Determinants of Small-Scale Irrigation Use: The Case of Jeldu District, West Shewa Zone, Oromia National Regional State, Ethiopia

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The study was conducted in Jeldu district on two peasant associations namely Metekoma and Laku. The objective of this study was to identify determinants of Small-scale irrigation use. A total of 118 farmers were randomly selected and interviewed by using semi structured questionnaire. A three-stage sampling technique was used to obtain a sample size of 118 rural farm households. Cross sectional data were collected through structured questionnaire, focus group discussion, key informants and observation. Household caloric acquisition was employed to measure household food security in the study area. The collected data were analyzed by SPSS version 20.0. Binary logistic regression model reveals that, out of eleven explanatory variables, age of household, educational level of household, Adult equivalent, cultivated land size, Oxen ownership of household, livestock ownership in TLU, and total farm income were found to be significant. Governmental and non-governmental should give attention on intensifying agricultural production in order to encourage the productivity of limited land. The study concluded that small scale irrigation is one of the viable solutions to secure household food needs in the study area. The study also suggested the proper management system of the irrigation schemes in order to sustainably use them.

**Keywords:** Use of Irrigation, Jeldu district, west shewa

**INTRODUCTION**

The Ethiopian economy is dominated by the agricultural sector. The agriculture sector has promising opportunities to transform itself from subsistence to a level of modern and commercial sector. Although the transformation towards a more manufacturing and industrially oriented economy is well underway, the agriculture sector continues to be the most dominant aspect of the Ethiopian economy, accounting for 46% of GDP, 73% of employment, and 80% of export earnings. Nevertheless, the low and declining performance of agriculture can be attributed to many interrelated factors. These include, among others, unreliable rainfall, soil and water erosion and degradation, crop pests and diseases, livestock pests and diseases, shortage of farm land, scarcity of animal feed, lack of improved and suitable technologies, poor marketing and service infrastructure, and low terms of trade. To address subsistence farming problem, the current Ethiopian government has undertaken verities of activities to enlarge irrigation in the country (Ministry of Finance and Economic Development, 2010).

Irrigation and water management practices are taken to greatly reduce the problem caused by rainfall variability, enhance productivity per unit of land, and increase the volume of annual production significantly. As a consequence, the irrigated farmland, irrigation production and the number of farmers who use irrigation in the country have notably increased, up to 80%, between 1990 and 2010 (MOFED, 2010). Estimates showed that there is sufficient water in the country to develop about 4.5 million hectares of which only about 0.16 million ha (5% of the potential) is actually irrigated land under full irrigation in Ethiopia (Ministry of Agriculture, 2011). However, irrigated agriculture has realized only 5% of its estimated potential and in terms of output it accounts for approximately 3% of the total food crop production (Eshetu et al., 2014).

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The development of small-scale irrigation is also one of the major interventions to increase agricultural production in the rural parts of a country. This helps farmers to overcome rainfall constraint by providing a sustainable supply of water for cultivation and livestock production (Asayehnegn, 2012). Irrigation development is being suggested as a key strategy to improve the agricultural productivity and to encourage the economic development (Ministry of Finance and Economic Development, 2007).

Irrigation in Ethiopia contributes to increase the farmers “income, household resilience and buffering livelihoods against shocks and stresses by producing higher value crops for sale at market and to harvest more than once per year. In turn, this provided them to build up their assets, buy more food and non-food household items, educate their children, and reinvest in further increasing their production by buying farm inputs or livestock. However, the benefits are very unevenly distributed among households (Eshetu et al., 2010). Irrigation contributes to livelihood improvement through increased income, food security, employment opportunity, social needs fulfillment and poverty reduction. Increase in agricultural production through diversification and intensification of crops grown, increased household income because of on/off/non-farm employment, source of animal feed, improving human health due to balanced diet and easy access and utilization for medication, soil and ecology degradation prevention and asset ownership are contributions of irrigation (Asayehnegn, 2012).

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. Irrigation contributes to agricultural production through increasing crop yields, and enabling farmers to increase cropping intensity and switch to high-value crops (Birhanu Ayana, 2011).

Even if Ethiopia has an enormous potential in terms of surface and ground water accessibility and land which are in most cases suitable for irrigation the adoption of small-scale irrigation is in its infant stage. The major constraint that slow down the implementation of the sub-sector among others are mainly primitive nature of the overall existing production system, shortage of agricultural inputs and low level of user participation in the development and management of irrigated agriculture, limited trained manpower and inadequate extension services (Ministry of Agriculture, 2011).

The country's strategy Agricultural Development Led Industrialization (ADLI) considers irrigation development as a key input for sustainable development. Thus, irrigation development, particularly small-scale irrigation is planned to be accelerated Ethiopia 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 (Ministry of Finance and Economic Development, 2010). In line with the development policy of the country, the Zonal Government of Jeldu, it is not well known to what amount the households using irrigation are better off than those who depend on rainfall and whether there exists unpredictability in technical efficiency among the farmers in the study area.

In study area there are ten major rives and several spring to be found that can be used for irrigation purpose. With this point of fact farmers have been practicing traditional irrigation system such as traditional river diversion and now a days, farmers are being practicing some of the modern irrigation mechanisms especially using water pumps (Woreda Bureau of Agriculture and Rural Development, 2016). However, it is not well known to what coverage the households that are using irrigation are better off than those who depend on rainfall in the study area. Therefore, this study was tried to fill these gaps by analyzing the determinant of rural households “participation in small-scale irrigation and its involvement on rural household income.

MATERIALS AND METHODS

Description of the Study Area

West Showa is one of the 18 Zones of Oromia Regional State. It has a total of 18 woreda, one city administration, 532 Kebele Administrations and 39 towns (West Showa Zone Office of Agriculture & Rural Development Work Plan, 2009, Unpublished). Jeldu is one of those 18 woredas of the zone where the study was conducted. It is located at a road distance of about 114 km, 72 km and 36 km from Addis Ababa, Ambo and Ginchin towns, respectively along the main road to Kachisi (Gindeberet District’s Administrative town). Geographically, it is situated between 9° 02' 47” to 9° 15' 00” N latitude and 38° 05’ 00” to 38° 12’ 16” E longitude (Birhanu Ayana, 2011). The woreda shares boundary with Illeta in the South, Gindeberet in the North, Ejere and Meta Robi in the East and Abuna Gindeberetweredas in the West (Birhanu, 2011). The study watershed, which stretches from South to North direction to the left side of the main road to Gindeberet, is also located in Jeludo wereda. It is part of21 the upper Blue Nile Basin and estimated to have an area of 92.6 Km². Its altitude ranges from 2,440 - 3,200 m a.s.l (Zemadim et al., 2010).

The woreda has a total area of 139,389 ha with variable agro ecology. It is characterized by having undulating topographic feature. The altitude of the woreda ranges from 1800m to 3200m a.s.l which is predominantly highland. The area receives bimodal rainfall pattern with short rainy season from March to April and main rainy season from June to September. The mean annual rainfall
Mixed crop-livestock farming system is the most common livelihood strategy in the study area. Barley is the dominant crop cultivated followed by wheat, potato and enset (false banana). Farmers used UREA, DAP, compost, farmyard manure, improved seeds, pesticide and herbicides to threat soil fertility problem and enhance crop yield. Cattle, sheep and equines were the dominant livestock species reared by farmers (Birhanu, 2011). Small scale irrigation through traditional diversion of the major river is also common along the dawn stream regions.

**Sampling methods and procedures**

In this study a multi-stage sampling procedure was employed. First, out of the potential Woredas in west shewa Zone that has small-scale irrigation schemes, Jeldu 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 out of the kebeles exist in the district two kebeles are purposively selected due to availability of irrigation. In the third stage, sampling frame was obtained from each Kebeles administrative office. In the fourth stage, the total households in the two sample Kebeles was stratified into the two strata (irrigation water user and non-user households). In the fifth stage, simple random sampling techniques were applied to select the sample unit from each strata at each kebele via probability proportionate to size procedure. From the total 2630 household found in two samples Kebeles, 118 sample households were selected. Hence, sample size of irrigation user and non-user respondent households was 70 and 48 respectively. The following formulas of sample size determination adopted from (Yamane, 1967).

\[ n = \frac{N}{1 + N(e)^2} \]

Where: \( n = \) Sample size; \( N = \) Total number of households in the selected Kebeles; \( e = \) precision level or sampling of error 9% (0.09)

\[ n = \frac{2630}{1 + 2630(0.09)^2} = 118 \]

**Data Source and Methods of Collection**

The data required for this study were collected from sample respondents using a semi structured questionnaire, focus group discussions, key informant interviews and field observation. The enumerators for the data collection were selected on the basis of their educational back ground and their ability of the local language. Two-day training was given to the enumerators about method of data collection and the contents of the questionnaire. After pretest was conducted and modification was made based on the feedback from the pretest, data collection proper was started in mid-February for two weeks with the day to day supervision of the researcher.

**Methods of Data Analysis**

Depending on the objectives of a given study and nature of data available, analysis to be made requires different approaches. The statistical significance of the variables in the descriptive part was tested for both dummy and continuous variables using chi-square and t-test, respectively.

**Econometrics model**

To identify the determinants that influence the use of irrigation water, the binary logistic regression analysis was employed. It is selected because of the model relevance to deal with dependent variables that are dichotomous in nature. The model assists in estimating the probability of irrigation water use status of a household that can take one of the two values, use of irrigation and nonuse.

The following Gujarati (1995), the functional form of logistic model is specified as follows:

\[ P(x) = \frac{1}{1 + e^{-z_i}} \]

For ease of exposition, we write (1) as:

\[ P(x) = \frac{1}{1 + e^{-z_i}} \]

Where \( P(x) = \) is a probability of give house hold is not participating small scale irrigation

\[ z_i = \text{is a function of n-explanatory variables (x) which is also expressed as:} \]

\[ z_i = \text{Bo} + \text{B}_{1}{\text{X}_1} + \text{B}_{2}{\text{X}_2} + \ldots \ldots \ldots + \text{B}_{n}{\text{X}_n} \]

\( \text{Bo} = \) is intercept

\( \text{B}_1, \text{B}_2 \ldots \ldots \text{B}_n = \) are slopes of the equation in the model

The probability that a given household is not participating small scale irrigation to the probability of that will participating small scale irrigation:

\[ 1 - P(x) = \frac{1}{1 + e^{-z_i}} \]

Therefore we can write:

\[ \frac{P(x)}{1 - P(x)} = \frac{1 + e^{z_i}}{1 + e^{-z_i}} = e^{z_i} \]

Now \( P(x) / (1 - P(x)) \) is simply the odds ratio in favor of participate small scale irrigation. The ratio of the probability that a household will not participate small scale irrigation to the probability of that it will participate small scale irrigation. Finally, taking the natural log of equation (4) we obtain:
### RESULTS AND DISCUSSION

**Descriptive Statistical Result of Factors Affecting Irrigation Use**

#### Demographic Factors Characteristics of Respondents

- **Age of the household head**
  
The mean age of household both for irrigation user respondents and none irrigation user respondents is 47.29 years with standard deviation of 13.07 years. As it can be seen in Table 2, the mean age of household head for irrigation user respondents and none irrigation user respondents was found to be 45.19 and 48.85, respectively. The statistical analysis revealed that, there is no significant difference in the mean age of sample household heads between irrigation user and none user respondents groups.

- **Household Labor**
  
The results in Table 2 show that the mean of user respondents’ household labor was equal to 4.84 adults’ equivalent and that of non-user respondents’ household was equal to 3.72 adults’ equivalent. The t-value shows that there was significant difference in labor between user and non-user respondents’ household. This significance mean variation shows that the variation in household labor between two groups has its own implications on the utilization of irrigation water. Therefore, farmers who have larger agricultural labor size have better chance to use irrigation.

- **Sex of the household heads**
  
The results presented in Table 3 show that among the 118 sample households, the number of female headed households and male headed households are found to be 20 and 98 in numbers and covers 18.2% and 82.8% respectively. Out of 20 female headed households, 12 which account 10 % is user respondents whereas 9 accounting 8% are non-user respondents. On the contrary,
among the 98 male headed households, only 37 (31%) and 60 (51%) found non-user respondents and user respondents respectively. The Chi-square value below shows that, there is significance relationship shows that when the variation in sex between two groups has its own implications on the use of irrigation.

**Educational Status of the Household Head**

Education is a very important determining factor in use of small-scale irrigation. A literate household is able to use modern agricultural technologies, perform farming activities based on cropping calendar, and manage resources properly. The educational level of the sampled household heads was categorized under literate and illiterate. The data obtained from the sample respondents revealed the 41% user respondents ‘and 59% of non-user households were found to be illiterate (who can’t read and write in Amharic and Afan oromo).

On the other hand, 22% of user respondents ‘and 26% of non-user households were literate (who can read and write in Amharic and Afan Oromo). The chi-square value for this variable shows that there is no significant association (at p<0.01) between educational level of the household head and use of small-scale irrigation.

**Socio-economic characteristics of respondents**

- **Cultivated land size of Sampled Respondents**

Land is prominent resource for the farm households and it was measured in hectares. Irrigation user respondents’ and non-user respondents were compared with respect to this variable and it was found that the average land holding in irrigation user respondents’ and non-user respondents was 2.52 ha and 3.90 ha, respectively. The t-value revealed that there is significant difference in mean land holding among irrigation user respondents’ and non-user respondents. The t = (-6.90) associated with this variable revealed that there is significant difference (at p<0.001) between the irrigation user respondents’ and non-user respondents. Therefore, better land holder farmers have better chance to use irrigation.

- **Annual gross farm income of Sampled Respondents**

The survey result revealed that the mean of annual farm income obtained by the user irrigation and non-user household was 11636.34 and 3449.78 respectively. The t-value shows that there is significance level, the mean of annual gross farm income obtained by the irrigation user respondents’ households was significantly larger than that was obtained by the irrigation non-user respondents’ households.

- **Farm Distance from Rivers of Sampled Respondents**

The results in Table 2 show that the mean of user respondents’ farm distance from rivers is 0.95 Km and the mean of non-user respondents’ farm distance from rivers is 1.70 Km. The t-value shows that, there significance level there was significant difference in mean farm distance from river between user and non-user household. This significance mean variation shows that the variation in distance from river between two groups has its own implications on the utilization of irrigation water. Therefore, farmers’ farms near to the river have better chance to use irrigation.

**Institutional Factors**

- **Access to Farm Credit**

The survey results in Table 3 show that in 2018/19 out of the total respondents 70.49% did use credit. However, out of the total irrigation user respondents (67.14%) and from the total non-user respondents (32.86 %) did use credit last year. The Chi-square value shows that there was no significant relationship between the use of credit and irrigation water use.

- **Transportation**

Transportation is a very important determining factor in use of small-scale irrigation. The transportation of the sampled household heads was categorized under pack animals and otherwise. The data obtained from the sample respondents revealed the 64% user respondents ‘and 36% of non-user households were found to be non-user. The chi-square test between the two groups was found to be significant.

### Table 2: Descriptive statistics of Continuous variables

<table>
<thead>
<tr>
<th>Variables</th>
<th>User Mean</th>
<th>User SD</th>
<th>Non-user Mean</th>
<th>Non-user SD</th>
<th>Total cases Mean</th>
<th>Total cases SD</th>
<th>t-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age household</td>
<td>45.19</td>
<td>13.26</td>
<td>48.85</td>
<td>12.80</td>
<td>47.29</td>
<td>13.07</td>
<td>1.53</td>
</tr>
<tr>
<td>HH in AE</td>
<td>3.72</td>
<td>1.36</td>
<td>4.84</td>
<td>1.56</td>
<td>4.36</td>
<td>1.57</td>
<td>4.13</td>
</tr>
<tr>
<td>Farm Distance from Rivers</td>
<td>1.70</td>
<td>0.94</td>
<td>0.97</td>
<td>0.62</td>
<td>1.27</td>
<td>0.85</td>
<td>-2.64</td>
</tr>
<tr>
<td>Annual gross farm income</td>
<td>636.34</td>
<td>558.36</td>
<td>449.78</td>
<td>496.70</td>
<td>529.30</td>
<td>529</td>
<td>-1.94</td>
</tr>
<tr>
<td>Cultivated land size</td>
<td>3.90</td>
<td>0.69</td>
<td>2.52</td>
<td>1.30</td>
<td>3.11</td>
<td>1.28</td>
<td>-6.90</td>
</tr>
<tr>
<td>Farm input</td>
<td>650.36</td>
<td>266.81</td>
<td>443.57</td>
<td>304.68</td>
<td>531.72</td>
<td>305.76</td>
<td>-3.90</td>
</tr>
</tbody>
</table>

Source: Own computation, 2018
Determinants of participation in small-scale irrigation

In the estimation data from the two groups; namely, participant and non-participant households were pooled such that the dependent variable takes a value 1 if the household was irrigation user (treated) and 0 otherwise. In this section, selected explanatory variables were used to estimate the logistic regression model to analyze the determinants of households’ behavior on irrigation water use. A set of 13 explanatory variables analyzed, the coefficients of five variables, namely Age of household, Family size, educational level of household, land cultivated and oxen ownership, were significantly different from zero and found to be significant to affect the irrigation use of the households in the study area (Table 4).

Table 3: Descriptive statistics of Categorical variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>User</th>
<th>Non-user</th>
<th>Total Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>SexHH</td>
<td>M</td>
<td>F</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>EducHH</td>
<td>Illiterate</td>
<td>Literate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>Credit Access</td>
<td>Non-user</td>
<td>User</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
<tr>
<td>Transportation</td>
<td>pack animals</td>
<td>other wise</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>%</td>
<td>No</td>
</tr>
</tbody>
</table>

Source: Own computation, 2018

Determinants of participation in small-scale irrigation

The possible justification is that most of the sample households use pack animals as a means of transportation due to lack of transportation facilities and unavailability of good roads. The odds ratio of the variable indicated that other things remain constant; the probability of the household being participated would decrease by a factor of 1.218 if this means of transportation become pack animals.

Household size in adult equivalent variable was negative and significant effect on irrigation water at 1% probability level. The odds ratio favoring the use of irrigation by a factor of 0.557 for the respondents’ household size engaged in agricultural labor force increase by one-person day equivalent. Therefore, the respondents’ household who has large size engaged in agricultural labor force has better chance to use irrigation water.

The regression result shows that Size of cultivated land had positively and significantly influenced the probability of use of irrigation at 5% significant level. This result implies that farmers with large farm size are more likely to use irrigation than those farmers who have small land size. The odds ratio of 2.902 for farm size indicates that, other things being constant, the odds ratio in favor of using irrigation increases by a factor of 2.902 as the farm size increases by one hectare.

Distance from a river had significant positive effects on the use of irrigation water at 1% significance level. The odds ratio disfavors the use of irrigation by a factor of 1.945 for the respondents’ farm distance from Rivers increased by 1 Km. Therefore, the respondents’ household farm located far from the rivers has less chance to use irrigation water and vice versa. Because, in the study area the major water source for irrigation is rivers. When the farm distance far from main irrigation canals which was constructed from the rivers, it needs high labor, financial and time costs to construct sub-canals towards individual farm and minimize the chances to use irrigation water.

CONCLUSIONS AND RECOMMENDATIONS

The main objective of the study was to identify the Determinants of small-scale irrigation among small holders’ farmers household in Jeldu district of West Shewa Zone, Ethiopia. A three-stage sampling technique was
utilized to obtain a sample size of 118 rural farm households. Cross sectional data were collected through structured questionnaire, focus group discussion, key informant and field observation.

The data were analyzed using descriptive statistics such as mean, standard deviation, percentage and frequency distribution and descriptive statistics, binary logistic regression models were used to identify determinants of small-scale irrigation. Accordingly, the binary logistic regression model result revealed that from the total nine (9) independent variables, five variables significantly influence small scale irrigation in the study area. These are age of household head, sex of household, family size, land cultivated and Distance from river.

The Committees have high responsibility to manage irrigation water used from rivers. However, these committees have not well functioned their responsibilities. Therefore, it was negatively affecting the fair distribution of irrigation water for the users in sample Kebeles. Small-scale irrigation is important development effort to ensure farm income if properly implemented. Based on the empirical findings reported in this thesis, the following recommendations are forwarded.

a) The age of the household head has a negative and significant effect on the adoption of irrigation farming. Age happens to be one of the human capital characteristics that have been frequently associated with no adoption in most adoption studies. Young people are associated with a higher risk-taking behavior than the elderly. Therefore, development agents and younger members should have to aware the elders the benefit of new technology in agricultural production through practical manifestation.

b) Distance from rivers had significant and negative effect on the use of irrigation water and the major sources of irrigation water in the study area are rivers. It is recommended that government, NGO and other stakeholders should focus on construction of new main irrigation canals for farmers whose land is far from the rivers.

c) Size of cultivated land is positively and significantly influenced the probability of use of irrigation and it was one of the most constraining factors. The opportunity of its expansion mechanism is very difficult in the study area due to the absence of bleak land. Thus, to diminish the problem of cultivated land scarcity, the existing land must be intensively used.

d) Transportation is positively and significantly influenced the probability of use of irrigation and it was one of the most constraining factors. This clearly indicates that for effective irrigation utilization, enhancing the beneficiaries (community participation), government and non-government support in promoting transportation facilities and expanding rural infrastructure (special rural road) so as to increase both the probability of participation and proper utilization of irrigation water.

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