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Economic Values of Irrigation Water in Wondo Genet District, Ethiopia: An Application of Contingent Valuation method

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Abstract

The study attempts to determine the economic value of irrigation water in Wondo Genet area by eliciting households' willingness to pay (WTP) using contingent valuation method (CVM) in the form of double bounded closed ended WTP questions with open ended follow up questions. Bivariate probit and probit models were applied to determine the mean and factors affecting willingness to pay for irrigation water, respectively. A sample of 154 households was randomly selected, and the survey was used for face to face interviews. The descriptive analysis shows that the irrigation water from Wosha and Werka rivers of Wondo Genet area is insufficient to produce cash crop and domestic use especially during the dry season. That is, 92.05% of the respondents reported that the reasons attributed to the insufficient availability of irrigation water for irrigation purpose were inequitable water distribution, population pressure, deforestation and illegal dweller. Furthermore, the econometric result shows that the total willingness to pay from double bound elicitation method was computed at 156,785.1 birr (1 US$=17 birr) per annum for five years, while the willingness to pay from open ended elicitation method was computed at 128,264.55 birr per year. The total annual WTP for irrigation water from double bound elicitation method was greater than from open ended elicitation method. Hence, policy makers should target double bounded elicitation method than open ended elicitation method to eliciting the willingness to pay for irrigation water. This study empirically proved that households' income, age, cultivated land, initial bids, awareness and educational level are the key determinants of demand for irrigation water. Therefore, significant socio-economic variables should also be considered while designing irrigation water related projects at household level.

Key Words: Contingent Valuation Method; Willingness to Pay; Irrigation Water, Double Bounded Dichotomous Choice, Ethiopia

Introduction

Water is one of the natural resources which are very vital for sustaining human life, achieving sustainable development and maintaining ecosystems services (Savenije 2001; UNESCO 2006). It has unique characteristics that determine both its allocation and use as a resource in agriculture. Irrigation is a vital component of agricultural production in many developing countries (Chandrasekaran *et al.* 2009). Globally, 2.5% of the surface water is fresh water, and it is suitable for drinking, agriculture (Devi *et al.* 2009), recreational and environmental activities. However, the fresh water has been treated as an almost free resource (Turner *et al.* 2004; Sadeghi *et al.* 2010). As a result, with rapid economic and population growth many water sources have become depleted, therefore, now water has become a scarce good (Ahmad *et al.* 2010). Due to the increasing scarcity of water competition and conflicts among uses and users of water resource arise. It is therefore necessary to make decisions about conservation and allocation of water that are compatible with social objectives such as economic efficiency, sustainability and equity (Agudelo 2001). Therefore, pricing of water can be considered as a tool to improve sustainable use of water resources (Chandrasekaran *et al.* 2009). But, since there is nonuse value attached to irrigation water, in practice, it is difficult to determine the monetary value of irrigation water using market price. In recent years, Economists uses the concept of willingness to pay (WTP) to determine the amount of money that consumer are willing to pay to improve the irrigation water resource. The estimated monetary values of the resources may be used for management decisions and assessment of policies.

In Ethiopia, there is ground water potential of 2.6 billion m^3, eleven major lakes with a total area of 750,000 ha and total annual surface runoff of 123 billion m3 (MoWR, 2002). Despite this abundance the country suffers from recurrent drought, food shortage, sanitation problems and poverty. Currently, therefore, the country has developed 15 years (2002-2016) regional and national water resource development plan to introduce efficient and sustainable uses of water resources for irrigation and other purposes. However, these development plans exclude or ignore the non use value of the irrigation water. The ignorance of the non use values from development plans enhances the complexity of irrigation water management decision and deterioration of the resource. In the study area the irrigation water from Werka and Wosha rivers is using for production of cash crops, different fruit trees and livestock productions. However, only the use values of the resource was considered and ignoring its non use values. As a result, the farmers facing shortage of irrigation water for annual and perennial crop production. The objective of this paper is to determine the value of irrigation water, which farmers would be willing to pay and thereby draw policy implications for sustainable use and management of the irrigation water. Besides, the study assessed the level of households' awareness about the availability of irrigation water and their attitude on the irrigation water problems, and determined the factors affecting households WTP.

Measuring Welfare Change

The economic values of environmental resource are defined in the context of human welfare (Krieger 2001; Agudelo 2001). That is, the values of environmental resources are measured using its effects on human welfare (Mitchell and Carson, 1989). A weaker, but perhaps ethically more neutral, criteria for welfare measure is Pareto improvement. In Pareto improvement a policy change makes at least one person better off without making any one person worse off. The idea of a potential Pareto improvement provides the rationale for public intervention to increase the efficiency of resource allocation (Haab and McConnell, 2002).

Change in environmental goods (irrigation water) can affect individual's welfare through changes in prices they pay for private inputs and goods in the market, and changes in the quantities of non-marketed environmental goods like irrigation water. This welfare changes can be measured using ordinary consumer's surplus, which holds income constant but not the level of utility. According to Hicks (1943) the welfare changes can also be measured using compensating surplus, compensating variation, equivalent variation and equivalent surplus. Compensating variation and compensating surplus measure the gains or loss from environmental goods and services, and hold utility constant at the initial level. However, equivalent variation and equivalent surplus measure welfare change and hold utility constant at some specified alternative level. Generally, these four welfare measures involve either payment or compensation to maintain utility at the specified level (Randall and

Stall (1980), cited in Mitchell and Carson 1989). If the proposed change is welfare increasing through changes in the quantity of environmental goods, which is the focus of this study (Irrigation Water), the appropriate welfare measure is the compensating surplus. This measure can be interpreted as the consumer's WTP in order to gain the quantity increase and still maintain their initial utility level (Mitchell and Carson 1989).

In Hicksian demand curve, the demand function for the public good requires accurate market data. But it is very difficult to obtain accurate market data and therefore, we can use a contingent valuation method, which requires the creation of hypothetical market scenario that is similar to actual market situation for irrigation water. From this method we can generate the WTP data, which will be used to conduct valuation process of the irrigation water without having to estimate the actual demand curve. This concept can be further emphasized from the relationship between the expenditure function and Hicksian compensated surplus measure. According to Haab and McConnell (2002), the expenditure function that provides the theoretical structure for welfare estimation is specified as:

$$\mathrm{M} = \mathrm{e}(\mathrm{p}, \mathrm{q}, \mathrm{u}) = \min_{\mathrm{x}}\{\mathrm{p}.\mathrm{x}/\mathrm{u}(\mathrm{x}, \mathrm{u}) \geq \mathrm{u}\} \quad (1)$$

Where: M is the minimum amount of income needed to maintain utility level given the price and public good vectors; q= is the vector of environmental goods; p= is a vector of prices; u=is level of utility when $\mathrm{u} = \mathrm{V}(\mathrm{p}, \mathrm{q}, \mathrm{y})$, x= is the vector of private goods and y= income. Let $\mathrm{p}_0, \mathrm{q}_0, \mathrm{u}_0, \mathrm{m}_0$ represent some initial level of those respective arguments and $\mathrm{p}_1, \mathrm{q}_1, \mathrm{u}_1, \mathrm{m}_1$ represent some succeeding levels. We can represent the compensation surplus by

$$\mathrm{WTP} = \mathrm{CS} = [\mathrm{e}(\mathrm{p}_0, \mathrm{q}_0, \mathrm{u}_0) = \mathrm{m}_0] - [\mathrm{e}(\mathrm{p}_0, \mathrm{q}_1, \mathrm{u}_0) = \mathrm{m}_1] \quad (2)$$

q_1 is preferred to q_0 for proposed new project brings welfare gain (just like in the case of this study). In this case, the compensated surplus (CS) measure tells us the consumers'' WTP for welfare gain. Contingent valuation is capable of obtaining the appropriate Hicksian measure for a proposed change in the public good (Mitchell and Carson 1989). It can be viewed as a way of estimating the change in the expenditure function (Haab and McConnell 2002). Coming to the case of this study we could determine the value of irrigation water using household WTP.

Empirical Reviews

Contingent valuation surveys have been widely applicable methods in valuing use and non use values of environmental goods and services (like water resource) (Whittington *et al.,* 1990; Whittington 1998)**.** According to, Birol *et al.,* (2006) more than 5000 CVM studies have been conducted in over 100 countries to examined water related issues and other resource. Some of the literatures which are relevant to this study are discussed below.

With the contingent valuation method in the form of closed ended WTP question, Mallios and Latinopoulos (2005) determine the factors contributing to WTP for irrigation water in Northern Greece. The study revealed that family size, amount of annual irrigation water consumption, number of family members working in agriculture, respondents' age and the nature of water shortage have a significant impact on farmers' willingness to pay for irrigation water.

Farolfi *et al.* (2006) employed contingent valuation method to estimate Swaziland households' willingness to pay (WTP) for an improvement in their water quantity and quality. The authors used the tobit regression models to analyse household willingness to pay for improvement domestic water quantity and quality. The study found that households in urban areas were less willing to pay for water quantity and quality compared to rural households. Besides, the study tried to analyze factors that affect WTP of households and found that the variables household income, water consumption, source of water, age of household head, gender of household head were significant determinants of household WTP.

Using the contingent valuation method Chandrasekaran, *et al.(*2009) estimated the economic value of tank irrigation water. The overall mean WTP value across seasons (wet and dry seasons) was 218.50/ha/year Indian Rupee. Besides, the study found that the area under rice cultivation and the water requirement were significant factors influencing farmers WTP in the wet and dry seasons, whereas, labor force was found to be insignificant impact on the farmers' WTP in the dry season.

Rogers *et al*. (1998) estimate agricultural and non-agricultural use values of irrigation water in arid zone of Haryana, India. The study defined agricultural use value and non-agricultural use value in terms of net value of output per unit of water input (USD/m3). The study reported that the agricultural and nonagricultural use value was estimated $0.019/m3 and $0.01/m3, respectively.

The contingent valuation study conducted in Cotacachi area of Ecuador by SANREM CRSP (2003) reported that the local individuals were willing to pay for the improvement in quantity and quality of the drinking water from irrigation water and other sources. The average willingness to pay of the households was computed at US$1.84. Besides, the study tried to analyze factors that affect WTP of local communities and found that the maximum WTP of the society was positively associated with respondent's income level and family size.

Tiwari (2005) provided the results of a case study on determining the economic value of irrigation water using both direct and indirect valuation techniques. The results indicated that the opportunity cost of irrigation water was considerably greater the maximum willingness to pay. The review concluded that there is unsustainable use of irrigation water at present. Tiwari used both the open and closed-ended questions elicitation methods. From the closed ended question the result found that WTP was related to respondents' gender, agricultural income, perceived water sufficiency, education, family size and landholding. On the other hand, the WTP from open-ended question was significantly varying with the farmers' attitude towards paying fee, sex, education, migrating family members, family size and access to credit.

Using the ordered probit model, Whittington *et al.,* (1990) estimated individuals' WTP for improved water services in rural areas of southern Haiti. The authors concluded that household wealth, education level of respondents, distance of the household from the existing water sources, quality of water and sex of respondents (female) were the major factors influencing the WTP of the respondents.

Banda *et al.,* (2007) used a tobit model to analyse factors affecting the probability that a household is willing to pay for both improved quantity and quality of water in rural area of South Africa. The study found that households' income, availability of water, households' access to a tap and water per capital, monthly water consumption were significant determinants of WTP. Besides, 62% of the households were willing to pay for improved water quantity.

WeldeGiorgis (2004) used CVM to estimate the WTP for irrigation water in Ethiopia. The author found that access to credit, total revenue earned in the preceding crop year, the respondent's age, education, quantity of fertilizer used, experience with irrigation and the size of cultivable land were the significantly factors influence farmers' willingness to pay for irrigation water.

Awad and Holländer (2010) applied the CVM in Ramallah including urban, rural and refugee camps to estimate the WTP for improved domestic water supply services for current and future generations. The mean annual WTP from dichotomous choice format with follow-up questions of 525 sample household heads was computed about 627 New Israeli Shekel per annum. The study identified the variable age, water consumption, the use of water filters and income as positive and significant determinant of WTP. On the other hand, the study found that the variable consumption has a negative and significant effect on WTP.

In Ethiopia, a limited number of CVM studies have been conducted to value the environmental resource. For example, Tsegabrihan (1999) also estimated WTP of small holder farmers for small scale irrigation schemes in Tigray using CVM. The author reported that about 90% of respondents were willing to pay for the main irrigation system alone up to birr 600. Besides, the study used OLS and ordered probit regression models and found that credit availability, education, income and fertilizer supply were the major determinants of respondents' WTP. However, the study has a problem in CVM scenario. That is, it is not clear that the WTP of the farmers whether it asks for irrigation water or land or both. Jonse (2005) also used CVM to valued non-agricultural uses of irrigation water in Abbay River-Basin of the Amhara Regional State, Ethiopia. The study revealed that the average WTP obtained from open-ended questions was birr 35.8 per annum for domestic uses before improvement and birr 54.28 after improvements. From single-bounded probit model the mean WTP also computed at birr 45.6 for domestic uses of irrigation water before improvement and birr 58.2 after improvements. Whereas, from the double-bounded model the mean WTP was computed at birr 25.8 to 45.55 for domestic uses of irrigation water before improvement and birr 40.35 to 58.1 after improvements. The probit model result of the study revealed that income of respondent, education, quality of water consumed and reduction of land size are among independent variables that have positive effects on probably of respondents accepting the posted bid, whereas, Family size, is negatively related to likelihood of saying yes to the first bid.

In general, the literatures above suggested that contingent valuation method is viable techniques to quantify households' WTP for non-marketed goods (like water resource) in the developing and developed countries. Thus the given literature above provided some sound footings to this study to value households WTP for irrigation water in Wondo Genet area.

Research Methodology

4.1 Sample Size and Data Collection Methods

A two-stage sampling technique was used when selecting respondents. In the first stage three kebeles (Wetera-Kechema and Wosha-Soyama and Shashe-Kekele) were purposively selected out of the 18 kebeles because they were identified as intensive users of irrigation water for crop, fruit tree and livestock productions. In the second stage, a total 154 households were selected using random sampling techniques. Both secondary and primary data were used for this study. The primary data were collected using face to face interviews with the heads or working members of the households. A CVM method in the form of double-bounded dichotomous choice elicitation method with open ended follow up question was also employed to elicit households' WTP for irrigation water. The double-bounded dichotomous choice format (yes-no, no-yes responses) makes clear bounds on unobservable true WTP. Besides, the yes-yes, no-no response sharpens the true WTP (Haab and McConnell 2002). Finally, the double-bounded dichotomous choice format help to elicited more information about respondent's WTP than single bounded format (Hanemann *et al.* 1991; Arrow *et al*. 1993).

4.2 Preliminary Survey and Bids

Before the final survey was conducted a pre-test was done using 40 randomly selected households. Then based on the pilot results the starting point prices identified for WTP in birr were 12.5, 25 and 50 birr per year. Given this, the actual survey was undertaken by dividing the total sampled households randomly into three groups (about 51 households). The field survey was successfully completed with relatively small number of protest zeros (about 2%). These protesters provided wrong value and after checked for sample selection bias they excluded from the data set. The criteria for selecting protest zero was based on the report of the NOAA Panel on contingent valuation by Arrow *et al*. (1993). Arrow *et al*. (1993) suggested that a respondent actually willing to pay the stated amount might answer in the negative, if the respondent believes the proposed scenarios distributed the burden unfairly, doubt on the feasibility of the proposed action and refusal to accept the hypothetical choice problem.

4.3 Empirical Model Specification

When the dependent variable in the regression model is continuous the analysis can be conducted using linear regression model. However, when the dependent variable in a regression model is binary the analysis could be conducted using linear probability or logit or probit models (Pindyck and Rubinfeld 1981). But, the results of linear probability model may generate predicted values less than zero or greater than one, which violate the basic principles of probability (Gujarati 2004).

However, logit or probit models generate predicted values between 0 and 1, and they fit well to the non-linear relationship between the probabilities and the explanatory variables (Pindyck and Rubinfeld 1981; Gujarati 2004). Besides, the probit model works well for bivariate models than logit model (Park 2008). Therefore, in this study probit model was used to determine the factors that affecting the WTP of households. Following Cameron and Quiggin (1994), the probit model was specified as:

$$y_i^* = \beta' x_i + \varepsilon_i \tag{3}$$

$$y_i = 1 \; if \; y_i^* > I_i^*$$

$$y_i = 0 \; if \; y_i^* < I_i^*$$

Where:

β'= vector of unknown parameters of the model
x_i= vector of explanatory variables
y_i^*= unobservable households' actual WTP for irrigation water
y_i= discrete response of the respondents for the WTP
I_i^*= the offered initial bids assigned arbitrarily to the i[th] respondents
ε_i= unobservable random component distributed $N(0, \sigma)$

The bivariate probit model was used to estimate the mean WTP from the double bounded dichotomous elicitation method. But, when the estimated correlation co-efficient of the error terms in bivairate probit model are assumed to follow normal distributions with zero mean and distinguishable from zero (See Equation 4 below), the system of equations could be estimated as seemingly unrelated bivariate probit (SUBVP) model (Haab and McConnell 2002). Therefore, in this study we were employed SUBVP to estimate the mean WTP of the respondents from the double bounded elicitation method. According to Greene (2003), a bivariate probit model was specified as:

$$y_1^* = \beta_1 x_1 + \varepsilon_1$$

$$y_2^* = \beta_2 x_2 + \varepsilon_2$$

$$E(\varepsilon_1/x_1, x_2) = E(\varepsilon_2/x_1, x_2) = 0$$
(4)

$$Var(\varepsilon_1/x_1, x_2) = Var(\varepsilon_2/x_1, x_2) = 1$$

$$Cov(\varepsilon_1, \varepsilon_2/x_1, x_2) = \rho$$

Where: y_1^*= i[th] respondent unobservable true WTP at the time of the first bid offered. $WTP = 1$ if $y_1^* \geq \beta_i^0$ (initial bids), 0 otherwise

y_2^*= i[th] respondent implicit underlying point estimate at the time of the second bid offered.

x_1 and x_2 = The first and second bids offered to the respondents respectively.

ε_1 and ε_2= Error terms for the first and second equations of equation 4 above

β_1 and β_2= Coefficients of the first and second bids offered

The respondents know their own maximum WTP,y_i^* but to the researcher it is a random variable with a given cumulative distribution function (cdf) denoted by $G\ (y_i^*,\ \boldsymbol{\theta})$ where $\boldsymbol{\theta}$ represents the parameters of this distribution, which are to be estimated on the basis of the responses to the CV survey. In the double bound elicitation method the log-likelihood function for the responses to a CV survey was also specified as:

$$lnL^{DB} = \sum\{d_i^{YY} ln\, G(\beta_i^u;\theta) + d_i^{YN} ln[G(\beta_i^u;\theta) - G(\beta_i^0;\theta)] + d_i^{NY} ln\left[G(\beta_i^0;\theta)\, G(\beta_i^l;\theta)\right] + d_i^{NN} ln\left[1 - G(\beta_i^l;\theta)\right]\} \quad (5)$$

Where $d_i^{YY} = 1$ if the *i*th response is (Yes, Yes) and 0 otherwise; $d_i^{YN} = 1$ if the *i*th response is (Yes, No) and 0 otherwise; $d_i^{NY} = 1$ if the *i*th response is (No, Yes) and 0 otherwise; $d_i^{NN} = 1$if the *i*th response is (No, No) and 0 otherwise;

Results and Discussion

5.1 Multiple Benefits and Problems of Irrigation Water

Awareness about the availability of irrigation water is very essential to elicit households WTP for irrigation water. The result showed that 92.05% of the respondents have an experience of using the water resources (from Worka and Wosha rivers) for irrigation to produce crops and vegetables. The main crops produced by importance and land coverage are sugarcane, khat, maize, fruit trees and vegetables. However, a majority of the sample respondents (92.05%) reported that the irrigation water received from the two rivers was inadequate. The reasons attributed to the insufficient availability of irrigation water were inequitable water distribution, population pressure, deforestation, illegal dweller on the forest area, and soil and water degradation. To be more specific, 39.74% of the respondents frequently mentioned population pressure as the first environmental problem followed by deforestation (27.81%) and illegal dwellers on the forest area (14.57%). On the other hand, about

7.95% of the respondents could not mention the cause of irrigation water problems (See Table 1). Suggestions were also elicited from the respondents to overcome the irrigation water problems. A majority of the respondents suggested that planting and maintaining trees was the first frequently mentioned protection measure followed by soil and water conservation, punishing illegal dweller and training users (See Table 2).

5.2 Households WTP for Irrigation Water

Using double bounded dichotomous choice format the mean WTP from responses of both the first and the second bids were estimated. The analysis was conducted using seemingly unrelated bivariate probit model. The result revealed that the correlation coefficient of the error term is less than one implying that the random component of WTP for the first question is not perfect correlation with the random component from the follow-up question. The annual mean WTP[2] was computed at 30.18 birr[3] per year per household for five years. At 95% confidence interval the WTP for irrigation water varies between 25.70 to 34.65 birr per year per households for five years (See Table 3). The mean WTP of the respondents from open ended elicitation method also computed at 24.69 birr per household per year for five years with the minimum 0 and maximum 200 birr. The result shows that the mean WTP from open ended response was less than the mean WTP from the double bound format. This may indicate the respondents' wants or free service from the government or free riding in the open ended questions. The willing respondents were also asked to point out their reasons for maximum WTP in birr. The respondents provided different reason for their maximum WTP. About 29.89% of the respondents reported that they could not afford more than what they stated because of inadequate income. While, the rest 70.11% reported that the amount they decided to pay was satisfactory (See Table 4). However, about 15% of the sample respondents' were not willing to pay for irrigation water. Specifically, of the 15% unwilling sampled respondents about 86.96% of the households were categorized as genuine zero bidders. Whereas, about 13.04% of the respondents stated protest[4] zero (See Table 5).

5.3 Determinants of Households' WTP for irrigation water

The estimated result on factors affecting the households' WTP for irrigation water is presented in Table 6 and it shows both the significant and insignificant variables. However, only the significant variables are discussed. However, since the result from the probit model in is not indicating the magnitude effect of the explanatory variables on the probability that respondents accept or reject the initial bids. Therefore, we estimated the marginal effects of the variables on the WTP. Table 6 shows the coefficient and marginal effects of the independent variables on the WTP.

It could be seen that monthly income (MINC) of the respondent found to have positive and significant relationship with the households' WTP. This positive effect indicated that respondents with higher monthly income were more likely to say yes to the first bids than households with lower income. A study by

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[2]The mean WTP from bivariate probit model was computed using the formula specified by Haab and Mconnell (2002) that is, mean WTP $= -\frac{\alpha}{\beta}$; α is a coefficient for the constant term, and β is a coefficient for offered bids to the respondents

[3]Ethiopian currency(17 Birr =1USD)

[4] The criteria for selecting protest zero was based on the discussion on NOAA panel guide on Arrow *et al.* (1993)

WeldeGiorgis (2004) recognizes significant association between households' income and WTP in birr. Keeping the influences of other factors constant at their mean value, a one birr increase in income of the respondent increases the probability of accepting the first bid in birr by about 0.05%.

Age of the respondents had also negative and significant effect on households' WTP in birr at 1% level of significance. This may be old people faced labor shortage to encroach the irrigation water resource and old people demanded less water resource than the young people. The negative relationship between WTP in birr and Age is inconsistent with the finding of Mallios and Latinopoulos (2005). That is, holding other things constant, a one year increase in age leads to a decrease in the probability of accepting the first bid by about 2%.

Education level of the respondents (EDUR) is positively and significantly related to WTP. That is, respondents with more years of schooling are willing to pay for irrigation water. One possible reason could be that literate individuals are more concerned about water resource than illiterate ones. This is consistent with the findings of Tegegne (1999 and Tiwari (2005). The result also revealed that holding other things constant, a unit increase in years of schooling of the respondent increases the probability of accepting the first bid by about 4.8%.

The size of cultivated land (LANDCULT) was one of the hypothesized variables in the probit model and it was hypothesized, and obtained positive and significant relationship with WTP. The significant result indicated that households who have higher cultivated land were more likely to say yes response for the initial bids than the respondents with small cultivated land. This is probably due to the fact that larger farm size demanded more water resource and providing more income. This result is consistent with the findings of Tiwari (2005) and WeldeGiorgis (2004). The marginal analysis on the total farm size showed that households having higher farm size are more likely to pay for irrigation water. The result revealed that keeping the influences of other factors constant, a one unit increase in the farm size increases the probability of accepting the first bid by 116%.

The coefficient of Awareness was significant at 5% probability level. That is, households having higher awareness about the availability of irrigation water and environmental problems are willing to pay positively. Aware households were also more likely willing to pay for irrigation water. That is, keeping other things constant, changing the dummy from 0 to 1 will increase probability of accepting the initial bid by about 34%. The coefficient of starting bid price has negative sign and significant at 10% level of significance. The initial bid (BID) has negative sign as the economic theory predicts. The negative sign indicates that as the bid amount increases the proportion of respondents who answer yes in the choice question decreases. The marginal analysis indicated that as the starting bid price increases by one unit, the probability of household's WTP for irrigation water by 0.92% respectively.

5.4 Aggregate WTP for Irrigation Water

In the previous section we have seen factors affecting households' willingness-to-pay for irrigation water. Theoretically, the next step in CV survey becomes aggregation. An important issue related to the measurement of welfare using WTP is aggregation of benefit obtained from the sample respondents to the total population. According to Mitchell and Carson (1989) there are four important issues to be considered regarding sample design and execution in order to have a valid aggregation of benefits: population choice bias, sampling frame bias, sample none response bias and sample selection bias. Random sampling method was used in this study using a list of household. In this paper in-person interview method is used, and Protest zero responses were excluded from the data set, and expected Protest zeros was accounted in the estimation of the total aggregate benefit of irrigation water. Hence, none of the above biases was expected in our analysis. Mean was used as a measure of aggregate value of irrigation water. In Table 7, the aggregate WTP was calculated by multiplying the mean WTP by the total number of households in the population. Following this, the aggregate WTP for irrigation water was computed at 156,785.1birr per year for five years. Whereas, from open ended questions the total WTP for restoring forest resource was also computed at 128264.55 birr per year. This result indicated that different elicitation methods give different WTP and therefore, policy makers should take care of when selecting the elicitation method.

Conclusion and Policy Recommendations

This study used double bounded elicitation method followed by an additional open ended format contingent valuation technique to elicit farmers' willingness to pay for irrigation water in Wondo Genet District, Ethiopia. The survey was administered via in-person interview through trained enumerators. Data from 151 households revealed that the irrigation water is inadequate and would be insufficient for productions of cash crops and other crops. This is because of population pressure, deforestation, soil and water degradations, and inequitable water distribution. The total WTP from the double bounded dichotomies choice was computed at 156,785.1 birr per year for five years. Whereas, from open ended format was also computed at 128,264.55 birr per year. 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. This could be a signal for the government and any concerned body to consider double bounded elicitation format as an important elicitation method while designing and implementing irrigation water projects.

The empirical findings on the determinants of WTP indicated that monthly income, age, cultivated land, initial bids, formal education and awareness are key factors influencing the WTP. Therefore, understanding of socio-economic characteristics that influenced households WTP significantly is a necessary and first step to achieve improved irrigation water.

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Table 1: Perceived main causes of irrigation water problems

Problems	Number of households	%
Population pressure	60	39.74
Deforestation	42	27.81
Illegal Dweller	22	14.57
Soil and water degradations	8	5.29
Inequitable water distribution	7	4.64
None	12	7.95
Total	151	100%

Source: Survey Data

Table 2: Alternative protection measures of irrigation water degradation

Protection Measures	Frequency	%
Planting and Maintaining Trees	61	40.39
Soil and Water Conservation	40	26.49
Punishing Illegal Dweller on the forest area	28	18.54
Training Users	10	6.62
None	12	7.95
Total	151	100%

Source: survey data

Table 3: Parameter estimates of bivariate probit model

Estimation results of the bivariate probit model			
Variable	Coefficient	Std. Err	z
Initial bid	-0.0201	0.0045	-4.43
constant	0.5166	0.1609	3.21
Second bid	-0.0085	0.0044	-1.95
constant	0.2945	0.1519	1.94
ρ***	0.9829	.0238	

Mean WTP=30.18 birr(95% CI, 25.70-34.65)

Log- likelihood= -154.15

Wald chi2(2)= 22.11

Prob>chi2=0.000

Likelihood-ratio test of rho=0: chi2(1)=38.40 Prob>chi2=0.000

Source: model output

Table 4: Reason for their Maximum WTP

Reason	Number of willing respondents	%
I could not provided more because of shortage of income	50	58.14
That amount is enough	36	41.86
Total	86	100%

Source: survey results

Table 5: Reason for zero WTP for irrigation water

Reasons for zero WTP	Frequency	%
We do not believe that the money we pay will actually be used for the proposed change	2	8.70
We received sufficient water quantities and we believed that the proposed project is unnecessary	1	4.34
Total protest answers	3	13.04
Lack of money	20	86.96
Total non-protest answers	20	86.96

Source: survey result

Table 6: The probit model estimation results of households' WTP

Independent variables	Estimated coefficient	Marginal effect	Std.Err	z-value
MINC	0.001	0.0005	0.0004	3.5***
AGE	-0.053	-0.0210	0.0159	-3.3***
SEX#	0.163	0.0650	0.3808	0.43
RMAR#	0.048	0.0193	0.4418	0.11
EDUR	0.12	0.0480	0.0604	1.99**
STAR#	0.098	0.0390	0.3691	0.26
TFS	0.003	0.0012	0.0534	0.06
TLU	0.112	0.0446	0.1238	0.9
LANDCULT	2.911	1.1612	0.9648	3.02***
NEARNESS	0.033	0.0133	0.1212	0.27
LSHEWR#	-0.021	0.0082	0.3559	0.06
BID	-0.023	-0.0092	0.0119	-1.92*
AWARNNES#	0.889	0.3414	0.3849	2.31**
Constant	-0.244		0.9181	-0.27
Number of observation	151			
Log likelihood	-48.67			
Pseudo R^2	0.5332			
LR $chi^2(13)$	111.18			
Prob > chi^2	0.000			

***, ** & * indicate significant level at 1%, 5% and 10%, respectively

(Source: model output)

Table 7: Estimation of Total Aggregate Benefits of irrigation water

Total Population (X)	Expected HHs to have a protest zeros (Y)[5]	Expected HHs with valid responses (Z)[6]	Mean WTP[7]	Aggregate Benefit (in Birr)[8]
5301	106	5195	30.18	156,785.1
5301	106	5195	24.69	128264.55

Source: own survey

[5] 3(0.02%) of our 154 sampled households were protest zeros. We excluded those protest zeros from further analysis after we have tested for sample selection bias. So Y is the expected number of households which are expected to protest for the proposed project. It is calculated by the percentage of sampled protest zeros (2%) by the total population 5301 (X).

[6] Is X-Y which is the total households in the study area which are expected to have a valid response

[7] Is the mean willingness to pay calculated from the double bounded dichotomous choice estimation and open ended elicitation methods

[8] Is mean multiplied by the number of total households which are expected to have valid response (Z*Mean WTP) measured in birr