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Willingness to Pay (WTP) for Improved Drinking Water in Urban Areas: A Case Study in Tirupattur District

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Abstract

The World Watch Institute has declared water scarcity may be the most underappreciated global environmental challenge of our time (WWI: 2007), The demand for water is growing at an alarming rate (Nina Brooks: 2007), the Sustainable Development Goals (UNESCO: 2011) aims at reducing the proportion of people without sustainable access to safe drinking water. The study based on the following objectives, i) to estimate the WTP value of improved water supply in the study area. The second objective is to study the relationship between water quality and health hazards among the households. The study was conducted in Tirupattur district of Tamil Nadu in India and it has been found this is the most under developed district in the state. Total number of sample is 500 rural households. Multistage simple random technique was used to collect the data, WTP model were used to estimate environmental goods in money terms, cost of illness method was used to measure the health impact of the respondents. Finally, it has been noticed that people were willing to pay for the quality water.

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Introduction

Millions of Indians currently lack access to clean drinking water and the situation is getting worse day after day and demand for water is growing at an alarming rate. India accounts for 2.45% of land area and 4% of water resources of the world but represents 16% of the world population. With the present population growth-rate (1.9 per cent per year), the population is expected to cross 1.5 billion by 2050. The Planning Commission, Government of India has estimated the water demand has increased from 710 BCM (Billion Cubic Meters) in 2010 to almost 1180 BCM in 2050 with domestic and industrial water consumption expected to increase almost 2.5 times. The trend of urbanization in India is exerting stress on civic authorities to provide basic requirement such as safe drinking water, sanitation and infrastructure. The industry and its water use in India stands at about 50 billion cubic meters which is nearly six percent of total fresh water abstraction (Central Pollution Control Board, 2001).

Water Scarcity in Tamil Nadu

According to the State of Environment Report of Tamil Nadu, the population and area of Tamil Nadu account for 7 % and 4% respectively to that of India but the available water resources of the state account for only 3%. The total precipitation in Tamil Nadu is around 32909 MCM. The surface water availability is about 17,563 MCM ground water availability is around 15,346 MCM. The demand for water is continuously on the rise with the growth of population, industry and agriculture whereas the availability of water remains almost constant.

Background and Motivation for Research

Many studies have been conducted in the developing Countries to measure the WTP for water services and treatment options. Still there is knowledge gap in this area. How does drinking water quality affect household willingness to pay (WTP) for drinking water in Vellore district?

- What are the major health problems due to polluted water?

Objectives:

The specific objectives of the study are:

1. To analyze the different factors influencing the households' willingness to pay (WTP) values.
2. To study the cost of illness experienced by the households due to polluted water.

Water related CVM empirical studies

Considering domestic water demand behavior, especially in developing countries, has attracted sizeable amount of research attention during the past three decades. The most influential research in this area was sponsored by the World Bank between 1987 and 1990, and carried out by what came to be known as the World Bank Water Demand Research Team. Using mostly contingent valuation methods, the team conducted willingness to pay studies in several developing countries including Uganda Whittington et al., (1998), Nigeria Whittington et al., (1990), Philippines Bohm et al., (1993), Pakistan Altaf et al., (1993), India Singh et al., (1993), Haiti Whittington et al., (1990), Brazil Briscoe et al., (1990), and Kenya Mu et al., (1990).

Most of these studies were conducted in the perspective of rural water supply. Following the prolific work by the World Bank Water Demand Research Team, several researchers have adopted the methodology and conducted similar studies in different contexts e.g., Perez-Pineda, (1999), Whittington et al., (2002), Hopkins et al., (2004), Gulyani et al., (2005) Casey et al., (2006), Pattanayak et al., (2006), Venkatachalam, (2006). The findings from this research generally confirm the set of WTP determinants revealed in earlier studies. For instance, Perez-Pineda's, (1999) study in four rural communities of El Salvador, Central America, showed that existing service characteristics, price of the improved service, together with a number of socio-economic features of respondents, are important determinants of willingness to pay. Similar findings are reported in studies conducted in four rural communities of Rwanda (Hopkins et al., 2004), the city of Manaus in Brazil (Casey et al., 2006), the town of Negombo in Sri Lanka (Pattanayak et al., 2006) and the peri-urban area of Mandapam in Coimbatore, India (Venkatachalam, 2006).

Methodology

Since Tirupattur district is encompassed with many industries, and these industries are letting out enormous amount of effluent into the open fields and river streams thereby contaminating the ecosystems. Due to this, water quality is very poor and it affects the health of the people in many ways. The investigator felt it is appropriate to do a study on willingness to pay for improved water in this district.

Tirupattur district, six blocks were selected only Vaniyambadi block showed unacceptably high salinity in the water throughout the year. Except few villages the water quality is better in but, drinking water supply is very less in this block to have test of urban areas and to know the peoples' willingness to pay for improved drinking water the investigator selected Vaniyambadi. On the basis of the water quality the wards are classified into severely affected villages and moderately affected villages. From the selected Taluks, five rural wards and five urban wards were selected for the study. were chosen at random. Total number of sample is 500, consisting urban households. The data are collected by both primary and secondary methods. The primary survey is carried out with the help of a well-structured and pre-tested schedule, specially designed for the objectives specified. Secondary data are collected from the local bodies like, Tamil Nadu Water Supply and Drainage Board at district level, Census Reports, District-Collectorate, Village Administrative Office, Journals, electronic sources and reports of research and non-governmental organizations. Primary household survey was conducted from March 2020 to December 2021.

The data collected from primary sources are analyzed with the help of both descriptive and quantitative tools. The percentages of household's distribution such as gender, education, rural urban etc., were also calculated. To determine the factors influencing the willingness to pay for improved water is analyzed with the help of Ordinary Least Square method. Logit model was used to find the factors influencing the visit to the doctor who was affected by water-borne sicknesses.

Describing the Economic Model for Willingness to Pay:

Water is a commodity which is not traded in the market and it is considered non-market commodity. To estimate willingness to pay for water non-market valuation technique is needed. Non-market valuation helps to estimate environmental goods in money term.

Consumer choice, both market and non-market commodity depends upon price as well as utility function. It is called as compensated demand function, otherwise known as Hicksian demand function. Consumers would like to maximize their utility from both quantity and quality of goods and services, according to their income and budget constraints.

The utility function *U* (q,m) ---- (4.1)

q = water quality

m = composite of all market goods

The expenditure function E (p, q, u) --- (4.2)

The consumer expenditure function E (p,q,u) is the minimal cost to the consumer for achieving utility level and quality product, when the price is p. The expenditure function is increasing function of 'price' and 'utility' and decreasing function of 'quality'.

Since the consumer wants to stay with the same utility, it is appropriate to use expenditure minimization problem.

Min (m + Pm) ----------------------- (4.3)

Subject to *U* = U (q, m) Where composite goods are equal to one (Pm = 1).

To solve the minimization problem and to obtain Hicksian demand for the corresponding goods, Lagrange's multiplier can be used.

The Hicksian demand is given as:

$H_d = H_d(p,q,u^*)$ ------------- (4.4)

By substituting the values of Hicksian demand in the minimum expenditure function to calculate the minimum expenditure

E* = E (p, q, u*) ---(4.5)

Minimum expenditure needs to achieve fixed level of utility *u** by using q level of water quality and it is determined by the price of other goods, the fixed level of utility and the water quality.

The expenditure function derivation, with respect to price gives corresponding Hicks's demand function.

$\partial E/\partial p_i = H_d(p,q,u^*)$ ---------- (4.6)

Willingness to pay for the improved water services is the integration of the marginal willingness to pay for the improved water quality

$$WTP = -\int_{q}^{q^*} \partial E(q, u^*)/\partial q \times dq \text{----- (4.7)}$$

Maximum amount of money, the consumer would be willing to pay in order to enjoy improved quality. The willingness to pay for the improved water quality is

WTP = E (p, q, u) – E (p, q*, u)

Where, *q* is polluted water and q* is an improved level of quality.

The difference in expenditure is either due to compensating surplus or equivalent surplus. If the utility level is initial it is known as compensating surplus, if it is final then it is equivalent surplus. WTP depends on age, location, occupation, income, household education level; waterborne diseases etc. [Whittington, *et al.* (1990); Briscoe, *et al.* (1990), and Altaf, *et al.* (1992). To get various determinants of *WTP* the following regression analysis is used.

$$\begin{aligned} WTP = {} & \beta_0 + \beta_1 WD + \beta_2 Age + \beta_3 HSize + \beta_4 Gender + \beta_5 Edu + \beta_6 Occu + \beta_7 NEM + \beta_8 MIF \\ & + \beta_9 NWBS + \beta_{10} NTA + \beta_{11} WBS + \beta_{12} DIS + \beta_{13} QW + \beta_{14} HT + \beta_{15} PCW \\ & + \beta_{16} TC + \beta_{17} IC + \varepsilon \end{aligned}$$

Where,

$\beta_0 =$ Constant

$\beta_i (i = 1,2,...17) =$ Regression coefficients

$WTP =$ Willingness to Pay (in Rs.)
$WD = Ward =$ Rural or Urban (Dummy variable taking value 1 for urban and 0 for rural)
$Age =$ Age of the household (years)
$HSize =$ Household size (Family Size in numbers)
$Gender =$ Sex of the household; Dummy variable taking value 1 for male and 0 for female
$Edu =$ Educational level of the respondent (0= no schooling; 1=primary; 2= secondary and
3=high school;4 = higher secondary; 5=higher education
$Occu =$ Occupation of the household (1=agriculture; 2= own business; 3=government employee and 4= others
$NEM =$ Number of earning members in the family
$MIF =$ Monthly income of the family in rupees
$NWBS =$ Number of family members affected by water borne sickness
$NTA =$ Number of times affected by water borne diseases
$WBS =$ Incidence of water borne disease (Dummy variable taking value 1 if affected by
Water borne disease and 0 otherwise)
$DIS =$ Distance between public tap and house
$QW =$ Water quality index
$HT =$ House type (1=hut; 2= tiled; 3=asbestos sheet and 4=concrete)
$PCW =$ Consumption of water per month
$TC =$ Total cost (Rs.) of treatment for water borne disease
$IC =$ Individual water pipe connection to home (Dummy variable taking value 1 for
Individual water pipe connection and 0 otherwise)

$\varepsilon =$ Error term
Dependent Variable: WTP (Rs.)

Logistic Regression

Cost of Illness (COI) approach was used to study the economic valuation of health impacts. For this purpose a logistic regression was used with visit to doctor as the dependent variable (it will take the value 1 if the respondent has visited the doctor or 0 otherwise.). the model can be written mathematically as

$$ln\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k + \varepsilon \quad (4.2.1)$$

Where p is the probability of visiting the doctor by the respondent, X_1, X_2… are independent variables which are assumed to influence the probability. The following variables were chosen for this purpose:

1. Family Size
2. Monthly income of the family
3. Ward (Urban or Rural)
4. House Type
5. Income Loss
6. Number of earning members per family

Results:

To estimate the willingness to pay value for improved water supply many socio-economic factors are taken into consideration.
Urban people are willing to pay Rs.411.80 for three months, whereas rural households WTP are Rs. 362.65.
Nearly 72 percent of the people draw water from Pubic tap. 95 percent of the people paying Rs. 50 per month either to the local authorities or as a bribe to the people who

are responsible to supply to get more amount of water. Own house peoples WTP is Rs.389.14, it is almost equal to total WTP Rs. 387.23. Whereas the people living in the lease are willing to pay very less amount of Rs. 318.39. Nearly 85 per cent of the households have been living in their own house.

To analyse the factors influencing the households' willingness to pay value OLS (Ordinary Least square) model was used. It has been found that 6 out of 17 variables included in the model influence the WTP value significantly. The remaining variables although not statistically significant, give us the expected sign. The study reveals that the households are affected by different types of waterborne diseases nearly 76 percent of the sample households are affected by some or other water-borne sicknesses. Especially people are affected by diarrhea and Skin diseases. 18.2 percent of the sample households are frequently affected by diarrhea and 10.6 percent are affected by skin problem. Next most prevailing sickness is frequent attack of cold and cough it comes up to 7.2 percent. 6.4 percent suffered by allergy, and Gastro entry it is 6.2 percent 5.4 percent of the people have respiratory and Kidney stone Problem. Thyroid problem has been also prevailing in these areas, 4.8 percent people had this problem. Water borne sicknesses like asthma, tuberculosis etc., are also existing.

Table-1 Regression Analysis

Variable	Regression coefficient	coefficient	Std. Error	t-value	p-value
Constant	β_0	167.063	78.702	2.123	0.034
Ward	β_1	38.278**	17.336	2.208	0.028
Age	β_2	-1.117	0.773	-1.444	0.149
Hsize	β_3	-1.788	7.370	-0.243	0.808
Gender	β_4	-7.446	16.685	-0.446	0.656
Education	β_5	-4.710	9.976	-0.472	0.637
Occupation	β_6	-10.027	6.658	-1.506	0.133
NEM	β_7	29.764*	15.321	1.943	0.053
MIF	β_8	0.014***	0.002	6.187	0.000
NWBS	β_9	-25.716*	16.321	-1.976	0.098
NTA	β_{10}	-13.790	8.851	-1.558	0.120
WBS	β_{11}	19.785*	20.440	1.893	0.081
Distance	β_{12}	11.061	11.611	0.953	0.341
QWIndex	β_{13}	52.856**	23.280	2.270	0.024
HouseType	β_{14}	8.193	8.699	0.942	0.347
PCW	β_{15}	0.020	0.030	0.671	0.502
TCTR	β_{16}	0.000	0.001	0.074	0.941
Iconnection	β_{17}	9.352	23.238	0.402	0.688
R^2		0.19			

*, **, *** Significant at 10%, 5% and 1% respectively.

Table 2 ANOVA for the Regression Fit.

		ANOVA(b)			
	Sum of Squares	df	Mean Square	F	Sig.
Regression	3592735	17	211337.3	6.663	.000
Residual	1.53E+07	482	31717.76		
Total	1.89E+07	499			

Source: Primary Survey, Vellore District

The coefficient of determination is 0.19 implying that 19% of the variation in the dependent variable, viz, WTP can be explained by the fitted model and 81% is left unexplained. The ANOVA table shows the overall fit of the model as indicated by the significance of the F-ratio.

It is found that 6 out of 17 variables included in the model influence the WTP value significantly (Table-3). The remaining variables although not statistically significant, give us the expected sign.

The nature of the Ward (WD) influences the WTP significantly at 5% level. Its coefficient is 38.278 and it is significant at 5% level. The variable WD is a dummy variable taking the value 1 for urban location and 0 for rural location. The variable has expected positive sign; It shows that households in urban area are willing to pay more by an amount of Rs. 38.278 towards water supply.

The number of earning members in a household (NEM) having employment is strongly significant and its coefficient is 29.764 and it is positive and significant at 5 percent level. This means that for every one earning member increase in the family, the household will spend additionally Rs. 29.764 towards water supply. The sign of the coefficient is on the expected lines because it is generally hypothesized that more earning members will increase the earning capacity of the family which in turn will provide more spending on family expenditure.

It is found that as expected, the income of the households (MIF) positively and significantly influences the WTP value. Monthly income of the family (MIF) is strongly significant at 1 percent level. Its coefficient is 0.014 and it is positive. This implies that for every one rupee increase in monthly income, the household is willing to pay 0.014 rupees towards getting good water supply.

The next variable that is significant is number of members who are affected by water borne diseases (NWBS). Its coefficient is -25.716 which is significant at 10% level only. The next Variable that is significant is incidence of water borne sickness in the family (WBS). This is dummy variable taking value 1 if there is incidence of water borne sickness and 0 otherwise. Its coefficient has expected positive sign with a value of 19.785 and it is significant at 10 percent level. This means that incidence of water borne sickness in the family will induce an additional expenditure of Rs. 19.785 towards water supply.

The next significant variable is water quality index (QWindex) and its coefficient is 52.856 and it is significant at 5 percent level. Thus, water quality has a positive effect on WTP. The table on regression analysis results show that monthly income of the family (MIF), water quality index (QWindex), location (Ward), number of earning members (NEM), incidence of water borne disease (WBS) and Number of family members affected by water borne sickness (NWBS) are statistically significant implying that these six variables affect the amount the households who are willing to pay for providing good water supply

The next variable is 7respondent's Age on WTP. Usually, this variable affects willingness to pay for improved quality positively; older the person more will be the willingness to pay for improved water quality. WTP for improved water quality and reliability of supply is expected to be positively related to 8education. Because of education people may understand better the consequences of using unsafe water and the need to have reliable water supply. Usually, the size of the household (Hsize) is expected to have positive relationship with WTP value. Because, a greater number of household members means higher will be the water requirement and therefore the

WTP value of these households would be greater than the households with smaller size. However, the size of the household does not have any significant influence on the WTP value.

Generally,10 gender is supposed to affect WTP. Because women are the one who take care of domestic household chores such travelling to other places to fetch water in times of need, hence they will be willing to pay. However, the negative sign of the variable Gender in the regression analysis suggests that the women are willing to pay less than the men.

The variable11 (DIS) distance between public tap and house is insignificant. We expected that the distance would affect the WTP value. However, the households may have some other source of which is closer to their house, or they may be used to travel long distance to fetch water.

The next variable12 is occupation which is insignificant. It does not play an important role in WTP. This variable on the WTP value is insignificant implying that there is not much difference among WTP values provided by the variable occupation.

The education is strongly significant at 1% level. Its coefficient is 39.75 and it is positive. This implies educated people are more willing to pay than the illiterates and less educated.

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Even the 15number of times affected by water borne sickness is insignificant.

All together 11 variables have statistically insignificant coefficients. The model given in the equation above contains 17 variables and so it is difficult to use it for predicting WTP as it requires the values of all the 17 variables. Hence a stepwise regression analysis was performed to extract best sub-set of variables from the 17 variables that will have maximum explanatory power.

Regarding the cost of treatment variable nearly 32 percent of the household are not much affected by the water borne sickness and they are not spending any amount for the treatment. 50 percent of the people's treatment cost is only ranges between Rs. 50.00 and Rs.1200.00. Their mean value is Rs. 1185.00. For medicine 51 percent is spent only up to Rs. 1000.00 remaining 17 percent, excluding 32 percent who are not affected only spending Rs. 100.00 to Rs.14500.00. whereas the least amount is Rs. 685.50. Regarding conveyance cost minimum Rs. 50.00, and maximum Rs. 3000.00, income loss, from Rs.100 to Rs. 55000.00. In this category also nearly, 54 percent spent up to Rs. 1500.00; however, the mean value is Rs. 959.35. (Table-5.54)

The mean total cost value is Rs.2877.00. Maximum amount is Rs. 1,00,450. Standard Deviation is 6452.25; it shows lot deviation among the respondents. 31.8 percent don't spend any amount, whereas 50 percent of the household spend up to Rs. 4000 only. It shows nearly 18 percent spend the maximum amount up to Rs. 100450.

VISIT TO THE DOCTOR FOR TREATMENT

Shows that more respondents from rural are affected by water borne diseases. In fact, 73.6% of respondents in rural area are affected while 70.4% of respondents in urban area are affected by water borne diseases.

Explains that rural respondents are visiting the doctor more than urban respondents. It shows many rural people either working in the leather factory or living in a polluted area i.e. for example Vannivedu village people are educated and working in the factories and the place most polluted area. In terms of working days lost also rural respondents are more affected than urban respondents.

An average of 3.63 number of working days are lost per rural family while for urban it is 3.13. Income lost per family in rural is Rs. 1555 while it is Rs.1097 for urban.

The average expenditure on health by the respondents is in two wards. It shows that rural respondents are more affected in terms of expenditure than respondents in urban area. On the average, a respondent in rural spends about Rs. 3035 towards, medicine, treatment and conveyance while respondents in urban area spend about Rs. 1097 only. In terms of treatment, medicine and conveyance also rural respondents spend more than their urban counterparts.

The above analysis shows that due to water borne diseases, rural respondents are very much affected. Cost of Illness (COI) approach was used to study the economic valuation of health impacts. For this purpose, a logistic regression was used with visit to doctor as the dependent variable.

Table Logit Model for Visit to the Doctor

	Coefficient	*Std. Error*	*z*	*p-value*
constant	2.11975	1.8865	1.1236	0.26117
F. size	-2.03893	0.4998	-4.0798	0.00005***
MIF	0.00007	0.0001	0.9952	0.31965
Ward	1.44450	0.8087	1.7861	0.07408*
HouseType	-0.23872	0.2831	-0.8432	0.39909
Income loss	0.03146	0.0053	5.9547	<0.00001***
NEM	1.62043	0.63289	2.5604	0.01046**

*, **, *** Significant at 10%, 5% and 1% respectively

In the case of visiting to the doctor, out of six variables only four variables are playing a significant role in influencing the dependent variable. We would discuss the nature and magnitude of the influence of the various explanatory variables included in the model on visit to the doctor. (Table). The remaining variables although not statistically significant, give us the expected sign. The analysis shows that family size, ward, income loss and number of earning member per family are important determinants of the likelihood that the respondent will visit doctor for treatment as the coefficients of these variables are statistically significant.

Policy implications

Environmental regulations relating to the tanning industry must be clear and unambiguous.

The common effluent treatment plants are cost effective methods of pollution control. Government should take step to establish such plants at suitable locations. Not only for common effluent plant but it is also possible for all the tanneries to construct an individual treatment plant since all the tanneries are earning lot of profit out of export. They should have moral and social responsibility to control pollution.

Environmental awareness should be created in the minds of the people in surrounded area.

Conclusion:

The costs of pollution are not taken into account either in the internal costing or their charges to consumer but passed on to society. Most of these impacts are social and different places have different levels of impact, it is logical that their prices should include the implied costs of these social impacts as well. This study has been tried to value improved water as well as the economic valuation of health damage due to tanneries and other industries.

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