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Research Article

Determinants of 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, Fiche, Ethiopia.
[2]Agricultural Economics and Agribusiness, Haramaya University, Dire Dawa Ethiopia.
[2]Co-author email: geta.endrias@gmail.com

The objective of the study was to analyse determinants of willingness to pay for irrigation water use by individual households. Both primary and secondary data were used for these purposes. The primary data were collected from 120 sample households drawn from two kebeles of Agarfa district. Descriptive and inferential statistics and tobit model were used to analyse the data. The result of tobit model showed that sex of the household, educational level of the household head, total annual income, credit utilization, and perceived trend in rain fed agricultural productivity were positively and significantly related to the probability willingness to pay whereas, family size and initial bid were negatively and significantly related to the probability willingness to pay. Therefore, these variables should be considered while designing irrigation water related projects in the area.

Keywords*:* Tobit model, Maximum willingness to pay for irrigation water, Initial bid

INTRODUCTION

Water is an integral part of the ecosystem, aninfinite natural resource and a social and economic good. Hence, the issues of water availability, access and quality are of fundamental importance to development, poverty reduction and ecosystem sustainability (Ayleward*et al*., 2010).

Ethiopia is "the water tower of Africa", located in North Eastern Africa. The country has more than 10 river basins with an annual runoff volume of 122 billion m^3 of surface water and an estimated 2.6 billion m^3 of ground water potential, which makes an average of 1557.5 m^3 water available per person per year (MoWR, 2002). This is a relatively large volume of water. Of the ten major river basins of the country the largest four river basins namely Abay, Baro-Akobo, Tekeze and Omo-Ghibe account for 80%-90% of the country's water resource.

In Ethiopia the agricultural sector heavily depends on rainfall, which is characterized by high spatial variability and seasonal fluctuation. The country is also characterized by rapid population growth. So as to meet the growing demand for food of this growing population the country needs to have the right optimal resource use, like water, to increase production and productivity. In this regard irrigation will play a vital role to increase production to meet the growing food demand and stabilize agricultural production and productivity (MoWR, 2002).

***Corresponding author**: Meseret Birhane, Department of Agricultural economics, Addis Ababa University, Fiche Ethiopia. Email: messamber@yahoo.com, Telephone: +251912078619

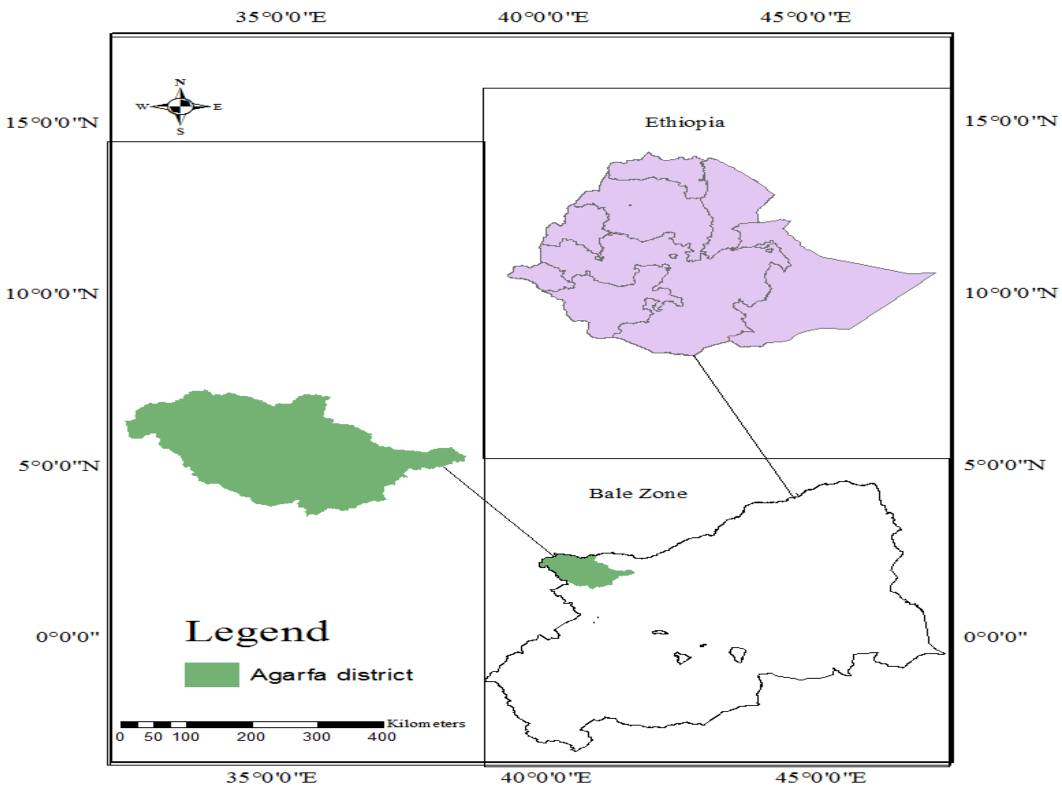

Figure 1. Location Map of the Study Area

However, according to Seleshi (2010) the country has about 5.3 million hectare (Mha) potential irrigable land. Yet, only about 640,000ha are irrigated, of which about 241,000 ha from small scale, 315,000 ha from medium scale and 84,000ha from large scales schemes. Nonetheless, some of the existing irrigation schemes are not operating at their full potential, while others are not functioning because of problems related to infrastructure, management and water shortages. A performance assessment conducted on six selected irrigation schemes (five small scales, one large-scale) confirmed they are performing poor (FAO, 2011).

Specifically to the Oromia Regional State there are 199 irrigation schemes. These irrigation schemes covered 33,765.19 ha of irrigated area, of which 4,627.29 ha is from small-scale, 2,800.01 ha from medium-scale and 26,338 ha from large-scale, making 37,479 household beneficiaries (Seleshi, 2010).

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The government of Ethiopia has designed policy and strategy to eradicate poverty in its five year plan called Growth and Transformation Plan (GTP) by maintaining agriculture as a major source of economic growth. To promote multiple cropping and better cope with climate variability and ensure food security, GTP will enhance the uses of the country's water resources. Expansion of small-scale irrigation was given priority while due attention was given to medium and large-scale irrigation to the extent possible (MoFED, 2010). Consequently, different irrigation projects starting from small scale to large scale projects are under implementation.

The existing irrigation policy of the country gives more emphasis on the construction of small scale irrigation projects rather than the valuation of the irrigation water. But the irrigation water policy has to focus on the pricing of irrigation water because valuation of irrigation water helps in an economy with high dependency on agriculture and a large percentage of the population lives in the rural areas. Furthermore, the need to fill the information gap on the determinants of pricing of irrigation water for policy measures is required. Therefore, this study is aimed to identify the determinants of farmers' willingness to pay for irrigation water use based on data generated from household survey in Agarfa district of Ethiopia.

MATERIALS ANDMETHODS

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 falls between $7^{0}17'$ North Latitude and $39^{0}49'$ East Longitude (Figure 1). 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 ºc. The minimum and maximum temperature is 10ºc and 25ºc 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).

Methods of Data Collection and Sampling Design

The study used data that were gathered from both primary and secondary sources. The primary datawerecollectedthroughfacetofaceinterviewofthesample householdheads using structured questionnaire. Besides, the data were supplemented by focus group discussion to generate qualitative information. In addition primary data were generated by personal observation during focus group discussion and by the interview of the officials from the office of the District Agriculture and Water Mineral and Energy.Secondary data were also collected from the District Water, Mineral and Energy Office and other relevant sources. A two-stage sampling procedure was employed to select the sample irrigation water user households. In the first Stage two *kebeles* were purposively selected on the basis of the availability of irrigation water schemes, then120 irrigation water user farm households were selected randomly from each sample *kebeles* using probability proportional to population size.

Empirical Model Specification and Analysis

In this study tobit model was used to identify the determinants of willingness to pay (WTP) and the maximum amount of money the individual would pay. This model has an advantage over other discrete models like Linear Probability Model, logistic, and probit. Tobit model revealed both the probability of WTP and its maximum WTP by the respondents.

Following Maddala (1992) and Johnston and Dindaro (1997), the tobit model can be defined as:

$$MWTP^* = \beta_0 + \beta' X_i + \varepsilon_i$$
$$MWTP_i = MWTP_i^* \ if \ MWTP_i^* \neq 0$$
$$= 0 \ if \ MWTP_i^* \ \leq 0$$

Where:

$MWTP_i$= the observed dependent variable, in this case maximum willingness to pay of each respondent.

$MWTP_i^*$ =is a latent variable which is not observed when it is less than or equal to zero but is observed if it is greater than zero.

X_i =vector of factors affecting WTP

β' =vector of unknown parameters

ε_i = error term that are independently and normally distributed with mean zero and common variance $\boldsymbol{\delta}^2$.

Note that the threshold value in the above model is zero. This is not a very restrictive assumption, because the threshold value can be set to zero or assumed to be any known or unknown value (Green, 2000). The tobit model shown above is also called a censored regression because it is possible to view the problem as one where observation of at or below zero are censored (Johnston and Dinardo, 1997 and Green, 2000).

The model parameters are estimated by maximizing the tobit likelihood function of the following form (Maddala, 1997 and Amamiya, 1985).

$$L = \prod_{MWTP_i^* > 0} \frac{1}{\delta} f\left(\frac{MWTP_i - \beta' X_i}{\delta}\right) \prod_{MWTP_i^* \leq 0} F\left(\frac{-\beta' X_i}{\delta}\right)$$

Where: f and F are respectively, the density function and cumulative distribution function of Y_i^*. $\prod_{MWTP_i^* \leq 0}$ Means the product over those i for which $MWTP_i^* \leq 0$, and $\prod_{MWTP_i^* \leq 0}$ means the product over those i for which $MWTP_i^* > 0$.

It may not be sensible to interpret coefficient of a tobit in the same way as one interprets coefficients in an uncensored linear model (Johnston and Dinardo, 1997). Hence, one has to compute the derivatives of the estimated tobit model to predict the effects of changes in the exogenous variables.

According to Scott Long (1997), McDonald and Mof fit the following techniques could be used to decompose the effect of explanatory variables into WTP and on the amount of WTP. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(MWTP_i)}{\partial X_i} = F(z)\beta'$$

Where, $\frac{\beta' X_i}{\delta}$ is denoted by z, following Maddala, (1997)

The change in the probability of WTP as independent variable X_i changes is:

$$\frac{\partial F(Z)}{\partial X_i} = f(z)\frac{\beta'}{\delta}$$

Table 1. Summary of descriptive statistics forcontinuous explanatory variables (N=120)

Variables	**Mean**	**Std. Dev.**	**Min.**	**Max.**
Age	39.42	8.42	25	64
Educational level	3.91	3.59	0	13
Experience in irrigated farming	4.14	3.50	0	32
Family size	6.1	3.33	1	18
Distance from market center	0.90	0.71	0.71	3.17
Total annual income	24366.9	13880.68	3450	92210
Livestock ownership in TLU	8.71	4.95	2.13	33.15
Initial bid	575	192.83	300	800

Table 2. Summary of descriptive statistics fordummy explanatory variables (N=120)

Variables	Frequency		Percentage	
	0	1	0	1
Sex of the household head	19	101	15.83	84.17
Access to credit	74	46	61.67	38.33
Perceived trend in rain fed agri. productivity	47	73	39.17	60.83
Labor shortage	58	62	48.33	51.67

The change in the amount of WTP with respect to a change in explanatory variable among individuals who are willing to pay is:

$$\frac{\partial E(MWTP_i \,/\, MWTP_i^* \neq 0)}{\partial X_i} = \beta' \left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)}\right)^2\right]$$

Where, F(z) is the cumulative normal distribution of Z, f(z) is the value of derivative of the normal curve at a given point (i.e., unit normal density), Z is the Z score for the area under normal curve, β' is the vector of tobit maximum likelihood estimate and δ is the standard error of the error term.

Based on review of empirical studies and personal observations, specific household characteristics which are hypothesized to affect households' maximum willingness to pay for irrigation water use were identified. These include sex of the household (SEX), household age(AGE), Education level of the household(EDU), household irrigation farming experience (EXP), family size (FSIZE), credit utilization of the household (CRDT), distance from market center (DMKT), total annual income (INCOME), Perceived trend in rain-fed agricultural productivity (TREND), livestock ownership (TLU), laborshortage (LAB) and Initial bid (BID1).

RESULTS AND DISCUSSION

Descriptive Results

From the total sample, 84.17% were male headed households and 15.83% were female headed households (Table 2). The result of the study showed that the average family size of the total sample respondents was about six. The average grade level the household head learned for the total sample respondents was about four. The survey result showed that the mean age of the total sampled farmers was about 39years.The mean amount of walking distance to the market center was 0.90 hour. Themean irrigated farming experience of the entire sample was 4.14years (Table 1).

About38%of the sample respondents had received credit while the remaining 62%hadnotreceived credit (Table 2). Of those who had received credit, about 30% received it from friends and relatives. The other41 % and 24% received it from microfinance and cooperatives, respectively. The rest5% received credit from merchants. In addition, 50% of the respondents received the credit to purchase fertilizer andabout1 3% for livestock rearing and fattening, yet only 15% received credit to purchase irrigation facilities. The remaining 17% and 4% used credit for the purpose of petty trade and home consumption, respectively.

Of all sample households included in the study about61%responded that rain fed agricultural productivity was decreased and the remaining 39% of the households responded that there was no decrease in rain fed agricultural productivity (Table 2). The majority of them, about 81%, believed that rainfall variability wast because for the decrease in productivity.

The minimum and maximum potential irrigable land size owned was 0.16 ha and 1.50 ha respectively. The average size of potential irrigable land for the total sample farmers was 0.60 ha. The average livestock ownership in terms of TLU for the total sampled households was 8.71 with the minimum and maximum

Table 3. Maximum Likelihood Estimates of the Tobit model

Variables	Coefficient	Std. Err	t-value
Sex	254.609**	112.651	2.26
Age	3.358	5.550	0.61
Educational level	46.791***	11.551	4.05
Experience in irrigated farming	-1.052	11.086	-0.09
Family size	-25.959**	12.723	-2.04
Credit utilization	129.662*	77.979	1.66
Distance from market center	-91.146	62.511	-1.46
Total annual income	0.0134***	0.003	4.85
Rain-fed agricultural productivity	217.278***	79.752	2.72
Livestock ownership in TLU	11.362	7.342	1.55
Labor shortage	54.896	74.130	0.74
Initial bid	-0.375*	0.211	-1.78
_Cons	-220.073	332.910	-0.66
Number of observations = 120			
Log likelihood = -720.06872			
Threshold value for the model: Lower =0.0000	Upper = + infinity		

***, **, * significant at 1%, 5%, and 10%, level respectively
Source: Survey, 2014

Table 4. Marginal effects of explanatory variables on the amount of willingness to pay

Variables	Change in probabilities of being irrigation water user	Change among irrigation water users	Change among the whole
Sex	0.155	166.158	217.670
Age	0.002	2.424	3.042
Education level	0.021	33.769	42.383
Experience in irrigated farming	-0.0005	-0.759	-0.953
Family size	-0.012	-18.735	-23.514
Credit utilization	0.056	95.024	118.175
Distance from market center	-0.042	-65.780	-82.560
Total annual income	$6.11e^{-06}$	0.010	0.012
Rain-fed agricultural productivity	0.108	152.640	193.659
Livestock ownership in TLU	0.005	8.200	10.292
Labor shortage	0.025	39.576	49.690
Initial bid	-0.0002	-0.271	-0.340

Source: Survey, 2014

being 2.13 and 33.15, respectively. Income from agricultural activities was the most important source of income for the farmers interviewed. A typical household earned a gross income of ETB 24366.90 for the year 2012/13 from different sources (Table 1). The average annual sale of a household from crop enterprises was ETB12256.98. The corresponding figure for the average annual income from the sale of livestock was ETB5367.32. Non-farm activities such as petty trade and other sources like sale of fire wood, non-farm employments are important sources of non-farm income for the sample households. The average non-farm income for the total sample was estimated to be ETB2371.18.

Econometric Results

The contingency coefficients and variance inflation factor (VIF) were computed to check associations between dummy and continuous variables, respectively. Both the VIF values and the contingency coefficients indicated that both sets of continuous and dummy variables have no serious multicollinearity problem. Thus, all hypothesized explanatory variables were included in the econometric analysis. The tobit model was used to identify the explanatory variables that affect households WTP for irrigation water use. Thus, the explanatory variables which affected WTP were discussed as follows (Table 3 and 4).

Sex of the household head: Sex of the household head was positively related to willingness to pay for irrigation water use and significant at 5% probability level. The result of tobit model revealed that male headed household were found to be willing to pay more for irrigation water use than female headed households. This is mainly because; female headed households have less resources possession endowment as well as some cultural constraints than male headed households.The marginal effect of the variable indicates that, keeping other factors constant, male headed households have 15.5% more probability of paying for irrigation water use than female headed households. Also, male headed households would pay ETB 166.16 more than female headed households.

Education Level of the Household Head: Educational level as expected was positively related to WTP and significant at 1% probability level. 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 was consistent with the findings of Anteneh (2013) and Tiwari (2005). Keeping other factors constant, the marginal effect of the variable indicates that a unit increase in education increases the MWTP for irrigation water use probability by 2.1%. Also, as the year of education increased by one year, the amount of cash a household is willing to pay for irrigation water use may increased by 33.77 ETB.

Family Size: This variable was significant at 5%probability level and negatively related to WTP. Keeping other factors constant, the marginal effect of the variable indicates that a unit increase in household member decreases the MWTP probability by1.2%. Also, when the family size of the household increased by one unit, the amount of cash a household is willing to pay for irrigation water use may decreased by 18.74 ETB.

This can be justified by the fact that an increase in family size decreases the per capital income of the member and, hence it will decrease the payment for irrigation water. The result was consistent with the hypothesis and the findings of Dagne (2008) and Simret (2009).

Credit Utilization: Credit was found to influence the willingness of the farm households to pay for irrigation water use positively and at 10% significance levels. Credit may solve financial constraints and enables the farmer to purchase productive inputs on time, access technologies and enhance farm production. The marginal effect of the variable indicates that, keeping other factors constant, farmers who received credit had 5.6% more probability of paying for irrigation water use than those farmers who did not receive credit. Also, farmers received credit would pay ETB95.02 more than those who did not receive credit. This result is in line with the studies conducted by Yokwe (2004).

Total Annual Income: Total annual income of a farm household was found to influence the willingness of the farmers to pay for irrigation water use positively at 1% significance levels. This result is also in line with the basic economic theory, which states that individual's demand for most commodities or services positively related with income level. Keeping other factors constant, the result of marginal effect shows that a one ETB increase in the total annual income increases MWTP for irrigation water use by 0.006%. And when income of the farmer increases by one ETB, the MWTP for irrigation water increased by .01 ETB. And also, the marginal effect result indicates that those households with higher income are willing to pay more for irrigation water than their counterparts with lower income.This result is inconformity with the studies done by Ayalneh and Birhanu (2012)

Perceived Trend in Rain-fed Agricultural Productivity: This variable was positively affect’s the willingness of the respondents to pay for irrigation water use at 1% significant level. The four year time horizon would provide an adequate period to realize whether crop productivity reduction (if there was any) was caused by changes in rainfall. If a productivity decline is related to rainfall, we expect that farmers may value more for irrigation water. This result is in line with the studies conducted by Simret(2009) and Zelalem (2010).

Initial Bid: The coefficient of initial bid was negative as expected and statistically significant at 10% probability level. As the bid amount increases, the respondents would be less willing to accept the scenario and that is consistent with the law of demand. Keeping other factors constant, the result of the marginal analysis indicated that as the starting bid price increases by one unit, the probability of household’s MWTP for irrigation water use decreased by 0.02%.Also, when the starting bid price increases by one ETB, the amount of cash the farmer could pay for irrigation water decreased by 0.27 ETB.

CONCLUSIONS

This study was conducted to identify thedeterminants of farmers’ WTP for irrigation water use. 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. Tobit model were used to identify and analyse the factors that determine farmers’ WTP for irrigation water use.

The result from the tobit model indicated that sex of the household head, educational level of the household head, credit utilization, total annual income, and perceived trend in rain fed agriculture, were found to be positively and significantly related to the probability of WTP whereas household family size, and the bid value offered were found to be negatively and significantly influence the probability of WTP for irrigation water use.Based on the findings from the survey, it can be concluded that the decision makersand the policy makers related to irrigation water use should consider the above factors in taking up the decisions.

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