ISSN 2316-6886
WRIM

Water Resources and Irrigation Management
v.11, n.1-3, p.8-21, 2022
DOI: 10.19149/wrim.v11i1-3.2798

Cruz das Almas, BA, Brazil – https://www3.ufrb.edu.br/seer/index.php/wrim/index

ORIGINAL PAPER

The determinants of household willingness to pay for irrigation water: in the case of Northern Showa, Amhara Region, Ethiopia

Markew Mengiste Neway* & Mesele Belay Zegeye

College of Business and Economics, Debre Berhan University, Debre Berhan, Ethiopia

Abstract: Agricultural transformation is the current major concern of the Ethiopian government. This is important for the transformation of subsistence agriculture to an irrigated modern agriculture with potential for commercialization. The role of irrigation water and its pricing is very crucial to promote water use efficiency. Therefore, this study aimed to evaluate the determinants and estimate the willingness to pay for the irrigation water in the North Shewa Zone of the Amhara Region of Ethiopia, in order to determine if the irrigation water is viable. The study data were collected from primary data sources from 800 sample farm households. A bivariate probit model was used to identify the determinants of households' willingness to pay for irrigation water in the study area. The results reveal that there is a positive willingness to pay for irrigation water in north Shewa Zone. In average, the willingness to pay for irrigation water of the household for 0.25 hectares of land was about 3001.47 Ethiopian birr (equivalent to 100.05 USD by the current exchange rate) for one irrigation season. Moreover, the study identified that household family size, agricultural experience, household expenditure, irrigation land, education level of the household head, and livestock asset measured by Tropical Livestock Unit had a positive effect on farmers' willingness to pay for irrigation water. While it is negatively influenced by age of the household head, farmers' distance from the market, and credit access. Based on the results, it is recommended that addressing credit constraints, improving the access to market via providing information and irrigation inputs. Thus, enhancing farm households' awareness about irrigation water and its efficient use should be precondition for effective execution of sustainable irrigation use and irrigation water charging systems.

Keywords: Bivariate probit model, sustainable irrigation, willingness to pay.

Introduction

Agriculture is the main source of employment and income in most developing countries (Diriba, 2018). Ethiopia as one of the developing countries highly depends on agriculture as the main source of employment and income (Woldemariam and Gecho, 2017). The agricultural sector has also abundant resource bases for future development.

* Corresponding author: E-mail: mmarkew@gmail.com
Editors: Mairton Gomes da Silva & Petterson Costa Conceição Silva
Received in: January 12, 2022
Accepted in: April 27, 2022

Ethiopia has huge surface water and groundwater resources potential that can be harnessed for development. It is clearly seen that water-centered development thinking is the footstep for the economic development of the country (Berhanu et al., 2014).

The agriculture sector has promising opportunities to transform itself from subsistence level to modern and commercial sector (Woldemariam and Gecho, 2017). Even if it has an opportunity to transform and contributes greatly to the country's economy, the structure of the sector is vulnerable because it relies on rain-fed agriculture. Therefore, water is a major factor constraining agricultural development in a developing country.

The issues of water availability, access, and quality are of fundamental importance to development and poverty reduction. Irrigation benefits the poor through higher production, higher yields, lower risk of crop failure, and higher and year-round farm and non-farm employment. Irrigation enables smallholders to adopt more diversified cropping patterns and to switch from low-value subsistence production to high-value market-oriented production (Hussain and Hanjra, 2004). Irrigation contributes to livelihood improvement through increased income, food security, employment opportunity, social needs fulfillment, and poverty reduction (Woldemariam and Gecho, 2017).

Irrigation is necessary for the maximum production of most farm crops, even in the areas of high rainfall, irrigation of second and third crop, or for multiple cropping when rainfall fails. Given the above fact estimating the economic value of water in agriculture is essential for setting water allocation and management policy (Medellín-Azuara et al., 2010).

The Ethiopian government recognized that investment in irrigation, particularly in small-scale and household level irrigation has the potential to transform livelihoods for small-scale farmers. In addition to the use of surface water, the use of underground water for irrigation is essential to secure agricultural growth for current and future generations (Hagos et al., 2012). Even if we have abundant land which can be used for irrigation in the country as well as in the north Shewa Zone, the country's potential irrigable land is 3.6 million ha. However, only about 290,000 ha of the potentially irrigable land are utilized so far, which is remaining very low usage (Puertas et al., 2015).

Thus, to develop this irrigation scheme the willingness of the farmer should be studied whether they are willing to pay for irrigation water or not. There is almost no knowledge or research in Ethiopia on the pricing that is essential for groundwater sustainability (Hagos et al., 2012). Water can be valued from a supply or demand perspective, resulting in a supply curve or a demand curve. For many individuals' farmers, the cost of water is based on the investments and operating costs of water storage and conveyance infrastructure (Young and Loomis, 2014).

Agricultural transformation is the current major concern of the Ethiopian government. To transform rain feed subsistence agriculture to modernized/commercialized agriculture; is necessary to use all alternative sources of water. In addition to the surface, there is plenty of underground water potential which can be produced at a low cost to use for irrigation especially in the highland area of the country in general, and in the northern Shewa zone in particular. Under these conditions, irrigation development offers the promise of improved food security and sustainable rural development by ensuring yearlong farming.

Studies conducted on agricultural water management and poverty in Ethiopia shows that an important tool to mitigate adverse effects of climatic variability and to reduce poverty (Hussain and Hanjra, 2004; Hagos et al., 2012). These authors reported that the irrigation is critically important to enhancing is productivity promoting growth, and reducing poverty.

The agriculture sector has immense potential in Ethiopia. So, Agriculture is the backbone of the Ethiopian economy by any measure such as contribution for total income, employment, and export. But the sector is still subsistence and rain feed and unable to feed the growing population and face food insecurity. The other challenge the agriculture sector face is rainfall variability due to climate change. To increase the level of food security in the study area irrigation is the best solution. In addition, the groundwater is also used for irrigation, and for this the willingness of the farmer needs to be studied.

Studies on different country proved that the education status of the household have significant effects on the farmer's willingness to participate and/or pay on small-scale irrigation schemes (Thorvaldson et al., 2010; Kiprop et al., 2017; Luo et al., 2018; Stedman et al., 2018; Meunier et al., 2019; Keough and Vásquez, 2020).

Studies conducted in Ethiopia also shows that education status of the household head (Mezgebo et al., 2013; Alemayehu, 2014; Ayana et al., 2015), income of the household (Angella et al., 2014; Kiprop et al., 2017; Kidane et al., 2019), distance from the market (Angella et al., 2014; Ayana et al., 2015; Kiprop et al., 2017), cultivated land size (Mezgebo et al., 2013; Alemayehu, 2014; Ayana et al., 2015), access to extension service or agricultural training and access to credit or credit utilization (Kiprop et al., 2017), experience in irrigation (Ayana et al., 2015), household family size (Alemayehu, 2014; Ayana et al., 2015), and age of the household head (Mezgebo et al., 2013; Angella et al., 2014) are the major determinant of household willingness to pay for irrigation water.

This study would contribute to the existing literature in designing an appropriate bid for willingness to pay study. In the previous studies, analysis of willingness to pay for irrigation water, the authors designed the bid based on the pilot survey (Mezgebo et al., 2013; Alemayehu, 2014; Kidane et al., 2019). While, Jaghdani and Brümmer (2016) setting the bid by using the existing informal water market price by calculating the price for 1 m^3 irrigation water.

In addition to the above two methods, according to Meunier et al. (2019) due to the lack of information about the intended quantity of water consumed simply use an open-ended question format. However, it is not an easy task to determine the irrigation water requirement by using a simple survey because there are so many factors that determine the irrigation water requirement.

Out of these factors the crop water requirement, the environment, and method of application of water are not taken into consideration and it needs scientific study. To design the bid, it is important to know the type of crop the groundwater is to be used and per hectares amount of water required in one growing season and this is not considered in the previous studies. To calculate the mean willingness to pay double-bound dichotomous choice model is used. Because the coefficient estimate from the double bound model is asymptotically more efficient than those from single bound model and the double-bound dichotomous model has also a narrower confidence interval as compared to single bound one (Hanemann et al., 1991).

Therefore, the major objectives of this study were to investigate the willingness of smallholder farms to pay for irrigation water and identify the factors that determine the willingness to pay for irrigation water service in the study area.

Material and Methods

Description of the study area

North Shewa zone is one of the 11 zones under the Amhara Regional State with a total area of 17,697.64 km^2. The administrative structure is included into 22 woredas and five city administrations, and has a population of 2,226,685 and a total of 556,671 households. From these total households, a total of 334,003 households were depending on agriculture. The zone is bordered on the south and the west by the Oromia Region, on the north by South Wollo, on the northeast by the Oromia Zone, and on the east by the Afar Region.

The highest point in the zone is Mount Abuye Meda (4,012 m), which is found in Gish Rabel woreda; other prominent peaks include Mount Megezez in Asagirt woreda. The zone is located at 8.38-10.42 North latitude and 38.4-40.3 East longitude, at an altitude of 1,500-4,012 m above sea level. The mean annual temperature of the zone is ranging from 10 to 25ºC. Most of the areas of the zone, the mean annual rainfall ranging from 800 to 1600 mm. This volume of water is sufficient for most crops to produce with quality; however, the rain is concentrated in some months of the year (from June to September).

Due to this scenario, the farm households in the zone are producing once a year. In addition, perennial rivers, underground waters and springs are found in the zone. In the zone, river diversion irrigation systems are practiced in the district using the rivers which are the main source of water for irrigation system. However, all of these diversions and using of underground water are not well constructed, and not used fully. Even if there is abundant water resource in the zone, the water use culture in the zone is still unused (Central Statistical Agency of Ethiopia, 2019).

Data collection and sampling techniques

All the information required to undertake this study is gathered from primary data sources. This study is based on household-level data gathered from north Shewa zone farmers. The data for analysis is based on a cross-sectional survey collected through a household questionnaire. The questionnaire was designed to gather data about the demographic, economic, social, institutional characteristics, and adoption practice, and consumption expenditures of farm households. In this study, samples were drawn by using a multi-stage sampling method. First, four major districts of the zone namely Minjar Shenkora, Angolela Tera, Moretna Jiru, and Menz Gera were selected purposively due to its high potential to agricultural practices and its topographical similarity. The study's sampling unit is farm households.

According to Central Statistical Agency of Ethiopia (2019), in the selected districts there are a total of 117,149 households, of which 104,280 and 12,889 were male and female headed, respectively. 70,418 (60.10%) households were depending on agriculture for living, while the rest lives in urban areas and depending on non-farming works for living. In this study, 800 sample households were drawn according to Malhotra (2012), in which suggest for a large homogenous population (between 35,001-150,000) a maximum sample of 800 respondents.

These sampled households are representative because the households in the selected areas are homogenous, and the selected sample districts are area representative because these districts includes the majority households and covers the majority share of agricultural practices of the zone. Second, from the total Kebeles of the selected districts, 30 Kebeles were randomly selected, and finally simple random sampling was used to select each respondent from each selected Kebeles. Due to missing information, four observations were dropped. Thus, the final sample size of the study is determined to be 796 farm households.

Bid design

As we discussed in the introduction section based on the water requirement of the vegetable the researcher has identified two vegetables (onion and potato). The water requirement of potato (Kifle and Gebretsadikan, 2016) and onion (Desta et al., 2017) were of 673 and 3,900 m^3, respectively, with 60% water field application for 0.25 hectares of land. In addition to the water requirement, the initial price for a 1 m^3 of water is taken from each woreda water office. Based on the above facts we estimated six bids for each woreda to maintain the randomness of the data and the bid ranges 750 up to 3375 Ethiopian birr. This research would be filling the methodological gap in designing the bid for willingness study for irrigation water.

Methods of data analysis

The collected data were compiled using STATA version 13. Since the dependent variable of this study was the household's willingness to pay for small-scale irrigation utilization, which is dichotomous, that takes a value of one when the household decides to use small-scale irrigation and zero otherwise. The dichotomous double-bound choice model was used to determine the farmer's willingness for irrigation water, and the bivariate model was used to determine the factors influencing households' participation decisions in small-scale irrigation utilization.

Econometric model

Two econometric models which are bivariate probit and double-bound dichotomous choice model with corresponding elicitation questionnaire formats were used. The double-bound closed-ended dichotomous model was used to drive the demand function for irrigation water and to calculate the mean willingness to pay for each woreda. The bivariate probit model was used to identify determinants of household's willingness to pay for irrigation water supply in the Northern Shewa zone.

The process of benefit estimation begins with the desired measurement for an individual: the net change in income that is equivalent to or compensates for changes in the quantity or quality of public goods. Begin with the preference function for an individual; let be the vector of private goods and the vector of public goods which may have characteristics of private goods. The individual maximizes his/her utility subject to his/her income Y.

$$U(X_i, W_i) \quad (1)$$

The indirect utility function is V (P, W, Y), given by:

$$V(P, W, Y) = \max X[U(X, W) = P*X \leq Y] \quad (2)$$

The utility has also changed from status quo u_{0j} to u_{1j} final outcome indicate the presence of the program and zero without the program, from: $u_{0j} = u(Y_j, Z_j, q^0, e_{0j})$ to $u_{1j} = u(Y_j - WTPj, Z_j, q^1, e_{1j})$.

Therefore, quality indicator q changes from q^0 to q^1. In this case, willingness to pay is the amount of income that the individual would give up to make him/her indifferent between the original state income "y" and environmental good or improved water q0, and improvement state income "y-WTP" and improve water quality.

Closed-ended double bound dichotomous choice model

In a double-bound dichotomous discrete choice format, the household was asked a follow-up question depending on his/her initial response. Suppose the household responded yes to an initial question given initial price "p". The follow-up will be some higher price $p^h > p$. If the household responds no to the initial question, the follow-up question will be some lower price $p^L < p$ (Freeman III et al., 2014). According to Verbeek (2004), a person willingness to pay is unobserved and presented by the latent variable WTP*, it will vary with personal characteristics X_i.

$$WTP = X_i\beta + \varepsilon_i \quad (3)$$

The latent variable has a clear interpretation of a person's willingness to pay, measured in birr (Ethiopian currency).

$$WTP = \alpha + \sigma P + \beta Z + \varepsilon \quad (4)$$

Where:
P – bid price; Z – vector of covariates; β – vector of the parameters; and ε – error term (Mamat et al., 2013; Addai and Danso-Abbeam, 2014).

The bivariate dichotomous choice model

The bivariate model is a useful point of departure because in its most general form it involves the estimation of two separate models. The bound on willingness to pay are the initial bid "p", the lower bid PL, and the upper bound Pu. Econometric modeling of data generated by the double bond question the format relies on the formula given by Haab and McConnell (2002):

$$WTP_{1j} = \mu_1 + \varepsilon_{1j} \quad (5)$$

$$WTP_{2j} = \mu_2 + \varepsilon_{2j} \quad (6)$$

Where:
WTP_{1j} – represent willingness to pay for J^{th} respondents for the first response; WTP_{2j} – represent willingness to pay for J^{th} respondents for the second response; and μ_1 and μ_2 – are the mean for the first and the second response.

This formulation is called the bivariate choice discrete model. Assume normally distributed error term with mean 0 and variance σ^2 and, then WTP_{1j} and WTP_{2j} have a bivariate normal distribution with mean μ_1 and μ_2, variance σ_{12}, σ_1^2 and σ_2^2 are the co-variance between the error of the WTP functions and ρ the correlation coefficient.

$$\rho = \frac{\sigma_{12}}{\sqrt{\sigma_1^2 + \sigma_2^2}} \quad (7)$$

The value of rho, the correlation coefficient for the first and the second response should be statistically significant or different from zero. The correlation between the two responses indicates that the second decision endogenous in the system and estimating individual probit model would give the insufficient result. If $\rho = 0$, that means estimating the model by using probit model is best.

Variable specification

The construction of an economic model involves the specification of variable and the relationships that constitute between the independent and dependent variables, and the specification of the variables that participate in each relationship. The expected sign of the variable, the nature of the variable, and the code assigned for specific variable are presented in Table 1.

Table 1: Summary of variables specification

Variables	Code	Type	Expected sign
Sex	SX	Dummy	+/-
Age of household head	AG	Continuous	-
Household family size	HFS	Continuous	-
Distance from the market	DFM	Continuous	-
Agricultural experience of the respondent	AGEXP	Continuous	+
Household total expenditure	Expend	Continuous	+
Potential irrigable land size	Irrland	Continuous	+
Total cultivable land	TCLS	Continuous	+
Livestock ownership	TLU	Continuous	+
Education level of the household	Edu_{02}	Dummy	+
	Edu_{03}	Dummy	+
Marital status of the household head	Mstaus	Dummy	+/-
Access to credit service	ATCS	Dummy	+/-

Results and Discussion

Data description

The study analyzed and discussed the data from CVM survey in two ways such as descriptive and econometric analysis. In the descriptive analysis demographic and socio-economic factors which have a relation with water supply and willingness to pay for improved irrigation water service were analyzed, as shown in Table 2. The socio-demographic characteristics of respondents are presented in the Table 3.

Table 2: Bid design and willingness response

Name of the woreda	Angolelana Tera	Menz Gera	Minjar Shenkora	Moretina Jiru
Bid 1	1125	2700	3375	2250
Bid 2	1063	2550	3188	2125
Bid 3	1000	2400	3000	2000
Bid 4	938	2250	2813	1875
Bid 5	875	2100	2625	1750
Bid 6	750	1800	2250	1500

Table 3: Socio-demographic characteristics of the respondents

Categorical Variables	Category	Shares(% in parenthesis)
Sex of the household	Male	717(90.08)
	Female	79(9.92)
Education level of the household	Illiterate	309(38.82)
	1 up to 8	385(48.37)
	9 up to 12	90(11.31)
	> 12	12(1.51)
Access to credit	Yes	425(53.39)
	No	371(46.61)
Off-farm Employment	Yes	493(61.93)
	No	303(38.07)
Saving	Yes	493(61.93)
	No	303(38.07)
Extension visit	Yes	743(93.34)
	No	53(6.66)
Farm cooperative	Yes	670(84.17)
	No	126(15.83)
Continuous variables	**Mean**	**Standard deviation**
Age of the household	43.19 (years)	10.92
Family size	4.97	2.08
TLU	6.26	4.32
Land size	1.69 (hectares)	2.87
Distance from the market	9.55 (km)	8.36
Distance from all-weather road	7.19 (km)	8.33
Irrigable land	0.16 (hectares)	0.42
Agricultural experience	24.40 (years)	12.10

As shown in Table 3, 90.08% of sampled farm households are male headed, and other 9.92% are female headed. The education profile of households' show that 38.82% are illiterate, 48.37% are completed grade 1 up to 8, 11.31% are completed grade 9 up to 12, and 1.51% are taken above grade 12. About 53.39% of the households get credit service, 46.61% not get. About 61.93% of the farm households had participated in off-farm activities and had saved money; 38.07% not participated and had not saved. Moreover, about 93.34% of the farm households get extension visit, 6.66% not get. 84.17% of the households are members of farm cooperatives, 15.83% are not. The average age of the household head is 43.19 years. The average family size is 4.97 family members. The average land size, irrigable land and livestock asset in terms of TLU are 1.69 hectares, 0.16 hectares, and 6.26 TLU, respectively. The average distance from the market and all-weather road were 9.55 and 7.19 km, respectively. Finally, the mean agricultural experience of the farm households was 24.40 years.

Result from dichotomous double bound choice model

The study is conducted to determine the mean willingness of the farmer for irrigation water in the study area. To determine the mean willingness to pay we employed the dichotomous double bound choice model and we found that farmers are willing to pay for 0.25 hectares of land for one irrigation period about of 3001.47 birr. The willingness of the farmer to pay for irrigation is different across woreda and the data is presented in the Table 4.

Table 1: Mean willingness to pay of the study area

Name of the woreda	Mean willingness	z	*P*-value
Angolela Tera	2028.226	16.66	0.000
Menz Gera	2670.715	40.20	0.000
Moretina Jiru	1999.935	39.73	0.000
Minjar Shenkora	3839.886	25.03	0.000
Zonal mean	3001.474	36.80	0.000

Result from bivariate probit model

The bivariate probit model was estimated to determine the household characteristics that predict households' mean willingness to pay for improved irrigation. The goodness of fit of the specified model, the Wald chi-square (40) was equal to 215.04, and the overall model was highly significant with a probability of prob > chi-square = 0:00, which shows that the variables included in the joint model are statistically significant in explaining the WTP decision of the household. The correlation between the two responses indicates that the second decision endogenous in the system and estimating individual probit model would give the insufficient result.

The probability of the household response

As shown in Table 5, after the marginal effect analysis we determine that the probability of the farmer response whether Yes-Yes, Yes-No, No-Yes or No-No.

Determinant of the household willingness to pay for irrigation water

From bivariate probit model the variable household level of education primary and secondary level, the age of the household, agricultural experience and tropical livestock unit are statistically significant at $p = 0.01$. Distance from the market and the amount of irrigable land of the respondent are statistically significant at $p = 0.05$. Whereas, the household family size and household total expenditure also significant at $p = 0.1$ (Table 6).

Table 2: Response probability

Response	Probability or marginal effect
Pr(answer1=1,answer2=1)	0.644
Pr(answer1=1,answer2=0)	0.073
Pr(answer1=0,answer2=1)	0.112
Pr(answer1=0,answer2=0)	0.171

Table 3: Marginal effects after bivariate probit

Variables	*dy/dx*	std Err	z	*P*-value
SX	0.0665306	0.05741	1.16	0.247
DFM	-0.0049623**	0.00205	-2.42	0.016
HFS	0.014175*	0.00828	1.71	0.087
AG	-0.0088459***	0.00267	-3.31	0.001
AGEXP	0.0102556***	0.0024	4.27	0.000
Expend	0.0000209*	0.00001	1.88	0.060
Irrland	0.139447**	0.05455	2.56	0.011
TCLS	0.0082695	0.00979	0.84	0.398
TLU	0.012814***	0.00479	2.68	0.007
$Educ_{02}$	0.2297775***	0.0433	5.31	0.000
$Educ_{03}$	0.2226741***	0.04265	5.22	0.000
MStus	0.0794794	0.05195	1.53	0.126
credit s	-0.1182569**	0.04958	-2.38	0.017

*** p < 0.01, ** p < 0.05, * p < 0.1; dy/dx is for discrete change of dummy variable from 0 to 1.

The household distance from the market has negative sign and it is significant at p = 0.05 (Table 6), implying that as farmers are far from the market center they did not get attractive price for their product and they are not interested to produce more. Besides farmers closer to the market incur lower cost and earn high benefit as compared to those who are far from the market, thus they are willing and able to pay to get sufficient irrigation water as emphasize Ayana et al. (2015). Therefore, as the household distance from the market center increase by 1 km the willingness of the farmer to pay for the development of the new irrigation water supply system will decrease by 0.5%, keeping other variables constant.

The variable age of the household has negative sign and significant at p = 0.01 (Table 6), showing that it affects the WTP of the respondent for irrigation water supply negatively and the likelihood of paying a higher price for development of new irrigation water service decrease as the age of the respondent increases. Other things being constant, as the age of the respondent increase by one year the likelihood of accepting both initial and higher bid is reduced, on average by 0.88%. A farmer who was in the large age group has less chance to use irrigation water. The reason could be that the elders have less skill to adopt improved irrigation technologies and they are also limited physical labor for the irrigation practices (Abera et al., 2017).

The willingness of the respondent to pay for new irrigation system development is positively related to the formal education of the respondent. From the result, we have got the respondent level of education both primary and secondary level was positive and significant at p = 0.01 (Table 6). This shows the likelihood of the respondent to pay for new irrigation system development increase as the level of household education increases relative to illiterate household’s since educated households are more expected to have the ability and awareness about the use and importance of irrigation water.

Therefore, the increase in the level of education has a positive and significant effect on WTP of the respondent. Being on primary education level and secondary educational level, the likelihood of accepting both initial and higher bid increased on average by 23.0 and 22.3%, respectively, as compared to illiterate group, keeping other things constant. There was no significant difference ($p > 0.1$) in willingness to pay between the primary and secondary education levels (Table 6). The result is parallel with the findings of Alemayehu (2014) and Ayana et al. (2015).

Household total expenditure has also a positive and significant effect on WTP for water service from the development of new irrigation system. The economic theory also stated that an individual/household demand for a particular commodity, the commodity that could be consumed depends on individual/household income. We take household expenditure as proxy for income because an individual with high income would consume more. Income and quantity demand are positively related with the exception of inferior goods (Bayrau, 2002).

According to Arbués et al. (2003), Nauges and Whittington (2010) and Whittington (2010), an increase in the household expenditure of the respondent increases the probability of paying for development of new irrigation water supply system. As the household expenditure of the household increases by 100 birr the likelihood of the respondent accepting both initial and higher bid increased by 0.21%, and it is also significant at $p = 0.1$.

The family size of the household has a positive and significant effect at $p = 0.1$ on willingness to pay for the development of new irrigation system water supply (Table 6). Keeping other variables constant as the size of the household increased by one person the likelihood of accepting both the initial and upper bid increased on average by 1.42%. Since irrigation is labor intensive activities it increases the farmer's interest to engage in irrigation and WTP. According to Alemayehu (2014), the households with large family size have abundant labor force, and in most of developing country children are sources of labor and engage in farming.

The size of irrigated land positively affected households' decision on development of new irrigation water supply system. The effect was significant at $p = 0.05$ (Table 6), this implies that all other factors remains constant. The probability of the respondent willingness to pay increased by a factor of 0.001 as the proportion of irrigated land size of the household increased by one unit. This can be justified by the fact that large irrigated land helps to boost agricultural output through intensive production and minimizes the risks through growing two or more crops within a year (Mezgebo et al., 2013).

Agricultural experience of the farmer has positive correlation with the willingness to pay of the household at $p = 0.01$. The agricultural experience of the respondent increased by one year the probability of the respondent to accept both initial and upper bid increased by 1.03% (Table 6). According to Chandrasekaran et al. (2009), experiences show that very high level of WTP for irrigation water is observed in developing countries. The result is consistent with other research findings.

The variable livestock measured in TLU (tropical livestock unit) has positive significant effect ($p = 0.01$) on household willingness to pay to participate in development of new irrigation water supply system (Table 6). Other factors being constant the probability of the respondent willingness to accept both initial and higher bid increased by 1.28% as the tropical livestock unit increase by one unit. The positive relationship between household willingness to pay and livestock holding might be due to the fact that livestock is the source of wealth; thus those who have many livestock may have enough money to spend on participating in the irrigation activity. According to Luo et al. (2018), livestock are an important source of cash in rural area that allow farmers to purchase farm inputs.

Access to credit was found to influence the willingness of the farm households to pay for irrigation water. There was significant negative (p = 0.05) correlation between access to credit and willingness to pay of the household (Table 6). In contrast to the current study, Birhane and Geta (2016) reported as access to credit increased the willingness to pay of the farmers; because it can help the farmer to solve financial constraints, and enables the farmer to purchase production input technologies and enhance farm productivity. However, in this study the result is contradictory with other research finding and the marginal effect of the variable indicates that keeping other factors constant, farmers who received credit had 11.83% less probability of paying for irrigation water use than those farmers who did not have access to credit.

This could be explained by the fact that household usually take out loan and spent the loan on non-productive business which will aggravate poverty rather than reducing it. The data collected from focus group discussion confirmed that households who take out regular loans would repay their loans by taking usury loans temporarily from someone else with a high-interest rate and they are not capable of repaying their loan.

In summary, the results show that the mean of WTP was 3001.47 birr per 0.25 ha in one crop season. These results seem plausible if they are compared with those obtained in other studies carried out in different parts of Ethiopia. For example, Alemayehu (2014) estimated an average WTP of 128.88 birr per hectare per year (US$ 6.78 ha/year). For 0.25 ha/year, were estimated average WTP of 1004.505 birr (Birhane and Geta, 2016), 726.55 birr (Aman et al., 2020), and 972.66 birr (Wassihun et al., 2022). As a result, the estimated mean WTP founded in this study is adequate. Therefore, the results confirmed that farm households are willing to pay for irrigation water use in the study area to its significance improvement in agricultural benefits.

Based on the findings of the study, the following recommendations are drawn (done by different stakeholders: government, NGO, and private individuals):

1) The result of the study showed that market accessibility increases farmers' willingness to pay for irrigation water, there is need to bring markets closer to the farmers. This will reduce the transaction costs involved and enable farmers to receive better returns;

2) The positive relationship between willingness to pay and education, needs the stakeholders to invest in education and educational ways like training, advisory and cooperatives, and enhancing awareness of the illiterate group of farm households through providing information about the use and benefits of irrigation, training and advisory service enables to get these farmers to use irrigation systems to get out of subsistence agriculture;

3) Based on the positive relationship between willingness to pay and farm agricultural experience, there is a need for sharing their experience each other through farm cooperative discussions;

4) Access to credit has a negative effect on willingness to pay signifying that the household usually taken out loan and spent the loan on consumption and non-productive businesses rather than on irrigation investments. The data collected from focus group discussion confirmed that people who take out regular loans would repay their loans by taking usury loans temporarily from someone else with a high-interest rate and they are not capable of repaying their loan. This needs an intervention to make the loan on the right way, and the loan should be directed to productive agricultural investments. In addition, get the farmers who have the capacity to involve in advancing irrigation technology, the incentive for participating farmers especially by the government, lease-based provision of the technology, mobilizing funds from another stakeholder to fill the financial gap is needed.

Moreover, the stakeholders should work on designing an underground water supply for irrigation water as far as farmers are willing to pay for it.

Conclusions

In conclusion, it is argued that water is an economic resource which is necessary in the development of irrigation and plays a vital role in agricultural transformation and economic development. Thus, this study has offered a preliminary analysis of the viability of irrigation water use and it's pricing in north Shewa zone, Amhara region, Ethiopia. Our estimations show that the viability of irrigation water use in the study area is positively and significantly determined by household family size, agricultural experience, household expenditure, irrigation land, education level of the household head and livestock asset measured by TLU, and negatively by age of the household head, farmers distance from the market and credit access.

Finally, the results of this study reach the knowledge of representatives of the studied zone is through presentation to the farm households, discussions and publications.

References

Abera, A.; Ahmed, F.; Abebe, A. Factors that affect the participation in irrigation practice and its effects on rural household farm income: The case of Boloso Sore woreda, Wolayta zone, Southern Ethiopia. International Journal of Contemporary Research and Review, v. 8, n. 9, p. 20293-20300, 2017. http://dx.doi.org/10.15520/ijcrr/2017/8/09/313

Addai, K. N.; Danso-Abbeam, G. Determinants of willingness to pay for improved solid waste management in Dunkwa-on-Offin, Ghana. Journal of Agriculture and Environmental Sciences, v. 3, n. 1, p. 181-201, 2014.

Alemayehu, T. Smallholder farmer's willingness to pay for improved irrigation water : A contingent valuation study in Koga irrigation project, Ethiopia. Journal of Economics and Sustainable Development, v. 5, n. 19, p. 5-15, 2014.

Aman, M.; Shumeta, Z.; Kebede, T. Economic valuation of improved irrigation water use: the case of Meskan District, Southern Ethiopia. Cogent Environmental Science, v. 6, n. 1, 1843311, 2020. https://doi.org/10.1080/23311843.2020.1843311

Angella, N.; Dick, S.; Fred, B. Willingness to pay for irrigation water and its determinants among rice farmers at Doho Rice Irrigation Scheme (DRIS) in Uganda. Journal of Development and Agricultural Economics, v. 6, n. 8, p. 345-355, 2014. https://doi.org/10.5897/JDAE2014.0580

Arbués, F.; García-Valiñas, M. Á.; Martínez-Espiñeira, R. Estimation of residential water demand: a state-of-the-art review. The Journal of Socio-Economics, v. 32, n. 1, p. 81-102, 2003. https://doi.org/10.1016/S1053-5357(03)00005-2

Ayana, M.; Teklay, G.; Abate, M.; Eshetu, F.; Mada, M. Irrigation water pricing in Awash River Basin of Ethiopia: Evaluation of its impact on scheme-level irrigation performances and willingness to pay. African Journal of Agricultural Research, v. 10, n. 6, p. 554-565, 2015. https://doi.org/10.5897/AJAR2014.9381

Bayrau, A. Analyses of affordability and determinants of willingness to pay for improved water service in urban areas, strategy for cost recovery: A case study of Nazareth Town, Ethiopia. Addis Ababa: Addis Ababa University, 2002. 130p. Masters Dissertation.

Berhanu, B.; Seleshi, Y.; Melesse, A. M. Surface water and groundwater resources of Ethiopia: Potentials and challenges of water resources development. In: Melesse, A. M.; Abtew, W.; Setegn, S. G. (ed). Nile River Basin: Ecohydrological challenges, climate change and hydropolitics. Cham: Springer, 2014. p. 97-117. https://doi.org/10.1007/978-3-319-02720-3_6

Birhane, M.; Geta, E. Farmers' willingness to pay for irrigation water use: The case of Agarfa District, Bale Zone, Oromia National Regional State. International Journal of Agricultural Economics. v. 1, n. 2, p. 35-39, 2016. https://doi.org/10.11648/j.ijae.20160102.13

Central Statistical Agency (CSA) of Ethiopia – North Shewa Zone Administration Office. Number of populations of the zone. Debre Berhan, 2019.

Chandrasekaran, K.; Devarajulu, S.; Kuppannan, P. Farmers' willingness to pay for irrigation water: A case of tank irrigation systems in South India. Water, v. 1, n. 1, p. 5-18, 2009. https://doi.org/10.3390/w1010005

Desta, F. Y.; Abera, K.; Eshetu, M.; Koech, R.; Alemu, M. M. Irrigation water planning for crops in the central highlands of Ethiopia, aided by FAO CROP WAT Model. African Journal of Agricultural Research, v. 12, n. 28, p. 2329-2335, 2017. https://doi.org/10.5897/AJAR2016.11659

Diriba, G. Agricultural and rural transformation in Ethiopia: Obstacles, triggers and reform considerations. Ethiopian Journal of Economics, v. 27, n. 2, p. 51-110, 2018.

Freeman III, A. M.; Herriges, J. A.; Kling, C. L. The measurement of environmental and resource values: Theory and methods. 3rd ed. Abingdon: RFF Press, 2014. 478p. https://doi.org/10.4324/9781315780917

Haab, T. C.; McConnell, K. E. Valuing environmental and natural resources: The econometrics of non-market valuation. Cheltenham: Edward Elgar Publishing, 2002. 352p.

Hagos, F.; Jayasinghe, G.; Awulachew, S. B.; Loulseged, M.; Yilma, A. D. Agricultural water management and poverty in Ethiopia. Agricultural Economics, v. 43, n. s1, p. 99-111, 2012. https://doi.org/10.1111/j.1574-0862.2012.00623.x

Hanemann, M.; Loomis, J.; Kanninen, B. Statistical efficiency of double-bounded dichotomous choice contingent valuation. American Journal of Agricultural Economics, v. 73, n. 4, p. 1255-1263, 1991. https://doi.org/10.2307/1242453

Hussain, I.; Hanjra, M. A. Irrigation and poverty alleviation: review of the empirical evidence. Irrigation and Drainage, v. 53, n. 1, p. 1-15, 2004. https://doi.org/10.1002/ird.114

Jaghdani, T. J.; Brümmer, B. Determinants of willingness to pay for groundwater: insights from informal water markets in Rafsanjan, Iran. International Journal of Water Resources Development, v. 32, n. 6, p. 944-960, 2016. http://dx.doi.org/10.1080/07900627.2015.1133405

Keough, A.; Vásquez, W. F. Willingness-to-pay for water resource protection in El Salvador. Water and Environment Journal, v. 34, n. s1, p. 192-206, 2020. https://doi.org/10.1111/wej.12518

Kidane, T. T.; Wei, S.; Sibhatu, K. T. Smallholder farmers' willingness to pay for irrigation water: Insights from Eritrea. Agricultural Water Management, v. 222, p. 30-37, 2019. https://doi.org/10.1016/j.agwat.2019.05.043

Kifle, M.; Gebretsadikan, T. G. Yield and water use efficiency of furrow irrigated potato under regulated deficit irrigation, Atsibi-Wemberta, North Ethiopia. Agricultural Water Management, v. 170, p. 133-139, 2016. https://doi.org/10.1016/j.agwat.2016.01.003

Kiprop, J.; Mulungu, K.; Kibet, N.; Macharia, A. Determinants of smallholder farmers' willingness to pay for irrigation water in Kerio Valley Basin, Kenya. Journal of Sustainable Development, v. 10, n. 2, p. 135-142, 2017. https://doi.org/10.5539/jsd.v10n2p135

Luo, F.; Wang, Q.; Sun, F. M.; Xu, D.; Sun, C. H. Farmers' willingness to participate in the management of small-scale irrigation in China from a social capital perspective. Irrigation and Drainage, v. 67, n. 4, p. 594-604, 2018. https://doi.org/10.1002/ird.2208

Malhotra, N. K. Basic marketing research: Integration of social media. 4th ed. Boston: Pearson Education, 2012. 672p.

Mamat, M. P.; Yacob, M. R.; Radam, A.; Ghani, A. N. A.; Fui, L. H. Willingness to pay for protecting natural environments in Pulau Redang Marine Park, Malaysia. African Journal of Business Management, v. 7, n. 25, p. 2420-2426, 2013. https://doi.org/10.5897/AJBM10.752

Medellín-Azuara, J.; Harou, J. J.; Howitt, R. E. Estimating economic value of agricultural water under changing conditions and the effects of spatial aggregation. Science of the Total Environment, v. 408, n. 23, p. 5639-5648, 2010. https://doi.org/10.1016/j.scitotenv.2009.08.013

Meunier, S.; Manning, D. T.; Quéval, L.; Cherni, J. A.; Dessante, P.; Zimmerle, D. Determinants of the marginal willingness to pay for improved domestic water and irrigation in partially electrified Rwandan villages. International Journal of Sustainable Development and World Ecology, v. 26, n. 6, p. 1-13, 2019. https://doi.org/10.1080/13504509.2019.1626780

Mezgebo, A.; Tessema, W.; Asfaw, Z. Economic values of irrigation water in Wondo Genet District, Ethiopia : An application of contingent valuation method. Journal of Economics and Sustainable Development, v. 4, n. 2, p. 23-36, 2013.

Nauges, C.; Whittington, D. Estimation of water demand in developing countries: An overview. Water Supply and Sanitation, v. 25, n. 2, p. 263-294, 2010. https://doi.org/10.1093/wbro/lkp016

Puertas, D. G-L.; van den Pol, B.; Kumsa, A.; van Steenbergen, F.; Haile, A. M.; Embaye, T. G. Status and potential of groundwater use in Ethiopian floodplains. Wageningen: Spate Irrigation Network Foundation, 2015. p. 1-22. (Overview Paper No. 17 – Practical Note Spate Irrigation).

Stedman, S.; Mnyimbiri, A. M.; Kawonga, Z.; Malota, M.; Njera, D.; Hall, R. P.; Holm, R. H. Using irrigation to kick-start multiple-use water services for small-scale farmers in Malawi: A case study of the Nkhata Bay District. Irrigation and Drainage, v. 67, n. 5, p. 645-653, 2018. https://doi.org/10.1002/ird.2282

Thorvaldson, J.; Pritchett, J.; Goemans, C. Western households' water knowledge, preferences, and willingness to pay. Canadian Journal of Agricultural Economics, v. 58, n. 4, p. 497-514, 2010. https://doi.org/10.1111/j.1744-7976.2010.01195.x

Verbeek, M. A guide to modern econometrics. 2nd ed. Chichester: John Wiley & Sons, Ltd., 2004. 446p.

Wassihun, A. N.; Nega, Y. M.; Kebede, W. M.; Fenta, E. E.; Ayalew, A. A. Smallholder households' willingness to pay for sustainable agricultural water supply in case of North West Ethiopia. Letters in Spatial and Resource Sciences, 2022. https://doi.org/10.1007/s12076-022-00300-0

Whittington, D. What have we learned from 20 years of stated preference research in less-developed countries?. Annual Review of Resource Economics, v. 2, p. 209-236, 2010. https://doi.org/10.1146/annurev.resource.012809.103908

Woldemariam, P.; Gecho, Y. Determinants of small-scale irrigation use: The case of Boloso Sore District, Wolaita Zone, Southern Ethiopia. American Journal of Agriculture and Forestry, v. 5, n. 3, p. 49-59, 2017. https://doi.org/10.11648/j.ajaf.20170503.13

Young, R. A.; Loomis, J. B. Determining the economic value of water: Concepts and methods. 2nd ed. Abingdon: RFF Press, 2014. 358p. https://doi.org/10.4324/9780203784112