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Economic Valuation of Improved Irrigation Water in Bahir Dar Zuria Woreda, Ethiopia

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Abstract: This study attempts to determine the economic value of improved irrigation water by eliciting farmers' willingness to pay (WTP) using contingent valuation method in Bahir Dar Zuria Woreda, Ethiopia. Single bounded and double bounded dichotomous choices with a follow up open ended questions were employed. Primary data obtained from 197 randomly sampled household heads was analyzed using both descriptive statistics and Econometric models. The descriptive analysis indicates that the mean annual income of the irrigators is twice more than that of non-irrigators. In this study, Probit and Bivariate Probit models were used to measure WTP and to determine the factors that influence the variation in WTP. To identify the basic determinants of maximum WTP, the author also used Tobit model. The mean willingness to pay for the provision of improved irrigation water is found to be birr 674.5 and 579 per year/0.25 ha from the double bounded dichotomous choice and open-ended questions, respectively. Consequently, the aggregate willingness to pay for improved irrigation water supply using the double bounded dichotomous choice and open ended questions is estimated about birr 15,703,709 and 13,480,278 per year, respectively. Among the surveyed households, 99 percent have shown their willingness to pay if there is an improvement in existing irrigation water supply. Thus, the result of this study suggests that it may be a good indicator for investment to expand the current irrigation projects and introducing irrigation water pricing.

Keywords: Contingent Valuation, Willingness to Pay, Improved Irrigation Water, Ethiopia

1. Introduction

Water is a precious natural resource, vital for life, development and the environment. It can be a matter of life and death, depending on how it occurs and how it is managed. When it becomes too much or too little, it can bring destruction or death. Irrespective of how it occurs, if properly managed, it can be an instrument for economic growth [7, 17].

Ethiopia has abundant water resources, including 12 river basins and 22 natural and artificial lakes. Annual surface runoff, excluding groundwater, is estimated to be about 122 billion m^3 of water. Groundwater resources are estimated to be around 2.6 billion m^3 [17].

Irrespective of Ethiopia's endowment with potentially huge irrigable land the area of land under irrigation is very low. Even if there are several irrigation development projects under construction (including Kesem-Tendaho, Koga, Rib, Gidabo, Megech-Sereba, Kobo-Girana, Raya-Azebo, and Adea-Betcho), by the end of 2009/10 national irrigation coverage is only about 2.4 percent [19]. This shows that water resources have made little contribution towards the development of irrigated agricultural sector.

Given the amount of water available, even while passing through the semi-arid, arid, and desert areas, it is evident that irrigation can provide an opportunity to improve the productivity of land and labor and increase production volumes [6]. But it could be possible if sufficient financial resources were made available [17]. Along with the required finance can be generated through the implementation of well-designed water pricing.

Water pricing can potentially raise significant financial resources to pay for the sustainable management of water resources. Indeed, in some countries like France and the Netherlands, it is the main source of revenue (over 90 percent) for the water sector. Revenues from water pricing are particularly important for developing countries in which funds from public budgets and from donor sources are unpredictable and may vary significantly from year to year [8]. Therefore, to implement water pricing, a study on the valuation of irrigation water based on users' willingness to pay is very important.

Generally, proper water pricing is among the several demand management measures to improve water use efficiency and productivity [21]. Implementing an effective water management system, however, is a complex task. One important requirement for success is sufficient knowledge about farmers' demand or willingness to pay for irrigation water. This information is important for the adequate implementation of water pricing policies, for accurate cost benefit analyses of investments in water supply or water market infrastructure, and also for determining an optimal distribution of the scarce resource between different users [22].

In this regard, the Ethiopian government has water pricing policy which is based on the willingness to pay by users of water systems [16]. Thus, central aim of this study is to determine the value of irrigation water, which farmers would be willing to pay for the provision of improved irrigation water in Bahir Dar Zuria Woreda.

2. Methodology of the Study

2.1. Description of the Study Area

The study was conducted in Bahir Dar Zuria Woreda selected three irrigation schemes namely chilal abay, negida and upper andasa which covers sebatamit, Upper Andassa and bete Mariam Kebeles. The study area is located to the South of Bahir Dar via Tis Abay –Bahir Dar gravel road and it is about 10-18 km far from Bahir Dar, the capital city of Amhara Regional state, Ethiopia [4].

The topographic features of the Bahir Dar Zuria woreda indicates that approximately 48 percent can be defined as rolling, 32 percent hilly, 13 percent mountainous, 7 percent valleys. The altitude in meters above sea level ranges from 1,750 to 2,300. And all of the woreda area can be classified within woina-dega climatic zone [18].

2.2. Data Type and Source

The data source for this study was obtained from primary sources. It was collected from a sample of three kebeles -sebatamit, yigoma huletu and bete Mariam- by using questionnaire.

2.3. Sampling Technique

The study combined a purposive sampling and random sampling techniques in the selection of the study site and the respondents respectively. In the first stage, the study site-Chila Abay, Negida, and Upper Andasa irrigation schemes- is purposively selected mainly because of the presence of Abay and Andasa rivers in the near of fertile lands which is suitable for irrigation.

After identifying the command area which includes sebatamit, yigoma huletu and bet Mariam kebeles, individual respondents were selected from each kebeles by applying the technique of random sampling.

Then, the total sample size (200) was distributed to the three kebeles based on the proportion of irrigation beneficiaries in each kebeles. Accordingly, 35 percent of the samples were drawn from sebatamit, 47.5 percent) and 17.5 percent from yigoma huletu and bete mariam kebeles respectively. Finally, by applying the technique of random sampling, individual respondents were selected from each kebeles.

Although 200 households were interviewed in three Kebeles of the Bahir Dar zuria Wereda, 3 observations were eliminated as invalid responses and these are too small to create sample selection bias. Therefore, further discussions are made using the remaining 197 households who gave valid responses.

Between March to April 2015, data was obtained from a survey in the irrigation command areas of the Chilal, Negida, and Upper Andasa irrigation schemes.

2.4. Value Elicitation Format

There are different elicitation methods used to estimate willingness to pay from a sample of households in contingent valuation surveys. The most commonly and widely used elicitation formats are open-ended, bidding game, payment card, single- bounded dichotomous choice, and double-bounded dichotomous choice methods. Among them especially dichotomous-choice (DC) format is the most widely used one [3]. The NOAA panel advocated this method as the most appropriate one in most circumstances [2].

According to [10] DBDC increase efficiency over SBDC method in three ways. First, the answer sequences *yes-no* or *no-yes* yield clear bounds on the WTP. For the *no-no* pairs and the *yes-yes* pairs, there are also efficiency gains. Finally, the number of responses is increased, so that a given function is fitted with more.

Therefore, in this study single-bounded and double bounded dichotomous choice approaches were applied. Following [3] an open-ended follow-up questions was also used to increase the precision of the estimate with dichotomous choice question.

2.5. Questionnaire Design

Contingent valuation survey questionnaires of this study have three sections. The first section contains the socio-economic characteristics of household respondents such as age, education, sex, income, and land ownership. The second section of the questionnaire seeks to generate data on households' actual experience on irrigation practice, credit access, using motor pumping, problems of the existing irrigation schemes and whether they grow cash crops or not.

The third section consists of CV questions of household's willingness to pay for the provision of improved irrigation water. This is based on the hypothetical market scenario that were designed. In this section, to elicit households' WTP the single bounded and double bounded dichotomous choice with open- ended follow up questions were used.

In this study, in order to generate primary data the field survey was under taken. Before the final survey was implemented, the focus group discussion and pilot survey were carried on. The focus group discussion was provide some information to make some modification in the design of the main survey questionnaire based on the responses so as to make it understandable for respondents. It was also provide important information for descriptive analysis. And the pilot survey was made to set the bids price for the contingent valuation elicitation part of the questionnaire.

2.6. Econometric Model Specification

The goal of estimating parametric (econometric) models from dichotomous choice CV responses is to calculate willingness to pay for the services described (in this case, improved irrigation water). In addition, parametric models allow for the incorporation of respondent characteristics into the willingness to pay functions. Understanding how willingness to pay responds to individual characteristics allows the researcher to gain information on the validity and reliability of the CV method, and to extrapolate sample responses to more general populations. Further, a richer set of explanatory variables that conforms to expectations makes the contingent valuation application more convincing [10].

2.6.1. Probit Model

In this study, the surveyed households were offered a double bound dichotomous choice question to indicate their willingness to pay for improved irrigation water by answering “yes” or “no” to the specified prices.

The basic model for analyzing dichotomous CV responses is the random utility model. [11] constructed/developed the basic (random utility) model for responses to dichotomous CV questions, putting them in a framework that allows parameters to be estimated and interpreted.

In the CV case, according to [10] there are two choices or alternatives, so that indirect utility for respondent j can be written as;

$$U_{ij} = U_i(Y_j, X_j, \varepsilon_{ij}) \quad (1)$$

Where, i = 1 is the final state (the state or condition that prevails when the CV program is implemented), and i = 0 for the status quo.

Y_j is the jth respondent's income,

X_j is households' socio-economic characteristics and attributes of the choice, and

ε_{ij} is a component of preferences known to the individual respondent but not observed by the researcher.

It is obvious that something has been changed from the status quo to the final state. It could be a measurable attribute- e.g. an improvement indicator q could change from q0 to q1 so that utility for the status quo would be $U_{0j} = U_0(Y_j, X_j, \varepsilon_{0j})$ and utility in the final state would be $U_{1j} = U_1(Y_j, X_j,\ q_{1,}\ \varepsilon_{1j})$.

Based on this model, respondent j answers yes to a required payment of B_j if the utility with the CV program exceeds utility of the status quo

$$U_1(Y_j - B_j, X_j, \varepsilon_{1j}) > U_0(Y_j, X_j, \varepsilon_{0j}) \quad (2)$$

Where, B_j is the bid amount in Birr andε_{0j}, ε_{1j} are the error terms

In other words, a farm household will agree to pay for irrigation water if the condition in Equation 2 is satisfied i.e. the utility derived after paying $B_j$for change is greater than utility derived without the change.

The Probit model takes the following form;

$$WTP_I{}^* = X_I{}^*\beta + \varepsilon_I \quad (3)$$

WTP* is unobservable, it is referred to as a latent variable, that is unobservable households' willingness to pay for the provision of improved irrigation water. But we can observe the dummy variable WTP_i which is defined as:

$$WTP_i = 1 \text{ If } WTP_i{}^* \geq B$$

$$WTP_i = 0 \text{ If } WTP_i{}^* < B$$

Where, WTP_i is willingness to pay of the i^th^ household (1, if the response is "Yes" and 0, if the response is "No")

X_i is Vector of independent or explanatory variables

β is Vector of parameters of the model

B is the bid randomly offered to the respondents

ε_i is Error term where, $\varepsilon_i \sim (0, \sigma^2)$

Based on the above justification, Probit model for households' preferences for the improved irrigation water service can be specified as follows:

$$WTP_i = \beta_0 + \beta_1 INCM + \beta_2 BID + \beta_3 EDU + \beta_4 AGE + \beta_5 FAMSIZ + \beta_6 LANDSIZ + \beta_7 EXPER + \beta_8 CASHCROP + \beta_9 CRED + \beta_{10} PUMPING + \beta_{11} OFFRINC + \beta_{12} SEXHH + \beta_{13} OX + \beta_{14} \text{CORR} + \beta_{15} \text{DISSAT} + \varepsilon_i \quad (4)$$

2.6.2. The Bivariate Probit Model

Bivariate Probit model is a natural extension of the Probit model which involves more than one equation, with correlated error terms, in the same way as the seemingly unrelated regressions model [9], This bivariate Probit model is interesting for modeling the joint determination of two variables.

According to [9], the general specification for a two-equation model is;

$$y_1{}^* = x'_1\beta_1 + \varepsilon_1, y_1 = 1\ if\ y_1{}^* > 0, 0\ otherwise \quad (5)$$

$$y_2{}^* = x'_2\beta_2 + \varepsilon_2, y_2 = 1\ if\ y_2{}^* > 0, 0\ otherwise \quad (6)$$

$$E(\varepsilon_1) = E(\varepsilon_2) = 0$$

$$Var(\varepsilon_1) = Var(\varepsilon_2) = 1$$

$$Cov(\varepsilon_1, \varepsilon_2) = \rho$$

Where y_1 and y_2 are WTP responses corresponding to the initial bid and 2nd bid price.

$\rho(rho)$, is the covariance between the errors term.

2.6.3. Tobit Model

Respondents who agreed to the given bid levels were asked to specify the maximum amount they would willingness to pay for the provision of improved irrigation water. Respondents who refused to pay the given bid were also asked to specify their maximum amount. Tobit regression is deal these open-ended responses.

The form of the Tobit model following [25] is:

$$MWTP_i^* = X_i\beta + \varepsilon_i, \quad i = 1, 2, 3 \ldots N \qquad (7)$$

$$MWTP_i = MWTP_i^*, if \quad MWTP_i^* > 0$$

$$MWTP_i = 0, \qquad if \quad MWTP_i^* \leq 0$$

Where, $MWTP_i$= is maximum willingness to pay of the i^{th} household

X_i= is vector of independent or explanatory variables

β = Vector of Coefficients

ε_i= is the error term where, $\varepsilon_i \sim (0, \delta^2)$

$MWTP_i^*$ = is the latent variable.

Thus, the Tobit model can be specified as follows;

$$MWTP_i = \beta_0 + \beta_1 INCM + \beta_2 BID + \beta_3 EDU + \beta_4 AGE + \beta_5 FAMSIZ + \beta_6 LANDSIZ + \beta_7 EXPER + \beta_8 CASHCROP + \beta_9 CRED + \beta_{10} PUMPING + \beta_{11} OFFRINC + \beta_{12} SEXHH + \beta_{13} OX + \beta_{14}\mathrm{CORR} + \beta_{15}\mathrm{DISSAT} + \varepsilon_i \qquad (8)$$

2.7. Welfare Measure

A plausible goal of welfare analysis is to expand the sample mean willingness to pay to the population. In such a case, it would be reasonable to calculate the welfare for each individual in the sample and then use the sample mean [10].

2.8. Mean and Aggregate WTP Estimation

The ultimate goal pursued in most contingent valuation studies is to estimate willingness to pay (WTP) measures and confidence intervals. Because WTP measures are non-linear functions of estimated parameters, procedures such as the delta method are inappropriate as they yield symmetric confidence intervals (CI). Non-symmetric CI obtained using Krinsky and Robb simulations are recommended [13, 10].

Following [1], the mean WTP and 95 percent confidence intervals are calculated using the approach developed by Krinsky and robb (1986).

For the open ended contingent valuation survey responses the maximum willingness to pay figures can be simply be averaged to produce an estimate of mean willingness to pay:

$$Mean\ WTP = \frac{\sum_i^n y_i}{n} \qquad (9)$$

Where n is the sample size and each y is household's maximum willingness to pay amount [10].

3. Results and Discussion

3.1. Descriptive Analysis

3.1.1. Socio-economic Characteristics of the Respondents

From the total surveyed households, 94.9 percent were male headed while only 5.1 percent respondents were female headed. The average household size of the surveyed households is 5.66 persons, ranging from 2 persons to 10 persons. The average age of the sampled respondents was 42.7 years with the minimum age of 23 years and a maximum of 80 years old.

The survey results also show that the average household yearly farming income is about 41,978 birr. The income level ranges from a minimum of birr 3,500 to a maximum of birr 126,500 per year. Besides agriculture, engagement in off-farm activities by members is another source of income for the household in the survey area. Thus, about 12.7 percent of the households interviewed earned off farm income, while 41.6 percent of the farmers had access to credit in the year 2014/15. The roofing of all sampled respondents' house is Corrugated iron sheet. The mean number of corrugated iron sheets was found to be 59.49 with a minimum of 29 and a maximum of 136 sheets.

Of the total household heads about 68 percent of them did not attend any formal education (illiterate) and the remaining 32 percent household heads attended formal education or they are literate. The average years of schooling for the household heads is 0.95 ranged from illiterate or zero years of schooling to a maximum of 9 years of schooling.

As shown in Table 1, 77.2 percent of the household heads have pumping motor either alone or sharing with other household heads and 80.7 percent of the respondents are growing cash crops which includes chat, sugarcane and/or coffee.

Regarding to the land ownership, the average land holding size of the sampled households is around 4.82 timad (1.21 ha), ranges from 1 to 14 Timad. Among the sampled household heads, 12.2 percent of them have no any irrigation experiences while the remaining 87.8 percent household heads have practical experiences in irrigation farming. In other words, the average number of years of practical irrigation experience was 4.67 which ranges from zero (no experience) to 14 years of experience.

Table 1. *Descriptive statistics of the socioeconomic characteristics of the respondents.*

Variables	Description	Variable Type	Measurement	Mean	min	max
bid1	Initial bid amount	Continuous	Birr [1$ ≅ 20.66 birr in April, 2015]	296.9	0	500
answer1	Willingness to pay when price is Bid1	Dummy	1= yes; 0=no	0.73	0	1
bid2	Follow up bid amount	Continuous	Birr	434.8	0	1000
answer2	Willingness to pay when price is Bid2	Dummy	1= yes; 0=no	0.7	0	1
MWTP	Maximum willingness to pay	Continuous	Birr	579.2	0	3000

Variables	Description	Variable Type	Measurement	Mean	min	max
INCM	Annual farming Income of the household	Continuous	Birr	41978.1	3500	126500
EDU	Education level of the household head	Continuous	Grade	0.954	0	9
AGE	Age of the household head	Continuous	Year	42.72	23	80
FAMSIZ	Family size of the household	Continuous	Number	5.66	2	10
LANDSIZ	Potential irrigable land size	Continuous	Timad (0.25 ha)	4.819	1	14
EXPER	Length of irrigation experience	continuous	Year	4.67	0	14
CASHCROP	Households whether Growing cash crops or not	Dummy	1=growing cash crop; 0=otherwise	0.8071	0	1
PUMPING	Having pumping motor	Dummy	1= having pumping motor; 0= Otherwise	0.77	0	1
CRED	Access to credit	Dummy	1= access to credit; 0= otherwise	0.416	0	1
SEXHH	Sex of the household head	Dummy	1=male; 0=female	0.949	0	1
OX	Number of oxen	Continuous	Number	1.756	0	5
OFFRINC	Off farm income	Dummy	1=earns off farm income; 0= otherwise	0.1269	0	1
CORR	Number Corrugated iron sheet	Continuous	Count	59.49	29	136
DISSAT	Dissatisfaction with the existing irrigation schemes	Dummy	1= dissatisfied; 0= otherwise	0.9543	0	1

Source; author survey, 2015

3.1.2. Households' Willingness to Pay for the Improved Irrigation Water

In the questionnaire, households were asked whether they are willing to pay for the improved irrigation water supply in the command area. Consequently, among the sample household heads about 99 percent are willing to pay if there is an improvement in the existing irrigation water supply. This indicates that the improvement of the existing irrigation schemes is supported by about 99 percent households.

Table 2. *Households' willing to pay.*

WTP	Frequency	Percentage	Cumulative
not WTP	2	1.015	1.015
WTP	195	98.985	100
Total	197	100	

Source; author survey, 2015

3.1.3. Income and Income Source of the Sampled Households

In the questionnaire households were asked to specify their source of income. Of the total respondents, 87.3 percent of them claimed that their only source of income is Agricultural activities. The remaining 12.7 percent obtained their livelihood both from agriculture and non-agricultural activities.

According to the survey results, the main non-farm activities in the study area are trade, Carpenter, and Daily laborer on construction or other non- farm activities. The mean annual income of the respondents was about 42,619 birr per household with a maximum income of 126,500 birr and with a minimum income of 5,750 Birr. From the total mean annual income of a sampled household, cash crops contributes the highest income (birr 16,250) followed by cereal crops (8,728), vegetables (7,131), dairy (5,247), income gained from sold livestock (1,863), woodlot (1,017), off-farm income (964), poultry (825), honey (342) and fruit (304), respectively.

However, these amount varies when the respondents classified into two: irrigators and non-irrigators. In the case of non-irrigating households, cash crops, vegetables, and fruits are excluded from their source of income since these items are growing by those households who have access to irrigation water.

As a result, irrigators had more income sources. The mean annual income of irrigators was about 45,572 birr per household with a maximum income of 126,500 birr and with a minimum income of 10,500 Birr. But the mean annual income of non-irrigators was less than half of the irrigators'; that is 21,329 birr per household with a maximum income of 38,000 birr and with a minimum income of 5,750 Birr. Such differences in income between the households who have and haven't access to irrigation supports the argument of [5]. They argued that investment in irrigation serve as a strategy to ensure food security and for poverty alleviation.

3.1.4. Challenges and Problems in the Existing Irrigation Schemes

In the structured questionnaire, households were asked to specify any challenges and problems they have faced/observed in the existing irrigation schemes. Attempt has been made to rank the major constraints of irrigated schemes from the most severe problems to the least. These are insufficient water supply (47.7 percent), absence of proper canals (35 percent), irrigation water access problem (12.2 percent), and the remaining 5.1 percent are other constraints (such as water distribution, water pollution, infrastructure, and seed constraints).

3.2. Econometrics Analysis

3.2.1. Results of the Probit Model

In Probit model, the dependent variable assumes the value of 1 if a household is willing to pay the proposed bid amount and 0 otherwise. The regression result is summarized in Table 3.

In this model, out of the fifteen explanatory variables, eight of them were significant variables in determining farmers' WTP for improved irrigation water supply. These are the bid level, farming income, education, family size, land size, having pumping motor, sex of the household heads, and dissatisfaction with the existing irrigation water supply.

Explanatory variables such as age, irrigation experience, credit access, off farm income, number of oxen, corrugated iron sheet are insignificant. The remaining variable, growing cash crops, has unexpected sign even if it significant.

Table 3. *Coefficient estimates of single bounded Probit model.*

Variables	Coef.	P>z	Marginal effect after Probit		
			dy/dx	P>z	X
bid1	-.005(.0011)***	0.000	-.0014(.0002)	0.00	296.95
INCM	.00001(7.6e-06)**	0.037	4.01e-06(.00)	0.04	41978.1
EDU	.117(.06)*	0.062	.029(.016)	0.06	.95
AGE	-.004(.01)	0.764	-.001(.003)	0.76	42.72
FAMSIZ	.175(.08)**	0.046	.043(.02)	0.03	5.66
LANDSIZ	.207(.08)**	0.019	.052(.02)	0.01	4.81
EXPER	.07(.05)	0.169	.017(.01)	0.18	4.67
CASHCROP	-1.25(.51)	0.014	-.21(.06)	0.001	.80
PUMPING	1.29(.43)***	0.003	.40(.15)	0.01	.77
CRED	.097(.28)	0.734	.02(.06)	0.72	.41
SEXHH	1.15(.43)***	0.008	.39(.16)	0.01	.94
OX	-.22(.18)	0.226	-.05(.04)	0.24	1.75
OFFRINC	-.25(.38)	0.504	-.06(.11)	0.53	.126
CORR	.0002(.007)	0.972	.00006(.001)	0.97	59.49
DISSAT	1.8(.55)***	0.001	.65(.15)	0.00	.95
_cons	-2.70(.97)	0.005			

Survey estimation result, 2015

***, ** &* represent statistically Significant at 1 percent, 5 percent and10 percent level of significant, respectively

Figures in parenthesis are robust standard Errors

The estimated coefficient of the bid value (bid1) was found to be statistically significant at 1 percent level of with the expected negative sign. This indicates that the probability of WTP to support for improving the existing irrigation water supply decreases (increases) as the bid price increases (decreases). The marginal effect estimates show that when the initial bid increases by one Birr, the probability accepting the initial bid decreases by around 0.15 percent, holding other things constant. This result is consistent with the findings of [23].

Farming income (INCM) has a positive impact on willingness to pay as the expected and it is significant at 10 percent. The results intuitively suggest that household income has a positive effect on the probability of accepting the proposed bid price. Keeping other factors constant at their respective mean, a 1 birr increase in the income of the household, increase households' probability of WTP about $4.01e^{-04}$ percent.

The land ownership variable (LANDSIZ) has a positive and statistically significant effect on the households' probability of willing to pay the proposed bid level at 5 percent level. As the land ownership of the household increased by one timad (0.25 ha), the amount of price that the household head is willing to pay will increase by about 5 percent, other factors remain constant. The possible explanation of this may be due to the higher benefit derived from cultivating the land or renting it in irrigation farming. This result is consistent with that of [15, 24].

Moreover, dissatisfaction with the existing irrigation water supply system (DISSAT) positively influenced farmers' WTP for improving the existing irrigation water provision at 1 percent level. The marginal effect estimates also show that households who are not satisfied by the existing irrigation water supply are 65 percent more likely to support its improvement. This may be due to the problems which is prevailed in the existing irrigation schemes.

Education (EDU) also positively influenced farmers' WTP for irrigation water. This could be due to the possibility that more educated household heads may have more knowledge and awareness about the economic benefit which results from improving the existing irrigation water supply. The marginal effect estimates show that one year increases in the education of the household head leads to an increase in the probability of saying "yes" or accepting the proposed bid price by about 3 percent holding other factors remain constant.

The sign of family size (FAMSIZ) is positive and statistically significant at 5 percent. Looking at the marginal effect, keeping other factors constant, as the family size of the household increased by one person, the amount of price that the household head is willing to pay will increase by about 5.03 percent. This may be the fact that a higher family size has labor potential to utilize additional water supply and/or needs to more sustenance which can be comes from mainly in irrigating farming than rain fed farming.

The dummy variable having pumping motor (PUMPING) has positive sign in line with expectation and statistically significant at 5 percent level. The marginal effect suggests that households who have pumping motor are 40 percent more likely willing to pay for the improvement of irrigation water provision. The possible reason may be that, farmers, who use pumping motor to irrigating their land, incur costs mainly fuel costs.

The variable sex of the household head (SEXHH) has a positive sign and it is statistically significant at 1 percent level. Thus, male headed households are 39 percent more likely to be willing to pay. The possible explanation is that male headed households may be financially strong than that of female headed households.

3.2.2. Results of the Bivariate Probit Model

In the case of bivariate Probit analysis there are two binary response variables that vary jointly. The result of covariates on the two responses are presented in Table 4.

The results produced by this model are generally consistent with expectations; it reveals a negative relationship between the bid values presented to respondents.

The first bid and second bid prices are both found to be statistically significant at 1 percent level. Holding other variables constant, a 1 birr increase/decrease in the initial and follow up bid prices, decrease/increase households' probability of willing to pay by about 0.12 percent and 0.08 percent, respectively.

Farming income (INCM) of the respondent found to have positive and significant relationship with the households' WTP. It is significant at 5 and 1 percent level in the first and follow up bid, respectively. Keeping the influences of other factors constant, a one birr increase in income of the respondent increases the probability of accepting the proposed bid price by about 0.001 percent.

Table 4. *Estimated Coefficients of the Bivariate Probit model.*

Variables	Coefficient [answer1]	P>Z	Coefficient [answer2]	P>Z	Marginal effect	P>Z
Bid1	-.006(.001)	0.000			-.0012(.0002)***	0.00
Bid2			-.004(.0012)	0.001	-.0008(.0001)***	0.00
INCM	.00001(7.64e-06)	0.035	.00003(8.37e-06)	0.000	.00001(.000)***	0.00
EDU	.11(.06)	0.086	-.007(.07)	0.925	.019(.01)	0.26
AGE	-.004(.01)	0.769	-.004(.01)	0.651	-.001(.003)	0.63
FAMSIZ	.18(.08)	0.035	.007(.07)	0.920	.034(.02)	0.13
LANDSIZ	.21(.08)	0.014	.11(.07)	0.102	.06(.02)**	0.01
EXPER	.06(.04)	0.163	-.05(.04)	0.256	.002(.01)	0.85
CASHCROP	-1.26(.49)	0.011	.35(.51)	0.491	-.06(.14)	0.66
PUMPING	1.26(.41)	0.003	.37(.49)	0.445	.36(.14)***	0.01
CRED	.11(.27)	0.679	-.15(.23)	0.506	-.008(.07)	0.9
SEXHH	1.03(.48)	0.032	-1.52(.66)	0.021	.22(.16)	0.17
OX	-.22(.18)	0.224	-.21(.16)	0.191	-.08(.04)	0.08
OFFRINC	-.28(.38)	0.457	-.79(.38)	0.039	-.23(.12)*	0.06
CORR	.0003(.007)	0.966	.006(.0078)	0.337	.001(.001)	0.5
DISSAT	1.84(.55)	0.001	.30(.83)	0.718	.55(.16)***	0.001
_cons	-2.43(1.15)	0.036	1.77(.90)	0.049		
/athrho	.37(0.62)					
Rho	.35					
Wald test of rho = 0: chi2(1) = .238641 Prob > chi2 = 0.0252						
Log pseudolikelihood = -136.47438						
Wald chi2(30) = 164.98 Prob > chi2 = 0.0000						

Survey estimation result, 2015
***, ** &* represent statistically Significant at 1 percent, 5 percent and10 percent level of significant, respectively
Figures in parenthesis are robust standard Errors

Off farm income (OFFRINC), even if it is indeterminate as a prior, has a negative and a statistically significance impact on WTP in the case of follow up bids. The marginal effect shows that, other factors remain constant, households who have off farm income are 23 percent less likely to willing to pay for the improved irrigation water supply. The possible explanation of this may be due to households' expectation that engagement in off-farm activities have higher benefit than the benefit of irrigation farming.

Land holding size of the household is statistically significant at 5 percent in the first equation. It is expected that as the land ownership of a household in timad increases, the opportunity of high income from crop production using irrigation water will be rise; this would lead to higher demand for improved irrigation water. Other factors remained constant, if land holding increases by 1 timad, the probability of accepting the bids increase by about 0.6 percent.

Having pumping motor is statistically significant at 1 percent level in the first equation. The marginal effect for full model shows that it is statistically significant at 5 percent. The effect of the variable on willingness to pay in the full model is positive. The marginal effect shows that household heads who have pumping motor will be 55 percent more likely to say yes for the proposed bids than those who have not. The rationale behind this result is that these farmers incur fuel costs to irrigate their land using motor pump.

3.2.3. Results of the Tobit Model

Tobit model is used to estimate the coefficients of explanatory variables for the open-ended questions to analyze factors that affect households' maximum willingness to pay for improved irrigation water supply.

In the Tobit model as shown in Table 5 income, family size, land size, and having pumping motor are statistically significant variables and the major determinant of maximum WTP for the improved irrigation water supply while the remaining variables are either insignificant or unexpected sign.

Farming income has a positive impact on the household heads' maximum willingness to pay and it is statistically significant at 1 percent level of significance. This result is the same as the result obtained in the Probit model. Thus, annual income of the households is one of the major determinant of respondents' maximum willingness to pay for the improvement of existing irrigation water. Besides, family size and land size are significant at 5 and 1 percent level, respectively. They have also a positive impact on respondents' MWTP for the provision of improved irrigation water.

Finally, the variable having pumping motor is found to be significant at 5 percent level of significance. Its positive sign shows that, households who have pumping motor are more likely to support the improvement. That is, this variable also one of the determinant of maximum WTP for the improvement of the existing irrigation schemes.

Table 5. *The Tobit model results of the maximum willingness to pay.*

MWTP	Coef.	T	95 percent Conf.	Interval
INCM	.008(.001)***	6.12	.006	.011
EDU	9.27(14.99)	0.62	-20.30	38.85
AGE	-2.35(2.87)	-0.82	-8.022	3.31
FAMSIZ	33.86(17.16)**	1.97	-.0005	67.73
LANDSIZ	39.31(14.43)***	2.72	10.83	67.79
EXPER	8.18(11.54)	0.71	-14.59	30.97
CASHCROP	-170.16(99.44)	-1.71	-366.37	26.04
PUMPING	210.93(85.54)***	2.47	42.15	379.71
CRED	59.80(56.55)	1.06	-51.78	171.39
SEXHH	-10.739(140.40)	-0.08	-287.75	266.28
OX	-74.62(39.16)	-1.91	-151.89	2.65
OFFRINC	-49.49(88.16)	-0.56	-223.44	124.45
CORR	1.42(1.67)	0.85	-1.87	4.73
DISSAT	135.75(146.24)	0.93	-152.77	424.29
_cons	-245.78(203.35)	-1.21	-646.99	155.43
/sigma	375.04(19.02)		412.57	

Survey estimation result, 2015

***, ** &* represent statistically Significant at 1 percent, 5 percent and10 percent level of significant, respectively

Figures in parenthesis are robust standard Errors

3.3. Comparison of Single-Bounded and Double-Bounded Model Estimates

The referendum double bounded format [12] has emerged a means to improve efficiency in contingent valuation applications. Following [12] Statistical efficiency of single bounded and double bounded model can be compared from three perspectives in a finite sample. First the precision of the estimates of constant and bid coefficients, which is measured using estimated standard errors; second the goodness of fit of the estimated WTP model; and third the precision of the estimates of welfare measures derived from the underlying coefficient estimates.

Table 6. *Comparison of SBDC and DBDC model estimates of households' WTP.*

Answer1	Probit model				Bivariate Probit model			
	Coef	Std. Err.	Z	P>z	Coef	Std. Err.	Z	P>z
Bid1	-.005	.00112	-5.26	0.00	-.006	.00117	-5.40	0.00
Constant	-2.70	.97	-2.78	0.00	-2.43	1.15	-2.10	0.03
Number of obs = 197					Number of obs = 197			
Wald chi2(15) = 82.42					Wald chi2(30) = 164.98			
Prob > chi2 = 0.0000					Prob > chi2 = 0.0000			
Pseudo R^2 = 0.4471								

Survey estimation result, 2015

As the coefficients of the bid and the constant terms are statistically significant for the two types of dichotomous-choice surveys, and standard errors of these coefficients of bids and constant terms are approximately the same for both double-bounded and single-bounded models. Besides, the two models have almost approximately the same value of z-statistics which is a measure of goodness of fit that does not much differing in the two models (Table 6).

This indicates that the use of double-bounded instead of single-bounded does not increase statistical efficiency. However, According to [13] SBDC approach yields inefficient welfare measures due to limited information obtained from each respondent. When we compare the welfare amount which is calculated by using the mean WTP, DBDC gives higher value than SBDC model. Therefore, the bivariate Probit model estimates (DBDC model) was used to obtain the aggregate economic value of improved irrigation water supply.

3.4. Estimation of Mean WTP

The mean WTP estimation was made using the two bid price answers. It was conducted in two steps. The first step was estimation of the bivariate Probit model; then finding the mean WTP using wtpciker command in Stata 13. To estimate the mean WTP the study resort to simulating confidence intervals with the Krinsky Robb procedure. The Krinsky Robb method uses random draws from assumed multivariate normal distribution to generate new parameter vectors. Table 7 presents a summary of the WTP estimates produced by statistically selected valuation models used in this study.

Table 7. *Summary of WTP and its Aggregate values.*

Elicitation format	Model	Mean WTP	Aggregate WTP for about 3,548 beneficiary households and 5820.5 ha. Land
Single bounded	Probit	454 Birr	10,570,028 Birr
Double bounded	Bivariate Probit	674.5 Birr	15,703,709 Birr
Open ended		579 Birr	13,480,278 Birr

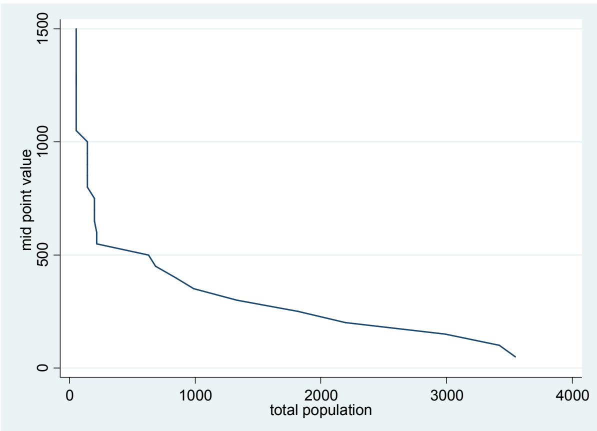
Survey estimation result, 2015

As Table 7 shows the mean willingness to pay is higher in double-bounded dichotomous choice format than that of single-bounded dichotomous choice format. Moreover, the mean WTP of the DBDC, which is 674.5 Birr per year per 0.25 ha, is greater than that of the mean WTP of open-ended questions, which is 579 Birr per year per 0.25 ha. This result is consistent with the findings of [15].

3.5. Estimating Aggregate Willingness to Pay (Aggregate Economic Value)

The aggregate willingness to pay for improved irrigation water supply can be estimated by taking the total number of beneficiary households in the command area. According to the Bahir Dar Zuria Woeda Agricultural Development Office, (2015) the total number of irrigation beneficiary households is estimated about 3,548 and the total irrigable area is about 5820.5 ha. Based on this figures the expected aggregate willingness to pay for improved irrigation water supply using the double bounded and open ended format is estimated about birr 15,703,709 and 13,480,278 per year, respectively.

3.6. Aggregate Demand for the Improved Irrigation Water



Source; author survey, 2015

Figure 1. *Aggregate demand curve for the improved irrigation water provision.*

The demand curve is derived with midpoint value of the maximum willingness to pay on the vertical axis and number of households in the command area on the horizontal axis (figure 1). The demand for improved irrigation water supply various at different price level. It is more or less downward sloping and convex to the origin; it is in line with the economic theory of demand. This implies an increase in the price of the improved irrigation water, decreases the quantity demanded for the improved irrigation water, other things remain constant.

4. Conclusion and Policy Implication

Pricing of water resources require valuing of water. Irrigation water is generally regarded as non-market good. Thus, in this study Contingent Valuation Method (CVM) is used to estimate the value households are willing to pay for any attempt to improve the existing irrigation water provision in Bahir Dar zuria woreda, Ethiopia.

Data obtained from 197 sampled household heads was analyzed using both descriptive statistics and Econometric models. The descriptive analysis indicates that the mean annual income of the respondents was about 42,619 birr per household. However, these figures are significantly vary between irrigator and non-irrigator households.

The mean annual income of irrigators and non-irrigators was about birr 45,572 and 21,329 per household, respectively. Such income differentials between irrigator and non-irrigator households are generally found to support the argument about the role of investment in irrigation as ensuring food security and a poverty reduction strategy.

In this study, three econometric models were employed; Probit, Bivariate Probit and Tobit. The result from the Probit model revealed that eight variables were significant in determining farmers' WTP for improved irrigation water supply. These are the bid level, farming income, education, family size, land size, having pumping motor, sex of the household heads, and dissatisfaction with the existing irrigation water supply.

In the Tobit model households' income, family size, land size, and having pumping motor are found to positively and significantly affect households' maximum willingness to pay for the improvement of the existing irrigation schemes.

Finally, in the Bivariate Probit model result, initial bid, and follow-up bid and off farm income were found to have a negative and significant effect on the households' probability of accepting that bid. In this model, variables such as income, land size, having pumping motor and dissatisfaction with the existing irrigation water supply have a positive effect on the households' probability of WTP for the provision of improved irrigation water.

In this study, the mean willingness to pay from the DBDC and open-ended questions were computed using the Krinsky Robb method. It was Birr 674.5 and Birr 579 per year/0.25 ha, respectively. Thus, in this study, the mean willingness to pay from open-ended questions is lower than the dichotomous choice questions.

Consequently, the aggregate economic value of improved irrigation water using households' willingness to pay was estimated about birr 15,703,709 and 13,480,278 per year for the double bounded and open ended questions, respectively. This showed that the value of irrigation water from open ended format was underestimated. Thus, in estimating the value of irrigation water at household level, it is important to use CVM in the form of double bounded elicitation format.

The findings of this study shows that the bid level, farming annual income, land size, family size, education, having pumping motor and dissatisfaction with the existing irrigation schemes are key factors that affect households' WTP for the improved irrigation water provision. Therefore, understanding of socio-economic characteristics that affect households' WTP significantly is a necessary and first step, for the concerned body, to achieve improved irrigation water and then to implement irrigation water pricing.

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