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Effect of Small-scale Irrigation on the Farm Households' Income of Rural Farmers: The Case of Girawa District, East Hararghe, Oromia, Ethiopia

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Abstract

Irrigation is one means by which agricultural production can be increased to meet the growing food demands in the world. This study evaluated the effect of small-scale irrigation on farm household income in production. The specific objective of this study is to identify the factors influencing participation in small-scale irrigation and provides bases for policy makers in Girawa district, Eastern Hararghe zone, Oromia, Ethiopia. Both primary and secondary data were collected for the study. Primary data were collected from 200 sample respondents drawn from both participant and non-participant households. Preliminary statistics and econometric models were employed for data analysis. The logistic regression estimation of factors affecting participation revealed that age of household head, non-farm income, livestock size, size of cultivated land, distance between plot and irrigation scheme, means of transportation and participation of household heads in social organization significantly affected the participation decision of households in irrigation farming. Results showed that participation in irrigation has a significant, positive effect on farm households' income. Therefore, policy makers should give due emphasis to the aforementioned variables to increase participation in irrigation farming and improve the livelihood of rural households.

Keywords: Irrigation, income, rural farm households, participation and logit model

Introduction

Ethiopia is an agrarian country where around 95% of the country's agricultural output is produced by smallholder farmers (MoARD, 2010). Agriculture contributes about 41% of the country's GDP, employs 83% of total labour force and contributes 90% of exports (EEA, 2012). Despite its dominance, in 2011 alone Productive Safety Net Program supported 7.4 million people, whereas an additional 4.5 million people were requiring emergency humanitarian assistance (FEWS NET, 2011).

Irrigation contributes to livelihood improvement through its direct and indirect benefits. The direct benefits of irrigations are; high productivity, lower risk of crop failure, and higher and year-round farm and non-farm employment, increased income, food security, and poverty reduction. Irrigation enables smallholders to adopt more diversified cropping patterns, and diversify income base sources. Indirectly irrigation benefits as a potential to become 'nuclei of growth' which are attractive for inward investments in other infrastructure and services such as banking to facilitate this growth (Hussien and Hanjira, 2004)

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The total irrigable land potential in Ethiopia is 5.3 million hectares assuming use of existing technologies, including 1.6 million hec-

tares through RWH and ground water. There are 12 river basins that provide an estimated annual run-off of ~125 billion m³ per year, with the potential of irrigating total of 3,731,222ha from surface water. The potential available estimates for RWH range from 40,000 to 800,000 ha. The area under irrigation development to-date is estimated to be 640,000 hectares for the entire country which is 5% of the potential irrigable (Awulachew *et al.*, 2010).

Agriculture in Ethiopia is heavily dependent on rainfall, which is highly varies both spatially and temporally. despite Ethiopia's agricultural enterprises, a high and growing human population, recurrent droughts and periodic floods, complicated by climate change that has been accompanied by severe soil and landscape degradation in some regions contributed to a situation of national food insecurity (FAO, 2011). This, therefore, calls for different interventions, irrigation being one of the options, which could help in adapting strategies to cope up with the challenging drought.

Though agriculture remains to be the most important sector of the Ethiopian economy, its performance has been disappointing and food production has been lagging behind population growth (Demeke, 2008), which is unable to fulfil the requirement of the ever-increasing number of mouths. Poor use of modern inputs can partly explain the low productivity of the sector and the internal inefficiency of the farmers in using the available agricultural resources. In the light of the foregoing this study examined farm household' income of smallholder irrigated and rain-fed farm production in Ethiopia, using Girawa district of Oromia national Regional State as a study area. Specifically, this study;

- ✓ To identify factors affecting household level irrigation participation of smallholder farmers.
- ✓ To provides a base for policy makers through the comparisons of farm income of irrigation users

and non-users with respect to similar areas.

Research methodology

The study was conducted in Girawa district, Oromia National Regional State, Ethiopia. According to CSA (2010), Girawa district has a total population of 263,924 of which 133,780 are male and 130,144 are female and total area of the district is about 1109.41 km² with density of 237.9 (BoARD, 2012). The climate condition of the study area 48.9%, 31.1% and 20% of Girawa district is kolla, Woina dega and Dega of Agro-ecological zones, respectively. The land altitude ranging from 1215 to 3405 meter above sea level (m.a.s.l). The annual rainfall ranges from 550mm to 1100 mm with annual temperature ranging from 20 °c - 27°c. The primary source of income is crop and *chat* production. Major types of crops grown in the area are sorghum, maize, common beans, highland pulses and many other vegetable crops like potatoes, onion, garlic, and leafy vegetables. Livestock rearing is the secondary source of livelihood for the rural people in the area (BoARD, 2012).

The district has a range of water resources, which are suitable for irrigation activities. Traditional irrigation has a long history in the district whereas modern irrigation schemes are not as much. The total irrigable land potential in the district is 6113ha, out of which 4014ha from surface water potential and the remaining 2100ha estimated to be ground water potential. However the estimated area under irrigation to-date is 3025.5 in which traditional irrigation accounts for 1842ha, modern irrigation covers 690.5ha and the area underground water (in the form of well) is 493ha that benefits about 29,332 households. Water management was undertaken by water user association themselves.

As sources of information both primary and secondary data sources were used. The primary data were collected using semi-structured questionnaire that was adminis-

tered by the trained enumerators. In addition to primary data, secondary data were also collected from relevant sources such as published and unpublished documents of the district and other relevant institutions (Care Gara Muleta) for general description and to augment primary data.

The sampling procedure used was two stage random sampling. In the first stage out of the kebeles exist in the district two kebeles are purposively selected due to availability of irrigation. In the second stage, to select sample respondents from the two kebeles, first the household heads in the two kebeles were identified and stratified into two strata: irrigation users and non-users. Then the sample from each stratum was selected randomly based on probability proportion to size. Finally, a total of 200 sample respondents; 100 users and 100 non-users were interviewed.

Data analysis

To address the objectives of the study, both preliminary statistics and econometric methods were employed. For this study, preliminary statistics such as mean, percentages, standard deviation, frequency of occurrence, chi-square and t-test were used. The statistical significance of the variables was tested for both dummy and continuous variables using chi-square and t-tests, respectively.

The logit model

The logit and probit are the two most commonly used models for assessing the effects of various factors that affect the probability of adoption of a given technology. These models can also provide the predicted probability of adoption. Both models usually yield similar results. However, the logit model is simpler in estimation than probit model (Aldrich and Nelson, 1984).

Hence, the logit model will be used in this study to analyze the determinant of Small-scale irrigation utilization. Following Gujarati (2003) and Aldrich and Nelson (1984) the logistic distribution function for the

utilization of small-scale irrigation schemes is specified as:

$$P_i = \frac{1}{1+e^{Z_i}} = \frac{e^{-Z_i}}{1+e^{-Z_i}} \tag{1}$$

Where, P_i = is the probability of using the irrigation for the i^{th} farmer and it takes 0 or 1. e^{Z_i} = stands for the irrational number e to the power of Z_i .

Z_i = a function of n-explanatory variables which is also expressed as:

$$Z_i = B_0+B_1X_1+B_2X_2+...+B_nX_n \tag{2}$$

Where, $X_1 X_2... X_n$ are explanatory variables. B_0 - is the intercept, $B_1, B_2 \dots B_n$ are the logit parameters (slopes) of the equation in the model.

The slopes tell how the log-odds ratio in favor of using the small-scale irrigation schemes changes as an independent variable changes. The unobservable stimulus index Z_i assumes any values and is actually a linear function of factors influencing adoption decision of small-scale irrigation schemes. It is easy to verify that Z_i ranges from $-\infty$ to ∞ , P_i takes 0 or 1 and that P_i is non-linear related to the explanatory variables, thus satisfying two requirements:

- As X_i increases P_i increases but never steps outside the 0 and 1 interval; and
- The relationship between P_i and X_i is non-linear, i.e., one which approaches zero at slower and slower rates as X_i gets small and approaches one at slower and slower rate as X_i gets very large. But it seems that in satisfying these requirements, an estimation problem has been created because P_i is not only non-linear in X_i but also in the B's as well, as can be seen clearly below.

$$P_i = \frac{1}{1 + e^{-Z_i}} \tag{3}$$

$$Z_i = B_0 + B_1 X_{i1} + B_2 X_{i2} + \dots + B_n X_{in}$$

This means the familiar OLS procedure cannot be used to estimate the parameters. But this problem is more apparent than real because this equation is intrinsically linear. If P_i is the probability of adopting a given small-scale irrigation scheme then $(1 - P_i)$, the probability of not adopting, can be written as:

$$1 - P_i = \frac{1}{1 + e^{Z_i}} \tag{4}$$

Therefore, the odds ratio can be written as:

$$\frac{P_i}{1 - P_i} = \frac{1 + e^{Z_i}}{1 + e^{-Z_i}} = e^{Z_i} \tag{5}$$

Now $\frac{P_i}{1 - P_i}$ is simply the odds ratio in favor of adopting small-scale irrigation schemes. It is the ratio of the probability that the farmer would adopt the utilization of small-scale irrigation schemes to the probability that he/she would not adopt it. Finally, taking the natural log of equation 15, the log of odds ratio can be written as:

$$Li = \ln\left(\frac{P_i}{1 - P_i}\right) = \ln(e^{B_0 + \sum_{i=1}^n B_i X_i}) = Z_i = B_0 + \sum_{i=1}^n B_i X_i \tag{6}$$

Where, Li is log of the odds ratio in favor of small-scale irrigation schemes adoptions, which is not only linear in X_i , but also linear in the parameters. Thus, if the stochastic disturbance term (u_i), is introduced, the logit model becomes:

$$Z_i = B_0 + B_1 X_{i1} + B_2 X_{i2} + \dots + B_n X_{in} + u_i \tag{7}$$

This model can be estimated using the iterative maximum likelihood (ML) estimation procedure. In reality, the significant explanatory variables do not have the same level of impact on the adoption decision of farmers. The relative effect of a given quantitative explanatory variable on the adoption deci-

sion is measured by examining adoption elasticity's, defined as the percentage change in probabilities that would result from a percentage change in the value of these variables. To calculate the elasticity, one needs to select a variable of interest, compute the associated P_i , vary the X_i of interest by some small amount and re-compute the P_i , and then measure the rate of change as $\frac{dX_i}{dP_i}$ where dX_i and dP_i stand for percentage changes in the continuous explanatory variable (X_i) and in the associated probability level (P_i), respectively.

When dX_i is very small, this rate of change is simply the derivative of P_i with respect to X_i and is expressed as follows (Aldrich and Nelson, 1984):

$$\frac{dX_i}{dP_i} = \frac{e^{Z_i}}{(1 + e^{Z_i})^2} B_i = \frac{P_i}{(1 - P_i) B_i} \tag{8}$$

The effect of each significant qualitative explanatory variable on the probability of adoption is calculated by keeping the continuous variables at their mean values and the dummy variables at their most frequent values (zero or one).

Results and discussions

Results of analysis of socio-economic characteristics of the surveyed households are presented in Table 1. They show that farm income of irrigation users were Birr 87290.45 and the average for the non-users were Birr 67983.62. The t-test analysis revealed that the mean annual farm income of the two groups was statistically significant at less than 1 % probability level. The average Crop income of irrigation users were Birr 19718 and the average for the non-users were Birr 12899. The t-test analysis revealed that the mean annual crop income of the two groups was statistically significant at less than 1 % probability level. The average live-stock income of irrigation users were Birr 5257 and the average for the non-users were Birr 4034. The t-test analysis revealed that

the mean annual crop income of the two groups was statistically significant at 5% probability level. The average annual non/off-farm income of irrigation users was 1694.48 birr while the annual average for non-users was 404birr. The t-test showed that there was statistically significant mean difference between the two groups at 5 % probability level.

The average age of users and non-users were 39 and 44 years respectively. From the statistical analysis performed, it is found out that there was statistically significance mean difference between users and non-users at less than 1 % probability level. The result indicates that irrigation users (4) had more

average years of formal schooling than non-users (2). The mean difference of the two groups was statistically significant at 1% probability level. Similarly on average irrigation users contacts extension gents (26 times) than non-users (13times). The t-test indicated that there was statistically significant difference between two groups in terms of frequency of extension contact f at 1% probability level. The study also showed that out of the 200 sample households 190 own (rear) livestock. The mean livestock holding for user households was 4.296 TLU and 2.987 TLU for non-users. The mean difference of the two groups was statistically significant at 1% probability level.

Table 1: Preliminary statistics for continuous variables

Variables	All sample (N=200)		Participants (N=100)		Non –participants (N=100)		t- value
	Mean	SD	Mean	SD	Mean	SD	
Income	77637	27529	87290	28098	67984	23358	-5.28***
Crop income	16309	11780	19718	14647	12899	11630	-4.27***
Liv income	4646	3763	5257	4471	4034	2778	-5.28***
Age	41.59	11.59	38.96	11.57	44.22	11.05	3.288***
Education	3.08	3.98	4.18	4.23	1.99	3.39	-4.037***
Extension	19.58	23.5	26	28.4	13.2	14.9	-4.004***
Livestock	3.64	2.43	4.30	2.53	2.99	2.15	3.945***
N-F income	1049.2	3819	1694.48	4924.42	404	2057.4	-2.418***
Irrigation dist	25.38	11.94	20.97	11.80	29.78	10.93	5.604***
Whether road dist	92.32	33.47	80.10	28.87	104.55	33.42	5.537***

Source: Own survey result. *, **, *** significant at 10%, 5% and 1% probability level respectively

The result also revealed that irrigation users had on average less weather road distance (80) than non-users (104) in minutes. The mean difference between the two groups with regard to distance from the weather road was statistically significant at 1% probability level. The result also shows that irrigation users had significantly less distance (20.97) of irrigation source than non-users (29.78) in minutes.

Table 2 shows that irrigation users (42%) have had significantly more fertile land than non-users (22%) according to their opinion. Similarly irrigation users were more participated (24.5%) in leadership of social organizations, than non-users (10%). The chi-square test between the two groups was found to be significant at 1% probability level. Finally the result also revealed that 35.5 percent of the users and 41.5% of non-users transport their produce on back animals.

Table 2: Preliminary statistics for discrete variables

Variables	Irrigation-users (N=100)		Non-users (N=100)		Total (N=100)		χ^2 - value
	Number	%	Number	%	Number	%	
Soil fertility							
Fertile	84	42	44	22	128	64	34.722***
Not fertile	16	8	56	28	72	36	
Social status							
Participated	49	24.5	20	10	69	34.5	18.608***
Not-part	51	25.5	80	40	131	65.5	
Transportation							
Pack animals	71	35.5	83	41.5	154	77	4.065***
Otherwise	29	14.5	17	8.5	46	23	

Source: Own survey result.***,* significant at 1% and 10% probability level

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.

As it was indicated in Table 4, the results indicated that participation is significantly influenced by seven explanatory variables. Age of household head, means of transportation, participation in social organization, non-farm income, and cultivated land area and distance from weather road and distance from irrigation scheme were significant variables which affect the participation of the household in small-scale irrigation scheme utilization.

Age was negatively and significantly related with probability of participation at 5% probability level. The odds ratio of 0.96 implies that, other things being constant, the odds ratio in favor of using irrigation decreases by a factor of 0.96 as age increase by one year. The reason was that older farmers are less likely to adopt innovations and thought to be more conservative in implementing modern technologies. This result is consistent with the findings of Bigsten and Abebe (2003) and Hilina (2005).

Irrigation distance has a negative and significant effect on probability of participation

at 5% probability level. The odds ratio of 0.96 for irrigation distance implies that, other things being constant, the odds ratio in favor of using irrigation water increases by a factor of 0.96 as irrigation distance decreases by one unit (in minutes). Within the same topography, this could be households who are situated in nearby places do not incur much cost to access the irrigation scheme; therefore, they quickly decide to participate in the scheme. This result is consistent with the findings of Abonesh (2006), Yenetila (2007) and Asayehegn *et al.* (2011).

Transportation has been found to be negatively related to the probability of being participated at 1 % significant level. 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 0.316 if this means of transportation become pack animals. Tracey-White (2005) puts idea of lack of transportation facilities and unavailability of good road hampered the farmers' decision and in turn agricultural productivity.

The result also showed that access of family members in non-farm income source had a Positive and statistically significant relation

with probability of participation at 10% probability level. Its odds ratio effect shows that, participation of family members in non/off-farm income increase probability of participation in irrigation farming by 1.001, other variables being constant. The implication of this result is that, irrigation farming like any other business requires financial capital. It also needs chemicals, seeds, fertilizers and in certain instances irrigation pipes and sprinklers. This result is consistent with the findings of Asayehegn *et al.* (2011), Yenetila (2007) and Haji (2003).

Cultivated land area was found to be positive and significantly affect probability of participation. The reason for this could be that fragmentation of cultivated land is a problem of crop diversification for most of the farmers in the study area. The odds ratio implies that if other factors are held constant, the odds ratio in favor of using irrigation water increases by a factor of 7.83 as farm size increase by one unit (ha). This result is consistent to the findings of Beyene *et al.* (2000), Hirko (2009) and Belay *et al.* (2010).

Similarly, weather road distance was found to be negative and statistically significant at 5% probability level with probability of par-

ticipation. The reason for this could be that, transport operators are in most cases reluctant to reach such areas and some of the farmers fail to get their produce to the market in time. This tends to disadvantage communal farmers to participate in the recent boom in irrigation farming. The values of odds ratio also implies that if other factors are held constant, the odds ratio in favor of using irrigation water decreases by a factor of 0.983 as weather road distance increase by one unit (minute). This result is consistent with the findings of Beyene *et al.* (2000) and Takele (2008).

Social organization, this variable has a positive and significant relationship to the probability of participation at 1% probability level. This is because those farmers that have position in social organization are parts that responsible in managing and resolving irrigation related conflicts, and therefore, it might be due to influential power over others. The odds ratio of the variable indicated that other things remain constant; the odds ratio in favor of using irrigation increase by a factor of 3.836 as the farmers being participated in social organization. This result is consistent with the findings of Haji (2003) and Yenetila (2007).

Table 3: Logistic regression results for determinants of participation in irrigation

Variables	Coefficient	Odds Ratio	SE	Z
Constant	4.119**		1.894	2.17
Age	-0.039**	0.962	0.017	-2.32
Sex	1.018	2.766	0.657	1.55
Education	0.03	1.031	0.075	0.4
Non-farm income	0.00012*	1.00012	0.0001	1.74
Family size	-0.094	0.91	0.122	-0.77
Economic active force	0.031	1.031	0.222	0.14
Cultivated land	2.058*	7.832	1.084	1.9
Livestock holding	0.03	1.03	0.092	0.33
Irrigation distance	-0.042**	0.959	0.021	-2.02
Farmers training	0.144	1.155	0.454	0.32
Extension	0.005	1.005	0.02	0.26
Transportation	-1.151***	0.316	0.452	-2.55
Social status	1.344***	3.836	0.402	3.35
Soil fertility	0.175	1.192	0.496	0.35
Weather road distance	-0.017**	0.983	0.008	-2.18
Number of obs = 200		Pseudo R ² = 0.2778		

Prob > χ^2 = 0.0000

Log likelihood = -100.12

LR χ^2 (15) = 77.01

Source: own survey result. *, ** and *** mean significant at 10%, 5% and 1% probability levels, respectively

Summary and conclusion

This study was carried out to examine the effect of small scale irrigation on farm households' income. For this study, both primary and secondary data were used. The primary data source was gathered from 200 sample households (100 users and 100 non-users) using semi-structured questionnaires. Secondary data were collected from different sources to support primary data. Data analysis was carried out using preliminary statistics and econometric techniques.

The logistic regression result shows that Participation is significantly influenced by seven explanatory variables. The variables age of household head, distance to irrigation scheme, size of cultivated land, non-farm income, means of transportation, distance to weather road and household head participation in social organizations were the significant variables which affect the participation of the household in irrigation farming.

Recommendations

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:

This study has found evidence that the irrigation in the study area has shown that participant households have more farm income than non-participant households. This has an encouraging message for program designers, implementers, and funding agents to take proper action to achieve the intended goals of securing households food security by improving efficiency in production.

The findings indicate that irrigation access is an important factor for increase farm households' income. Concerned bodies should

give attention for promoting access to irrigation to encourage household farm efficiency.

Access to irrigation through irrigation development for rural households will have major impacts. These are not only an increase in household production, income and reduction of dependency on food aid, but also have a significant positive impact on the overall rural economy.

Therefore, government and other stakeholders should provide support through the establishment of more irrigation project and other agricultural production increasing projects that can assist farmers to produce their own food and be food secured. Policy makers need to promote irrigation development so that farmers can irrigate more crops, fruits, vegetables and other fresh produce.

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 non-adoption in most adoption studies. Among the several reasons that could explain the negative effect of age on adoption is the fact that older farmers tend to stick to their old production techniques and are usually less willing to accept change. In addition young people are associated with a higher risk-taking behavior than the elderly. So development agents and younger members should have to aware the elders the benefit of new technology in agricultural production through practical demonstration.

Nearness to the water source is also negatively related to participation in irrigation. Those households that are situated near the water source are willing to participate. Therefore, the construction of small scale irrigation should consider the distance be-

tween the water source and villages for a better use of the schemes by households.

Farmer's position in local organizations has a positive influence on the adoption of water technology. This tends to reveal that farmers with positions are more likely to have easy access to information due to their influential power over others. So it is necessary to correct such biased flow of information towards positioned farmers and ensure evenly dissemination of information on new agricultural technologies through farmers' local organizations.

Size of cultivated land and household participation in irrigation farming are positively and significantly related indicating larger farm size improves household participation. Households with large farm size are found to be participated more than others however; there may not be a possibility of expanding cultivated land size anymore because of increasing family size and degradation of the existing farm land. Therefore, household must be trained as to how to increase production per unit area (productivity).

Farmers cannot adopt technologies if roads and transport are inadequate and poor for them to acquire technology-related inputs, or to market their produce. The infrastructure issue typically illustrates that the adoption process does not only depend on the farmers' willingness, but partakes to an overall sustainable rural development process. So in this empirical findings distance from the main (all weather) road negatively and significantly influences the participation of farmers in irrigation technology. Therefore, the government should strengthen recent efforts of expanding rural road networks in order to open-up market for irrigated crops and the provision of necessary inputs for irrigated agriculture.

The study revealed that means of transportation used in the study area negatively and significantly influenced farmers' small-scale irrigation utilization. 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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