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Participation in Small-Scale Irrigation Practice: The Case of Abay Chomen District of Oromia National Regional State, Ethiopia

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Abstract: This study was conducted to identify factors that determine household's participation in small-scale irrigation. Two-stage sampling technique was used to select 167 target respondents. Both primary and secondary data were used in this study. Double hurdle model was employed to identify the determinants of participation and intensity of participation in small-scale irrigation. The result revealed that number of oxen, market distance, farm distance from irrigation water source, market information and credit use significantly determine participation in small-scale irrigation. The analysis also indicated that age, number of oxen owned, market distance, education level, road distance and access to credit significantly determine the intensity of participation in small-scale irrigation. To solve the problems and improve small-scale irrigation participation, the government, especially irrigation development office of the district should attempt to hamper factors that hinder participation in small-scale irrigation and enhance factors that initiates participation in small-scale irrigation identified in the study area.

Keywords: Determinants, Double Hurdle Model, Participation, Small-Scale Irrigation

1. Introduction

Agriculture plays a pivotal role in Ethiopian economy [1]. About 73% of the population is living in rural areas, creating their income from agriculture and relying on a limited resource- land [2] and 95% of the country's agricultural output is produced by smallholder farmers [3]. The sector remains the mainstay of the country's economy in terms of income, employment and generation of export revenue. Agriculture sector's contribution to Ethiopian GDP, although showing a slight decline over the years has remained very high. The sector approximately contributes 38.5% of GDP, which is still far greater than the industry's share (15.6% of GDP) [4]. Agriculture also provides employment opportunities to about 83% of the population and supplies raw materials for 70% of the country's agro-industries [5] and about 70% of Ethiopia's foreign exchange is derived from agricultural exports [6]. This indicates that agricultural growth is not only necessary to feed the population, but is also the driving force behind foreign exchange generation in Ethiopia. This shows that agriculture is still being the main source of livelihood and it needs great attention for improvement and transformation of the country's economy.

Ethiopian agricultural practice has been traditionally dominated for centuries by small-scale farmers and its performance has long been adversely affected by shortage of rain and water that left many to sustain their lives on famine relief support [7]. From the total production, about 97 percent of Ethiopia's food crops are produced by rain-fed agriculture, where as only 3% is from irrigated agriculture [6]. Due to high dependency on rain-fed agriculture and other topographic and low adaptive capacity and other related factors, Ethiopia ranks the ninth most susceptible country in the world to natural disasters and weather-related shocks [8].

But the small-scale irrigation (SSI) contributes to poverty alleviation by enhancing productivity which leads to an increase in income and promoting economic growth and employment [9]. Irrigation also changes the lives of the rural households by increasing their production and productivity. A rapid increase in the area covered by irrigation, especially small-scale water use, provide farmers with opportunities to raise output on a sustainable basis and contribute to the reliability of food supplies [10]. This indicates that there should be new means of production through irrigation water application by smallholder farmers rather than strongly relying on rain-fed agriculture. Hence increasing the opportunity and reducing the hindrance to irrigation participation needs to be made because irrigation is one means by which agricultural production can be increased to meet the growing food demands in Ethiopia, since agriculture still plays a critical role in the economy.

The government of Ethiopia has placed great emphasis on the development of irrigation facilities so as to increase agricultural production and productivity. This may help farmers overcome the cost problem for modern irrigation construction and overcome the problem of shortage of moisture for production. In line with this goal, the government also has planned to undertake a medium and large scale irrigation study and designing activities and making them ready for concerned relevant stakeholders [4]. This shows that the experts from universities and research institutions engaged in conducting research activities on participation in irrigation practice at different levels contributes to the success of this goal.

The irrigation potential in Oromia region is the highest from the country, but its level of utilization is not as per its potential [11]. Horro Guduru Wollega is one of the wettest zones from the region even though its farming system is highly dependent on rain-fed farming [12]. Although Abay Chomen is the district found in this zone consisting of high irrigation potential, the potential available for irrigated farming is not intensively used [13]. There was no scientific evidence why the farmers in the district are not using this potential to increase their production and hence improve their standard of living. Therefore, this study was mainly concerned with finding out the factors that determine the farmers participation in irrigation practice and intensity of participation.

2. Research Methodology

2.1. Description of the Study Area

Abay Chomen District is found in Oromia regional state of Ethiopia, containing 19 kebeles, located at 9° 31’ 42” to 9° 59’ 48” N latitude and 37° 10’ 03” to 37° 28’ 44” E longitude and the capital of the district Fincha town is 289 kms northwest of Addis Ababa. The area receives high rainfall in one season of the year. The total area of the District is estimated to be 801.7 km^2; approximately 45, 37, 4, 3 and 11% of the total area are cultivated land, non-cultivated, water bodies, settlements, and woodlands and forests, respectively [14]. The Ethiopian population projection by CSA for 2017, based on 2007 national census reported a total population for this district to be 64,672, of whom 33,263 (51.43%) were male and 31,409 (48.57%) were female; 15,232 or 23.55% of its population were urban dwellers [15].

The altitude of the study area ranges from 1,061 to 2,492 meters above sea level (masl) with two agro ecological zones, mid-highland and low land. The northern part of the district (low land), which is mainly situated at altitude ranging from 1,138 to 1,687 masl in the Nile River Basin, is owned by Fincha Sugar Factory and is entirely being used for irrigated sugarcane (*Saccharum officinarum* L.) production. At altitudes ranging from 2,213 to 2,492 masl (mid-highland), smallholder farmers practice mixed farming systems that integrate both crops and livestock (animals used for traction, meat and milk).

The recent years meteorological data of the nearby representative stations, Fincha Sugar Factory and Shambu Meteorological Stations showed that the mean annual minimum and maximum temperatures of the district are 13.4 and 27.2°C, respectively, and the mean annual rainfall is 1,399 mm [14]. The area has a uni-modal rainfall pattern and the highest intensity of rainfall is recorded in the month of July. The area is characterized as hot to warm moist lowland and tepid to cool moist mid-highlands based on the classification of agro-ecological zones of Ethiopia [16].

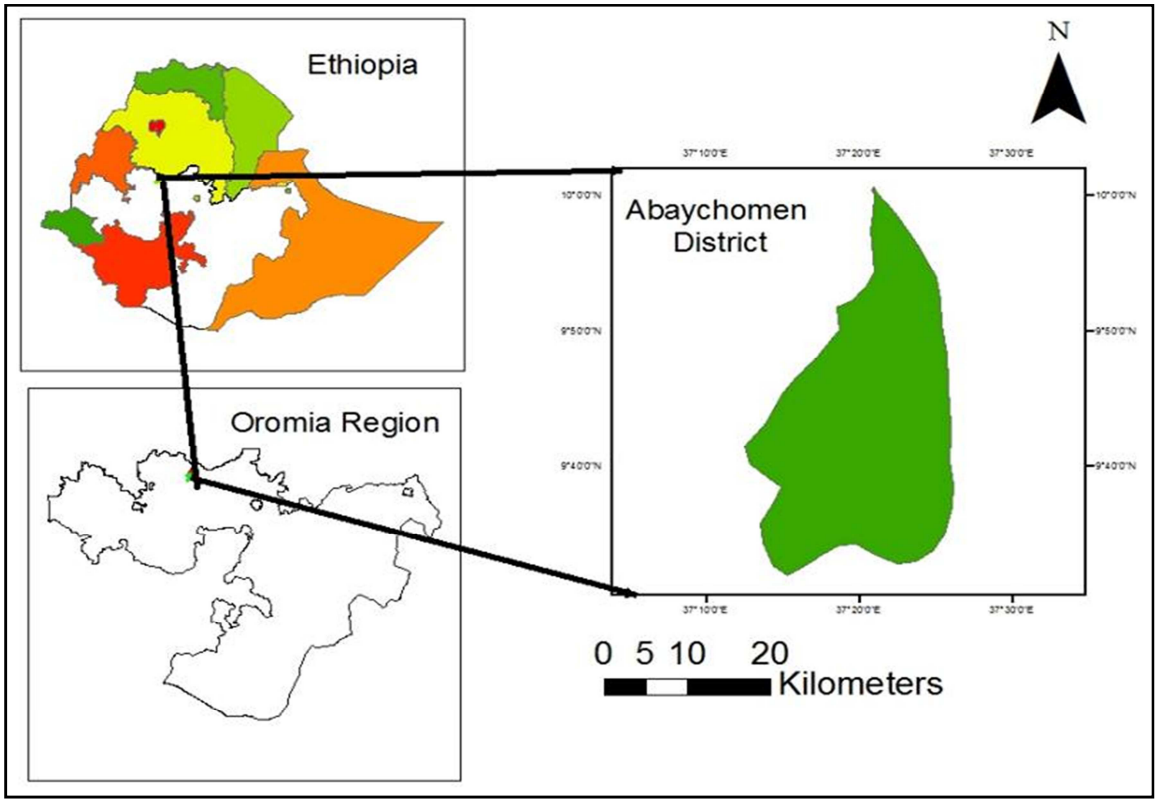
2.2. Sampling Method and Sample Size

The farming households were actually the ones making day to day decisions on farm activities. Therefore, a household was the basic sampling unit. In this study, a two-stage sampling technique was used to generate the required primary data. At the first stage, three kebeles from 16 non urban, mid-high land farmer kebeles in the district were selected randomly. On the second stage, by stratifying the households into participant and non-participant, a probability proportional to sample size sampling procedure was employed to select 167 sample households from which 80 participants and 87 non-participants were randomly selected, after preparing sample frame of participants and non-participants in the selected kebeles. But five observations (three participants and two non-participants) were excluded from the analysis due to missing values and 162 sample, 77 participants and 85 non-participants were used in the analysis. This sample size is assumed to represent the population, since the district is more or less homogeneous in terms of climate, resource endowment and other factors related to the issue of the study.

2.3. Types of Data, Data Sources and Methods of Data Collection

For this study, both quantitative and qualitative data from primary and secondary sources were collected. The source for primary data was the sample farmers in Abay Chomen district and the source for secondary data are local offices,

higher governmental organizations, different publications and policy documents. To obtain primary data, semi structured questionnaire, with both closed and open-ended questions was used as a tool to collect data from sample households. For the purpose of getting data on the determinants of irrigation practice, the questionnaire covered a range of topics including demographic characteristics of households and socioeconomic structure; market access, access to credit, area of irrigated land, distance of farm land from water source, educational status, cultivable land size and other related factors were considered.



Source: Own design with the help of GIS expert

Figure 1. *Location Map of Abay Chomen District, Oromia, Ethiopia.*

For the collection of primary data, enumerators, with at least secondary education that can speak local languages were recruited. Necessary care was taken in recruiting the enumerators. They were given an intensive training on data collection procedures, interviewing techniques and the detailed contents of the questionnaire. The households' questionnaire was translated in to local language (Afaan Oromoo), to convey the questions effectively to the rural interviewees and it was pre-tested, administered, filled by the trained and experienced enumerators. Strict supervision was made by the researcher during the course of the survey.

Secondary data were collected from documents and publications of different organizations and relevant local offices as well as journal documents. For focus group discussion and key informant interviews, unstructured interview (guiding question) was used as a tool of data collection. Three focus groups, one from each selected kebeles consisting of 8 to 10 purposively selected farm household heads were used for collecting the detailed data using guiding questions and the district office of irrigation development coordinator and irrigation extension coordinator were interviewed considering them as key informants.

2.4. Methods of Data Analysis

2.4.1. Descriptive Statistics

In this study, descriptive statistics was used to explain the different characteristics of the farm households in the study area. The descriptive Statistics such as mean and standard deviation were used for these analyses. The significance of the variables was tested for both dummy and continuous variables using chi-square (χ^2) and student t-test statistics, respectively.

2.4.2. Econometric Model Specification

The dependent variables in this study are the participation decision of the farmers in small-scale irrigation practice and intensity of participation in small-scale irrigation practice. Since one of the dependent variables of this study, 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. If the scope of this study is only the participation decision of the farmers, it is possible to use either binary logit or binary probit model. As indicated in

[17], logit or probit models are widely applied to analysis of determinant studies for a limited dependent variable and their result is similar. Contrary to this, [18] suggests that although both model results with similar outputs, the logit model is easier in estimation, even though this is not the problem nowadays, since it is the work of the computer software within the couple of seconds. This two models are used only for the analysis of probability of participation in particular technology. This means they are only suited in determining the probability models but not for linear models. Tobit model, Heckman two step 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.

It was found that the two dependent variables were determined by different sets of explanatory variables from double hurdle model result, which fulfil the assumption of double hurdle model not Tobit. In addition to the above condition, test on the best fit of the models among Tobit and Double hurdle model using log-likelihood ratio test following [19], was made and Double hurdle was found to be the best fit than Tobit model. The significant variables were not the same for the two dependent variables. Therefore, the Double hurdle model was selected and used for the sake of analyzing the determinants of participation decision (first hurdle) and intensity of participation in small-scale irrigation (the second hurdle).

Intensity of participation in irrigation practice by the farmers was measured in terms of the proportion of land allocated to irrigated farming by farmers. Therefore, this variable (proportion of irrigated land) is continuous limited dependent variable. It can be zero or some value greater than zero. Truncated regression as one part of double hurdle model has been used in estimating the intensity of participation in irrigation practice by farmers by using the data that is truncated from below with the lower limit of proportion of Irrigated land at zero. The double hurdle model with the two parts is specified using two different latent variables, to model each decision process, with a probit model to determine participation decision and a truncated regression model to determine the intensity of participation in small-scale irrigation [20].

Participation decision equation is specified as follows:

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

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

Intensity of Participation Equation is specified as:

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

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

where Y_{i1}^{*} is unobserved (latent) variable for the participation decision in small-scale irrigation,

Y_{i1} is the observed discrete decision of the farmer whether he/she has participated or not in small-scale irrigation practice,

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_1's are the index of explanatory variables determining the participation decision of the farmers in small-scale irrigated farming,

β_1's refers to the index of parameters related with explanatory variables determining participation decision of the farmer,

ε_{i1} is the error term of the participation equation which is normally distributed ($\varepsilon_{i1} \sim N(0, \delta_1^2)$), with zero mean and constant variance,

Y_{i2}^{*} is unobserved (latent) variable for the intensity of participation in small-scale irrigation,

Y_{i2} is the observed actual proportion of land allocated for small-scale irrigation by the farmer,

X_2's are the index of explanatory variables determining the intensity of participation in small-scale irrigated farming by the farmers,

β_2's refers to the index of parameters related with explanatory variables determining intensity of participation in small-scale irrigation by the farmers,

ε_{i2} is the error term of the intensity of participation equation which is normally distributed ($\varepsilon_{i2} \sim N(0, \delta_2^2)$) with zero mean and constant variance.

2.5. Description of Variables and Hypothesis

2.5.1. Dependent Variables

i. Participation Decision of Farmers in Small-Scale Irrigation Practice

The first dependent variable was participation in small-scale irrigation practice taking value of 1 if the farmer participated and 0 if not participated in small-scale irrigation practice. The main intension here is to identify the factors determining the participation of the farmers in small-scale irrigation practice.

ii. Intensity of Participation in Small-Scale Irrigation Practice by Farmers

This variable is a continuous variable measured in terms of proportion of land irrigated by the farmers. It represents the actual proportion of land under small-scale irrigated farming by the households in 2016/2017. It take zero value if the farmer is non participant and takes continuous value greater than zero if the farmer is participant.

2.5.2. Explanatory Variables

For explanatory variables, there is no underlying principle for what variables should be included in the model [21]. Hence, the study was based on economic theory and empirical studies conducted previously to know which independent variables influence individual participation in small-scale irrigation practice at farm household level. Therefore, the regressors found most commonly affecting irrigation practice are summarized and the expected signs and

hypothesis is given in Table 1.

Table 1. *Summary of the definition and hypothesis of explanatory variables.*

List of explanatory variables	Nature and measurement units of variables	Hypothesized direction of significance
Age of household head (Age)	Continuous (years)	Negative
Sex of household head (Sex)	Dummy (1 if female, 0 otherwise)	Negative
Educational status (Education)	Continuous (class year)	Positive
Income (Income)	Continuous (ETB)	Positive
Number of oxen (Oxen)	Continuous (TLU)	Positive
Cultivable land size (Land size)	Continuous (hectare)	Positive/Negative
Market distance	Continuous (hours)	Negative/Positive
Market Information	Dummy (Access=1, 0 otherwise)	Positive
Training	Dummy (1 if trained, 0 if not)	Positive
Credit access (Credit)	Dummy (1 if used, 0 if not)	Positive
Distance of plot of land from water source (Farm distance)	Continuous (hours)	Negative
Family size	Discrete	Positive
Total Livestock owned (Livestock)	Continuous (TLU)	Positive
Access to non-farm activity (Non-farm activity)	Dummy (Access=1, 0 otherwise)	Positive

3. Results and Discussion

This chapter is concerned with the discussion of the results obtained from the survey data and secondary data from both qualitative and quantitative analysis. Therefore, it includes the descriptive analysis of the farm household characteristics in the study area, factors determining the participation decision of the farm households in small-scale irrigated farming as well as factors determining the intensity of participation and the impact of small-scale irrigation on household income. Lastly, major challenges (constraints) and opportunities in small-scale irrigated farming in the study area are presented in this chapter.

3.1. Socioeconomic Characteristics of Sample Farmers

The summary of socioeconomic characteristics of the farmers along with the mean difference test (t-test) of continuous variables is presented in Table 2. After estimating the mean values, the significance of mean difference test was undertaken by two-group mean comparison test for the continuous variables. The distribution of the categorical variables related with irrigation participants and non-participants is given on Table 3. The proportion of the respondents falling into these categories are given and the difference of the proportion across participants and non-participants was tested by using chi-square test.

3.1.1. Demographic Characteristics

The mean age of non-participants was 44.13 years and that of participants was 39.51 years. The mean difference age of household head between the non-participants and participants was significant at 5% (Table 2). The result indicated that the age of non-participants was higher as compared to participants. When coming to family size and sex of household head, the descriptive analysis revealed that there was no significant difference between participants and non-participants.

3.1.2. Social and Human Capital

The mean years of education for the non-participants and participants was 1.78 and 5.78 years of schooling, respectively and the difference was significant at 1% level of significance (Table 2). About 62.4% of the non-participants and 19.5% of the participants had no training on irrigation (Table 3). The difference between the participants and non-participants in terms of training access was significant at 1% significance level. The other one is the mean irrigation experience of the total households in the study area was 3.89 years. But the mean irrigation experience of the non-participants was 1.21 where as that of the participants was 6.84 years (Table 2). The mean difference of irrigation experience between the non-participants and participants was negative and it was significant at 1%. Someone may assume that the irrigation experience of non-participants would be zero, but in this particular case of study the experience of non-participants on average was different from zero, because they were participating in irrigated farming some years ago, but not practicing currently. This indicates that, there was dis-adoption in irrigated farming and it is one problem observed in the study area which needs further analysis for the reason behind dis-adoption by researchers in the future.

3.1.3. Asset Holding/Economic Characteristics

The mean annual income of the non-participants was Birr 30175.35, where as that of the participants is Birr 50753.48. The descriptive analysis revealed the difference was significant at 1% significance level. The income of the participants was higher as compared to non-participants. The mean number of oxen owned for the non-participants was 1.6, where as that of the participants was 3.61. The descriptive analysis revealed that there was significant difference (at 1%) on the number of oxen owned by households between participants and non-participants in irrigation practice. On the other hand, the mean cultivable land size of the household for non-participants was found to be 2.36 ha and that of the participants is 3.31 ha and the difference was significant at 1% level of significance. The mean livestock holding of the non-participants was 10.32 TLU, while that of the participants was 12.75 TLU. There was significant difference at 5% level of significance. The analysis on proportion of households that does not have access to non-farm activity indicates that there was no

significant difference between the two groups.

Table 2. *Summary statistics of continuous variables.*

	For the Total Observation =162		Non-participants=85		Participants=77		Mean diff. test
Variable	**Mean**	**Std. Dv.**	**Mean**	**Std. Dv.**	**Mean**	**Std. Dv.**	**(t value)**
Age	41.93	12.85	44.13	12.83	39.51	12.51	2.32**
Income (1000)	39.96	28.56	30.18	22.25	50.75	30.91	-4.90***
Oxen	2.56	1.51	1.6	1.00	3.61	1.25	-11.35***
Land size	2.82	1.82	2.36	1.57	3.31	1.95	-3.43***
Market distance	1.04	0.62	1.14	.63	0.96	0.61	1.90**
Farm distance	11.06	5.85	15.22	4.56	6.46	2.97	14.32***
Family size	5.67	1.87	5.74	1.96	5.60	1.77	0.49
Livestock	11.47	6.69	10.32	6.29	12.75	6.92	-2.34**
Education	3.68	3.84	1.78	2.15	5.78	4.19	-7.76***
Road distance	0.397	0.165	0.46	0.16	0.33	0.14	5.29***
Experience	3.89	5.40	1.21	2.65	6.84	6.09	-7.76***

** and ***, indicates significant at 5% and 1% level of significance
Source: Own computation from the survey data, 2017.

3.1.4. Institutional Characteristics

The mean market distance of the non-participants was 1.14 hour, where as that of the participants was 0.96 hour. The difference in the distance of the market from household residence between participants and non-participants was significant at 5% significance level. The chi-square test indicates that there was significant difference between participants and non-participants on accessibility of market information concerning input and output price at 1% level of significance. The proportion of households those did not use credit are 80% for non-participants and 42.9% for participants and the difference between participants and non-participants was significant at 10% significance level.

3.1.5. Physical Characteristics

The mean walking distance of land from irrigation water source for the total households in the study area was found to be 0.18 hour. But the mean distance of land for the non-participants was 0.254 where as that of the participants was 0.11 hour. The analysis revealed that there was significant difference between participants and non-participants at 1% level of significance. There was significant difference on the main road distance of households between participants and non-participants at 1%. The result of the analysis shows that the distance of main road from farm for non-participants was higher as compared to participants.

Table 3. *Distribution of categorical variables across participant and non-participants.*

		For the Total Observation =162	Non-participants=85	Participants=77	Chi^2 value
Variable		**Frequency (proportion/%)**	**Frequency (proportion/%)**	**Frequency (proportion/%)**	
Training	Not trained	68 (41.98)	53 (62.35)	15 (19.48)	30.49 ***
	Trained	94 (58.02)	32 (37.65)	62 (80.52)	
Sex	Male	151 (93.21)	78 (91.76)	73 (94.81)	0.59
	Female	11 (6.79)	7 (8.24)	4 (5.19)	
Market info.	No access	75 (46.30)	66 (77.65)	9 (11.69)	70.7 ***
	Access	87 (53.70)	19 (22.35)	68 (88.31)	
Credit	No access	101 (62.35)	68 (80.00)	33 (42.86)	23.74 *
	Access	61 (37.65)	17 (20.00)	44 (57.14)	
Non-farm activity	No Access	134 (82.72)	69 (81.18)	65 (84.42)	0.29
	Access	28 (17.28)	16 (18.82)	12 (15.58)	

* and ***, shows significant at 10% and 1% level
Source: Own computation result from survey data, 2017

3.2. Factors Determining Participation in Small-Scale Irrigation

The probit regression part of double hurdle model result, given on Table 4, shows that out of the 14 explanatory variables, five explanatory variables were found significantly determined the participation decision of the farmers in small-scale irrigated farming, at different significance levels. These variables include number of oxen, market distance, farm distance from irrigation water source, market information and credit use. These variables influences the participation decision of the farm household in different directions.

Number of oxen (Oxen): This variable was found be significant at 1% significance level and positively related to household participation decision in small-scale irrigation practice. It shows that all other factors being kept constant, predicted probability of small-scale irrigation participation decision increases as the number of oxen of the household increases. When coming to the marginal effect of this variable, 0.1992 indicates that a unit increase in the number of oxen leads to increase in probability of participating in small-scale irrigated farming by 19.92%, holding other factors constant at their mean level. This finding is inherent in the area, because farmers that have large number of oxen

use their oxen as draft power for land preparation rather than using other mechanized way of land preparation and they are more likely involve in small-scale irrigated farming. The study result was consistent with the work of [22, 23].

Market distance: This variable was found negatively and significantly affected the participation decision of the farmers in small-scale irrigation at 1% significance level. The estimated marginal effect of this variable, (-0.3106), indicates that the probability of participating in small-scale irrigated farming decreases by 31.06% as the market distance increases by one walking hour on foot. This finding was the same with the finding of [24] and contradictory with the finding of [25]. The possible reason for this finding is that the farther the farmer from the market center, they face the problem of taking their product to the market easily and this may have lead them not to participate or participate less in small-scale irrigated farming as compared to the farmers nearer to the market.

Table 4. *Estimated participation model part of double hurdle (probit part).*

Variables	Coefficient	Robust Std. Err.	Z	Marginal Effect
Age	-0.0057	0.0190	-0.30	-0.0015
Road distance	-0.4205	1.7406	-0.24	-0.1085
Oxen	0.7723***	0.2527	3.06	0.1992
Land size	0.0939	0.1692	0.55	0.0242
Market distance	-1.2043***	0.3520	-3.42	-0.3106
Farm distance	-0.5030***	0.1175	-4.28	-0.1297
Family size	-0.1167	0.1153	-1.01	-0.0301
Livestock	-0.0549	0.0392	-1.40	-0.0142
Education	-0.0756	0.0972	-0.78	-0.0195
Sex	0.7530	0.6533	1.15	0.2459
Market information	3.0370***	0.9078	3.35	0.6700
Training	0.6435	0.5519	1.17	0.1590
Credit use	0.6693*	0.3847	1.74	0.1849
Non-farm activity	0.9144	0.5785	1.58	0.2911
Constant	2.132	1.570	1.36	
Number of observation = 162				
Wald chi2(14) = 64.87				
Prob > chi2 = 0.0000				
Log pseudolikelihood = -14.770713 Pseudo R2 = 0.8682				

* and *** indicates significant at 10% and 1% respectively.
Source: Own computation from survey data, 2017

Distance of plot of land from water source (Farm distance): This variable was significant at 1% level of significance and have 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 walking hour on foot, the probability of participating in small-scale irrigated farming decreases by 12.97%, holding other factors constant. This finding is not surprising, because in developing world, where mechanization is at its minimal stage and every activity is handled manually, an increase in distance of farm land from irrigation water source highly hinders irrigation activity. This phenomena is due to difficulty of bringing water to one's farm land since it involves higher cost as the land becomes more farther from the water source. This finding is in-line with the findings of studies [23, 24, 26].

Market information: Market information on the input and output price by the farmers was found significantly determining the participation decision of the farmers in small-scale irrigation at 1% probability level. It positively influenced the participation decision of the farmers in small-scale irrigated farming. The result of marginal effect of this variable, 0.67, reveals that the predicted probability of participating in small-scale irrigation increases by 67% for the farmers having the market information on input and output price as compared to the farmers who do not have market information. The possible reason for this result may be the encouragement that could be obtained from the possible profitability of irrigated farming expectation when there is access to market information on input and output prices. This finding was consistent with the findings of Abebaw *et al*. and Kinfe *et al*. [24, 27].

Credit access (Credit): Access to credit was one of the variables hypothesized as one determinant of the farmers participation decision in small-scale irrigation practice. This variable was also found significantly influencing the participation decision of the farmers in small-scale irrigated farming as it was hypothesized. It was found significantly and positively related with the participation decision of the farmers in small-scale irrigated farming at 10% level of significance. From the result of the probit part of double hurdle model, it indicates that the predicted probability of participating in small-scale irrigation increases by 18.49% for the discrete change in this variable from 0 to 1 (change from non user of credit to credit user). In other words it implies that the probability of participating in small-scale irrigation practice for the farmers that have credit access was higher by 18.49% as compared to those farmers who do not have credit access. This result is not surprising, because the farmers in the study area uses credit for irrigated farming as well as rain-fed farming to buy inputs. The same result was found by researchers such as Muhammad *et al*., Sithole *et al. et al*. and Nhundu *et al*. [23, 28, 29].

3.3. Factors Determining Intensity of Participation in Small-Scale Irrigation

The intensity of participation in small-scale irrigation was one of the dependent variables in this study. It was specified as truncated part of double hurdle model under methodology part of this study. Therefore, factors determining the intensity of participation in small-scale irrigation by the farmers in Abay Chomen district was analyzed using the truncated part of double hurdle model. The result is presented on Table 5. The factors that were found to have significant determining power on the intensity of participation were six variables, out of 14 explanatory variables included in the model. These significant variables that determine the intensity of participation were age, number of oxen owned, market distance, education level, road distance and access to credit.

Age of household head (Age): The age of the household head was found significantly affected the intensity of participation in small-scale irrigated farming of farm households at 10% level of significance. The value of the coefficient of this variable indicates that the proportion of land allocated under irrigated farming decreases by 0.78 % as the age of the household head increases by one year (Table 5). This indicates that the aged the farmer, the lower the intensity of participation in small-scale irrigated farming. This was because the farmers who lived long have more wealth than younger farmers do and hence they may not want to exert more effort for their livelihood. The other reason for this finding could be related to the reason that older farmers do not have long term planning and they do not worry about the development on long term and they do not want to invest their time and energy in tiresome job that will bring the long term benefit and improvement in the productivity of their production. This finding was in agreement with the work of scholars such as Wang *et al*. and Pokhrel *et al*. [30, 31].

Table 5. *Estimation of truncated part of double hurdle model.*

Variables	Coefficient	Robust Std. Err.	Z
Age	-0.0078*	0.0042	-1.87
Experience	0.0044	0.0054	0.81
Oxen	0.1281**	0.0544	2.35
Market distance	-0.2284**	0.1157	-1.97
Farm distance	-0.0121	0.0125	-0.97
Family size	0.0054	0.0179	0.30
Total livestock	-0.0022	0.0080	-0.27
Education level	0.0351***	0.0130	2.69
Road distance	-0.0579*	0.0335	-1.73
Sex	0.1416	0.1436	0.99
Market information	0.0500	0.1544	0.32
Training	-0.0237	0.0861	-0.27
Credit use	0.1921**	0.0935	2.05
Non-farm activity	-0.0418	0.1212	-0.34
Constant	0.2515	0.2698	0.93
/sigma	0.2947***	0.0724	4.07
Limit: lower = 0 Number of observation = 77			
upper = +∞ Wald chi2(15) = 33.55			
Log pseudolikelihood = 25.02105 Prob > chi2 = 0.0039			

*, **, and ***, shows significant at 10%, 5% and 1% respectively
Source: Own estimation from survey data, 2017

Number of oxen owned (Oxen): This variable was found significantly and positively determined the intensity of participation at 5% significance level. This implies that, all other factors being kept constant, the proportion of irrigated land increases by 12.81%, as the number of oxen owned by the household increases by one. This was because farmers that have large number of oxen uses their oxen as draft power on time for land preparation, as it is common in the country and they were more easily able to prepare large area of land than the households that have lower number of oxen and hence more likely involve in small-scale irrigated farming.

Market distance: The result revealed that distance of the market from residence was found negatively and significantly affected the intensity of participation in small-scale irrigation practice by the farmers at 5% significance level. This implies that the proportion of land irrigated by a farmer decreases by 22.84% as the market distance increases by one walking hour on foot. This finding is consistent with the work of Abebe *et al*. [7].

Education level of household head (Education): This variable was found significantly affected the intensity of participation in small-scale irrigation by the farm households at 1% significance level. It shows that an increase in the year of schooling of household head by one year, leads to an increase in the proportion of land irrigated by the farmer by 3.51%. The same finding was reported by the scholars such as Wang *et al*. and Pokhrel *et al.* [30, 31].

Main road distance from farm land (Road distance): The distance of main road from farmland significantly influenced the intensity of participation in small-scale irrigated farming by the farm households at 10% significance level. The coefficient of this variable indicates that an increase in the distance of main road from the farmland by one walking hour on foot, leads to a decrease in the proportion of irrigated land by 5.79%, holding other factors constant. This result would be related with the problem of transporting the product to the market. It was evident that when the farmland is far from the main road, farmers face the difficulty of selling their product at a time and their product will be spoiled, since most of the products are easily perishable. Because of this reason, this factor may have forced farmers to irrigate smaller area of land.

Credit use (Credit): This variable was also found significantly and positively influencing the intensity of participation in small-scale irrigated farming by the farmers, at 5% level of significance. From the result of truncated regression, it indicates that the proportion of land covered by irrigation increases by 19.21% for the discrete change in this variable from 0 to 1 (change from the farmer that did not used credit to the farmer that used credit). 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 19.21%. This finding is in-line with the result reported by Abebe *et al.* [7].

4. Conclusions and Recommendations

4.1. Conclusions

This study examined the factors determining participation and intensity of participation in small-scale irrigation by the farm households. The study used double hurdle model to analyze the determinants of participation and intensity of participation in small-scale irrigation in the study area. The sample of 162 of the farm households selected by multi-stage sampling technique was used in the analysis.

Participation in small-scale irrigation and intensity of participation in small-scale irrigation are shown to be independent of each other and determined by different sets of explanatory variables. After identifying the best fitting model, the study identified the economic, demographic, institutional and physical factors jointly determined the participation of the farm households in small-scale irrigated farming. Five of explanatory variables were found to be significant determinants of participation decision of the farmers in small-scale irrigation. These variables were number of oxen, market distance, farm distance from irrigation water source, access to market information and access to credit. Number of oxen, market information and access to credit positively and significantly determined participation decision of the farmers in small-scale irrigation, while farm distance from irrigation water source and market distance were negatively and significantly determined the participation decision in small-scale irrigation. Age of household head, number of oxen, market distance, education level, road distance and access to credit. Of these explanatory variables, age, market distance and road distance negatively and significantly determined the intensity of participation in small-scale irrigation. This finding reveals that households with older age of household head, farther from market and farther from main road, irrigated lower proportion of land as compared to those farmers with lower value of these variables. Education level, number of oxen, and access to credit where found positively and significantly determining the intensity of participation in small-scale irrigation by the farmers. This implies that, the farmers with higher level of education, higher number of oxen and those that have access to credit were found irrigating higher proportion of land as compared to their counter parts. Therefore, it needs calling up on stakeholders to take part in enhancing the irrigated farming by reducing the hindrances and strengthening available enabling factors in the study area.

4.2. Recommendations

The findings of this study leads to the following specific recommendations.

Market experts of the district should disseminate market information on the input and major products prices, so that the farmers can use the information in deciding the type and timing of crop produced by irrigated farming in Abay Chomen district.

To enable farmers have oxen for farming, the mechanisms such as credit facilities should be put in place so that the farmers can use it for buying the oxen for rain-fed as well as irrigated farming.

The credit system and utilization means need to be facilitated more in the study area to enable the farmers to use the credit in small-scale irrigation because this variable was one of the significant variables found affecting irrigation practice in Abay Chomen district.

The study also revealed that farm distance from irrigation water source was found to be hindrance for participation in irrigation with significant effect. This variable was found to be one of the most important determinants of participation in irrigation. Therefore solutions for distance of farm from water source, such as ground water development and water harvesting should be considered and encouraged for the farmers to use it in irrigating their farm land.

Local market linkage between producers and small traders as well as linkage to other markets should be created to the farm-gate if possible to reduce the hindrance coming because of market distance and access problem that discourages participation and intensity of participation in irrigation.

Age was negatively related with intensity of participation in irrigation, hence adult farmers should be encouraged and the aged farmers should be linked to younger farmers to increase the proportion of irrigated land by pooling the resource.

Road distance was found to be a barrier for participation in small-scale irrigation in the study area; therefore, road infrastructure and transportation facility should be improved to enable farmers easily transport products to market.

Household head's education level was found to be significant determinant of the intensity of participation in small-scale irrigation. Therefore, the farmers should be educated by a means that fits with their living condition, such as adult education.

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