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# FACTORS INFLUENCING RURAL FARM HOUSEHOLDS PARTICIPATION DECISION ON IRRIGATION IN ILLU ABBA BORI ZONE, OROMIA REGION, ETHIOPIA

**TolesaSoresa(MSc)[a]*,Tibebu Alemu (MSc) [b]*Sharmila Raman (Dr.) [c]***

## *Abstract*

*The overall objective of this study is to analyze factors affecting participation decision and effects of the variables on income of smallholder farmers in Illu Abba Bor Zone in five Woredas'. The study was based on cross-sectional data collected from a sample of 238 households using stratified random sampling technique. Both descriptive and inferential (econometric) analysis were followed in the study. The econometric analysis employed is Heckman two-step procedure to identify factors influencing rural farm households' participation decision in small scale irrigation and to determine effect of factors on households' income. The findings from the study showed that, distance from nearest water source to household home,non- farm & off-farm income were negatively and significantly related to participation in the scheme. However, household head education status, livestock holding, amount of production input used, total family size of household, access to extension services, availability of active labor force and land topography of the household head influence positively and significantly.*

***Keywords:*** Small-scale Irrigation;   Heckman two-stage model; Ethiopia

## Introduction

According to Asayehegn (2012), agricultural production in Ethiopia is primarily rain fed and dominated by smallholder farming system. Rainfall is erratic and unevenly distributed between seasons and agro ecological regions led to poor yields, low productivity, food insecurity and poverty within the farming population, thus emphasizing the need for irrigation in the region. Irrigation development is a key to the sustainable and reliable agricultural development, and thus, for the overall economic development of the country. Accordingly, enhancing small-, medium-, and large-scale irrigation development has been identified as an important tool to stimulate economic growth and rural development, and is considered as a cornerstone of food security and poverty reduction in Ethiopia (MoARD, 2011).

Similarly, Ethiopia's Agricultural Policy Investment Framework (PIF) and Agricultural Growth Program (2010/11–2019/2020) present the strategic framework for prioritizing and planning investments in order to drive Ethiopia's agricultural growth and development, which is in line with the national vision of becoming a middle-income country by 2025. Water utilization and the expansion of smallholder irrigation are the programs of primary strategies (Tesfaye and Seleshi, 2014).

Furthermore, considering the current situation with growing population pressure in the highland areas and a rapidly declining natural resource base has necessitated irrigated agriculture. In line with this, irrigation is given prime attention on the country‟s development agenda since it enables smallholders to adopt more diversified cropping patterns, and to switch from low - value staple production to high-value market- oriented production which makes food available and affordable for the poor (Asayehegn, K., Chilot, Y., and Sundar, R., 2011).

Irrigation systems have expanded in recent years to bring water control, which, together with rapid increases in water productivity, has greatly boosted agricultural production and incomes (FAO, 2011). For instance, in Ethiopia during the first Growth and Transformation Plan (GTP1), the government provides more resources to develop irrigation on all scales, and puts equal emphasis on big commercial farmers.

Accordingly, during the GTP1, ranges from 2010-014/15, Ethiopia specifically plans to add 658,340 hectare of medium- and large-scale irrigation by 2014/15, which is five times the number (i.e., 127, 243 hectare) developed during the base year (2009/10). Similarly, the projected development of SSI is an increase of additional 1,000,000 hectare by 2014/15, which would more than double the 853,100 hectare developed in the base year of 2009/10. The Growth and Transformation Plan (GTP) of the country envisages the development of irrigation to cover 1.8 million hectare by 2015. Although successfully putting these plans into effect would certainly attain rapid growth in the irrigation sector for smallholders, the actual practices on the ground delivered lack luster results, most likely due to its over ambitious nature (MoFED, 2010).

This paper examined factors determining participation decision and extent of participation of smallholder in small scale irrigation in Illu Abba Bori Zone. The data used for this study comes from the surveys which were conducted in selected five woredas' of Illu Aba bori zone, Ethiopia in 2017. Our sample consists of 228 farm households coming from five districts.

## Methods

The study employed both descriptive and econometric techniques to assess households' participation decision on small scale irrigation and its effect on their income. The descriptive analysis was performed using frequencies, means, and mean differences, standard error an dstandard deviation values. Furthermore, t test for continuous variables and $\chi 2$ test for categorical variables were analyzed. Thus, the t-test was used to test the significance of the mean value of continuous variables of the two groups of users and non-users. Likewise the potential discrete (dummy) explanatory variables were tested using the chi-square ($\chi$ 2) distribution.



### Econometric Model

### The Heckman Model

Regression models which evoke a yes or no or present or absent response are known as dichotomous or dummy dependent variable regression models. They are applicable in a wide variety of fields and are used extensively in survey or census-type of data. On the other hand a regression model in which the variation in dependent variable (yi) is explained by an independent variable ($x_i$) continuously is known as classical linear regression model (Gujarati,2004; Verbeek, 2004; Green, 2003; Woodridge, 2002).

This study was targeted to investigate the contribution of small irrigation on income of rural households by categorizing them as participant and non-participant. Thus the independent variables are of both types that theyare categorical and continuous. Smallscale irrigation participat ionis a dependent variable, which is dichotomous taking on two values, one if the household participate in small-scale irrigation and zero otherwise. Estimation of this type of relationship requires the use of qualitative response models. In this regard, the non-linear probability models, logit and probit models are the possible alternatives. The logit and probit models guarantee that the estimated probabilities will lie between the logical limit of 0 and 1, and their choice revolves around practical concerns such as the availability and flexibility of computer programs, personal preference, experience and other facilities because the substantive results are generally indistinguishable (Maddala, 1983).

The ordinary least squares (OLS) regression and linear probability models leads to biased estimate because one of the dependent variables in this study is a dummy variable which takes a value of zero or one depending on whether or not the households participate in small-scale irrigation. The other reason for the in appropriateness of linear regression analysis is that the effect of the program may be over or underestimated if the program participants are more or less able (due to certain unobservable characteristics) to derive benefits compared to eligible non-participants (Zaman, 2001).

In order to correct for the unobservable sample bias problem in the regression, Heckman's two-step estimation (Heckit) procedure can be applied, as suggested by Heckman (1978). Heckman‟s two stages rely on the assumption that specific distributions of the unobservable characteristics jointly influence participation and outcome. His key contributions to program evaluation include the following: (a) he provided a theoretical framework that emphasized the importance of modeling the dummy endogenous variable; (b) his model was the first attempt that estimated the probability (i.e., the propensity score) of a participant being in one of the two conditions indicated by the endogenous dummy variable, and then used the estimated propensity score model to estimate coefficients of the regression model; (c) he treated the unobserved selection factors as a problem of specification error or a problem of omitted variables, and corrected for bias in the estimation of the outcome equation by explicitly using information gained from the model of sample selection; and(d) he developed a creative two-step procedure by using the simple least squares algorithm.

In the first stage, a probit regression is computed in order to estimate the probability that a given household irrigate or not. In this stage, the household's decision is modeled as a dichotomous choice problem of nonparticipant and participant households on small scale irrigation farming.

Then, the inverse Mills ratio (l) for every household is estimated by dichotomous-choice probit model described the ratio of probability density function to cumulative normal distribution function.

## Descriptive Analysis

The descriptive analysis tools used are mean, percentage mean, mean difference and standard deviation. The descriptive statistics was run to observe the distribution of the independent variables. The socio-demographic, socio-economic and institutional characteristics of the respondents household heads were analyzed. The sample under consideration consists of 238 smallholder farm households. Of the total sample respondents 89 (37.39%) were participants of irrigation farming and 149 (62.60%) were non-participants. Chi-square ($\chi$ 2) and t – statistics tests were used to identify whether the explanatory variables are statistically significant or not. The t-test is used to test the significance of the mean value of continuous variables of the two groups of users and non-users and chi-square ($\chi$ 2) is used to test the significance of the mean value of the potential discrete (dummy) explanatory variables.



Generally, in this section socio-demographic characteristics of sample households such as age of household heads, sex of household heads, total family size and number of adult labor force of family members; economic characteristics of sample households such as livestock holding, cultivated land size and inputs in production used; farm or plot characteristics like topography of land owned by household head; households characteristics or attributes such as education status of household heads and accessibility to information; institutional characteristics such as availability of extension services and credit services characteristics of sample households; and distance of household residence from nearest water source and nearest market for discrete as well as continuous variables were analyzed. The below table shows the mean value of each groups and mean difference of all covariates with their respective t-values.

**Table 1. Mean, Standard Deviations and mean difference of Continues variables for both irrigation users and nonusers.**

| Variables | Total Sample | Irrigation user | Nonuser | Mean difference | t-value(p>t) |
|---|---|---|---|---|---|
| | Mean(Std.de) | Mean(Std.de) | Mean(Std.de) | | |
| Hhage | 43.88(8.36) | 45.88(7.22) | 42.68(879) | 3.2 | 2.9011(0.0041)** |
| Famexp | 20.92(8.2) | 22.41(6.955) | 20.033(8.76) | 2.38 | 2.18(0.0299)** |
| Totfam | 5.65(1.488) | 6.17(1.49) | 5.348(1.399) | 0.830 | 4.31(0.000)*** |
| Cultland | 10.91(3.0599) | 11.96(3.27) | 10.28(2.74) | 1.68 | 4.25(0.000)*** |
| Livestock | 6.92(1.907) | 7.61(1.866) | 6.51(1.81) | 1.1 | 4.474(0.000)*** |
| Input | 2089(1114.73) | 2639.77(1317.4) | 1761.061(817.22) | 878.7 | 6.35(0.000)*** |
| Famlabor | 2.98(1.04) | 3.49(1.14) | 2.684(0.854) | 0.809 | 6.19(0.000)*** |
| Dishom | 1.37(0.433) | 1.236(0.368) | 1.46(0.448) | 0.223 | 3.96(0.000)*** |
| Dismark | 4.98(1.44) | 4.57(1.28) | 5.22(1.48) | 0.655 | 3.46(0.006)*** |

***and **implies significance level at 1% and 5% probability level respectively

Source: own survey data, 2017

As indicated on the above table among the continuous variables there are significant mean difference between users and non user at one percent level of significance for six variables (totfam, cultland, livestock, inpt, famlabor, and dishom,) and the remaining variables are significant at 5%.

**Table 2: Table showing mean, of discrete variables for both irrigation users and non users**

| Variables | | Irrigation user % | Non use % | Pearson Chi square Value |
|---|---|---|---|---|
| Sexhh | Male | 94.38 | 94.63 | 0.0067(0.930) |
| | Female | 5.62 | 5.37 | |
| Hheduc | Literate | 94.38 | 51.01 | 0.543(0.461) |
| | Illiterate | 5.62 | 48.99 | |
| Access to information | Accessed | 52.81 | 63.09 | 2.4378(0.118) |
| | Not accessed | 47.19 | 36.91 | |
| Access to credit | Accessed | 82.02 | 69.13 | 4.8094(0.028) |
| | Not accessed | 17.98 | 30.87 | |
| Access to extension | Accessed | 87.64 | 64.43 | 15.26(0.006) |
| | Not accessed | 12.36 | 35.57 | |

Source: own survey result of 2017

Among discrete variables only two of them are significant at five percent level (access to credit and access to extension).

## Factors Influencing the Performance of Small Holder Farmers participation decision on small scale irrigation



The Heckman two stage model was used to analyze the issue. In the first stage of the Heckman's two stage model, selection equation is estimated by maximum likelihood as an independent probit model to determine the decision to join irrigation farming using information from the whole sample of members and non-members. A vector of inverse Mills ratios (estimated expected error) can be generated from the parameter estimates (Greene, 1993). The level of contributed income use, *Y*, is observed only when the selection equation equals 1 and is then regressed on the explanatory variables, ***X***, and the vector of inverse Mills ratios from the selection equation by ordinary least squares (OLS). Therefore, the second stage reruns the regression with the estimated expected error included as an extra explanatory variable, removing the part of the error term correlated with the explanatory variable and avoiding the bias. Sample selection bias has been corrected by the selection equation, which determines whether an observation makes it into the nonrandom sample.

Table3. Estimates result of the binary probit model and its marginal effect (participation equation)

| Acirrig | Coefficient | Std. Err | Z | P>\|Z\| | [95percent confidence | interval] | Marg. Co |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| sexhead | -.6829806 | .5248842 | -1.30 | .193 | -1.711735 | .3457735 | -.2475866 |
| Hhage | -.004229 | .020151 | -.21 | .834 | -.0437241 | .0352662 | -.001533 |
| Hheduc | .6809491 | .2562775 | 2.66 | .008 | .1786546 | 1.183244 | .2468502 |
| Totfam | .207392 | .1080831 | 1.92 | .055 | -.0044462 | .4192316 | .0751817 |
| Famlabor | .3826408 | .166661 | 2.17 | .030 | .0363881 | .7289001 | .1387107 |
| Acinfo | -.190249 | .2537016 | -.75 | .453 | -.6874949 | .306997 | -.068967 |
| livestock | .1494119 | .0743957 | 2.01 | .045 | -.0035989 | .2952249 | .0541632 |
| Input | .0005461 | .00011652 | 3.31 | .001 | .0002224 | .0008698 | .000198 |
| Cultland | -.044463 | .0718944 | -.62 | .536 | -.1853733 | .0964474 | -.0161182 |
| Landtopo | .7770408 | . 2122421 | 3.66 | .000 | .3610538 | 1.193028 | .2816842 |
| Dishom | -.946778 | .2970791 | -3.19 | .001 | -1.529042 | -.3645136 | -.3432155 |
| Dismrkt | -.1245983 | .0825692 | -1.51 | .1231 | -.2864309 | .0372344 | -.045161 |
| Accredit | -.3049196 | .2535232 | -1.20 | .229 | -.8018159 | .1919766 | -.1105361 |
| Acexten | .4963147 | .2578573 | 1.92 | .054 | -.0090763 | 1.001706 | .1799185 |
| Farminc | -.0001249 | .0000474 | -2.64 | .008 | -.0002177 | -.000032 | -.0000453 |
| nonoffinc | -.0001445 | .0000589 | -2.45 | .014 | -.0002664 | -.0000291 | -.0000524 |
| Cons | -.5512721 | 1.096793 | -.50 | .615 | -2.700948 | 1.598408 | |
| **Probit regression** | | | | | **Number of observation = 238** | | |
| | | | | | | | **LR chi2 = 118.48** |
| **Prob> chi2 = 0.0000** | | | | | | | |
| **Log likelihood = -98.081583** | | | | | | | **Pseudo R2 = 0.3766** |
| **Source: own survey result of 2017** | | | | | | | |

The likelihood ratio chi-square value, 118.48, was found statistically significant at 1% significance level. This implies that, the model was statistically significant and the regression coefficients give the change in the probit index or z-score for a unit change in the predictors. Moreover; the small value of Pseudo-R (0.3766) for probit model indicates that there was no systematic difference in the distribution of covariates between irrigation scheme users and non-users in the study area. Out of the total sixteen explanatory variables, output for the probit /participation equation shows that ten variables of which seven are continuous and three are dummies, were found to be significantly creating variation on the probability of rural farm households' participation in small-scale irrigation.

Among the factors assumed to affect the household participation decision in the small-scale irrigation scheme in the study area, household head education status, livestock holding, amount of production input used, access to extension services, total family member of household head, availability of labor force and topography of land owned by the household head affect participation decision in the small-scale irrigation scheme positively and significantly. Distance from nearest water source to household home, farm income different from irrigation farm, and nonfarm & off farm income were negatively and significantly affected participation in small scale irrigation scheme.



The impact of each significant quantitative and qualitative explanatory variable on participation decision on SSI was calculated by keeping continuous variables at their mean value and dummy variables at their most frequent value. But, under probit model coefficient of the variable have no direct interpretation; thus, we can use marginal effect. With the above brief background, the effect of the significant explanatory variables on smallholder rural farm households' decision to participate in small-scale irrigation is discussed based on conditional marginal effect estimation result of the binary Probit model as follows.

**Education**: Educational attainment by the household head could lead to awareness of the possible advantages of modernizing agriculture by means of technological inputs; enable them to read instructions on fertilizer packs and helps for better innovation and invention to diversify household incomes. The marginal effect of the variable shows that keeping all other variables constant at their mean value, educated household heads have 24.68 percentage points more chance of participation in small-scale irrigation than those illiterate household heads. This is consistent with Asayehegn et al. (2011) found that education plays a key role for household decision in technology adoption. Similarly, Tesfaye et al. (2008) reported the same result.

**Total family member of household and Availability of family labor force**:

Total family member of household was found to influence households' decision to participate in small-scale irrigation positively and significantly at 10% level of significance. The marginal effect of this variable reveals that as the family member increases from its mean value by one unit, the probability of the households' participation in small-scale irrigation increases by 7.52 percentage points, while keeping all other variables constant at their mean value. The marginal effect of this variable reveals that as the family labor force increases from its mean value by one unit, the probability of the households' participation in small-scale irrigation increases by 13.87 percentage points. Similarly, Shimelis, (2009) reported the same result.

**Livestock**: livestock holding, measured in tropical livestock unit, was found to have positive and significant effect at 5% level of significance on the probability to participate in small-scale irrigation. The positive relationship indicates that households with larger livestock holding may have money to spend on any possible cost to participate in the irrigation activity. In the study area marginal effect of this variable shows that as the number of livestock in tropical livestock unit increases from its mean value by one unit, the chance to participate in small-scale irrigation increase by 5.41 percentage points, while keeping all covariates constant at their mean value.

**Input**: The result of the study shows availability of agricultural input has statistically significant at 1% significance level. This means that, households who have capacity to use various type and large amount of agricultural inputs have more chance to participate on irrigation farming. The marginal effect of this variable reveals that as the inputs of agricultural production increases from its mean value by one unit the probability of the households' participation in small-scale irrigation increases by 0.02 percentage points. Thus, small-scale irrigation promotes the use of improved agricultural technologies. W. Zeweldet, al. (2015) also obtained similar result as this one.

**Household head land topography**: This variable was found to influence households' decision to participate in small-scale irrigation positively and significantly at 1% level of significance. The marginal effect of this variable reveals that as household land topography becomes flat the probability of the households' participation in small-scale irrigation increases by 28.16 percentage points for a unit change while keeping all other variables constant at their mean value. This is consistent with results from (Bacha et al., 2011).

**Distance of nearest water source from household resident**: This variable was found to influence small-scale irrigation participation negatively and significantly at 1% significance level. The implication of this negative relationship was that the farther households' residence from the water source, the lesser would be farmers' initiative to participate in small-scale irrigation. The marginal effect of this variable shows that as the distance from the farmers' residence to the water source increases from mean value by one kilometer, the probability of participation in small-scale irrigation less by 34.32 percentage points. This result is consistent with Abonesh findings (2006).

**Access to extension services: A**ccess to extension service influences the farm households' participation in small-scale irrigation positively. The result of this study also reveals that access to extension services is statistically significant at 10% level of significance. The marginal effect reveals that keeping all other variables constant at their mean value, the discrete effect change from 0 to 1 in access to extension service increases the probability of participation in small-scale irrigation by 17.99 percentage points higher than their counterparts elsewhere. Not clear. Because it is vague. Specify the particular extension services.

**Farm income different from irrigation farming (farming):** This variable influences the farm households' participation in small-scale irrigation negatively at 1% level of significance. The marginal effect of this variable shows that as farm income different from irrigation farming source increases from mean value by one Birr, the probability of participation in small-scale irrigation less by 0.005 percentage points than their counter parts elsewhere. The result of this finding is in line with the findings of Jamal Haji & Mohammed Aman (2013).

### Outcome Estimation of Heckman Second Stage

To estimate the effect of parameters on farm households' income from small scale irrigation Heckman second stage use OLS. For the second stage of the model i.e., outcome equation, again the above sixteen demographic, institutional and socio economic variables and inverse mills ratio (lambda) were used. With this brief background, the effect of the significant explanatory variables on smallholder households' income level was discussed below.

Table .4 Heckman second stage (OLS) estimates for income equation.

| | Coefficient | P > \|Z\| |
|---|---|---|
| **Irriginc** | | |
| **Sexhead** | **-714.2019** | **0.299** |
| **Hhage** | **-17.65507** | **0.589** |
| **hheduc** | **703.3028** | **0.098*** |
| **totfam** | **301.9616** | **0.056*** |
| **famlabor** | **487.3277** | **0.094*** |
| **acinfo** | **-307.7757** | **0.363** |
| **livestock** | **187.8674** | **0.125** |
| **input** | **.1719957** | **0.500** |
| **cultland** | **-79.5287** | **0.329** |
| **landtopo** | **705.2958** | **0.137** |
| **dishom** | **-1284.743** | **0.030**** |
| **dismrkt** | **-10.03784** | **0.942** |
| **accredit** | **130.972** | **0.739** |
| **acexten** | **902.9928** | **0.087*** |
| **nonoffinc** | **-.0986674** | **0. 362** |
| **farminc** | **-.1255225** | **0.158** |
| **const** | **-853.98** | **0.683** |
| **Mills lambda** | **1226.389** | **0.149** |
| **No. of observation** | **238** | |
| **Censored observation** | **149** | |
| **uncensored observation** | **89** | |
| **Wald chi2** | **53.70** | |
| **prob> chi2** | **0.000** | |

** Significant at 5%, * Significant at 10%

Source: own survey result of 2017

**Inverse Mills ratio (lambda):** According to the model output, the estimates of mills lambda (inverse Mills ratio), is statistically not significant providing evidence for the absence of selectivity bias.

**Household head education status:** This variable is significant at 10 percent probability level. The regression analysis shows that being literate household head has an influence on the increment of small-scale irrigation farm income. The coefficient of the variable shows that as the household gets education small scale irrigation farm income of the household increases by Birr 703.30. This is in line with the result of Vandewalle (2000).

**Family size of the household**: Total family member in number is positive and significantly at 10% significance level affects the income of rural farm household. If household head family size increases by one income of rural farm household head increases by 301.96 birr. This is due to the fact that large family size is an alternative means of obtaining labor force. This result is in line with FAO (2000), that suggested irrigation, especially surface irrigation system is labor intensive than rain-fed agriculture keeping other things unchanged

**Distance of nearest water source from household resident:** This variable also found to be statistically significant at 5% significance level and negatively influence households' income from small scale irrigation.

**Access to extension service (acexten):** This variable is statistically significant at 10% level of significance and has the expected positive sign. The coefficient of the variable indicates keeping all other variables constant, on average the income of households who have access to extension service would be higher by Birr 902.99 compared to households who do not have access to extension service. Other similar studies also came up with positive and significant relationship (Abonesh et al., 2006).

**Conclusion:** In this paper, we analyzed participation decision of rural farm households on irrigation schemes and its impact on their incomes in Mettu woreda by using descriptive and inferential statistical methods. Heckman's two-step estimation (Heckit) procedure developed by Heckman (1978) depends on the assumption that specific distributions of the unobservable characteristics jointly influence participation and outcome was applied to identify factors influencing rural farm households' participation decision in small scale irrigation and to determine effect of factors on households' income. To analyze the impact of significant quantitative and qualitative explanatory variables probit model was used to find the marginal effect of the variables.

Among the factors, household head education status, livestock holding, amount of production input used, access to extension services, total family member of household head, availability of labor force and topography of land owned by the household head had positive and significant impact on the participation decision in the small-scale irrigation schemes. However, distance from nearest water source to household home, farm income different from irrigation farm, and nonfarm & off farm income had negative and significant impact on participation in small scale irrigation scheme.

Among the significant explanatory variables on smallholder rural farm households' decision to participate in small-scale irrigation educated household heads, have more chance of participation compare to illiterate household heads. Number of livestock, inputs of agricultural production, distance of water source, family size of the household and access to extension services have positive and increasing impact on the irrigation activity.

General Recommendations:

1. The government must implement a specific irrigation policy framework to cater the needs of the utilization of available water sources.
2. Financial institutions including microfinance institutions should be more in the rural areas and must provide timely credit for the irrigation purposes.
3. Expansion of new irrigation technology adoption and creating additional access through integrated water investment would consequently result in substantial agricultural productivity on a sustainable basis and thereby increase small holder farmers‟ income from irrigation.
4. Lack of education affect participation decision in small scale irrigation and thereby affect households‟ income from irrigation. Thus government and other concerning bodies have to work seriously on adult education for farmers.

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