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Determinants of smallholder farmers' willingness to pay for improved irrigation systems: Evidence from Northwest, Ethiopia

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Abstract

This study attempted to identify determinants of farmers' maximum willingness to pay (WTP) for improved use of irrigation water. From a population of 1 380, 177 sample households were selected for primary data collection. From the total sample of households, 77.97% of respondents were willing to pay for sustainable irrigation water use via constructing improved irrigation water channels. On the other hand, 22.03% of the respondents were not willing to pay. For data analysis, both descriptive statistics and the tobit model were applied. The result from the tobit regression model reveal that education level, livestock ownership, annual income, irrigation experience, irrigable land size and access to and frequency of extension service were significant variables of farmers' maximum WTP. Based on the findings, it is possible to conclude that most rural households are willing to pay for and use improved irrigation water. Hence, the study suggests that this could serve as a good indicator that the official body concerned should introduce pricing for irrigation water for farmers and consider these variables when designing an improved irrigation water supply system.

Key words: willingness to pay, contingent valuation, irrigation water, tobit model

1. Introduction

Water is a finite and vulnerable resource from which irrigation water is generally regarded as a non-market good, and plays a vital role in economic development (Ejeta *et al*. 2019). It is a precious and crucial resource that is used for sustainable development and poverty-reduction programmes, playing an important role in the agricultural sector (Getnet *et al*. 2022). When water is used effectively and safely, its productivity in irrigation-based agricultural and non-agricultural production would be optimum (Mansour *et al*. 2022). Ethiopia has abundant water resources, including 12 river basins and 22 natural and artificial lakes. Annual surface runoff, excluding groundwater, is estimated to be about

122 billion m³ of water. Groundwater resources are estimated to be around 2.6 billion m³ (Aman *et al*. 2020). Despite Ethiopia's endowment with a potentially huge area of irrigable land, irrigation development is very low (Astatike 2016). However, future use and quality are affected by the effective use, financing and management of water with increasing population growth (Ejeta *et al*. 2019).

In Ethiopia, agriculture is the dominant economic sector and also food supplier, relying largely on rainfall. It contributes 43% of the GDP, about 80% of employment, and approximately 75% of export commodity values (Bayleyegn *et al*. 2018). Due to increasing population growth and food demand on one hand, and increasing pressure on rain-fed agriculture from land degradation and climate variability on the other, the importance of irrigation farming cannot be denied (Gebul 2021). Irrigation farming has been necessitated by the shortage of land and the need to maximise the limited land available to grow food (Ejeta *et al*. 2019). Improvements in irrigation infrastructure are embraced as a possible solution to maximise agricultural production to satisfy the food demands of the ever-increasing population and improve the income of smallholder farmers (Berhe *et al*. 2022). Despite the government's commitment and efforts, irrigation infrastructure development in Ethiopia is still low due to a low level of community participation, lack of site-specific, reliable hydrological data, poorly designed irrigation infrastructure and high construction costs (Gebul 2021). The estimated irrigation potential of the country is estimated at roughly 5.3 million hectares (Mha) of potentially irrigable land (Aman *et al*. 2020). Despite this, only approximately 640 000 hectares are irrigated, with 241 000 hectares located in small-scale projects, 315 000 hectares in medium-scale projects, and 84 000 hectares in large-scale projects (Mekonen *et al*. 2022).

Furthermore, the fundamental problem that always arises with irrigation development is the lack of expansion of modern and water-efficient irrigation canals, and the source of this problem is the financial attitude of farmers (Eshete *et al*. 2020). Farmers are irrigating the same types of vegetables across the schemes, and their demand for irrigation remains consistent across seasons and kebeles, exacerbating the situation (Mekonen *et al*. 2022). The necessary funding can be generated through the implementation of well-designed water pricing (Fagundes & Marques 2023). Water pricing can potentially raise significant financial resources to pay for the sustainable management of water resources (Zhang & Oki 2023). In some countries, like France and the Netherlands, water pricing is the main source of revenue for the water sector (Astatike 2016). Revenues from water pricing are particularly important for developing countries, as funds from public budgets and donor sources are unpredictable and may vary significantly from year to year (Astatike 2016).

In this regard, the Ethiopian government has a water-pricing policy that is based on the willingness of users to pay for the water system (Ayana *et al*. 2015). However, levels of experience with estimating households' willingness to pay (WTP) and collecting fees for irrigation water use in the country are low (Gidey & Zeleke 2015). Studies done previously showed that the Awash geographical area is the only basin in Ethiopia where irrigation water pricing is practised (Mekonen *et al*. 2015). It is advisable to examine farmers' WTP before introducing water pricing (Mu *et al*. 2019) The effectiveness of the irrigation water fee for the sustainable development of the sector depends to a great extent on several site-specific factors (Birhane & Geta 2016). Therefore, there is a need to understand the inhabitants' willingness to pay for a better irrigation water supply. To end this, a hypothetical market programme can be designed for the supply of sustainable irrigation water based on WTP measures. Specific to the area of interest, namely Amhara Region, Dangila District in northwestern Ethiopia, there is a year-round water resource and the potential for irrigable land to be available. Due to the absence of a well-constructed and modern irrigation scheme, local farmers are still irrigating their farmlands in the form of the traditional river diversion system, with severe labour costs and time. However, the district has fertile land that can be cultivated, although the water used for irrigation purposes flows freely. The effective implementation of a water management system is a complex task. It requires sufficient knowledge about farmers' demand or willingness to pay for improved irrigation water use. This information is a basic element of the effective implementation of water-pricing policies, along with water supply or water market infrastructure for the provision of improved irrigation water. Considering this, the central aim of this study was to identify determinants of farmers' maximum WTP for the value of improved irrigation water use.

2. Research methodology

2.1 Description of the study area

The study was conducted in Dangila District in the Agew Awi administrative zone in Amhara Regional State, northwestern Ethiopia (see Figure 1). The capital of the district is located about 80 kilometres southwest of the regional capital, Bahir Dar. The climatic zones are classified as Dega, Weyna Dega and Kolla. There are 27 rural kebeles in the district, among which 16 have access to perennial rivers. Abay, Zuma, Ashar, Guder, Quashine and Awsi are the major perennial rivers in the district. Even though the district has a long history of traditional irrigation practices and indigenous knowledge, the majority of local farmers are still practising the traditional irrigation agriculture that entails a river- diversion system.

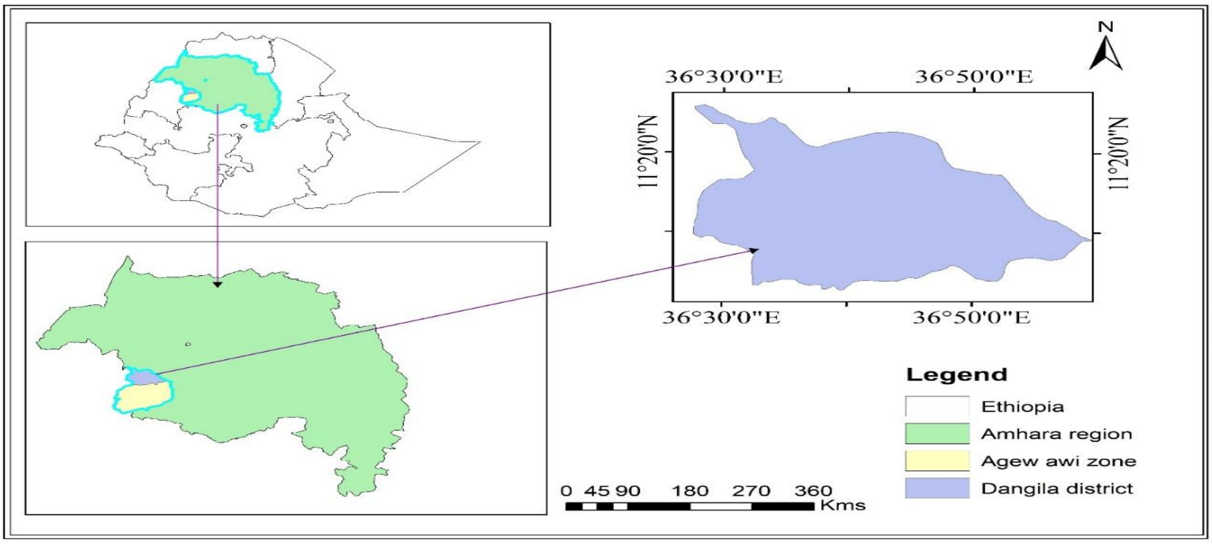

Figure 1: Location of the study area
Source: Own construction using ArcGIS 10.8

2.2 Sources and methods of data collection

Both primary and secondary data sources were used. Primary data was collected from the study area through face-to-face interviews from sample household heads using a structured questionnaire. In addition, the data was supplemented by focus group discussions to generate qualitative information. Secondary data was collected from the district office of agriculture and rural development and other relevant sources. Before conducting the final contingent valuation survey, a pre-test of the draft questionnaire was done on 21 selected respondents who were assumed to be representative of the households living in the two kebeles.

The objective of conducting a pre-test was to check the soundness of the questionnaire, incorporate or exclude important variables relevant to the study area, and to determine the appropriate set of initial bid values stated by farmers. Based on the result of the pre-test survey, the required modifications and adjustments were made to the draft questionnaire, after which the final questionnaire was developed. Accordingly, four mostly and frequently stated values were selected as a starting value for the double-bounded dichotomous choice contingent valuation method (CVM) format. These values were 200, 300, 400 and 500 Ethiopian birr (ETB) per year per 0.25 (1/4 ha) of irrigable land, which were selected and for which initial bid values for improved use of the irrigation scheme were asked. The double-bounded dichotomous choice format determines the set of bids by making the initial bid if the first response is "Yes", and half of it if the response is "No" (Getnet *et al*. 2022). Households' maximum WTP for the hypothetical nonmarketable irrigation water was determined by using open-ended CVM (Getnet *et al*. 2022). If we assume that B1 represents the amount of the first bid, and the second bid amount, B2, depends on the response to the first bid, then if the individual responds "yes" to the first bid, B1, the second bid is some amount greater than the first bid (B2 > B1). If the respondent answered "no" to some randomly stated bid, B1, then the second bid amount B2 is some amount smaller than the first bid (B2 < B1). As a result, there are four possible individual responses. These are (a) both answers are yes; (b) both answers are no; (c) a yes is followed by a no; and (d) a no followed by a yes. Hence, the bounds on WTP are (Haab & McConnell 2002):

- For the yes-yes responses: B1 < WTP ≥ B2,
- For the yes-no response: B1 ≤ WTP < B2,
- For the no-no response: B1 > WTP < B2,
- For the no-yes response: B1 > WTP ≥ B2,

where B1 is the first bid and B2 is the second bid.

The contingent valuation method (CVM) uses social science interviews or questionnaire surveys during which respondents are asked to make a hypothetical market decision regarding the non-market goods at hand (Boxall & Beckley 2012). Because of flexibility in and adaptability to non-market valuation tasks, the contingent valuation method was applied to identify determinants of farmers' maximum WTP for improved use of irrigation water (Getnet *et al*. 2022). According to Young *et al*. (1996), the two popular elicitation techniques for CVMs are dichotomous choice questions and open-ended questions, and these were applied in this study. In other words, if the respondents agreed to pay the offered bid, the follow-up bid was doubled, and in case of a no response, the respondents were offered a bid that was half of the initial value (Tang *et al*. 2013). In the open-ended elicitation technique, sampled households were asked directly to state their maximum WTP for the use of the improved irrigation scheme. Then, the respondents agreed to the given bid levels and were asked to answer an open-ended question to freely specify the maximum amount that they would be willing to pay for the use of the improved irrigation water supply. Following Mitchell and Carson (1989), amounts of 100, 200 and 400 birr, 150, 300 and 600 birr, 200, 400 and 800 birr, and 250, 500 and 1 000 birr were assigned randomly across the sampled households to avoid starting point bias.

2.3 Sampling size and sampling procedure

Based on the Dangila district office for agriculture and rural development, in 2021 there were 1 380 irrigation beneficiary household heads in the area commanded by the Zuma and Quashiny irrigation schemes in the Afesa and Gayita kebeles, respectively. The study used a two-stage sampling procedure, namely a purposive and random sampling technique, in the selection of the study site and the sample households, respectively. In the first phase, two kebeles, namely Afesa and Gayita, were selected purposively from 27 rural kebeles in Dangila District based on the availability of fertile and arable land, proximity to a source of water (irrigable land is close to rivers), absence of a modern and well-constructed irrigation scheme in the area, and local farmers' experience in irrigating their farm. In the second phase, irrigation water users were selected randomly from each kebele using probability proportional to size, and the desired sample size was 177. Regarding the determination of the sample size, the study used a simplified formula provided by Lamola and Yamane (1967) at a 95% confidence level, 0.5 degree of variability and a 7% level of precision:

$$n = \frac{N}{1+N(e^2)},$$

where n is the sample size, N is the population size (total households using irrigation water), and e is the level of precision. Hence, the desired sample size (see Table 1) was equal to 177:

$$n = \frac{1380}{1+1380(0.07^2)} = 177.$$

Table 1: Number of sample households taken from sample kebeles

Sample kebeles	Total household size	Sample size
Afesa	798	102
Gayita	582	75
Total	1 380	177

2.4 Method of data analysis

Descriptive statistics, such as means, percentages and standard deviations, were computed to explain different socio-economic characteristics of the sample households. In addition, inferential statistics, such as the t-test and chi-square test, were applied to test the statistical significance of the continuous and dummy variables, respectively, among the willing and non-willing households.

2.4.1 Specification of econometric model

The tobit model is used to identify factors of willingness to pay and the maximum amount of money that the sampled respondent is willing to pay for the most improved use of irrigation water. In this study, the farmer's maximum willingness to pay for the improved use of irrigation water was taken as the dependent variable. According to Johnston and DiNardo (1997), the tobit model has an advantage over other models, both logistic and probit, in that it reveals both the probability of WTP and the maximum WTP of the respondents as a result of dealing with the problem of censored data. Furthermore, when the respondents' answer to the double-bounded WTP questions was "yes-yes", then the maximum WTP could be greater than the previous bid, and if the respondents' answer was "no-no", the maximum WTP would be less than the stated or assigned bid (Jordan & Elnagheeb 1994). If the dependent variable, maximum willingness to pay, takes values below the lower limit and above the upper limit for some part of the population, and positive continuous values for the rest of the population, then it is taken as the appropriate model (Agarwal *et al*. 2013). Based on Maddala and Lahiri (1992) and Johnston and Dinardo (1997), the tobit model can be described as:

$$MWTP_i^* = X_i\beta + \epsilon_i, \quad \text{where } i = 1, 2, 3, 4 \ldots N \qquad (1)$$

$$MWTP_i = MWTP_i^*, \text{ if } MWTP_i^* > 0$$

$$MWTP_i = 0, \text{ if } MWTP_i^* \leq 0,$$

where

$MWTP_i$ = the observed dependent variable, in this case the farmer's maximum willingness to pay of each household (ith household);

$MWTP_i^*$ = a latent variable that is not observed when it is less than or equal to 0, but is observed if it is greater than 0;
X_i = factors influencing farmers' WTP;
β = vector of unknown parameters; and
ε_i = error terms that are independently and normally distributed, with mean zero and common variance σ2.

Following this form (Amemiya 1985), the model parameters were estimated by maximising the tobit likelihood function of

$$L == \prod_{MWTPi^*>0} \frac{1}{\delta} f\left(\frac{MWTPi - \beta\prime x}{\delta}\right), \quad (2)$$

where

f and F are the density function and cumulative distribution function of Yi^*, respectively;
$\prod MWTP_i^* \leq 0$ means the product over those i for which $\prod MWTP_i^* \leq 0$; and
$\prod MWTP_i^* > 0$ means the product over those i for which $\prod MWTP_i^* > 0$.

It may not be sensible to interpret the coefficient of a tobit in the same way as one interprets coefficients in a non-censored linear model (Johnston & Dinardo 1997). Hence, one has to compute the derivatives of the estimated tobit model to predict the effects of changes in the exogenous variables.

Table 2: Description of dependent and explanatory variables

Variables	Definition of variables	Type	Unit of measurement
MWTP	Maximum willingness to pay	Continuous	Ethiopian birr (ETB)
Sex	Sex of household head	Dummy	1 if male, 0 otherwise
Age	Age of household head	Continuous	In years
Edustat	Educational level	Continuous	Grade level
Famsz	Family size	Continuous	Number of members
TLU	Livestock ownership	Continuous	Tropical livestock unit
Totinc	Household's annual total income	Continuous	Ethiopian birr (ETB)
Irrexp	Irrigation farming experience	Continuous	In years
Land	Potential irrigable land	Continuous	Timad (0.25 ha)
Irrdissats	Dissatisfaction with the existing irrigation schemes	Dummy	1 if satisfied, 0 otherwise
Frextn	Frequency of access to extension services	Dummy	1
Hhldsdis	Household's distance from the source of irrigation	Continuous	In kilometres
Bid1	Initial bid amount	Continuous	Ethiopian birr(ETB)
answer1	Willingness to pay when price is bid1	Dummy	1 = yes, 0 = no

3. Results and Discussion

3.1 Contingent valuation results

In the study area, households were asked whether they were willing to pay for the provision of an improved irrigation scheme by giving them four randomly assigned initial bid values and using their corresponding follow-up bids for 0.25 ha of irrigable land per year. Out of the total sample of households, 77.97% were willing to pay, and 22.03% were not willing to pay for irrigation water use. The specified reason for all non-willing respondents was that they could not afford any cash amount for the scenario.

Table 3: Distribution of willing and non-willing respondents

Direct payment in cash	Willing		Unwilling		Total	
	N	%	N	%	N	%
	138	77.97	39	22.03	177	100

Note: N = number of respondents
Source: Own survey, 2021

3.2 Household characteristics

The survey results show that 85.88% of the sampled households were male headed and the rest (14.12%) were female headed. The average age of the sampled respondents was 51.4 years, with a minimum age of 30 years and a maximum of 65 years old. From the total household heads, about 57.06% had no formal education (illiterate), and the remaining 42.94% of household heads had attended some formal education or were literate. The mean family size was 6.4 persons, ranging from three to nine. The survey results identified that about 95.48% of respondents were dissatisfied with using the existing traditional irrigation water system, while the remaining 4.52% of respondents were satisfied with the existing traditional irrigation water supply. The farm households had a mean length of irrigation experience of 20.07 years, with a minimum and maximum of three and 30 years respectively. In addition, the mean household total annual income was 19 769.7 ETB, ranging from a minimum of 5 000 to a maximum of 70 000 ETB per year.

3.3 Determinants of farmers' willingness to pay for improved irrigation water use

Table 3 below describes the association between the categorical variables and the respondents' WTP. By willing households, we are referring to the households that are willing to forgo some fraction of their income to obtain and use an improved irrigation water supply by improving the existing traditional irrigation scheme. In terms of sex composition, of the total WTP respondents, 92.02% were headed by men headed and 7.98% were headed by women. Of the non-willing households, male-headed households contributed 64.1%, while female-headed households comprised 35.9%. The chi-square value in the table shows the presence of a significant difference being male- and female-headed households regarding their WTP. In terms of sex composition, we found that being male was more favourable in terms of willingness to pay, as described in the table. Regarding the educational level of the respondents, there was a significant association between farmers' access to education and willingness to pay. This result indicates that the educational level of the respondents had a significant effect on the farmer's decision to pay and improve the existing traditional irrigation scheme.

Table 4: Association between categorical variables and willingness to pay

Variable	Categories	Willing		Unwilling		χ^2-value	Total	
		N	%	N	%		N	%
Sex of household	Male	127	92.02	25	64.1	19.6***	152	88.88
	Female	11	7.98	14	35.1		25	14.12
Educational status	Literate	74	53.7	2	5.12	29.2***	76	42.94
	Illiterate	64	46.3	37	94.88		101	57.06
Dissats (Irrigation dissatisfaction)	Yes	131	94.5	1	2.6	0.44	132	74.5
	No	7	5.5	38	97.4		45	25.5
Extn (Access to extension service)	Yes	123	89.1	30	79.2	3.8**	153	86.4
	No	15	10.9	9	20.8		24	13.6
Distance from the source of irrigation water	Yes	20	14.5	15	38.5	11.01**	35	19.78
	No	118	85.5	24	61.5		137	80.22

Notes: N = number of respondents; *** and ** indicate statistical significance at 1% and 5% respectively
Source: Own survey, 2021

From all those surveyed, 13.6% of the respondents did not receive frequent extension services per month, while the remaining 86.4% had access to these services. The results of the chi-square test indicated an association between the frequency of farmers' access to extension services and the willingness to pay (WTP) of the willing and non-willing groups regarding the proposed interventions. In terms of households' distance to the source of irrigation water, 80.22% of the respondents were near the source, while the remaining 19.78% lived far from it, and this distance was statistically significant and associated with the two willingness groups.

Table 5: Summary of relationship between continuous independent variables and willingness to pay

Variables	Willing		Non-willing		T-value		Total
	N	Mean	N	Mean		N	Mean
Age of household head	139	55.3	39	39.6	-14.37	177	51.6
Famsz (Family size)	138	7.2	39	3.8	-15.6	177	6.4
TLU (Tropical livestock units)	138	5.9	39	3.3	13.4***	177	5.4
Totinc (Total annual income)	138	22 967	39	8 453	9.6***	177	19769
Exp (Experience in irrigation farming)	138	23.7	39	7	17.3***	177	20.07
Land (Potential of irrigable land)	138	1.57	39	.64	9.6***	177	1.4

Notes: N = number of respondents; *** indicates statistical significance at 1%
Source: Own survey, 2021

It was expected that the respondents' age would influence farmers' WTP decisions to obtain and use an improved irrigation water supply. However, the t-value results indicate that there was no statistically significant difference in the mean age of the willing and non-willing respondents, which was 55.3 and 39 years, respectively. The mean number of livestock owned by the willing and non-willing farmers was 5.9 and 3.3 in TLU, respectively. The result of the t-test indicates there was a significant mean difference between willing and non-willing respondents, indicating that livestock ownership influences the farmers' willingness-to-pay decision for improved use of irrigation water. The mean income of the willing and non-willing households was ETB 22 967 and ETB 8 453, respectively. The respondent's annual income shows the presence of a statistically significant mean difference between the willing and non-willing groups. The mean number of years of experience in irrigation farming of the willing and non-willing groups was 23.7 years and seven years, respectively. The t-value result indicated that there was a statistically significant difference in the mean farming experience between the willing and non-willing respondents. The potential of irrigable land is one of the most important factors of physical input for rural households. The mean of potential irrigable land owned by the willing and non-willing farmers was 1.57 ha and 0.64 ha, respectively, and the t-test confirmed that there was a significant mean difference in landholding among the willing and non-willing respondents.

Regarding the econometric results, and as discussed in the methodology section, the tobit model (see Table 6) was used to analyse the explanatory variables that affect farmers' willingness to pay for improvements in the irrigation scheme, as it showed both the probability of WTP and the maximum WTP for the respondents. Before estimating the effects of the explanatory variables, a multicollinearity test was conducted. The results showed no multicollinearity issues among the variables. The contingency coefficient (CC) value for the dummy variables was below 0.75, and the variance inflation factor (VIF) for the continuous variables was under 10, indicating that multicollinearity was not a significant concern.

Table 6: Tobit regression results

MWTP	Coefficient	Change in probabilities of WTP	Change in intensity of WTP	Overall change	95% Conf	Interval	Sig
sex	6.575 (74.653)	0.09	5.465	0.858	-140.824	153.974	
age	-1.742 (2.469)	-0.000	-1.452	51.394	-8.592	5.108	
edustat	129.109 (42.198)	0.045	107.603	1.429	45.791	212.426	***
famsz	0.346 (22.335)	0.000	0.288	6.446	-43.753	44.445	
TLU	59.966 (22.383)	0.021	49.977	5.398	15.773	104.159	***
totinc	0.006 (0.003)	2.14E-06	0.005	19769.7	0	0.012	**
irriexp	9.996 (4.687)	0.001	8.331	20.073	0.742	19.251	**
irrdissats	72.179 (98.251)	0.031	57.821	0.954	-121.812	266.171	
land	104.718 (42.749)	0.036	87.275	1.368	20.313	189.124	**
frextn	153.65 (66.26)	0.079	119.171	0.864	22.822	284.478	**
hhldsdis	20.3 (59.535)	0.006	17.032	0.197	-97.249	137.85	
Bid1	0.896 (0.191)	0.0003	0.746	312.429	0.519	1.272	***

Notes: No. of observations = 177; log pseudolikelihood = -956.25561; F (12, 165) = 41.40; Pro > F = 0.000; pseudo R^2 = 0.1144; threshold value for the model: Lower = 0.0000, Upper = + infinity; MWTP = maximum willingness to pay; *** and ** indicate significance at the 1% and 5% levels, respectively; the figures in parentheses indicate the standard errors for each coefficient.
Source: Own computation

3.3.1 Educational level of household head (Educ)

The educational level of the respondent was positively related to WTP and significant at a 1% level of probability. Keeping other factors constant, the marginal effect of the variable indicates that a unit increase in the level of education increases the farmers' WTP for improved use of irrigation water by 0.045%. Similarly, as years of education increases by one unit year, the amount of cash a household is willing to pay for improved use of the irrigation scheme may increase by 107.6 Birr. This shows that respondents with more years of schooling are more willing to pay for irrigation water. One possible reason could be that more literate individuals are more concerned about water resources, as education provides knowledge and enables households to get information, and the information creates awareness about the benefits obtained from improved irrigation water. This is in contrast with the awareness of less educated or illiterate individuals. This is consistent with the findings of Astatike (2016), Birhane and Geta (2016) and Ejeta *et al*. (2019,

3.3.2 Livestock ownership in TLU

The number of livestock owned was related to WTP and was found to be positively significant at the 1% level of probability. Keeping all others constant, the marginal effect shows that, for each additional increment in the number of tropical livestock units, the probability of households' willingness to pay for the improved irrigation scheme will increase by 0.021%, ceteris paribus. Similarly, when the number of livestock owned by a household increases by one unit, the amount of cash a household is willing to pay to improve the irrigation scheme could increase by nearly 50 birr. A possible reason could be that livestock ownership comprises a lion's share of the rising income and wealth of rural households due to its direct role in agricultural productivity. The study conducted by Ejeta *et al*. (2019) confirmed that households with a larger number of oxen most likely will be willing to pay for and to participate in irrigation practices.

3.3.3 Total annual income (Totinc)

Households' total annual income has a positive sign and is statistically significant at the 5% level of significance. The marginal effect of the result shows that an increase in the total annual income of the household by 1 000 birr increases the probability of households' WTP for use of an improved irrigation water supply by 0.00214%, keeping other factors constant. Similarly, when the income of the farmer increases by 1 000 birr, the amount of cash the farmer could pay increases by 0.005 birr. The result shows similarity with the study done by Birhane and Geta (2016), and is in conformity with the study by Ejeta *et al*. (2019).

3.3.4 Experience in irrigation farming (Exper)

Experience in irrigation farming was found to be statistically significant at the 5% level, with the expected positive sign. The result suggests that a one-year increase in the irrigation farming experience of a household head increases the probability of households' WTP for improved irrigation water use by 0.0019. When the irrigation farming experience of a household head increases by one year, the amount of cash that the household could pay for improved irrigation water use would increase by 8.33 birr, holding other factors constant. A possible explanation is that households with longer irrigation farming experience can easily realise the benefit from improved use of the irrigation scheme, and hence are more likely to attach high value to the improved use of irrigation water than those with fewer years of irrigation farming experience. This result is consistent with the findings of Assefa (2012) and Ejeta *et al*. (2019).

3.3.5 Households' irrigable land size (Land)

Irrigable land size of the household is statistically significant at 5% and positively related to WTP for improved irrigation water use. Keeping other factors constant, if the irrigable land size of a household increases by 0.25 ha, the probability of WTP for improved irrigation water use increases by 0.036%. Similarly, when the irrigable land size of the household increases by 0.25 ha, the amount of cash that the household could pay to improve the use of the irrigation scheme and water use increases by 87.3 birr. The possible explanation for this is that there is a high opportunity for income from irrigation farming. This variable also has a positive impact on respondents' maximum WTP (MWTP) for the provision of improved irrigation water. The result is consistent with that of Mezgebo *et al*. (2013).

3.3.6 Access to frequency of extension contact (Extn)

The result of access to extension services has been positively related to WTP and is significant at the 5% level of probability. It is a positive sign that shows that a household's access to extension contacts is more likely to support the improvement of the existing irrigation schemes. Holding other factors constant, the result of the marginal effect shows that, when there is access to extension services, this contact increases the probability of willingness to pay for improving the existing traditional irrigation scheme by 0.079%. Similarly, the provision of extension services to local farmers increases willingness to pay by 119.2 birr. The probable reason is that access to extension contact plays a constructive role in motivating farmers to adopt and use improved irrigation practices, or improves their perception of these. Our result confirms that of Falola et *al*. (2013) and Nirere (2012), but contradicts the findings of Kiprop *et al*. (2017) that the frequency of access to extension services reduces the probability of farmers' willingness to pay. The probable expectation may be that farmers who have access to extension services are better placed to have other sources of water and may have adopted more efficient technologies compared to those who have no access to the service.

4. Conclusions and implications

Water is generally regarded as a non-market good. The objective of the study was to identify determinants of farmers' WTP for the use of improved irrigation water services. The study used both primary and secondary data. The primary data was collected from 177 sample households. The tobit model was used to identify major determinants of farmers' WTP for improved use of irrigation water. Four sets of initial bid prices – 100, 200 and 400 birr, 150, 300 and 600 birr, 200, 400 and 800 birr, and 250, 500 and 1 000 birr per 0.25 ha per year – proportionally distributed to the survey questionnaire identified for and applicable to this study. Variables like education level, livestock ownership, total annual income, experience in irrigation farming, irrigable land size and access to frequency of extension services had a positive effect on farmers' maximum WTP for improved use of irrigation water. The result indicate that 77.97% of the respondents were willing to pay for improved use of irrigation water. It is possible to conclude that the majority of rural households are willing to pay to improve and use improved irrigation water.

In general, the recommendations of this study include to advise policy makers, development agencies and irrigation administrators to identify key socioeconomic variables for improved use of irrigation water. An innovative approach to irrigation management is necessary. This innovative approach should be farmer-centred. Therefore, it is recommended that the government take action and implement effective water pricing based on farmers' WTP for the sustainable and reliable use of improved irrigation water.

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