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Full Length Research Paper

Determinants of individual willingness to pay for quality water supply: The case of Wonji Shoa Sugar Estate, Ethiopia

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This paper analyses the determinants of households' willingness to pay (WTP) for quality water supply, using the contingent valuation method (CVM). The study was conducted with randomly selected households in the factory villages of Wonji Shoa Sugar Estate, Ethiopia. The value elicitation method used is a close ended format questionnaire with additional close ended format and open ended follow up questions, which is closer to the market scenario respondents are familiar with. The empirical model used in this study is Tobit model. The result of the study revealed that the income of the household, education level of the respondent, reliability on existing water supply, respondent perception about quality of the existing water supply, household family size and age of the respondent are significant variables that explain WTP. The mean WTP for quality water supply is found to be $ 0.025 per 20 L container which is well above the current tariff rate of $ 0.005 per 20 L container charged by Oromiya regional government in Ethiopia. The demand for safe drinking water was also estimated for the study area.

Key words: Willingness to pay, contingent valuation study, safe water, demand.

INTRODUCTION

Safe drinking water is an essential component of primary health care and has a vital role in poverty alleviation. There is a positive correlation between increased national income and the portion of population with access to improved water supply. According to World Bank (1994) an increase of 0.3% investment in household access to safe drinking water generates 1% increase in GDP. Unreliable supply and shortage of water affect life of human beings in various ways. According to the WHO 2010 progress report on sanitation and drinking, of the six billion people on earth, 884 million do not get their drinking water from safe source, and almost all of them live in developing regions. Sub Saharan Africa accounts for over a third of that number, and is lagging behind in fulfilling the Millennium Development Goal (MDG) target. Only 60% of the population in the subcontinent is using improved sources of drinking water despite an 11% points improvement since 1990 (WHO and UNICEF, 2010).

Ethiopia like any other developing countries has many constraints to make potable water easily accessible. Only 38% of total population and 26% of rural population have access to safe and clean water (WHO and UNICEF, 2010). Moreover, Ethiopia is off track to meet the MDG target of access to safe drinking water by 2015 (WHO and UNICEF, 2010). To improve access to safe clean water, the government of Ethiopia has prepared a water and sanitation policy document as an integral part of the country's water management policy. This document clearly indicates the right of every Ethiopian to get access to adequate and quality water to satisfy their basic needs in order to achieve rapid socio economic development through better health care and productivity (MoWR, 1999). In this document, to improve the financial base needed for water development projects and other public

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undertakings, cost recovery mechanism was considered as one of the basic drinking water project financing mechanisms. Wonji Shoa sugar Estate (WSSE) is the oldest agro industry in Ethiopia located in the boundary of the Great African Rift Valley and it has a total population of 22,635. The community of the estate and its adjacent area largely depends for drinking on ground water sources with high fluoride content. The fluoride content of the ground water ranges from 2.4 to 18 mg/l which are by far greater than the maximum permissible concentration of 1.5 mg/l of fluoride content in drinking water (WHO, 1984). The high fluoride content in drinking water causes problem of dental and skeletal flourosis in the community. The potential way of tackling the problem is through provision of clean tap water supply.

However provision of clean water involves costs and the community need to be willing to share the costs. Therefore, there is a need to understand the inhabitants' willingness to pay for a better and cleaner water supply. In the absence of market to determine the price or value of such environmental service non market valuation techniques, such as asking people directly what they would be willing to pay for such service in a hypothetical market scenario, could be used. This method is known as contingent valuation method and people are asked directly how much money they would pay for change in environmental quality. Thus, adequate understanding of the socio economic circumstances is required to determine the household water demand behaviour and the factors that determine their willingness to pay. This paper, therefore tries to assess the determinants of the willingness to pay for quality water service in WSSE.

METHODS

Contingent valuation method

Water lies between the two extreme of purely public and private goods. Given the nature of the good, we do not know how much monetary value people attach to water quality improvement. We use contingent valuation which is a direct valuation method to elicit the value individuals attach to this non-marketed environmental goods. Since we are proposing to improve the quality of water to be delivered to the society, the use of willingness to pay (WTP) format is appropriate, given the property right structure (Mitchell and Carson, 1989). The relevant welfare measure is therefore the Hecksian compensating surplus. A number of theoretical and methodological issues and criticisms have been raised concerning the application of the contingent valuation method in general and in its application in developing countries in particular. A look into literature indicates that, at least at the theoretical level, a large number of criticisms, particularly those related to economic theory, is in one way or other, linked with problems in details of specific studies, such as how the questionnaire was prepared and the way data were collected and analysed. Such concerns are in general linked to how well and carefully the studies are conducted (Hanemann, 1994, 1996; Hanemann et al., 1994).

A common value elicitation method is the dichotomous choice format. However, an alternative to dichotomous choice questions, the use of an open ended follow up question in addition to binary (close ended) one has been proposed and used by Mitchell and Carson (1989). Moreover, Green et al. (1995) argue that a binary question with open ended follow up question provides better information and plausible response on WTP than alternatives such as the double referendum method. In addition, the problem of high non-response rate would be minimized and the idea of unfamiliarity with the market scenario is not a problem particularly when open-ended questions are presented as a follow-up to binary questions. In fact such an elicitation format is closer to what respondents in Ethiopia and other developing countries are used to, as compared to the referendum method. The respondents, as buyers of a commodity, would first expect the price to be stated by the seller and then after some bargaining would decide on the final amount he or she would pay.

Sampling design

In this study, a two stage simple random sampling technique is used to select 126 sample households. During the initial step of sampling out of 11 villages of the estate (2 factory villages and 9 plantation villages), one factory village and three plantation villages were randomly selected. These are Wonji factory village and R_3, L_3, and E_3 from plantation villages. In the final stage 91, 12, 11, 12 households were randomly selected from Wonji factory village, R_3, L_3 and E_3 respectively using proportional to size sampling technique.

Survey design and implementation

Before designing the contingent valuation survey method a focus group discussion was made in the early September 2008. The focus group meeting allowed the researchers to identify the water supply problems of the enterprise and to come up with the first draft questionnaire having three parts. The first section deal with household water use practice, present status of water supply situation, water supply period, status of water related disease and household evaluation of existing water supply situation such as quantity and reliability. The second section consists of contingent valuation question. In this section hypothetical market scenario was developed based on the expected situation of improved water supply. In this section of the questionnaire to elicit households' willingness to pay, the dichotomous choice format questions with one additional dichotomous choice and with open ended follow up questions was used. In the third part of the questionnaire, questions related with socio economic and demographic characteristics of the households such as sex, age, education level and family size of the respondent as well as average monthly income were included based on Mitchell and Carson's (1989) method.

After designing the draft questionnaire, pre testing was conducted through focus group discussion with estate water supply section head and seventeen randomly selected households. In the pre-test, an open ended question was used to elicit the WTP amount by asking respondents to state the maximum amount they would be willing to pay for water per 20 L containers. The purpose of the pre test was to assess if there is a need to make modification on the designed questionnaire, to choose appropriate payment vehicle and to obtain starting values (as close-ended with an open-ended follow up format is used) so that the objective of the survey can be met.

Based on the pre-test, the order of the questionnaire was restructured, making questions on household characteristics (particularly question with economic characteristics, income) to appear in the last part; the willingness to pay section was polished so that it becomes easier to understand by both the respondents and the interviewers; the payment vehicle is chosen to be monthly tariff; and the starting bid value was also obtained. In the pre test, six households from plantation villages (E3 and R3) were willing to

Figure 1. Severe tooth fluorosis.

pay ($0.004, $0.009, $0.009, $0.009, $0.013, $0.009 /20 L). Hence $0.009 is used as one starting value. Six households from factory villages were willing to pay ($0.022, $0.022, $0.044, $0.031, $0.035, $0.022 per 20 litres). Hence, the average $ 0.022 is used as second starting point. Five relatively rich households from factory village were willing to pay ($0.044, $0.066, $0.044, $0.088, $0.088 /20 L). Hence, the average $0.044 is used as the third starting value. The starting prices ($0.009, $0.022 and $0.044) were equally and randomly distributed in all the villages interviewed. Households interviewed in the pre test were not included in the main survey.

A total of four enumerators two of them diploma holders and two college students and two supervisors including one of the researchers participated in the main survey. For this purpose, two days training was given to enumerators on the nature of the survey and how to administer it. The survey was conducted from October 15 up to November 5, 2008.

Hypothetical scenario

Hypothetical market scenario was designed to show the before project (current water supply) and after project (improved water supply) situations of the sugar estate and presented to the respondents. Before the project:- WSSE has been supplying potable water to the employees free of charge since its establishment. But the quality and reliability of water supply is not up to the standard. For instance, the fluoride content of water ranges from 2.4 mg/l up to 18.8 mg/l which is by far greater than the permissible concentration of 1.5 mg/l. This excessive concentration of fluoride is the cause of dental fluorosis in children and skeletal fluorosis in adults (Figure 1). This leads to additional cost for medication and early retirement from job. The prevalence rate of dental fluorosis ranges between 69 and 98%.

Moreover, the occurrences of disease related with poor quality of water result in wastage of working time, less productivity and hence fall in income and loss of life in worst case. After the project:- To solve problems related to water quality the Wonji Shoa sugar estate is planning to supply clean and reliable tap water to the employees. This water is safe for health, and is available for use at any time and collection of water need not take much time and effort. The investment cost will be covered by the estate and extrapolate to the users by charging monthly water bill.

Empirical model

The dichotomous choice format followed by open ended question that finally produce continuous value of the respondent including zero, will be used to elicit the willingness to pay for quality water supply. Tobit econometric model was used to analyse the determinants of WTP and the maximum amount of money that individuals are willing to pay. This model has an advantage over other discrete choice models (Linear probability model, logistic, and probit) in that, it reveals both the probability of willingness to pay and the maximum WTP of the respondents. Following Maddala (1997) and Jhonston and Dindaro (1997), the Tobit model can be defined as:

$$MWTP_i^* = \beta_0 + \beta' X_i + \varepsilon_i$$

$$MWTP_i = MWTP_i^* \; if MWTP_i^* \succ 0 \qquad (1)$$

$= 0$ if $MWTP_i^* \leq 0$

where MWTP is a vector of willingness to pay which is censored at 0; X is a matrix of explanatory variables that are hypothesized to influence willingness to pay; β is vector of unknown parameters to be estimated corresponding to the matrices of explanatory variables X; ε is error term which could be independently and normally distributed with mean zero and common variance sigma square and; $MWTP_i^*$ is a latent variable corresponding to MWTP. Note that a value of MWTP is observed when it is greater than zero.

It may not be sensible to interpret coefficients of a Tobit regression 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 Long (1997) and McDonald and Moffitt (1980) the following techniques could be used to identify the effects of explanatory variables on the probability of WTP and on the amount respondents are willing to pay. The marginal effect of an explanatory variable on the expected value of the dependent variable is:

$$\frac{\partial E(MWTP_i)}{\partial X_i} = F(z)\beta' \qquad (2)$$

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

The change in the probability of willingness to pay as independent variable X_i changes is:

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

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

$$\frac{\partial E(MWTP_i / MWTP_i^* \succ 0)}{\partial X_i} = \beta' \left[1 - Z\frac{f(z)}{F(z)} - \left(\frac{f(z)}{F(z)} \right)^2 \right] \qquad (3)$$

where, F(z) is the cumulative normal distribution of Z, f(z) is the value of the derivative of the normal curve at a given point (that is, unit normal density), Z is the Z-score for the area under normal curve, β' is the vector of Tobit maximum likelihood estimates and δ is the standard error of the error term.

Table 1. Descriptive statistics.

Variable	Mean	Std. dev.	Min.	Max.
gender	0.66	0.48	0	1
Education level	0.75	0.44	0	1
Household size	4.59	1.82	1	10
Age of the respondent	41.63	8.45	28	60
Household income per month in US dollar	149.58	82.43	25	303
Perception about quality of existing water source	0.89	0.31	0	1
Incidence of flurosis in the household	0.83	0.38	0	1
Type of employment	0.78	0.42	0	1
Reliability of the existing water source	0.84	0.37	0	1
Bid value in US dollar	0.02	0.13	0.01	0.04
Willingness to pay in US$	0.025	0.019	0	0.07

Table 2. Maximum likelihood estimates of Tobit model.

Variable	Estimated coefficients
Constant	10.4121 (7.2964)
Age of the respondent	-0.4171*** (0.13679)
Education level	6.9243** (3.2337)
gender	-0.3805 (1.9475)
Household size	-2.8082*** (0.5486)
Perception about quality of existing water source	13.0167*** (4.4415)
Reliability of the existing water source	6.7383* (3.4436)
Type of employment	-6.1514 (4.0244)
Household income	0.0166*** (0.0013)
Incidence of flurosis in the household	0.0713 (2.8570)
Bid value	0.0318 (0.0557)

***, **,* indicates significance at 1, 5 and 10% levels respectively. Figures in parentheses are standard errors.

RESULTS AND DISCUSSION

Data description

The descriptive statistics results are presented in Table 1. Expecting that household size and age could affect willingness to pay, these were included as repressors. Income, education level of the household head and gender are another set of variable that are expected to influence willingness to pay. The incidence of flurosis, reliability of existing water supply source, perception about quality of existing water supply and type of employment is also used as explanatory variables. To test whether or not the stated willingness to pay is sensitive to the bid value randomly assigned to respondents, bid value was also included. Moreover, we also report the mean willingness to pay of the sampled household.

Determinate analysis

Estimate of the parameters of the variables expected to affect willingness to pay for quality water supply are shown in Table 2. The dependent variable is a continuous variable that individuals respond as maximum willingness and ability to pay for the improvement service recalling the benefits expected out of it. A total of 10 explanatory variables were considered in the econometric analysis, out of which six variables were found to significantly influence the individual willingness to pay for quality water supply. The parameter estimate for the income variable was significant ($P<0.1$) and positive, as expected, indicated that richer households are willing to pay more. Hence, income is a strong determinant in explaining willingness to pay and any attempt to introduce cost sharing for the provision of quality water should take into account ability of the users in addition to their WTP.

The marginal effect result presented in Table 3 shows that when the income of the household increases by $1, it will increase the probability of willingness of a household to pay for quality water by 0.03%. Also, when income of a household increase by $1, the amount of cash the household could pay for quality water would increase by

Table 3. Marginal effects of the explanatory variable on the amount of willingness to pay.

Explanatory variable	Change in probabilities as independent variable changes	Change among individuals who are willing to pay	Change among the whole
Age of respondent	-0.00079	-0.40122	-0.40985
Education level	0.022438	6.467184	6.71049
gender	-0.00071	-0.36599	-0.37374
Household size	-0.00534	-2.69919	-2.75722
Quality Perception	0.101342	10.96319	12.05092
Reliability	0.024783	6.233591	6.502169
Type of employment	-0.00694	-6.00997	-6.08532
Household income	0.000317	0.015999	0.016344
Case of disease in household	0.000137	0.068536	0.070019
Bid value	$6.06^{*}\ 10^{5}$	0.030607	0.031265

0.016 cents, other factors being constant. The variable that measure age of the respondent had the expected negative parameter estimate, suggesting that older people have shorter planning horizon and are willing to pay less than younger generation. The marginal effect result shows that for each additional increase in age of the respondent, the probability of the willingness to pay for quality water supply will decrease by 0.079%. Also, as the age of a respondent increases by one year, the amount of cash he is willing to pay for quality water may decrease by 0.4012 cents, *ceteris paribus.* Household size was found to have significant ($P<0.1$) and negative effect. This suggests that willingness to pay for quality water supply decreases as household size increases. This might be due to the availability of labor to collect water from other source or the high opportunity cost of using income for clean water, due to high demand for food and other necessities in such families. The marginal effect result shows that when the family size of a household increases by one person, it will decrease the probability of willingness of a household to pay for quality water by 0.53%.

Similarly, when the family size of a household increases by one person, the amount of cash a household is willing to pay for quality water may decrease by 2.6992 cents, other factors being constant. Education level of the respondent was another variable found to be significant ($P<0.05$). Since the parameter estimate is positive, it implies that educated respondents tend to be willing to pay more than uneducated ones. This is perhaps because educated household tend to be more aware about the impact of dental and skeletal fluorosis. The marginal effect of the result shows that the respondent being educated, the probability of willingness to pay for quality water increases by 2.24%. Also, as the years of education increases by one year, the amount of cash the household is willing to pay for quality water may increase by 6.4672 cents, other factors held constant. Reliability of the existing water supply was found to have significant ($P<0.1$) effect with a negative parameter estimate. This means that as respondents feel the existing water supply is unreliable; he/she become more willing to pay for improvement. This is perhaps because searching water from another source is time taking and tiresome. According to Table 3, the marginal effect of the variable shows that those respondents having reservation on the reliability of the existing water source will have 2.48% more probability of paying for quality water supply than those who are satisfied. Also, respondents having reservation on reliability of the existing water supply, would pay 6.2336 cents more than those respondents satisfied with the existing source, other variable held constant.

The coefficient for respondent perception about quality of water services has positive and significant ($P<0.1$) effect on WTP. One possible reason could be those household who perceive the poor quality and health hazards of the current water service are likely to pay more for improved water services. The marginal effect of this variable reveals that respondents who perceived the existing water quality to be poor have a 10.13% more probability of paying for quality water supply compared to respondents who did not recognize the quality of water. Those respondents who perceived poor quality of water are willing to pay 10.9632 cents more for quality water than those who perceive the water quality is acceptable, *ceteris paribus*. The parameter estimate for initial bid value was positive but not significant suggesting that there is no significant starting point bias. This could be due to the care taken in conducting the survey work.

Derivation of aggregate demand and estimation of consumer's surplus for quality water supply

The aggregate demand for drinking water has been derived from WTP information. The aggregate demand curve is derived using the mid willingness to pay amount along the vertical axis and the number of households' willing to pay at least that mid value per 20-L container

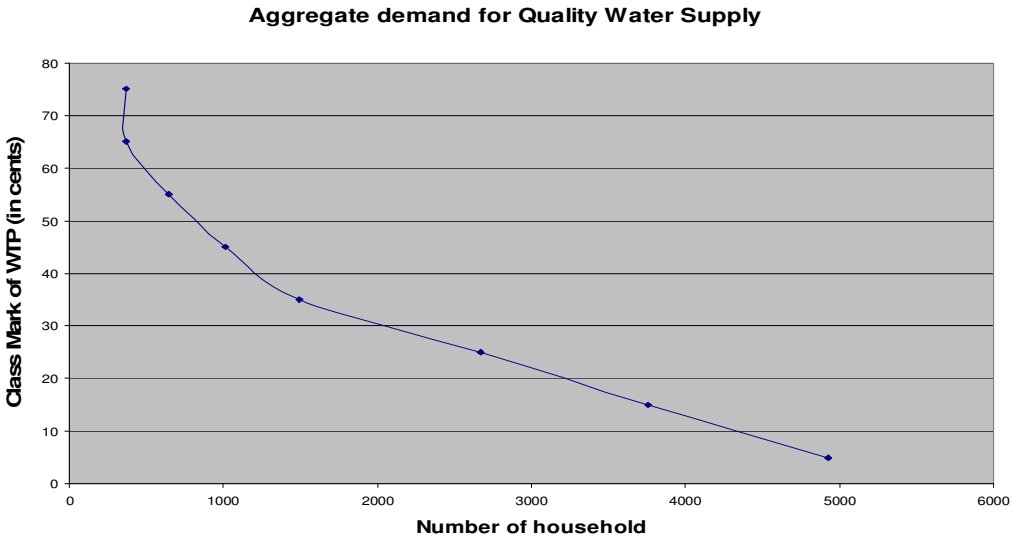

Figure 2. Estimated demand curve for improved water supply service in WSSE.

along the horizontal axis, (Figure 2). The figure shows the aggregate demand curve for the improvements in water supply services using the observations in the study. Any point on the curve shows all the households that prefer the improved water service but do not bid more than the corresponding value on the mid WTP axis. In order to get the demand in terms of quantity, it just requires multiplying the number of households by average daily consumption of water at each point. The demand schedule that has been derived could helps policy makers to make sound water tariff decisions and investment. The information on the frequency distribution of WTP bids is also useful in estimating the demand for improved water services in terms of the tariff versus number of households.

As shown in Figure 2, the demand curve is negatively sloped indicating the fall of the demand for improved water supply service as user charges increase, like most other economic goods, other things remaining the same. If water is considered as a free resource to the society, the consumers' surplus would be the total area under the demand curve. The area under the demand curve represents the gross value of consumers' surplus if the tariff rate is zero. Therefore, the gross consumer surplus is estimated at Birr 1505.60 or $ 132.54 if every household is using only 20 L per day from quality water services, with supply left unrestricted. Considering the average daily water consumption of 60 L per household, the daily total consumer's surplus will be Birr 4,516.74 or $ 397.60 if the consumption per household is only one unit (20 units container). The analyses also give an indication about water supply fee to be charged per unit. Current tariff rate of Oromiya Regional Government Water Resource office is $ 0.0049 for consumption from 0 to 3 M^3, $ 0.0056 for consumption from 4 to 5 M^3 , $ 0.0067 for consumption from 6 to 8 M^3, $ 0.0081 for consumption from 9 to 11 M^3 and $ 0.0099 for consumption above 11 M^3 at private connections and $0.0044 at public tap for 20 L of water. This cost covers only the operation and maintenance cost. Thus, if the estate proposes a flat tariff rate for the new service at $ 0.013 per 20 L, which is well below the mean WTP of own survey $ 0.025 per 20 L, the inhabitants of WSSE are willing to share the cost of the estate. This helps the government in general and the estate in particular to implement the national water resource policy objective.

The total financial benefits of the quality water supply project are the sum of expected revenue of the estate, consumer's surplus to the society, and the dead weight loss. If tariff is set for water supply services, the consumers' surplus discussed earlier can be minimized by shifting consumer surplus partly to dead weight loss and partly to the revenue of the estate. If a new tariff rate of $ 0.013 per 20 L is implemented the consumers' surplus (CS) decreases from 132.53 to $ 72.94 for consumption of 20 L per day. The rest of the benefit is distributed to the estate out of which $ 49.63 in the form of revenue and $ 9.96 as a dead weight loss (DWL) per 20 L per day. In general, the results of this study can serve as a useful tool for federal, regional government and the estate for improving water supply services, and as a spring board for future detailed study. The aggregated WTP amounts shows that the estate could collect sufficient resource for both service modernization and could also reduce existing subsidies.

Conclusions

Urban water supplies provided by public utilities are facing an acute crisis in many developing countries. As such, the urban and industrial centers of Ethiopia are also

characterized by poor water supply services. At the moment, Wonji Shao sugar estate (WSSE) is providing unreliable and poor quality water service. In this paper, we used the contingent valuation method to analyze the willingness to pay (WTP) of households for improved water supply and the determinants of households WTP. Tobit econometric model was used for determinant analysis. The result of this study showed that income, household size, age of the respondent, education level of the respondent, reliability of the existing water supply and respondent perception on the quality of the existing water source are important variables that explain the WTP for improved water supply.

Moreover, the inhabitants of the sugar estate were willing to pay more than the current water tariff rate of the federal and regional government. Important policy implications of these results are the need to consider the demand side of the market for water as opposed to the supply side in service providing development programs and the need to consider the effect of awareness, income and education in water development programs and design mechanisms to address them appropriately. Valuation of water services is the key component of an appropriate incentive for balanced and coordinated investment in the sector in different parts of the country. This study will serve as a springboard for further detailed studies. It should be noted that such studies should also be complemented by other studies including the examination of investment costs and a comparison of these costs with benefits measured using revealed, as opposed to stated preference.

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