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Comparative Analysis of Small Scale Irrigation Users' Household Income Among Smallholder Farmers: The Case of Horo District, Ethiopia

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Abstract: Agriculture is the mainstay of the country's economy and the major source of foreign exchange earnings and domestic consumption. To improve the prevailing low level of production and productivity the use of yield improving inputs is of paramount important. As the potential to increase production by bringing more resources into use became more and more limited, the efficiency with which the farmers use available resources has received the utmost attention. This being the case, in this study, an attempt was made to compare analysis of small scale irrigation users' household income among small holder farmers. Allocations of the number of sample households 64 from non-user and 64 from users of irrigation and was proportional to the number of household for non-user and user of irrigation living in each sampled three kebels. Logit models were used to estimate determinants of household income. According to the finding of this study, Education of household head, Livestock holding measured in Tropical Livestock Unit (TLU), and Use of input have statistically and positive contribution to income. Therefore, the strengthening both formal and informal education and vocation or skill training, adequate veterinary service (improved breed), improved water supply points, introduce of timely and effective forage development program for Livestock holding, high yield variety to supply (provide) to households, awareness creation on management (how to use input, sowing and weeding) and to introduce new inputs like chemical fertilizers, new seeds, pesticides and etc.

Keywords: Logit, Small Scale Irrigation, Income, Smallholder Farmers

1. Introduction

Ethiopia is found in the horn of Africa having area coverage of about 1.2 million square kilometers. It is endowed with rich biological diversity. The country blessed with abundant water resource for irrigation [1]. In fact, the agricultural system does not yet fully benefited from irrigation potential [9].The irrigation coverage of Ethiopia is less than 5% which makes the households' agricultural production to remain brunt on rain-fed agriculture [16] and low income to be generated.

Agriculture in Ethiopia is operated by smallholder farmers, where 80% of the people that predominantly depend on it for ensuring their livelihood. The sector remains at subsistence level [8] failing to feed the ever exploding population. Consequently, special attention has been paid to the areas with high rainfall variability, high land degradation and high moisture deficit to tackle the problem of food insecurity [7]. The use of supplementary irrigation from either traditional or modern water harvesting structures is considered as the primary measure to be taken against the problem. In this direction, the FDRE government of Ethiopia is making serious efforts by allocating fairly large amount of budget for the development of infrastructures including water irrigation accessibility and use [2]. Small scale irrigation boosts agricultural production and thereby increases income of households in rural areas [17]. It also increases crop productivity and ensures household food security [12]. Despite the fact that Ethiopia has around 122 billion m^3 volume of water that runoff annually from its 12 river basin [24] irrigation coverage is low [16]. Numerous studies outlined attributable factors like poor performance of irrigation systems [12], inequitable, unreliable and lack of water storage and supplies [24], and physical, socio-cultural and economic constraints [22].Large areas within the irrigation systems suffer from severe water shortages, resulting in declining of productivity and income of households [4]. Horo District is an irrigation potential area, with an estimated 5,483 hectares of water bodies [15]. However, the living standard of the community is subsistence. Therefore, in this study, comparative analyses of small scale irrigation users' household income among small holder farmers were examined at household level. To this end, this particular study was aims at investigating whether access to small scale irrigation users' household income among small holder farmers.

2. Objectives of the Study

The general objective of this study is comparative analysis of small scale irrigation users' household income among small holder farmers in the study area.

Specific objectives of study are:-

1) To describe the farm characteristics between irrigation user and non-user.
2) To compare irrigation user and non-user on households incomes.

3. Research Methodology

3.1. Description of the Study Area

Horo district is located in Horo Guduru Wollega Zone of Oromia Regional State, at about 314km west of Addis Ababa capital city of Ethiopia. Geographically, it is located between $9^0$34'N latitudes and 37^0 06'E longitudes [10]. The district is bordered by Jarte Jardaga district in the North, Jimma Ganati district in the South and East South, and Abe Dongoro district in the West and Abayi Choman district in the east.

According to [11] the total population of Horo district was 76,162 of these 73,983 and 2,179 were rural and urban population respectively. Similarly, 38,256 are females and 37,906 are males in the District. In each, 36,811 are males and 37,172 are female in rural, whereas 1,095 are males and 1,084 are females in urban area. Like other parts of the highlands of the country, there are mixed cultivation of livestock rearing and crop production, in which subsistence agriculture is the main economy development of the community.

The information of temperature and rainfall data for this study was obtained from Shambu Meteorological Station. The distribution of rainfall is unimodal, characterized by a prolonged wet season from June to September and a short dry spell showers from mid-February to April. There is a long dry period from October to the end of February. Based on data obtained from [14], the mean annual rainfall in the study area is about 1566 mm. The mean annual temperature is about 16.6°C and the mean minimum temperature is 10.78°C whereas the mean maximum temperature is 22.32°C. There is slight temperature difference throughout the year. The hottest months are from February to May maximum temperature recorded is about 24.6°C (in April/May) and the coldest months are from July to December with the mean minimum temperature 9.8°C (in December). Based on altitudinal variations, Horo District has three Agro-Climatic Zones which correspond to the classification systems: 43% Dega (2500-3500 m) 55.56% Woina Dega (1500-2500 m), and 1.24% Kola (500-1500 m) [14].

3.2. Sampling Techniques

In this study, out of twenty two kebeles of the district, three kebeles was purposively selected supposing better irrigation potential. The total households in the three Kebeles were stratified into two strata: irrigation user and non-user households. The lists of total irrigation user households in the selected Kebeles were obtained from the District Irrigation Development Authority and the number of non-irrigation user households in the selected Kebeles was obtained from their respective kebele administration. The irrigation users and non-users were selected from the three selected Kebeles of the district to ensure homogeneity of factors except irrigation. Then, the sample respondents from each stratum were selected via probability proportionate to size procedure. Accordingly, 128 respondents were selected from the three Kebeles.

General, the district as a whole and the specific study area particularly are purposively selected using the following criteria.

1. Almost more than half of districts highland, where there is relatively irrigation potential available and good irrigation practices known.

2. Horo district has a long history of traditional irrigation practices and indigenous knowledge. And hence, it is possible to grab the opportunities and capitalize on.

3. There are relatively better irrigation activities in the study area that gives opportunity to government in developing modern small-scale irrigation schemes.

The sampling design of this study was involve a stratified random sampling technique, with non-users and user of irrigation. Both probability and non-probability sampling methods was employed in sampling and selection process. Probability sampling was used to generalize the result from the sample to the household, allow to calculate the exactness of the estimates obtained from the sample and to specify the sampling error. Non probability sampling techniques can be used hence the district was selected purposively

3.3. Sample Size Determination

Once the total population obtained, the next step was determining total sample size of the survey, based on the established sample frame of the selected households. Following this, total sample size was determined using probability proportional to sample size-sampling technique [5].

$$n_1 = \frac{no}{(1 + no / N)}$$

Where;

$$no = \frac{Z^2 * (P)(q)}{d^2}$$

1) n_1 = finite population correction factors [5]. less than10000
2) Z = standard normal deviation (1.96 for 95% confidence level)
3) p =is 1-P i.e. (0.9)
4) q = 0.1 (proportion of population to be included in sample i.e. 10%)
5) N = is total number of population
6) d =is degree of accuracy desired (0.05)

Based on [5], from 1519 total of households in three kebels, a total of 128 sample households' was selected using simple random sampling techniques for the study. Allocations of the number of sample households 64 from non-user irrigation and 64 from users of irrigation and was proportional to the number of household for non-user and user of irrigation living in each sampled three kebels

Table 1. *The summary of total households of kebeles and sample size selected in kebeles.*

Kebeles selected based on SSI potential and coverage	Total Households in kebeles	Kebeles levels sample size based on proportion to size	Users of irrigation of household	Non-user irrigation of household
Rifent Gabar	452	38	19	19
Gudina Abuna	565	48	24	24
Abe Dulacha	502	42	21	21
Total	1519	128	64	64

Source: HWIDA and selected Kebeles (2022)

3.4. Data Types, Source and Method of Collections

In this study, both primary and secondary data were utilized. To obtain primary data, semi-structured questionnaire with both closed and open-ended questions was developed. Three enumerators, who are fluent speakers of the local language, Afaan Oromo, was recruited from their respective selected Kebeles and an intensive training on data collection procedures, interviewing techniques and the detailed contents of the questionnaire was given to them. The questionnaire was translated into to Afaan Oromo to allow enumerators better understand the questions and properly administer the interviews.

On the other hand, necessary care was taken in recruiting the enumerators and strict supervision was made during the course of survey work for the sake of the successful achievement of the study. Personal observations of physical features, informal a discussion with farmers and agricultural extension workers of the selected Kebeles was also be made as necessary.

Moreover, secondary data was obtained from different literatures, published thesis and document data of respective organization, (District Irrigation Development Authority, District Office of Agricultural, District Office Rural Land and Environmental Protection) etc.

3.5. Methods of Data Analysis

To address the objectives of the study, both descriptive analysis and econometric methods were employed. Descriptive statistics such as mean, percentages, standard deviation, chi-square and t-test were used.

3.6. The Logit Model

The logit and probit are the two most commonly used models for assessing the impact of irrigation on income. These models can also provide the predicted probability of irrigation user and non-user households. Both models usually yield similar results. However, the logit model is simpler in estimation than probit model [3].

Hence, the logit model used in his study the comparative analysis of small scale irrigation users' household income among small holder farmers. Following [11] and [3] the logistic distribution function for the irrigation user of small-scale irrigation is specified as

$$p_i = \frac{1}{1 + e^{zi}} = \frac{e^{zi}}{1 + e^{zi}} \quad (1)$$

Where, P_t = is the probability of using the irrigation for the i^{th} households and it takes 1=user irrigation or 0=non-user irrigation, e^{zi} = stands for the irrational number e to the power of Z_i.Zi = a function of n explanatory variables which is also expressed as:

$$Z_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots\ldots\ldots + \beta_n X_n \quad (2)$$

Where,

1) X_1 X_2… X_n are explanatory variables.
2) β_0- is the intercept,
3) β_1, β_2 … B_n are the logit parameters (slopes) of the equation in the model.

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

1) As X_i increases P_i increases but never steps outside the 0 and 1 interval; and
2) The relationship between P_i and X_i is non-linear, i.e., one which approaches zero at slower and slower rates as X_i gets small and approaches one at slower and slower rate as X_i gets very large.

But it seems that in satisfying these requirements, an estimation problem has been created because P_t is not only non-linear in X_i but also in theβ's as well, as can be seen clearly below

$$pt = \frac{1}{1+e^{-(B0 + B1X1+B2X2 +? \ ....+Bn)}} \quad (3)$$

This means the familiar OLS procedure cannot be used to estimate the parameters. But this problem is more apparent than real because this equation is intrinsically linear. If Pt is the probability of household user of small- scale irrigation then (1- P_t), the probability of non-user household irrigation, can be written as:

$$1 - pt = \frac{1}{1+e^{zi}} \quad (4)$$

Therefore, the odds ratio can be written as:

$$\frac{pi}{1-pi} = \frac{1+e^{zi}}{1+e^{-zi}} = e^{zi} \quad (5)$$

Now is simply the odds ratio in favor of user of irrigation of small-scale irrigation. It is the ratio of the probability that the household would the user of small scale irrigation to the probability that he/she would non user it. Finally, taking the natural log of equation 5, the log of odds ratio can be written as:

$$Li = \ln(\frac{pi}{1-pi} = \ln(e^{BO+\sum_{i=1}^{n} BiXi}) = zi = \beta o + \sum_{i=1}^{n} \beta ixi \quad (6)$$

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

$$zi = \beta_0 + \beta 1X_1 + \beta_2 X_2 + \ldots + \beta_n X_n + u_i \quad (7)$$

This model can be estimated using the iterative maximum likelihood (ML) estimation procedure. In reality, the significant explanatory variables do not have the same level of impact on the income decision of households. The relative effect of a given quantitative explanatory variable on the income is measured by examining adoption elasticity's, defined as the percentage change in probabilities that would result from a percentage change in the value of these variables. To calculate the elasticity, one need to select a variable of interest, compute the associated P_t, vary the X_i of interest by some small amount and re-compute the Pi, and then measure the rate of change as $\frac{dxi}{dpi}$ where dx_i and dP_i stand for percentage changes in the continuous explanatory variable (X_i) and in the associated probability level (P_t), respectively.

When dxi is very small, this rate of change is simply the derivative of P_t with respect to X_i and is expressed as follows [3]:

$$\frac{dxi}{dpi} = \frac{e^{zi}}{(1+e^{zi})^2} Bi = \frac{pi}{(1-pi)Bi} \quad (8)$$

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

For income level of small scale irrigation was statistically desirable to sort out problem of multicollinearity among the continuous variables and check the association among discrete variables before estimating a model. The term multicollinearity refers to a situation where two or more explanatory variables can be highly linearly related. The consequences of multicollinearity are as follows. In the case of perfect multicollinearity we cannot estimate the individual regression coefficients or their standard error.

In case of high multicollinearity individual coefficients can be estimated and the OLS estimators retain BLUE property, but the standard errors of one or more coefficients tend to be large in relation to their coefficient values.

Multicollinearity is essentially a sample (regression) phenomenon in the sense that even if the X variables are not linearly related in the population (i.e, population regression function), they can be so related in particular sample. When we postulate the population regression function (PRF), we believe that all X variables included in the model have a separate or independent effect on the dependent variable Y. But if it was happen that in any given sample that is was to estimate the PRF some or all X variables are so highly collinear that we cannot isolate their individual influences on Y.

For all these reasons, the fact that OLS estimators are best linear unbiased estimators (BLUE) despite (imperfect) multicollinearity is of little help in practice to consider that the estimation and hypothesis testing are free from flaws [11]. Therefore, the correlation coefficients and a variance inflation factor (VIF) techniques was employed to detect the problem of multicollinearity [11]. In the case of the VIF factor technique, each selected explanatory (X_i) was regressed on all other explanatory variables, the coefficient of determination (R_i^2) constructed in each case was evaluated to detect whether multicollinearity is a serious problem.

$$\text{VIF } (\beta_i) \text{ is defined as, VIF } (\beta_i) = (1-R_i^2)^{-1} \quad (9)$$

Where, R_i^2 is the squared multiple correlation coefficient between X_i and the other explanatory variables [18].

3.7. Description of the Study Variables and Hypotheses

The dependent variable**:** In the estimation of the comparative analysis of small scale irrigation users' on household income and the dependent variable was the annual household income. Annual household income was included both agricultural (farming and non-farming) and non-agricultural off-farm incomes. The non-agricultural or income was obtained from off-farm activities was consider because, income that was obtained from irrigation activity can be compensated by non-agricultural or off farm activities. The contribution of irrigation to household income might be exaggerated if the inclusion of non-agricultural or income was obtained from off-farm activities is ignored. It means that if the household income from non-agricultural or off farm activities was omitted and only agricultural income is considered the share of income obtained from irrigation activities might be higher than when income from both agricultural and non-agricultural or off farm activities are considered. Therefore, as much as possible, it was plausible to include every source that can generate income to household.

The explanatory/ independent variables**:** Variables that tend to explain a given dependent variable are said to be explanatory or independent variables or repressors. The income of a household is determined by a wide variety of technical and social factors. The technical factors in crop production include mainly land topography and type of input used. Among the social factors, individual and family characteristics are quite important. Based on theoretical relationship and findings of empirical studies, the following explanatory variables were hypothesizing to explain the dependent variable.

4. Result and Discussions

This chapter is devoted to present results and discuss the main findings.

4.1. Household Socio-Economic Characteristics

This section describes the analysis of survey data and its interpretation. In the first section, the sample households demographic characteristics are discussed. Particular reference is given to the factors hypothesized to influence income, such as family size, education level, land holding, asset holding, labor availability, access and source of credit for irrigating and non-irrigating households. These descriptive analyses help to frame the econometric results obtained in the study.

4.2. Household Characteristics

Household members are the major sources of labour for agricultural practices in agrarian societies. The household characteristics such as age, size of family, education level and etc. differ from one household to the others. The details of these characteristics for the sampled households in the study area are depicted in tables 3.

Table 2. *Households Characteristics.*

Characteristic	Irrigation User(N=64)			Non user Irrigation (N=64)			Total household (N=128)			t-value for difference
	Min	Max	Av	Min	Max	Av	Min	Max	Av	
Family size	1	12	4.9	1	13	5.6	1	13	5.2	2.4**
Number of family members involved on Agri-activiteis	1	8	3.9	1	10	4	1	10	3.9	3.7***
Dependency ratio	1	5	1.6	1	6	0.8	1	6	1.2	1.1

Source: Data surveyed 2022

***, ** indicate significant at the 1% and 5% significance levels, respectively

Family size is useful for formulating various development plans and for monitoring and evaluating their implementation. Average family size at the national level in Ethiopia was 4.7 [6].

Table (3) reveals that, the minimum, maximum average and t-value of the sampled household of irrigation user non-user are depicted in this table. In the study area, the average family size was 5.2 with a minimum 1 and maximum of 13. The t-test shows that there is significant difference in family size between the irrigating and non-irrigating households at a 5% level of significance.

In rural Ethiopia, number of family members involved on Agri-activiteis is the main source of labor for all income sources. Family size in adult equivalents indicates the sample households average family labor force for agricultural production and other income-generating activities.

The number of family members who engaged in agricultural activities differs from household to household of the study area. Accordingly, the number of family members engaging in agricultural activities in the study area was 3.9,1 and 10 are indicate average, minimum and maximum of user and non-user irrigation respectively. The t-test shows that there is significant difference between irrigating and non-irrigating households at 1 % level of significant (Table 3). Thus, irrigating households have owned better labor input than non-irrigating households.

The dependency ratio shows the ratio of economically inactive compared to economically active. Economically active members of a household, whose age is from 15 to 64, are assumed to be the principal sources of income for the household. Household members under 15 and over 65 are assumed to be economically inactive and dependent on economically active members of a household [15]. Members of holdings with high dependency ratios might not be able to participate in programs and projects due to time, labor and/or financial constraints, that is, dependency ratio is thought to be negatively related to income of households [9]. In the study area, accordingly the number of family members engaging in agricultural activities in the study area was 1.2,1 and 6 are indicate average, minimum and maximum of user and non-user irrigation respectively. The t-test shows that there is statistically insignificant difference between irrigating and non-irrigating households (Table 3).

Table 1. *Sex, gender and education of the household head.*

Characteristic	Irrigation User(N=64)	Non user Irrigation(N=64)	Total household(N=128)	Chi-square test for difference(χ^2)
	Percent	Percent	Percent	
Household Head gender				
1) Male	90.5	84	87.25	
2) Female	9.5	16	12.75	
3) Total	100	100	100	4.4**
Household Head Education				
1) Illiterate	24	65	44.5	
2) Read and write	48	24	36	
3) Elementary complete	27	11	19	
4) High school and above	1	0	0.5	
5) Total	100	100	100	24.7***
Age of household head				
1) 15-30 years	17	14	16	
2) 31-45 years	53	47	50	
3) 46-64 years	28	34	31	
4) 65 and above	2	5	3	
5) Total	100	100	100	1.9

Source: Data surveyed 2022
***, ** indicate significant at the 1% and 5% significance levels, respectively.

In the study area, the head of the household generally is responsible for the coordination of the household activities. As such it is pertinent to examine attributes such as sex and education of the head as one component of irrigation participation decisions. Of the 128 sampled households, about 87.25% were male-headed. The percentage of non-irrigating female household heads was more than irrigating (Table 4). There is a significant difference in the sex of the sampled household heads for irrigating and non-irrigating households at a 5 % significance level (Table 4).

Educated people can more easily contribute to the generation of new technologies and more readily utilize those technologies. It is one of the main factors affecting adoption of irrigation technologies to improve agricultural productivity [19]. The education level of household heads is higher for irrigating households than non-irrigating households (Table 4).

The average age of the household heads in the study area was 45 years with a minimum of 25 and maximum of 81 years. The age of the household head influences whether the household benefits from the experience of an older person, or has to base its decisions on the risk-taking attitude of a younger farmer. There is no significant difference in the distribution of household head age of the sampled households between irrigating and non-irrigating household heads (Table 4).

4.3. Wealth Characteristic

In agricultural production wealth of land holding, Livestock, agricultural tools and other capital assets are the most important. Therefore, the study looks the access of wealth characteristic of land holding, cultivated land and Livestock between irrigating and non-irrigating household

Table 4. *Average Land holding, Cultivated land and Livestock (TLU).*

Characteristic	Irrigation User (N=64)	Non user Irrigation (N=64)	Total household (N=128)	t-value for difference
Land holding	1.45	1.2	1.35	1.90
Cultivated land	1.2	0.75	0.98	6.45***
Livestock (TLU)	4.9	3.5	4.2	4.7***

Source: Data surveyed, 2022
***, ** indicate significant at the 1% and 5% significance levels, respectively.

Land is the major productive asset in agrarian countries like Ethiopia. The average land holding size of the sample households in the study area is 1.35ha. There is no significant difference between irrigating and non-irrigating households in average land holding size (Table 5).

However, there is a significant difference in their cultivated land size. Irrigating households have larger cultivated land area than non-irrigating households. Irrigation may generate income and allow accumulation of other productive assets by irrigating households, which facilitate cultivation of additional land through share in and rent in from non-irrigating households. There is a significant difference between irrigating and non-irrigating households at the 1% significance level (Table 5).

Livestock are the most important productive assets in the household. In the study area, livestock are important source of power for ploughing, transportation, and riding. It also considered as a saved asset used during periods of food shortage. The average livestock holding for sample households was 4.2 TLU. Irrigating households possess a larger average number of livestock (4.90) than non-irrigating households (3.5). There is a significant difference between irrigating and non-irrigating households at the 1% significance level (Table 5).

4.4. Crop, Livestock and Off-Farm Income of Irrigation User and Non-User Households

Total cropping income is the amount of mean annual income of a household obtained from both types of cropping systems, rain fed and irrigation.

Livestock play a significant role as income sources in rural Ethiopia. Sale of live animals and their products are main livestock-related income sources in the study area. The livestock income category includes income from the sale of livestock, livestock products (i.e. milk, eggs, honey etc.) and other by-products like hide and skin. The values of sale and own consumption livestock and livestock products were estimated based on the average annual nominal prices.

Off- farm and other incomes are important parts of total income in rural households of Ethiopia. The source of off-farm income in the study area, employment on other farms during weeding and harvesting seasons, sale of wood, sale of local drinks (tela), renting of irrigable lands, artisan (blacksmith and weaving and), brokering, sale of wood (charcoal), onion and tomato trading.

Table 5. *Average crop income, Livestock and off-farm income.*

Characteristic	Irrigation User (N=64)	Non user Irrigation (N=64)	Total house hold (N=128)	Percent	t-value for difference
Crop income	35,890	23,282	29,586	82	9.45***
Livestock income	7,460	3,350	5,405	15	1.90
Off-farm income	1240	983	1,111.5	3	0.35
Total in come	44,590	27,615	36,102.5	100	8.7***

Source: Data surveyed 2022
*** indicates significant at the 1% significance level.

The total mean annual household income in the study area was ETB 36,102.5 (Table 6). From the total mean annual income of a household, cropping contributes the highest income share (82%) followed by livestock (15%) and off-farm (3%), respectively. Irrigating households earn higher income from cropping than non-irrigating households.

However, there is no significant difference between irrigating and non-irrigating households in their livestock and off-farm incomes. The total income significant difference arises from the cropping income difference, which is suggestive of the both the mechanism and the degree to which irrigation access increases household incomes. The next section discusses the results of econometric analysis that assesses the impact of irrigation on income.

5. The Models Results

Econometric model for Income Analysis

The income of a household is determined by wide arrays of factors both technical and social. In addition to the descriptions given above, analysis of the impact of irrigation on the household's incomes of the irrigating user and non-user was estimated using the logit model by using SPSS version 16 and Stata version 12. The Logit analysis suggests that several variables have a statistically significant impact on the income of the household, many of which are consistent with the hypothesized relationships. The analysis indicates which determinants are more important for the improvement of household income. Some variables appear to be insignificant.

Table 6. *Maximum likelihood estimates of the Logit model.*

Variables	Coefficient	SE	t-value
Constant	-12029.6	13819.18	-0.8705
Family size	36402.4	18110.64	2.01**
Farm size	21320.2	10933.43	1.95
Access to credit	23809.5	7002.79	3.4***
Education	91.4	37.21	2.456**
Total Livestock unit	7940.7	1212.32	6.55***
Access to irrigation	24320.45	348.62	2.3**
Input	163.32	50.25	3.25***
Age HH	- 0.457	1.088	-0.42
Gender HH	129.185	1845.5	0.07
R^2 value	0.726		
Adjusted R^2	0.701		
Number of Obs.	128		
LR $chi^2(10)$	385.25		
Log likelihood	-1825.12		

Source: Data surveyed 2022
***,**,*-Significant at 1%, 5% and 10% significant levels, respectively

As indicated in table 6, the coefficient of determination and the adjusted R^2 values are 0.72 and 0.70 respectively. It means that about 72% of the variation in the dependent variable is explained by the independent variables, indicating relatively high explanatory power of the model.

Education of household head has statistically significant positive impact on the income of a household. This seems rational; educated human capital can more easily adopt technologies like irrigation and make more informed production decision. Education can increase the marginal productivity of labor. The increase in productivity of labor is one of the important factors to increase income of a household.

In the same way livestock holding measured in Tropical Livestock Unit (TLU) is found to have a positive and significant influence on income of households. A unit TLU increase in livestock holding would increase the total income of a household by Birr 7,940.7, other factors being constant. Livestock, besides its direct role in raising agricultural productivity, helps households stabilize consumption by absorbing income shocks that might arise from crop failures triggered by natural disasters. Oxen are the sole draught power sources and hence lack of oxen besides its negative effect on land productivity signifies a lower economic status of farm households. Households who do not own oxen either acquire the much needed pair of oxen at a cost or forced to share/ rent out their land, which means a substantial reduction in income. 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

Household family size is positively associated with household income, and statistically significant. Access to irrigable land by allowing households to use family labor and other farm resources more intensively makes households more productive and hence better off. The results further indicate one unit increase in the active labor force of an average household would raise the total income of the household by Birr 36,402.4. Household family size in adult equivalent means a larger amount of labor available to the household. Labor increases productivity per ha of land, and in turn, household income increases for a given land base. The positive association between labor and household income seems reasonable.

Irrigation user influences the household total income significantly with a positive sign as expected. As [19] suggest, access of irrigation shifts the production function and offsets the diminishing marginal return by doing so increases income and used as a source of economic growth. According to [20], the production function analysis of irrigated and non-irrigated farm size, the result shows that irrigation shifts the agricultural production frontier to a higher level. This evidenced as, keeping others constant, the total income of irrigation user households would be higher by Birr 24,320.45 than households who non-irrigation farming. Irrigation allows farm households to use farm resource in a more productive way in at least two ways. First, it enables the production of vegetables and cereal crops twice and sometimes three times a year. Second, it helps improve livestock productivity by providing feed during the dry seasons and minimizing the cost of paying for fodder. Participation in small-scale irrigation, therefore, enables farm households to improve their well-being by not only allowing higher income but also minimizing risk and smoothening household consumption.

Land is key assets of rural farm households and fixed inputs to increase production and income. From the result, Land size is for household head, user and non-user of irrigation house hold have statistically insignificantly determined income of household.

Use of input influences household income significantly, and as hypothesized has a positive impact. Households who use input have higher household income. As [19] suggest, one of the main strategies for agricultural development depends on the availability and financing of new inputs like chemical fertilizers, new seeds, pesticides and the like.

Age of household head age, Gender of household head, and non-user of irrigation house hold have statistically insignificantly determine income of household. Household access to credit determines income of household positively at 1 percent significant level. The result also consistence with the finding of [21]. The correlation coefficient between any pair of explanatory variables was estimated to detect the presence of multicollinearity. The values of correlation coefficient are small and tend to show that there is no as such a serious multicollinearity problem. In addition, the values of VIF are very low, and therefore, there is no serious multicollinearity problem among the variables included in both models.

6. Conclusions and Recommendation

6.1. Conclusions

Based on the above findings of the study, the following implications or concluding remarks can be drawn for further consideration and improvement of irrigation development in the region in particular and in the country at large. The study revealed that access to irrigation has got a significant and positive contribution to income, implying that in a country like Ethiopia, irrigation development is crucial in improving the livelihood of the population. 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 be encouraged and strengthen in terms of number and capacity to reach the needy households. Furthermore, during the study some of the costs for irrigation development activities were not available (was not possible to get) and hence, irrigation was considered only form the point of view of households' gross income. Therefore, further research that take into consideration costs and examine the profitability aspect of irrigation development should be conducted.

6.2. Recommendations

According to the finding of this study, Education of household head has statistically significant positive on the income of a household. Educated human capital can more easily adopt technologies like irrigation and make more informed production decision. Education can increase the marginal productivity of labor. The increase in productivity of labor is one of the important factors to increase income of a household. Therefore, the strengthening both formal and informal education and vocation or skill training.

Livestock holding measured in Tropical Livestock Unit (TLU) is found to have a positive and significant influence on income of households. The necessary effort should be made to improve the production and productivity of the sector. This can be done through the provision of adequate veterinary service (improved breed), improved water supply points, introduce of timely and effective forage development program, provision of training for the livestock holders on how to improve their production and productivity, improving the marketing condition and etc.

Access to irrigation has got a significant and positive contribution to income, irrigation development is crucial in improving the livelihood of the population. Therefore, awareness creation should be made to the household to develop interest on irrigation use, increases the potential of irrigation by constricting different irrigation technology, human capacity development through training on irrigation use and management. Access to credit 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, full fill deficiency gap, the recently emerging rural financial institutions should be encouraged and strengthen in terms of number and capacity to reach the needy households.

Use of input influences household income significantly, and as hypothesized has a positive Impact. Households who use input have higher household income. The main inputs used in the study area are chemical fertilizers, improved seeds and agricultural chemicals. Households who use one or more of these farm production inputs was usually have higher crop yields and hence higher income. Therefore, high yield variety to supply (provide) to households, awareness creation on management (how to use input, sowing and weeding) and to introduce new inputs like chemical fertilizers, new seeds, pesticides and the like.

Conflicts of Interest

The authors declare that they have no conflict of interests.

Ethical

This study follows all ethical practices during writing.

Transparency

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study was reported; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained.

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