International Journal of Agricultural Economics
2016; 1(2): 35-39
http://www.sciencepublishinggroup.com/j/ijae
doi: 10.11648/j.ijae.20160102.13

Farmers' Willingness to Pay for Irrigation Water Use: The Case of Agarfa District, Bale Zone, Oromia National Regional State

Meseret Birhane[1, *], Endrias Geta[2]

[1]Department of Agricultural Economics, Addis Ababa University, Addis Ababa, Ethiopia

[2]Department of Agricultural Economics, Haramaya University, Dire Dawa, Ethiopia

Email address:

messamber@yahoo.com (M. Birhane), geta.endrias@gmail.com (E. Geta)

[*]Corresponding author

To cite this article:

Meseret Birhane, Endrias Geta. Farmers' Willingness to Pay for Irrigation Water Use: The Case of Agarfa District, Bale Zone, Oromia National Regional State. *International Journal of Agricultural Economics.* Vol. 1, No. 2, 2016, pp. 35-39. doi: 10.11648/j.ijae.20160102.13

Received: May 9, 2016; **Accepted**: May 20, 2016; **Published**: July 28, 2016

Abstract: Conceptually correct and empirically accurate estimates of the economic value of water are essential for rational allocation of scarce water resource across locations, uses, users, and time periods. In Agarfa District, there is a water resource, specifically Weib River, which could be suitable for irrigation purpose. Yet, there is no well-constructed irrigation scheme in the area. The objectives of the study were to evaluate their willingness to pay for irrigation water use per hectare of irrigable land per year. Seemingly unrelated bivariate probit model was used to calculate the mean willingness to pay for irrigation water use per hectare per year. Out of the total sample households, 20% of the total households were not willing to pay and 80% were willing to pay for irrigation water use. The result of the seemingly unrelated bivariate probit model showed that households' mean annual willingness to pay amount was Birr 4018.02 per hectare per year, which suggests the possibility of a substantial amount of revenue from local community for development, maintenance and operation of irrigation projects.

Keywords: Willingness to Pay, Contingent Valuation Method, Seemingly Unrelated Bivariate Probit

1. Introduction

Water is one of the natural resources which is very vital for sustaining human life, achieving sustainable development and maintaining ecosystem services (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 (Sadeghi et al. 2010).

Africa is home to about 13% of the world's population, but has only about 9% of the world's water resources. Average annual per capita availability of water resources in Africa is lower than the world average and higher than only that of Asia. This low level of water availability in Africa is due to three basic sources of water risk: "The first major source of risk is that of a significant decline in the average rainfall since the late 1960s. This is because in recent times many of the continents experienced increased aridity as the mean annual rainfall declined by 5% and 10% between 1931-1960 and 1968-1997 respectively. The second basic concern with the water resource situation in Africa is that in terms of comparative hydrology, runoff is low in Africa due to high evaporative losses. The third major source of water risk in Africa is the high variability of supply, due to highly variable rainfall. The variability ranges from zero in some Namibian deserts to very high in the western equatorial areas (PANAFCON, 2003)". The major outcome of these extremes of rainfall is a high frequency of floods and drought on the continent. The high variability of rainfall and river flow also reduces runoff and exacerbates vulnerability to erosion and desertification. This extreme variability of climate and hydrological conditions imposes high costs on livelihoods, and raises the riskiness of development interventions.

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).

The effectiveness or the success of irrigation water fee for the sustainable development of the sector highly depends on a number of site specific factors. Thus prior to the introduction of irrigation water use fee, the examination of the farmers' willingness to pay has a paramount significance. In the area of interest, namely Agarfa district, specifically Weib River, there is a water resource which might be suitable for irrigation purpose. However, there is no well-constructed irrigation scheme and regulation to use the resource. In addition, no attempt has been made to quantify farmers' willingness to pay (WTP) for irrigation water use in order to develop sound interventions aimed at developing irrigation scheme. This motivated the study to investigate the farmers' WTP for irrigation water use, in the hypothetical market constructed in the study area. Accordingly, this study will be undertaken to provide baseline information for the local authorities' so that they can make an informed decision in the introduction of irrigation water fee. The objective of the study was to estimate farmers' economic valuation of irrigation water use.

2. Research Methodology

2.1. Description of the Study Area

This study was conducted in Agarfa District, which is found in Bale zone of the Oromia National Regional State. There are 18 districts and 2 urban administrative towns in Bale zone. Agarfa District is one of those 18 districts (AWCPO, 2012). Agarfa District falls between 7°17' North Latitude and 39°49' East Longitude. Agarfa town is specifically located around 453 km South East direction from Addis Ababa. It is located around the border of Arsi zone following the rugged and broken terrain of Wabe Gorge. It is found in the extreme North Western Corner of the zone, which is bounded by Shirka district of Arsi zone in the North, West Arsi zone in South West, Dinsho in south, Sinana in South East, and Gasera in North East. The total area of the district is 114,084 ha which ranked the 15th largest district among the zone districts.

The lowest and highest altitude of the district is 1000m and 3000m above sea level, respectively. The lowest area occupies the North East part of the district (around the border of Arsi zone) whereas the highest elevation is Hora Mountain which is found around South Western part of the district. The mean annual temperature of the district is 17.5°C. The minimum and maximum temperature is 10°C and 25°C respectively. The average annual rainfall is 800ml whereas 400ml and 1200ml is the minimum and maximum annual rainfall recorded in the district, respectively (AWFEDO, 2009).

The total population of the district was estimated to be 104,412 (CSA, 2008), which is unevenly distributed in rural and urban areas. There is high concentration of population in rural areas of the district than urban areas. The urban population is only 14% of total population. This indicates the majority of the livelihood of Agarfa district population highly depends on agricultural activity.

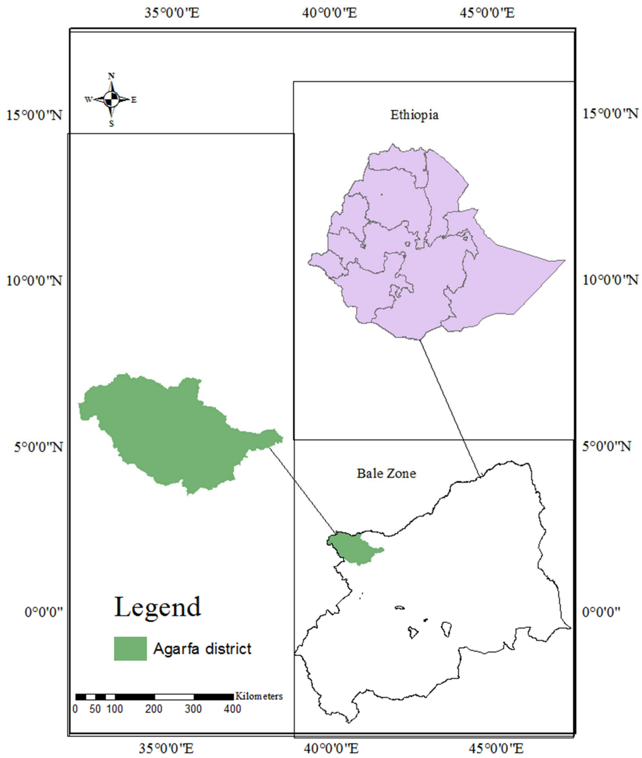

Figure 1. *Location Map of the Study Area.*

2.2. Methods of Data Collection

The primary data were collected from sample of farmers in the study area through structured questionnaire using face to face interview. Besides, the data were supplemented by focus group discussion to generate qualitative information. The information from the focus group discussion was also used to refine the questionnaire. The data were collected by four experienced and competent enumerators and the researcher. The enumerators were trained on how to conduct and manage CV questions and how to approach farmers during the interview.

A pre-test of the draft questionnaire was done on 20 selected respondents who were assumed to be representative of the households living in the two *Kebeles*. All the four enumerators and the researcher have participated in the pre-testing. The main purpose of the pre-test was to determine sets of bids, and to select appropriate wording and ordering of questions. Moreover, it was targeted to enable the enumerators to develop experience in conducting CV survey. In addition, focus group discussion was made to decide on the appropriate initial bids. After the necessary adjustments were made to the draft questionnaire and setting bid prices, the final questionnaire was developed.

Accordingly, four most frequently stated values were then selected as a starting value (price) for the double bounded dichotomous choice format. These values were 300, 500, 700 and, 800 Birr per year per *timad* (1/6 hectare) of irrigable land.

Following Cameron and Quiggin (1994), sets of bids were determined for double bounded dichotomous choice format by making twice the initial bid if the first response is "Yes" and half of it if the response is "No". These sets of bids are (300, 150, 600), (500, 250, 1000), (700, 350, 1400), and (800, 400, 1600) Birr per year per *timad* of irrigable land. These bid sets were assigned randomly across the respondents to avoid starting point bias (Mitchel and Carson, 1989).

2.3. Sample Size and Sampling Technique

There are several approaches to determine the sample size. These include using a census for small populations, imitating a sample size of similar studies using published tables, and applying formulas to calculate a sample size. In this study a simplified formula provided by Yamane (1967) was used to determine the required sample size at 95% confidence level, 0.5 degree of variability and 9% level of precision.

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

Where n is the sample size, N is the population size (total irrigation water user households), and e is the level of precision. The district has 21 rural and 2 urban kebeles with total of 3,476 irrigation water user households (AWARDO, 2013). Hence, the sample size is equal to:

$$n = \frac{3{,}476}{1+3{,}476(0.09)^2} = 119.2223 \approx 120$$

Regarding the sampling method, a two-stage sampling procedure was employed to select 120 sample irrigation water user households. In the first Stage two *kebeles* were purposively selected on the basis of the availability of irrigation water schemes, then 120 irrigation water user farm households were selected randomly from each sample *kebeles* using probability proportional to size.

2.4. Methods of Data Analysis

Specification of econometric models

The bivariate probit model is used to estimate the mean WTP from the double bounded dichotomous elicitation method. But, when the estimated correlation coefficient of the error terms in bivariate probit model are assumed to follow normal distributions with zero mean and distinguishable from zero, the system of equations could be estimated as seemingly unrelated bivariate probit (SUBVP) model (Haab and McConnell, 2002). Therefore, in this study SUBVP was employed to estimate the mean WTP of the respondents from the double bounded elicitation method.

Following Haab and McConnell (2002), the econometric modeling for the formulation of double-bounded data is given as:

$$\mathrm{WTP}_{ij} = \mu_i + \varepsilon_{ij} \quad (2)$$

Where:

WTP_{ij} is the j^{th} respondent's WTP and i=1, 2 represents first and second answers;

μ_1, μ_2 = mean value for first and second response;

ε_{ij} = unobservable random component.

Setting $\mu_{ij} = X_{ij}\beta_i$ allows the mean to be dependent upon the characteristics of the respondents.

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 *j* answers to the first bid and to the second bid is given by (Haab and McConnell, 2002):

$$\begin{aligned}
\mathrm{pr}(\mathrm{yes},\mathrm{no}) &= \mathrm{pr}(\mathrm{WTP}_{1j} \geq t^1, \mathrm{WTP}_{2j} < t^2) \\
&= \mathrm{pr}(\mu_1 + \varepsilon_{1j} \geq t^1, \mu_2 + \varepsilon_{2j} < t^2) \\
\mathrm{pr}(\mathrm{yes},\mathrm{yes}) &= \mathrm{pr}(\mathrm{WTP}_{1j} > t^1, \mathrm{WTP}_{2j} \geq t^2) \\
&= \mathrm{pr}(\mu_1 + \varepsilon_{1j} > t^1, \mu_2 + \varepsilon_{2j} \geq t^2) \quad (3) \\
\mathrm{pr}(\mathrm{no},\mathrm{no}) &= \mathrm{pr}(\mathrm{WTP}_{1j} < t^1, \mathrm{WTP}_{2j} < t^2) \\
&= \mathrm{pr}(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} < t^2) \\
\mathrm{pr}(\mathrm{no},\mathrm{yes}) &= \mathrm{pr}(\mathrm{WTP}_{1j} < t^1, \mathrm{WTP}_{2j} \geq t^2) \\
&= \mathrm{pr}(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} \geq t^2)
\end{aligned}$$

The j^{th} contribution to Likelihood function becomes;

$$\begin{aligned}
\mathrm{L}_j\left(\frac{\mu}{t}\right) &= \mathrm{pr}(\mu_1 + \varepsilon_{1j} \geq t^1, \mu_2 + \varepsilon_{2j} < t^2)^{YN} \\
&\times \mathrm{pr}(\mu_1 + \varepsilon_{1j} > t^1, \mu_2 + \varepsilon_{2j} \geq t^2)^{YY} \quad (4) \\
&\times \mathrm{pr}(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} < t^2)^{NN} \\
&\times \mathrm{pr}(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} \geq t^2)^{NY}
\end{aligned}$$

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^2_1 and σ^2_2, then WTP_{1j} and WTP_{2j} have a bivariate normal distribution with means μ_1 and μ_2, variances σ^2_1 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 j^{th} contribution to the bivariate probit likelihood function is given as:

$$L(\mu/t) = \Phi_{\varepsilon1\varepsilon2}(d_{1j}(t^1 - \mu_1)/\sigma_1), d_{2j}(t^2 - \mu_2)/\sigma_2), d_{1j}d_{2j}\rho \quad (5)$$

Where:

$\Phi_{\varepsilon1\varepsilon2}$ = the bivariate normal cumulative distribution function with zero means $d_{1j} = 2y_{1j} - 1$, and $d_{2j} = 2y_{2j} - 1$

$y_{1j} = 1$ if the response to the first question is yes, and 0 otherwise

$y_{2j} = 1$ if the response to the second question is yes, and 0 otherwise

ρ = Correlation coefficient

σ = standard deviation of the error.

After running regression of dependent variable (yes/no indicator), on a constant and on independent variable consisting of the bid levels, the mean WTP value is determined as follows depending on the normality assumption of WTP distributions (Haab and McConnell, 2002):

$$\text{Mean WTP} = -\alpha/\beta \quad (6)$$

Where:

Mean WTP= the mean willingness to pay for irrigation water use; α = the intercept of the model, β = slope coefficient of the bid values.

3. Results and Discussion

3.1. The Contingent Valuation Survey Results

Out of the total sample households, 20% of the total households were not willing to pay and 80% were willing to pay for irrigation water use (Table 1). The specified reason for all non-willing respondents was that they cannot afford any cash amount for the scenario.

Table 1. *Distribution of willing and non-willing respondents.*

Means of payment	Willing		Non-willing		Total	
	N	%	N	%	N	%
Cash in Birr	96	80	24	20	120	100

Source: Own survey, 2014

Four sets of bid prices which were identified from the pilot survey were used for the study as discussed in the methodology part. These are (300, 150, 600), (500, 250, 1000), (700, 350, 1400) and (800, 400, 1600) Birr per *timad* per year which were proportionally distributed to the survey questionnaires (Table 2).

Table 2. *Frequency of the respondents' responses for initial and next bids.*

Means of payment			Frequency of respondents					Total
			Yes-Yes	Yes-No	No-Yes	No-No	Non-willing	
300	600	150	20	6	0	1	3	30
500	1000	250	13	5	3	3	6	30
700	1400	350	8	5	6	3	8	30
800	1600	400	4	7	8	4	7	30
Total			45	23	17	11	24	120

Source: Own survey (2014)

As indicated in Table 3, one can understand from the joint frequencies of discrete responses, 37.5% responded "Yes-Yes" for both the first and second bids, 29.17% (out of which 68.57% were non-willing) responded "No-No" for both bids, 19.17% responded "Yes-No" and the remaining 14.17% responded "No-Yes".

Table 3. *Joint frequency of discrete response.*

Joint Response	Frequency	Percentage
Yes-Yes	45	37.5
Yes-No	23	19.17
No-Yes	17	14.17
No-No	35	29.17

Source: Own survey, 2014

The survey result also indicated that 66.18% of the respondent who accepted the first bid gave similar response to the second bid and 67.31% of the respondents who rejected the first bid also rejected the follow up bid (Table 3). This may indicate the presence of the first response effect on response for the second question which is in line with prior studies done by Solomon (2004) and Ayalneh and Birhanu (2012).

3.2. Users' Willingness to Pay for Irrigation Water

The mean WTP of the respondents for the irrigation water use was calculated using the formula specified by Haab and McConnell (2002). The coefficients α and β were estimated by running the seemingly unrelated bivariate probit model using the first bids and second bids as explanatory variables as shown in Table 4, respectively. Accordingly, the mean WTP estimated from the initial bid and the follow up bid values ranged from 669.67 to 773.45 Birr per year per *timad*.

According to Haab and McConnell (2002), the researcher must decide which estimates from the double bounded question to use so as to calculate the mean WTP. They explained that parameter estimates from the first equation are generally used in the computing mean WTP. The reason behind is the fact that the second equation parameters are likely to contain more noise in terms of anchoring bias as the respondent is assumed to take the clue from the first bid while forming his WTP for the second question. This was also applied by Ayalneh and Birhanu (2012). Thus, 669.67 Birr per year per *timad* estimated from the first equation were used in this study to estimate the mean WTP. Hence, the average household's WTP is estimated to be Birr 4018.02 per household per year per hectare if the scenario of constructing irrigation dam on Weib River is implemented.

Table 4. *Parameter estimates of bivariate probit for mean WTP.*

Variables	Coefficients	Std. Err.
WTP initial bid		
Bid1	-0.0023	0.0006
_Cons	1.553	0.3672
WTP second bid		
Bid2	-0.0008	0.0003
_Cons	0.621	0.2224
ρ***	0.823	0.1267

Log-likelihood= -148.573

Likelihood-ratio test of rho= 0: chi2 (1) = 11.032 prob.>chi2=0.000

Source: Own survey (2014)

4. Summary and Conclusion

This study was conducted with the objectives of estimating the mean price per unit irrigated area per year. Both primary and secondary data were collected for these purposes. The primary data were collected from 120 sample households from two *Kebeles* of Agarfa District. Seemingly unrelated bivariate probit model was used to calculate the mean WTP for irrigation water use per hectare of irrigable land per year.

Four sets of bid prices which were identified from the pilot survey were used for the study. These are (300, 150, 600), (500, 250, 1000), (700, 350, 1400) and (800, 400, 1600) Birr per *timad* per year which were proportionally distributed to the survey questionnaires. The result of the CVM survey showed that out of 120 sampled respondents 80% of them were willing to pay for irrigation water use, whereas 20% respondents were not willing to pay.

The seemingly unrelated bivariate probit model revealed that the mean WTP for the respondents was Birr 669.67 per year per *timad* per household which is estimated to be about 4018.02 Birr per hectare per year per household. The mean WTP of households could be an indicator to the importance of irrigation in the households' livelihood and the significance of water resource to the community in the study area.

Based on the findings from the survey, it can be concluded that the rural households are willing to pay for irrigation water use. Thus, the participation of the community should be ensured in every decision making and formulation of policies and strategies which are related to the irrigation water use. This promotes the commitment of the community for the conservation programs and helps them to develop a sense of ownership which has its own contribution for the sustainability and effectiveness of irrigation water use.

References

[1] UNESCO (United Nations Educational, Scientific and Cultural Organization), 2006. Water: a shared responsibility. United Nations second world water development report, United Nations Education: New York.

[2] Devi, J. S., B. Joseph, K. Karunakaran, B. Anurdha and K. R. Devi, 2009. People's attitudes towards paying for water: India Review Article, *Current Science*, 97 (9).

[3] Sadeghi, A., M. G. Mohayidin, Md A. Hussein and A. Baheiraei, 2010. Determining the economic value of the irrigation water in production of wheat in Iran. University Putra Malaysia. *Australian Journal of Basic and Applied Sciences,* 4 (6): 1391-1402.

[4] PANAFCON (Pan–African implementation and partnership conference on water), 2003. Reports and proceedings of the Pan–African implementation and partnership conference on water (PANAFCON), Addis Ababa, December 8-13 /2003, UN – water/Africa.

[5] Ahmad I., M. ul, Haq, and A., Sattar, 2010. Factors determining public demand for safe drinking water (A Case Study of District Peshawar). Pakistan Institute of Development Economics Islamabad, Pakistan.

[6] Agudelo, J., 2001. The economic valuation of water: principles and methods. Research Report, Series No. 5, IHE Delft. The Netherlands.

[7] Chandrasekaran, K., S. Devarajulu, and P. Kuppannan, 2009. Farmers' willingness to pay for irrigation water: a case of tank irrigation systems in South India. *Journal Article Water,* 1: 5-18.

[8] Agarfa Woreda Cooperatives Promotion Office (AWCPO), 2012. Saving and Credit Cooperative Society document. Agarfa, Ethiopia.

[9] AWRADO (Agarfa Woreda Rural and Agricultural Development Office), 2013. Agricultural report of Agarfa district. Agarfa, Ethiopia.

[10] CSA (Central Statistical Authority), 2008. Statistical Abstract of Ethiopia. Addis Ababa.

[11] Cameron, T. A. and J. Quiggin, 1994. Estimation using contingent valuation data from a "Dichotomous choice with follow up" questionnaire'. *Journal of Environmental Economics and Management,* 27 (3): 218–34.

[12] Mitchell, R., and Carson, R., 1989. Using surveys to value public goods: The contingent valuation method. The John Hopkins University press, Washington D. C.

[13] Yamane, T., 1967. Statistics, an introductory analysis. 2nd edition. Harper and Row Inc., New York. 345p.

[14] Haab, C. and K. McConnel., 2002. Valuing environmental and natural resource. The econometrics of non-market valuation. Northampton: Endard Elgar Publishing.