Geddafa et al., *Cogent Engineering* (2021), 8: 1960250
https://doi.org/10.1080/23311916.2021.1960250

cogent engineering

CIVIL & ENVIRONMENTAL ENGINEERING | RESEARCH ARTICLE

Determinants of smallholder farmers' participation and level of participation in small-scale irrigation practice in Gemechis district, West Hararghe Zone, Ethiopia

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Received: 20 April 2021
Accepted: 21 July 2021

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Reviewing editor:
Sanjay Kumar Shukla, Universita degli Studi di Palermo, Palermo, Italy

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Abstract: The study was conducted to assess factors that determine a household's participation and intensity of use in the Gemechis district. A multi-stage sampling technique was employed and 167 sample households were selected by using the Cochran formula. Both quantitative and qualitative data types from primary and secondary sources were collected. Cross-sectional data were gathered through a semi-structured questionnaire survey. For both dummy and continuous variables, chi-square (χ2) and independent t-test statistics were used, respectively, to test the significance of the mean value of the two groups of participants and non-participants. The double hurdle model was used to analyze determinants of farmers' decision to participate and intensity of use of small-scale irrigation practice. Results of the first part of the double hurdle (probit) model revealed that the sex of household heads, household size, the annual income of the household, farm distance from the water source, access to extensions, and credit services were found to significantly determine the participation decisions of farmers in the small-scale irrigated agriculture, at different significance levels. In the second part of the double hurdle (truncated) model indicates household size, access to own oxen, farming

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PUBLIC INTEREST STATEMENT

Irrigation is a man-made application of water to guarantee double cropping as well as a steady supply of water in areas where rainfall is unreliable. Irrigation agriculture can escalate productivity, protects against risks of crop loss due to deficient rainwater supplies, promotes the use of yield-enhancing farm inputs, and generates additional employment. A huge amount of efforts and expenditures are being made on the development of irrigation technology in Ethiopia either through the farmers-managed or agency-managed irrigation systems. However, the intensity of participation and return on investments is unsatisfactory. Ascertaining factors that hinder farmer participation in irrigation technology is an effective way to enhance irrigation effectiveness. This finding identified and analyzed various factors affecting farmer's participation and its intensity in the adoption of small-scale irrigation.

experience, and access to credit services were found to significantly determine the intensity of participation in small-scale irrigated farming, at different significance levels. Results further showed that farm distance from irrigation water was found to be a barrier for participation in irrigation with significant effect. Therefore, ground-water development and rainwater harvesting ponds should be practiced close to the irrigation land.

Subjects: Agriculture & Environmental Sciences; Biology; ICT; Biotechnology

Keywords: Small-scale irrigation; double hurdle model; participation; Ethiopia

1. Introduction

The Ethiopian agricultural sector runs the pillar of the country's economy in relation to income, employment, food security, and the generation of export revenue (ADEA (Association for the Development of Education for Africa), 2014; Asayehegn, 2012). Agriculture provides employment opportunities to about 83% of the population and provides raw materials for 70% of the country's agro-industries (EEA (Ethiopian Economic Association), 2012). About 70% of Ethiopia's foreign exchange is resulting from agricultural exports (FAO (Food and Agricultural Organization), 2015). Despite its importance, for the national economy, the sector is highly based on subsistence farming, seasonal, and heavily hooked into erratic rainfall distribution. The production of agricultural outputs using modern technologies such as small-scale irrigation at the smallholder level is at its embryonic stage (FAO (Food and Agricultural Organization), 2015). The frequent failures of agricultural production have forced many of the societies to food insecurity which often turns into famine (Abebaw et al., 2015). Therefore, small-scale irrigation is a priority area to meet the food demand of the ever-increasing population growth in Ethiopia.

Irrigation development is one among the pillar principles within the agricultural sector that have been promoted in most areas of the country to increase yield and cropping intensity and diversify agricultural production in order to earn more stable incomes (Awulachew, 2010). Irrigated agriculture plays a crucial role in stabilizing agricultural productivity and production, mitigating the negative impacts of variable or insufficient rainfall and providing sustainable food security (Getaneh, 2011). Ethiopia has a significant potential for irrigation both in terms of the available land and water resources. It has 5.1 million hectares of land which will be advanced for irrigation (Awulachew et al., 2010; FAO (Food and Agricultural Organization), 2015; Tsehaye, 2014). The country has abundant water resources, including more than 10 river basins and 22 natural and artificial lakes, hence known as the Water Tower of Africa (ADF (African Development Fund), 2005). The annual runoff volume of the country is 122 billion m^3 of surface water and 2.6 billion m^3 of groundwater. Because of the ample availability of land and water resources, the country started modern irrigation in the 1960s by private investors in the Middle Awash Valley (ADF (African Development Fund), 2005).

Nevertheless, only 3% of Ethiopia's food crops are produced from irrigated agriculture till 2014. About 97% of the irrigation potential in terms of land and water resources has not been developed so far (FAO (Food and Agricultural Organization), 2015). The West Hararghe zone experienced a decline in crop production by 27% due to the late-onset and early cessation of the seasonal rains in 2012 (MoARD (Ministry of Agriculture and Rural Development), 2013). However, the extreme rains, flooding, and hailstorm, and rivers that can serve as irrigation areas during the dry season were reported within the zone in the same year. The interventions so far made in the zone towards the development of small-scale irrigation are very limited or no effort has been made on the dissemination activity. However, the development of an irrigation system requires the active participation of the community for sustainable operation.

There's an enormous gap between the community's participation and the potential of the irrigation applied in the study area. Some studies (Assefa, 2008; Ayala et al., 2018; Mengistie &

Kidane, 2016; Tesfaye et al., 2015; Tsehaye, 2014) were conducted within the country along with small-scale irrigation on food security, livelihood, and poverty alleviation. However, they ignored the analysis of factors that determine smallholder farmers' participation and level of participation in small-scale irrigation and consequently the study area. Thus, this study was conducted to fulfill the knowledge gap of factors that are barriers to the development of small-scale irrigation farming and further to contribute to the expansion of irrigation activities in the study area and national level where the agro-ecological and socio-economic conditions are comparable.

2. Materials and methods

2.1. Description of the study area

The study was conducted in the Gemechis district of the West Hararghe zone, Oromia National Regional State, Ethiopia. Gemechis district is one of the 14 districts in the West Hararghe zone. It is located at a distance of 333 km from Addis Ababa and 17 km from the zonal town of Chiro with an 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 temperatures of the district is 20–30°C, respectively with rainfall of 850–1000 mm. The dominant soil sort in the district is sandy-loam. The rain distribution is bimodal in nature with the main rainy season ranging from June to September, and few 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 categorized by a crop-livestock farming system. The water sources for irrigation are river or stream, pond, shallow well, and groundwater is that the most available and surface irrigation is common within the area (District office of agriculture, 2012). Major crops produced by irrigation are onion, tomatoes, potatoes, cabbage, sugarcane, sweet potato, hot pepper, and chat.

2.2. Sampling methods and sample size

In this study, a multi-stage sampling technique was employed to pick sample households in order to gather primary data. Within the first stage, the Gemechis district was selected purposively due to its potential and abundance of small-scale irrigation practice. Within the second stage, four rural *Kebeles*[1] were randomly selected from 18 irrigated *Kebeles*. In the third stage, households were stratified into participant and non-participant, subsequently, a probability proportional to the size of selected *Kebeles* was employed to identify the sample size in each *Kebeles* (Table 1). The list of the participants and non-participant household heads , names were obtained from each *Kebeles'* DA officers. Finally, respondent households were randomly interviewed. The sample size was determined by following Cochran's (1977) formula and adjusting the degree of precision to 0.07 due to shortage of resources, and 167 sample households were selected.

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

Where: n is the sample size, Z is a 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 the 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 the formula (2)

$$ni = \frac{Ni\ (n)}{\sum^{N} i} \tag{2}$$

https://doi.org/10.1080/23311916.2021.1960250

Table 1. Proportional sample size of households in each selected kebeles

Name of kebele	Strata		Total Household	Sample size		Total sample size
	Non-participants	Participants		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

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 the total population in the selected four *kebeles* and n is the total sample size.

2.3. Data type, source and collection methods

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

2.4. Methods of data analysis

2.4.1. Descriptive statistics

Descriptive statistics such as minimum, maximum, mean, and standard deviation were used to summarize the data. For both dummy and continuous variables, chi-square (χ2) and independent t-test statistics were used, respectively, to test the significance of the mean value of the two groups of participants and non-participants in terms of explanatory variables.

2.4.2. Econometric model

Dependent variables: the dependent variables for determinants of adoption during this study are the participation decision and intensity of participation of the farmers in small-scale irrigation practice. Household participation decisions in small-scale irrigation practice is dichotomous, it takes a value of 1 if the household has participated in small-scale irrigation practices and zero otherwise. It had been estimated by using the probit model. The intensity of participation in irrigation practice by the farmers was measured in terms of the proportion of the land irrigated by the farmers from the total farmland they owned and it is the continuous limited dependent variable. It was estimated by using a truncated regression model.

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

Participation decision equation is specified as follows:

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

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

Intensity of Participation Equation is specified as:

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

Table 2. Description of the explanatory variables specified in the Double Hurdle Model

Explanatory Variable	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		+
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	Households 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	+
Market Distance	Continuous	Distance of a market place from the HHHs' home	Km	-
Farm Distance	Continuous	Distance of plot of land for irrigation 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	number of agricultural extension contact in the cropping year/ season (1 if the farmer has got at least one extension, 0 otherwise)	Proxy/categorical	+

(*Continued*)

Explanatory Variable	Variable Type	Description of the Variable	Measurability	Expected Sign
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 favourable response, 0 otherwise	Proxy/categorical	+

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

Where: Y_i^* is 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 refer to the variable and parameters related with the participation equation and the intensity of participation, respectively, X is 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 $\mathcal{E}_i$ is the error term of the participation equation, which is normally distributed $\mathcal{E}_i \sim N(0,\delta_1^2)$ with zero mean and constant variance.

2.4.3. Description of variables and their hypothesis

Table 2 below shows the explanatory variables used in the double hurdle model with their specifications.

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	0.010***
Education Level of HHH	6.43	3.58633	4.25	3.63839	−3.771	0.010***
Household Size	7.79	2.80068	4.62	2.27825	−8.003	0.010***
Annual Income of HH	242,031.75	637,813.93	71,914.42	127,975.50	−2.639	0.009***
TLU	3.13	1.78246	2.02	2.05261	−3.548	0.010***
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	0.010***

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

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)	0.001	0.010***
	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	0.010***
	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)	0.001	0.010***
	No	7(11.11)	82 (78.85)	89 (53.29)		

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

3. Results and discussion

3.1. Descriptive statistics results and discussion

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 a significant difference ($p < 0.01$) in the mean age of household heads between participants and non-participants in irrigation. The results showed that the age of non-participants was higher than 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 a 1% level of significance (Table 3). The results revealed that the education level of the participants was higher than compared to non-participants. The mean household size of participants was 7.79, whereas the number of non-participants was 4.62 and highly significant at 1% level of significance.

The household size of participants was higher than compared to non-participants. The results in Table 3 indicate that an average of the annual income of household heads of irrigation participants was Ethiopian Birr 242,031.75 with a standard deviation of Birr 637,813.93 which is greater than that of the non-participants Birr 71,914.42 with a standard deviation of Birr 127,975.50. There was a highly significant difference in the annual income of households between participants and non-participants in irrigation.

The mean livestock holdings 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 results imply that livestock holding by participants was higher than compared to non-participants (Table 3). There was no significant difference in the farming experience of the household heads between participants and non-participants in irrigation and the results also revealed there was no significant difference in market distance from homestead.

The results in Table 3 indicate that the average farm distance from homestead and water source of irrigation participants was 1.79 km with a standard deviation of 1.95060 km which is lower than that of the non-participants 5.76 km with a standard deviation of 2.75662 km. There was a highly

Figure 1. Farmers' perception on small-scale irrigation in Gemechis district.

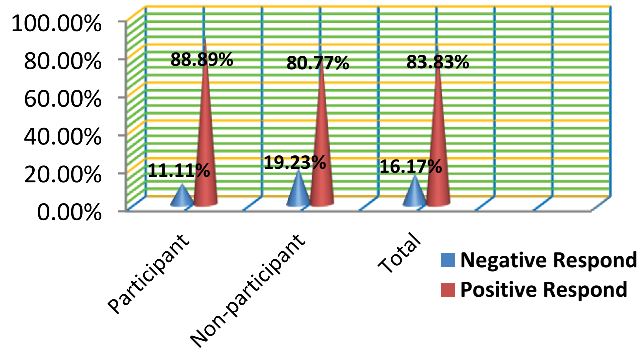
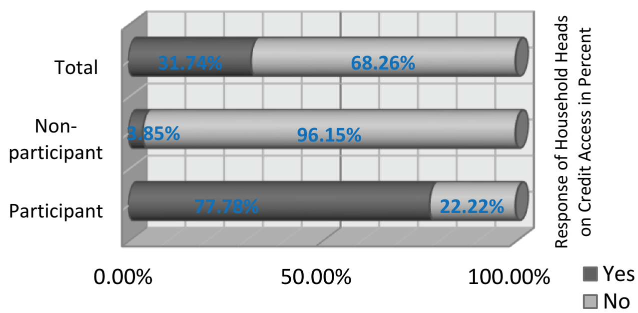


Figure 2. Accessibility of credit service in Gemechis district.



significant ($p < 0.01$) difference in the farm distance between participants and non-participants in irrigation from their homestead and water source.

Significant differences between the participants and non-participants exist in all the variables except the sex of the household head and access to market information (Table 4). The majority (84.43%) were male-headed, while 15.57% were female-headed. The female-headed households' proportion for participant and non-participant was 26.92% and 73.08%, respectively. The male-headed households' proportion for participant and non-participant was 39.72% and 60.28%, respectively. The chi-square test results on this variable shows that there was no significant difference between participants and non-participants (Table 4).

The descriptive analysis revealed that there was a highly significant difference at 1% in the access of oxen by households between participants and non-participants in irrigation practice. This designates that the participants have more access to oxen than non-participants. The proportion of households that have access to non-farm activity for non-participants was about 75%, whereas that of participants was about 96.83% and the chi-square value of the proportionality test for this variable shows that there was no significant difference.

The majorities (65.87%) of households do not have any information on input and output prices; whereas 34.13% have information (Table 4). The chi-square test results on this variable illustrate 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 not this access were 11.11% and 78.85% for participants and non-participants, respectively. The chi-square test result on this variable indicates that there was a significant difference between participants and non-participants at 1%.

Table 5. Maximum likelihood estimates of double hurdle models for participation and intensity (level) 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	0.048**	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	0.001***	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	

The farmers' positive responses for participants and non-participant were 88.89% and 80.77%, respectively. The farmers' negative responses for participants and non-participant were 11.11% and 19.23%, respectively. For the total observation, 83.83% have positive responses, while 16.17 have a negative response (Figure 1). This suggests most of the farmers' have a good attitude and understand the benefits of irrigation technology.

Access to credit services was another important categorical variable that was analyzed along with participants and non-participants. For the total sampled households, about 68.26% did not use credit, whereas 31.74% have credit access. The households that have credit access for participants and non-participant were 77.78% and 3.85%, respectively. The households that had no credit access for participants and non-participant were 22.22% and 96.15%, respectively (Figure 2). This specifies that participant households have more credit access than non-participants and facilitate their farm production using irrigation with the help of credit access.

3.2. Econometric model results and discussion

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 the Tobit model since the Γ = 150.38 which exceeds the critical χ^2 value with 15 degrees of freedom [$\chi^{2(}15) = 24.996$] (Appendix 1). To demonstrate the strength of the model specification, Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC) are included. The model with the lowest AIC and BIC is always preferred (Appendix 1). In comparison to the Tobit model, the AIC and BIC values of the double hurdle model are much inferior (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 the double hurdle model is the appropriate choice in this study.

Based on the results of the Variance Inflation Factor (VIF), the data had no serious problem with multicollinearity. This is because, for all continuous explanatory variables, the values of VIF are certainly less than 10 (Appendix 2). Therefore, these continuous explanatory variables were comprised in the model. Similarly, the contingency coefficient (CC) results show the absence of a strong association between different hypothesized discrete explanatory variables, since the respective coefficients are very small (less than 0.75) as given in appendix 3. Therefore, the dummy variables were incorporated into the model. For the endogeneity test, there was no explanatory variable that was expected to be endogenous in the model and hereafter no need to undertake the test.

3.2.2. Factors determining participation in small-scale irrigation

The probit regression part of the double hurdle model result, given in Table 5, reveals that out of the 15 explanatory variables, six were found to significantly determine the participation decision of the farmers in small-scale irrigated farming. These variables consist of the sex of the household head, household size, annual income of the household head, farm distance from the water source, access to extension, and credit services.

Sex of Household Head: As the probit model shows the sex of the household head had a positive and significant influence on the participation of small-scale irrigation at 5% significance level. This reveals that being male-headed households are more likely to participate in small-scale irrigation than female-headed households. The justification for this is that male farmers might have more access to information, extension, and credit services, whereas female-headed households lack time for gathering information about new technology because women are involved in many responsibilities in the home such as cooking and child care. The results are consistent with Yenealem's (2013) binary logit model results show that the adoption of improved maize variety is influenced by gender, where female-headed households adopt the improved varieties less.

Abebaw and Haile (2013) also obtained associated results in a study of membership for agricultural cooperatives in Ethiopia. The results opposed by Kileo (2014) illustrate that female-headed households decided to adopt new technology compared to males.

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's increase in a family member, the probability of participation in small-scale irrigation increases by 2.04%. Larger household sizes would be more suitable since they imply more labor available and hence greater chances of participation. Numerous adoption studies found out a positive impact of family labor on technology adoption such as Techane (2002), Bayissa (2011), and Asfaw et al. (2011). However, Josephson et al. (2014) stated limitations in livelihood options with large households as one prime driver of extreme and continuous poverty in arid rural areas. The results also contrast with Tufa 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 of Households: A statistically significant positive association ($P < 0.01$) was found among the total annual income and participation of small-scale irrigation. It was a highly determined households' decision which is an indicator of household economic status. High-income household heads could have the capacity to hold additional labor, land, and equipment for irrigation operations. These findings are associated with findings by Sufdar et al. (2013) who suggest 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 association with household participation decisions in small-scale irrigation practice. It designates that as the distance of plot of land from the irrigation water source and homestead increases by 1 km, 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 the plot of land from the 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 cannot follow up the farm activity closely and frequently and may not get a better yield. The opportunity cost of the time lost in traveling to and from an irrigation farm is great. Also, in the study area, every activity is carried out manually, so that an increase in distance of farmland from irrigation water source exposed households pay high cost due to difficulty of bringing water to one's farmland. This finding is in line with the findings of studies by Aseyehegn et al. (2012), Beyan Ahmed et al. (2014), Sithole et al. (2014), and Hirko et al. (2018).

Access to Extension Services: This variable was significant at 5% level of significance and has a positive relationship with household participation decisions in small-scale irrigation practice. Households who have access to extension services have a 56.74 percentage point greater chance of participation in small-scale irrigation than their counterparts while keeping all other variables constant at their mean value. This means that 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 vital role in the inspiration of farmers towards the adoption of improved irrigation practices. Farmers that have regular contact with agricultural extensions get information on new technologies more frequently and easily. This might increase their agricultural production and productivity (Madhusudan Bhattarai et al., 2002); found that contact with the farmers to extension services and their access to up-to-date farm information increases their agricultural production and productivity. This result is also consistent with Ransom et al. (2003), Feleke and Zegeye (2006), and Kapalasa (2014).

Access to Credit Services: This variable was significant at 5% level of significance and has a positive association with household participation decisions 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 rises the probability of participation in small-scale irrigation by 22.39 percentage points higher than their counterparts. The positive relationship reveals 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 equipment. Very few farmers in the surveyed sample accessed credits for agricultural purposes showing the existence of obstacles to access the service. The same result was found by researchers such as Muhammad-Lawal et al. (2013), Sithole et al. (2014), Nhundu et al. (2015), and Hirko et al. (2018).

3.2.3. Factors determining intensity of participation in small-scale irrigation

The truncated regression part of the double hurdle model result, given in Table 5, reveals that out of the 15 explanatory variables, four explanatory variables were found to significantly determine 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 to positively influence 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 sizes may mean having sufficient labor essential to manage and operate irrigation practices. The probable reason for this finding is that irrigation practices are labor-intensive and hence households with a relatively great labor force uses the technologies on their farm plots more than other similar signs found for other technologies (Hailu, 2008).

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

Farming Experience: The farming experience was found to significantly and positively determine the intensity of participation at 5% significance level. The proportion of irrigated land increases by 2.70% as the farming experience increases by 1 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 Tufa and Tefera (2016) and Musa H. Ahmed et al. (2016).

Access to Credit Services: Access to institutional credit can play a crucial role in the level of participation in irrigation technology. The study has revealed 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 households have credit services. In other terms, the proportion of land irrigated by the farmers those used credits exceed the proportion of land irrigated by the farmers who did not use credit by about 54.95%. This finding is consistent with Ejigu et al. (2011), Islam et al. (2015), Lapple et al. (2015), and Hirko et al. (2018).

4. Conclusion and recommendations

Irrigation development is the main strategy of the Ethiopian government to use untapped water resources. The expansion of irrigated agriculture is vital for improvement of agricultural productivity and land shortage to feed the ever-increasing country's population growth. It plays a crucial role in mitigating the negative impacts of variability or shortage of rainfall, and cropping intensity.

Ethiopia has a significant potential for irrigation both in terms of the available land and water resources. However, there is an enormous gap between the community's participation and the potential of the irrigation applied in Ethiopia especially in the study area. Therefore, this study was conducted to assess factors that determine a household's participation and intensity of use in irrigation technology. The study used both qualitative and quantitative data collected from primary and secondary sources. Primary data were collected through a semi-structured questionnaire survey. The double hurdle model was used in order to analyze the determinants of participation and intensity of participation in small-scale irrigation. The results of the first part of a double hurdle; the probit model shown that sex of household head, household size, annual income of the household, farm distance from the water source, access to extension services, and credit services were found to significantly determine the participation decision of the farmers in small-scale irrigated farming. While the results of the second part of a double hurdle, truncated model, showed that household size, access to own oxen, farming experience, and access to credit services were found to significantly influence the intensity of participation in small-scale irrigated farming.

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 given instant 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, the concerned institutions should develop a way for interested households to access credit use. The study has shown that farm distance from irrigation water source and homestead was found to be an obstacle for participation in irrigation with significant effect. Therefore, groundwater development and rainwater harvesting pond should be practiced close to irrigation land.

Citation information
Cite this article as: Determinants of smallholder farmers' participation and level of participation in small-scale irrigation practice in Gemechis district, West Hararghe Zone, Ethiopia, Tale Geddafa, Emebet Abera & Fikire Gedefa, *Cogent Engineering* (2021), 8: 1960250.

Note
1. *"Kebel"is the smallest administrative unit of Ethiopia, similar to a ward.*

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

Funding
The authors received no direct funding for this research.

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Disclosure Statement
The authors declare no competing interest.

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Appendix

Appendix 1. 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			

Appendix 2. 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 3. Contingency Coefficient (CC)

Variable	Sex	Oxen Access	Off-farm	Market Information	Extension	Credit Access	
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