Journal of Natural Sciences Research www.iiste.org
ISSN 2224-3186 (Paper) ISSN 2225-0921 (Online)
Vol.14, No.3, 2023

Determinants of Adoption and Intensity of Small-Scale Irrigation Practice in Gemechis District, West Hararghe, Ethiopia

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Abstract
The study was conducted to assess factors that determine household's participation and intensity of use in the Gemechis district. A multi-stage sampling technique was employed to select 167 sample households by using Cochran formula. Both quantitative and qualitative data types from primary and secondary sources were collected. A cross-sectional data were collected through semi-structured questionnaire survey. For the dummy and continuous variables, chi-square (χ^2) and independent t-test statistics were used, respectively. Double hurdle model was used to analyze determinants of farmers' decision to participate and intensity of use of small-scale irrigation practice. The probit model results revealed that sex of household head, household size, annual income, farm distance from water source, access to extension and credit services were found significantly determined the participation decision of the farmers in small-scale irrigated farming. The truncated model indicates household size, access to oxen, farming experience and access to credit services were found significant.
Keywords: Small-Scale Irrigation, Double hurdle model, Adoption, Ethiopia.
DOI: 10.7176/JNSR/14-3-02
Publication date: February 28th 2023

1. Background

The Ethiopian agricultural sector runs the pillar of the country's economy in terms of income, employment and generation of export revenue (ADEA, 2014). Agriculture provides employment opportunities to about 83% of the population and supplies raw materials for 70% of the country's agro-industries (EEA, 2012) and about 70% of Ethiopia's foreign exchange is resulting from agricultural exports (FAO, 2015). Despite its importance for the national economy, the sector is highly based on subsistence farming, seasonal and heavily dependent on erratic rainfall. The distribution of rainfall varies from region to region. As a result, the production capacity also varies. The production of agricultural outputs using modern technology at smallholder level is at its minimal stage (FAO, 2015). However, the population growth and food demand is rapidly increasing in the country. The frequent failures of agricultural production forced many of the societies to lead their live dependent on assistance from different organizations for food (Abebaw *et al.,* 2015).

Irrigation development is one of the many components in the agricultural sector that has been promoted in most areas of the country in order to increase and diversify agricultural production so that income. It plays a key role to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall (Getaneh, 2011). It has also potential to increase both yields and cropping intensity (Awulachew, 2010). Ethiopia have the potential of 5.1 million hectares of land that can be developed for irrigation through the river and spring diversion, pump, gravity, pressure, underground water, water harvesting and other mechanisms (Tedros, 2014).

However, about 97 percent of Ethiopia's food crops are produced by rain-fed agriculture, whereas only 3 percent is from irrigated agriculture (FAO, 2015). The West Hararghe zone experienced a reduction in crop production by 27% due to the late onset and early cessation of the seasonal rains in 2012 (MOARD, 2013). Nevertheless, the excessive rains, flooding and hailstorm, swamps and rivers that can serve as irrigation area during the dry season were reported in the zone in the same year. There is a huge gap between the potential and the level of irrigation applied in the country. Some studies (Mengistu, 2008; Tedros, 2014; Abonesh et al., 2015; Dereje and Desale, 2016; Gamachu et al., 2018) were conducted in the country along small scale irrigation on food security, livelihood and poverty alleviation. However, they ignored analysis of determinants of small scale irrigation and the study area.

Therefore, this study was conducted to assess factors that determine farmers' decision to participate and intensity use of small-scale irrigation practice in Gemechis district, West Hararghe Zone, Ethiopia, so as to fill the knowledge gap required and further to contribute the expansion activities of the study area and national level where the agro ecological and socio economic conditions are similar.

2. MATERIALS AND METHODS

2.1 Description of the study area

The study was conducted in Gemechis district of West Hararghe zone, Oromia National Regional State, Ethiopia. Gemechis district is one of the 14 districts in West Hararghe zone. It is located on a distance of 333Km from

Addis Ababa and 17Km from zonal town of Chiro with altitude of 1300-3017 m a.s.l (Zonal irrigation development authority, 2014). The geographical location of the district lies between 8°10'N latitude and 40° 45'E longitude. The minimum and maximum temperature of the district in degree Celsius is 20-30°c respectively with rainfall of 850 - 1000 mm. The dominant soil type of the district is sandy-loam. The rain distribution is bimodal in nature with main rainy season starting from June to September and small rains extending from March to May. The agro ecology of the district is 15% highland, 45% midland and 40% lowland. The farming system of the district is characterized by mixed farming system. The water source for irrigation is river or stream, pond, shallow well and ground water is the most available and surface irrigation is common in the area (District Office of Agriculture, 2012). Major crops produced by irrigation are onion, tomatoes, potatoes, cabbage, sugarcane, carrot, sweet potato, hot pepper and chat.

2.2 Sampling Methods and Sample Size

In this study, multi-stage sampling technique was employed to select sample households in order to collect primary data. In the first stage, Gemechis district was selected purposively based on its potential and abundance of small scale irrigation practice. In the second stage, four rural *Kebeles* were randomly selected from 18 irrigated *Kebeles*. In the third stage, households were stratified into participant and non-participant, afterwards a probability proportional to sample size was employed. The list of participant and non-participant household heads name was obtained from each *Kebeles'* DA officers. Finally, respondent households were randomly interviewed. To determine the representative sample from the study area, the formula for sample size determination adjusting degree of precision to 0.07 due to shortage of resource, following Cochran (1977) has been used and 167 sample households was selected.

$$n = \frac{z^2 * (p)(q)}{d^2} \quad (1)$$

Where: n is sample size, Z is standard normal deviation (1.81 for 93% confidence level), p is the proportion of the population participating in irrigation which is P = 0.5, that is 50% due to unknown variability, q = 1-P =0.5 (50%) and d is desired degree of precision, (0.07) in this case.

The sample selected from each selected kebeles was proportional to the sample population in each kebele and the formula for this purpose was determined by formula (2)

$$ni = \frac{Ni\ (n)}{\sum Ni} \quad (2)$$

Where: ni is the sample to be selected from i's kebele, Ni is the total population living in selected i's kebele, ∑ is the summation sign, ∑Ni is the sum of total population in the selected four kebeles and n is otal sample size.

Table 1: Proportional sample size of households in each selected *kebeles*

Name of kebele	Number of households (HHs)			Sample size		Total sample size
	Non-participants	Participants	Total HH	Non-participants	Participants	
Kase Badiya	364	98	462	28	8	36
Walenso Arbafano	394	345	739	30	27	57
Homacho Gulabuba	200	220	420	16	17	33
Homacho Dayyo	387	147	534	30	11	41
Total	**1345**	**810**	**2155**	**104**	**63**	**167**

2.3 Types, Sources and Methods of Data Collection

For this study, both quantitative and qualitative data from primary and secondary sources were collected. The primary data were collected on one-to-one interview using a semi-structured survey questionnaire. During the personal interview demographic and socioeconomic characteristics of households were collected. Purposively selected focus group discussion and key informant interview were also used for collecting primary data. Secondary data were gathered from different published and unpublished sources including books, journal articles, CSA of Ethiopia, documents of district agricultural office and relevant local offices.

2.4 Methods of Data Analysis

2.4.1. Descriptive Statistics

The descriptive statistics such as minimum, maximum, mean and standard deviation were used to analyze socioeconomic, demographic, institutional and physical Characteristics of sampled households. For both dummy and continuous variables, chi-square (χ^2) and independent t-test statistics were used, respectively to compare participants and non- participants in terms of explanatory variables.

2.4.2 Econometric Models

Dependent variables: The dependent variables for determinants of adoption in this study are the participation decision of the farmers and intensity of participation in small-scale irrigation practice. Household's participation decision in small-scale irrigation practice is dichotomous (binary), it takes a value of 1 if the household has participated in small-scale irrigation practice and zero otherwise. It was estimated by using probit model. Intensity of participation in irrigation practice by the farmers was measured in terms of the proportion of the land irrigated by the farmers and it is continuous (zero or some value greater than zero) limited dependent variable. It was estimated by using truncated regression model.

Tobit model, Heckman two steps and Double hurdle model are the models suited to analyze the factors determining the probability of participation and intensity of participation under different underlying assumptions. By employing test on the best fit of the models among Tobit and Double hurdle model using log-likelihood ratio test following Newman et al. (2003), was made and Double hurdle was found to be the best fit than Tobit model. Therefore, the Double hurdle model was selected and used for the sake of analyzing the determinants of participation decision and intensity of participation in small-scale irrigation.

Participation decision equation is specified as follows:

$Y_{i*1} = X_1\beta_1+\varepsilon_{i1}$, $\varepsilon_{i1} \sim N(0,\delta_1^2)$ (3)

$$Y_{i1} = \begin{cases} 1, if\ Y_{i*1} > 0 \\ 0, if\ Y_{i*1} \leq 0 \end{cases}$$

Intensity of Participation Equation is specified as:

$Y_{i*2} = X_2\beta_2+\varepsilon_{i2}$, $\varepsilon_{i2} \sim N(0,\delta_2^2)$ (4)

$$Y_{i2} = \begin{cases} X_2\beta_2 + \varepsilon_{i2}, if\ Y_{i1} = 1\ and\ Y_{i*2} > 0 \\ 0, if\ Y_{i*2} \leq 0 \end{cases}$$

Where: Y_i* s unobserved (latent) variable for the participation decision and intensity in small-scale irrigation, the subscript i refers to the i^{th} household, the subscripts 1 and 2 refers to the variable and parameters related with the participation equation and the intensity of participation, respectively, X is are the index of explanatory variables determining the participation decision and intensity of participation, β is the index of parameters related with explanatory variables determining participation decision and intensity of the participation and ε_i is the error term of the participation equation which is normally distributed $\varepsilon_i \sim N(0,\delta_1^2)$ with zero mean and constant variance.

2.4.3 Description, Type, Measurability and Hypothesis of Explanatory Variables

Description of variables, variable type, measurability of variable and their hypothesis are described in Table 2 below.

Table 2: Description, type, measurability and hypothesis of explanatory variables

Explanatory variables	Variable type	Description of the variable	Measurability	Expected sign
Age	Continuous	Age of household head	Years	+/-
Sex	Dummy	Sex of HH head (0=female, 1=male).	Proxy/categorical	+
Education Level	Continuous	Formal education level of HH head	Years/number of grades attended	+
Household Size	Continuous	Measured in terms of adult equivalent of persons living together in one household.	Number	+/-
Annual income	Continuous	Total annual income of the household from all activity	Ethiopian Birr (ETB)	+
Land Size	Continuous	Total area of cultivable land and suitable land for irrigation owned by the household	Hectares	+
Livestock holding	Continuous	total livestock owned by farmers and equivalent to Tropical Livestock Unit (TLU)	Number	+
Access to Oxen	Dummy	Household's of holding Oxen (1 Having own Oxen, 0 otherwise)	Proxy/categorical	+
Farming Experience	Continuous	Farming experience of household head	Years	+
Off-farm Activity	Dummy	Off-farm activity (1 if a household head participated in off-farm income generating activities and 0, otherwise	Proxy/categorical	+/-

Explanatory variables	Variable type	Description of the variable	Measurability	Expected sign
Market Distance	Continuous	Distance of a market place from the HHHs' home	Km	-
Farm distance	Continuous	Distance of plot of land from water source	Km	-
Market information	Dummy	Information concerning the demand and price issue of the product (1 for having this access, 0 otherwise)	Proxy/categorical	+
Extension Access	dummy	Access of agricultural extension contact in the cropping year/season (1 if the farmer has got at least one extension, 0 otherwise)	Proxy/categorical	+
Credit Access	Dummy	Credit accessibility (1 a farmer accessed a credit before growing season, 0 otherwise)	Proxy/categorical	+
Farmers' perception	Dummy	Farmers' perception on the importance of Irrigation (1= if favorable response, 0 otherwise	Proxy/categorical	+

3. RESULTS AND DISCUSSION

3.1. Descriptive Statistics Results

Table 3 presents the t-value comparison of means of selected variables by participation status for the surveyed sampled households. According to Table 3, significant differences between the participants and non-participants exist in all the variables except farming experience and market distance.

There was significant difference ($p < 0.01$) in mean age of household heads between participants and non-participants in irrigation. The result indicated that the age of non-participants was higher as compared to participants. The mean years of education were 6.43 and 4.25 years of schooling for participants and non-participants, respectively and highly significant at 1% level of significance (Table 3). The result indicates that, the education level of the participants was higher as compared to non-participants. The mean household size of participants was 7.79 whereas non-participants was 4.62 and highly significant at 1% level of significance. The household size participant was higher as compared to non-participant. The results in Table 3 indicates that an average of annual income of household heads of irrigation participant was Birr 242,031.75 with standard deviation Birr 637813.93 which is greater than that of the non-participants Birr 71,914.42 with standard deviation Birr 127975.50. There was a high significant difference in the annual income of households between participants and non-participants in irrigation.

The mean livestock holding of the non-participants was 2.02 TLU, while that of the participants was 3.13 TLU and significant at 1% level of significance. The result implies that the livestock holding by participants was higher as compared to non-participants (Table 3). There was no significant difference in farming experience of household heads between participants and non-participants in irrigation and also the result shown there was no significant difference in market distance from homestead. The results in Table 3 indicates that an average of farm distance from homestead and water source of irrigation participant was 1.79 Km with standard deviation 1.95060 Km which is lower than that of the non-participants 5.76 Km with standard deviation 2.75662 Km. There was a high significant ($p < 0.01$) difference in the farm distance between participants and non-participants in irrigation from their homestead and water source.

Table 3: Descriptive statistics of continuous variables across participant and non-participants of small-scale irrigation

Variables	Participant (N= 63)		Non-participant(N=104)			
	Mean	SD	Mean	SD	t-test	p-value
Age of HHH	37.90	17.00827	57.82	15.46419	7.765	0.000***
Education Level	6.43	3.58633	4.25	3.63839	-3.771	0.000***
Household Size	7.79	2.80068	4.62	2.27825	-8.003	0.000***
Annual Income	242031.75	637813.93	71914.42	127975.50	-2.639	0.009***
TLU	3.13	1.78246	2.02	2.05261	-3.548	0.001***
Farming Experience	11.22	7.50149	5.64	4.30831	1.928	0.056
Market Distance	5.24	3.17609	5.64	4.30831	0.649	0.517
Farm Distance	1.79	1.95060	5.76	2.75662	10.003	0.000***

Note: ***indicates level of significance at 1%, HHH=Household Head.

According to Table 4, significant differences between the participants and non-participants exist in all the variables except sex of household head and access of market information.

The majority (84.43%) were male-headed while 15.57% were female-headed. The female-headed households' proportion for participant and non-participant were 26.92% and 73.08%, respectively. The male-headed households' proportion for participant and non-participant were 39.72% and 60.28%, respectively. The chi-square test result on this variable shows that there was no significant difference between participants and non-participants (Table 4). The descriptive analysis shown that there was highly significant difference (at 1%) on the access of oxen by households between participants and non-participants in irrigation practice. This implies that the participants have more access of oxen than non-participants. The proportion of households that have access to off-farm activity for non-participants was about 25% where as that of participants was about 3.17% and the chi-square value of the proportionality test for this variable indicates that there was significant difference.

The majority (65.87%) of households does not have any information on input and output prices; whereas 34.13% has information (Table 4). The chi-square test result on this variable shows that there was no significant difference between participants and non-participants. Households who have extension access were 88.89% and 21.15% while those who have no this access were 11.11% and 78.85% for participant and non-participant, respectively. The chi-square test result on this variable shows that there was significant difference between participants and non-participants at 1%.

Table 4: Descriptive statistics of the discrete variables across participant (N = 104) and non-participants (N = 63)

Variable		Participant	Non-participant	Total		
		Frequency	Frequency	Frequency	Ch^2-test	p-value
Sex of HH head	Male	56(39.72)	85(60.28)	141(84.43)	0.273	0.155
	Female	7(26.92)	19(73.08)	26(15.57)		
Oxen Access	Yes	57(90.48)	8(7.69)	65(38.92)	0.000	0.000***
	No	6(9.52)	96(92.31)	102(61.08)		
Off-farm Activity	Yes	2 (3.17)	26 (25.00)	28 (16.77)	0.002	0.001***
	No	61 (96.83)	78 (75.00)	139 (83.23)		
Market Info. Access	Yes	24 (38.09)	33(31.73)	57 (34.13)	0.406	0.250
	No	39(61.91)	71(68.27)	110 (65.87)		
Extension Access	Yes	56 (88.89)	22 (21.15)	78 (46.71)	0.000	0.000***
	No	7(11.11)	82 (78.85)	89 (53.29)		

Note: *Figures in parenthesis represents the percentage of respondents involved, ***indicates level of significance 1% and HHH=Household Head.*

The farmers' favorable (positive) response for participant and non-participant were 88.89% and 80.77%, respectively. The farmers' unfavorable (negative) response for participant and non-participant were 11.11% and 19.23%, respectively. For the total observation, 83.83% have favorable response while 16.17 have unfavorable response (Figure 1). This implies most of the farmers' have good attitude and understood the benefit of irrigation technology.

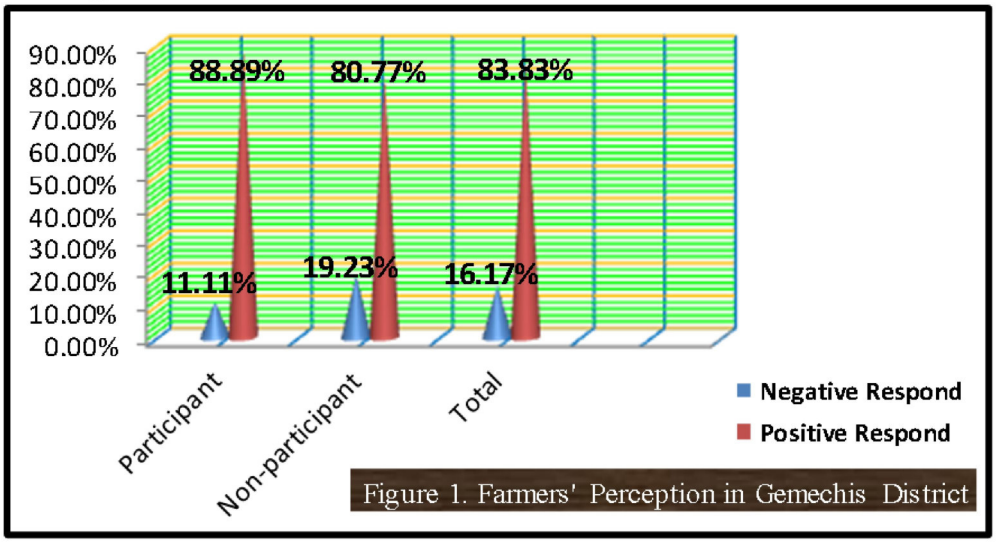

Figure 1. Farmers' Perception in Gemechis District

Access of credit service was another important categorical variable that was analyzed across participants and non-participants. For the total sampled households, about 68.26% did not use credit, whereas 31.74% have

credit access. The households who have credit access for participant and non-participant were 77.78% and 3.85%, respectively. The households who have no credit access for participant and non-participant were 22.22% and 96.15%, respectively (Figure 2). This indicates the participant households have more credit access than non-participant and facilitate their farm production using irrigation by help of credit access.

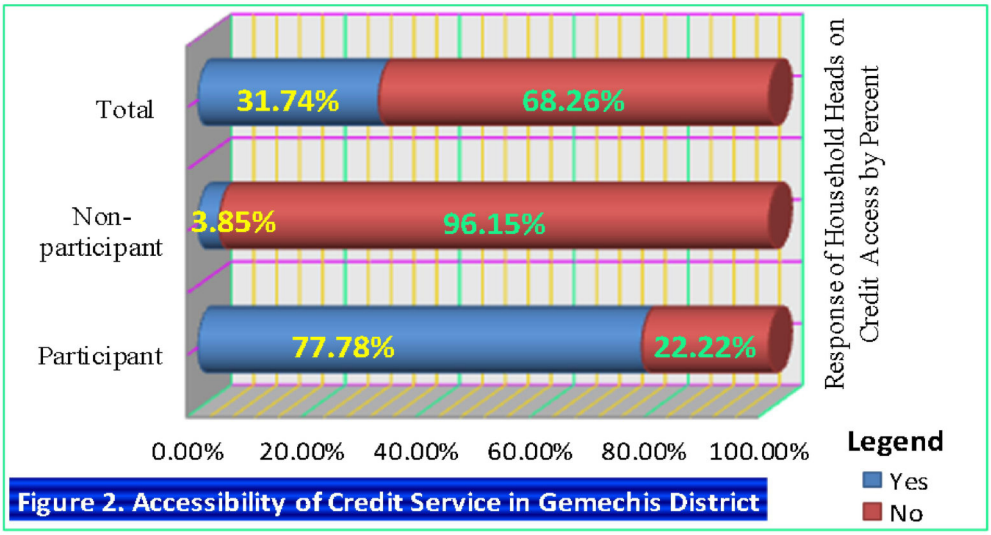

Figure 2. Accessibility of Credit Service in Gemechis District

3.2 Econometric Results

3.2.1 Test statistics of the regression models

The results of the likelihood ratio test between the Tobit and the two step modeling (using Probit and Truncated regressions) show that the Double-Hurdle model is superior to Tobit model since the Γ=150.38 which exceeds the critical χ^2 value with 15 degree of freedom [$\chi^2(15)$= 24.996]. For the strength of model specification, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) are included. Model with lowest AIC and BIC is always preferred (Table 4). In comparison to the Tobit model, the AIC and BIC values of the double hurdle model are much lower, indicating that the two-part model has to be favored to explain participation decision and intensity. Rejections of the null-hypothesis indicate that farmers' decision about participation and level of participation was taken at two different stages and Double Hurdle model is the appropriate choice in our case.

Table 5. The test statistics of the double hurdle versus the Tobit model

	Probit, D	Truncated Regression	Tobit
Loglikelihood Ratio	-13.17	-83.78	-189.81
Wald χ^2/ LR chi^2	(15) = 195.01	(15) = 21.04	(15) = 65.67
Number of observation (N)	167	91	167
AIC	58.33	201.56	413.62
BIC	108.22	244.25	466.63
Hypothesis	H_0: Tobit Specification		
	H_1= Double Hurdle Specification		
Critical Value	$X^2_{15,0.05}$ = 24.996		
Decision: Reject Ho B/C x^2-Test Double Hurdle versus Tobit: Γ= 150.38			

Based on the results of VIF, the data had no serious problem of multicollinearity. This is because, for all continuous explanatory variables, the values of VIF are by far less than 10 (Appendix 1). Therefore, these continuous explanatory variables were included in the model. Similarly, the contingency coefficient (CC) results showed absence of strong association between different hypothesized discrete explanatory variables, since the respective coefficients were very low (less than 0.75) and the tolerance values were above 0.10 as given on (appendix 2). Therefore, the dummy variables were included in the model. For endogeneity test, there was no explanatory variable that was expected to be endogenous in the model and hence no need of undertaking the test.

3.2.2 Factors Determining Participation in Small-Scale Irrigation

The probit regression part of double hurdle model result, given on Table 6, reveals that out of the 15 explanatory variables, six explanatory variables were found significantly determined the participation decision of the farmers in small-scale irrigated farming, at different significance levels. These variables include sex of household head, household size, annual income of household, farm distance, access to extension services and access to credit services.

Sex of Household Head (Sex): As the probit model indicates sex of household head had positive and significant

influence on the participation of small-scale irrigation at 5% significance level. This shows that being male headed households are more likely to participate in small-scale irrigation than female-headed. The justification for this is that male farmers might have more access to information, extension and credit services whereas female headed households have lack of time for gathering information about new technology due to women are involved in many responsibilities in the home such as cooking and child care. The result consistence with Yenealem (2013) the binary logit model results revealed that the adoption of improved maize variety is biased by gender, where female headed households adopt the improved varieties less. Abebaw and Haile (2013) also obtained similar result on a study of membership for agricultural cooperatives in Ethiopia. The result opposed with Kileo (2014) states that female headed households made the decision to adopt new technology as compared to their female counterparts.

Household Size: The estimated coefficient of household size was positive and significant at the 5% level. The value of marginal effect (0.0203795) shows that with one person increase in family member, the probability of participation of small-scale irrigation increases by 2.04 percent. Larger household sizes would be favourable since they imply more labour available and hence higher chances of participation. Plenty of adoption studies found out a positive impact of family labor on technology adoption such as Techane (2002), Bayissa (2011) and Solomon et al (2011). However, Josephson et al. (2014) reported limitation in livelihood options with large households as one prime driver of extreme and continuous poverty in arid rural areas. The result also opposed with Aman et al.(2014) stated that the higher the number of household members, the more they will consume their production and increase in the number of dependent family members which would disproportionate volume of production.

Annual Income: A statistically significant positive association ($P<0.01$) was found between the total annual income of household and participation of small-scale irrigation. It was highly determined households' decision which is indicator of household economic status. High income household heads could have the capacity to possess additional labour, land and equipment for irrigation operation. The findings correlate with findings by Sufdar et al. (2013) who suggests that households with high income are more likely to adopt biogas technology as compared to households with low income.

Farm Distance from Water Source: This variable was significant at 5% level of significance and has a negative relationship with household participation decision in small-scale irrigation practice. It indicates that as distance of plot of land from irrigation water source increases by one kilometer, the probability of participating in small-scale irrigated farming decreases by 2.22%, holding other factors constant. The implication of this negative relationship was that the farther plot of land from water source, the lesser would be farmers' initiative to participate in small-scale irrigation. The possible justification could be households who are far from the irrigation scheme can't follow up the farm activity closely and frequently and may not get a better yield. The opportunity cost of the time lost in travelling to and from an irrigation-farm is high. Also in the study area every activity is handled manually, so that, an increase in distance of farm land from irrigation water source exposed household to incur high cost due to difficulty of bringing water to one's farm land. This finding is in-line with the findings of studies by Kinfe et al. (2012), Beyan et al. (2014), Sithole et al. (2014) and Temesgen et al. (2018).

Access to Extension Services: This variable was significant at 5% level of significance and has a positive relationship with household participation decision in small-scale irrigation practice. Households who have access to extension service have 56.74 percentage points more chance of participation in small-scale irrigation than their counter parts, while keeping all other variables constant at their mean value. This means the discrete effect of a change from 0 to 1 in access to extension service increases the probability of participation in small-scale irrigation by 56.74 percentage points higher than their counterparts. Agricultural extension services play a crucial role in the motivation of farmers towards the adoption of improved irrigation practices. Farmers that have frequent contact with agricultural extension get information on new technologies more frequently and easily. This might increase their agricultural production and productivity (Madhusuda *et al.,* 2002) and Koundouri et al. (2003), found that exposure of the farmers to extension services and their access to up to date farm information increased the probability to adopt new technology. This result is also consistent with early literature Ransom et al. (2003); Feleke and Zegeye (2006); Kapalasa, (2014).

Access to Credit Services: This variable was significant at 5% level of significance and has a positive relationship with household participation decision in small-scale irrigation practice. The discrete effect of a change from 0 to 1 (change from non-user of credit to credit user) in access to credit service increases the probability of participation in small-scale irrigation by 22.39 percentage points higher than their counterparts. The positive relationship indicates those households who have access to credit have a better possibility of participation in small-scale irrigation because credit helps the farmers to purchase inputs such as seeds, fertilizers and irrigation equipments. Very few farmers in the surveyed sample accessed credits for agricultural purposes indicating the existence of obstacles to access the service. The same result was found by researchers such as Muhammad et al. (2013), Sithole et al. et al. (2014), Nhundu et al. (2015) and Temesgen et al. (2018).

3.2.3 Factors Determining Intensity of Participation in Small-Scale Irrigation

The truncated regression part of double hurdle model result, given on Table 6, reveals that out of the 15 explanatory variables, four explanatory variables were found significantly determined the intensity of participation in small-scale irrigated farming, at different significance levels. These variables include household size, access to own oxen, farming experience and access to credit services.

Household Size: Household size was found positively influenced the intensity of cultivating irrigation land at 5% probability level. This implies that, all other factors remain constant, the proportion of irrigated land increases by 9.28%, as the number of household size increases by one person. Large household size may mean having sufficient labor required to manage and operate irrigation practice. The probable reason for this finding is that irrigation practice are labour intensive and hence the household with relatively high labour force uses the technologies on their farm plots more than others similar signs found for other technologies (Hailu, 2008).

Access to Own Oxen: This variable was found significantly and positively determined the intensity of participation at 1% significance level. This implies that, all other factors being kept constant, the proportion of irrigated land increases by 59.06%, as household owned one oxen. Most farmers of the study area have not their own Oxen; they have prepared their farmland by hand hoe. Therefore, farmers that have own oxen use for land preparation and they were more easily able to prepare large area of land than the households that have no own oxen and hence more likely involve in small-scale irrigated farming.

Farming Experience: farming experience was found significantly and positively determined the intensity of participation at 5% significance level. The proportion of irrigated land increases by 2.70%, as the farming experience increases by one year while other factors remain constant. Experienced farmers are expected to have greater access to productive resources (such as land and labor) and be able to apply improved agricultural technologies. This result is consistent with the research results by Aman and Tewodros (2016) and Musa et al (2016).

Access to Credit Services: Access to institutional credit can play a vital role in the participation intensity of irrigation technology. The study has shown that there is a positive and significant ($p<0.05$) relation between the use intensity of irrigation technology and access to credit. This implies that, all other factors being kept constant, the proportion of irrigated land increases by 54.95%, as household have credit service. In other words, the proportion of land irrigated by the farmers those used credit exceeds the proportion of land irrigated by the farmers with who did not used credit by about 54.95%. The finding is consistent with Abebe et al. (2011), Islam et al. (2015), Lapple et al. (2015) and Temesgen et al. (2018).

Table 6: Maximum likelihood estimates of double hurdle models for participation and intensity of participation of small-scale Irrigation in Gemechis District

First Hurdle (Probit)-Participation Equation					Second Hurdle (Truncated Model)-Intensity Equation			
Variables	Coef.	Std. Error	P-value	Marginal Effect	Coef.	Std. Error	P-value	Marginal Effect
Age of Household Head	-0.0247125	0.0246677	0.316	-0.0010981	-0.0059836	0.005946	0.312	-0.0059836
Sex of Household Head	2.222321	1.126311	0.041**	0.0987447	0.2532905	0.3115382	0.416	0.2532905
Education Level	0.0551284	0.0996942	0.580	0.0024495	0.0457236	0.0275029	0.096	0.0457236
Household Size	0.4586552	0.2250867	0.042**	0.0203795	0.0927761	0.0422315	0.028**	0.0927761
Annual Income	7.82e-06	3.12e-06	0.002***	3.48e-07	1.29e-07	1.37e-07	0.344	1.29e-07
TLU	0.5639741	0.3244202	0.082	0.0250592	0.0539569	0.0498658	0.279	0.0539569
Oxen Access	12.96026	469.9258	0.978	0.5758654	0.5906228	0.2041674	0.000***	0.5906228
Farming Experience	0.0668304	0.0606376	0.270	0.0029695	0.02700	0.0116479	0.020**	0.02700
Off-farm Activity	-0.0718683	1.175014	0.951	-0.0031933	-0.3461568	0.2916194	0.235	-0.3461568
Market Distance	-0.0425158	0.1618816	0.793	-0.0018891	-0.0020868	0.0199392	0.917	-0.0020868
Farm Distance	-0.4989052	0.2375799	0.036**	-0.0221679	-0.0005019	0.0458891	0.991	-0.0005019
Market Information Access	0.3262882	1.170274	0.780	0.014498	0.1494643	0.162667	0.358	0.1494643
Extension Access	4.183877	2.001908	0.037**	0.5673623	0.4039678	0.2528009	0.110	0.4039678
Credit Access	5.040523	2.19591	0.022**	0.2239664	0.5466131	0.2881075	0.052**	0.5466131
Farmers' Perception	12.76889	469.9269	0.978	0.1859029	0.5495165	0.2877567	0.056	0.5495165
Constant	5.962937	469.9217	0.990		0.6372697	.05686423	0.262	
sigma					0.6463532	0.0567413	0.000	
Number of observation = 167		**Pseudo R^2 = 0.8810**			**Number of observation = 91**		**Limit: lower = 0**	
LR $chi^2(15)$ = 195.01		**Log likelihood = -13.165951**			**Wald $chi^2(15)$ = 21.04**		**upper = +inf**	
Prob > chi^2 = 0.0000					**Prob > chi^2 = 0.1355**		**Log likelihood = -83.780165**	

4. Conclusion and Recommendation

The study was identified and analyzes the factors determining participation and intensity of use in small-scale irrigation by the farm households of Gemechis district with four Kebeles. The study used double hurdle model to analyze the determinants of participation and intensity of participation in small-scale irrigation. The first part of double hurdle (probit model) was used 15 explanatory variables, out of them six explanatory variables were found significantly determined the participation decision of the farmers in small-scale irrigated farming, at different significance levels. These variables include sex of household head, household size, annual income of household, farm distance from water source and homestead, access to extension services and access to credit services. The second part of double hurdle (truncated model) was used also 15 explanatory variables, out of them four explanatory variables were found significantly determined the intensity of participation in small-scale irrigated farming, at different significance levels. These variables include household size, access to own oxen, farming experience and access to credit services.

Based on the above result the following recommendations were drawn:

- Access to extension services was positively and significantly related to farm households' participation in small-scale irrigation. We recommend agricultural extension should be give immediate contact and flow with farm households to provide reliable and recent information and skills on small-scale irrigation.
- Credit service enables farmers to purchase agricultural inputs such as seeds, fertilizers and irrigation equipment.This variable was positively and significantly related to both farm households' participation in small-scale irrigation and intensity of use. Thus, concerned institution should develop the way to interested households accessed credit use.
- The study shown that farm distance from irrigation water source and homestead was found to be barrier for participation in irrigation with significant effect. Therefore, ground water development and rainwater harvesting pond should be practiced closed to irrigation land.

Appendices

Appendix 1. Variance inflation factor (VIF)

Variable	VIF	Tolerance Level
Age of Household Head	1.63	0.612667
Education of Household Head	1.28	0.778892
Household Size	1.49	0.671017
Annual Income	1.07	0.937599
Total Livestock Holding	1.19	0.838296
Farming Experience	1.24	0.803426
Market Distance	1.05	0.951491
Farm Distance	1.77	0.566437
Mean VIF	1.34	

Appendix 2. Contingency Coefficient (CC)

Variable	Sex	Oxen Acc	Off-farm	Market Inf	Extension	Credit Acc.	Perception
Sex	1.0000						
Oxen Access	0.0718	1.0000					
Off-farm Activity	-0.2494	-0.3254	1.0000				
Market Info.	0.0653	0.1247	-0.0526	1.0000			
Extension Access	0.1372	0.4835	-0.2595	-0.0664	1.0000		
Credit Access	0.2262	0.7409	-0.2760	0.1734	0.5075	1.0000	
Perception	0.0806	0.1504	-0.0641	0.2475	-0.1105	0.1645	1.0000

Abbreviations

CSA: Central Statistical Authority; CC: Contingent Coefficient; EIAR: Ethiopian Agricultural Research Institute; FAO: Food and Agriculture Organization; NGOs: Non-Governmental Organizations; TLU: Tropical Livestock Unit; VIF: Variance Inflation Factor; ZIDA: Zonal irrigation development authority.

Acknowledgements

The authors are grateful to thank Gemechis district agricultural office, respondent households, group discussants, and key informants for their willingness to contribute to the study by being the source of necessary data and information.

Authors' contributions

All authors had their own crucial role in the process of completing this study. Study design, data collection, and

data analysis, critically review and provide comments on the content and structure of the paper. All authors read and approved the final manuscript.

Funding
Not Available

Availability of data and materials
The authors want to declare that they can submit the data at any time based on publisher's request. The datasets used and/or analyzed during the current study were available from the authors on reasonable request.

Competing interests
The authors declare that they have no competing interests.

Ethics approval and consent to participate
Ethical clearance letters were collected from Agricultural Office of West Hararghe zone for both the study participants and the researchers. Hence, all participants throughout the research, including survey households and key informants were fully informed of the objectives of the study. They were approached friendly in free moods until they do this research.

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