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Determinants of Smallholder Rural Farm Households' Participation in Small Scale Irrigation and Its Effect on Income in North Gondar Zone of Amhara Regional State, Ethiopia

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Abstract:
Intensifying agriculture is recognized to be a necessary pre-condition for the development of the agricultural sector in Ethiopia in general and in North Gondar Zone in particular. In this regard, various governmental and non-governmental organizations initiated small-scale irrigation schemes throughout the country including the Amhara region. Despite these efforts, however, smallholder farmers in the study area are found to be indisposed to participate in small-scale irrigation schemes. Therefore, this study analyzed and investigated the factors that affect participation of smallholder farmers in small-scale irrigation and also it explored the effect of participation in small-scale irrigation on the income of rural farm households in Dembia Woreda of North Gondar Zone. Three stage sampling procedure was adopted for the selection of sample respondents. Results are based on data collected from a survey of 240 randomly selected rural farm households. Descriptive statistics and Heckman's two-stage estimation were used to estimate determinants of small-scale irrigation participation and household income. The analysis revealed that distance from household's farm to the nearest market center, education level of the household head, distance from household's residence to the water source, access to extension service, total livestock holding, access to information, availability of family labor force, access to credit and gender of the household head are important determinants for participating in small-scale irrigation. The analysis further revealed that irrigation participation, access to credit, gender of the household head, size of cultivated land, access to extension service and total livestock holding are positively and significantly associated with household total annual income. Finally, based on both descriptive and econometric results, improving rural farm households' access to extension service and livestock sector, are likely to enhance participation in small-scale irrigation schemes thereby improve small holder rural farm households total annual income.

Keywords: *Small-scale irrigation, income, rural farm households, Heckman two stage model, user, non-user, Dembia, north Gondar, Ethiopia*

1. Introduction

Ethiopia, like other Sub-Saharan African countries, is predominantly an agrarian country with the vast majority of its population directly or indirectly involved in agriculture where around 95% of the country's agricultural output is produced by small holder farmers (MoARD, 2010). Hence it is the backbone of Ethiopian economy; it contributes about 50 % of the GDP, 85% of the employment, 90% of the export earnings and 70% of the supply of industrial raw materials (World Bank, 2010).

Having all these importance, agriculture continues to face a number of problems and challenges. The major ones are adverse climatic conditions, rainfall dependent, lack of appropriate land use system resulting in soil and other natural resources degradation, limited use of improved agricultural technologies, the predominance of subsistence agriculture and lack and/or absence of business oriented agricultural production system, limited or no access to market facilities resulting in low participation of the smallholder farmers in value chain or value addition of their produces (Belay and Degnet, 2004; Spielman et al., 2010).

According to (MoARD,2010)currently the government of Ethiopia is trying to transform from traditional and manual, rain-fed, supply driven and production oriented agriculture to technology intensive and mechanized, irrigated, market oriented agriculture, through full packages of value addition and postharvest technologies. To this end, the objective of the growth and transformation include achieving a sustainable increase in agricultural productivity and production, accelerating agricultural commercialization and agro-industrial development, reducing degradation and improving productivity of natural resources and achieving universal food security and protecting vulnerable households from natural disasters. This potentially and intensively utilizes the three major resources (land, labor, and water) for its productivity focused and intensive agriculture.

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 (Asayehegn, 2012).

According to Haile (2008), there are four interrelated mechanisms by which irrigated agriculture can reduce poverty, including (i) *increasing overall food production* and income it leads to reduction of food prices, it helps poor households meet their basic needs and associated with improvements in household overall economic welfare, (ii) *protecting against risks of crop* loss due to erratic, unreliable or insufficient rainwater supplies, (iii) *promoting greater use of yield enhancing farm inputs* and (iv) creation of additional employment, which together enables people to move out of the poverty cycle. In addition, Zhou et al. (2009) mentioned how irrigation contributes to increased value of agricultural production by increasing crop yields and enabling farmers to increase cropping intensity and switch to higher-value crops. Therefore, irrigation can be an indispensable technological intervention to increase household income. In order to respond to growing food demand, some proportion of the pressure could be met by increasing productivity rather than extensive agriculture. The three methods to increase food production are: increasing agricultural yield per a given plot, increasing the area of arable land, and increasing cropping intensity (number of crops per year). Irrigation has the potential to increase both yields and cropping intensity in Ethiopia (Awulachew et al., 2010). irrigation increases agricultural productivity and farm income per hectare. It insulates the national agricultural economic sector against weather-related shocks and provides a more stable basis for economic growth and poverty reduction. It supports the process of transforming traditional subsistence agriculture into market-oriented production of high value crops (Asfaw, 2007).

Small-scale irrigation is a policy priority in Ethiopia for rural poverty alleviation and growth as well as climate adaptation ((MOFED, 2006; GoE, 2007). Although the country has 4.5 million ha of irrigable land, irrigation covers only 0.16 million ha or about 5% of the total irrigable land and less than 5% of total renewable water resources are withdrawn annually so there is considerable scope for expansion. The dependence of most of the farmers on rain-fed agriculture has made the country's agricultural economy extremely fragile and vulnerable to the impacts of weather and climatic variability leading to partial or total crop failure, which in turn resulted in food shortages (World Bank, 2006; MoWE, 2011).

Amhara Regional State, with a population of about 18 million, is the second most populous administrative region in Ethiopia (CSA, 2007).Like other eight regions of Ethiopia, the economy of Amhara is largely dependent on agriculture with small holder cultivation of cereals, pulses, horticultural crops and oilseeds mainly characterized by subsistence farming mixed with livestock rearing. Some drought- prone areas of the region are food insecure due to a combination of factors such as erratic and unreliable rainfall, degraded natural resource base, high population density and low productivity caused by poor agricultural management practices.

The region is endowed with a potential irrigable land area of 0.6 million ha (3.9%) out of total land mass of15.5 million hectares within the four major river basins (Awulachew et al., 2005; BoWRD, 2005). In addition, it enjoys a considerable potential for surface water harvesting by small-scale dams and river diversions and also underground water resources. However, the total area under irrigation to date amounts only to about 76 thousand ha, this is less than 2% of the total cultivated land in the region (BoWRD, 2005).North Gondar zone is an irrigation potential area. Using this huge potential, smallholder farmers' in the study area benefited from participation in small-scale irrigation through increasing cropping intensity as aresult the living standard of the community improves. But, itis not surprising to find some households reluctant to participate in small-scale irrigation schemes depend on rain fed agriculture alone and the output produced is not sufficient to feed their household. However, the effect of small scale irrigation on income and the determinants of participation is an empirical question. The principal objectives of this study are to identify determinants of small scale irrigation utilization by smallholder farmers and to explore the effect of small scale irrigation participation on gross income of smallholder rural farm households.

1.1. Description of the Study Area

The study was conducted in Dembia Woreda, North Gondar Zone of Amhara National Regional State, Ethiopia. The Woreda capital, Koladiba, is located 750 km North of Addis Ababa and 35 km southwest of the zonal capital, Gondar. Total area of the Woreda is 1490 km2 with 45 kebeles (of which five are urbancenters). According to (CSA, 2007) the Woreda has total population of 270,994 (247,643 rural and 23,351 urban). The total population can be disaggregated by gender as follows, rural: male 127,361, female 120,282; urban: male 10,724, female 12,627. The Woreda have a total of 49,528 rural households with five mean household size. The altitude of the of the Woreda ranges from 1790 and 2600 meter above sea level. The agro ecology of the Woreda is temperate (Woinadega)with mean annual minimum and maximum temperature of11℃ and 32℃respectively and the mean annual rain fall ranges from 995 to 1175mm. The major crops grown in the area includes teff, barley, wheat, faba bean, sorghum, finger millet, maize, chickpea, and others. Different vegetables and fruits such as tomato, potato, onion, pepper, lettuce, carrot, garlic, and etc. grow in the area both using irrigation and rainfall.

1.2. Sample Size and Sampling Method

Three stage sampling procedure was adopted for the selection of sample respondents. In the first stage, out of 18 Woredas under the current administrative structure in North Gondar Zone, Dembia Woreda was selected purposively because of its irrigation potential. In the second stage, out of 40 rural kebeles that are found in Dembia Woreda, five kebeles were purposively selected on the basis of their irrigation potential. In the third stage, first the household heads in the five sample kebeles were identified and stratified in to two

strata: irrigation user and non -user. Then the sample respondents from each stratum were selected using systematic random sampling technique. Total sample of 240 rural households of which 112 households from irrigation non-user and 128 irrigation user households have been drawn by taking in to account probability proportional to size of the identified households in each of the five selected kebeles. Irrigation non-users were selected within Kebeles of irrigation users to ensure homogeneity of factors except irrigation.

1.3. Data Source and Method of Data Collection

For this study both primary and secondary sources have been gathered. The conventional household survey was the main method used to collect quantitative information through a carefully designed structured interview schedule. Pre-testing of the questionnaire was carried out with the enumerators and depending on the results, some adjustments have been made to the final version of the questionnaire and proper data collection was started with the day to day supervision of the researcher. Focus group discussion, key informant interview and direct personal observation were also used to collect qualitative primary data. The personal observation of the site helped to understand the over-all process of irrigation development and crosscheck data gathered through household survey and key informant interview. In addition to primary data, secondary data that could supplement the primary data were collected from published and unpublished documents, District and Zonal Offices of Irrigation Development, District and Zonal Offices of Agricultural and Rural Development, District and Zonal Offices of Finance and Economic Development.

2. Methods of Data Analysis

Descriptive statistics (mean, frequency, percentage and standard deviation) and Heckman's two stage estimation (Binary Probit at the first stage and Ordinary Least Squares at the second stage) were used to analyze the collected data. 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, after inserted, coded, pretested and analyzed using STATA version 12. Because evaluating the effect of small scale irrigation on an outcome variable (income in this case) using regression analysis can lead to biased estimate since OLS model does not take care of the selection bias that may arise due to self-selectivity of households to the irrigation scheme or due to unobservable nature of the dependent variable for some observations. The reason for this is that, the effect of small scale irrigation may be over (under) estimated if small scale irrigation participants are more (less) able due to certain unobservable characteristics i.e. if household income of the irrigation participants is significantly higher than that of non participants we cannot necessarily attribute this difference to the effect of the irrigation program because of the self-selectivity component that should be taken care of.

The common version of the Heckman procedure is to estimate in two stages. In the first stage, estimate the selection or participation equation (the probability of participating in small scale irrigation) using probit model and derives maximum likelihood estimates with data from both participants and nonparticipants, using the estimation result "Inverse Mills ratio" is constructed. The inverse Mills ratio (lambda) is the tool for controlling bias due to sample selection (Heckman1979). The second stage involves including the Inverse Mills ratio as an additional explanatory variable to the household income equation or outcome equation and estimating the equation using OLS modelusing data from the participant households only. If the coefficient of the 'selectivity' term is significant then the hypothesis that the participation equation is governed by an unobserved selection process or selectivity bias is confirmed. The general specification of Heckman two-stage model is;

$$yi = Xi\beta + \epsilon i$$

Where yi is the individual household's income from small scale irrigation. It is observable for the participants and unobservable for the nonparticipant households. X_i is a vector of observable factors that affect the level of income from small-scale irrigation and ϵi is the error term.

Let the selection model for household's participation in small scale irrigation be explained by the equation stated below. Here, the equation indicates that household's participation depends on

some value pi* of a latent variable.

pi* = $Zi\alpha + \mu i$

Thus, we can determine the participation and small-scale irrigation income from the selection equation as stated below.

$$pi = \begin{cases} 1 \text{ if } pi^* > 0 \\ 0 \text{ if } pi^* \leq 0 \end{cases}$$

With the decision to participate in small scale irrigation given by pi=1 if household participate and pi=0 otherwise, where pi is a variable indicates participation in small-scale irrigation, Z is a vector of variables that affect households' decision to participate and $\mu_i i$s the corresponding error term. The outcome equation (for our case income from small scale irrigation) is explained as:

$$yi = \begin{cases} Xi\beta + \epsilon i \text{ if } pi^* > 0 \\ \text{Unobservable if } pi^* \leq 0 \end{cases}$$

As shown above, problems arise when estimating βif $\mu i$and $\epsilon i$are correlated. And further assuming that:

$$\mu i \sim N(0,1)$$

ϵi ~N (0,$\sigma 2$)

$$\text{Corr}\ (\mu i, \epsilon i) = \rho$$

Put differently, the error terms ($\mu i and \epsilon i$are assumed to follow a bivariate normal distribution with mean 0, variances$\sigma \mu and \sigma \epsilon$ respectively, and correlation coefficient ρ.The other assumption is (ε,u) is independent of X and Z i.e. the error terms are independent of both sets of explanatory variables.

The conditional expected income of individual households who participate in small scale irrigation becomes,

$$E\{yi/pi=1\} = Xi\beta + E(\epsilon i/pi\ =1\}$$
$$= Xi\beta + \frac{\rho\phi(Zi\alpha i)}{\Phi(Zi\alpha i)}$$
$$= Xi\beta + \rho\lambda$$

If the correlation coefficient ρ=0, estimating the model using OLS gives unbiased result. The term $\rho\phi(Zi\alpha i)/\Phi(Zi\alpha i)$is known as inverse Mill's ratio; usually represented by lambda (λ) and reflects for the selection variable that captures for selection bias.
Therefore, in our two stage choice context we simultaneously model participate in small scale irrigation and the effect of the irrigation schemes on household's income.

3. Results and Discussions

3.1. Socio-demographic Characteristics of Households

Gender of the household head is an important variable influencing the participation decision in irrigation. The total sample of the study is composed of 20% female headed households while the portion of female headed households who are irrigation users is reduced to 3.91%. Discussion with sample households revealed that male-headed households hardly faced labor shortage for irrigation due to physical, technological, socio-cultural and psychological fitness of farm instruments to males than females. The chi-square test of sex distribution between the two groups was run and the difference was found to be statistically significant at 1% level of significance.

Education also plays a key role for household decision in technology adoption. It creates awareness and helps for better innovation and invention. The study revealed that 40.63% of the users and 75% of the non-users are found to be illiterate. The study indicated that farmers who had higher education level show eagerness to grasp new ideas and to try the technology by allocating some of the scarce resources. Similarly, in this study the chi square test shows that there exists significant difference between users and non-users in relation to education level, at1% level of significance.

Age of the household head of sample respondents ranged from 24 to 78 years with mean of 47.39 years. The average ages of users and non-users was found to be 48.53 and 46.08 years respectively. The mean age difference between the two groups, however, is found to be statistically insignificant suggesting age has very little influence on the participation decision.

The average number of economically active family labor force for users and non-users were 6.48 and 5.27adult equivalent, respectively and that of the total sample was 5.92. The mean difference of the labor force in adult equivalent between the users and non-users was found to be statistically significant at 1% level of significance suggesting labor availability is an important factor influencing households' decision to participate in small-scale irrigation.

The average land holding of the surveyed households is 1.58 hectare with a minimum of 0.5 to a maximum of 3.5 ha with mean land holding f 1.74 hectare and 1.4hectarefor the user and non user respectively. The mean difference between the two groups is statistically significant at 1% level of significance and it shows land holding difference determines small-scale irrigation participation and income level. In the study area the major means of land acquisition is through land redistribution, inheritance and, rented in land. Although the Ethiopian government policy does not allow the sale of land, as it is considered a public property. However, the renting out of land through certain agreeable arrangements between individuals is a common practice in all study areas. This is mainly done through contractual arrangements to share the harvest and tends to occur when the owner of the land cannot cultivate by himself/herself. The land is rented out for a temporary period (e.g. one year or 2-3 years) to the cultivator on the basis of different crop sharing agreements. The rate of share depends on the quality of the land, access to irrigation and distance of the farm plot from the village however; a 50 to 50 percent ratio is the most common crop sharing arrangement. The survey result revealed that about 66.41% of users and 46.43% of non-users renting in land during the survey year. This shows that irrigation users are better off practicing land renting in than non-users are. On the other hand, 12.5% of the users and 25.89% of the non-users have rented out their plots of land for different reasons. The major reason for renting-out land was reported to be lack of oxen, seed shortage, labor shortage and disability. Whereas, possible reasons for renting-in land, 24.58% of the respondents reported shortage of land, 16.25% having extra seed, labour and shortage of land, 8.33% having extra labour and shortage of land, 5.42% having extra seed and shortage of land and the remaining 2.5% having extra labour. In the study area most of the female headed households renting out their farm plot to the male headed households.

Reason for renting-in land	Non-users		Users		Total sample	
	N	%	N	%	N	%
Shortage of land	23	20.54	36	28.13	59	24.58
Possess extra seed, labor and face shortage of land	16	14.29	23	17.97	39	16.25
Possess extra labor and face shortage of land	6	5.36	14	10.94	20	8.33
Possess extra seed and face shortage of land	3	2.68	10	7.81	13	5.42
Possess extra labor	4	3.57	2	1.56	6	2.5

Table 1: Distribution of sample respondents by reasons they have provided for renting in land
Source: Computed from own survey data

Farm animals have an important role in rural economy. They are source of draught power, food, such as, milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport. Farm animals in the study area also serve as a measure of wealth. To help the standardization of the analysis, the livestock number was converted to tropical livestock unit. The farmer with higher number of oxen was more confident to participate in small-scale irrigation than his/her counterparts because he/she has one of the most important factors of production which enables the farmers to finish farming activities efficiently on time. The average livestock holding of respondents was 6.21 TLU, where the minimum is 1 and the maximum is 13.48. The mean livestock holding of users was 7.18 while that of the non-users was 5.1TLU. This study indicated that there was a significant difference in livestock holding between users and non-users at a 1% significance level. This shows that users have higher livestock holding than the non-users. It could also indicate that users have better access to financial source through sell of livestock which could be used to purchase farm inputs, such as high yielding variety seed and fertilizer, and livestock used for minimizing risk.

Livelihood of households within the farming community was found to depend on diverse portfolio of activities and income sources. Farmers in the study area reported that they earn income both from farm and off farm activities. The farm income includes the sale of rain fed crops, irrigated crops and sales of livestock and its products. The off farm activities include working as a guard, grain and livestock trading, sale of Tela (local beer), sale of firewood and charcoal, stone mining, petty trading, weaving, mat making, pottery and handcraft and income earned from households' labor supplied outside their own farm plot etc. The mean annual income of sample households is found to be Birr 42136.65 with a minimum of Birr 16945 and a maximum income of Birr 65349. There is much difference in mean annual income between irrigation users and non users. Households with access to irrigation have mean annual income of Birr 56166.59 and the average for the non-users is Birr 26102.44. The t test analysis revealed that the difference of mean annual total income of the users and non-users are statistically different from each other at 1% level of significance. Household income or consumption expenditure data has been used as one means to compare the welfare level among households. However, in developing countries consumption is typically preferred over income as the former better captures the welfare level of a household. In the country as a whole and particularly in the study area asking questions pertinent to yield of crops, and income earned is sensitive. Farmers were reluctant to respond truly when requested to comment on yield and income aspects. They usually underestimate the yield and income earned because of the fear that higher taxes might be levied on them due to high yield and income, possibility of exclusion from aid the government agencies and/or NGOs supply in the area was also another concern. Hence, yield and income data obtained by interviewing farmers are subject to underestimation. Therefore, to overcome this biasness the study used expenditure approach to assess the effect of small-scale irrigation on income since the problem created by underestimation may not create bias in the analysis of effect of small-scale irrigation on income. The reason that we prefer expenditure approach instead of income approach is that; first expenditure is believed to vary more smoothly than income i.e. expenditure is considered as more stable compared to income, secondly expenditure is more readily observed, recalled and measured than income and thirdly people are more willing to tell expenditure than income. Access to market is a determinant of profitability and sustainability of agricultural produce. The average distance of respondents' farm from the nearest market place is found to be 6.55 km with a minimum of 2 km and a maximum of 14 km. The average for households with access to irrigation is 6.05 km while the corresponding figure for the non-user households is 7.14 km. The result shows that the user households have a better access to market. The mean difference between the two groups with regard to distance from the nearest market center is statistically significant at 1% level of significance. Almost all of the small-scale irrigation user households revealed as they didn't get reasonable price for the agricultural products produced by irrigation. According to their opinion the main reason for the low price of the agricultural products produced by irrigation was the nature of the product. The commodities produced by small-scale irrigation have perishable nature that is why as soon as harvested the entire farmer supplies such products to the market simultaneously since it can't be stored. As a result, the supply of such products exceeds the demand in the market and it makes the price go down.

It is widely accepted that agricultural extension services play a pivotal role in the motivation of farmers towards the adoption of improved irrigation practices. The introduction of high valued crops, efficient use of water and proper use of inputs have all been deemed as significant factors for crop production and productivity. According to the survey 85.94% of the users and 15.18% of the non-users get extension service. Extension service here refers to advice, training, demonstration related to horticultural production. The chi square test indicated that there is significant relationship between access to irrigation and access to extension service at 1% level of significance.

Variables	Non-users (N=112)		Users (N=128)		Total sample (N=240)		T-value for mean difference
	Mean	st.dev.	Mean	st.dev	Mean	st.dev.	
age	46.08	11.34	48.53	12.00	47.39	11.74	1.6194
famlabor	5.27	2.24	6.48	2.30	5.92	2.35	4.1225***
dismkt	7.14	2.43	6.05	2.46	6.56	2.50	-3.4630***
livestock	5.1	2.33	7.18	2.57	6.21	2.67	6.5433***
totinc	26102.44	2918.4	56166.59	6829.15	42136.65	15957.39	43.2534***
cultland	1.4	0.77	1.74	1.00	1.58	0.913	2.8934***
dishom	4.07	1.49	3.36	1.53	3.69	1.55	-3.6354***

Table 2: Summary of descriptive statistics for continuous variables by access to irrigation
Source: Computed from own survey data
*Note: *** represent statistically significant at 1% significance level*

The mean difference between the user and non-user in terms of distance from the water source is statistically significant at 1% level of significance. The mean distance of the sample household from the water source is 3.69km with minimum of 0.5km and maximum of 7km. The mean distance of the user households from the water source is 3.36km while the corresponding figure for the non-user is 4.07km indicates that the user households have better irrigation access.

Credit either in the form of cash or kind from different sources, is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. The comparison by access to irrigation disclosed that 79.69% of the users and 32.14% of the non-users had utilized credit. although the access is equal to all households without any difference, this implies that users had better access to credit compared to non-users. The chi square test result revealed that the relationship between access to credit and access to irrigation is statistically significant at 1%level of significance. Respondents reported about problems revolving around credit were related to many factors. 8.33% of the respondents refrained from credit because of high interest rate, 12.5% because of shortage of money for down payment, 7.5% because of shortage of money for repayment, 5.42% because of its unavailability on time and 8.75% of the sample households said that they don't want credit.

Problems Related to Credit Use	Non-users (N =112)		Users (N =128)		Total sample (N =240)	
	N	%	N	%	N	%
High interest rate	18	16.07	2	1.56	20	8.33
Shortage of money for down payment	22	19.64	8	6.28	30	12.5
Not available on time	10	8.93	3	2.34	13	5.42
Shortage of money for repayment	14	12.5	4	3.13	18	7.5
Don't want credit	12	10.71	9	7.03	21	8.75

Table 3: Distribution of sample households by types of constraints faced in the use of Credit
Source: Computed from own survey data

Information on market prices and channels is one of the important aspects for livelihood improvement of rural farm households. In focus group discussion with participants it was noted that there were lack of market information directly affected farmers from obtaining a reasonable and better price for their produce. Due to lack of market information many farmers produce similar crops in similar seasons leading to a flooding of the markets with the same type of agricultural produce which in turn forced them to sell their produce at lower prices. In addition to this, market information is crucial to producers to know the price of the product in relation to its quality, to know the demand of their product (number of consumers) this helps them to adjust their way of production. Although information on marketing of irrigation products and agricultural inputs is a determinant factor for producers, only 50.42% of the sample households secure information and 49.58% didn't get information. The comparison by access to irrigation disclosed that 68.75% of the users and 29.46% of the non-users have access to information, while 31.25% of the users and 70.54% of the non-users did not get information. The percentage difference on access to information was statistically tested and it was found to be significant at1%level of significance. This revealed that there was systematic association between access to information and small-scale irrigation participation.

variables	values	Non-users (N=112)	Users (N=128)	Total sample (N=240)	χ^2-value (p-value)
Sex head	Female	43(38.39)	5(3.91)	48(20)	0.000***
	Male	69(61.61)	123(96.09)	192(80)	
Education	Illiterate	84(75)	52(40.63)	136(56.67)	0.000***
	Literate	28(25)	76(59.37)	104(43.33)	
Access to information	No	79(70.54)	40(31.25)	119(49.58)	0.000***
	Yes	33(29.46)	88(68.75)	121(50.42)	
Access to credit	No	76(67.86)	26(20.31)	102(42.50)	0.000***
	Yes	36(32.14)	102(79.69)	138(57.50)	
Access to extension	No	95(84.82)	18(14.06)	113(47.08)	0.000***
	Yes	17(15.18)	110(85.94)	127(52.92)	

Table 4: Summary of descriptive statistics for discrete variables by access to irrigation
Source: Computed from own survey data
*Note: ***and** represent statistically significant at the 1% and 5%, significance level, respectively and numbers in parentheses indicate percentages.*

3.2. Results of Probit Model for the Determinants of Small-Scale Irrigation Participation

The results of the model showed that distance of farmers' farm from the nearest market center is associated with the probability of the participation of farmers in small-scale irrigation negatively and significantly at 1% level of significance. The negative association implies that for a unitary increase in distance between the farmers' farm and the nearest market centers, there will be less chance for participation in small-scale irrigation. When farms are far from the market, the transaction cost for acquiring input and sale of output will be high and this will, in turn, reduce the relative advantage of participating in small-scale irrigation. Especially for perishable commodities if the market place is located far away from the farm, the commodity may perish before arriving the market. The marginal effect of this variable reveals that, keeping all other variables constant at their mean value, as the distance from farmer's farm to the nearest market increases from 6.56 to 7.56 kilometer, the probability of participation in small-scale irrigation reduces by6.36 percentage points. Distance of households' residence from the water source also was found to influence small-scale irrigation participation negatively and significantly at 1% significance level. The possible justification could be households who are farther to the irrigation scheme incur much cost to access their farm so they can't follow up the farm activity closely and frequently and may not get a better yield. Conversely, the nearer a household resides to a water source, the higher the probability of participating in irrigation scheme due to the fact that the opportunity cost of the time lost in travelling to and from an irrigation-farm for households located a short distance from irrigation schemes would be much lower than households located much farther. The marginal effect of this variable shows that as the distance from the farmers' residence to the water source decreases from 3.69 to 2.69 kilometer, the probability of participation in small-scale irrigation increases by 9.90 percentage points, while other variables are kept constant at their mean value. Livestock holding measured in tropical livestock unit, was found to have positive and significant effect at 1% level of significance on the probability to participation 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. Moreover, the implication of the result was that livestock are an important source of cash in rural areas to allow purchase of farm inputs that are needed to participate in small-scale irrigation. Farmers who have large number of livestock might consider their asset base as a mechanism of insuring any risk associated with the participation in small-scale irrigation. Evidence from the study area also reflects that farmers who have larger number of livestock are wealthier and have sufficient number of oxen to plough their field timely. The marginal effect shows that as the number of livestock in tropical livestock unit increases from 6.21 to 7.21,the chance to participate in small-scale irrigation increases by 5.8 percentage points, while keeping all covariates constant at their mean value.

The econometric results of the probit model confirmed that family labor force in adult equivalent was found to influence households' decision to participate in small-scale irrigation positively and significantly at 5% level of significance. The positive association implies that like other parts of Ethiopia, labor is one of the most extensively used inputs of agricultural production in the study area. A household with large labor force can participate in small-scale irrigation more than a household with small number of labor force. The marginal effect of this variable reveals that as the family labor force increases from 5.92 to 6.92, the probability of the households' participation in small-scale irrigation increases by 5.27percentage points, while keeping all other variables constant at their mean value. It is widely accepted that agricultural extension services play a pivotal role in the motivation of farmers towards the adoption of improved irrigation practices. The introduction of high valued crops, efficient use of water and proper use of inputs have all been deemed as significant factors for crop production and productivity. Moreover, farmers that have frequent contact with development agents get information on new technologies more frequently and easily. Therefore, access to extension service influences the farm

households' participation in small-scale irrigation positively at 1% significant level. The econometric result of the probit model confirmed that that those households who have access to extension service have 60.25 percentage points more chance of participation in small-scale irrigation than their counter parts, while keeping all other variables constant at their mean value. On the other hand,the discrete effect of a change from 0 to 1 in access to extension service increases the probability of participation in small-scale irrigation by 60.25 percentage points higher than their counterparts, holding other variables constant at their mean value. Sex difference of household head has influence in the participation in small-scale irrigation. Male headed household is more likely to adopt modern irrigation system than female headed household. Because females of the study area as females of elsewhere have triple burden (production, reproductive and childcare), and also they have less access to information about the technology due to the above mentioned burden than male headed household The probit model result of this study revealed that gender of household head is statistically significant at 5% level of significance and the marginal effect reveals that keeping all other variables constant at their mean value, male headed households have 46.41 percentage points more chance of participation in small-scale irrigation than female headed households keeping all other variables constant at their mean value. Access to market information is found to influence participation in small-scale irrigation, significantly and positively at 1% significant level. Access to market information helps farm households to market perishable farm products at the right time without loss of quality. Moreover, it plays a key role by providing accurate information on the demand and supply of farm inputs and outputs. The marginal the discrete effect of a change from 0 to 1 in access to information of the household increases the probability of participation in small-scale irrigation by 33.72 percentage points while keeping all other variables constant at their mean value. Credit access positively influences irrigation participation decision of households at 1% significance level. The positive relationship could be because credit helps farmers purchase inputs such as seeds, fertilizers. The marginal effect of this variable revealed that those households who have access to credit have 35.46 percentage points more chance of participation in small-scale irrigation than those households who do not have access to credit, while keeping the all other variables constant at their mean value.

Explanatory variables	Coefficient	Z	P>|Z|	Marginal effect (+)
Distance from market	-0.1645865	-2.66	0.008	-0.0636426***
Distance from water source	-0.2561372	-2.74	0.006	-0.0990435***
Access to information	0.8989766	3.25	0.001	0.3372398***
Livestock holding	0.1507195	2.99	0.003	0.0582805***
Cultivable land	0.1690745	1.23	0.220	0.065378
Gender of household head	1.247815	2.43	0.015	0.4641474**
Family labor force	0.1364162	2.13	0.033	0.0527496**
age	-0.0901137	-1.12	0.261	-0.0348453
Access to credit	0.9352274	3.45	0.001	0.3545781***
Access to extension	1.726107	5.90	0.000	0.6025183***
constant	-1.014941	-0.43	0.667	
Dependent variable	Irrigation Participation Decision			
Number of observations	240			
Log pseudo likelihood	-53.198789			
Wald chi2 (13)	108.78			
Prob > chi2	0.0000			

Table 5: Maximum likelihood estimates of the binary probit model and its marginal effect on the determinants of small-scale irrigation participation

*Source: Computed from own survey data, Note: *** and ** indicate significant at the 1% and 5% level, respectively, (+) For dummy variables the marginal effect is the discrete change of dummy variables from 0 to1, P>|z| correspond to the test of the underlying coefficient being 0. For definitions of variables*

3.3. Results of the Second Stage of Heckman Two Stage Model (OLS model)

Irrigation as one of the technology options available enables the farmers to diversify their production, practice multiple cropping and supplement moisture deficiency in agriculture. In doing so, it helps the farmer to increase production and income. The ordinary least square model indicated that irrigation influences the household total income significantly with a positively at statistically significant at 1% level of significance. The result shows that, in the study area those who have access to irrigation have the chance of producing twice or more in a year as, a result increased and stable production income and consumption. The coefficient of this variable revealed that, keeping all other variables constant, on average the total annual income of irrigation user households would be higher by Birr 29154.16 than households who do not participate in irrigation farming. livestock holding measured in Tropical Livestock Unit is found to have a positive and significant influence on income of households, and it is statistically significant at 1% level of significance. Livestock holding in tropical livestock unit contributes to total household income directly through the sale of livestock and their products, and indirectly through use as a source of draught power for crop production activities. Households with larger number of livestock particularly oxen, therefore, are likely to raise farm income for they can use other farm inputs more efficiently by bringing additional land into cultivation through either cash rent or share cropping basis. The study result revealed that, a unit TLU increase in

livestock holding would increase on average the total income of a household by Birr 1112.97,while keeping all other variables constant at their mean value. Credit solves the liquidity constraints of households and it enables the farm households to purchase farm inputs such as seeds, fertilizers timely which all makes the production and productivity of a given farm plot increases. According to the results of the study, it is significant at 1% significant level and keeping all other variables constant, on average the income of households who have access to and utilized credit would be higher by Birr 6634.95 compared to households who do not have access to credit. Land is key asset of rural farm households and this asset is a prerequisite in the productive activities for agricultural production. The study revealed that land is positively associated with household total income as expected and is statistically significant at 10% level of significance. The result discloses that, as the cultivated land size increases, the household is able to increase and diversify the quantity and type of crop produced on the cultivated land this may in turn imply increased income of the household. The coefficient of the variable also shows that as the household gets one more hectare of land on average the total annual income of the households' increases by Birr 1274.74 keeping all other variables constant at their mean value. The ordinary least square result confirmed that there is a positive relationship between access to extension service and household income level at 5% significant level. The positive relationship indicates that in the study area, those households who get technical advice, training or those who participated on field demonstrations are well aware of the advantage of agricultural technologies and willing to adopt new technologies and produce more, thereby improving the household level of income. 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 4371.16 compared to households who do not have access to extension service.

Explanatory Variables	Coefficient	P-value
constant	28003.41	0.000***
Livestock	1112.968	0.000***
Distance to market	-60.332	0.768
Cultivated land	1274.743	0.061*
Education	296.441	0.429
Access to information	1032.005	0.405
Access to irrigation	29154.16	0.000***
Sexhead	6835.594	0.010***
Family labor force	192.460	0.361
Age	284.549	0.264
Access to credit	6634.947	0.000***
Agesquare	-2.841	0.272
Access to extension	4371.16	0.016**
Lambda	-3028.899	0.035**
Dependent variable	household total annual income	
Number of observations	240	
Censored observations	112	
Uncensored observations	128	
Wald chi2 (24)	103.66	
Prob > chi2	0.0000	

Table 6: Heckman two stage estimates for the outcome equation
Source: Computed from own survey data
*Note: ***, **, and * indicate statistically significant at the 1%, 5%, and 10% level, respectively*

3.4. Conclusions and Policy Implications

Utilization of irrigation increases the opportunity for crop intensity and diversification, which increase agricultural production and income. Irrigation user households have significantly larger mean annual income as compared to irrigation non-user households. Having access to irrigation had significantly improved the living standards of farming households. Market information plays a significant role in small-scale irrigation participation and enhancing total income. Farm households that have access to market information are able to know the price of the product in relation to its quality, know the demand of their product (number of consumers) this helps them to adjust their way of production. Moreover, purchasing of the right input at the right time from the right enterprise and supplying of the products to the right customer with a reasonable intermediary cost is possible when there is market information. However, farm households may constrain a working capital for better production, transporting and processing as irrigation intensifies labor and input. Hence, Credit either in the form of cash or kind from different sources, is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. This saves livestock from sale and land from rent out or shared out, at uncertain seasons. Moreover, a household with larger size of active labor force in adult equivalent induces income from on/off or nonfarm livelihood activities and reduces the expenses for labor that adds to the total income. As active labor force of the household increases, the dependency ratio and power constraint decreases. On the other hand, family labor problems can be solved and replaced by the livestock owned, serves as a source of income and draft power. Wealth of households also determined by the livestock, owned mainly oxen. Therefore, networking households with customers through

information sources such as mobile and telephone service is a determinant factor. Formation of self-help cooperatives and saving and credit associations in rural areas also bridges producers with their clientele solving the working capital deficiencies. It is crucial the introduction and promotion of labor saving technologies through labor multiplication as a replacement of human labor for households with shortage labor for intensive production.

5. References

i. Asayehegn, K.,(2012).Negative impact of small-scale irrigation schemes: A case study of Central Tigray regional state, Ethiopia. Agricultural Research and Reviews Vol. 1(3), pp. 80 – 85.
ii. Asfaw, D., (2007). Scaling up Agricultural Water Development in Africa, the Case of Ethiopia: Minister of Water Resources, Federal Republic of Ethiopia Australian Journal of Agricultural and Resource Economics, 49: 159–175.
iii. Awulachew, S.B., Merrey, D.J.; Kamara, A. B.; Van Koopen, B.; De Vries, F. Penning; and Boelle, E. ,(2005). Experiences and Opportunities for Promoting Small-Scale/Micro Irrigation and Rainwater Harvesting for Food Security in Ethiopia. IWMI Working Paper 98, 2005.
iv. Belay, K., Degnet, A., (2004). Challenges Facing Agricultural Extension Agents: A Case Study from South-western Ethiopia. African Development Bank, Blackwell Publishing Ltd, Oxford, UK.
v. BoWRD (Bureau of Water Resources Development of Amhara) (2005). Water harvesting, regional irrigation, land and water inventory report. Volume II. Cambridge and London.
vi. CSA (Central Statistics Agency) (2007). Summery and statistical report of 2007 population and housing census of Ethiopia: Population size by age and sex [internet][cited 2012 Dec 29]. Available from: http://www.csa.gov.et.
vii. GoE (Government of Ethiopia) (2007). Climate Change National Adaptation Programme of Action (NAPA) of Ethiopia. Ministry of Water Resources and National Meteorological Agency, June 2007.
viii. Haile, T., (2008). Impact of irrigation development on poverty reduction in Northern Ethiopia. PhD thesis, National University of Ireland, Cork.
ix. Heckman, J., (1979). Sample selection bias as a specification error. Econometrica. 47(1):153-162.
x. MoARD (Ministry of Agriculture and Rural Development) (2010). Ethiopia's Agriculture Sector Policy and Investment Framework: Ten-year Road Map (2010-2020).
xi. MoFED, (2007). Annual Report on Macroeconomic Developments for 2006/07, Addis Abeba, Ethiopia.
xii. MoWE (Ministry of Water and Energy) (2011). Water and Development quarterly bulletin 5. MWR: Addis Ababa.
xiii. Spielman D., Byerlee D., Avid J., Alemu D., Kelemework D., (2010).Policies to promote cereal intensification in Ethiopia: The search for appropriate public and private roles, Food Policy, 35: 185-194.
xiv. World Bank, (2006). Ethiopia: Managing Water Resources to Maximize Sustainable Growth. A World Bank Water Resources Assistance Strategy for Ethiopia. Washington DC: World Bank.
xv. World Bank, (2010). Ethiopian Agricultural Growth Project. Project appraisal document. Addis Ababa: Ethiopia.
xvi. Zhou Y, Zhang Y, Abbaspour CK, Yang H, Mosler J. H., (2009). Economic impacts on farm households due to water reallocation in China's Chaobai Watershed [Internet]. [cited 2012 Dec 21].Agricultural Water Management 96(2009) 883-891.Available from: http://www.syngentafaundation.org.