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Article

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GENERAL & APPLIED ECONOMICS | RESEARCH ARTICLE

Economic valuation and its determinates of improved irrigation water use; evidence based on South Gondar Zone, Ethiopia

Aklok Getnet^{1*}, Ermias Tesfaye², Yasin Ahmed³ and Mohammed Ahmed⁴

Abstract: The main aim of the research was to analyze economic evaluation and determinants of willingness to pay decisions for efficient irrigation water use improvement. Use for this purpose total of 300 HHs was selected using the Multi-stage sampling technique. The collected data was analyzed using econometrics model. In the econometric part, a seemingly unrelated bivariate probit model was applied to estimate households' mean willingness to pay and its determinant's for efficient irrigation water use. Leads by a double bounded dichotomous choice method. From seemingly unrelated bivariate probit model regression results, the mean and aggregate willingness to pay off the households 950.7 ETB (€25.7) per month per household per hectare was 1087159.09 ETB (€29382.7) per month and ($12 \times 1087159.09 = 13045909.08$ ETB per year) respectively. The Mean and aggregate willingness to pay from the open-ended questions to be 926.059 ETB (€25.03) per month per household per hectare was 1072990.52 ETB (€28,999.74) per month respectively also, The bivariate probit model result revealed that bid values, sex of the household head, irrigation farm size, extension service significantly affected households' WTP in both initial and followed up bid values So, policymakers should be households have a high willingness to pay for improved irrigation water use systems and the government should implement irrigation water management practices to supply reliable irrigation water to the farmers and should set up proper irrigation water pricing at an amount close to the mean WTP that households were willing and able to pay.

Subjects: Environment & Economics; Economics; Environmental Economics

ABOUT THE AUTHOR



Aklok Getnet

Aklok Getnet was born in Ebenat Woreda, North Gondar Zone of Amhara Regional State in February 1994. He also attended his elementary, secondary and preparatory school education at Ebnat Secondary and Preparatory High School in North Gondar Zone. After completion of his high school education, he joined Bahir Dar University College of Agriculture and Environmental Science (BU) in October 20125 and graduated with BSc Degree in Agricultural Economics in July 03/2018. Soon after his graduation, the author joined Bahir Dar University College of Agriculture and Environmental Science in October 2019 to pursue of his MSc degree in Agricultural Economics in regular program. After the accumulation of his master degree he joined Jinka University College of Agriculture and Natural Resource as lecturer in Department of Agricultural Economics.

Keywords: willingness to pay; double bounded dichotomous choice; open ended question

1. Introduction

Water is a finite valuable natural resource which is essential for sustainable development through using irrigation farming. But, climate change, water supply limits, and continued population growth have intensified the search for measures to conserve water in irrigated agriculture, the world's largest water user (Giordano et al., 2019). Therefore, encouraging the financing of water-conserving irrigation technologies is widely believed to make more water available for cities and the environment for the longer-term water supply reliability and quality (Aydogdu, 2016).

Globally, the population is expected to grow rapidly, and resulting increasing irrigation has existed as a prerequisite to farming that use of the return from the limited land available to cultivate agricultural production (Ndlovu, 2015). Irrigation farming is one of the measures required to bring about sustainable food production by adopting more diversified cropping patterns and is also an important tool for mitigation of climate change conditions such as drought and famine in developing countries (Kljajic et al., 2013). Despite irrigation having this importance, its development in Africa is the lowest supply of surface water is affected by seasonal rainfall flow (Aydogdu, 2016). Therefore, efficient water resource uses needs by creating the driving force for sustainable irrigation development.

In sub-Saharan Africa, it is not only the scarcity of freshwater sources, climate change and the deterioration of freshwater quality supply of water that is an issue but also the level of management and efficiency of its use. Therefore, actions are necessary among the important political-economic priorities to improve the improving the design of irrigation canals will reduce water losses through evaporation and seepage Irrigation systems (Hamdy. et al., 2020). One strategy is to scale back water demand by adopting conservation programs and improving water use sustainability and efficiency, and another driving force involves a water pricing policy. This policy has the advantage that the income may be wont to finance developments of sustainable irrigation systems. Economic valuation of water can also be considered a prerequisite for the sustainable use of water resources by comparing farmers' willingness to pay and the opportunity cost of water (Aman et al., 2020).

Like many sub-Saharan African countries, irrigation facilities in Ethiopia are relatively backward, lack water control infrastructure, and lack technical experts to support irrigation development, leading to low crop yields and low utilization efficiency of irrigation water resources (Fikirie et al., 2017). The sensible experience of estimating households' willingness to pay (WTP) and collecting fees for irrigation water in Ethiopia is low (Mezgebo & Ewnetu, 2015). According to (Ayana, 2015), the awash geographical area is the only basin in Ethiopia where irrigation water pricing is practiced. Therefore this low experience of fees payments for irrigation water use can be one reason for the less productive use of irrigation water in Ethiopia (Ejeta et al., 2019) and (Angella et al., 2014).

Recently, the Ethiopian government has focused on the design to measure various activities to boost the irrigation system, particularly on the supply side, and seems to disregard the effective demand of the irrigation users (Aman et al., 2020). However, there is a need for fulfillment within the improvement of irrigation water use system is sufficient knowledge about farmers' demand or WTP for improved irrigation water (Zakaria, 2014). As a result, the implementation of such policy is opposed to the supply-side regulating the pricing mechanisms and considering the WTP of the irrigation water users (Alemayehu, 2014). Consequently, the need to estimate farmers' WTP for improved irrigation water use is timely research to enhance irrigation systems.

Several studies have shown the economic valuation of improved irrigation water use in Ethiopia and others Countries. There is some empirical evidence worldwide. For example, (Aman et al., 2020); (Birara Endalew Beneberu Assefa, 2019); (Yibeltal, 2018); (Fikirie et al., 2017); (Mekonnen A,

2015); (Mezgebo et al., 2013) and (Nega et al., 2012). However, most studies valued water using a single bounded discrete model. But, the single-bounded dichotomous choice approach yields inefficient welfare measures due to limited information obtained from each respondent. As a result, the researcher is motivated to investigate economic valuation of improved irrigation water use by using double bounded discrete model.

2. Review related literature

There are different studies in environmental valuation through WTP approach using contingent valuation method. However, this subsection favored on reviewing number of previous studies where the contingent valuation method has been used to determine WTP for a specific improvement or conservation of environmental resource specially, water in Ethiopia and out said of Ethiopia. For instance, Tolera et al., (2019) conducted a study on determinants of farmers' willingness to pay for improved irrigation water use in the case of Woliso district, Ethiopia. His collected data from two hundred fifty-one sampled households and he also, use Tobit model. The finding revealed that a combination of socioeconomic variables were determined the farmers maximum willingness to pay. Consequently, the result of the Tobit model showed that education level of household head, irrigable land size and credit utilization were the factors that influence the farmers' probability and maximum willingness to pay for improved irrigation water use positively. On the other hand, initial bid influenced the households' probability and maximum willingness to pay negatively.

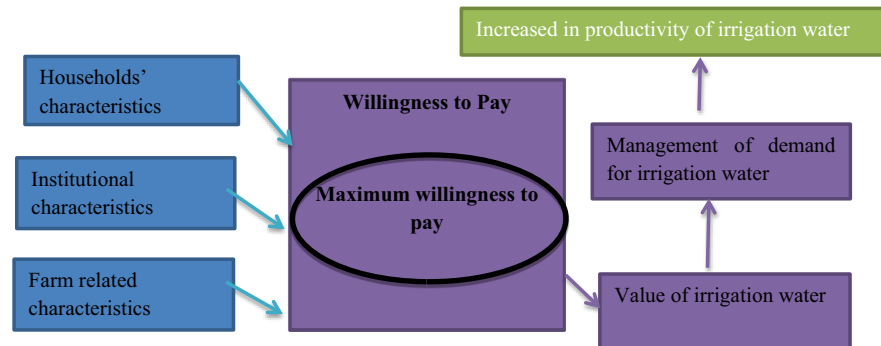
Birara Endalew Beneberu Assefa (2019) examined the determinants of farmers' willingness to pay for the conservation of church forests in northwestern Ethiopia. Tobit model was employed to analyze the determinants of households' maximum willingness to pay for the conservation of church forests. Consequently, the result of the study revealed income of the household was one of the other factors that had a statistically positive influence on households' willingness to pay in terms of cash for the conservation of the church forest. The possible explanation from the report was having more income increases the purchasing power of sample respondents. Whereas the result from the CV survey revealed mean willingness to pay in terms of cash and labor is 178 ETB. (1787.75 ETB) man-days, respectively.

Fikirie et al. (2017) conducted a study titled economic valuation of improved irrigation water use: the case of South Shoa Zone Oromia Ethiopia. They used the double bounded dichotomous choice method eliciting contingent valuation method to elicit the respondents of the sample household. The mean willing to pay for the estimated mean willingness to pay for the improved irrigation water use was Birr 575.23. On the other hand, means estimation was made on the open-ended question it was estimated to be 562. The report suggested that "as a matter of fact that, households become free riders in the open-ended questions" the mean willingness to pay in double bounded dichotomous choice format is higher than that of open-ended CVM questions.

Mekonnen. A, (2015) conducted on Irrigation water pricing in Awash River Basin of Ethiopia. The study attempted to identify the factor which affected the households' willingness to pay for conservation of irrigation water. In addition the author was estimated the value of irrigation water in Awash River Basin of Ethiopia. Logit and probit were the econometric models to identify the factors and estimate the value of Irrigation water price. The result from the logit model showed that the controversial influence of education level on households' willingness to pay. This result showed education level of household had a negative influence on the probability of households' willingness to pay for conservation of irrigation water use. Mekonnen explained that "educated respondents had the fear of increased price if they identify themselves willing to pay. On the other hand households with accessed to credit were more willing to pay for irrigation water than those households with no accessed. Similarly Irrigators with longer irrigation experiences were also more willing to pay than those relatively short periods of experience. The study also estimated the mean willingness to pay for irrigation .Consequently, the result from the probit model showed it was Birr 88 per hectare per year per person. The calculation was made

Figure 1. Conceptual framework of households' willingness to pay.

Source authors design, 2020



using the probit model as: mean WTP $WTP = \frac{\beta_0}{\beta_1}$ where β_0 is a constant term and β_1 is the coefficient of the bid level.

Consequently result from probit model stated that, the estimated coefficient of the proposed bid value was statistically significant and affected the probability of households' willingness to pay for irrigation water negatively. Whereas irrigation farming experience was found to had highly statistical significant influence on households' probability of willingness to pay with positive sign. The author suggested that households with longer irrigation farming experience could easily realize the benefit from irrigation and hence is more likely to attach high value for irrigation agriculture than those who have no or shorter years of irrigation farming experience. Furthermore households' annual income and market access were the other explanatory variables which influence the probability of households' willingness to pay.

The other objective of the probit model was to estimate the central value of the irrigation water as a result it was Birr 614 per annual per timade per household. But it was Birr 417 from open ended question. The aggregate demand from close ended and open ended was estimated as birr 35,513,760 and 24,147,622 respectively.

Generally, except few, all studies did not conduct detail analysis for each (DBDC or open ended) question to answer what are the determinant factors which determine probability of willingness to pay (WTP) and maximum willingness to pay. Because the factors which significantly influence WTP may not influence MWTP similarly so, more studies should be regressed in different econometric model differently.

The conceptual framework of this study will base on the assumption that willingness to pay is influenced by a number of socio economic factors such as households' characteristics, institutional characteristics and farm related characteristics (Figure 1). Besides As study by Omondi .S. (2014) reported, quantifying farmers' willingness to pay help to manage the water demand as a result it increase the efficiency and productivity of the irrigation water use.

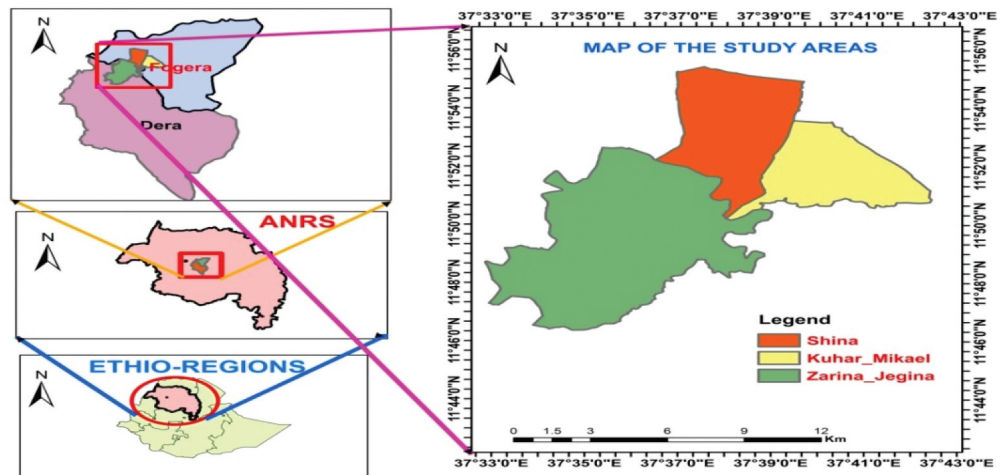
3. Materials and methods

3.1. Description of study area

For this study, the Gumara irrigation scheme is irrigation kebeles bounded by the Fogera and Dera districts of South Gondar Zone ANRS Ethiopia. The name Gumara irrigation scheme originated from the Gumara River and is located in South Gondar and ranges between Mount Guna from the east and Lake Tana in the west (Figure 2).

Fogera district is one of the districts in Amhara National Regional State and found in South Gondar Zone. Border by Lake Tana, source of Blue Nile. It is situate at 11°05'N latitude and 37°04'E longitude. The district has a total land area of 117,414 hectares. The land use pattern of the district

Figure 2. Map of study area.



including 51,662 hectares of cultivated land, 25,831 hectares of pasture land, and 16,434 ha for other purposes, and the water bodies" account for 23,483 hectares (Kedir, 2011). IPMS (2005) indicate that, flat land accounts for 76%, mountain and hills 11% and valley bottom 13%. The high proportion of plain topography creates the opportunity for irrigation. The altitude ranges from 1774 to 2410 masl. The mean annual rainfall is 1215 mm and ranges from 1100 to 1340 mm (MOA 2005).

Dera is one of the other woredas in the Amhara region of Ethiopia. It is a part of the south Gondar Zone and is bordered to the south by the Abay River which separates it from the east Gojam from the west; it is bordered by Lake Tana, to the north by Fogera, and to the east by Estie. Dera woreda covers total area 158,948 ha, of which 35% is plain, 20% is mountainous, 18% is gorges and 27% is undulating. The altitude of the woreda ranges from 1,500 m to 2,600 m above sea level while the annual average rainfall is 1,250 mm. 85% of agro-ecology Woynadega while 15% is Dega (Deraworeda agricultural office).

3.2. Data type, source and methods of data collection

The study used primary data collected through focus group discussion (FGD) and individual interviews. Primary data were collected from sampled household heads in the study area through a structured questionnaire using face-to-face interviews. Secondary data were gathered from selected irrigation kebeles' irrigation offices. Besides, secondary data was gathered from the Fogera and Dera irrigation office.

The questionnaire was administered in two main sections. The first section provides several socioeconomic characteristics of households. The second section contains the contingent valuation scenario and the question of households' probability and maximum willingness to pay for the provision of improved irrigation water use. The questionnaire was translated into the Amharic language to ease the data collection process and reduce errors.

The data was collected by well trained and experienced enumerators. Before starting the actual survey, training about the objective of the study and how to manage the CV survey data was given to enumerators. Besides, pre-test survey was under taken to check the performance of the enumerators' understanding toward the questionnaires and customization of the questionnaire in to the local context.

Focus group discussion and key informant was held to decide on the appropriate initial bid values. Pilot survey was also conducted on 18 randomly selected households before the actual

survey was started to check the validity of the questionnaire. Accordingly the pilot survey was conducted with due supervision of the researcher and the necessary adjustment to the draft questionnaire was made by the researcher. After the necessary adjustment was made to the draft questionnaire the final questionnaire was developed.

3.3. Sampling technique and sample size

The study was conducted in three potential Kebeles under the command area of Gumara irrigation schemes, which have a high irrigation potential in Dera and Fogera woredas, South Gondar Zone of Amhara Regional State. From the total irrigation kebeles, three kebeles were selected based on irrigation potential. Kebeles that had more or less improvement in irrigation water use are not considered for sample selection because the sampled kebeles need to have the same existing irrigation water use system. From the three potentiate Kebeles were selected from the individual respondents by applying a systematic random sampling technique. Thus, 300 households were selected based on probability proportionate to the sample size technique. Therefore, total sample size was distributed to each selected kebeles based on the proportion of Gumara River irrigation beneficiaries in each kebeles as shown in Table 1.

In this study, sample size was determined following Yaman (1967)

Yaman (1967)

$$n = \frac{N}{1 + N(e)^2} \quad (3)$$

Where n is the sample size, N is the population (total irrigation water user households by using Gumara River), and e is the level of precision (0.05) for this study. N = 1171 according to (Shina, Kuhar Michael and Jigna kebeles irrigation office, 2019). Therefore the sample size is equal to: 300

3.4. Method of data analysis

The gathered data was analyzed using both descriptive statistics and econometrics models based on contingent valuation method.

3.4.1. Contingent valuation method

The contingent valuation method is a valuation based on a survey that offers the respondents a chance to make an economic decision on non-market goods. According to (Kedir, 2011); World Bank (2002), states that, Contingent valuation is a method of estimating the value that a person places on a good, habitually one that is not sold in markets, such as environmental quality or good health. CV is also claimed, to recover existence or non-use values which other methods cannot. In natural resources, contingent valuation studies generally derive through the elicitation of respondents' willingness to pay to prevent injuries to natural resources or to restore injured natural resources (Abdul Rahim, 2005).

Table 1. Sample size distribution

Name of selected kebeles	Number of user population	Number of user sample farmers
Jigna kebele	630	161
Kuhar Michael	248	64
Shina kebele	293	75
Total	1171	300

Source Jigna, Kuhar Michael and Shina kebeles irrigation office, 2019

These approaches, however, have their advantage and disadvantages. For instance, several studies such as those (Nega Assefa 2012);(Tesfahun Alemayehu, 2014); (Meseret Birhane and Endrias Geta, 2016) conducted a study regarding irrigation improvement focused on open-ended follow-up questions to analyze both probability and maximum willingness to pay. However, open-ended contingent valuation questions are doubtful to provide the most reliable valuations because responses to open-ended questions are unreliable and biased (Arrow K et al., 1993). As a result, the researcher is motivated to investigate farmers' willingness to pay for improved irrigation water use using double bounded contingent valuation method followed by open-ended questions to analyze the probability of willingness to pay and amount of WTP respectively.

3.4.2. Descriptive analysis

Descriptive statistics including percentage, frequency, mean, minima and maxima were computed to present the socioeconomic characteristics and willingness to pay status of sample households.

3.4.3. Econometric model specification

The ultimate goal of estimating the econometric model from the double bounded dichotomous choice format of the contingent valuation method was to calculate the household's willingness to pay for providing the irrigation service described in the scenario and to answer the question What are the factors that influence the households' probability of willingness to pay in two different bid levels. On the other hand, the goal of estimating the economic model from open-ended format was to answer what are the factors that influence the households' maximum willingness to pay for improved irrigation water use. Binary probit and bivariate probit model are appropriate models for analyzing the influence of factors on discrete dependent variables.

3.4.3.1. Bivariate probit model. Binary probit econometric model are efficient and unbiased to estimate the coefficient of independent variables for the single bounded dichotomous choice model. Whereas, bivariate probit econometric model is efficient and unbiased to estimate the coefficient of independent variables for the double bounded dichotomous choice model. Therefore, bivariate probit model is a joint model for two binary outcomes with correlated error terms, in the same way for seemingly unrelated bivariate regression model (Greene, 2003). SUBPM takes two independent binary probit models into account and estimate them together by considering their non-zero correlation of error terms between two equations. However binary Probit Regression model can produce unbiased, but inefficient estimators for exogenous variables because it assumes the error terms are not correlated with each other, also it ignores the unobservable heterogeneity between the two equations. Hence, an alternative approach to control for unobservable heterogeneity is to consider a Seemingly Unrelated Bivariate Probit model, as it provides a way of dealing with two separate binary dependent variables (Greene, 2003).

The other comparative advantage of the seemingly unrelated bivariate probit model is to calculate the mean level of farmers' willingness to pay for improved irrigation water use.

Therefore, in this study a Seemingly Unrelated Bivariate Probit model was employed to estimate the coefficient of independent variables for the double bounded dichotomous choice to identify factors which influence probability of households' willingness to pay and to quantify their mean WTP in two bid levels jointly. The Marginal effects and predicted values for the probability of farmers' willingness to pay in the two separate binary outcomes could be estimated similarly to those for the binary probit models. Marginal effects for the joint probability, say $P(y_1 = 1 \text{ and } y_2 = 1)$ are also available.

The most general econometric model for the double bounded CV Data comes from Haab and McConnell (2002), formulations

$$wtp_{ij} = \mu_i + \varepsilon_{ij} \quad (1)$$

Where, wtp_{ij} = is the j th respondent i 's wtp

and $i = 1, 2$ represents first and second answers.

μ_1, μ_2 = is the mean value for first and second response and

ε_{ij} = unobservable random component

To construct the likelihood function, the probability of observing each of the possible two bid response sequences (yes-yes, yes-no, no-yes, no-no) are given as follows. The probability that the respondent i answers to the first bid and to the second bid is given by Haab and McConnell (2002):

$$A, \text{pr}(\text{yes}, \text{no}) = (\text{wtp}_1 i \geq t^1, \text{wtp}_2 i < t^2) = \text{pr}(\mu_1 + \varepsilon_1 i < t^1, \mu_2 + \varepsilon_2 i < t^2),$$

$$B, \text{pr}(\text{yes}, \text{yes}) = (\text{wtp}_1 i > t^1, \text{wtp}_2 i \geq t^2) = \text{pr}(\mu_1 + \varepsilon_1 i > t^1, \mu_2 + \varepsilon_2 i \geq t^2)$$

$$C, \text{pr}(\text{no}, \text{no}) = (\text{wtp}_1 i < t^1, \text{wtp}_2 i < t^2) = \text{pr}(\mu_1 + \varepsilon_1 i < t^1, \mu_2 + \varepsilon_2 i < t^2)$$

$$D, \text{pr}(\text{no}, \text{yes}) = (\text{wtp}_1 i < t^1, \text{wtp}_2 i \geq t^2) = \text{pr}(\mu_1 + \varepsilon_1 i < t^1, \mu_2 + \varepsilon_2 i \geq t^2) \quad (2)$$

the i^{th} contribution to likelihood function becomes

$$Li\left(\frac{\mu}{t}\right) = * \text{pr}(\mu_1 + \varepsilon_1 i \geq t^1, \mu_2 + \varepsilon_2 i < t^2) YN,$$

$$* \text{pr}(\mu_1 + \varepsilon_1 i > t^1, \mu_2 + \varepsilon_2 i \geq t^2) YY$$

$$* \text{pr}(\mu_1 + \varepsilon_1 i < t^1, \mu_2 + \varepsilon_2 i < t^2) NN$$

$$* \text{pr}(\mu_1 + \varepsilon_1 i < t^1, \mu_2 + \varepsilon_2 i \geq t^2) NY. \quad (3)$$

where : t^1 First bid price , t^2 second bid price; $YN = 1$ for yes no answer, 0 otherwise;

$YY = 1$ for yes yes answer, 0 otherwise; $NN = 1$ for no no answer, 0 otherwise;

$NY = 1$ for no yes answer, 0 otherwise;

This formulation is referred to as the Bivariate Discrete Choice Model. Assuming normally distributed error terms with mean 0 and respective variances σ_1^2 and σ_2^2 , then WTP_{1j} and

WTP_{2j} have a bivariate normal distribution with means μ_1 and μ_2 , variances σ_1^2 and σ_2^2 and correlation coefficient ρ . Given the dichotomous responses to each question, the normally distributed model is represented as bivariate probit model.

the i^{th} contribution to the bivariate probit likelihood is given as;

$$L\left(\frac{\mu}{t}\right) = \varphi e^{1/2} \left(d_1 i^{(t^{1-\mu}/\sigma_1)} \right), \left(d_2 i^{(t^{1-\mu}/\sigma_2)} \right), d_1 d_2 i \rho \quad (4)$$

where, $\varphi e^{1/2}$ = the bivariate normal cumulative distribution function with zero means

$d_1 i = 2 y_1 i - 1$ and $d_2 i = 2 y_2 i - 1$, $y_1 i =$
 1 if the response to the first equation is yes and 0, otherwise $y_2 i = 1$ if the response to the second
 and equation is yes and 0, otherwise ρ = correlation coefficient σ = standard deviation of the error

Then after running regression of dependent variable of two equations (yes/no indicators), on a constant and on Independent variables consisting of the bid levels, the mean WTP value was calculated Following the approach developed by Krinsky and Robb (1986). Therefore, the mean WTP value of improved irrigation water can be calculated as follows as:

$$\text{Mean WTP} = x' \beta' / \mu \sigma' \quad (5)$$

where : x' = raw vector of sample mean including 1, for the constant term

$\beta'^{(k-1 \times 1)}$ = estimated coefficients

$\mu \sigma'$ = coefficient on the bid variable and in constant only models

$x' = 1$ β is the coefficient in the constant term

Whereas, the mean WTP from open ended contingent valuation response could be estimated Following to (Habb.C and McConnell 2002 as:

$$\text{mean WTP} = \sum_{i=0}^n y_i / n \quad (6)$$

Where n is the sample size and y is maximum amount of willingness to pay reported by households.

4. Result and discussions

4.1. Socio economic characteristics of sample households

The data were collected from 300 respondents, but only 288 respondents were used for statistical analysis. Additionally, from the descriptive statistics revealed in Table 2 that among 288 sampled households, 256 (89%) were male-headed households and 32 (11%) were female-headed households. Age of the household head, the average age of the sampled respondents was 45.3 years with the minimum age of 22 years and a maximum of 75 years old. Regarding education level of household head, the average attainment of household was 4 classes with the minimum 0 and maximum of 12 class years. The survey result presented in Table 2 revealed that the average family labor force of the total sampled household was about 4 persons with the minimum 1 person and maximum of 6 persons. In Table 2 it is also demonstrated that the average household's yearly income is about birr 51,416. The income level ranges from a minimum of birr 3500 to a maximum of birr 100000. Experience of irrigations practices is another continuous variable of households'

attribute and the mean experience of sample households in irrigation practices was about 11 years with the ranges from a minimum of 2 years to a maximum of 15 years.

4.2. Households' willingness to pay

As Hanemann et al., (1966) recommended, before to the elicitation question, individuals were asked if they might pay anything. As a result, the solicitation of double bound CVM; individuals were asked "yes" or no questions to assess their WTP for improved irrigation water use. Accordingly, out of the total 288 households used for statistical analysis, 283 (98.26%) of the respondent were willing to pay money for the proposed irrigation project and also the reaming, 5 (1.74%) of them weren't willing to pay money for the given scenario (as indicated in Table 3,4). Those, unwilling household heads reported that they could not afford to pay for the proposed improvement. This suggests that the given scenario is supported by about 98% of households. Those that failed to WTP, considered because the economic reason might be treated as having true zero WTP (Birara Endalew Benerberu Assefa, 2019).

Those, unwilling household heads reported that they couldn't afford to pay money for the proposed improvement (Table 5). This suggests that the given scenario is supported by about

Table 2. Household characteristics for categorical variable

Explanatory variable	Categories	Freq.	%	Obs.
Male headed household	Male	256	89.32	288
	Female	32	10.68	

Source, authors' survey data, 2020

Table 3. Household characteristics for continuous variables

Explanatory Variables	Obs.	Mean	Std. Dev.	Min	Max
Age of household head	288	45.34722	14.07165	22	75
Education level of household head	288	4.440972	4.759365	0	12
Family labor force	288	3.680556	1.539957	1	6
Total annual income of household	288	51,416.67	28,792.42	3500	100,000
Irrigating experience of household head	288	10.78819	5.086047	2	15

Source, authors' survey data, 2020

Table 4. Households' willingness to pay for the proposed scenario statistics

Willingness to pay any amount of money	Freq.	Percent	Cum.
Willing	283	98.26	98.26
Unwilling	5	1.74	100.00
Total	288	100.00	

Source: Authors survey data, 2020

Table 5. Number of zero willingness to pay bids with reasons

No.	Reasons	Total	
		No	%
	Management will misappropriate the money	1	20
	Cost of production is too high	1	20
	Land sizes are too small	1	20
	Crop yield is too low and Prevalence of crop diseases	1	20
	Water is not well distributed	1	20
Total		5	100

Source: Authors survey data, 2020

98% of households. These results didn't show a WTP because the economic reason may well be treated as having true zero WTP (Gebremariam, 2021).

As presented in Table 6 that out of the 5(1.74%) households who were unwilling to pay anything in the least for better irrigation water use system. A number of the respondents stated that management would misappropriate the cash. Others said the price of production under the scheme was too high, land sizes were too small, crop yield was too low, and water wasn't well distributed. Others too cited prevalence of crop diseases. During this case, misappropriation of the funds sounds like protest because the respondents seem to possess value for the project but undecided the funds are used of cause.

4.3. Joint responses of households' WTP

As (Hoyos et al., 2010) explained efficiency within the elicitation of WTP may be increased if repeated questions are used. Following this, double-bonded CVM followed by an open-ended question was used for this study. Households were also categorized supported their joint responses to the primary and therefore the second bids as we discussed in the methodology part if a household responds "Yes 'to the first bid he/she could be asked for an increased amount of the first bid and also the discounted amount for those that respond" No' to the primary bid. Accordingly, the joint responses of respondents are Yes-Yes, Yes-No, No-Yes, and No-No. Table 6 depicts the joint response of sample households for the first and also the next minimum or maximum bids. Therefore, the descriptive statistics revealed that among 288 sampled households, 126 (43.75%) households were willing to pay the maximum amount beyond the stated bids both within the first bid and second bid values (Yes-Yes). Whereas for respondents who were willing to pay in the first bid and not willing to pay in the follow-up maximum bid values (Yes-No) was 72 (26.06%). The proportion of households who weren't willing to pay at the first bid level and willing

Table 6. Joint responses of households' WTP

Joint responses	Freq.	Percent	Cum.
Yes—Yes	126	43.75	43.75
Yes—No	72	26.04	69.79
No—Yes	27	9.37	79.16
No—No	63	20.84	100
Total	288	100.00	

Source: Authors survey data, 2020

in the second maximum bid level (No-Yes) was found to be 27 (9.37%), and also the remaining 63 (20.84%) of respondents were felt to No-No (who aren't willing at both level of bids).

4.4. Estimation of mean willingness to pay

In the practice of the contingent valuation method zero bidders are presented with follow-up open-ended inquiries to ascertain whether or not they are expressing a protest bid against the valuation or they place no value on the resource (Cooper et al., 2002). For this study open-ended and double bounded contingent valuation methods were used to compute the mean willingness to pay and used for comparison between the open-ended and double bounded results. This study used double bounded CVM followed by an open-ended question hence, efficiency in the elicitation of WTP increases if the repeated question is used (Gelo & Koch, 2015). Accordingly, the results of the contingent valuation survey revealed that the mean maximum WTP of sampled households was about ETB 926.7 (€25.05) with the ranging from ETB 0 to 3000 annually per hectare (0.25 hectare) of irrigable land toward the development of sustainable irrigation water use (as indicated in Table 6).

4.4.1. Estimation of mean from double bounded dichotomous choice format

As Table 7 depicts, the significant and positive sign of Rho (ρ) indicates the existence of positive relationship between the 2 WTP responses. This significant but imperfect correlation between the two error terms verifies that seemingly unrelated bivariate probit model is that, the correct econometric model to estimate mean WTP amount. The likelihood ratio test of the model confirms the interdependence between two probit equations at less than a 1% significance level. This indicated that the two equations estimated concurrently. Because the model result indicated both the initial follow-up bid had a statistically significant at 1% level. This means that the rise within the number of bids decreases the respondents' willingness to pay. The probability of willingness to pay only the second response (WTP2) by the sample households was about 57.85%. As against to this, the joint probability that household heads fail to willingness to pay in both of the responses is about 13.11%, and this indicated that they're more likely to fail to willingness to pay both responses (WTP1 and WTP2) simultaneously. Moreover, the regression output in Table 7 revealed that the coefficient of the initial and follow-up (second-bid values) have negative and significant at less than 1% significant probability level, respectively.

The mean WTP estimation in double bounded dichotomous choice was made based on WTP in first and second bid values through the subsequent. Accordingly (Krinsky et al., 1966), the primary procedure was calculating the mean WTP of equation one and mean WTP of equation two from a seemingly unrelated bivariate probit model which is displayed (in Table 8). The mean level of farmers' WTP was found to be ETB 950.7 (€25.69) annually per timid (0.25hectar). Whereas, the descriptive statistics from open-ended questions indicated in Table 7, the mean level of user farmers' WTP was found to be ETB 926.1 (€25.03) annually per 0.25 ha which is a smaller amount than the mean WTP from the double bounded dichotomous choice format. This comparison result's in step with the finding of (Aman et al., 2020), who suggested a possible reason that households become a free riders within the open-ended questions.

Table 7. Households' minimum, maximum and mean willingness to pay for better irrigation water

Variable	Obs.	Mean	Std. Dev.	Min	Max
Maximum willingness to pay	288	926.059	639.842	0	3000

Source: Authors survey data, 2020

Table 8. Parameter estimates of a seemingly unrelated bivariate probit model

WTP	Coef	Robust Std. Err	Z	P> z	[95% Conf. Interval]
B1	-.0023819	.0009627	-2.47	0.003	-.0042688 -.0004949
_cons	1.941436	.5918425	3.28	0.001	.7814456 3.101425
WTB2	Coef.	Robust Std. Err	Z	P> z	[95% Conf. Interval]
B2	-.0005104	.0003871	-1.32	0.0087	-.001269 .0002482
_cons	.5545097	.3694068	1.50	0.133	-.1695142 1.278534
Rho	.6942757	.1851148			.1544699 .9148696
Joint probability of success = 0.5785					
Joint probability of failure = 0.1311					
Wald test of rho = 0:					
chi2(1) = 5.7393					
Prob> chi2 = 0.0166					
Mean WTP =950.7					
Source: own survey, 2020					

This implies that at 95% confidence interval the mean WTP varies –0.001269–0.0002482 Birr/ hectare/year. However, the rational being the very fact that the second-equation parameters are likely to contain more noise in terms of anchoring bias where the respondents are assumed to take.

4.4.2. Estimated aggregate farmers' willingness to pay

As indicated in Table 9, one amongst the last main objectives of WTP contingent valuation study is to calculate or estimate the aggregate WTP of the goods valued or the analysis of welfare measures using the value of total WTP obtained from the sample households to the whole population within the irrigation command area. For valid analysis the advantages, the various bias of the sample design during contingent valuation study has to be minimized, and protest zero responses should be excluded from the data (Carson & Mitchell, 1993). Lastly, as indicated in Table 8, supported the NOAA¹ panel guide following (K et al., 1993), protests zero households are excluded from the aggregation, and hence we expected none of the various biases within the analysis.

The total farmers' WTP for improved irrigation water use can be estimated by taking the entire number of beneficiary households less the protest zero bidders and their total irrigable land sizes within the command area. In line with key informants of the district agriculture experts and office heads the total number of irrigated land is estimated to be 372.5; 439.5 and 1008 hectares, and also the total beneficiary households are estimated to be 248; 293 and 630 in Kuhar Michael Kebele, Shina Kebele and Jigna Kebele respectively. Consequently, the total amount of willingness to pay for the irrigation project area was calculated by multiplying the mean WTP value obtained from seemingly bivariate Probit regression model. The valid number of households was obtained after deducting the expected protest zero responses (20)² from the total population.

As a result, aggregate WTP has found to be ETB 6644257.16 (€179574.52) and ETB 6472327.68 (€174927.77) from double bounded and open-ended questions respectively. This aggregate willingness to pay result was greater than research findings (ETB 156786.1 from double bound elicitation method and ETB 128,264.55 from open ended elicitation method (Kassahun, 2009).

Table 9. Estimated total willingness to pay from open ended and double bounded format

Stratifications based on amount of solid waste generated	Total households (No.)	Sample households (No)	Willing to pay households		Total Households WTP for better SWM	Open ended Total WTP	Double bounded Total WTP
			No.	%			
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Kuhar Michael Kebele	630	155	152	53.7	619	573,230.52	588,483.3
Shina Kebele	248	61	60	21.2	244	225,958.40	231,970.8
Jigna Kebele	293	72	71	25.1	288	273,801.6	266,704.99
Total	1171	288	283	100%	1151	1,072,990.52	1,087,159.09

Source: Survey result, 2020

Table 10. Estimated coefficient of bivariate probit model

Explanatory variables	Coef. WTPB1	Robust Std.	Coef. WTPB2	Robust Std.	(dy/dx)
Male headed household	1.170388	.4544416***	.7887913	.3662606**	.3204408
Age of household head	-.0231935	.009289**	-.0065204	.0065196	-.0030711
Education level of household head	.0019241	.0345717	.056161	.0223101**	.0211762
Family labor force of household	.0902435	.1033234	.1908559	.065311***	.0741969
Irrigated farm size of household	.1636535	.0948406*	.1290348	.0535491**	.0529005
Total annual income of household	.0000197	6.53e-06***	4.91e-06	4.48e-06	2.37e-06
Irrigating experience of household head	.0009255	.0279159	-.0185387	.0205766	-.0069486
Credit utilization of household	.6137633	.2465132**	.1385599	.177219	.0665685
Extension contact of household head	.8047887	.2771524***	1.158176	.239655***	.4341196
Farm distance from water source	.0881848	.024757***	.0125511	.0163278	.0070727
Perceived trend of rain agro productivity	.4566076	.3590951	.4063045	.2550684	.164938
Dissatisfaction of existing water supply	1.03971	.4145015**	.9645326	.5910984	.3569315
Initial bid value	-.0053108	.0014465***	---	---	-.0001416
Followed up bid value	-----	-----	-.0017084	.000289***	-.0006426
Cons	-.8072134	1.094979	-2.354842	.770704	

Rho.668162

Wald test of rho = 0: chi2(1) = 10.101 Prob> chi2 = 0.0015

Source Authors' Survey, 2020

***, ** & * represent statistically Significant at 1 percent, 5 percent and 10 percent level of significant, respectively, WTPB1, WTPB2 represents willingness to pay at initial and followed up bid values respectively. Whereas, (dy/dx) represent marginal effect.

One of the main steps in analyzing data obtained from contingent valuation method is estimating and aggregating benefit. After, calculating mean WTP for better irrigation water in the above section, next, the total willingness to pay of households was estimated based on the proportion (willing versus not willing households). As discussed in the above, the survey covered 288 sample households and only 283 were valid out of 1171 total user households within the study area. The results of the study show that, about 283 (98.26%) of the households were willing to pay for better irrigation water use system. Based on our estimation a total of 1150 ($1171 \times 0.9826 = 1151$) households were WTP for proposed irrigation project.

From the above table, the number of households in each sample Kebele (columns 6). The amounts of WTP for each Kebele and the total households WTP in that Kebele. To obtain the WTP for households (column 7 and 8) from open ended and double bounded approach respectively. As discussed in the previous section, the mean WTP from open elicitation and double bounded method (926.059 and 950.7 ETB /month respectively), multiplied by the corresponding number of households willing to pay. Finally, the total willingness to pay (TWTP) was obtained by adding the WTP of the total households in each Kebele (column 8 and 9). The result indicated that, the TWTP is 107, 2990.52 ETB/month or (€28,999.74) from open ended elicitation method (column 7), and 108, 7159.09 ETB/month (€29,382.68) from double bounded elicitation method (column 8). The total WTP across sample Kebeles were also calculated and result indicated that significant amount of difference. The TWP of the Kuhar Michael Kebele, Shina Kebele and Jigna Kebele sample Kebeles were ETB 573,230.52; ETB 22,5958.40 and ETB 27,3801.6 per month, respectively from open ended elicitation method (column 7), and ETB588483.3; ETB231970.8 and ETB 266704.99/month respectively from double bounded elicitation method (column 8). This finding is in line with previous studies (Ayenew & Meride, 2015).

4.5. Estimated households' demand curve for improved irrigation water use

The sampled household demand toward the scenario of improving irrigation water use at different price levels could be observed through driving demand curve as shown in Figure 3. The demand curve is derived with the midpoint value of maximum WTP along the X-axis and the number of sampled irrigation water user farmers that are willing to pay per 0.25 hectare per year along the Y-axis. Moreover, the figure was formulated following some appropriate mathematical equations to get constant (K)³ and width (W)⁴ to set the stated level of maximum WTP class along the "X" axis.

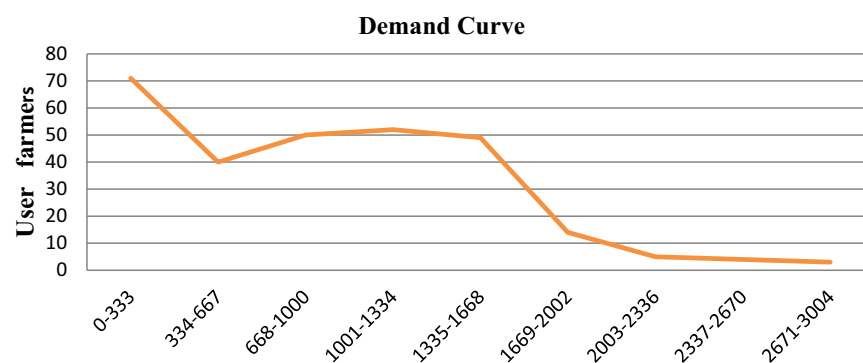
As shown in Figure 3, even if the demand curve is not downward everywhere it has a downward sloping in the long term perspective. It is in line with the economic theory of demand. The downward sloping of the demand curve implies an increase in the price of the improved irrigation water decreases the quantity demand for the improved irrigation water use system, other things remain constant. The negatively sloped aggregate demand curves for the supply of irrigation water ascertains the law of demand if the good is assumed a normal good.

4.6. Determinants of households' probability of willingness to pay

As we discussed in methodology part one of the objective of double bounded dichotomous choice format was used to identify farmers' probability of willingness' to pay for improved irrigation water use after the estimation of seemingly unrelated bivariate probit model. Before the analysis of the determinant factor of households' probability of WTP, the researcher checked either the dependent variables (WTPB1 and WTPB2) are regressed jointly using seemingly bivariate probit or independently using binary probit by considering the concept "when to use what." To do so a bivariate probit model was run to check whether the correlation between two error terms (ρ) is different from zero and whether the test of significance ($\text{Prob} > \chi^2$) is accept or reject the null hypothesis which is $\rho = 0$.

Figure 3. Sample households demand curve.

Source: Survey result, 2020



Accordingly If the correlation between the two error term is significantly different from zero or if the test of significance ($\text{Prob} > \chi^2$) is rejected the null hypothesis, seemingly unrelated bivariate probit model is appropriate assumed the errors are normally distributed with mean zero.

As a result of the executed seemingly unrelated bivariate probit model this is clearly shown in appendix, the value of ρ is about 0.66 with a positive sign implying there is the positive correlation between the error terms of the dependent variables with a significance level of 0.0015. Which means we have an evidence to reject the null hypothesis ($\rho = 0$). Therefore, seemingly unrelated bivariate probit model is found to be an appropriate (see table 3.11).

From bivariate probit model, sex of the household head (SEX), irrigation farm size (IFS), development agent contact of household head (EXTENSION), and bid values were statistically significant on probability of willingness to pay in both initial bid and follow up bid responses toward the improvement of irrigation water use. The result also revealed that age of the household head (AGE), total annual income level of the household (INCOME), credit utilization of the household (CRDT), distance from the water source (DISOURCE) and dissatisfaction (DISSATISFY) were found to have significance influence on probability of willingness to pay in the first bid response (WTPB1). Whereas, maximum level of education of household head (MLEDU) and family labor force (WAGEFS) were found to have a significance influence in the probability of willingness to pay in the followed up bid response (WTPB2).

5. Discussion on bivariate probit model result

Irrigating farm size (IFS)

The bivariate probit model has revealed that irrigation farm size was found to have a positive influence on the probability of households' willingness to pay in initial bid values as well as in followed up bid values at 10% and 5% significant levels respectively (Table 10). This would mean that the households who had large size irrigated farms would be more likely willing to pay for the proposed project. The possible clarification behind the result could be households who had large size irrigated farms might hope to get higher returns from higher engagement from irrigation using an improved irrigation system. The marginal effect of bivariate probit regression indicated that, holding the influences of other factors constant as the irrigated land size of household increases by one hectare (0.25 ha). The probability of household willingness to pay in the proposed bids for improved irrigation water use increasing by 5.3% this result is in agreement with the results from several previous similar studies: (Alem Mezgebo et al., 2013; Nega Assefa, 2012; Karthikeyan C., 2010)

Extension service (EXTENSION)

The bivariate probit model result also has demonstrated a positive and significant effect of the development contact at a 1% level of significance on the probability of households' willingness to pay in both the initial and the follow-up bid response. The positive effect of the extension contact on households' probability of WTP the possible explanation could be those who get an extension or development contact might have knowledge and awareness to decide about the technology of irrigation. Based on the calculated marginal effect of the bivariate probit model, a household that had contact with the development agent is more likely willing to pay in the given bids on average about 43.4% holding the influences of other variables constant. This result is confirmed by the hypothesis and the finding of (Njoko, 2014)

Bid value

As a result of the bivariate probit, model regression implied that the bid value was found to have a negative and significant influence on the probability of households' willingness to pay in both bid responses (B1, influence WTPB1, and B2, influence WTPB2) at 1% level of significance. The negative sign of initial bid values tells us the higher the bid amount is the lesser the probability of willingness to pay in that bid. The marginal effect of the bivariate probit model indicated that as the starting bid prices increase by 100 birrs per year the probability of households' willingness to pay

decreases on average, by about 0.02%. This result confirms the hypothesis and is in line with the study conducted by (Ayana, 2015; Yibeltal, 2018)

Meal headed household (SEX)

Concerning to sex of the household head, it positively and significantly affects the households' probability of willingness to pay first and followed up bid response at 1% and 5% levels of significance respectively. This would tell us male-headed households are more likely willing than female-headed households. This is because; most probably males had more economic decision power than females. The marginal effect after bivariate probit regression output indicated, keeping the influence of other factors constant, male-headed households have on average about 32% more probability of willingness to pay in the proposed bid for improved irrigation water use than female-headed households. The result is as expected and a similar result was reported by other studies (Tesfahun Alemayehu, 2014; Meseret Birhane and Endrias Geta, 2016).

Age of household head (AGE)

This variable was regressed under the bivariate probit model that was found to have statistically significant and negatively affect households' probability of willingness to pay specifically, in the initial bid values toward the proposed project at a 5% level of significance. The negative relation of age with the probability of households' willingness to pay in the propose bid values is that the older the household head is, the lesser the probability of the households' willingness to pay in the propose bid values. This is mainly due to older household heads being more likely to reject new ideas and fashions. From the marginal effect as the age of the household increases by one year the probability of households' willingness to pay in a given bid value goes down on average by about 0.3%. This result is in line with (Alem Mezgebo et al., 2013) and contradicted the result reported by (Ibrahim A. and Robert H. 2010)

Total annual income of the household (INCOME)

This variable affected the probability of households' willingness to pay in the dichotomous response specifically, in the initial bid values positively and significantly at a 1% level of significance. This result was found as per the prior hypothesis. This positive effect indicated that households with higher income were more likely willing to the proposed bid toward the scenario than that household with lower income. The possible explanation for the result obtained in this study could be that those households that have higher income levels have a higher demand for most commodities or services according to the basic economic theory. Keeping the influence of other explanatory variables constant, with one birr increase in the total annual income, the probability of households' willingness to pay increases on average by about 24%. This result is confirmed by (Yibeltal, 2018)

Utilization of credit (CRDT)

The bivariate probit model revealed that credit utilization positively and significantly influences the probability of households' willingness to pay in the proposed bid value toward the given scenario at less than a 5% level of significance. This implies that households who received the credit could be more likely willing to pay at the given bid level than those who did not receive credit. The possible reason could be household who received credit might have an opportunity to overcome the financial constraint and enables the farmer's inclination toward purchasing productive service or good for enhancing farm production. From the marginal effect of the bivariate probit model, the relation is interpreted as farmers who received credit had on average about 6.6% more probability of willingness to pay in the proposed bids than those farmers who did not receive credit keeping the influence of other explanatory variables constant. This result is in line with similar studies conducted by (Mekonnen Ayana, 2015; Tadesse Tolera et al., 2019)

Farm distance from the irrigation source (DISOURCE)

It had statistically significant and positive effect on the probability of household willingness to pay in proposed bid values specifically in the initial bid values (WTPB1) at less than 1% significance level. This tell us the distance the water source from the farm is, the households

are more likely willing to pay in a given bids for improved irrigation water use. The possible explanation might be farmers whose farm are far from the irrigation water source might receive a little water because of their distance from the water source and they may more likely willing whereas, farmers whose farm are near to the irrigation water source might receive a plenty of water because of the farm proximity to the water source and enables them lesser willingness to pay for the improvement of irrigation water use. Marginal effect result indicated that as the distance of farm is increase by one minute the probability of willingness to pay in a given bid values for the provision of improved irrigation water use increase on average by about 0.1% keeping the other influencing factors constant. This study is congruent with the finding of similar previous studies like (Chandrakanth M., 2011) and contrary with (Alhassan M.2012)

Education (MLEDU)

This explanatory variable was found to have a significant positive influence on the probability of households' willingness to pay in second bid values at less than 5% level of significance. This tells us households with more years of schooling are more probably willing to pay in a given bid for improved irrigation water use. One possible reason could be the higher the academic level of individuals could enable households more concerned on resource improvement than that lower academic level. The marginal effect after this model showed that keeping the influence of the other factors constant, as year of schooling increase by one year, the probability of households' willingness to pay in a bid increase on average by about 2.1%. This result was as expected and confirmed with (Yibeltal, 2018; Tesfahun Alemayehu, 2014; Tadese Tolera et al., 2019) and contradicted with (Mekonnen Ayana, 2015).

6. Conclusions and policy implication

The study attempts to evaluate of irrigation water by eliciting farmers' willingness to pay on Gumara irrigation project using contingent valuation method. From the result of this study, the researcher concluded that there are a high degree and level of WTP in the Gumara irrigation scheme for improved irrigation water use to provide sustainable irrigation water. The estimated total WTP from this study can be considered as the societal benefits of recovering the cost of sustaining water service and can be used in future cost-benefit analysis for policy formulation. However, the estimated mean WTP from open-ended elicitation format was less than the double bounded elicitation format that might be due to a human being may want a free service from government or the benefit of improved irrigation water use at the expense of others. The study revealed that. The Mean and aggregate willingness to pay from the open-ended questions to be 926.059 ETB (€25.03) per month per household per hectare was 107, 2990.52 ETB (€28,999.74) per month respectively. This shows that, there is an opportunity for improving irrigation water use. Therefore, the government should implement irrigation water management practices to supply reliable irrigation water to the farmers and should set up proper irrigation water pricing an amount close to the mean WTP that households were willing and able to pay.

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Notes

1. The National Oceanic and Atmospheric Administration (NOAA) convened a panel of prominent social scientists established in 1992, to assess the reliability of contingent valuation (CV) studies. The product of the panel's deliberations was a report that laid out a set of recommended guidelines for CV survey design, administration, and data analysis.
2. The invalid responses are calculated by multiplying the sum total percentage of the protest responses in the sample by the total population in the command area. Expected invalid response = $0.017 \times 1171 = 20$ households. Thus, the valid number of responses = $1171 - 20 = 1151$ households.
3. $k = 1 + 3.322 \log 288 = 9$, where: 288 is sample size /n.
4. $W = \frac{x_{\max} - x_{\min}}{k}$, where: x max and x min are MWTP then $W = 333.3$.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data Availability Statement (DAS)

The study is based on three potential Kebeles under the command area of Gumara irrigation schemes, which have a high irrigation potential. Other information related to the study area was derived from districts Development agent and irrigation offices. <https://doi.org/10.1080/23322039.2022.2090663>

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