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Research Article

Small-scale Irrigation Scheme Utilization and Farmers' Willingness to Pay for Irrigation Water: The Case of Bosha-01 Irrigation Scheme in Central Oromia

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Abstract

Irrigated agriculture plays a crucial role in enhancing domestic food security and alleviating poverty. However, many of the small-scale irrigation schemes in Ethiopia are operating below their full potential. In several schemes, there is a noticeable gap between the designed potential and the actual area irrigated. This discrepancy is primarily due to poor management and a lack of regular maintenance. Furthermore, the absence of irrigation service fees, which would allow farmers to fund routine maintenance and ensure the sustainability of the irrigation schemes, has been a significant obstacle. This study aimed to identify the factors influencing household participation in small-scale irrigation schemes, the intensity of irrigation water use, and farmers' willingness to pay for water use. It was conducted in the Arsi Zone, Tiyo District, focusing on the Bosha-01 small-scale irrigation scheme, with a sample of 150 households. The results of the two-limit Tobit model indicated that several factors significantly influenced participation and water use intensity, including the household's education level, involvement in irrigation scheme planning, access to extension services, and the distance from the main road. Additionally, the study found that the mean willingness to pay (WTP) for irrigation water use was 155.33 Birr per 0.25 hectares per year. The censored regression model revealed that family size, income from crop production, and the household's perception of water sufficiency significantly affected farmers' WTP. The findings also highlighted that the irrigation scheme was underperforming, poorly managed, and lacked any system for charging users or requiring contributions for maintenance. Based on these results, the study recommends several policy measures, including strengthening institutional frameworks, coordinating actions among stakeholders, training farmers to encourage greater participation in scheme maintenance, developing social services, and improving farmers' incomes. These measures are essential to ensure the sustainable utilization of irrigation schemes.

Keywords

Small-scale Irrigation, Household Participation, Willingness to Pay, Two-limit Tobit

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1. Introduction

In countries like Ethiopia, where poverty is widespread, low farm productivity, and degraded natural resources are persistent challenges, the need for irrigation in the agricultural sector is critical. Small-scale irrigation has been widely recognized by donor agencies and development partners as a strategic intervention to enhance food security in Ethiopia. This approach is particularly relevant given the country's vulnerability to droughts and the need for more consistent food production.

Irrigated agriculture plays a central role in the country's poverty reduction efforts. It increases agricultural productivity, enhances the sustainable use of land and water resources, reduces reliance on rain-fed agriculture, and mitigates the effects of erratic rainfall and periodic droughts [1]. As a result, irrigation is a key priority within Ethiopia's agricultural transformation and food security strategies. Both regional governments and non-governmental organizations (NGOs) are working to promote small-scale irrigation schemes to stabilize food production.

Globally, irrigated agriculture has significantly contributed to food security. Without irrigation, much of the impressive growth in agricultural productivity over the past 50 years would not have been possible. However, the overall performance of irrigation and drainage investments has often fallen short of the expectations of planners, governments, and financing institutions [2]. In Ethiopia, the high cost of initiating new irrigation projects and the underperformance of existing irrigation systems necessitate an assessment of factors that could improve their efficiency.

Given the high investment costs of new irrigation systems, the focus has shifted toward improving the performance of existing small-scale irrigation schemes. Successful implementation of these schemes requires the active participation of all stakeholders in both the planning and implementation stages. According to Desta's idea [3], in a country facing recurrent drought and famine, irrigated agriculture is indispensable. Ethiopia cannot address its significant food deficit through rain-fed agriculture alone. To mitigate food insecurity, the Ethiopian government has recommended various strategies, including the development of new modern small-scale irrigation schemes, rehabilitation of traditional systems, and the sustainable utilization of surface and groundwater as well. However, the contribution of smallholder farmers to irrigation use has been hindered by inadequate attention to the non-technical aspects of irrigation systems. While significant resources have been allocated to constructing infrastructure, there has been insufficient focus on integrating socio-economic and technical factors that determine the efficient use of irrigation systems [3, 4].

The Context of Small-Scale Irrigation in Ethiopia specially in the Oromia National Regional State, and particularly in the Arsi Tiyo district, small-scale irrigation has been chosen as a strategic intervention to address food production challenges. Despite the construction of numerous small-scale irrigation schemes by the government and NGOs, many have failed to meet their intended objectives. These schemes often underperform, with significant gaps between the designed potential and the actual area irrigated. The primary causes of these issues include poor management, lack of regular maintenance, and insufficient integration of socio-economic and technical considerations.

Moreover, the absence of an effective water charging system for irrigation water use has hindered the financial sustainability of these schemes. Without a system in place to cover operational and maintenance costs, there has been limited incentive for farmers to efficiently use the available water resources. This has contributed to the underutilization and low productivity of the irrigation systems in the region. Consequently, it is essential to study farmers' willingness to pay (WTP) for irrigation water, as this could provide valuable insights into improving the financial sustainability of the schemes and ensuring more efficient water use.

The Need for the Study was to investigate farmers' decisions to participate in irrigation schemes and their willingness to pay for water depend on various factors, including food insecurity and the resource potential of the area. Irrigation schemes are typically initiated in response to local needs, such as alleviating food insecurity or improving agricultural productivity. In the Arsi zone, for example, the total planned area for irrigation under these modern small-scale schemes was 2,578.5 hectares, benefiting 7,221 households. However, the actual area irrigated was only 2,352.5 hectares, benefiting 5,794 households [5].

In the Tiyo district, located in the central part of the Oromia region, about 178.8 hectares of land were under traditional small-scale irrigation, benefiting 490 households, while 635 hectares were under modern small-scale irrigation, benefiting 1,483 households [6]. Despite these efforts, the causes for the low levels of irrigation water use in the area have not been thoroughly explored. Furthermore, no studies have been conducted to assess farmers' willingness to pay for irrigation water in this region.

The research Objective was to study aims to analyze the determinants of household participation in small-scale irrigation schemes, the intensity of irrigation water use, and farmers' willingness to pay (WTP) for irrigation water use. By exploring these factors, the study was sought to identify ways to improve the performance of existing irrigation schemes, enhance the sustainability of irrigation scheme. Thus, the findings are crucial for policymakers, NGOs, and international organizations involved in irrigation development. They also provide experience and baseline data for future studies on irrigation water use, offering vital information for sustainable irrigation practices and contributing to the broader knowledge base on irrigation systems.

2. Research Methodology

2.1. Description of Study Area

The study was conducted in the Oromia National Regional State, specifically in the Arsi Zone, Tiyo District, focusing on the Bosha-01 small-scale irrigation scheme. Arsi Zone, one of the 17 zones in the Oromia region, is located in the southeastern part of Ethiopia. Geographically, it is situated between latitudes 6°45' and 8°58' N, and longitudes 38°32' and 40°50' E. The zone covers an area of approximately 23,821 km², and is subdivided into 25 districts and 501 Peasant Associations (PAs). The capital town of the zone, Asella, is located 175 kilometers southeast of Addis Ababa. Tiyo District, located in the northwestern part of Arsi Zone, has Asella as its capital. The total area of Tiyo District is about 650 km² [7], and it consists of 18 PAs.

Arsi Zone is characterized by four traditional agro-ecological zones: 29.1% of the area is lowland (Kolla), 27.5% is midland (Woina-dega), 39.7% is highland (Dega), and 3.7% is classified as too cold (Wurch). The zone features a diverse range of landscapes, with altitudes ranging from 500 to 3,300 meters above sea level (m. a. s. l). The annual rainfall in the zone ranges from 700 to 2,000mm, while the annual temperature ranges between 10°C and 25°C [8].

Tiyo District, in particular, has 11% of its area in the lowland, 52% in the midland, and 37% in the highland agro-ecological zones. The district also boasts varied landscapes, with altitudes ranging from 1,650 to 3,200 meters above sea level (m. a. s. l). According to Tiyo district agriculture and rural development, the annual rainfall in Tiyo ranges from 700 to 1,658mm, with temperatures ranging between 10°C and 25°C [7].

According to the Population and Housing Census carried out, the population of Arsi Zone was projected to be approximately 3.22 million [9]. Of this, 86.93% of the population lived in rural areas, while 13.07% resided in urban areas. The population density of the zone is 135 persons per km². In Tiyo District, the projected population was 188,858, with about 92% living in rural areas. The population density in Tiyo is 291 persons per km² [9, 10].

2.2. Irrigation Scheme Description

This study focused on the Bosha-01 small-scale irrigation scheme, located in Tiyo District. The Luga spring water serves as the primary source of irrigation for this scheme. Bosha-01 is situated between longitudes 39°02' and 39°10' E, and latitudes 8°00' and 8°05' N, at an altitude of 1,700 meters above sea level (m. a. s. l). The scheme is located approximately 35km from Asella town, along the road to Ogolicho via Meki, and about 190 km from Addis Ababa. It is designed to irrigate 100 hectares of land [6]. A map of the study area is presented in Figure 1.

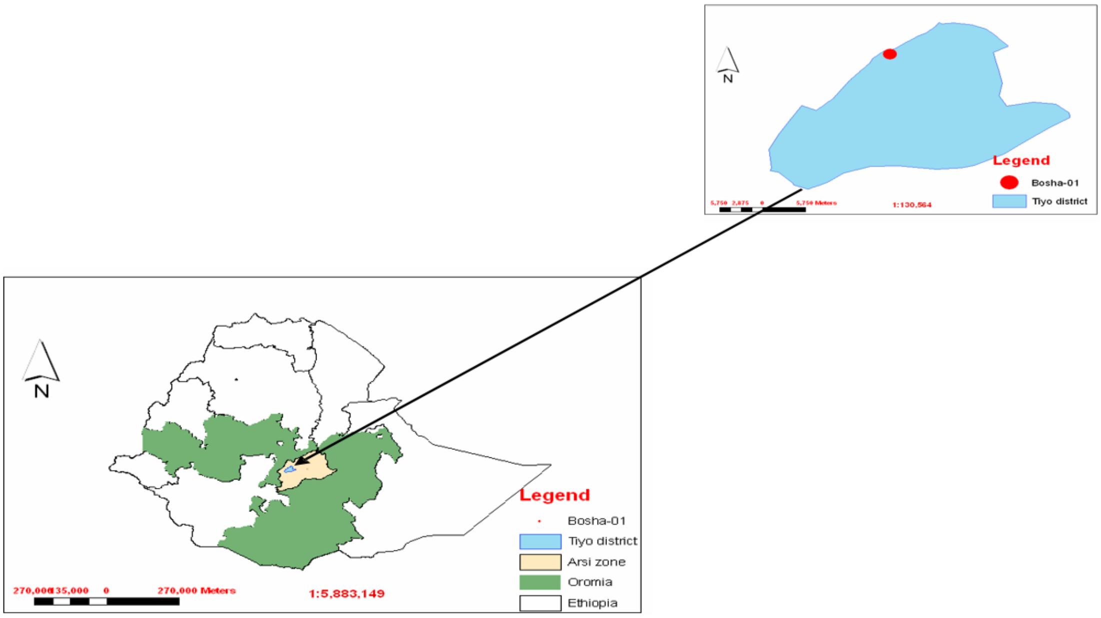

Figure 1. *Location of the study area and the irrigation scheme.*

The total investment cost for the Bosha-01 irrigation scheme was 276,340 Birr, with funding provided by the International Fund for Agricultural Development (IFAD). The infrastructure developed for the scheme includes a 3 km access road, headwork development, a main canal, two secondary canals, tertiary canals, and various farm structures such as drops, division boxes, off-takes, and culverts. The scheme's design specifies a water duty of 2.4 liters per second per hectare, requiring a total discharge of 120 liters per second from the Bosha spring to irrigate the 100-hectare area. The primary crops grown under irrigation in the Bosha-01 scheme include tomatoes, potatoes, onions, cabbage, sugar cane, chat, and mangoes.

2.3. Sampling Design and Methods of Data Collection

2.3.1. Sampling Design

In this study, a multistage sampling technique was used to select 150 sample households. During the initial step of the sampling, out of the potential districts in Arsi Zone that have modern small-scale irrigation schemes, Tiyo district was purposively selected. In the second stage, modern small-scale irrigation schemes in the district were listed and one-irrigation scheme was selected using simple random sampling technique. In the third stage, the total number households in the irrigation scheme were listed and stratified into two strata: Irrigation water users and non-irrigation users within the command area based on the household lists which were obtained from water users committee of the scheme.

Finally, the lists of the total sample households in both strata (users and non-users) were prepared. Ninety-four (94) irrigation water users and 56 non-users were selected based on probability proportional to size random sampling technique. Therefore, a total of 150 households were interviewed (Table 1).

Table 1. *Total number of households (HH) in irrigation scheme and sample size.*

Name of District	Sampled Scheme	Total HH in the Scheme	Irrigation user		Non- irrigation user		Total Sampled
			Total HH	Sampled HH	Total HH	Sampled HH	HH
Tiyo	Bosha-01	365	229	94	136	56	150

Source: survey data, 2007

2.3.2. Methods of Data Collection

In this study, both primary and secondary data were collected. Primary data were collected from sample respondents through a structured questionnaire using face to face interview, which was designed to generate data on social, institutional and economic aspects of the households. Moreover, field trips were made before the actual survey to observe the overall features of the selected scheme and to pre-test the questionnaire. For pre- testing purpose, 15 farm households were interviewed. After pre-testing, a second meeting was held with the enumerators to discuss on their field experiences, clarity of questions, unexpected responses and additional response options for questions.

2.3.3. Methods of Data Analysis

Descriptive statistics are important to have a clear picture of the characteristics of sample units. It is used to explain the different socio-economic, institutional and other characteristics of the sample households. These include mean, percentage, standard deviation and frequency of occurrence for the irrigation water user and non-user farmers. The statistical significance of the variables was tested for both dummy and continuous variables using chi-square and t-tests, respectively.

Economic model is also used. OLS estimation by using only the limit observations result in both inconsistent and biased parameter estimates. This occurs when the dependent variable to be modeled is limited in its range, because there are unobservable factors that affect the household decisions.

In this respect, the right method is to apply a Tobit (censored) regression model as suggested by Tobin [11]. Additionally, as pointed out by Green, the maximum likelihood estimators of the Tobit model are consistent and asymptotically normal [11, 12]. Thus, this study used a Tobit regression model to explain household's small-scale irrigation scheme utilization and farmers' willingness to pay for irrigation water use.

Specification of two-limit Tobit model for irrigation utilization

A two-limit Tobit model was used to identify factors that affect irrigation water use. This method estimates the likelihood of participation in small-scale irrigation water use and the extent (i.e., intensity) of utilization. Originally presented by Rosett and Nelson and also expression discussed by Maddala and Long [13-15], this model is appropriate because the dependent variable is the proportion of the acreage of land under irrigation, thus, the dependent variable ranges between 0 and 1. The two-limit Tobit model can be represented as:

$$y_i^* = \beta^* u_i \tag{1}$$

Where y_i^* is a latent variable (unobserved for values smaller than 0 and greater than 1) representing the use of the irrigation water, x is a vector of independent variables, which includes the factors affecting irrigation water use; β is a vector of unknown parameters, and u_i, is a disturbance term assumed to be independently and normally distributed with zero mean and constant variance σ; and i = 1, 2...n (n is the number of observations). Denoting y_i (the proportion of acreage on which the irrigation water is used) as the observed dependent (censored) variable, we have:

$$y_i = \begin{Bmatrix} 0 \; if \; y_i^* \leq 0 \\ y^* \; if \; 0 \leq y^* \leq 1 \\ 1 \; if \; y_i^* \geq 1 \end{Bmatrix} \tag{2}$$

Using the two-limit Tobit, the extent of irrigation water use was regressed against various factors hypothesized to influence the farmers' irrigation water use decision.

The log likelihood function for the general two-limit Tobit model can be given as follow:

$$logL = -\frac{1}{2}\sum_{j\varepsilon C} w_j \left[\left(\frac{y_i - x\beta}{\sigma}\right)^2 + log2\pi\sigma^2\right] + \sum_{j\varepsilon R} w_j \; log\Phi\left(\frac{y_{Lj} - x\beta}{\sigma}\right)$$

$$+ \sum_{j\varepsilon R} w_j \; log\left[1 - \Phi\left(\frac{y_{Rj} - x\beta}{\sigma}\right)\right] + \sum_{j\varepsilon I} w_j \; log\left[\Phi\left(\frac{y_{2j} - x\beta}{\sigma}\right)\right] - \Phi\left(\frac{y_{1j} - x\beta}{\sigma}\right) \tag{3}$$

Where C's are point observations, L's are left censored observations, R's are right-censored observations, and I's are intervals, and Φ is the standard cumulative normal distribution, and the w_j is the normalized weight of the j^{th} observation.

Unlike traditional regression coefficients, the Tobit coefficients cannot be interpreted directly as estimates of the magnitude of the marginal effects of changes in the explanatory variables on the expected value of the dependent variable. In a Tobit equation, each marginal effect includes both the influence of the explanatory variables on the probability of participation as well as on the intensity of irrigation water use. The total (marginal) effect takes into consideration that a change in an explanatory variable will affect simultaneously the number of irrigation water users and the extent of irrigation water use by both current and new irrigation users. To obtain the decomposition for the case of a two-limit-Tobit, begin in equation (10). Given the assumption that the distribution Ui is independently and normally distributed with zero mean, the expected value of the latent variable for the two-limit Tobit is

$$E\left(\frac{y^*}{x}\right) = \beta' x \; and \; \frac{\partial E\left(\frac{y^*}{x}\right)}{\partial x_i} = \beta_i \tag{4}$$

However, the conditional expected value of the truncated outcome is formulated by Long and Maddala [14, 15] is

$$E\left({}^{y}/_{x}, L < y^* < U\right) = \beta x + \sigma\left(\frac{\phi(Z_L) - \phi(Z_U)}{\Phi(Z_U) - \Phi(Z_L)}\right) \tag{5}$$

Where '(z) and Ù (z) are the cumulative distribution and density function for the standard normal.

Following the extension of the McDonald-Moffit [16] decomposition for the case of a two- limit Tobit, the total marginal effect of a change in an independent variable on the expected value of the extent of irrigation water use (i.e., the percent of the acreage under the irrigation technology) is equal to a weighted sum of:

(a) The change in the probability of participation in irrigation water use as an independent variable x_i changes for non-users is:

$$\frac{\partial \Phi(Z_L)}{\partial x_i} = \phi(Z_L) \frac{\beta_i}{\sigma} \tag{6}$$

(b)The change in the intensity of irrigation water use for farmers with respect to a change in an explanatory variable among those that have used some proportion is:

$$\frac{\partial E\left({}^{y_i}/_{U} > y_i^* > L, x\right)}{\partial x_i} = \beta_i \left(\frac{1 + Z_L\phi(Z_L) - Z_U\phi(Z_U)}{\Phi(Z_U) - \Phi(Z_L)} - \left[\frac{\phi(Z_L) - \phi(Z_U)}{\Phi(Z_U) - \Phi(Z_L)}\right]^2\right) \tag{7}$$

(c) The change in probability of irrigation intensity (proportion) on 100% basis with respect to a change in an explanatory variable is:

$$\frac{\partial \Phi(Z_U)}{\partial x_i} = \phi(Z_U) \frac{\beta_i}{\sigma} \tag{8}$$

(d) The total marginal effect of an explanatory variable on the expected value of the dependent variable for all observations is:

$$\frac{\partial E\left({}^{y}/_{x_i}\right)}{\partial x} = \beta_i\left(\Phi(Z_U) - \phi(Z_L)\right) \tag{9}$$

Where xi is an explanatory variable, z is the cumulative normal distribution, z is $\frac{\beta_i x_i}{\sigma}$ which indicates that the Z-score for the area under normal curve β_i is a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term,

$$Z_L = \frac{L - x_i\beta}{\sigma}$$

$$Z_U = \frac{U - x_i\beta}{\sigma}$$

Where L and U are threshold values (L=0 and U=1), ϕ and Φ are probability density and cumulative functions of the standard normal distribution, respectively.

Specification of normal Tobit model for willingness to pay

The econometric model applied for analyzing factors influencing the farmer's willingness to pay and amount of cash payment for irrigation water use is the Tobit model shown in equation (9). This model was chosen because it has advantage over other models (LPM, Logistic and Probit) in that, it reveals both the probability of willingness to pay and amount of cash payment for irrigation water use.

Following Maddala, also Amemiya, Johnston and Dinardo [14, 17, 18] expressed and defined the Tobit model as:

$$y_i^* = \beta x_i + u_i \tag{10}$$

$$y_i = \begin{cases} y_i^* \; if \; y_i^* > 0 \\ 0 \; if \; y_i^* \le 0 \end{cases}$$

where, i= 1, 2...n (n=number of observations),

y_i = the observed dependent variable, is the amount of cash payment for irrigation water use in Birr,

y_i*= the latent dependent variable (index variable) which is not observable,

x_i = vector of factors affecting willingness to pay and amount of cash payment for irrigation water use,

β_i = vector of unknown parameters and u_i = residuals that are assumed to be independently and normally distributed with mean zero and a common variance σ^2 ($u_i \sim N(0, \sigma^2)$) to capture random influences.

Therefore, the observed zero values are not due to censoring, but due to the decisions of the individuals. Note that the threshold value in the above model is zero. As Amemiya explained, this is not a very restrictive assumption, because the threshold value can be set to zero or assumed to be any known or unknown value. The Tobit model shown above is also called a censored regression model because it is possible to view the problem as one where observations of y_i* at or below zero are assumed in Johnston and Dinardo formulation. Also, Maddala and Amemiya explained the model parameters are estimated by maximizing the Tobit likelihood function of the following form expressions [14, 17, 18]:

$$L = \prod_{y_i^*>0} \frac{1}{\sigma} \phi\left(\frac{y_i - \beta_i x_i}{\sigma}\right) \prod_{y_i^* \le 0} \Phi\left(\frac{-\beta_i x_i}{\sigma}\right) \tag{11}$$

Where ϕ and Φ are respectively, the density function and cumulative distribution function of yi*, $\prod y_i^* \le 0$ means the product over those i's for which yi* ≤ 0, and $\prod y_i^* > 0$ means the product over those i's for which yi*> 0.

An econometric software known as 'Limdep' was employed to run the Tobit model. It may not be sensible to interpret the coefficients of a Tobit model in the same way as one interprets coefficients in an uncensored linear model is considered by Johnston and Dinardo [18]. Hence, one has to compute the derivatives of the estimated Tobit model to predict the effects of change in the exogenous variables.

Equation (11) represents a censored distribution of the amount of cash payment for irrigation water use since the value of WTP for all non-willing water users equal to zero. Following Tobin model [11], the expected amount of cash payment for irrigation water use E (y) is:

$$E(y) = x\beta\Phi(z) + \sigma\phi(z) \tag{12}$$

Where x is a vector of explanatory variables, Φ (z) is the cumulative normal distribution of Z, and Z is equal to $\frac{\beta_i x_i}{\sigma}$, ϕ(Z) is the value of the derivative of the normal curve at a given point (i.e., unit normal density), z is the Z-score for the area under normal curve, , is the a vector of Tobit maximum likelihood estimates and σ is the standard error of the error term.

Also, McDonald and Moffitt [16] proposed the following techniques to decompose the effects of explanatory variables into willingness to pay and amount of cash payment for irrigation water use effects. Thus, a change in x_i (explanatory variables) has two effects. It affects the conditional mean of y_i* in the positive part of the distribution, and it affects the probability that observation [will fall in that part of the distribution. Therefore, similar approach is used in this study.

1) The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(y)}{\partial x_i} = \Phi(z)\beta_i \tag{13}$$

2) The change in the probability of willingness to pay for irrigation water use as independent variable x_i changes is:

$$\frac{\partial \Phi(z)}{\partial x_i} = \frac{\phi(z)\,\beta_i}{\sigma} \tag{14}$$

3) The change in the amount of cash payment with respect to a change in an explanatory variable among irrigation water users is:

$$\frac{\partial E(y_i / y_i^* > 0)}{\partial x_i} = \beta_i \left\{1 - \frac{\phi(z)}{\Phi(z)} - \left(\frac{\phi(Z)}{\Phi(Z)}\right)^2\right\} \tag{15}$$

Specification of interval regression model for willingness to pay

This study has also employed double bounded dichotomous elicitation format of contingent valuation method which has proved to be a valuable approach for assessing the value of non- market resources and public goods. This elicitation format enables to create lower and upper bounds of payment. The amount of payment that a respondent would be willing to pay lies in a specified interval of payment, i.e., in between the lower and upper bounds. The issue addressed here is how to analyze data that has interval-censored, left-censored and right- censored values. Following the censored econometric model proposed by Cameron. This model also jointly evaluated by James and Cameron [19, 20], which produces separate estimates for the standard deviation of the

WTP and the parameters of the model, assuming a linear functional form for the magnitude of WTP, the econometric model (Interval Regression Model) is specified as follows:

$$Y_i = X_{i\beta} + \varepsilon_i \tag{16}$$

Where Y_i represents lower and upper values of farmers' monetary payment for irrigation water use, X_i is socioeconomic and institutional characteristics affecting the amount of payment for irrigation water made by a household and ε_i is the error term.

2.4. Defined Variables and Working Hypotheses

Once the analytical procedures and their requirements were known, it was necessary to identify potential explanatory variables and describing their measurements. Accordingly, the key variables expected to have influence on small-scale irrigation scheme utilization and willingness to pay for irrigation water uses of households were explained in Table 2.

Table 2. Variables and their measurement included in the model.

Variable included	Code	Type of variables	Hypotheses Y_1	Y_2	Measurement
Household's small-scale irrigation scheme utilization	Y_1	Continuous	Y_1		Measured by ratio (Proportion of land under irrigation, 2007)
Household's WTP for irrigation water use	Y_2	Continuous		Y_2	Measured by monetary value in Birr
Education level of the household	EDULEVEL	dummy	+	+	1 if the household literates and 0 otherwise
Age of the household	HAGE	Continuous	+		Measured in years
Sex of the household	HSEX	Dummy	+		1 if the household is male and 0 otherwise
Family labor force	FLABOR	Continuous	+		Measured in man-equivalent
Household family size	HSIZE	Continuous		+ or -	Measured in number
Dependency ratio	DRATIO	Continuous		-	Measured in ratio
Household's perception on water sufficiency	HPWSUF	Dummy		+	1 if HH perceives the water sufficiency positively and 0 otherwise
Income from crop production	BSINCOME	Continuous		+	Measured in Birr
Off/non-farm income	OFFNON	Continuous		+	Measured in Birr
Household participation in scheme planning	PSCHEME	Dummy	+		1 if HH participate in scheme planning and 0 otherwise
Irrigation farming experience of the household	IRREXPER	Continuous	+		Measured in years
Distance from market center	DMARKET	Continuous		-	Measured in kms
Training on irrigation utilization management	IRRTRAIN	Dummy	+		1 if the household gets training and 0 otherwise
Access to improved technology for irrigation	AITEC	Dummy	+		1 if HH access to improved technology for irrigation and 0 otherwise
Access to extension service	AEXTEN	Dummy	+		1 if HH access to extension service and 0 otherwise
Insect and pest infestation	PESTINS	Dummy		-	1 if the household faces insect & pest infestation and 0 otherwise
Distance from the main road	DROAD	Continuous	-		Measured in kms
Fertility of soil status	SOILSTAT	Dummy		+	1 if the irrigable land is fertile and 0 otherwise
Distance irrigation plot of HH from water source	DSOURCE	Continuous	-		Measured in kms
Ownership of radio of the household	ORADIO	Dummy		+	1 if HH owns radio and 0 otherwise

Variable included	Code	Type of	Hypotheses	Measurement
Access to credit for crop production	CREDIT	Dummy	+ or -	1 if HH access to credit service and 0 otherwise

3. Results and Discussion

3.1. Determinants of Participation in Irrigation Scheme and Intensity of Irrigation Water Use

As previously discussed, the two-limit Tobit regression model was applied to analyze the determinants of the household's proportion of land under irrigation. The Tobit model offers the advantage that its coefficients can be further disaggregated to assess the effects of changes in both the probability of household participation in small-scale irrigation schemes and the intensity of irrigation use. The results from the maximum likelihood estimation of the two-limit Tobit model were presented in Tables 3 and 4.

The econometric model considered 11 explanatory variables, of which 4 were found to significantly impact the probability and intensity of irrigation use among the sample households. These variables were the household head's education level (EDULEVEL), participation in irrigation scheme planning (PSCHEME), access to extension services (AEXTEN), and distance from the main road (DROAD).

The education level of the household head (EDULEVEL) was one of the factors which positively and significantly influenced the probability and intensity of small-scale irrigation use. Educated farmers are better able to access and utilize irrigation information, recognize its benefits, and manage irrigation practices effectively. Thus, the marginal effect of this variable showed that literate households have 2.19% more probability of using irrigation compared to non-irrigation users. Also, literate households have 26.1% probability of using irrigation at full capacity than non-irrigation users. The proportion of area of land under irrigation of literate households was 0.008 higher than the illiterate farmers.

The household's participation in the irrigation scheme planning (PSCHEME) was also another factor that was positively and significantly related to the likelihood and intensity of small-scale irrigation use. Households that participate in irrigation scheme planning gain access to valuable information and develop a sense of ownership over the scheme, with their views and concerns likely considered in the planning process. Additionally, such participation enables farmers to better manage irrigation practices, including scheduling water use, planting times, cultivation, and operation and maintenance, compared to non-participating farmers. The marginal effect of this variable indicated that participant households have 3.57% more probability of using irrigation compared to non-irrigation users. Also, participant households have 39.27% probability of using irrigation at full capacity. The proportion of area of land under irrigation of participant households was 0. 0121 higher than the non-participant farmers.

The results of the Tobit model also showed that access to extension service (AEXTEN) was important factors that positively and significantly influenced the likelihood and intensity of small-scale irrigation use. Extension services are a key source of information for adopting irrigation technology. Through these services, farmers receive training on the benefits, practices, and features of modern agricultural technologies. Extension services also expand farmers' knowledge of improved seed varieties, cultural practices, and other agricultural innovations, positively impacting farm income and irrigation decisions aimed at boosting production and productivity. As a result, farmers with better access to extension services are more informed and more likely to use irrigation water compared to those without such access. The marginal effect of this variable also reveals that farmers that have access to extension service have 3.06% more probability of using irrigation compared to non-irrigation users. Also, farmers that have access to extension service have 29.63% probability of using irrigation at full capacity. The proportion of area of irrigation of farmers who have access to extension services was 0.0091 higher than farmers that don't have access to extension service.

The results of the Tobit model also showed that the distance of the farmer's residence from the main road (DROAD) was found to negatively and significantly influence the probability and intensity of small-scale irrigation use. Farmers located far from the main road face higher transaction costs for selling their output and acquiring inputs, which can reduce their income and lower their incentive to use irrigation water. In contrast, farmers near the main road have a location advantage, allowing them to sell their produce at better prices, which may encourage greater use of irrigation. The marginal effect of this variable shows that for each additional kilometer distance from the road, the probability of irrigation water use would decrease by 1.21%. Also, each additional kilometer increase in distance from the main road would reduce the probability of irrigating land at full capacity by 13.64%. For each additional increased distance from the main road in kilometers, the proportion of land under irrigation would reduce by 0.0017.

3.2. Analysis of Determinants of Farmers' Willingness to Pay for Irrigation Water Use

3.2.1. Estimation of the Mean WTP Value

To estimate the mean WTP value for this study, the starting point was to calculate the mean WTP of the sample respondents. In this framework, the probability that household would be willing to pay or probability of saying yes for given bid value can be estimated. Thus, the truncated mean WTP value was calculated employing the following equation as specified by Hanemann (1989) as: $\mathrm{E(WTP)} = \ln(1 + e^{\beta_0})/-\beta_1$

That is, first the intercept and slope of bid would be estimated by regressing dependent variable (yes or no response) on the initial bid value, other explanatory variable held constant, and then these estimated coefficients would be replaced in the above formula to calculate the mean WTP value. Therefore, using this procedure the estimated mean WTP was found to be 155.33 Birr per 0.25 ha per year.

Table 3. Maximum likelihood estimates of the two-limit Tobit model.

Explanatory variables	Estimated coefficients	Standard error	t-ratio
Constant	0.6763	0.4766	1.4789
HSEX	-0.2436	0.2729	-0.8928
HAGE	0.0090	0.0083	1.0828
EDULEVEL	0.4143	0.2290	1.8102*
FLABOR	0.0703	0.0920	0.7647
IRREXPER	0.0035	0.0181	0.1905
PSCHEME	0.6234	0.2198	2.8366***
AITEC		0.1754	0.3483
AEXTEN		0.2247	2.0926**
IRRTRAIN	0.0611	0.1186	0.6175
DSOURCE	0.4703	0.0873	0.9883
DROAD	-0.2166	0.1150	-1.8831*

Number of observations =150
Log likelihood function = -23.9833
Threshold values for the model: Lower=0.0000, Upper=1.0000
Û =0.452
z =2.36
Ù(z)= 0.0246 and '(z)=0.9909

***, ** and * indicate statistically significant at 1%, 5% and 10% probability levels, respectively.
Source: Survey data, 2007

Table 4. Marginal effects of independent variables on the intensity of irrigation for water use.

Explanatory Variables	Effect of change in independent variable on dependent variable			
	Non-irrigation users[1]	Maximum irrigation users[2]	Intermediate irrigation Users[3]	For all observations
	$\partial\Phi(ZL)/\partial x_i$	$\partial\Phi(ZU)/\partial x_i$	$\partial E(\frac{y}{u} > y > L, x)/\partial x_i$	$\partial E(y_i)/\partial x_i$
HSEX	-0.0145	-0.1535	-0.0047	-0.1817
HAGE	0.0004	0.0057	0.0002	0.0067

Explanatory Variables	Effect of change in independent variable on dependent variable			
	Non-irrigation users[1]	Maximum irrigation users[2]	Intermediate irrigation Users[3]	For all observations
	$\partial\Phi(ZL)/\partial x_i$	$\partial\Phi(ZU)/\partial x_i$	$\partial E(\frac{y}{u} > y > L, x)/\partial x_i$	$\partial E(y_i)/\partial x_i$
EDULEVEL	0.0219	0.2610	0.0080	0.3090
FLABOR	0.0028	0.0443	0.0014	0.0525
IRREXPER	0.0001	0.0022	0.0001	0.0026
PSCHEME	0.0357	0.3927	0.0121	0.4648
AITEC	0.0025	0.0385	0.0012	0.0456
AEXTEN	0.0306	0.2963	0.0091	0.3507
IRRTRAIN	0.0005	0.0734	0.0023	0.0868
DSOURCE	-0.0034	-0.0544	-0.0017	-0.0643
DROAD	-0.0121	-0.1364	-0.0017	-0.0643

Source: Derived from the main equation in table 3

[1]non-irrigation users were observations at the lower limit (0)

[2]Maximum irrigation users were observations at upper limit and that fully irrigated their land

[3]Intermediate irrigation users were observations between the lower limit (0) and upper limit (1) and they did not use irrigation to the full capacity

3.2.2. Estimates of the Parameters and Their Marginal Effects on the Amount of Cash Payment for Irrigation Water Use

Table 5 presents the estimates of the variables that are expected to influence farmers' willingness to pay (WTP) for irrigation water use. The dependent variable is continuous, representing the maximum amount individual farmers are willing and able to pay for the service, based on the benefits they anticipate. A Tobit model, censored from below, was used to analyze the factors affecting households' maximum WTP, as farmers are not paying a non-zero amount for the service. The econometric model included 11 explanatory variables, of which six were found to significantly impact the willingness to pay for irrigation water use among farm households.

The results of the Tobit model can be also used to identify the effect of changes in the explanatory variables on the amount of cash payment for irrigation water use. Table 6 shows the effect of marginal changes (derivates) in explanatory variables on the amount of cash payment for irrigation water uses among users and the entire sample households. The variables were household family size (HSIZE), dependency ratio (DRATIO), income from crop production (BSINCOME), ownership of the radio (ORADIO), household's perception on water sufficiency (HPWSUFF) and the pest and insect infestation (PESTINS) were found to have significant influence on the amount of cash payment for the irrigation water use.

The results of the model showed that household family size of (HSIZE) was negatively and significantly related to the probability of willingness to pay and the amount of payment for irrigation water use. This means that the amount of cash expected to be paid by households would decrease with increases in household size. This might be because compared to households with small family size, households with large family size have larger cash expenditures to meet household needs such as clothing, education, the cumulative effect of which depletes the household's cash deposit. The marginal effect results showed that when the family size of a household increases by one person, it would decrease the probability of willingness of a household to pay for the irrigation water use by 0.84%. Also, when the family size of a household increases by one person, the amount of cash the household could pay for irrigation may decrease by Birr 4.001, other factors being constant.

The results of the Tobit model also showed that dependency ratio (DRATIO) has negative and significant relationship with willingness to pay for irrigation water use and its intensity. This was due to the fact that as the proportion of economically less active or dependent members to the economically active members of the family becomes higher, irrigation farm activity which by its nature is labor intensive would produce and earn less income as compared to those households with less dependency ratio. Thus, the more dependency ratio in the household, the less active labor force the farmer would have. The marginal effect results show that as the dependency ratio of a household increases by one, it would decrease the probability of the willingness of a household to pay for the irrigation water use by 1.13%. Also, when the dependency ratio of a household increases by one, the amount of cash the household could pay for irrigation may decrease by Birr 5.39, other things held constant.

The result also showed that income from crop production (BSINCOME) has positive and significant influence on the probability of farmers' WTP for irrigation water use and amount of payment. It was obvious that those households that generate more income from crop production would be more willing to pay for irrigation water as they would have the ability to do so, more specifically from the additional income generated from irrigated crop production. Thus, the higher the amount of income per production season the more the farmer would be concentrated to ensure sustainability of the scheme and more likely to be willing to pay for irrigation water use. The marginal effect results showed that when the income level of a household increases by one Birr, it would increase the probability of willingness of a household to pay for the irrigation water use by 0.004%. Also, when the income level of a household increases by one Birr, the amount of cash the household could pay for irrigation may increase by Birr 0.002, other factors held constant.

Ownership of radio of the household (ORADIO) was another important factor, which is positively and significantly related to farmers' willingness to pay for irrigation water use and its amount. Information from radio enhances the ability of farmers to access and use irrigation technologies. Farmers that own radio may get different information on extension service, credit service, crop price, improved seed variety and input price than those farmers don't possess radio. The marginal effect of this variable also revealed that farmers that own radio have 5.81% more probability of paying for irrigation water than those farmers did not possess. Also, farmers that own radio, would pay Birr 27.74 more than those farmers that did not own radio.

Household's perception on irrigation water sufficiency (HPWSUF) was another factor, which was positively and significantly related to farmers' WTP for irrigation water use and its amount. Thus, farmers who have access to sufficient water can use irrigation water timely and effectively more than farmers do not have sufficient access. The marginal effect of this variable also revealed that farmers who have responded to have sufficiency water have 4.35% more probability of paying for irrigation water compared to farmers who recognize water scarcity. Also, farmers who have responded to have sufficiency water would pay Birr 20.78 more for irrigation water than those that face water scarcity, other factors held constant.

Pest and insect infestation (PESTINS) was negatively and significantly related to the farmers' willingness to pay for irrigation water use and its intensity. This might be due to the fact that the study area was low land with a high temperature, which created favorable conditions for insect and pest reproduction. As a result, pest and insect in the area affect crop production and which in turn decreases the farmers' income. Therefore, households faced with pest and insect infestation had less intention to be willing to pay for irrigation water use than households that do not have this problem on his/her plots. The marginal effect results revealed that a household who frequently faces pest and insect infestation will have a 3.7% less probability of paying for irrigation water compared to farmers do not face such situations. Also, farmers who face insect and pest infestations would pay Birr 17.65 less than those that do not face such problem, other factors being constant.

Table 5. Maximum likelihood estimates of the Tobit model.

Explanatory variables	Estimated coefficients	Standard error	t-ratio
Constant	-67.2365	103.796	-0.6478
EDULEVEL	0.7995	10.7687	0.0742
HSIZE	-4.5759	2.5381	-1.8029*
DRATIO	-6.1525	2.6980	-1.8279*
BSINCOME	0.0020	0.0011	1.7608*
OFFNON	17.2786	15.7497	1.0971
CREDIT	1.4219	11.5681	0.1229
DMARKET	4.8855	5.1811	0.9429
ORADIO	31.661	11.4912	2.7560***
HPWSUFF	23.7208	11.7162	2.0246**
SOILSTAT	9.9289	11.0001	0.9026

Explanatory variables	Estimated coefficients	Standard error	t-ratio
PESTINS	-20.1427	12.0862	-1.6667*
Number of observations =150			
Log likelihood function =-611.5210			
Threshold values for the model: Lower=0.0000 Upper=+ infinity			
Û =57.5865			
z=1.63			
Ù(z)=0.1057 and ‘(z)=0.9484			

***, ** and * indicate statistically significant at 1%, 5% and 10% probability levels, respectively.
Source: Survey data, 2007

Table 6. Marginal effects of explanatory variables on the amount payment for irrigation water use.

Explanatory variables	Change in probability being irrigation water use $\frac{\partial F(z)}{\partial X_i}$	Change amongirrigation water users $\frac{\partial E\left(\frac{Y_i}{X_i}\right)>0}{\partial X_i}$	Change among the whole $\frac{\partial E(Y_i)}{\partial X_i}$
EDULEVEL	0.0015	0.7000	0.7582
HSIZE	-0.0084	-4.0009	-4.3398
HDRATIO	-0.0113	-5.3902	-5.8350
BSINCOME	0.0004	0.0018	0.0020
OFFNON	0.0317	15.1360	16.3870
CREDIT	0.0026	1.2456	1.3485
DMARKET	0.0013	4.2796	4.6334
ORADIO	0.0581	27.7382	30.0273
HPWSUFF	0.0435	20.7818	22.4968
SOILSTAT	0.0182	8.6977	9.4736
PESTINS	-0.0370	-17.6470	-19.1033
Source: Based on model output			

3.2.3. Interval Regression Model for the Determinants of Amount of Payment for Irrigation Water Use

Interval regression model was used as an alternative or to deliver certain additional information for analyzing factors that explain the intensity (magnitude) of cash payment for irrigation water use decision. The ranges of bid values used for analysis were <Birr 40, Birr 40-Birr 80, Birr 80-Birr 120, Birr 120-Birr 160, Birr 160-Birr 200 and > Birr 200. The extreme bid values of the categories on either end of the ranges or left-censored or right- censored observations for irrigation water use. The other categories were interval observations. Therefore, Table 7 shows the results of interval regression model.

Table 7. Interval regression model results of magnitude of cash payment.

Variables	Coefficients	Standard error	t-ratio
EDULEVEL	4.5860	11.5747	0.40
HSIZE	-2.2088	2.6980	-0.82
HDRATIO	-31.0467	27.9867	1.11
BSINCOME	0.0021	0.0012	1.70*
OFFNON	3.8895	16.3000	0.24
CREDIT	-6.5123	12.6231	-0.52
DMARKET	0.6907	5.6885	0.12
ORADIO	20.5206	12.2248	1.68*
HPWSUFF	17.2649	12.5777	1.37
SOILSTAT	15.0493	11.8730	1.27
PESTINS	-19.4443	13.0141	-1.49*
-Constant	30.2829	113.4462	0.27

* Represents significance at 10% probability level Source: Survey results, 2007

The econometric model results of the interval regression model on the magnitude of cash that a household was willing to pay showed that only three variables; namely: Income from crop production (BSINCOME), ownership of radio (ORADIO) and pest and insect infestations (PESTINS) were found to have significant effect on the amount of cash that a household would be willing to pay (Table 7). When the two models were compared, the Tobit model showed better fit as the number of variables that were found to be significant exceeded that of interval regression.

The interval regression model showed that income from crop production (BSINCOME) has positive and significant influence on the probability of farmers' WTP for irrigation water use. It was obvious that those households that generate more income from crop production would be more willing to pay for irrigation water as they would have the ability to do so, more specifically from the additional income generated from irrigated crop production. The marginal effect results showed that a unit increase in the income from crop production of household increases the amount of cash the household could pay for irrigation water by Birr 0.0021, *ceteris paribus.*

Ownership of radio (ORADIO) was another important factor, which was positively and significantly related to farmers' willingness to pay for irrigation water use. Radio enables farmers to access information on irrigation technologies from different sources. Thus, farmers who have radio might be able to recognize and understand the advantages of irrigation more than farmers do not have radio to use different technologies. The marginal effect of the result has shown farmers that own radio would pay Birr 20.52 than those who don't have radio, *ceteris paribus*.

Pest and insect infestation (PESTINS) was negatively and significantly related to farmers' willingness to pay for irrigation water use. This might be due to the fact that was low land with a high temperature, which creates favorable conditions for insect and pest reproduction. As a result, pest and insect in the area affect crop production and which in turn decreases the farmers' income. Therefore, households faced with pest and insect infestation had less intention to be willing to pay for irrigation water use than households that do not have this problem on his/her plots. The marginal effect results households that face such problem would pay Birr 19.44 is than those farmers do not face such conditions, *ceteris paribus*.

4. Conclusion and Policy Implications

4.1. Summary and Conclusion

Ethiopia is predominantly an agrarian country, with the majority of its population engaged in agriculture, either directly or indirectly. The agricultural sector is largely based on traditional and subsistence farming systems, which are characterized by limited access to improved agricultural technologies and weak institutional support. These factors, coupled with recurring famines and droughts, make the country highly vulnerable to food insecurity. Given the unsustainable nature of rain-fed agriculture in addressing these challenges, many food-secure countries have turned to irrigation technologies to boost agricultural productivity and sustainability.

Irrigation development holds significant promise due to its potential for higher yields per unit of land. However, small-scale irrigation schemes in Ethiopia, such as the Bosha-01 scheme in the Arsi Zone, face numerous challenges. There was limited information to which extent is the scheme potential being exploited, the extent (intensity) of its use, and insufficient involvement from farmers or communities in ensuring sustainable management. Additionally, the lack of monitoring, evaluation, and feedback mechanisms, combined with poor capacity-building efforts at the grassroots level, has contributed to suboptimal irrigation water use and poor management of irrigated crops.

This study aimed to identify and quantify the socio-economic, demographic, and institutional factors influencing rural households' participation in small-scale irrigation schemes, their intensity of irrigation water use, and their willingness to pay (WTP) for irrigation services in the Bosha-01 irrigation scheme in the Arsi Zone. The study also sought to assess the organizational, managerial, institutional, and operational aspects of these schemes, with a focus on ensuring the sustainability of water use and infrastructure management.

Arsi Zone, located in the southeastern part of Ethiopia, encompasses 25 districts with an area of 23,821km². Primary data for this study were collected from 150 farm households who are potential beneficiaries of the Bosha-01 scheme. A multi-stage random sampling technique was used to select the households, and data were gathered through structured questionnaires, open-ended checklists, focus group discussions, and interviews with key stakeholders. The study found that key components of the irrigation management system, such as water allocation, distribution, and organizational activities, were not functioning effectively in the study area. This failure was attributed to the absence of strong Water User Associations (WUAs), lack of financial resources, and insufficient institutional support, requiring coordinated efforts from various stakeholders. Moreover, the absence of irrigation service fees and cost-recovery mechanisms had led to poor operation and maintenance of the irrigation system. To address these issues, the study suggested implementing irrigation service fees to ensure sustainable water use. Strengthening WUAs to facilitate equitable water distribution and mobilize farmers for maintenance, along with providing training on irrigation techniques and water conservation, was also recommended.

Descriptive statistical analysis, chi-square, and t-tests were used to compare irrigation users and non-users. Econometric techniques, including the two-limit Tobit regression model, were employed to assess the determinants of small-scale irrigation water use, intensity, and farmers' WTP. The results showed that several factors, including the education level of the household head, participation in irrigation planning, access to extension services, and proximity to roads, significantly influenced the likelihood of irrigation use and its intensity.

Regarding farmers' WTP for irrigation water, the study found that 69.3% of respondents were willing to pay for irrigation services, with an estimated mean WTP of 155.33 Birr per 0.25 ha per year. The Tobit regression model revealed that factors such as household size, dependency ratio, income from crop production, ownership of a radio, perceptions of water sufficiency, and pest infestations significantly influenced WTP.

4.2. Policy Implications

A comprehensive understanding of the factors influencing smallholder farmers' participation in small-scale irrigation schemes and their willingness to pay (WTP) for irrigation water is crucial for policymakers and development workers. Such insights can aid in the design and implementation of effective irrigation plans and enhance the management of existing irrigation projects, ensuring the optimal and sustainable use of water resources. Based on the findings of this study, several strategic elements are proposed to improve farmers' utilization of small-scale irrigation schemes and enhance the effectiveness of limited irrigation projects in Ethiopia.

One key finding of the study was that the education level of the household head positively and significantly influences the utilization of small-scale irrigation schemes. This suggests that increasing the educational status of farmers through adult education programs, improved use of farmer training centers, and expanded primary education can increase both the likelihood and intensity of irrigation water use. Educated farmers are more likely to adopt irrigation technologies and engage more effectively with the scheme, leading to higher productivity.

The study also highlighted the importance of farmers' participation in the planning stages of irrigation schemes. Households that were involved in the planning process were more likely to use irrigation systems and to apply irrigation more intensively. Therefore, it is essential to involve farmers from the outset in future irrigation projects to ensure they are more invested in the scheme's success and that the system is better tailored to their needs.

Access to extension services was another factor positively associated with irrigation participation and intensity. Farmers who received extension services were more likely to engage in irrigation and use it more intensively. Providing farmers with access to new, market-driven crop varieties, offering training on irrigation practices, and organizing visits to successful irrigation schemes can promote the adoption of more efficient practices, ultimately contributing to greater utilization of the schemes.

Conversely, distance from an all-weather road negatively affected both the likelihood of participating in irrigation schemes and the intensity of irrigation use. This suggests that improving rural road networks is crucial for better access to markets, inputs, and irrigation services. Strengthening rural infrastructure will facilitate the movement of irrigated crops to markets and provide farmers with the necessary resources to optimize their use of irrigation.

The study also found that factors such as household size, dependency ratio, household perception of water sufficiency, income from crop production, radio ownership, and pest and insect infestations significantly influenced farmers' willingness to pay for irrigation water. Specifically, household size and dependency ratio were found to negatively impact WTP. This indicates that households with larger sizes or higher dependency ratios may struggle to allocate sufficient funds for irrigation services. Policymakers should focus on creating diverse on-farm and off-farm income opportunities to increase per capita income, as well as promote family planning initiatives to improve household productivity.

Farmers' perception of water sufficiency was another significant factor positively related to their WTP. Ensuring that irrigation water is available and accessible, especially in the middle and tail-end areas of the irrigation system, is crucial. Proper construction and maintenance of water canals, as well as strengthening the organizational and managerial functions of Water User Associations (WUAs), are essential for effective water distribution and conflict resolution.

Income from crop production was also positively associated with farmers' willingness to pay for irrigation water. Providing specialized extension services, such as training on efficient irrigation techniques and improving access to inputs like seeds, fertilizers, and chemicals, would enable farmers to increase their income and, in turn, enhance their willingness to pay for irrigation services.

Moreover, ownership of radios was found to positively influence farmers' WTP. Radio ownership provides farmers with access to vital information on irrigation technologies, crop prices, and agricultural services, making them more informed and willing to pay for water use. Expanding access to communication channels will enable farmers to stay updated on best practices and opportunities related to irrigated agriculture.

Lastly, pest and insect infestations were found to negatively impact farmers' willingness to pay for irrigation water. To address this, appropriate pest control techniques, such as integrating cultural practices, increasing access to agro-chemicals, and improving farmers' knowledge of local pest management practices, should be emphasized. By addressing pest and insect issues, farmers will be more likely to invest in irrigation and enhance the overall success of the irrigation scheme.

Abbreviations

FAO	Food and Agriculture Organization
MoRW	Ministry of Water Resources
WTP	Willingness to Pay
NGO	Non-governmental Organization
TDIDO	Tiyo District Irrigation and Development Office
OIDA-CBO	Oromia Irrigation Development Authority-Central Branch Office
AZARDO	Arsi Zone Agriculture and Rural Development Office
TDARDO	Tiyo District Agriculture and Rural Development Office

Author Contributions

Takele Mengesha Goshu: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing

Getahun Nagari Nukuse: Data curation, Supervision, Visualization

Tekle leza Mega: Conceptualization, Validation, Visualization

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Conflicts of Interest

The authors declare no conflicts of interest.

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Research Fields

Takele Mengesha Goshu: Factors Impacting Farmers' Willingness to Pay for Water, Small-Scale Irrigation Systems and Water Management, Farmers’ Willingness to Pay for Irrigation, Irrigation Technology Adoption in Developing Countries, Determinants of Farmers' Willingness to Pay for Irrigation, Effect of Small-Scale Irrigation on Productivity.

Getahun Nagari Nukuse: Impact of Irrigation on the Livelihood of Irrigation-User Farmers, Socio-Economic and Institutional Determinants of Irrigation Utilization, Factors Affecting Farmers' Willingness to Pay for Soil Conservation, Water Resource Management in Sub-Saharan Africa, Sustainable Water Use in Agriculture, Policy Impact on Irrigation Schemes, Water Scarcity and Agricultural Productivity.

Tekle Leza Mega: Effects of Climate Change on Livelihood Strategies of Farm Households, Effect of Small-Scale Irrigation on Improving Household Income, Determinants of Farmers' Willingness to Pay for Irrigation, Water Pricing and Sustainability of Irrigation Schemes, Factors Affecting Farmers' Willingness to Pay for Soil Conservation, Agricultural Economics and Water Utilization, Farmers’ Willingness to Pay for Irrigation, Rural Development and Irrigation Access.

Senapathy Marisennayya: Analysis of Rural Households' Resilience to Food Insecurity, Determinants of Adoption and Intensity of Improved Haricot Bean Varieties, Status of Household Food Security, Its Determinants, and Coping Strategies, Water Scarcity and Agricultural Productivity, Economic Impact of Irrigation in Farming, Sustainable Water Use in Agriculture, Water Pricing and Sustainability of Irrigation Schemes, Factors Affecting Farmers' Willingness to Pay for Soil Conservation, Socio-Economic and Institutional Determinants of Irrigation Utilization.