

Determinants of Small Holder Rural Farm Households' Participation in Small Scale Irrigation in Western Ethiopia, in Case of Assosa District in Assosa Zone (Heckman Two-Stage Model)

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Abstract
Increasing technology adoption including irrigation among smallholder farmers has a big potential to uplift living standards of poor through increasing production and consumption pattern. The objective of this study was analyzing determinant of smallholder farmer participation in small scale irrigation and its intensification in western Ethiopia, in case of Assosa district in Assosa Zone. The study used data from 329 respondents from six selected kebeles of Assosa woreda in Assosa zone, through structured questioner. The descriptive statistics and Heckman two stage econometric methods were employed to analyze data collected from sampled household. The significance of coefficient of inverse Mill's ratio (λ) indicates the presence of selection bias and the effectiveness of applying Heckman two stage model. In the first stage of probit regression results of study show that the adoption decision of small scale irrigation use were driven by factors such as sex of the head, education, farm size, attend training at farmer training center, distance to irrigation, credit use, total livestock unit, ethnicity, active labor and development agent advice significantly determine participation in small scale irrigation. In the second stage, the intensification of small scale irrigation use was influenced by family size, credit use, ethnicity of farm household head and lambda. The policies which expand the accessibility of credit service, dissemination of productive agricultural technology information, and creating opportunity of education for farm household has potential to increase the chance of small scale irrigation adoption decision and strengthen the level of adoption among smallholder farmers.
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INTRODUCTION

The study of how individuals are able to escape poverty is a central issue of economic development theory. Of the poor people worldwide (those who consume less than a 1 dollar-a-day), 75 percent work and live in rural areas and projections suggest that over 60 percent will continue to do so up to 2025 (Mendola, 2007). These are good reasons to give emphasis to research on rural poverty reduction, and to redirect attention and expenditure towards agricultural development.

In Less Developed Countries (LDCs) in general and Sub-Saharan Africa (SSA) in particular, economic policy highly rely on agriculture. Poverty reduction and the growth of income can generally be realized through agricultural growth that creates spillover effects to the remaining sectors (World Bank, 2014). However, production and productivity of the agricultural sector in SSA is low due to low technological adoption including irrigation and techniques among others (Abraham *et al*., 2014; Gashaw *et al*., 2014). Agriculture provides largely to the economic growth of many low income countries like Ethiopia with the potential of irrigation. Since, agriculture is the leading sector of the economy as source of income, employment and foreign exchange. Additionally, more than half of the less developed countries population gets their food from own production. The country used this agricultural output as an input for industries so it can stimulate the growth of industrialization**.** Hence, agriculture is Ethiopia's most important sector and it is the main stay of economy that contributes about 34.122% of the Gross Domestic Product (GDP), 75% of the employment of the country's labor force, 70% of export earning and 70% of the supply of industrial raw materials (FAO, 2017).

Drought is becoming frequent and many people have been repeatedly exposed to hunger and famine due to the high rainfall dependency of the agricultural production in Ethiopia. Depend on this, the Ethiopian government use different strategies to avoid or minimize the deep-rooted food insecurity at the household level. Among these strategies the introduction of different water harvesting schemes for the farmers to be able to produce enough for the whole year round is the major one. Hence, both government and non government organizations in Ethiopia have been initiating and implementing micro irrigation projects because irrigation contributes to livelihood improvement through increased income and food security, employment opportunity and poverty reduction (Tsegazeab, 2016). Therefore, this calls for different interventions, irrigation being one of the options, which could help in adapting strategies to cope up with the challenging drought and to ensure food security as well as the household income at national level in general and household level in particular.

There is a high irrigation potential in Benishangul Gumuz region, but its level of utilization is not as per its potential. Contrasting to its natural endowment like water accessibility, the developments of irrigation in the region and specifically in the study district is the lowest and hence, this necessitates conducting an empirical analysis to verify the factors responsible for low status of adopting irrigation practice in the study area. In the study area there is large number of small holder rural farmers that is known by practicing small scale irrigation that consisting of high irrigation potential, but the potential available for irrigated farming is not intensively used. There is limited scientific evidence why the farmers in the study area are not using this potential to increase their production and improve their income. Therefore, this study was mainly concerned to find out the factors that determine the farmer's adoption decision in small scale irrigation practice and intensity of participation in the study area.

The adoption of more efficient farming practices and technologies that augment agricultural productivity and improve environmental sustainability is instrumental for achieving economic growth, food security and poverty alleviation. In line with this, the Woreda has constructed different irrigation schemes having the objective of increasing agricultural productivity to improve the food security situation of the farming communities and to decrease reliance on the erratic rainfall. However, a significant attempt has not been made to study and analyze the determinant and intensity of small scale irrigation of rural farmers in the study area. Not only in the study area, especially the study on intensity of participation in irrigation practice is scanty as a whole in the country and globally. Beside as per the knowledge the researcher, in the Woreda there are different ethnic groups, among these groups there are indigenous and settlers. Therefore variables like ethnicity difference (i.e. indigenous or new settlers) and duration of residence were included in this study as explanatory variables that no one dealt with. Therefore, this study was designed to identify demographic, institutional and socio-economic factors that determine the smallholder farm house hold irrigation adoption decision and extent of adoption.

LITERATURE REVIEW

New technology adoption is a decision-making process in which an individual passes from first knowledge of an innovation, to forming an attitude toward an innovation, to a decision to adopt or reject, to implementation of new idea, and to confirmation of the decision (Ray, 2001). Agricultural technology adoption states to the decision to use a new technology, method, practice, etc. by a farmer (Feder, Just & Zilberman, 1985). On the other hand, extent of technology adoption is defined as the level of adoption of a given technological package among user (Nkonya, Schroeder & Norman, 1997). The expansion of new agricultural technology application has increased agricultural productivity, contributed to overall economic growth, and reduced food insecurity and poverty in developed and some developing countries (Bandeira & Rasul, 2005; Cornejo & McBridgje, 2002).

Different research on technology adoption across various region witness that demographic, institutional and socio-economic factor affects the farm house hold decision to adopt new technology and its intensification. Using double hurdle model in Ethiopia, Temesgen (2018), found 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 from truncated part of double hurdle model shows 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. The demographic factor such as sex of a respondent is mostly used as one of determinant factors of participation in irrigation and found that male headed households are the most likely participant in small scale irrigation practice (Kinfe ***et al***., 2012; Muhammad ***et al***., 2013; Gebrehaweria ***et al***., 2014) and irrigate more area (Abebe ***et al***., 2011). Likewise, the variable age of household head also shown that it affects the area of land allocated for improved irrigation technology negatively (Wang ***et al***., 2015; Pokhrel ***et al*.,** 2016). This indicate that the more aged the farmers, they allocate more of their land to non improved traditional farming practice rather than improved technology such as irrigated farming, because older farmers have shorter plan of living at this age.

More ever, Leta *et al.,* (2018), examined that age, educational level, contact frequency with agricultural development agent, access to mass media, participation in irrigation related training and livestock ownership were the variables that significantly influence households' use of small scale irrigation. Astatike (2016), applying Heckman selection model (two staged) in Bahir Dar Zuria Woreda examined that the decision of farmers to adopt small scale irrigation were determined by the different socio economic, demographic and institutional variables such as owning irrigation land, having pumping motor and dissatisfaction with the existing irrigation schemes are the most significant influencing factors that determine irrigation participation.

The above studies of the empirical literature showed that socio-economic, demographic characteristics and institutional variables like education level of household, access to credit, livestock holding, access to extension contact, owning irrigation land, access to mass media, distance to market and availability of farm labor are influence adoption and intensity of small scale irrigation.

METHODS

Description of the study area

This study emphasized on Benishangul-Gumuz Regional State particularly Assosa woreda. According to the national census of 2018 done by Central Statistics Agency of Ethiopia, the total population of Assosa woreda reported is 104,147. Assosa Woreda which has 74 rural kebeles, total area approximately 2,903 square kilometer and located at a distance of 667 km in West of Addis Ababa (BoFED, 2017). The rainy season starts from April/May up to October/November with an average annual rain fall that ranges from 800 mm to 2000mm. The temperature ranges from 20^0 C – 35^0 C (highest) to 12^0 C – 20^0 C (lowest) (BOFED, 2014).

Due to agricultural dependence on rain water, many crops are planted during rainy seasons (Meher). The dominant cereal crops like maize, teff, pulses and sorghum produced in Meher season and collected from October to January. Beside, fruits like Mango, Banana and Papaya and vegetables like Cabbage, Tomato, Onion, Sweet potato as well as many crops and vegetables are produced by many rural small holder farmers. Like other rural areas, in Assosa Woreda of the dwellers, the source of the population livelihood also depends on the practice of mixed agricultural farming system especially practice of small scale irrigation.

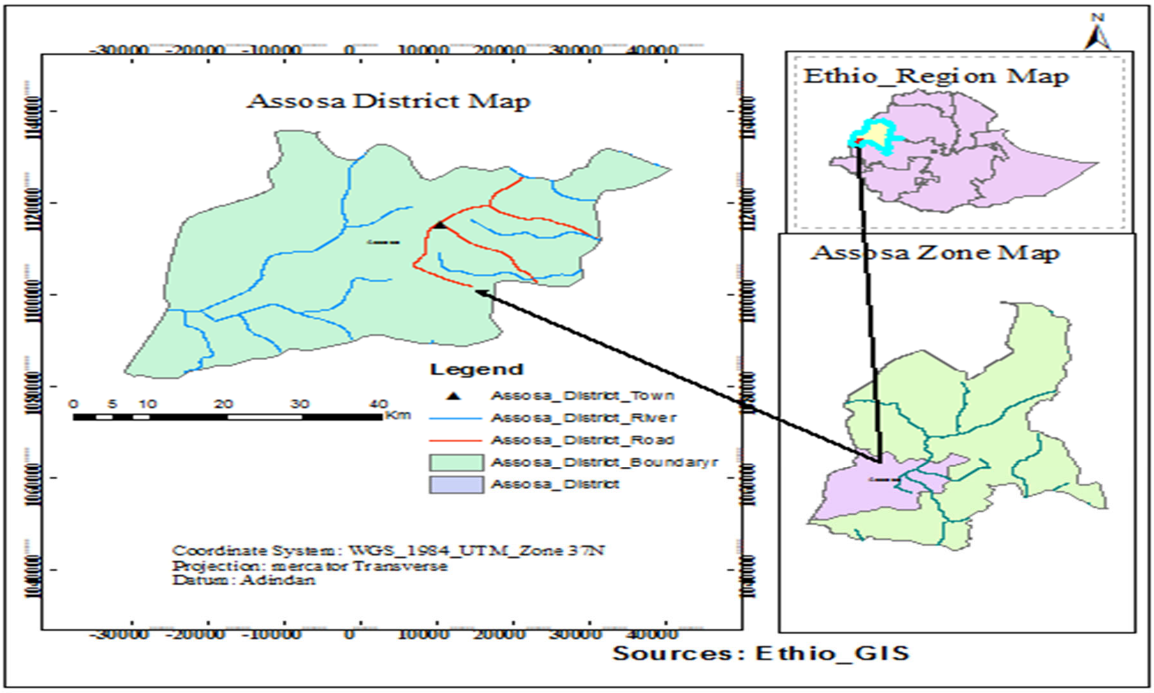

Figure 1: The Location of Assosa district in Ethiopia

Research strategy

In this inquiry, both quantitative and qualitative research strategies was employed. The quantitative strategy used to investigate the data that was collected using structured questionnaire from 329 sampled farm household heads. The qualitative research strategy used to analyze data that was collected using the unstructured interviews with local traders; rural experts; kebele administrative body; and consumers to capture supplementary information and to observe the validity of information's from household survey.

Research design

The cross-sectional (survey) research design was applied in this study. Accordingly, demographic, socio-economic and institutional data related to small scale irrigation adoption status of smallholder farm family was collected for the harvest year of 2019/20 and analyzed through econometric and descriptive methods.

Sampling size determination

The samples for this study distinguished according to the formula for sample size determination for finite population given by (Yamane, 1967) as shown below;

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

Where "n" is required sample size, "N" the total number of households in the selected kebeles (1847hhs) and "e" acceptable error margin (0.05).

Thus, the total sample size can be calculated by using the above formulas.

$$n = \frac{1847}{1 + 1847\ (0.05)^2} = 329 \quad (2)$$

Therefore in this study the number of sample households is 329 and then to determine each kebeles sample size using probability proportional sampling technique, is computed as follows;

$$n = \frac{Ni}{\sum_{i=1}^{k=6} N} * n \quad (3)$$

Where "ni" is sample size of i[th] kebele, "Ni" total household of i[th] kebele, " $\sum_{i=1}^{k=6} N$ " total number of household in the selected six kebeles and "n" total sample size.

Table 1: Stratified and proportionately selected sample size determination

Kebeles	Household nos	No. of users	No. of non-users	How to compute	Total sample size	Sampled users	Sample non-users
Mengele 39	281	131	150	281/1847*329	50	23	27
Amba 11	304	121	183	304/1847*329	54	21	33
Selga 22	290	160	130	290/1847*329	52	29	23
Mengele 32	310	115	195	310/1847*329	55	20	35
Mengele 29	320	120	200	320/1847*329	57	21	36
Amba 13	342	178	164	342/1847*329	61	32	29
Total	1847	825	1022		329	146	183

Source: Kebeles administrative office and own computation (2020)

Methods of data analysis

In this study the descriptive statistics such as mean, standard deviation, percentages, frequency, t- test, Chi-square and graphs were used in analyzing the data. Furthermore, the dependent variables in this study are the adoption decision of the farmers in small scale irrigation. Since the dependent variables of this study, household's adoption decision in small scale irrigation is dichotomous (binary), it takes a value of 1 if the household is adopter of small scale irrigation and zero otherwise. Therefore, the dependent variable in this model is discrete consisting of two outcomes, yes or no. In this case, using Ordinary Least Square/OLS technique for such variables poses inference problems, and thus not appropriate for investigating dichotomous or limited dependent variables. In such circumstances, maximum likelihood estimation procedures such as logit or probit models are generally more efficient (Gujarati, 1995).

Several investigators used different models for analyzing the determinants of small scale irrigation adoption at farm level. Various adoption studies have used Tobit model to estimate adoption relationships with limited dependent variables while the others used double-hurdle model. However, it is conceivable to use Heckman's (1979) two step procedure in case of anticipated problem of selection bias in the sample. Selection bias was anticipated in this study because among the representative not all households are believed to participate in small scale irrigation adoption due to individual problems.

The Heckman two-step selection model allows for separation between the initial decision to adopt technology, including irrigation ($Y > versus\ Y \leq 0$) and the level of their application. The model uses in the first step a probit regression to assess the probability of decision to adopt and in the second step uses ordinary least squares (OLS) to determine the intensity of adoption (Green, 2007) and the method correct sample selection bias. This technique used in order to control the selectivity bias and endogeneity problem and to obtain consistent and unbiased parameter estimates (Green, 2007). In selection model procedure, sample bias is determined by the relationship between the residuals of the two stages (stage 1 and stage 2). Estimates are biased if the residuals in the stage 1 and 2 are correlated. Similarly, Stage 1 does not affect stage 2 results if the residuals are unrelated. Positive and negative correlations between residuals are indicated respectively, by positive and negative mu(μ) values, which is the correlation between error terms of two regression model.

The first stage Heckman two steps or the probit model is to analyze the factors determining the probability of adopting small scale irrigation and specified as:

$$pr\ (Y_{1i} = 1/x_{1i,}\ \beta_{1i}) = \Phi\ \big(f(x_{1i,}\ \beta_{1i})\big) + \ \varepsilon_i \quad (4)$$

Where; Y_{1i} is an indicator variable that is equal to unity for small scale irrigation user households; Φ is the standard normal cumulative distribution function; $x_{1i,}$ is variable that affect adoption decision and was described in Table 2; β_{1i} is a coefficient to be estimated. The variable Y_{1i} takes the value 1 if the household is adopter of small scale irrigation and 0 otherwise. This can be shown mathematically:-

$$Y_{1i}^* = \ \beta_0 + \ \beta_{1i}X_{1i} + \varepsilon_i \quad (5)$$

Where; i = 1, 2, 3……………….n

$$Y_{1i} = \begin{cases} 1\ if\ Y_{1i}^* > 0 \\ 0\ if\ Y_{1i}^* \leq 0 \end{cases} \quad (6)$$

Where Y_{1i}^* is a latent variable of marginal utility the farmer's get from adoption of small scale irrigation, β_0 is constant term, ε_i is error terms in the first stage model assumed to be normally distributed with zero mean and constant variance(δ^2).

In the second stage parameters can consistently be estimated by OLS by incorporating an estimate of the inverse Mills ratios denoted as λ_i from probit regression model as additional explanatory variable as specified bellow:-

$$Y_{2i} = \alpha_0 + \alpha_i X_{2i} + \mu_i \lambda_i + \nu_i \quad (7)$$

Where:

Y_{2i} = represents the proportion of land allocated for small scale irrigation by the farmer,

X_{2i} = implies the explanatory variables determining the intensity of participation in small scale irrigated farming shown in Table 2,

α_0 =is the constant term in OLS regression model,

α_i =is the parameters to be estimated in the second stage,

λ_i =is the inverse mills ratio computed from first stage estimation,

μ_i =implies the correlation between first and second stage error terms or corr (ε_i, ν_i),

ν_i = is the error terms in the second stage.

According to Heckman (1979), the IMR (λ_i) is a variable for controlling bias due to sample selection. This term is constructed using the model in the probit regression (first stage) and then incorporate into the model of the second stage (OLS) as an independent variable. It can obtain:-

$$\lambda_i = \frac{\phi(\beta_0 + \beta_{1i} X_{1i})}{\Phi(\beta_0 + \beta_{1i} X_{1i})} \quad (8)$$

Where, $\phi(\beta_0 + \beta_{1i} X_{1i})$ denotes the standard normal probability density function and $\Phi(\beta_0 + \beta_{1i} X_{1i})$ denotes the cumulative distribution function for a standard normal random variable.

But the value of λ_i is not known, the parameters β_0 *and* β_{1i} can be estimated using a probit model, based on the observed binary result. Then the estimated IMR calculated as:-

$$\widehat{\lambda_i} = \frac{\phi(\widehat{\beta_0} + \widehat{\beta_{1i}} X_{1i})}{\Phi(\widehat{\beta_0} + \widehat{\beta_{1i}} X_{1i})} \quad (9)$$

Hypotheses and justification of explanatory variables

One of the important parts in this section is to specify and hypothesize the dependent and explanatory variables that were used in the model. Regarding to its definition, measurement and hypotheses of variables, which was used in our model, summarized in the Table 2.

Table 2. Explanation of hypothesized effect of explanatory variables on small scale irrigation adoption and its intensity

Code	Definition	Scale measurement	Nature of variables	Expected effect
Irrgg	Small scale irrigation adoption decision	User =1 Non user=0	Binary	
Pirrl	Proportion of land irrigated	In hectare	Continuous	
Aghh	Age of farm household head	In year	Continuous	-+
Sexhh	Sex of farm household head	1 if male,0 otherwise	Dummy	+
Fshh	Family size of households	In number	Continuous	+
Eduhh	Education status of the head	1 if literate, 0 otherwise	Dummy	+
Duresi	Duration of residence	In years	Continuous	+
Ethi	Ethnicity of farm household head	Indigenous =1 Settler =0	Dummy	+-
Sicl	Size of cultivated land	In hectare	Continuous	+
Usecrids	Use of credit services	Yes=1,0 otherwise	Dummy	+
Livow	Livestock ownership	TLU	Continuous	+
Distmkt	Distance to the market	In Km	Continuous	-
Offfarm	Participate in nonfarm activity	Yes=1,0, otherwise	Dummy	+
Distirr	Distance of plot of land from water source	In Km	Continuous	-
Das	Contact with development agent advice	Frequency of contact with Das	Continuous	+
Parlfor	Participation of farm labor force	In number	Continuous	+
Atftc	Attending training at farmer training center	Yes=1,0 otherwise	Dummy	+

Source: Authors hypothesis (2020)

RESULTS AND DISCUSSION

Descriptive analysis

Out of total sample of 329 smallholder farm household, 146(44.4%) participated in adoption of small scale irrigation in their cultivation, while the remaining 183(55.6%) were no practicing small scale irrigation. Table 3 illustrate the mean, minimum and maximum age of head, size of land ownership, distance to market center, number of family, size of active family, distance to irrigation, total livestock unit, development agent advice and duration of residence for total survey, irrigation adopter and non-adopter in comparison.

The descriptive statistics result for continuous variable (Table 3, t-value) show that there was no statistically significant difference between small scale irrigation adopter and non-adopter concerning age of head and distance to market center while there was significant difference in land holding and handiness of family labor. This demonstrates the importance of family labor force and arable land whether the household to adopt or not to adopt productive technology.

Table 3. Description of continuous variables

	Non-user(N=183)			User(N=146)			Total(N=329)			
Variables	Mean	Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	t-test
Age of HH	42.04	23	65	42.76	24	59	42.36	23	65	-1.0091
Land size	2.13	0.25	5	2.52	0.5	5	2.30	0.25	5	-4.5474***
Family size	6.49	3	10	6.907	3	11	6.70	3	11	-2.8927***
Size of active family	5.45	1	10	6.13	2	10	5.7	1	10	-3.5497***
Distance to market	7.23	1	19	7.16	1	18	7.20	1	19	0.1897
TLU	9.51	4.529	20.4	10.8	4.529	20.4	10.11	4.529	20.4	-3.7301***
Development agent advice	2.08	0	7	2.66	0	6	2.34	0	7	-3.2663***
Distance to irrigation	1.35	0.25	4	1.14	0.25	3	1.26	0.25	4	3.5708***
Duration of residence	26.2	12	45	27.9	15	45	27.03	12	45	-2.8680***

*Note: ***, ** and * imply statistically significant at 1%, 5% and 10% respectively.*
Source: Computed from own survey data (2020)

Table 4. Summarizes frequency, percentage and level of influence of dummy variable. Accordingly, there was statistically significant difference between users and non-users of irrigation in education level of head, sex of the head, ethnicity of the head, attained training at farmer training center, affordability of credit and participation in nonfarm activities.

Table 4. Description of dummy variables

		Irrigation				
Variables	Type	Non-users	Users	Total	Percent	Chi^2-test
Sex of household head	Female	64	32	96	29.18	
	Male	119	114	233	70.82	6.8109***
Education status of the household head	Illiterate	78 42	105	120	36.47	
	Literate	104		209	63.53	6.8030***
Participate in non-farm activity	No	127	71	198	60.18	
	Yes	56	75	131	39.82	14.6522***
Attending training at FTC	No	147	52	209	63.53	
	Yes	36	84	120	36.47	51.1696***
Have access to credit	No	117	58	175	53.19	
	Yes	66	88	154	46.81	19.2702***
Ethnicity of household head	Settler	103	109	212	64.44	
	Indigenous	80	37	117	35.56	12.1799***

Note: ****, ** and * imply statistically significant at 1%, 5% and 10% respectively.*
Source: Computed from own survey data (2020)

An econometric estimation results

In this sub-section, Heckman two stage selection analysis is executed to identify the household-level demographic, socio economic and institutional factors that determine the decision of smallholder farmers to adopt or not to adopt small scale irrigation in the first stage by applying probit regression. In the second stage, the conditional estimation/OLS method was used to investigate factors that influence the level of their adoption.

However, before running the regression analysis, the diagnostic tests, such that, the existence of multicollinearity and the problem of heteroscedasticity of variables included in the model are needed to be checked for explanatory variables. According to Gujarat (2004), when the values of VIF approach to infinitive there is serious problem of multicollinearity, while if VIF is below 10 there is no much problem. In this study all the computed value of VIF for explanatory including IMR variable was blow five. Therefore, there is no evidence of multicollinearity problem among the explanatory variables included in the model. The data were also tested for heteroscedasticity using the Breusch-Pagan test (Wooldridge, 2012). The Breusch-Pagan test evaluates the null hypothesis of a constant variance in the data. The Chi-square value results of STATA output were presented in appendix---. Accordingly, the null hypothesis of a constant variance was not rejected implying absence of heteroscedasticity in survey data.

Factors determining farmer's small scale irrigation adoption decision

Table 5 shows the probit regression and marginal effect of probit outcomes of factors that influence the likelihood of farmer's small scale irrigation adoption decision. The models constructed with 15 independent variables and out of these 10 variables are significantly determining the adoption decision with hypothesized sign. These variables include size of farm land, ethnicity of the household head, livestock ownership, sex of household head, education status of household head, participation in labor force activity, distance to irrigation, access to credit service, attending training at farmer training center and development agent advice are statistically significant and economically meaning full results, that affects the probability of small scale irrigation participation. Whereas, age of household head, size of family, duration of residence, distance to the nearest market and participating in non-farm activity insignificantly but all variables with expected sign influence the small scale irrigation adoption decision.

Table 5: Factors that determine farmer's small scale irrigation adoption decision - Probit model

Variables	Parametric estimation			Marginal effect		
	Coefficient	Std.Err.	z	Coefficient/dF /dx	Std. Err.	P>|z|
Aghh	.0160794	.0135569	1.19	.0062897	.0053	0.235
Sexhh	.4177582	.1857535	2.25	.1589477**	.06798	0.019
Fshh	.0706669	.0550746	1.28	.0276425	.02154	0.199
Sicl	.3307449	.1087438	3.04	.1293761***	.0425	0.002
Livow	.0461188	.0241873	1.91	.0180401*	.00946	0.057
Parlfor	.1177497	.0484966	2.43	.0460597 **	.01895	0.015
Distirr	-.4612583	.1704456	-2.71	-.1804284***	.0665	0.007
Distmkt	-.0069122	.025065	-0.28	-.0027038	.00981	0.783
Eduhh	.3033379	.1821193	1.67	.1171707*	.06912	0.090
Ethi	-.5470826	.1734323	-3.15	-.2076232***	.063	0.001
Duresi	.0147623	.015205	0.97	.0057745	.00595	0.331
Offfarm	.1961275	.1759148	1.11	.0768882	.06901	0.265
Usecrids	.3790371	.1655754	2.29	.1477575	.06392	0.021
Das	.135666	.0514173	2.64	.0530679***	.02014	0.008
Atftc	.992518	.1719034	5.77	.0530679***	.0201	0.000
Con	-4.257388	.9137255	-4.66			

Number of observation = 329; LR chi2 (15) = 139.09; Probability > chi2 = 0.0000
Log likelihood = -156.41297; Pseudo R^2 = 0.3078
****, ** and * imply statistically significant at 1, 5 and 10% respectively.*
Source: Computed from own survey data (2020)

As specified in Table 5, the marginal effect report of the probit regression provides the probability that a farm household able to adopt small scale irrigation. Accordingly, the interpretations of each significant variable were explained here under.

The farm size of respondent was positive and had statistically significant influence at 1% level on the adoption of small scale irrigation. The marginal effect result indicates that a farmer, who has one additional hector of arable land, would increase the likelihood of small scale irrigation adoption by 12.93%. This result is in line with the argument of the previous study which was done by (Beyan; Jafer & Adem, 2014) and Abebaw (2015) which claimed that larger arable land ownership enable farmers to have more flexible in their decision making, greater access to discretionary resource, and give more opportunity to adopt new farm practice including irrigation.

In line with prior expectation, sex of household head was positive and had statistically significant influence at 5% level on the adoption of small scale irrigation. The result indicates that female headed households are 15.9 percent of marginal effect less likely to participate in small scale irrigation; other things remain constant, as compared to their counterparts of male. This finding is similar with (Gebregziabher, Regassa & Holden, 2012) & Tsegazeab (2016) and according to their finding the probable reason is due to cultural biases where female headed households have limited resource access and males have more exposure to other social and economic activities and the above results coincide with this effect.

As hypothesized, distance to irrigation water was found to be negatively and significantly influenced the probability of adoption of small scale irrigation decision at 1% significance level. Keeping other variables constant at their respective mean level, the probability of participating in irrigation for a household decreased by 18.04% as the distance of water source from his/her plot of land increase by one kilometer. This implied that the longer the distance between a plot of land and the irrigation water, the lower will be the probability of adoption of small scale irrigation. This finding is similar with Beyan, (2014) and Petros, (2017).

In the same genre, development agent advice was statistically significant and positively affects participation in irrigation at 1% probability level. The marginal effect verify that receiving extension service for one more day augments the likelihood of adopting small scale irrigation technology by 5.3 percent, citreous paribus. It implied that extension workers play a fundamental role in transferring knowledge to the farmers easily thereby improving production, income and food security and it is consistent to the previous hypothesis stated in this study. The result is in line with the empirical finding of Kidanemariam *et al.,* (2017) which claim that contact with extension services gives farmers greater access to information on technology, via communications and more opportunities to participate in demonstration tests.

As hypothesized, education level of household head was found to be positively and significantly influenced the probability of adoption of irrigation. Holding other variables constant, as compared to illiterate farmers the probability of adoption of small scale irrigation for literate farmers would increase by 11.7%. This is due to the fact that educational attainment by the household head could lead to awareness of the possible advantages of modernizing agriculture by means of technological inputs; able to understand and apply different sort of irrigation technology in their farm land which, in turn, would enhance households' food supply. This result is consistent with work of Ogunniyi *et al.*, (2018), they forwarded that having education increases the probability of adoption of irrigation by farmers.

As expected, attending training at farmer training center has shown positive influence on likelihood of small scale irrigation adoption decision at 1% level of significance. Keeping other variables constant, a farmer who attend training at farmer training center have 5.3% better opportunity to adopt small scale irrigation than those who is not attend training at farmer training center. Hence, attending training at farmer training center was increase farmers chance to adopt small scale irrigation because it enables farmers to make right decision on how to apply irrigation on their farm land with minimum probability of risk and it empowers farmers to obtain on time irrigation technology information.

Access to credit affects farmer's probability of participation in irrigation use significantly and positively at 5% significance level. The positive relationship could be because those households who have access to credit have a better possibility of getting farm inputs and hence the probability of participation in small scale irrigation increases. Keeping other variables fixed, availability of credit service encourages the likelihood of household small scale irrigation adoption decision by 14.77%. The finding is in line with Godfrey *et al*., (2014). Therefore, this study revealed that the probability of adopting irrigation technology for households with credit access is higher than households without credit access. Contrary to this, the variable ethnicity of household was negative and had statistically significant influence at 1% level on the adoption of small scale irrigation. The result indicates that indigenous households are 20.76 percent of marginal effect less likely to participate in small scale irrigation; other things remain constant, as compared to their counterparts of new settler. The probable reason is due to most indigenous households are highly engaged in non-farm activity like on dig out of gold and other traditional activity than agricultural production in the study area. This implies most probably new settler households are highly participated in irrigation practice than indigenous households and it is statistically significant.

As expected, the availability of family labor force has positive impact on likelihood of small scale irrigation adoption at level of significance 5%. The marginal effect verify that the availability of one more active person in family increase the probability of irrigation technology adoption by 4.6%, holding all other factors constant. This finding is consistent with the results of Beshir, Emana, Kassa, & Haji (2012), which reason out that improved farm practices including irrigation are labor intensive and hence the household with relatively high labor force uses the technologies on their farm plots better than those with little labor force in family.

Results of the second stage of Heckman two stage model (OLS model)

The Heckman model in the second stage estimation identifies the factors that determine the intensity of small scale irrigation adopted using the OLS model. The coefficient of inverse Mill's ratio /Lambda is significant at 1% level. The significance of Mill's ratio discloses the presence of selection bias and the effectiveness of applying Heckman two stage models due to its ability to handle the selection problem. The positive sign of lambda reflects that the error terms in the adoption decision model and selection equations are positively correlated.

Table 6 reveals that the regression results of variables that affect the level of small scale irrigation adoption among smallholder farmers. Out of 13 explanatory variables family size, credit use, ethnicity and lambda significantly influence the intensity of small scale irrigation adoption. Accordingly, the interpretations of each significant variable were explained here under.

Table 6: Results of the second stage selection estimation (intensification of small scale irrigation adoption)

Variables	Coefficient	Std. Err.	z	P>|z |
Aghh	.0011595	.0026165	0.44	0.658
Sexhh	.0124763	.0416521	0.30	0.765
Fshh	.0205717*	.0112308	1.83	0.067
Livow	-.002909	.0051349	-0.57	0.571
Parlfor	.0056982	.0112653	0.51	0.613
Distirr	.0546838	.0392632	1.39	0.164
Distmkt	.0004924	.0048061	0.10	0.918
Eduhh	.0465086	.038637	1.20	0.229
Ethi	-.0810307**	.0413704	-1.96	0.050
Duresi	.0035101	.0032662	-1.07	0.283
Offfarm	.048826	.0343721	1.42	0.155
Usecrids	.0946554***	.035719	2.65	0.008
Atftc	.0713919	.0507007	1.41	0.159
Mills lambda	.1959636	.0718076	2.73	0.006
Con	.6064958	.2665316	2.28	0.023

Number of observation = 329; Censored observation = 146; Uncensored Observation = 183; Wald chi^2 *(13) = 22.53; Prob >* chi^2 *= 0.0476*

****, ** and * imply statistically significant at 1, 5 and 10% respectively.*

Source: Computed from own survey data (2020)

Analogous to the first stage result, credit use and ethnicity determine both adoption decision and intensity of adoption significantly with expected sign. Moreover, family size has positive and significant effect on intensity of adoption at 10% level of significance. Access to credit service was found significantly and positively influencing the intensity of participation in small scale irrigated farming by the farmers, at 1% level of significance. From the result of second stage OLS regression, it indicates that the proportion of land covered by irrigation increases by about 0.09 hectare for credit user farmers as compare to the farmer who did not use credit. This suggests that households, who had access to credit service, are more likely to intensify small scale irrigation adoption than farmers who did not used credit by about 0.09 hectare, holding other factor constant. This finding is in line with the result reported by Abebe *et al.,* (2011).

Family size of the farm household head also found positive and significant influence on intensity of small scale irrigation adoption at 10% significance level. One additional person in family enhances the use of proportion of land irrigated by 0.02 hectare, holding all other variables constant. In the same genre, ethnicity of the farm household head is also shown expected sign and statistically significant at 5% level. This suggests that the proportions of land irrigated by indigenous farmers are less than the proportion of land irrigated by new settler households by about 0.08 hectare, keeping other variables constant.

Regarding the effect of the remaining variables, age of household head, participation in non-farm activity, education, duration of residence, livestock ownership, sex of the head, distance to irrigation, distance to market, active labor force and attending training at farmer training center were statistically insignificant to influence the intensity of small scale irrigation adoption.

CONCLUSION AND POLICY IMPLICATION

Conclusion

A remarkable improvement in agricultural productivity in majority of developing countries in late 1960s resulted from agricultural transformation agenda including of agricultural research, extension services and rural infrastructural development that basically underline the role technology adoption among smallholder's farmer in increasing production was vital. Technological change in agriculture comprises of introduction of high yielding variety of seeds, fertilizers, plant protection measures and irrigation. These changes in agricultural sector augment the productivity per unit of land and bring about rapid increase in production to tackle the severe problem of poverty. In Ethiopia, even though some progress has been recorded over time, the use of agricultural technologies especially irrigation is found at its low level signifying the role of empirical studies. To this end, this study was conducted with the aim of investigating the institutional, demographic and socioeconomic factors that influence the adoption decision and extents of small scale irrigation among smallholder farmers. Accordingly, the descriptive statistics and Heckman two stage econometric methods were employed to analyze data collected from sampled household. The significance of coefficient of inverse Mill's ratio (λ) indicates the presence of selection bias and the effectiveness of applying Heckman two stage model.

The adoption decision of small scale irrigation use was driven by factors such as ethnicity, sex, education status of the head, size of cultivable land, development agent advice, access to credit, attending training at farmer training center, distance to irrigation, active labor force and total livestock unit. While the intensity of small scale irrigation application was influenced by family size, access to credit, ethnicity of farm household and lambda.

Policy implication

In light of these findings, development agent advice and education status of the head is being a crucial factor in enhancing the farmer small scale irrigation adoption. Therefore, it is suggested that policy makers should targeted the extension program to the less educated farmers for its effective delivery through special training, seminars, field demonstrations, and technical support to enhance the adoption rate of small scale irrigation. Moreover, the policies which expand the accessibility of credit service, dissemination of productive agricultural technology information, and creating opportunity of education for farm house hold has potential to increase the chance of small scale irrigation adoption decision and strengthen the level of adoption among smallholder farmers.

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