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Effect of Small Scale Irrigation on Improving Household Income: The Case of Hembecho Irrigation Scheme in Boloso Sore Woreda, Wolaita Zone, Ethiopia

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ABSTRACT

Small scale irrigation is an important strategy in reducing risks associated with rainfall variability and increasing income of rural farm-households. The objective of this study is to analyze and compare the effect of irrigation on income between the different types of smallholder irrigated and non-irrigated farms in the Boloso Sore District of Wolaita Zone, Ethiopia. The data was collected form ***171*** *household heads (composed of* ***77*** *Irrigation users and* ***94*** *Non-users) using both purposive and stratified random sampling methods. Both descriptive and econometric data analysis techniques were applied. In the econometric analysis the effect of small scale irrigation on household income was analyzed by using the Heckman two-stage procedures. The descriptive study shows significant difference in the annual income between Users and Non-users. The result of the econometric model reveals that in the first stage of the Heckman two-sage procedures the variables that are found to determine participation decision in irrigation are: household size, education, and land size, access of credit, frequency of extension, tropical livestock unit, dependence ratio, and oxen. The result of the second Stage Heckman model are: level of education, access of extensions, access of information, input use, distance from residence to market, tropical livestock unit. And the Inverse Mills ratio was found to determine household income. The findings imply that, in the study area, small-scale irrigation development is crucial in improving the livelihoods of the rural farm households. Without provision of the necessary supporting equipment' and materials, adequate supply of improved input technologies and proper skills in the management of small-scale irrigation schemes, the benefits from irrigation become low. Thus, special attention should be given to community irrigation schemes in the study area, so that they can fully benefit from the resources available to them and improve their performance and income.*

KEY WORDS: *Household income, Heckman Two Stage Model, Small Scale Irrigation*

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I. Introduction

Ethiopia is the second most populous country in sub-Saharan Africa and third in the continent with an estimated population of Ethiopia is 112, 078,730 as of December 30, 2019, (Ethiopia Economic Association, 2019, World Population Review). Agriculture is the mainstay of the country's economy in terms of income, employment and generation of export revenue. Agriculture's contribution to Ethiopia's gross domestic product (GDP) remains high at approximately 44% and employing about 84% of the labour force (DFID, 2002). The sector heavily depends on rainfall, and its production and productivity are strongly influenced by climatic and hydrological variability reflected in dry spells, droughts and floods. Smallholder subsistence farming, using traditional modes of production, is dominant and accounts for over 90% the agricultural output (MoWR, 2009).

Heavy reliance on rain-fed agriculture during conditions of very variable rainfall and recurrent drought affects agriculture and thus adversely affects the country's economy. In 2006 the World Bank estimated that hydrological variability coasted the economy over one third of its growth potential and had led to a 25% increase in poverty rates. Thus, Irrigation contributes to livelihood improvement through increased income, food security, employment and poverty reduction. To this end, Hussain and Hanjira (2004) confirmed a strong direct and indirect linkage between irrigation and poverty. Direct linkages operate through localized and household level effects, whereas indirect linkages operate through aggregate or sub-national and national level impacts. Irrigation benefits the poor through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns, and to switch from low value staple production to high-value market-oriented production. Increased production makes food available and affordable for the poor. Therefore, enhancing irrigation investment development has been identified as one of the core strategies to delink economic performance from rainfall, and thus to enable sustainable growth and development (MoFED, 2006 and World Bank, 2006).

At the same time as, such irrigation intervention activities are particularly important, maximizing return to investments equally require improvements in access to appropriate technologies, market, supportive services and efficient institutional arrangements for effective and sustainable irrigation management systems. These knowledge gaps that exist regarding the maximization of benefits to smallholder irrigation farms in the study area in particular and in the country in general should be filled.

The various empirical studies undertaken in Ethiopia have extensively examined the factors that influence adoption of a particular technology, efficiency or income in a selected locality. Most of them are on rain-fed system. Some irrigation studies are focused only on its poverty impact (Fitsum and Holden, 2003, Gebrehaweria, *et al*., 2009). Others mention about its impact on efficiency as an outcome of other studies (Hussien, 2006). However, Limited attempts have nevertheless been made to study the effect of irrigation on household income, to compare the level of efficiency and income among irrigated and non-irrigated farms simultaneously.

In line with the government's huge plan of irrigation development throughout the regions, *a* priori information on the performance of existing irrigation schemes is a problem to be researched. In this regard, investigation on the performance of the existing small-holder irrigation schemes with farming systems is paramount important. Besides, in order to provide empirical insight as to how to optimize productivity and income effect of such schemes in the study areas of the country is necessary to examine the effect of irrigation on income of the households.

II. Methodology

2.1. Description of Study Area.

Boloso Sore District is one of the 12 Districts in Wolaita Zone, Ethiopia. Based on the 2007 Population Census conducted by the CSA, this District has a total population of 197,973, of which 96,392 and 101,581 are men and women respectively. The economic activities of the District are based on agriculture and the major crops that are cultivated in the Districts are teff, maiz, and sweet potato. The cash crops are coffee; ginger. The study area has three agro-climatic zones: highland altitude (Dega), mid altitude (WoinaDega) and low land altitude (Kolla). The average monthly temperature varies between 24^0C and 26^0C. The maximum rainfall it receives is from June to September and it is 1200mm to 1300mm.The study Kebeles are located in the Kolla agro-ecology. There are three main rivers that are crossing some parts of district cultivable land used to irrigation purpose. The Rivers are Woyibo, Tiyo and Koyisha Rivers and there are 3 main irrigation schemes in the district which are irrigated from these rivers. On these schemes farmers are using by modern and traditional method. This study area focuses on three SSI schemes namely Matala Hembecho, Tiyo Hembecho and Gurumo koyisha irrigation schemes. Totally in the District, from three different rivers which are crossing different villages, about 4,751hectars (ha) of farm land is producing maize, tomato, teff, head cabbage, ginger sweet potato. The totally 23,755 households have been beneficiary from these irrigation schemes.

2.2. Data and Data Collection Methods

Both primary and secondary data sources were used for the study. The primary data was collected using interview schedule that covered crop production, water application input use, prices of inputs and outputs, information on land and livestock holding, equipment's possession, and other Institutional, socioeconomic and demographic characteristics of households from both groups of farms. The interview schedule was pre-tested on 20 sample households. The secondary data were collected from literature and from District and zonal development offices, Agricultural Research Center. Prior to the final administration of the interview schedule, two experienced enumerators who participated in the interviews were properly trained on the objectives and contents of the interview schedule.

2.3. Sample size determination and Sampling Techniques

Purposive, stratified and systematic random sampling methods were used to select the district, villages and samples of farm households respectively for the current investigation.

Firstly, Boloso Sore District from Wolaita Zone was selected purposively in consultation with Woaita Zone Agricultural Development Department. Secondly, the villages (the lowest administration units), were selected on the basis of the list of villages with irrigation access in the District. The concerned office had provided the list and three villages from each were selected on the basis of having higher numbers of beneficiaries' smallholder irrigation schemes. Thirdly, the investigator had conducted the inventory of small-scale irrigation management system that existed in each of the selected village namely Matala-Hembecho, Tiyo-Hembecho and Gurumo-Koysha. Then stratified random sampling procedure was used to select irrigation users and non-users. To determine the sample size Probability proportionate sampling technique was employed to determine 171 households. Lastly, systematic sampling procedure was used to select sample households without replacement techniques. The study was applied a simplified formula provided by Yamane (1967), statistically estimated at 93% confidence level; degree of variability = 0.07.

$$n = \frac{N}{1+N(e^2)} = \mathbf{171} \qquad (1)$$

Where n is the sample size, N is the total household size in the three schemes, and e is marginal error (7%).

Table-1 Distribution of Samples by Village

Sampled Kebeles	Scheme Name	Irrigation		Total	Sample		
		Users	Non- users		Users	Non Users	Total
Matala	Hembecho	266	257	523	42	42	84
Tiyo	Hembecho	113	97	210	18	16	34
GurumoKoysha	Hembecho	101	223	324	17	36	53
Total		**480**	**577**	**1057**	**77**	**94**	**171**

Source: Own survey , 2019

2.4. Methods of Data Analysis

Two types of data analysis methods, namely descriptive statistics refers to the use of ratios, percentages, means and standard deviations. Chi-square and t-test were used in the process of comparing socio economic, demographic and institutional characteristics of households. The econometric analysis employed the Heckman two- step procedure to identify the factors that affects the participation and the effect of small scale irrigation on household income. The general hypothesis of the modeling approach is that shown area of particular irrigation is linked directly to the farmers' decisions on participation choices for irrigation scheme. Irrigation users make their decisions on participate in the context of their own strategies or rules, which affect the conversation of non- users of irrigation to users in its current condition.

2.5 Estimating the Degree of Income Diversification (Simpsons Index of Diversity)

The Simpsons Index of Diversity (SID) is used in this study to estimate the degree of income diversification among farm households in the Western Region. The SID takes into consideration both the number of income sources as well how evenly the distributions of the income between the different sources (Minot *et al*., 2006). This reason justifies the choice of the SID as applied in this study over other measures of diversification such as the Herfindahl. The SID ranges between Zero (0) and One (1). Thus, 0 denotes specialization and 1 the extremity of diversification. The more the SID value is closer to one, the more diversified the household is.

The SID general formula is given as: $\mathbf{SID=1-\sum_{i=1}^{n} Y}$ **(2)**

Where, SID=Simpsons Index of Diversity, n=number of income sources, I=Proportion of income coming from the source i, the value of SID ranges from Zero (0) to One (1), however, if there is only one Source of Income, Pi=1, then SID=0.

The Mean of Income Shares approach was used to estimate the income shares obtained by the farm households in the Western Region of Ghana. This approach estimates the shares of incomes at the individual household level by finding the share of each income source in THI for each household. The mean share for each income source for all households is then found. The general Mean of Income Shares formula is given as:

$$\mathbf{MIS} = \left(\sum_{k=0}^{n} \mathbf{yih} / \mathbf{Y} \right) / n \qquad (3)$$

Where *i*= the income source, *Y*=Total Income, *y*= income from particular activity,
h=the household, *n*= the number of households. Equation (3) is applied in this study as:
The sum of Total Household Income (THI) is given as:

$$\mathbf{THI=\sum_{i=1}^{n} Yi} \qquad (4)$$

Where: THI=Total Household Income, thus income coming from all sources *i*
i=1, 2, 3, 4….9, farm and Non-farm income.

(a) The mean Share of Farm Income (SFI) is given as:

$$\mathbf{SFI} = \sum \left[\frac{\sum fci / thi}{n} + \frac{li / thi}{n} + \frac{nri / thi}{n} \right] \qquad (5)$$

(b) The mean Share of Non-farm Income (SNFI) is given as:

$$\textbf{SNFI}=\sum\left[\frac{\sum cci/thi}{n}+\frac{li/thi}{n}+\frac{nri/thi}{n}\right] \qquad \textbf{(6)}$$

Where, *sfi*=share of farm income, *snfi*=share of Non-farm income, *thi*=total household income, *fci*=food crop income, *cci*=cash crop income, *nri*=natural resource income, *livsti*= livestock income, *fwi*=farm wage income, *nfwi*=Non-farm wage income, *sei*=self-employment income, *rei*=remittance income, *othersi*=other sources income, *n*=number of households. The first equation (i.e., the selection or participation equation) attempts to capture the factors governing membership in a program. This approach involves estimation of a probit model for participation equation, followed by the insertion of a correction factor-the inverse Mills ratio, calculated from the probit model - into the second 2SLR model of interest. If the coefficient of the inverse Mills ratio is significant then the hypothesis that the participation equation is governed by an unobservable selection process is confirmed. However, if its coefficient is insignificant, 2SLS estimates can safely be used for the model. Thus, irrigation participation equation (selection equation) can be specified as follows (Greene, 2003; Heckman, 1979 and Wooldridge, 2009):

(a) First, a Probit model for participation decision or selection equation is estimated.

Probability equation $\mathbf{P_i^{*} = \beta_1 X_{1i} + \mu.\ \ \mu i \sim N(0,1)}$ **(7)**

where P_i^{*} is index, latent variable for participation in irrigation whereas X_{1i} is a vector of variables that affect participation decision, the vector X_1 is assumed to contain all variables in the vector X_2 plus some more variables (unless otherwise stated); and u_i is an error term.

Threshold index equation**:** $\mathbf{P=1 \text{ if } \begin{cases} P > 0 \\ 0 \text{ if } Pi^{*} < 0 \end{cases}}$ **(8)**

Where, Pi = 1 if D i is observe and zero otherwise.

(b) Level of participation decision:

$$\mathbf{Y_i = \sum_{i=1}^{n} \beta_i X_{xsi} + \varepsilon i} \qquad \textbf{(9)}$$

where yi is observed only if Z*i>0 and the disturbances $\boldsymbol{\varepsilon_i}$ follows a normal distribution with zero means and constant variances and covariance's which is uεσ . Where,**yi** = the observed value of household income, **χsi** = s variables determining household income, **βs** = vector of unknown parameters of the household income and **εi** =error term.If only the households who participate in irrigation are included in the second step, the IMR was computed as follows:

$$\boldsymbol{\lambda = \left(\frac{\phi(X_{1,}\alpha)}{\Phi(X_{1,}\alpha)}\right)} \qquad \textbf{(10)}$$

Where denotes IMR, ϕ is the normal probability density function (PDF), Φ (.) is the standard normal cumulative density function (CDF), $X_1$is a vector of factors known to influence a household's decision to participate. A significant coefficient of the λ indicates that the selection model must be used to avoid inconsistency. Then, the new λ is used in Equation (11) as an explanatory variable. If ρ = 0, then there is no evidence of the selection bias and the regression reverts to OLS. When ρ≠0, standard regression techniques applied to the first equation (9) correlated with X_1, yield biased results, which is corrected by including IMR in the second regression. It can be shown that the expected value of SID_i^{*} when SID is observed which is given by Equation (13). The new equation for the second stage regression (level of crop choice or diversification) equation is then given by:

$$\mathbf{E(D_i \backslash X_1, Pi=1) = \beta X_2 + \rho\, \lambda(\delta X_1) + \upsilon_j} \qquad \textbf{(11)}$$

Where E is the expectation operator, D_i is the extent (continuous) of participation in the program (Simpson index of richness), X_2 is a vector of independent variables that will affect D_i and β is the vector of the corresponding coefficients to be estimated, *ρ*is the correlation between unobserved determinants of probability to participation and unobserved determinants of level of participation in the program υ, δis a vector of unknown parameters. Equation (11) gives the expected level of participation in the program SID_i, given vectors of observable factors X_2 and given that the household has already made the decision to participate. This can be explained by vector of observable characteristics X_2 and the IMR evaluated at $\lambda(\delta X_1)$. To the extent that $\lambda(\delta X_1)$ is correlated with X_2, the regression equation (11) resulting estimates will be biased unless ρ = 0.

Table 2: Hypothesized variables and their expected signs

Variables	Type	Measurement	Sign
AGE	Continuous	Age in years	-
DR	Continuous	No. of dependent persons in HH (>65 and <15 yrs)/	-
HHSI	Continuous	Household size in number	+
EDUC	Categorical	1=illiterate,2=1-4,3=5-8,4=9-12,5= above 12	+
TLU	Continuous	Tropical Livestock Unit	+
SIZLAN	Continuous	Land size in hectare.	+
ACCRID	Dummy	1= Access credit, 0=Otherwise	+
OXEN	Continuous	In numbers	+
SOIFER	Dummy	Perception in soil fertility(takes 1= if fertile 0=otherwise)	+
ACCEX	continuous	Number of extension contact infrequency.	+
AINFO	Dummy	Received information service(1= yes, 0= otherwise)	+
DISMAR	Continuous	Distance from the main market measured by km	+
IU	Dummy	Using improved seed (1=user, 0=otherwise)	+

III. Results and Discussion

Age of the household heads (AGE): The average age of users and non-users were 56.49 and 58.79 years with standard deviation of 8.24 and 7.26 respectively. From the statistical analysis performed, there was statistically significance mean difference in age of the HHs head between users and non-users at less than 10 % probability level. (t = 1.93, p=0.055). (Table 3)

Household Size (HHSI): The average family size of the user and non-user on the study area was 5.37 and 4.80 respectively. Households with larger family size can perform different agricultural activities than their counterpart's households with small family size. The t- test result shows a significant mean difference in household size between the users and non-users at less than1% probability level (t= 3.59, P=0.000).

Dependency ratio (DR): Having higher economically active labor force is paramount important especially for the labor intensive irrigation farming. According to (OBPED, 2007), the economically active family labor force is (15-64 years of age). Thus, for the total sample households the mean of users family labor was 0.43 and the non-users family users was 0.37. The t- test result shows a significant mean difference in dependency ratio between the two groups at 5% probability level. (t=2.48; p=0.014).Table 3.

Livestock holding (TLU): The total sample of Tropical Livestock Units (TLU) was approximately 4.02 (ranging from 1.54 to 6.20).The highest livestock holding 6.20 (TLU) was that of irrigation users farms. The t-test result shows that significant mean difference in livestock holding between the irrigated users and non-users farm at 1% probability level. (t= 5.52; P=0.000).Table 3.

Oxen power (OXEN): On the average, individual sample households had about 1.29 oxen. Referring to the ownership of the two groups of sample households, irrigation users and non-user had about 1.59 and 1.04 oxen respectively. The survey result indicates that about 1.3% of irrigation users and 20.21% of non-users did not possess any oxen, while those owning only one ox constitute 37.66% of irrigation users and 55.32% of non-users. This shows that non-users have less access to draught oxen power as compared to users in the study area. The most widely used method of overcoming shortage of oxen was exchange of labor for oxen, pairing oxen with others, borrowing oxen from relatives and hiring oxen. The t- test result shows that significant mean difference oxen power between the irrigation users and non users at 1% probability level (t=5.94; P= 000).

Distance to market (DISM): The smaller distance to the town may help irrigation users to access the market administration and technical support. As it was indicated in the Table 3 there was significant difference in the average distance between village and town for users and non users of irrigation. The mean distance of the market ranges from 2.55km for users and 2.57km for non users. The t- test result shows that the mean difference in market distance between the two groups was insignificant (t= 0.34; P= 0.71). Table 3.

Agricultural extension service (ACCEX): Agricultural extension service refers to advice, training and demonstration of agricultural techniques provided to farmers to transform the traditional agricultural practices to modern system. The mean agricultural extension services level of the irrigation and non-irrigated housed were 2.69 and 2.28 respectively. The t- test shows that significant mean difference in frequent access to extension service between users and non users at 1% probability level. (t= 5.85; P= 000). Table 3.

Table 3: The Mean of Irrigation users and non-users by sampled households

Variables	Users (n=88)	Non-users (n= 52)	Total (n= 140)	t-value
	Mean (SD)	Mean (SD)	Mean (SD)	
AGE	56.49(8.24)	58.79(7.26)	57.75(7.78)	1.93*
HHSI	5.37(1.04)	4.80(1.02)	5.0(1.06)	3.59***
DR	0.43(0.13)	0.37(0.15)	0.40(0.15)	2.48*
TLU	4.89(1.03)	3.15(0.83)	4.02(1)	5.52**
SIZLAN	0.38(0.20)	0.30(0.15)	0.34(0.18)	2.67**
OXEN	1.59(0.51)	1.04(0.67)	1.29(0.66)	5.94***
ACCEX	2.69(0.46)	2.28(0.0.45)	2.46(0.50)	5.85***
DISMA	2.55 (.52)	2.57(0.38)	2.56(0.45)	0.34

Source: Household Survey (2019)

Access to credit services (ACRID): In the study area 72.7 % of irrigation users have access to credit while 27.3 % of them have not access to credit. From the sampled household, about 60.23% get access to credit and the remaining 39.77% did not get credit in the survey season. The reason for those who did not get access to credit include lack of collateral (21%), high cost of credit (40%), no need of credit (35%) and lack of access to credit (5%). The chi square -test result of access to credit shows the two groups statistically significant association at 5% probability level ($\chi 2$ = 9.12, p=0.030). Table -4

Educational status of household(EDU):Table 4 shows that 38.6% are illiterate while the remaining 19.8%, 22.8 %, 12.2%, attended grade 1-4, junior and secondary high school respectively. Non-users had less access to education as compared to irrigation users in the study area. The t- test result shows a significant mean difference in educational level of households between the users and non-users at 1% probability level. ($\chi 2$ =13.83; p=0.000).

Access to Information (AINFO: The information provided in the study area was TV and Radio. Information accessed households in the study area were about 36.2% whereas 63.8 % had not. Both users and non-users of irrigation who got information attend at the same rate 22% every day. The chi square result reveals that irrigation users and non-users had statistically significant association at 5% probability level. ($\chi 2$ = 2.64 p= 0.04). Table -4

Input use of the households (IU): In the study area there is service cooperative union and agricultural office are jointly working in providing farm inputs specially improved seed. The agricultural office plays a role in proposing the demand and distribution of inputs to rural farmers, and the union plays a role in providing the inputs and credit. About 69.1 % of irrigation user use improved inputs while only 30.9 % of users do not use agricultural inputs. Similarly 63.9 % of non-users of irrigation use input and 36.1% of them did not use. The chi-tests indicate that there was significant association between agricultural input utilization and access to irrigation at 5 % probability level. ($\chi 2$ = 9.12, p=0.003) .Table-4.

Household's perception on soil fertility (SOIFER): Farmers have experience of ranking fertility level of their farmland. Group discussion with the farmers revealed that they categorize their farmland in to fertile if it is easily ploughed, has good water holding capacity and give better yield. On the contrary farmers classify land as infertile if the soil is hard to plough, has sandy and rocky texture, and has poor water holding capacity. And also they classify as medium based on yield and plough in between the former and the lateral. Based on farmers' soil fertility perception, about 46.89% and 53.21% of their soil is medium, and fertile, respectively. Fertile soil may encourage farmers using irrigation due to its better ability to produce more. It was found that there are no statically significant difference b/n irrigation users in terms of fertile land, compared to non-users of irrigation. The chi -test result reveals the two groups were statistically insignificant association at 5% probability level. ($\chi 2$ = 3.390, p=0.06). Table 4.

Table -4: Access of information, credit input use and perception of soil fertility

Variables		Users (n= 77)	Non-users(n= 94)	Total(n=171)	$\chi 2$ -value
		Freq (%)	Freq (%)	Freq (%)	
AINFO	Yes	33(42.9)	29(30.9)	62(36.2)	2.64**
	No	44(57.1)	65(69.1)	109(63.8)	
ACRID	Yes	56(72.8)	47(50)	103(60.2)	9.12**
	No	21(27.2)	47(50)	68(39.8)	
INPU	Yes	65(69.1)	60(63.9)	125(71)	9.12**
	No	12(30.9)	34(36.1)	46(29)	
SOIFER	Fertile	35(45.46)	56(59.57)	91(53.21)	3.39**
	No fertile	42(54.54)	38(40.43)	80(46.79)	

EDUC	Illiterate	27(35)	39(41.45)	66(38.6)	13.83***
	1-4	13(17)	21(22.34)	34(19.88)	
	5-8	19(24.7)	20(21.27)	39(20.74)	
	9-12	8(10.4)	13(13.9)	21(12.28)	
	Above 12	10(13)	1(0)	11(0.06	
	Total	77(100)	94(100)	171(100)	

***, ** and * indicates 1%, 5% and 10% level of significance respectively;
Source: own computation from survey data, 2019

Crop income: Total cropping income is the amount of mean annual income of a household obtained from both types of cropping systems. The mean annual income of a household from cropping income in the sample households was ETB 26,638.5. This shows that the total mean annual cropping income of irrigating users (36,111) was substantially higher than that for non-irrigating users (Birr 17,166). The t-test shows that there was a significant mean difference crop income between irrigated users and non-users households at 1% probability level. Table-5

Livestock income: Livestock are the most important productive assets in the household. In the study area, livestock are important source of power for plough, transportation, and riding. Livestock also consolidate the social organization as they serve in payment for blood compensation and gifts for relatives. They play role in religious and cultural ceremonies and serve as source of prestige. It also considered as a saved asset used during periods of food shortage. The average livestock holding for sample households was 6,682.5. Irrigating users possess a larger average number of livestock (7,232) than non-irrigating users (6,133). There was a significant mean difference between irrigated and non-irrigated users at 1% probability level (Table 5).

Off-farm income: Off- farm income is an important part of total income in rural households of Ethiopia. They are significant for purchasing power and house hold income. Petty trading was one source of off-farm income in the study area. The sources of off-farm income in the area other than weeding and harvesting seasons were sale of wood, sale of local drinks (tela), renting of irrigable lands, artisan (blacksmith, weaving and pottery), brokering, sale of wood (charcoal), house rent and remittance. Irrigated user households also get off-farm income from the rent of water pump and houses rent in the area. Water pumps were rented on average for ETB 12.50/hour. The average off-farm income for sample households was ETB 1900. The total mean annual household off farm income in the study area was ETB 35,221 which is roughly equal to the average lower class household per capita income for Ethiopia as a whole. The total mean annual income of a household, cropping contributes the highest income share (75.63%) followed by livestock (19%) and off-farm (5.37%), respectively. (Table 5)

Size of cultivated area and cropping pattern: land is a limiting factor to production, its supply being fixed. In the study area, the average cultivated land of the total sampled farmers was 0.34 hectares per household, ranging from 0.13 ha to 0.75 ha. The study area is well known for local-market vegetable production. Vegetables like ginger, onion, tomato, pepper and cabbage are some of the crops produced by irrigation farmers, while crops like maize and teff are mainly produced by rain-fed farmers. Some farmers in the area cultivate perennial crops like banana and papaya, often in their back yards. The t- test result shows that significant mean difference in size of cultivated area and cropping pattern between the irrigated and non irrigated farmers at 1% probability level. (t=2.67; p=0.008) Table-5

Table 5. Sample households' source of farm income (%)

Characteristics	Users (N=77)	Non-users (N=94)	Total(N=171)	%	t-value
Crop income	36,111	17,166	26,638.5	75.63	7.7***
Livestock income	7,232	6,133	6,682.5	19	5.52***
Off-farm income	1500	2300	1900	5.37	-0.45
Total income	44,843	25,599	35,221	100	7.6***

*** indicates significant at the 1% significance level.

IV. Econometric Analysis Results

The Heckman-Two-Step approach considered the Probit estimate likelihood of irrigation participation, whether the farmers participated(decided to participate) on irrigation or not as a first step and the second Stage Linear Regression (2SLR) estimate was made for the level of income as the second step. Soundness of the model was established by Wald test. The chi-square of the model regression in the study area indicated overall goodness of fit (showing a strong explanatory power) of the model with statistical significant at a probability of one per cent. The Wald test of the regression $\chi2$ (13) = 121.44 confirmed that the coefficients of the level of participation equation was significantly different from zero. As a result, it can be concluded that the model fulfilled conditions of good fit. The probit model's estimates underlying the Heckman-Two-Step estimation procedure. The table clearly shows the binary dependent variable: one (1) if the household participated in irrigation and zero (0) otherwise. Eight variables significantly explained the probability of participation on irrigation. These are household size **(HHSI)**,Land size (**LANSI**),access of credit(**ACA**),access of extension(**AES**), tropical livestock unit (**TLU**), dependence ratio (**DR**), oxen (**OXEN**) and education(**EDUC**). In addition, the effect of irrigation represented by Simpson index, which was significantly determined by level of education **(EDUC)**, access of extensions**, (ACCEXT**). Access of mass media (**AINFO**), input use (IU), distance from residence to market **(DFRM)**, and tropical livestock unit **(TLU).**The model results were discussed below.

Household size (HHS): As contrary to expectation, family size was negatively and significantly correlated with the likelihood of participation decision in irrigation project at 1% probability level. The partial effect indicated that as the family size increased by one unit the probability of participation decision in irrigation project of the households decreased by25.28%. This justifies managing a large family requires a substantial financial commitment and in times of economic hardship this may make farmers with more households more risk averse and less likely to choose participation decision. This result is in conformity with the findings of Tesfaye L., (2003), and Mesfin (2010).

Size of cultivated land (LANSI): As expected, size of cultivated land was positively and significantly associated with the decision to participate in irrigation at less than 5% probability level. Implies that households with larger cultivated land also own more plots spatially distributed over various locations difficult to exploit the agricultural potential of the area in irrigation use. All other factors held constant, the marginal effect indicates that, a one hectare increase in cultivated land size, the probability of participating in irrigation project increased by 65.61 percent.This result is consonant with the findings of Tesfaye L., (2003) and Mesfin (2010).

Access to credit (ACRID): Access to credit service had positively and significantly associated with the decision to participate in small scale irrigation at less than 5percent probability level. The positive relationship indicates that access to credit service might encourage households to decide in irrigation participation because they can afford input and labor costs of their farm activity. Other things being held constant, the marginal effect suggest that one unit increase in credit access enhances household likelihood to participation irrigation project by 34.6 percent. The result is consistent with Tafesse (2007).

Extension contact (ACCEXT): extension contact had significant effect on farmers' participation decision and level of participation in irrigation at less than 1% probability level. Extension service is one of the major sources of information to use irrigation technology. It is through extension services that the farmers get training on advantages, practice and characteristics of all aspect of modern agricultural technologies. Moreover, extension service widens the household's knowledge with regard to use of improved variety of seed, cultural practices and other agricultural technologies has positive impact on household farm income and decisions for irrigation water use to increase production and productivity. Therefore, farmers who have better access to extension services have better awareness and are more likely to use irrigation water than those who do not have access to extension service. Similar result was reported by Abonesh (2013), Tafesse (2007), and Takele (2008). The marginal effect of the extension contact reveals that aunt increase in extension contact would leads to increase participation decision and level of participation by 40.18% and 0.07 respectively.

Tropical Livestock Unit (TLU): participation decision and level of participation of the households was significantly and positively affected by the number of livestock ownership at less than 1% and 5% probability level respectively. The marginal effect indicates that as the households' livestock unit increases by one TLU, the probability of participating in irrigation decreases by 25.52% and 2.8% respectively of household participation decision and level of participation. This suggests that the households' livestock units are often considered as a proxy for wealth or risk bearing as they may invest resources in livestock activities. In other words, the households may prefer more livestock as a risk coping mechanism. This survey result, however, contradict earlier findings by Haji (2003), Mesfin (2005), Abonesh (2013), Yenetila, (2007).

Dependency ratio (DPRATI): Dependency ratio is positively significant at 1% probability level. The result indicated that an increase in family size, whose members are more of inactive labor force, increases the number of dependent family members. The increase in dependent family members causes shortage of labor force to accomplish agricultural activities including irrigation farming. This condition of the family in return decreases the supply of enough income for a household and its members. Consequently the households' ability to be income becomes less. The marginal effect shows that a one unit increase in dependency ratio results increases of level of participation by about 57.5%. This result is consistent with prior results reported by Ngiggi (2003), and Tesfaye L., (2003).

Oxen power: - As expected, oxen power positively and significantly affected by participation decision at less than 1% probability level. Keeping all others variables held constant, the partial effect indicated that an increase in the number of ox by one led to increase the probability of participation decision on irrigation by 32.64percent. This justifies that animal power may increase the size of land cultivated with a given amount of labor and other inputs. In addition, the informal survey verified that if the households have more oxen, they will perform farming activity timely and properly. Even if they face land shortage, more oxen owners can rent in land to produce multiple cereal crops.

Education (EDUC) - Education had positively and significantly related with participation decision and level of participation at less than 5% and 1% probability level respectively. The marginal effect of the variable shows that a unit increase educational level would lead to increase participation decision and level of participation by 53.12 percent and 0.012 respectively. The implication is that the higher a farmer's educational attainment level is in the better his/her access to various farm technologies, input and output market, and to collect constructive information from peers. Thus, an increase in levels of educational attainment, therefore, is one of the most important factors in improving the technical efficiency of farms. Similar findings were also reported by Munir *et al.,* (2009) among others.

Access to information (AINFO): This variable was found significantly and positively affecting level of participation at 10% level of probability. The marginal effect of the variable also shows that a one unit increase in access of information from different source results increase about 5.1 % on the intensity of improved irrigation technology use. This implies that having a TV and radio may increase the participation motives, because the household may obtain information on demand, supply and price of the crop. However, with the study area a household found that majority who do not owned a TV and radio.

Input use: (IU) – These result shows that input use has positive and significant effect on household level of participation at 5% level of probability. As one unit of the input use increase, total household level of participation in irrigation increase by 6 percent. This implies that the support of union or government office, 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 which enhances household income. This study is concurrent with Maddison A. (1970), among others.

Distance to the nearest market center (DFRM): Distance to the nearest market place is a factor which has a negative influence on the intensity of use of technology inputs by farmers in the study area. The implication of this result is that, farmers who lives in areas far away from market centers are reluctant to adopt improved agricultural inputs, because they may have limited information access to modern agricultural inputs and their market price. The marginal effect shows that a one unit increase in distance to the market results a reduction of level of participation by about 5.3%. Similar result was reported by Takeshi (2002) in his study on adoption situations of new rice varieties in West Africa.

Lambda (λ) – the coefficient of mills ratio (Lambda) with Heckman Two stage estimation was significant at the probability of less than 10%. This indicates sample selection bias existence of some unobservable household characteristics determining likelihood to participation decision in irrigation and there by affecting the level of participation in irrigation.

Table -6 Estimation result for the Binary Probit and 2SLR model

Variables	Probit Result		2SLResult	
	Coef(St.err)	Marginal	Coef(St.err)	Marginal
AGE	0.0515(0.032	0.0202	.021(0.13)	.-164
HHS	-0.644(0.147)	0.252***	.010(0.01)	1.004
EDUC	0.016(0.274)	.531*	.012(0.006)**	2.194
LANSI	1.671(0.910)	0.656*	-.053(0.06)	-.838
ACA	0.9319(0.476)	0.346**	-.026(0.037)	-.702
AES	1.023(0.282)	0.401***	.076(0.022)***	3.480
AINFO	0.114(0.426)	0.0045	.051(0.029)*	-1.757
IU	0.5871(0.441)	0.2208	0.060(0.031)*	1.896
DFHHM	-.141(0.314)	-0.0554	-0.050(.026)*	-1.950
TLU	.650(0.168)	0.255***	0.028(0.012)**	2.39
DR	3.520(0.976)	1.382***	0.188(.038)	0.575
SOFE	.201(0.279)	0.079	-0.010(0.022)	-.425
OXEN	.831(0.239)	0.326***	-0.014(0.026)	0.042
CONST	-15.212(3.184)	0.000	-0.184(.122)	-1.506

Mills lambda	**-0.698(0.244)****	**-2.29**
Number of obs =171,	**No obs=171, Censored obs = 77,**	
LR chi2(13) = 121.44 ,	**Un Censored obs =94 ,**	
Prob> chi^2 = 0.0000	**Wald chi2(13) = 50.96**	
Pseudo R^2 = 0.5160,	**Prob> chi2 = 0.0000,**	
Log likelihood = -56.963017	**Rho = -0.40121, sigma=1.738972,**	
	IMR =0.095583	

V. Conclusion and Recommendations

5.1. Conclusion

This study examined the impact of irrigation on income of smallholder farms in the Ethiopia. A total of 171 household farms were sampled from three villages found in the Boloso sore districts of Wolaita Zone, Ethiopia. In order to address these stated objectives, Heckman two-stage procedure was used to measure the effect of irrigation on household income. Amulti-stage random sampling procedure was employed for the selection of sample respondents. In the first stage three villages were purposively selected from the respective district which was using irrigation. In the second stage, the total households in the three villages were subdivided into two strata of irrigation user and non-user households. The required data were collected through interviews of farm household heads using structured interview schedule. Primary data were collected using interview schedule. Secondary data were also collected from relevant sources to supplement the data obtained from the survey.

The Heckman two-step procedure was used to analyze the effect of different explanatory variables on farmers' participation decision in small-scale irrigation water use, and the effect of irrigation water use on household income. In the first stage of the Heckman two-step procedure household size, education, Land size, access of credit, access of extension, tropical livestock unit, dependence ratio, oxen were found to determine participation in irrigation. Additionally the Heck man two-step procedure model the mill ratio result shows that the users are 26% beterr off than the non-users. Thus, the study empirically demonstrated that access to irrigation has a significant contribution in increasing levels of income smallholder farmers in the study area. Therefore, we can conclude that for a country such as Ethiopia, irrigation development can play a crucial role in improving livelihood of the rural population. Having said this, mere access to irrigation will not bring the expected change if the provision of adequate equipment and materials, supply of improved input technologies, and most importantly the skills for proper handling and management of small-scale irrigation schemes, are lacking.

5.2. Recommendations

Based on the above findings of the study, the following recommendations can be suggested for the improvement of irrigation development in the study area in particular, and for areas of similar situation in the country at large.

✓ It was learned that, within the study area, extension service and education are positively and significantly related income of the farmers. This indicates that the two factors are fundamental in improving the performance of farmers' overall operation. Therefore, government representatives in the area should emphasize the provision of education and special trainings of agents so that farmers can efficiently use the available resources to increase their productivity and income.

✓ Farmers' access to irrigation through small-scale irrigation schemes should be encouraged in order to increase crop productivity, and hence increase their income to reduce poverty. According to the findings of this study, the existing smallholder irrigation farms within the study area show considerable variability in income. Future development strategies should therefore consider these differences and characteristics in targeting future irrigation programs of intervention for smallholder farms.

✓ The use of irrigation increases production and income of households. The effect of the irrigation on these aspects is dependent on the marketing of the products. However, the finding shows low market value in time of harvesting season doesn't encourage increasing agricultural production. The problem will be serious when similar farmers harvest the same crop at the same time. The production of onion, tomato, and head cabbage are easily perishable in nature and thus needs immediate market. Production of maize is also highly susceptible to damage in the storage due to weevil. Obtaining reasonable market price is a reward for boosting production. Therefore, that agricultural production in the irrigated farm need to be guided by reliable market and concerned bodies should give more emphasize and work on solving marketing problems of agricultural product by establishing, and strengthening cooperatives, cooperative unions, improving post-harvest technologies like providing storage facilities, pesticides for beneficiaries of irrigation users are essential for better contribution of Small scale irrigation on improving households income in the area as well as in the nation too.

✓ The amount of credit received was found to significantly influence household income. This could imply that households largely needed external financial sources to back-up their own financial constraints to meeting production expenses. Hence, for sustainable increase in agricultural output, farming households should get sufficient amount of money so that they can purchase high yielding variety seeds, fertilizer and agro-chemicals. Therefore, to fill this capital deficiency gap, the recently emerging rural financial institutions should been courage and strengthen in terms of number and capacity to reach the needy households.

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