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Willingness to Pay for Access to Improved and Reliable Piped Water: A Contingent Valuation Study in Kerala, India

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Abstract

Kuttanad lies at the very heart of the backwaters in Alappuzha district, southern part of India. It is the area with the lowest altitude in India, and one of the few places in the world where farming is carried out below sea level. The place is an amazing labyrinth of shimmering waterways composed of lakes, canals, rivers and rivulets. However, it is an example of scarcity among plenty in case of potable water. In the research study, the amount that the people of Kuttanad are willing to pay for accessing pure and potable water is estimated using contingent valuation method. Double bound dichotomous choice method is used to collect the WTP information and the actual amount people are willing to contribute is estimated using a logistic model. Using the model it was found that the people are willing to pay USD 0.67[1] per kilolitre of water. This means a family of four members is ready to pay around USD 5.64 per month if they get potable quality of water through pipeline at home. This is a very significant result considering the fact that currently a household pay an average of just USD 0.69 per month for the existing pipeline connection.

Keywords: Bid amounts, contingent valuation, dichotomous choice, logistic model, willingness to pay.

1. Introduction

Access to safe drinking water is one of the basic human rights. The Millennium Development Goals formulated at the summit of world nations under the auspice of United Nations in 2000 at New York consider access to safe drinking water as one of the priority goals (United Nations 2000). Compared to the dismal 69% of the people with access to sources of water in 1990, in 2010 overall 92% of the population of India have access to improved sources of water (World Health Organization 2012). However, this does not mean that all these people have continuous access to required quantity of safe and clean water. Water quality problems, insufficient supply of water and inadequate operation and maintenance are serious concerns which need to be addressed (Vedachalam 2012). This is mainly due to the fact that many of the water supply projects are still government-led and fully paid for by government with least beneficiary participation (World Bank 2013).

[1] Conversion rate used is USD=INR 70

As a response to this challenge government of India initiated sector wise reform measures wherein the government's role was limited to that of a facilitator and communities are expected to manage and contribute to the costs of water supply projects. With the advent of these reform measures World Bank and other international funding agencies like Asian Development Bank (ADB), Japan bank for international cooperation (JICA), etc. have increased financial assistance to the water supply projects in India. As a prerequisite for these foreign investments, it is made mandatory to assess the willingness of the communities to participate and contribute towards these projects. This is also required to demonstrate the viability of cost recovery and to ensure the success of the water supply schemes.

The study area Kuttanad, located in Alappuzha district of Kerala is globally acclaimed for its tourism potential. The wealth of paddy in the area is what earned Kuttanad its unique moniker. It is the area with the lowest altitude in India, and one of the few places in the world where farming is carried out below sea level. The place is an amazing labyrinth of shimmering waterways composed of lakes, canals, rivers and rivulets. Although Mother Nature has profusely blessed Kuttanad with rivers, back water lakes and paddy fields, it is an example of scarcity among plenty in case of potable water. The existing clean water distribution projects managed by Kerala Water Authority failed to reach every needy household. The issue of access to clean and potable drinking water is a very old issue in this region which is still unresolved. Against this background, this research studied the existing water scarcity issues in the Kuttanad taluk and tried to estimate the amount that the residents of Kuttanad are willing to pay for access to potable water.

Contingent Valuation (CV) estimates the value people place on commodities that are not exchanged in regular markets by creating a hypothetical market place. The approach asks people the amount they are willing to pay (WTP) for a hypothetical project. Comparisons of stated and actual willingness to pay for piped water connections in Kerala, found that contingent valuation studies correctly predicted 91% of actual decisions to connect to piped water (Griffin et al. 1995). Contingent Valuation studies can be found in large numbers in estimating the amount people are willing to pay for improvement in water quality (Genius and Tsagarakis 2006), the value of national parks (Lee and Han 2002), improvement in health care (Bayoumi 2004), etc. WTP surveys were used to estimate project benefits in 80% of the 35 water supply and sanitation projects processed by ADB during 2000-2006 (Gunatilake et al. 2006). Majumdar and Gupta (2009) used CV method to estimate the amount people of Calcutta, India are willing to pay for good quality water. Considering a transition phase from fully subsidized to full cost recovery the study estimated that people are willing to pay USD 0.05 per kilolitre of water. The authors consider this amount as a base for full cost recovery payment regime which could be introduced in the future. Dasgupta and Dasgupta (2004) and Raje et al. (2002) have also studied WTP for water quality improvement in other parts of India. A review of contingent valuation method is available in Antony and Rao (2010).

The paper is organized as follows. Section 2 gives the study overview. The willingness to pay estimation methodology is posited in Section 3. Empirical findings are discussed in Section 4 and conclusions are drawn in Section 5.

2. Study Overview

The reliability and accuracy of a CV survey is critically dependent on the ability of the survey instrument to explain the project clearly, the ability to present the project appear plausible and on the creation of a realistic payment method for the project (Carson et al. 2001). As a first step, a meaningful and simple CV questionnaire relevant to the local realities was designed. The questionnaire prepared in English was translated to the vernacular language, Malayalam for the field study.

Complete information on the hypothetical project, the expected benefit for the local population, the amount required to pay to get the connection and the payment mechanism, if the project is implemented were documented in the questionnaire itself. It was clearly documented that by paying the charge, the subscribers will be supplied uninterrupted potable water with sufficient pressure. Also a market for pure water was created by mentioning about the reduction in expenditure in terms of less cost for health and more income by more productive days.

The monthly charge/ bid amount to be used for the survey was finalized after looking into the existing tariffs of various state water authorities. In the national capital Delhi the monthly tariff rate for domestic consumption of water varies from USD 0.04 to USD 0.52 per kilolitre based on the consumption pattern (Delhi Jal Board 2015). In Mumbai the charges are in the range of USD 0.14 to USD 0.57 (Maharashtra Jeevan Pradhikaran 2015). In Kerala, the charges vary from USD 0.06 to USD 0.57 per kilolitre depending on the usage. World bank estimated the cost of water per kilolitre in Kerala in decentralized community led approach and centralized government led approach as USD 0.62 and USD 0.87 respectively (World Bank 2013). Based on the various existing water tariffs and the World Bank study report the first bid amounts to be offered was randomly selected as one among; Rs. 20, Rs. 40, Rs. 60, Rs. 80, Rs. 100, Rs. 120 and Rs. 140 (USD 0.29, USD .57, USD 0.86, USD 1.14, USD 1.43, USD 1.71 and USD 2) per kilolitre of water. If the respondent answered yes to the first bid amount their willingness to pay 1.5 times the original amount was asked. In case of the respondents who were not willing/ able to pay the first bid amount their willingness to pay the half of the first bid amount was asked. Instead of asking respondents' willingness to pay per kilolitre their willingness to pay total amount based on the water they may require was asked. For estimating the total amount average per capita consumption of 70 litres as suggested by GOI for rural areas is assumed (Government of India 2005).

The study area was the entire Kuttanad taluk comprising 12 panchayats. The total population of the study area is estimated to be 210 thousand (Government of Kerala 2016). A stratified two stage sampling was used for the survey. Factoring in two stratifications and 7 bid amounts the sample size required for the analysis becomes 420 (Gunatilake et al. 2007). However, to include at least 25 to 30 samples from each panchayat ward, the total sample size for the study was fixed at 650.

3. Willingness to Pay Estimation

If the contingent valuation survey was as simple as to ask each individual the amount they are willing to pay for the project, a simple arithmetic mean would have given the average willingness to pay (WTP) amount. However, in a dichotomous choice method we only know that the respondent is agreed/ disagreed to pay the given amount for the project. If the respondent says yes then we can say that the actual amount the respondent willing to pay is in between the bid amount and a maximum limit (theoretical infinity). And when the respondent disagrees, it need not mean that the respondent is actually not willing to pay for the project, but just that he is not ready to pay the given bid amount (b). In this case he may be willing to pay an amount in the interval $0 \leq \text{WTP} \leq b$.

In the dichotomous choice with follow-up method we have two bid amounts and the estimation is more complex. Here if the respondent is willing to pay the initial amount, we ask whether he is willing to pay a higher amount. In case the respondent is not ready to pay the initial bid amount a lower amount is offered. Let b^1 be the first amount offered and b^2 the second amount offered. Then the actual amount a person is willing to contribute may be any of the following based on his answer to first and second bid questions.

1. If the individual answers YES to the first question and NO to the second, then his WTP is in the interval $b^1 \leq w < b^2$.
2. For an individual answers YES to the first question and YES to the second the actual WTP is $b^2 \leq w < \infty$.
3. If an individual answers NO to the first question and YES to the second his WTP is $b^2 \leq w < b^1$.
4. Finally if the individual answers NO to the first and again NO to the second question the actual WTP lies in the interval $0 \leq w < b^2$.

The unknown value the respondent willing to pay, ‘ w_i ’ can be estimated using the WTP function

$$w_i = z_i(X_{wi}, \beta_w) + \varepsilon_i, \tag{1}$$

where β_w represents a vector of parameters, X_{wi} denotes the influencing variables, and ε_i represents error term with mean zero and SD σ.

To the question to contribute given amount for the project under discussion the person will respond ‘Yes’ if

$$z_i'\beta + \varepsilon_i \geq b_i \tag{2}$$

and ‘No’ if

$$z_i'\beta + \varepsilon_i < b_i, \tag{3}$$

where b_i denotes the bid amount offered to i^{th} respondent.

This can also be written as;

$$P(\text{Yes}) = P\left(\varepsilon_i \geq b_i - z_i'\beta\right) \tag{4}$$

and

$$P(\text{No}) = P\left(\varepsilon_i < b_i - z_i'\beta\right). \tag{5}$$

If we assume that $\varepsilon_i \sim N(0, \sigma^2)$ the equation becomes;

$$P(\text{Yes}) = P\left(v_i > \frac{b_i - z_i'\beta}{\sigma}\right), \tag{6}$$

$$P(\text{Yes}) = \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{b_i}{\sigma}\right), \tag{7}$$

where $v_i \sim N(0,1)$ and $\Phi(\cdot)$ is the distribution function of standard normal distribution.

In a double bound dichotomous choice format, the probability for each of the four cases is as follows.

Case 1: Those who say ‘Yes’ to both bid amount

$$P(\text{Yes,Yes}) = P\left(w_i > b_i^1, w_i \geq b_i^2\right), \tag{8}$$

$$P(\text{Yes,Yes}) = P\left(z_i'\beta + \varepsilon_i \geq b_i^2\right), \tag{9}$$

$$P(\text{Yes,Yes}) = \Phi\left(z_i'\frac{\beta}{\sigma} - \frac{b_i^2}{\sigma}\right). \tag{10}$$

Case 2: Those who say ‘Yes’ to the first bid amount and ‘No’ to second bid

$$P(\text{Yes,No}) = P(b_i^1 \leq w_i < b_i^2), \tag{11}$$

$$P(\text{Yes,No}) = P(b_i^1 \leq z_i'\beta + \varepsilon_i < b_i^2), \tag{12}$$

$$P(\text{Yes,No}) = \Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^1}{\sigma} \right) - \Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma} \right). \tag{13}$$

Case 3: Those who say 'No' to the first bid amount and 'Yes' to second bid

$$P(\text{No,Yes}) = P(b_i^2 \le w_i < b_i^1), \tag{14}$$

$$P(\text{No,Yes}) = P(b_i^2 \le z_i'\beta + \varepsilon_i < b_i^1), \tag{15}$$

$$P(\text{No,Yes}) = \Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma} \right) - \Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^1}{\sigma} \right). \tag{16}$$

Case 4: Those who say 'No' to both bid amounts

$$P(\text{No,No}) = P(w_i < b_i^1, w_i < b_i^2) \tag{17}$$

$$P(\text{No,No}) = P(z_i'\beta + \varepsilon_i < b_i^2) \tag{18}$$

$$P(\text{No,No}) = 1 - \Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma} \right). \tag{19}$$

The probabilities defined in (10), (13), (16) and (19) represent the intervals illustrated in Figure 1.

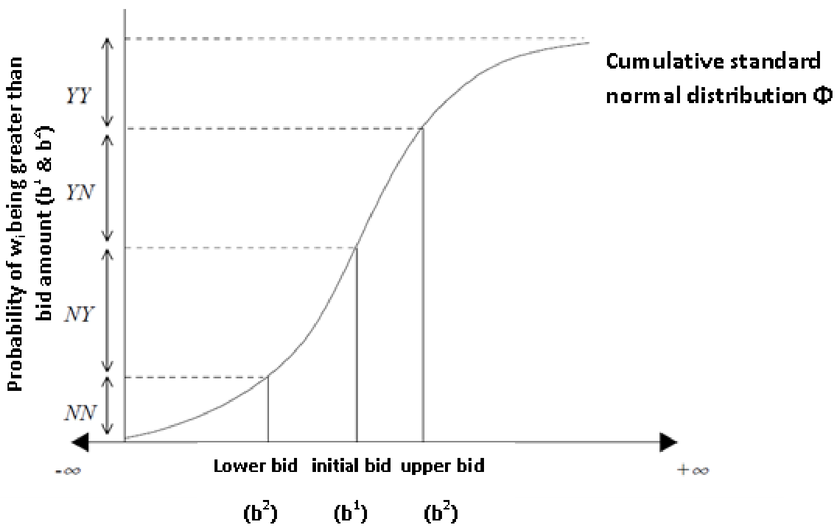

Figure 1 WTP intervals in double bounded dichotomous choice model

The log-likelihood function obtained by combining the expressions in (10), (13), (16) and (19) is

$$\log L = \sum_i \begin{bmatrix} I_i^{yy} \ln\left(\Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma} \right) \right) + I_i^{yn} \ln\left(\Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^1}{\sigma} \right) - \Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma} \right) \right) \\ + I_i^{ny} \ln\left(\Phi\left(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma} \right) - \Phi(z_i' \frac{\beta}{\sigma} - \frac{b_i^1}{\sigma}) \right) + I_i^{nn} \ln\left(1 - \Phi(z_i' \frac{\beta}{\sigma} - \frac{b_i^2}{\sigma}) \right) \end{bmatrix} \tag{20}$$

where $L_i^{yy}, L_i^{yn}, L_i^{ny}$ and L_i^{nn} are indicator variables taking the value 1 or 0 depending on the response of the i^{th} individual to the first and second bid amounts.

The coefficient value (β) is estimated using maximum likelihood estimation method. Then WTP value is estimated as

$$WTP = \tilde{z}'\hat{\beta}. \tag{21}$$

Model estimation and calculation of WTP was carried out in STATA (Lopez-Feldman 2010).

4. Empirical Findings

In any contingent valuation survey we must ensure that the respondents are sensitive to the bid amount. That is as the bid amount increases the percentage of respondents ready to contribute towards the project should decrease. In our survey overall 29% of the respondents answered positively to the first bid. To the lowest bid amount, 76% answered YES. As the bid amount increased the YES respondents were 49%, 32%, 17%, 12%, 6% and 4% respectively.

Overall 63% of the respondents are willing to contribute at least some amount for the project. This includes those who said YES to the first bid and those who said NO to the first bid, but YES to the low bid amount. Among the respondents with an existing pipeline connection only 51% are willing to contribute towards the project. Also it is interesting to note that among those respondents who are not happy with the quality or quantity of water they receive through existing pipeline connection, 71% are ready to contribute towards the proposed project.

Table 1 gives the coefficient estimates and z-statistics for the estimated model. Wald test proposed by Harpman and Welsh (1999) is used as the measure of goodness of fit. The Wald statistic indicates the improvement of the fitted model with covariates over a model with only constant term. A low p value indicates the failure to accept the null hypothesis that all estimated coefficients jointly equal to zero. This indicates the validity of the model. Variable water quality was a rank variable with 1 indicating very good quality and 5 indicating very bad quality. As expected the coefficient has positive sign which means that the respondents who are not getting good water prefer more to contribute towards the proposed project. The variable 'buying water' is an indicator variable specifying whether the respondent purchases water or not. The positive sign of this variable denotes that those respondents who have to purchase water prefer the project. The variable indicating presence of pipe connection is negatively related to the bid values. The model indicates that a male respondent is less likely to contribute towards the project. This is expected as generally the women in households are more concerned about the shortage of water and they are the ones who generally go and collect water in case it is not available in their own premises. The number of years of education of the respondent is considered for the model. The average number of years of education is 10. Education is found to be positively related. Working respondents are found to be more supportive of the project as indicated by positive sign for its coefficient. The average size of a family in the study area is found to be 4. The variable family size has a negative sign. This could be due to the fact that in big households there will be people to get water even if water is not readily available in own premises. One more reason could be, for big households the water requirement is more and therefore the amount they need to pay also will be more.

Table 1 WTP double bound model coefficient estimates

Variable	Coeff. Estimate	z-value
Constant	28.68	2.94*
Water Quality (Summer)	8.08	3.31*
Buying water	40.93	9.32*
Pipe Connection	-10.92	-3.17*
Gender (Male)	-7.55	-2.12*
Education of respondent	0.81	1.78*
Work respondent	5.94	1.64*
# of family members	-2.72	-2.56*
Wald	118.83	
p-value	<0.001	

Note: * indicates significance at ten percent level

Table 2 gives the WTP amount calculated based on the model. It shows that the people on an average are willing to pay USD 0.67 per kilolitre of water if they get quality potable water in the required quantity. This means a four member family is ready to pay USD 5.64 monthly for getting quality water.

Table 2 Willingness to pay amount

	Coeff.	Std. Err.	95% Confidence Interval
WTP Amount (USD)	47	0.02	[0.64 0.73]

Table 3 indicates the reasons why 37% of the respondents are not willing to participate in the project. From the table we can understand that the high tariff rates deter the respondents to say YES for the new project. The respondents who have pipeline connection expressed the feeling that they get water at much cheap rates. So it is natural that they won't be willing to pay high rates.

Table 3 Reasons for not willing to pay

Reasons	% of respondents
High rate & Financial constraints	48%
Water available at less tariff	47%
Good water is available	5%
TOTAL	235 (100%)

5. Conclusions

The study reveals that 63% of the respondents are willing to contribute towards the project. The amount people are willing to pay was estimated as USD 0.67 per kilolitre of water. This means a family of 4 members is ready to pay USD 5.64 monthly if they get required quantity of quality water through pipeline at home. This is a very significant result considering the fact that currently a household pay an average of just USD 0.69 per month for the existing pipeline connection. The fact that people are willing to pay USD 0.67 per kilolitre of water which is almost 9 times the amount they currently pay is a very significant indicator. It is to be noted that 51 percent of the households with pipeline connection are also interested in this project.

The funding agencies generally look for the economic viability any project. World Bank in 2008 estimated the total cost (including capital and maintenance cost) per kilolitre of water in a decentralized community led approach in India at USD 0.62. So this result is very significant as the government can approach international funding agencies more confidently for loans to implement water supply projects. The result is an attestation that if the water supply project is effectively implemented and the people are daily provided uninterrupted pure potable water, they will pay back the money through tariffs and this amount may be enough for loan repayment.

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