0%	

Income comparison between irrigation users and non-users

According to the analyses, the mean income of irrigation users from irrigation production, rainfed agriculture crop production, livestock production and livestock output such as milk, meat, egg is 161,262 ETB. However, the non-user households have an income of 95,463 ETB (Table10). Irrigation users mean income is greater than that of non-users by 65,799 ETB. The result shows, the income of irrigation users is better than that of non-users and it is significant at 5% level of significance (Table 9).

Table 8 Household Income Comparison

Descriptive								
		Obs.	Mean	Std. dev	Std. Error	Min	Max	Sig.
Income from Irrigation in ETB	Non-Users	172	0.000	0.0000	0.0000	0.0	0.0	
	Irrigation users	172	55172	44466.34	3390.52	0.0	305520.0	.000
	Total	344	27586	41820.76	2254.82	0.0	305520	
Income from rainfed crop production in ETB	Non-Users	172	14761	6221.88	474.41	0.0	41200	
	Irrigation users	172	18142	12754.00	972.48	0.0	86000	.002
	Total	344	16451	10161.75	547.88	0.0	86000	
Income from live stock in ETB	Non-Users	172	80702	39498.59	3011.7	1960	252600	
	Irrigation users	172	85257	54565.08	4160.5	0.0	445050	.376
	Total	344	82979	47616.49	2567.3	0.0	445050	
Total Income in ETB	Non-Users	172	95463	42525.19	3242.5	196000	278200	
	Irrigation users	172	161262	78403.35	5978.1	19500	515767.5	.000
	Total	344	128362.93	71075.030	3832.1	1960	515767.5	

Source: Own computed from survey 2020

5. Summary and Conclusion

5.1. Summary

The objective of this study was to identify determinant factors for irrigation use and assess the contribution of small-scale irrigation in improving the livelihood of small holder farmers. The study was conducted at Mereb-leke woreda; Medhin, May weyni and Hadush-adi kebeles. The selection Woreda and kebeles was purposively on the basis of the irrigation potential.

The finding of the study describes family size, cultivated land size, ownership of cultivated land, access to irrigation water source, distance to farmers training center and frequency of getting training are the major factors that significantly influence the probability of rural households to participate in small-scale irrigation. These all variables positively influenced the irrigation participation of the household heads in the study area. According to the analysis, the change in rainfed crop production and livestock production and the change in cropping system are indicators for the contribution of irrigation in increasing the income of households.

5.2. Conclusion

The main contribution of SSI for the improvement of the livelihood of smallholder farmers are increasing the yield of crop and livestock production, change of cropping system to cash crop, introduction of new better yielding crop varieties, and employment generation.

Finally, the result of this study indicates that small-scale irrigation development has a positive impact on livelihood improvement of rural households.This suggests that small-scale irrigation has an important role on rural household income. According to the analysis the income and

consumption of participants is better than non-participants. Generally households who are engaged in small-scale irrigation have better life style than that of households who don't.

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Annex 1. Research Questioner

The contribution of small-scale irrigation in the livelihood of smallholder farmers at Mereb-Leke Woreda, Central Tigray, Ethiopia

Household Interview guide

Name of respondent	
Kebelle	
Got	
Name and surname by which homestead is known	
Cell phone number of respondent	

Section One: Household Demographics

1.1 Households composition, education and occupation. (Please fill all your family members in the given table by using codes given below the Table)

No	Name	Sex	Age (year)	Marital Status	Relation-ship To HH- head	Years of schooling	Major occupation	
							Primary	Secondary
1								
2								

Variable codes; Sex:1=Male 2=Female Marital status:1=Single 2=Married 3=Divorced 4=Widowed 5=others_____ Relationship to household head: 1=Head 2=Husband 3=Wife 4= Daughter 5= Son 6=Grandchild 7=Parent 8=Laborer 9=Sister 10=Brother11=Step child 12= others_____ Years of schooling: 0=Illiterate 1=Religious school 2= 1stgradecomplete 3=2ndgrade complete 4=3rdgrade complete

5=4thgrade complete 6=5thgrade complete etc. Occupation: 1=Farmer 2=Trader 3=Housewife 4=Construction 5=Weaving 6=Carpentry 7=Student 8=herding 9=others (specify) _____

Section Two: Household assets

2.1. Land owned

2.1.1. Please list the land owned by your family and fill the codes for use of plot and, soil quality and slope of land from the variable code given under the table.

No	Name of plot	Plot size in hectare	When did you obtain this land (year)	Use of the plot during the last one year	Soil quality	Slope of the plot
1						
2						

Variable codes; Use of plot land: 1=Own cultivated 2=owned but cultivated by others household (sharecropped) out 3=Owned but cultivated by other hh (Rented out) 4=Grazing land others (specify._____ Soil quality: 1=fertile, 0= Infertile Slope of the plot: 1=level 2=mountainous 3= steep

2.2. Livestock holding: Number and value owned during the last one year.

Type of livestock	Number owned and present at your farm	How often animal feed on residue /by-products of irrigated crops (0=none, 1=up to a quarter (25%), 3=half (50%), 4=more than half (50-100%)	If you would sell, how much you receive in the last year? (Birr)	Total value (Birr)

2.2.1. Livestock product sales

I. Before starting small scale irrigation

No	List of products	Unit	Amount of product per cow/goat/sheep/hen	Total product	Unit price	Total value (Birr)
1						
2						
3						

II. After the starting of irrigation

No	List of products	Unit	Amount of product per cow/goat/sheep/hen	Total product	Unit price	Total value (Birr)
1						
2						
3						

2.2.2. Income from animal rent

No	List of animal power	Unit	Amount of animal employed for rent	Unit price	Total value (Birr)
1					
2					

Section Three: Household activities and Income

3.1. Farming

1. Did you have cultivated land? Yes/No
2. If yes, total area of land for cultivation _____(in ha)
3. How many years since started farming (Farming experiences)? _____years
4. Did all your household members participate in farming work? Yes/ No

5. If no, how many of them participated? _____ (in number)
6. Did you face labor shortage? Yes/ No
7. If yes, how did you solve the problem of labor shortage? 1. Hiring 2. Labor exchange 3. Other_____
8. Total area of land cultivated during the last one year (2011 E.C) _____ (in ha).
9. Total area of land cultivated during last year on which fertilizer was used_____ (in ha)
10. Total area of land covered by improved seeds during the last one yea_____ (in ha).

3.1.1 Inputs

1. Please indicate the activity given in the table below.

No	Activity	Yes = 1 No =0	If the answer is yes ,			
			Amount	Unit	Source	Value(Birr)
1	Did you use any manure from your herd on your field?					
2	Did you purchase any fertilizer for use on your field?					
3	Did you purchase improved seeds for use on your field?					
4	Did you purchase irrigation motor pump					
5	Did you purchase chemical for pest control					

3.1.2 Crop output and sales during rain fed agriculture

Variable codes: Teff =2 Maize=3 Sorghum=4 Finger millet = 5 Groundnuts = 6 Sesame 7= Line seed= 8 Chickpea= 9Tomato = 10 Onion = 11Cabbage= 12 Swiss chard = 13 Bananas = 14 Gesho = 15 Papaya = 16 Avocado = 17 Orange = 18 Lemon= 19 Mango= 20 other =21 (specify) _____

1. **Please indicate the amount of food production you got from rain fed agriculture only in the last one year in the table given below by using the above codes.**

Crop name	Yield (kg)	Is it produced by irrigation? 0= no, 1=Yes	Values (Birr)	For own consumption (kg)	Values (Birr)	For sale (kg)	Value (Birr)	To others as payment for rent or gift (kg)	Values (Birr)	Total value (birr)

Crops sold by members of the homestead (please use the codes that are listed in 3.1.2 above)

Crop type	Before the starting of irrigation			After the starting of irrigation		
	Amount produce (kg)	Amount sold (kg)	Cash received (ETB)	Amount produce (kg)	Amount sold (kg)	Cash received (ETB)

Section Four: Irrigation capacity

1. Do you have irrigable land? Yes/ No

2. If yes, what is the size of the irrigable land_____ (in ha)?

3. When did you own this irrigable land? 1. Before1year 2. Before 2 years 3. Before 3 years 4. Other_____

4. How many times do you produce per year using irrigation? _____ (number)

5. What is the source of water for your irrigation? 1. Rivers 2. Springs 3. Ponds 4. Wells 5. Dam 6. Diversion 7. Other_____

6. What is the approximate distance of main irrigation water source from center of plot? _____ (in km).

4.2. Crop output and sales out of irrigation agriculture

4.2.1. Please indicate agricultural product you got from irrigable land only in the last one year.

Crop type	Yield (kg)	Value (Birr)	For own consumption (kg)	Value (Birr)	For sale (kg)	Value (Birr)	To others as payment for rent or gift (kg)	Value (Birr)	Total value (Birr)

Variable codes: Teff =1, Maize=2, Sorghum=3, Finger millet = 4, Groundnuts = 5, Sesame =6, Line seed= 7, Chickpea= 8=, Tomato = 9, Onion = 10, Cabbage= 11, Swiss chard = 12, Bananas = 13, Gesho = 14, Papaya = 15, Avocado = 16, Orange = 17, Lemon= 18, Mango= 19, other=21 (specify) _____

4.3. Other sources of Income

8. Do you or your household members under take some additional income generating activities of off farm in the last one year? a. Yes b. No

9. If yes, indicate the income earned from other activities in the table below.

Source	Value (Birr)
Non-farm employment	
Farm work	
Hiring out oxen	

Renting/sharecropping out land	
Sale of firewood/charcoal	
Sale of beverages	
Petty trade (net profit)	
Livestock and livestock output trade	
Weaving	
Food aid	
Handcrafts	
Sale of local drinks	
Sale of livestock output (eg. fluid milk, Butter, Cheese, Chicken, Egg, Honey, Bees wax, etc.)	
Others(specify)	

Section Five: Agricultural Extension, Credit, Marketing and other institutional Support services

5.1. Agricultural Extension

10. Is there farmers training center (FTC) in your kebelle? Yes/No

11. If your answer is yes, how far is the FTC from your home? _____ (in Km)

12. How long do you take from your home to FTC_____ in minutes?

13. Did you have some social position in the community? Yes/No

14. If yes, what is your position? _____

15. Did you have some Social Networks in the community? Yes/ No

16. If yes, what is your Social Network? 1. Edir 2. Equib 3. Unions 4. Basic cooperatives

5. Other_____

17. Is there an Agricultural Development Agent in your kebelle? Yes/ No

18. If yes, had you get an extension support during the last one year? Yes/No

19. If yes, have you participated in the training program organized last year? Yes/No

20. If yes, in which topics you had been trained from the lists mentioned in the table below (see codes listed under the table).

No	Training topics	How many rounds you have been trained (numbers)	For how long you have taken (days)
1			
2			

1=livestock production, 2= fruits and vegetables, 3=crop diversification, 4=marketing, 5=irrigation, 6=post-harvest processing, 7= storage of farm produce, 8=farm management,

9= credit, 10= household food security, 15=others _____

Section six: Household Expenditures (Food and Non-food consumption Expenditure)

33. Indicate the type and amount of food expenditures of your family for the last one year in the following table by using the variable codes below this table

No	Food type code	Total food consumed		
		Amount	Unit	Value (Birr)
1				
2				
3				

Variable codes 1=Teff, 2= Barley, 3= Wheat, 4= Maize, 5= Sorghum, 6= Lentils, 7= Faba bean=, 8=Field peas, 9= Chick peas, 10= Guava, 11= Linseed, 12=Sesame, 13= Sun flower, 14= Tella, 15= Arequi, 16= Teji, 17= Beer, 18= Coffee, 19= Honey, 20= Sugar, 21= Tea, 22= Berberie, 23= Salt, 24= Onion, 25= Bread, 26= Macaroni, 27= Potato, 28= Tomatoes, 29 = Carot, 30= Karia, 31= Gomen, 32= Banana, 33= Zeytihun, 34= Cheese, 35= Butter, 36= Beef meat ,37=Chicken, 38=Eggs, 39=Others

34. Would you indicate the household's non-food expenditure in the last one year (2019)? (Use the variable codes given below the table)

No	Item code	Total expenditure		
		Amount	Unit	Value(Birr)
1				
2				
3				

Variable codes 1= Clothes/Shoes for Adults 2= Clothes/Shoes for Children 3= Energy consumption 4= Soap, Omo 5= Cosmetics (including butter) 6= Lines (sheets, towel, blankets) 7= Furniture and lamp 8= Transport materials 9= Building materials for house 10= Ceremonial expense 11= Contribution to social association 12 = Donation to organization 13= Taxes and contribution to kebelle 14 = Medical treatment and medicine 15= School fees 16= Educational materials … 22 = others

35. for how many months you can satisfy your food demand from own farm production? _____

36. If there is shortage during which months is the shortage? _____

37. What do you think the main causes of food deficit in your particular area? 1. Variability in rainfall 2. Incidence of pest, diseases, weeds etc. 3. Lack of access to credit 4. Lack of appropriate extension support 5. Other_____

38. General assessment of the livelihood of the society

38.1. Crop production assessment and marketing

Crop type	Before starting irrigation practices				During the time of irrigating			
	Amount produced (kg)	Amount consumed (kg)	Amount sold (kg)	Cash received (ETB)	Amount produced (kg)	Amount consumed (kg)	Amount sold (kg)	Cash received (ETB)

38.2. Livestock production and marketing assessment

LS type	Before starting irrigation practices				During the time of irrigation			
	Amount produced (No)	Amount consumed (No)	Amount sold (No)	Cash received (ETB)	Amount produced (No)	Amount consumed (No)	Amount sold (No)	Cash received (ETB)

39. New crops that are produced during the time of irrigation

Crop type	Production and marketing of crops using irrigation water			
	Amount produced (kg)	Amount consumed (kg)	Amount sold (kg)	Cash received (ETB)