Determinants of Small Scale Irrigation Utilization by Smallholder Farmers: The Case of Misrak Azernet Berbere *Woreda*, Southern Ethiopia

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Abstract: In countries like Ethiopia where wide spread poverty, food insecurity, low farm productivity and degraded natural resources are key problems, the need to use irrigation water in agricultural system is very crucial. The purpose of this study was to identify the determinants of utilization of small scale irrigation by smallholder farmers in Misrak Azernet Berbere woreda of Southern Ethiopia. A two stage sampling technique was applied to select sample rural Kebele administrations and households. The study was based on the data obtained from 177 sample households from two rural Kebele of the woreda through cross-sectional survey during 2017 production year. The study used both descriptive statistics and econometric model to analyze the data. Tobit model was used for identifying factors that influence utilization and intensity of utilization of small scale irrigation. The result of the model showed that sex of household head, age of household head, education level of household head, total annual income, access to information and access to extension services had significantly and positively influenced utilization and intensity of utilization of small scale irrigation while distance from residence to water source had significantly and negatively influenced utilization and intensity of utilization of small scale irrigation. The finding of the study suggests that the government and stakeholders should give emphasis to strengthening the existing extension service, strengthening the provision of formal and informal education, increasing farmers' income, promoting and empowering females, provision of information about agricultural technologies and construction of small scale irrigation canals to improve small scale irrigation utilization in the study area.

Keywords: Intensity of Utilization, Users, Non-users, Tobit Model

1. Introduction

In Ethiopia, agriculture accounts about 36% of the GDP, employs about 85% of the labor force and contributes around 81% of total export earnings of the country [6]. The sector is dominated by over 15 million smallholders producing about 95% of national agriculture production. This shows that overall economy of the country and food security of the majority of the population depends on smallholder agriculture. The growth of agricultural sector is taken as an engine and the last resort to take-off the national economy [7].

Although the country is endowed with three main resources namely land, water and labor for agricultural production, the sector in the country is mostly small scale, rainfall dependent, traditional and subsistence farming with limited access to technology and institutional support services. Hence, the ability of the nation to address food and nutritional insecurity, poverty, and to stimulate and sustain national economic growth and development is highly dependent on the performance of agriculture. Yet achieving higher and sustained agricultural productivity growth remains one of the greatest challenges facing the nation [25]. Rainfall is erratic and unevenly distributed between seasons and agro ecological regions lead to poor yields, low productivity, food insecurity and poverty within the farming population, thus it emphasizing the need for irrigation in the country.

According to [11] irrigation contributes to livelihood improvement through increased income, food security,

employment opportunity, social needs fulfillment and poverty reduction. Increase in agricultural production through diversification and intensification of crops grown, increased household income because of on/off/non-farm employment, source of animal feed, improving human health due to balanced diet and easy access and utilization for medication, soil and ecology degradation prevention and asset ownership. Misrak Azernet Berbere *woreda* which is found in Siltie zone, SNNPR has 3 rivers, 32 springs with a potential irrigable land of about 9,300 hectares. Currently in addition to existing small scale irrigation schemes, there are improved small scale irrigation schemes constructed by NGOs [14].

Drought due to climate change (El nino and La nina) is currently the major challenges that faces in Ethiopia. Agricultural production in Ethiopia is primarily rain-fed, so it depends on erratic and often insufficient rainfall. As a result, there are frequent failures of agricultural production. Due to that Ethiopia cannot hope to meet its large food deficit through rain-fed agriculture alone. To mitigate the food insecurity that is prevailing in Ethiopia, different strategies have been suggested by the government. One way for enhancing productivity of the small holder farming is through the promotion of small scale irrigation schemes [20, 18].

There is a great potential of small scale irrigation in Misrak Azernet Berbere *woreda* but there is no information about factors influencing utilization of small scale irrigation and intensity of utilization by smallholder farmers in the study area. Therefore, a thorough study on these issues may help to identify the irrigation utilization constraints at farm level and thereby develop policy recommendations to increase utilization of small scale irrigation. Thus, this study aims to contribute information on the determinants of utilization of small scale irrigation by smallholder farmers in Misrak Azernet Berbere *woreda* of Southern Ethiopia.

2. Research Methodology

2.1. Description of the Study Area

The study was conducted in Misrak Azernet Berbere *woreda* of Siltie zone, SNNPR. It is found in the Eastern part of the Siltie zone and is about 52 km from its capital, Worabe. The administrative center of *woreda* is Kilto town, which is located 192 km West of capital of SNNPR, Hawassa and 221 km South of Addis Ababa and from. The *Woreda* is bordered by Guraghe zone in the Northwest, Merab Azernet Berbere *woreda* in the West, Hadya zone in the South Hulbareg in the East and Alicho Wiriro *woreda* in the Northeast. The *Woreda* has 21 *Kebeles* of which 17 are rural and 4 are urban with total area of 19,404 hectares. The amount of land used for crop production is 10,875 ha while 9 ha, 2671.3 ha and 310 ha are under grazing land, forest and water bodies respectively. Most of the area has fluvisols followed by leptosols and solonchaks soils. Mixed farming (crop production and the rearing of livestock) is widely practiced in the *woreda*. Agriculture in the *woreda* is mainly characterized by rain fed production system.

The major crops grown in the *woreda* are cereals such as wheat, maize, teff, barely, sorghum, pulses such as fababeans and field peas, and vegetable such as irish potato, onions and cabbage among others. Chat is one of the cash crops grown in the *woreda*. It has three agro-climatic zones *Wurch* (upper highlands), *Dega* (highlands) *Weyna dega* (midlands); its altitude ranges between 2001 to 3500 masl and geographically located 7.1'-7.69' N latitude and 37.95'-38.5' E longitude. The temperature range 12.6 to 20°C and the area receives an annual rainfall of 1001 to 1200 millimeter (mm). There are quite some livestock in the *woreda*; there are 120,776 cattle, 320,347 shoats, 40,522 equines, 237,000 poultry and 15,830 bee colonies.

It has a total population of 77,754, of which 35,273 (45%) are males and 42,481 (55%) are females. The number of male-headed households is 10,701 and the number of female-headed households is 2,587. There are 39 education centers with a total of 20,318 students (10,389 males and 9929 females) attend regular school both in formal and alternative basic education centers in the 2016/2017 fiscal year. In terms of health services, there are 24 health facilities available in the *woreda*, 4 health centers, 16 health posts, and 6 private clinics [13].
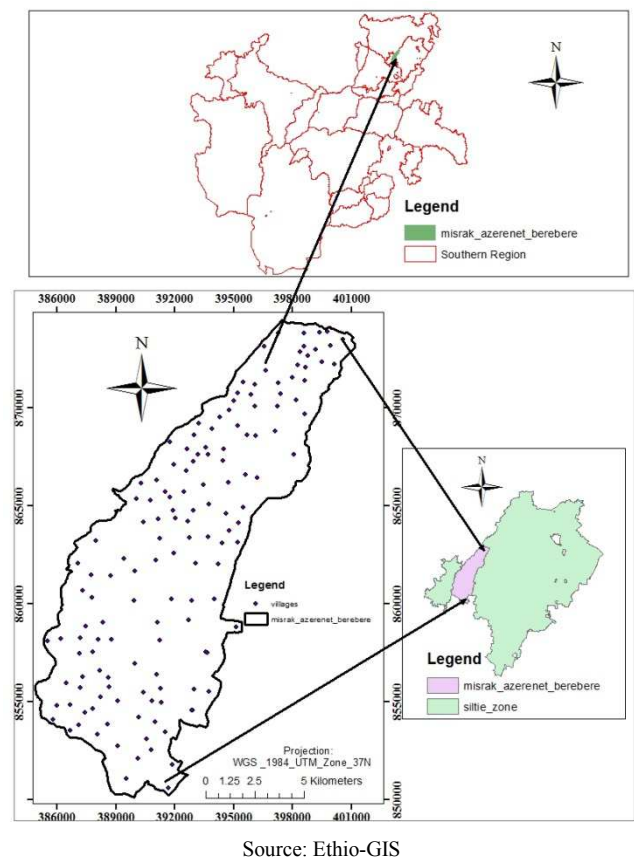
Source: Ethio-GIS

Figure 1. *Location map of the study area.*

2.2. Sampling Procedure and Sample Size Determination

For this study, two stage sampling technique was implemented to select representative *kebeles* and sample farm

households. Misrak Azernet Berbere *woreda* was used because of their huge potential for small scale irrigation and familiarity of the researcher for the study area. In the first stage, from Misrak Azernet Berbere *woreda* two *kebeles*, which are Lay-Uminan and Goda were purposely selected from the 17 rural *kebeles* based on their potential to small scale irrigation in consultation with *woreda* agricultural and natural research office. In the second stage, from selected rural *kebeles* 177 farmers were selected randomly based on probability proportional to population size of the selected *kebeles*.

For this study a simplified formula provided by [30] to determine the required sample size at 95% confidence level and e = 0.07

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

Where, n is the sample size
N is the population size (total household size), and
e is the level of precision

$$n = \frac{N}{1+N(e)^2} = \frac{1357}{1+1357(0.07)^2} = \frac{1357}{7.6493} = 177.4$$

Therefore total samples of 177 were used.

2.3. Type and Source of Data

For this study quantitative data type have been gathered and analyzed. In order to generate this data, both primary and secondary data source were used.

2.4. Method of Data Collection

The required data were collected through farm household survey using structured questionnaire. The questionnaire was pre-tested to check its appropriateness for gathering all the required information and modified according to the feedback obtained. The final modified structured questionnaire was used to collect data from the sample farmers.

2.5. Methods of Data Analysis

In this study, descriptive statistics and econometric model were used to analyze the data collected from the study area. Descriptive statistics is one of the techniques used to summarize data collected from a sample. Descriptive statistics such as mean, frequency, percentages and standard deviation were used in the process of examining and describing socioeconomic, demographic and institutional characteristics of the study area while t-test and chi-square test were used to compare different groups with respect to household farm characteristics.

The econometric model adopted for this study was Tobit model since the study intended to assess factors that influence utilization and intensity of utilization of small scale irrigation. Following [16], the Tobit model can be express as follows:

$$AI_i = \beta_0 + \beta_i X_i + u_i$$

$$AI_i^* = \beta_0 + \beta_i X_i + u_i$$

$$AI_i = AI_i^* \quad \beta_0 + \beta_i X_i + u_i > 0 \qquad (2)$$

$$= 0 \text{ if } \quad \beta_0 + \beta_i X_i + u_i \le 0$$

Where
AI_i = is ratio of irrigated area of land to total cultivated land of the ith farmer
AI_i^* = is the latent variable and the solution to utility maximization problem of intensity of utilization subjected to a set of constraints per household and conditional on being above certain limit,
x_i = Vector of factors affecting level of utilization and intensity of utilization
β_i = Vector of unknown parameters, and
u_i = Is the error term which is normally distributed with mean 0 and variance σ^2.

The model parameters are estimated by maximizing the Tobit likelihood function of the following form [16, 5].

$$L = \prod_{AI^*>0} \frac{1}{\alpha} f\left(\frac{AI_i - \beta_i X_i}{\alpha}\right) \prod_{AI^*\le 0} F\left(\frac{-\beta_i X_i}{\alpha}\right) \qquad (3)$$

Where f and F are respectively, the density function and cumulative distribution function of AI_i^*, $\prod_{AIi \le 0}$ means the product over those i for which $AI_i^* \le 0$, and $\prod_{AIi >0}$ means the product over those i for which $AI_i^* > 0$.

An econometric software known as "STATA version 12" was employed to run the Tobit model. As cited in [10], it may not be sensible to interpret the coefficients of a Tobit in the same way as one interprets coefficients in an uncensored linear model. Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of changes in the explanatory variables. According to [17, 15, 10, 22] proposed the following techniques to decompose the effects of explanatory variables into adoption and intensity effects. Thus, a change in x_i (explanatory variables) has two effects. It affects the conditional mean of AI_i^* in the positive part of the distribution, and it affects the probability that the observation would fall in that part of the distribution. Similarly, this procedure was used in this study.

1. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(AI_i)}{\partial x_i} = F(Z)\beta_i \qquad (4)$$

Where, $\frac{\beta_i x_i}{\sigma}$ is denoted by z, following [16].

2. The Change in the probability of utilization of irrigation as independent variable x_i changes is:

$$\frac{\partial F(Z)}{\partial x_i} = F(Z) \frac{\beta_i}{\sigma} \qquad (5)$$

3. The change in the intensity of adoption with respect to a change in an explanatory variable among adopters is:

$$\frac{\partial E(AI_i / AI_i^* > 0)}{\partial X_i} = \beta_i \left[1 - Z\frac{f(Z)}{F(Z)} - \left(\frac{f(Z)}{F(Z)}\right)^2 \right] \qquad (6)$$

Where, F (z) is the cumulative normal distribution of Z, $f(z)$

is the value of the derivative of the normal curve at a given point (i.e., unit normal density) and Z is the z-score for the area under normal curve, β is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

Table 1. Codes, description, types and hypothesis of explanatory variables in the model.

Variable code	Variable description	Variable type	Hypothesis
TOTINC	Total income	Continuous	+
DISMKT	Distance from the nearest market	Continuous	-
EDUC	Education level of household head	Dummy	+
DISHOM	Distance from the water source	Continuous	-
ACINFO	Access to information	Dummy	+
LIVESTOCK	Total livestock holding	Continuous	+
FAMSIZE	Family size	Continuous	+
CULTLAND	Size of cultivated land	Continuous	+
SEXHEAD	Sex of household head	Dummy	+ /-
AGE	Age of household head	Continuous	-
ACCREDIT	Access to credit facility	Dummy	+
ACEXTEN	Access to extension service	Dummy	+

3. Results and Discussion

This chapter presents the results obtained from descriptive and econometric analyses. In the descriptive statistics mean, frequency, percentages, standard deviations were computed in the process of examining and describing socioeconomic, demographic and institutional factors affecting farmer utilization of small scale irrigation. Moreover, t-test and chi-square test were computed to make comparisons between irrigation user and non-user groups with respect to some explanatory variables under consideration. The econometric

analysis were also employed to identify factors that affect utilization and intensity of utilization of small scale irrigation and to measure the relative importance of significant explanatory variables on utilization and intensity of utilization of small scale irrigation.

3.1. Demographic and Socioeconomic Household Characteristics

Out of the total sample household heads interviewed during survey 101 (57%) were irrigation users and 76 (43%) were irrigation non-user.

Table 2. Distribution of users and non-users of household heads by sex.

Sex	Users		Non- users		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Male	96	95	56	73.7	152	85.9
Female	5	5	20	26.3	25	14.1
Total	101	100	76	100	177	100

Source: Own computation of survey data (2017).

3.1.1. Sex of the Household Head

As shown in Table 2, of the entire household heads interviewed, about 85.9% were male-headed while the remaining 14.1% were female-headed, who are divorced or widowed at the time of survey. The survey result shows that 95% of irrigation users are headed by male and the rest 5% are headed by female and out of 76 non-user 56 (73.7%) and 20 (26.3%) are headed by male and female respectively. As the result, chi-square test shows that there is statistically significant difference between those household heads that are the user of irrigation and non-user in terms of their sex at 1% probability level and this shows male headed households are more likely to be irrigation users than female headed households (Table 5).

3.1.2. Age of Household Head

The average age of the sample household head was found

to be 45.24 years where the minimum is 23 and the maximum is 80 years. The average age implies that most of the household heads were within their productive age bracket. The average household age of users is 47.48 years and the corresponding figure for non-users of the irrigation is 42.28 years. The mean age difference between the two groups was found to be statistically significant at 1% level of significance suggesting age has influence on utilization decision (Table 4).

3.1.3. Family Size

The average family size of sample farm households in man equivalent was estimated to be 3.12. The minimum and maximum family size of sample farm household was 0.85 and 6.45 respectively. The average family size of irrigation user was 3.40 and 2.76 for irrigation non-user. The result shows that households that user of irrigation have larger household size than households that do not use irrigation. The t-test result

indicated that, there is a significant difference between irrigation users and non users in terms of family size at 1% significance level (Table 4).

3.1.4. Education Level of the Household Head

As shown in Table 3 the result of the study showed that 15.3% of the sample household heads were unable to read and write, where as 84.7% of the sample household heads were literate. About 9.9% of users and 22.4% of non-users of irrigation were unable to read and write, 90.1% of irrigation users and 77.6% of irrigation non-users found to be literate. The chi-square test result revealed that there was a statistically significant proportion difference between irrigation users and non-users in terms of literacy at 5% level of significance (Table 5).

Table 3. Distribution of sample household heads by education.

Household head education level	Users		Non- users		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Literate	91	90.1	59	77.6	150	84.7
Unable to read and write	10	9.9	17	22.4	27	15.3
Total	101	100	76	100	177	100

Source: Own computation of survey data (2017).

3.1.5. Total Size of Land Holding

In this study, the average land holding for the sampled household was 0.70 hectare. The land holding size of the sample household varies from 0.13 to 3.00 hectare. The comparison of two groups in terms of land holding showed that the mean land holding for users of irrigation is 0.82 hectare and the corresponding figure of land holding for non-users of irrigation is 0.55 hectare. Independent sample t-test results revealed that land holding has a positive effect on utilization of small scale irrigation. This difference is statistically significant at 1% significance level (Table 4).

3.1.6. Total Livestock Holding

The number of livestock owned by a household in the study area is considered as a measure of wealth. In a mixed farming system the contribution of livestock to crop production cannot be undermined. They are an important source of income, food and draft power for smallholding farmers. In addition to these, they are source of animal dung for organic fertilizer and fuel and means of transport. The types of livestock found in the study area were cattle, equine, sheep, goat and chicken. The study showed that from total sample household 174 (98%) households own livestock. The average number of livestock in TLU was 3.14, where the minimum is 0 and the maximum is 12.21. As shown in Table 4 the mean livestock holding for irrigation user household heads in TLU is 3.65 while that of the non-users of irrigation is 2.46 TLU. The t-test result showed that the Tropical Livestock Unit (TLU) was positively and significantly related to utilization of small scale irrigation at 1% significance level (Table 4).

Table 4. Summary of results of descriptive statistics analysis for continuous variables.

Variable	Users (n=101)		Non –users (n=76)		Total sample (n=177)		t-value
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation	
AGE	47.48	11.50	47.48	9.56	45.24	10.99	3.196[***]
FAMSIZE	3.40	1.08	2.76	0.98	3.12	1.08	4.153[***]
LAND	0.82	0.54	0.55	0.42	0.70	0.51	3.745[***]
TLU	3.65	1.91	2.46	1.39	3.14	1.80	4.606[***]
TOTINC	16850.30	9576.81	10169.28	6101.57	13981.61	8886.74	5.321[***]
DISMKT	3.54	3.36	3.77	2.54	3.64	3.03	-0.504
DISHOM	0.60	0.92	1.24	1.48	0.88	1.23	-3.514[***]

[***] represents statistically significant at 1% significance level
Source: Own computation of survey data (2017).

3.1.7. Total Annual Income

Farmers in the study area reported that they earn income both from on-farm and off/non-farm activities. On-farm income refers to annual farm income obtained from sale of crop, livestock and livestock products. Off/non-farm activities comprises any farm activities takes place outside own plot or farm and any non-farm activities. The off/non-farm activities include casual labor, salaried employ, trading, handicraft, remittance etc. Remittance is the main source of off/non-farm income for most of the households. The survey result revealed that the mean annual income of sample households is found to be Birr 13,981.61 with a minimum of Birr 2,000 and a maximum income of Birr 54,970. The maximum and minimum total annual income of user is Birr 54,970 and Birr 2,100 respectively while for non-users of irrigation is Birr 32,512 and Birr 2,000 respectively. There is much difference in mean annual income between irrigation users and non-users. As indicated in Table 4 households mean total annual income of irrigation user is Birr 16,850.30. However households mean total annual income of non- user of irrigation is Birr 10,169.28. The t-test analysis also revealed that there is significant difference in total annual income of household between the users of irrigation and non-users of irrigation at 1% level of significance (Table 4).

3.2. Institutional Characteristics of the Household

3.2.1. Distance from Residence to Water Source

The average distance between farmers residence to the water source in kilometer for the sample households is found to be 0.88 km with a minimum of 0.001 km and a maximum distance of 6 km. Comparing small scale irrigation users versus non-users in terms of distance from the water source, the average distance of irrigation user is 0.60 km; the corresponding figure of non-user household is 1.24 km. The t-test result for mean difference between the user and non-user is statistically significant with regard to distance to farmers residence to the water source at 1% level of significance (Table 4).

3.2.2. Distance from the Nearest Market

It refers to the distance between the household home and the nearest market. Farmers having nearness to market will have a chance to get information from other farmers and input suppliers in the market place. Moreover, the nearness of market increases access to and utilization of agricultural inputs due to advantage of minimum transportation cost which intern increases utilization of small scale irrigation. Access to market is also a determinant of profitability and sustainability of agricultural produce. The average distance between the households' home and the nearest market in kilometer for the sample households is found to be 3.64 km with a minimum of 0.05 km and a maximum distance of 25 km. As clearly indicated in Table 4 the average distance of irrigation users to the nearest market is 3.54 km; the corresponding figure of non-user households is 3.77 km. However the t-test result for mean difference of the two groups with regard to distance from household home to the nearest market is statistically insignificant (Table 4).

***Table 5.** Summary of results of descriptive statistics analysis for dummy (discrete) variables.*

Variable	Category	Users Frequency	Non-users Frequency	Total sample Frequency	χ^2-value
Sex	Male	96	56	152	16.32***
	Female	5	20	25	
Education level	Literate	91	59	150	5.21**
	Unable to read and write	10	17	27	
Access to information	Yes	87	48	135	12.65***
	No	14	28	42	
Access to credit	Yes	29	13	42	3.23*
	No	72	63	135	
Access to extension	Yes	99	61	160	15.75***
	No	2	15	17	

***, ** and * represents statistically significant at 1%, 5%, and 10% significance level, respectively.
Source: Own computation of survey data (2017).

3.2.3. Access to Information

Access to information about irrigation crop production, protection and marketing has a key role in agriculture. Access to market information encourages farmers to produce more in quantity and in a quality of the product. Ownership of mobile phone, radio and access to market information by the household head is used as a proxy to measure information access. In view of this, household head that has mobile phone and radio had better information access than others. The result of the study revealed that 76.3% of the sample households have access to information and the rest 23.7% of the sample have no access to information.

Comparing irrigation user and non user households, majority of the user households get information than non-user in the study area. According to the study result shown in Table 6, 87 (86.1%) users had access to information and the rest 14 (13.9%) had no access to information and the corresponding figure for non users had access to information and had no access to information is 48 (63.2%) and 28 (36.8%) respectively. Chi-square test result revealed that there was a statistically significant and positive relationship between the utilization of irrigation and access to information at 1% significance level (Table 5).

***Table 6.** Distribution of sample household heads by access to information.*

Access to information	Users		Non- users		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	87	86.1	48	63.2	135	76.3
No	14	13.9	28	36.8	42	23.7
Total	101	100	76	100	177	100

Source: Own computation of survey data (2017).

3.2.4. Access to Credit Service

Credit is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. Credit can be either in the form of cash or kind from different sources. The availability of financial resource has a decisive role in the agricultural production process. Access to credit can address the financial constraints of farmers. The main source of credit in the study area is micro

finance institute, neighbors and relatives and cooperatives. According to the survey result in Table 7, only 23.7% of sample households have access to credit. The comparison by utilization of irrigation showed that 29 (28.7%) of irrigation users and 13 (17.1%) of non-users had access to credit, while 72 (71.3%) of user and 63 (82.9%) of non-user had not access to credit.

As indicated in Table 8, the major problems associated with access to credit like religious reason, high interest rate, no access to credit supply, not available on time and no need of credit were reported by respondent in the study area. There were 70 (39.5%) of households who refused to take credit due to religion reason. Those who no need of credit, not take credit

due to high interest rate account for 16.9% and 13% respectively, and those who did not take credit due to not available on time were about 4%. However, only 1.1% of the sample farmers were interested in receiving credit, but not qualified to meet the borrowing requirements due to lack of collateral. Only few farmers, 1.7% claimed that credit service was not available in their area. The survey result showed that there was limited use of credit by sample respondents mainly due to religious reason in the study area, since taking credit with interest rate is forbidden in Islam religion. As shown in Table 5, the chi-square test result revealed that there is a positive relationship between access to credit and utilization of irrigation at 10% level of significance.

Table 7. Distribution of sample household heads by access to credit.

Access to credit	Users		Non- users		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	29	28.7	13	17.1	42	23.7
No	72	71.3	63	82.9	135	76.3
Total	101	100	76	100	177	100

Source: Own computation of survey data (2017).

Table 8. Distribution of sample households by major types of problems associated with access to credit.

Problem related to credit access	Users (n=101)		Non- users (n=76)		Total (n=177)	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
No collateral	2	2	0	0	2	1.1
No access to credit	2	2	1	1.3	3	1.7
No need	19	18.8	11	14.5	30	16.9
High interest rate	9	8.9	14	18.4	23	13
Not available on time	3	3	4	5.3	7	4
Religion	37	36.6	33	43.4	70	39.5

Source: Own computation of survey data (2017).

3.2.5. Access to Extension Services

Extension services usually play a major role in disseminating new and improved farming techniques. The extension service is delivered to farmers mainly via Development Agents (DAs) through sharing of modern agricultural knowledge and information to improve farmers' lives in a better way. They give technical advices to farmers by organizing trainings and demonstration at farmers training center (FTC) and visit to farmers' fields. About 90.4% of the sample respondents reported that they had access to agricultural extension services. Those sample farmers who

had access to extension services, on average 2.14 times per month visited by development agents.

According to the survey result in Table 9, 90.4% of sample households had access to extension services. The survey result revealed that 99 (98%) of the users and 61 (80.3%) of the non-users had access to extension service. About 2 (2%) of the user and 15 (19.7%) of non user had not access to extension services. The chi-square test result indicated that there is significant relationship between utilization of irrigation and access to extension service at 1% level of significance (Table 5).

Table 9. Distribution of sample household heads by access to extension services.

Access to extension services	Users		Non- users		Total	
	Frequency	Percent	Frequency	Percent	Frequency	Percent
Yes	99	98	61	80.3	160	90.4
No	2	2	15	19.7	17	9.6
Total	101	100	76	100	177	100

Source: Own computation of survey data (2017).

3.3. Econometric Results

This section of the thesis presents the model result on factor affecting utilization and intensity of utilization of small scale

irrigation by smallholder farmers in the study area. The econometric model known as Tobit model was used to see the relative influence of different demographic, socioeconomic and institutional variables on utilization and intensity of utilization of small scale irrigation. One of the assumptions of

the classical linear regression model is that there is no multicollinearity among the explanatory variables. Multicollinearity refers to the situation where there is either an exact or approximately exact linear relationship among two or more explanatory variables, making it difficult or impossible to isolate their individual effect on the dependent variable in the regression model [8].

A statistical package known as STATA was also employed in this study to compute the VIF and CC values. Based on the output the maximum computed value of VIF obtained for continuous variables was found to be 1.60. The contingency coefficient for the dummy variables included in the model was less than 0.75. The values of VIF which is less than 10 and CC value less than 0.75 were revealed the absence of a severe multicollinearity problem among these potential explanatory variables included in the model.

3.3.1. Determinants of Utilization and Intensity of Utilization of Small Scale Irrigation

After checking existence of multicollinearity a total of twelve explanatory variables were included into the econometric model. The results of the model show that all coefficients of the variables hypothesized to influence utilization of small scale irrigation, except size of cultivated land and age of household head, have the expected sign and of the twelve variables included in the model, seven are found to have statistically significant effects on the utilization and intensity of utilization of small scale irrigation. Those explanatory variables which are statistically significant are presented and discussed. These are sex of household head, age of the household head, education level of household head, total income, access to information, access to credit and access to extension (Table 10).

***Table 10.** Maximum likelihood estimates of Tobit model.*

Variable	Coefficients	Std. Error	t-ratio
SEXHEAD	0.263**	0.1116046	2.36
AGE	0.005*	0.0029515	1.75
EDUC	0.189**	0.0927182	2.03
FAMSIZE	0.003	0.0308752	0.10
CULTLAND	- 0.059	0.0652716	-0.90
DISHOMW	-0.057*	0.0302095	-1.90
LIVESTOCK	0.018	0.0206432	0.87
TOTINC	0.000***	3.75e-06	2.80
DISMKT	-0.007	0.0096318	-0.71
ACINFO	0.165**	0.0824922	2.00
ACEXTEN	0.571***	0.1663942	3.43
ACCREDIT	0.111	0.0710859	1.57
Constant	-1.287***	0.2694219	-4.78

Number of observation = 177 LR chi2 (12) = 74.61 Prob > chi2 = 0.0000, Pseudo R^2=0.3130, Log likelihood function = -81.890475, left-censored observations = 76 at Intensity of utilization i <=0, uncensored observations = 101, right-censored observations = 0.
***, **,* represents 1%, 5% and at 10% level of significance respectively.
Source: Model output.

i). Sex of Household Head

Sex of the household head (being male) has a positive and significant influence on the utilization and intensity of utilization of small scale irrigation at 5% level of significance (Table 10). This implies that male headed households are more likely to utilize small scale irrigation than female headed households in the study areas. This might be due to the fact that female triple role in the society which are productive, reproductive and community service and are usually endowed with less resource and less access to new information related to availabilities of new technologies. Then due to the case they are slowly adopting small scale irrigation as compared to male-headed households. This is consistent with the research result of [27, 4, 1].

ii). Age of Household Head

Age of household head has a positive and significant influence on the utilization and intensity of utilization of small scale irrigation at 10% significance level. The probable reason of this result is that as older farmers had more knowledge from previous farm experience, resource and authority that would allow them utilizing small scale irrigation than younger farmers. Therefore, older farmers are more probable to utilize

small scale irrigation than younger farmers in the study area. The study conducted by [9, 29] also obtained a similar results in their studies. In contradict with a study by [3, 21] found that younger farmers are more likely to adopt new technologies compared to older farmers.

iii). Education Level of Household Head

The sign of this variable is consistent with prior expectation that means positively and significantly influenced the probability households to utilization and intensity of utilization of small scale irrigation. Its coefficient was significant at 5% level of significance. This is due to the fact that education is one of the important indicators of human capital that can raise their information acquisition and adjustment abilities thereby increasing their decision making capacity towards adopting agricultural technologies more specifically utilization of small scale irrigation. Studies by [4, 19, 9] also obtained similar results in their studies.

iv). Distance from Residence to Water Source

Distance from water source has a negative and significant relationship with utilization and intensity of utilization of small scale irrigation at 10% level of significance (Table 10). The negative relationship tells us the farther the households

residence are from water source, the less likely they use irrigation as compared to households that are located at close proximity. This might be due to plots far away from home take more time, energy and transportation costs to undertake irrigation farming practices. On the contrary, the closer a household resides to a water source, the higher the probability of participating in irrigation due to the fact that the opportunity cost of the time lost in travelling to irrigation-farm for households located a short distance from irrigation water source would be much lower than households located much farther. Besides, the lower transaction cost households located near water sources enjoy, and also are likely to have a better awareness of the associated agricultural technologies due to their proximity. A study by [2, 24, 3, 23], found similar results in their studies. However, [11] found that distance had no impact on participation in Ethiopia.

v). Total Annual Income

The regression results show that the annual income by households is significant at 1% level of significance and positively related with utilization and intensity of utilization of small scale irrigation by households. This might be due to the fact that as farmer gets more annual income that could be increases the probability of investing in new agricultural technologies. It is also the main determines of purchasing power of farmers with existing price. So that households that have more income have more probability to utilize small scale irrigation than those households who have less income in the study area. The result of the study is consistent with earlier study by [3, 2, 28].

vi). Access to Information

Ownership of mobile phone, radio and access to market information which is an indirect measure for accessing information has a positive and significant effect on the likelihood of utilization and intensity of utilization of small scale irrigation at 5% level of significance. Acquisition of information about a new technology is an additional factor that determines adoption of technology. It enables farmers to learn the existence as well as the effective use of irrigation

technology and this facilitates its adoption. Farmers will only adopt the technology they are aware of or have heard about it. Access to information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objective over time. This shows that those households who have access to information have more probability of utilization of small scale irrigation than those household heads that have no access to information. A study by [3, 26] found similar result.

vii). Access to Extension Services

Access to extension has significant and positive influence on utilization and intensity of utilization of small scale irrigation at 1% level of significance in the study area (Table 10). Access to extension services found to be a key aspect in technology adoption. Farmers are usually informed about the existence as well as the effective use and benefit of new technology through extension agents. Extension agent acts as a link between the innovators of the technology and users of that technology. This implies that those farmers who have access to extension service are more likely to adopt small scale irrigation than who have not access to extension services. The relation between access to extension and technology adoption was reported to have a similar result in earlier studies such as [4, 28, 19, 12].

3.3.2. Effects of Changes in the Significant Explanatory Variables

All dummy and continuous significant explanatory variables do not have the same level of influence on farmers' decision of utilization and intensity of utilization of small scale irrigation. Using a decomposition procedure suggested by [17], the result of Tobit model was used to assess the effects of changes in the explanatory variable in to utilization and intensity of utilization of small scale irrigation. So that relative importance of the significant explanatory variables can be seen by examining the changes in probabilities of utilization and intensity of utilization of small scale irrigation that would result from changes in values of these explanatory variables and presented in Table 11.

Table 11. Effects of changes in the explanatory variables on probability of utilization and intensity of utilization of small scale irrigation.

Variable	Change in the probability of utilization	Change in the intensity of utilization	Total change
SEXHEAD	0.263	0.226	0.263
AGE	0.005	0.234	0.005
EDUC	0.189	0.160	0.189
DISHOMW	-0.057	-0.050	-0.057
TOTINC	0.000	0.146	0.000
ACINFO	0.165	0.126	0.165
ACEXTEN	0.571	0.516	0.571

Source: Model output.

As indicated in Table 11: sex of the household (being a male) increases probability utilization of small scale irrigation and intensity of utilization by 26.3% and 22.6% respectively (all other factors kept constant). Similarly, a unit increase in age of the household head would increases the probability of utilization of small scale irrigation and intensity of utilization by 0.51% and 23.41 respectively (all other factors remain constant). Change in the education status of household head

from unable to read and write to literate (able to read and write) increases utilization of small scale irrigation and intensity of utilization by 18.9% and 16.0% respectively (all other factors kept constant). One percent increase in distance from residence to water source decreases the probability of utilization by 5.7% and intensity of utilization of small scale irrigation by 5.0% (all other factors kept constant). While a one percent changes in annual income increases the

utilization and intensity of utilization of small scale irrigation by 0.001% and 14.6% respectively (all other factors remain constant). But the change on probability of utilization of small scale irrigation from change in annual income was very small as compared to the changes resulting from other significant explanatory variables (Table 11).

Access to information (change from no access to information to access to information) results about 16.5% increases in probability of utilization of small scale irrigation and 12.6% increases in the intensity of utilization of small scale irrigation. Similarly, access to extension services had found to be positively influences the adoption and intensity of utilization of small scale irrigation. A change in the access to extension services (change from no access to extension services to access to extension services) results in increases in probability of utilization of small scale irrigation and intensity of utilization of small scale irrigation by 57.1% and 51.6% respectively, which were very high as compared to changes resulting from other explanatory significant variables (Table 11).

4. Conclusion and Recommendations

4.1. Conclusion

The result of descriptive statistics revealed that demographic, socioeconomic and institutional factors played major roles in utilization and intensity of utilization of small scale irrigation. From the total sample of 177 households 57% were irrigation user and the rest 43% were non-user. The chi-square test revealed that all dummy variables which are determinants of utilization of small scale irrigation are statistically significant. These are sex of household head, education level of household head, access to information, access to credit and access to extension services. The result of t-test also revealed that all continuous variables except distance to market have significant relationship with utilization of small scale irrigation. This include age of household head, family size, total land, total annual income and distance to water source from residence of household.

Tobit model was chosen and used for econometric analysis because it has advantage over other adoption models in assessing both the probability of utilization and intensity of utilization of small scale irrigation. A total of twelve explanatory variables were used in Tobit model for regression and the model result indicated sex of household head, age of household head, education level of household head, total annual income, access to information and access to extension services have a positive relationship and significant for utilization and intensity of utilization of small scale irrigation. The single significant variables' that have negative relationship with utilization and intensity of utilization of small scale irrigation was distance from residence to source of water.

4.2. Recommendations

Based on the research findings of this study, the following points are recommended to increase farmers' utilization of small scale irrigation by smallholder farmers. Access to extension services was positively and significantly related with the utilization and intensity of utilization of small scale irrigation. The study found out it was the major determinant variable among other explanatory variables due to the fact that the influence on utilization and intensity of utilization were very strong. Therefore polices should give more attention on strengthening the existing extension service through providing material necessary for existing farmer training center, irrigation based short and long-term training, giving chance to upgrade through education and providing incentives based on achievement on their *kebeles*.

Sex of household head had a positive and significant effect on utilization of small scale irrigation. The positive relationship indicates that male headed households are found to be more likely to utilize irrigation as compared to female headed households. This indicates that women have not benefited much from small scale irrigation. But for sustainable and progressive impacts by small scale irrigation it should be given more attention to female headed households. Therefore, polices and strategies should provide solution to increase female headed household participation on small scale irrigation through irrigation program that targets females headed households, providing agricultural inputs and materials like motor pump and empower females through providing equal access to resources. It is also important to encouraging female headed households to participate in small scale irrigation using special trainings and extension services.

Education was also found to be one of a significant variable that affect utilization and intensity of utilization of small scale irrigation positively. Drawing from the result, policies should emphasize strengthening of formal and non formal education in rural farming areas. According to the result, the other important determinant of utilization and intensity of utilization of small scale irrigation was access to information. Hence, polices should set emphasis on provision of information about agricultural technologies through using available mass media, market places and farmer training centers. The study revealed that distance from the water source had negatively and significantly determine utilization and intensity of utilization of small scale irrigation. Therefore, government, NGOs and other stakeholders should give attention for construction of small scale irrigation canals to decrease the distance from residence to water sources.

The age of household head had significant and positive relation with utilization and intensity of utilization of small scale irrigation. Hence, knowledge and experience of old farmer should be acknowledged and sharing of their experience and knowledge to younger farmers should be given emphasis.

Total annual income of household had positive and significant effect on probability of utilization and intensity of utilization of small scale irrigation. This implies that those households who get more annual income have more probability of utilization and intensity of utilization of small scale irrigation than those household who gets less annual income. It is

important to stress that due to capital requirements for acquisition of irrigation technologies, increasing farmers' income should be given emphasis which resolves the financial constraints of farmers.

Based on the results from this study, some suggestions for future research can be inferred. First the study is confined to few variables, lack of data on biophysical, technological and psychological factors. Secondly, the method of data collection was based on only structured questionnaire since other methods like FGD and key informant interview are important to get more information and hidden aspects information. Hence there is a scope for further studies including those factors and other data collection methods listed above at *woreda*, *zonal*, regional and national level.

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