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# Determinants of Small-Scale Irrigation Utilization by Smallholder Farmers' in Rift Valley Basin, Wolaita Zone, Ethiopia

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**Abstract**
The objectives of the study were to identify factors that determine household's participation decision on small-scale irrigation and to assess the constraints for the development and management of irrigation schemes in the study area. In this study multi-stage sampling techniques were used to select 150 target respondents in which 90 irrigation users and 60 non-irrigation user. To collect the required data several methods like interview schedule, focus group discussions and key informant interview were used. Various documents were reviewed to collect the secondary data. To analyze the data, binary logit model was used to identify the determinants of small-scale irrigation utilization. The findings of the study revealed that among the sixteen explanatory variables entered into the model, eight of them were found to be statistically significant. These variables include total income of the household, conflict over irrigation water utilization, training and technical advice, education status of household head, farm size, financial constraint, proportion of irrigated land size, and access to market information. Most of the coefficients of these variables exhibited the expected signs with the hypothesis. Besides, different constraints related with poor technology choice, conflicts in water use and use rights, lack of market access, lack of training on irrigation technologies, lack of irrigation structure maintenance, absence of government support, and poor linkage between research and extension services in the area of irrigation water management and development were forwarded by the participants. Therefore, to alleviate these problems and improve small-scale irrigation utilization, woreda agricultural and rural development office and other concerned bodies should attempt to address those factors that hinder small-scale irrigation utilization in the study area.
**Keywords**: Binary logit model, Determinants, Small-scale irrigation, Smallholder farmer

## INTRODUCTION

Ethiopia is mostly dominant with agricultural activities where around 95% of the country's agricultural output is produced by smallholder farmers (MoARD, 2010). Over the years, Ethiopia has been investing millions of dollars in regional projects aimed at improving the country irrigation water problems. But the approach has been myopic. As such, many costly and well meaning efforts have failed to provide the requirements to manage the water resources for sustainable development, and to support socio-economic development. It has become abundantly clear; therefore, that water development and management can no longer be treated as a sectoral issue for it cuts across a vast number of uses. Nowadays, in Ethiopia, irrigation plays the key role in the performance of agriculture, which increases income growth that is essential for national economic growth (Hussain and Biltonen, 2001).

According to the Ethiopian Growth and Transformation Plan (GTP 2010/11-2014/15), the main objectives of the water sector development plan are to develop and utilize water for different social and economic priorities in a sustainable and equitable way to develop irrigation schemes so as to ensure food security, to supply raw materials for agro-industries and to increase foreign currency earnings. In irrigation sub sector, the country is believed to have the potential of 5.1 million hectares of land that can be developed for irrigation through pump, gravity, pressure, underground water, water harvesting and other mechanisms. Thus, irrigation development, particularly small scale irrigation will be accelerated (MoFED, 2010).

Agricultural production in Ethiopia is primarily rain-fed; so, it depends on erratic and often insufficient rainfall. As a result, there are frequent failures of agricultural production. Irrigation has the potential to stabilize agricultural production and mitigate the negative impacts of variable or insufficient rainfall. In some areas of the country, delayed entrance of rainy seasons, early withdrawal and mal-distribution of rain were challenges from which great lessons have been drawn to seriously look into expansion of small, medium and large scale irrigation in perspective. Especially, in the study area there are many problems such as lack of effective and efficient manpower utilization, the community is mostly dependent on rain fed agricultural production system (i.e. focus on subsistence farming rather than commercial production/cash crop production), poor time and resource management system, etc. at the irrigation scheme (WBoARD, 2014).

All these factors may face as problems in order to achieve the development objectives of the country. Moreover, Agricultural Development–led Industrialization Strategy focuses that smallholder farmers need to efficiently use modern agricultural technologies and increase production and productivity. Therefore, the purposes of this study were to identify factors that determine household's participation decision on small-scale irrigation and to assess the constraints for the development and management of irrigation schemes in the study area.

## RESEARCH METHODOLOGY

### Description of the Study Area

The study was conducted in Humbo Woreda which is geographically located from $6^0$42'26'' to $6^0$45'36''N of latitudes and $37^0$46'09'' to $37^0$48'48'' E of longitudes in the Rift Valley Basin. The sources of water for the schemes are from different Rivers and Lake Abaya. The mean annual rainfall in the study area is between 841.3 to 1134.1 mm with a mean value of about 987.6 mm. The mean annual minimum and maximum temperatures are 13 $^0$C and 31$^0$C, respectively. The dominant soil type of the area is mainly clay loamy with clay texture. The total mean annual flow from the Rift Valley River Basins is estimated at about 5.6 billion meter cube (Awulachew *et al*. 2007).

Humbo woreda is the largest woreda among the 12 Woredas in Wolaita Zone and it has a total population of 155,495 from which 77,481 are males and 78,008 are females. The total number of household is 31,519. Out of which 25,558 are male headed and 5,961 are female headed households. 96.5 percent of the population lives in rural areas. Mixed agriculture is the main economic activities and population density is estimated at 283 person/ km$^2$ and it is one of the highest population density areas in Ethiopia (CSA, 2002). The major crops grown in the study area are cereals such as teff, maize, sorghum, cotton and root crops like sweet potatoes, ensete, carrot and fruits like mango, avocado and banana (WBoARD, 2014).

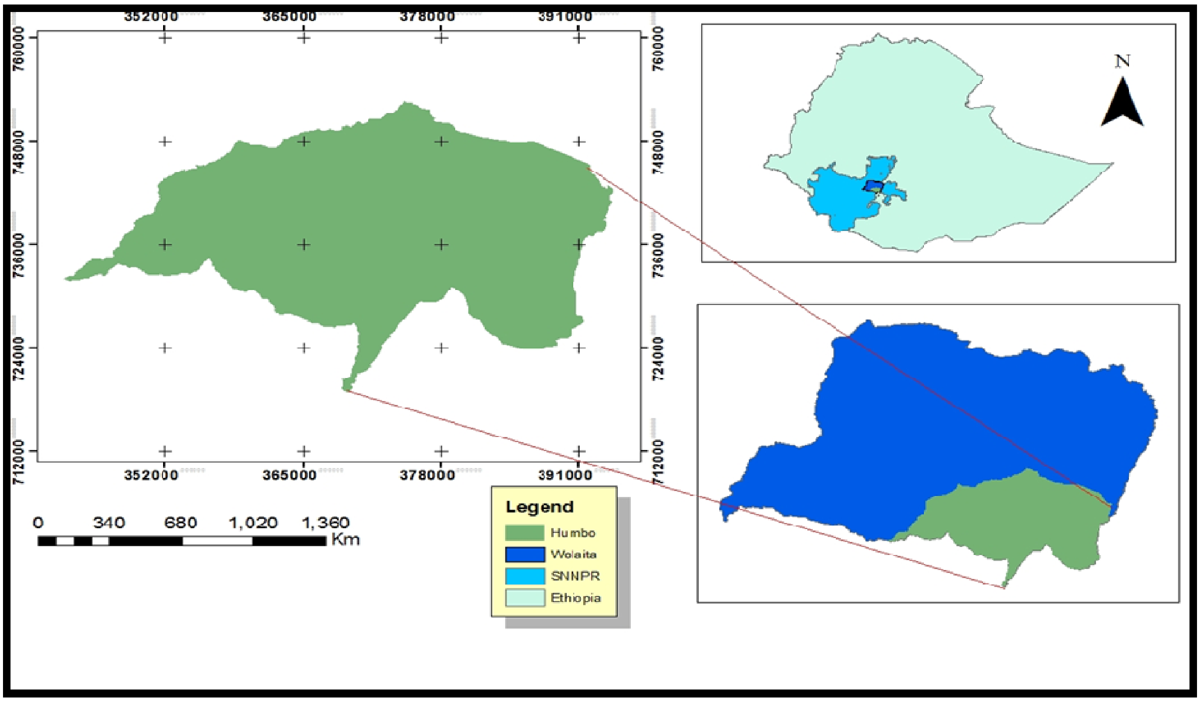


Figure 1: Location of the study area

### Sample Size and Sampling Techniques

The research design of the study was cross-sectional survey. In this study, multistage sampling techniques were used to select the sample respondents. First, out of the potential Woredas in Wolaita Zone that has small-scale irrigation schemes, Humbo Woreda was purposively selected because the woreda has large number of small-scale irrigation schemes and the potential of the Woreda for irrigation activities. In the second stage, modern small-scale irrigation schemes in the Woreda were listed and one irrigation scheme was selected using simple random sampling technique. In the third stage, the total number of households in the irrigation scheme were listed and stratified into two: Irrigation users and non-irrigation users within the study area based on the household list which was obtained from water users committee of the kebeles. Irrigation users were again stratified in to upstream, middle and downstream beneficiaries based on their location with the basic assumption that there would be inequality in water distribution. This will make the sample more representative rather than comparison purpose. Finally, 90 users and 60 non-irrigation user respondents were selected using probability proportional to size. Therefore, a total of 150 respondents were interviewed.

### Data and Methods of Data Collection

For this study both qualitative and quantitative data were collected from primary and secondary sources. To collect the required data several methods like interview schedule, focus group discussions and key informant interview were used. The secondary data were collected from different sources such as relevant books, woreda agriculture and rural development report, internet and journal articles through reviewing the secondary sources.

**Methods of Data Analysis**

The collected data were compiled by using SPSS Version 20. Since the dependent variable of this study is household's participation decision in small-scale irrigation utilization, which is dichotomous that takes a value of one if the households decided to use small-scale irrigation and zero otherwise, binary logistic regression model was used to determine the factors influencing household's participation decision in small-scale irrigation utilization, and the data were analyzed by using this model.

**Model specification**

Following Gujarati (2003), the functional form of logit model can be specified as follows:

$$P_i = E(Y=\frac{1}{x_i}) = \frac{1}{1+e^{-(\beta_0+\beta_1 x_1)}} \text{ ------------------------ (1)}$$

For the case of exposition, we write (1) as;

$$P_i = \frac{1}{1+e^{-z_i}} \text{ ------------------------ (2)}$$

The probability of the given household is not participating on small scale irrigation is expressed as by (2) while, the probability of participating on small scale irrigation is;

$$1-P_i = \frac{1}{1+e^{z_i}} \text{ ------------------------ (3)}$$

Therefore, we can write;

$$\frac{P_i}{1-P_i} = \frac{1+e^{z_i}}{1+e^{-z_i}} \text{ ------------------------ (4)}$$

Now, (Pi/1-Pi) is simply the odds ratio in favor of participating on small scale irrigation. The ratio of the probability that a household will not participate on small scale irrigation to the probability of that it will participate on small scale irrigation.

Finally, taking the natural log of equation (4) we obtain:-

$$L_i = \ln(\frac{P_i}{1-P_i}) = Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \text{ ------------ } + \beta_n X_n \text{ ----------- (5)}$$

Where $P_i$ = is a probability of being participate on small scale irrigation, ranges from 0 to 1

Zi = is a function of n explanatory variables (x) which is also expressed as:-

$$Z_i = \beta o + \beta 1X1 + \beta 2X2 + - - - - - - - - + \beta nXn \text{ ------------ (6)}$$

$\beta o$, is an intercept, $\beta_1, \beta_2$, ---------$\beta_n$ are slopes of the equation in the model

Li = is log of the odds ratio, which is not only linear in Xi but also linear in the parameters.

Xi = is vector of relevant household characteristics

If the disturbance term (Ui) is introduced, the logit model becomes

$$Z_i = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \text{ ------------ } + \beta_n X_n + U_i \text{.................. (7)}$$

## RESULTS AND DISCUSSION

**Major Constraints for the Development and Management of Irrigation Scheme**

Different constraints were forwarded and underlined by the participants of the focus group discussions and key informant interviews as the major challenges hindering the development and management of irrigation system in the study area. Some of the factors are problems related with poor technology choice (i.e. irrigators are highly dependent on traditional irrigation systems such as furrow, basin and boarder irrigation systems rather than modern irrigation systems), too small landholdings, conflicts in water use and use rights, lack of market access, lack of training on irrigation technologies, lack of irrigation structure maintenance, lack of inputs (i.e. improved seeds, fertilizers and agro-chemicals), water scarcity, absence of government support, and poor linkage between research and extension services in the area of irrigation water management.

Binary logistic regression model was used to identify factors influencing household participation decision on small-scale irrigation. Variables included in the model were tested to check the existence of multi co-linearity effect. The dummy and categorical variables were tested using contingency coefficient, and continuous variables were tested using variable inflation factor. Contingency coefficient value ranges between 0 and 1, and as a rule of thumb variable with contingency coefficient below 0.75 shows weak association and value above it indicates strong association of variables. The contingency coefficient for the dummy and categorical variables included in the model was less than 0.75 that didn't show multi co-linearity to be a serious concern. As a rule of thumb continuous variable having variance inflation factor of less than 10 are believed to have no multi co-linearity and those with variance inflation factor of above 10 are subjected to the problem and should be excluded from the model. The computational results of the variance inflation factor confirmed the non-existence of association between the variables and were included in the model.

The model was assessed for its goodness of fit by examining how well the model classifies the observed data (in the classification table) or by examination of how likely the sample results actually are, given the estimates of model parameters (Hosmer and Lemeshow, 1989). The result indicates that (the model chi-square value) the parameters included in the model taken together were significantly different from zero at less than 1% level of significance. Thus, the hypothesis set that the entire coefficient except the intercept was rejected. The value of chi-square (155.467) indicates also the goodness of fitted model (Table 1). Another measure of goodness of fit in the logistic regression model is seeing how much the observed value is correctly predicted. In other words, the observation is grouped as users if the computed probability of adoption is greater than or equal to 0.5 (50%), and as non-users, otherwise. Based on this, the result showed that about 93.3% of the non-users, and 94.4% of the users were correctly predicted using the cut off value of 0.5. Overall, the model correctly predicted 94% of the sample cases (Table 1). Thus, the model predicted both user and non-user groups of small-scale irrigation accurately.

Table 1: Parameter Estimate of the Logistic Regression Model

| Explanatory variables | Estimated Coefficient (B) | S.E. | Wald statistics | Sig. level (P) | Odds ratio Exp(B) |
|---|---|---|---|---|---|
| SEX | 0.469 | 0.997 | 0.221 | 0.639 | 1.598 |
| AGE | -0.067 | 0.070 | 0.924 | 0.337 | 0.935 |
| EDU | 0.360 | 0.181 | 3.981 | 0.046** | 1.434 |
| ACTFOR | 0.502 | 0.387 | 1.681 | 0.195 | 1.652 |
| FARMSIZE | 6.584 | 2.667 | 6.096 | 0.014** | 8.476 |
| IRRLANDSZ | 8.004 | 3.145 | 6.478 | 0.011** | 0.001 |
| SOILFERT | 0.081 | 1.122 | 0.005 | 0.942 | 1.085 |
| TOTINC | 0.000 | 0.000 | 7.500 | 0.006*** | 1.003 |
| TLU | -0.126 | 0.342 | 0.136 | 0.712 | 0.882 |
| FINANCONST | -4.210 | 2.131 | 3.903 | 0.048** | 7.387 |
| FARMDIST | -2.025 | 1.268 | 2.548 | 0.110 | 0.132 |
| EXTVISIT | 1.615 | 1.175 | 1.889 | 0.169 | 0.199 |
| TRAINING | 4.073 | 1.562 | 6.796 | 0.009*** | 18.706 |
| RECVCREDIT | 0.135 | 1.204 | 0.013 | 0.911 | 1.144 |
| MKTINFO | 2.997 | 1.633 | 3.368 | 0.066* | 0.050 |
| IRRCONFLICT | -5.751 | 1.598 | 12.953 | 0.000*** | 24.521 |
| Constant | -7.715 | 4.188 | 3.394 | 0.065 | 4.322 |
| Pearson- $\chi^2$ value = 155.467*** | | df = 16 | | P = 0 .000 | |
| -2log Likelihood = 46.437 | | | | | |
| Prediction success(overall) = 94.0 | | | | | |
| Correctly predicted non-user = 93.3 | | | | | |
| Correctly predicted user = 94.4 | | | | | |

Source: Model output; *, **, *** significant at 10%, 5% and 1% probability level, respectively

**Significant Explanatory Variables in Logit Model**

The result of the logistic regression model is presented in Table 1. Out of the hypothesized sixteen independent variables eight were found to influence household participation decision on small-scale irrigation in the study area. These are total income (TOTINC), education status (EDU), farm size (FARMSIZE), training and technical advice (TRAINING), access to market information (MKTINFO), financial constraint (FINANCONST), proportion of irrigated land size (IRRLANDSZ) and conflict over irrigation water utilization (IRRCONFLICT). These significant variables are discussed in detail in the following section.

**Total income of the household:** The variable was significant at 1% significance level and positively related to household participation decision on small-scale irrigation. This implies that all other things being kept constant, the odds ratio in favor of small-scale irrigation utilization decision increases by a factor of 1.003 as the total income of the household increases by one birr. The possible reason for this is that having more diversified sources of income would encourage households to participate in irrigation activities by providing a start-up capital.

**Education status of household head:** This variable was hypothesized to increase the probability of household's participation decision on small-scale irrigation. As a prior hypothesis, this variable has a positive relationship to household's participation decision on small-scale irrigation and affect significantly at 5% probability level. Other factors hold constant, the odds ratio in favour of increasing household's participation decision on small-scale irrigation by a factor of 1.434 as the household head education level increases by one year of schooling.

**Farm size:** Availability of appropriate farm size is highly important when farmers are ready to adopt new technology. Farm size was positively related to the use of small-scale irrigation and significant at less than 5%. This implies that all other things being kept constant, the odds ratio in favor of small-scale irrigation utilization increases by a factor of 8.476 as the farm size of the household increases by one unit. The possible reason for this is that farmers who have large farm size could more likely involve in irrigation water use. The study result is in agreement with the work of Haile *et al*. (2001) stated that farm size determines the type and amount of production in the context of smallholders.

**Training and technical advice:** the variable was significant at 1% significance level and positively related to household participation decision on small-scale irrigation. This implies that all other things being kept constant, the odds ratio in favor of small-scale irrigation utilization increases by a factor of 18.706 for those respondents who have got training and technical advice regarding irrigation activities. The basic assumption is that the more training and technical advice is provided by the extension agent to the farmers, the higher is the probability of the farmers to utilize small scale irrigation.

**Access to market information:** this variable was positively and significantly affects the probability of participation decision on small-scale irrigation utilization at less than 10% significance level. This implies that all other things being kept constant, the odds ratio in favor of small-scale irrigation utilization increases by a factor of 0.050 for those respondents who have access to market information. The possible reason for this is that having more access to up-to-date market information on prices of inputs and outputs would encourage households to participate in irrigation activities and widened their knowledge on new market-oriented production system. The result is in line with the work of Abonesh *et al.* (2006) stated that farmers' irrigation use decisions are mostly based on market price information.

**Financial constraint:** this variable was negatively and significantly affects the probability of participation decision on small-scale irrigation at less than 5% significance level. This could be due to the fact that availability of cash at hand is pre-requisite to purchase or rent irrigation pumps and its related expenses like fuel and repairing. Moreover, irrigation activities are much expensive as compared to rain-fed in terms of use of external inputs like fertilizers and physical labor. Therefore, irrigation activities are more capital and labor intensive as compared to rain-fed and needs sufficient cash at hand for efficient production and productivity. All other things being kept constant, the odds ratio in favor of small-scale irrigation utilization decreases by a factor of 7.387 for those households who constrained financially.

**Proportion of irrigated land size:** this variable was significantly and positively affects household's participation decision on small-scale irrigation at less than 5% as a prior expectation.

This implies that all other things being kept constant, the odds ratio in favor of small-scale irrigation utilization increases by a factor of 0.001 as the proportion of irrigated land size of the household increases by one unit. This can be justified by the fact that large irrigated land helps to boost agricultural output through intensive production and minimizes the risks through growing two or more crops within a year.

**Conflict over irrigation water utilization:** this variable was negatively and significantly affects the probability of participation decision on small-scale irrigation at less than 1% significance level. This implies that all other things being kept constant, the odds ratio in favor of small-scale irrigation utilization increases by a factor of 24.521 for those households who face conflict over irrigation water utilization.

## CONCLUSION

Ethiopia is mostly dominant with agricultural activities where around 95% of the country's agricultural output is produced by smallholder farmers. Nowadays, in Ethiopia, irrigation plays the key role in the performance of agriculture, which increases income growth that is essential for national economic growth. The objectives of the study were to identify factors that determine household's participation decision on small-scale irrigation and to assess the constraints for the development and management of irrigation schemes in the study area. In the study multi-stage sampling techniques were used. Primary data were collected through interview schedule. Various documents were reviewed to collect the secondary data. To analyze the data, binary logit model was used to identify the determinants of small-scale irrigation utilization. The findings of the study revealed that among the sixteen explanatory variables entered into the model, eight of them were found to be statistically significant namely: total income of the household, conflict over irrigation water utilization, and training and technical advice were significant at 1% ($P<0.01$) probability level; education status of household head, farm size, financial constraint, and proportion of irrigated land size were significant at 5% ($P<0.05$) probability level, and access to market information was significant at 10% ($P<0.10$) probability level. Most of the coefficients of these variables exhibited the expected signs with the hypothesis. Moreover, different constraints related with poor technology choice, too small landholdings, conflicts in water use and use rights, lack of market access, lack of training on irrigation technologies, lack of irrigation structure maintenance, absence of government support, and poor linkage between research and extension services in the area of irrigation water management and development were forwarded by the participants. Therefore, to alleviate these problems and improve small-scale irrigation utilization, woreda agricultural and rural development office and other concerned bodies should attempt to address those factors that hinder small-scale irrigation utilization in the study area.

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