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Willingness to Pay for Improved Water Services: A Case of Darjeeling, India

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Abstract: This paper uses a Double Bounded Dichotomous Choice (DBDC) Contingent Valuation (CV) method to elicit willingness to pay (WTP) for improved water services in the hill town of Darjeeling in India. The findings of the bivariate probit model reveal that gender of the head of the family, age of the head, total time taken to collect water, water treatment, water source and distance were among the significant and the major determinants of WTP for improved water services. The WTP estimated using the delta method was about INR 494.00 (USD 1 ~ INR 60.00 as of March 2014) per month, which is about 12 times the amount they currently pay. A major policy implication is that there is a huge potential for investment in water projects in the town because of the high WTP and the households' preference for local water body or any organised service provider over the private water vendors.

Key words: Contingent valuation, willingness to pay, bivariate probit; double bound dichotomous choice (DBDC).

Introduction

Assuring a sustainable supply of water coupled with an improvement in the infrastructure is one of the major challenges in most of the urban areas in developing countries and to meet such challenges necessary resources need to come from domestic consumers (Oca and Bateman, 2006). Also the lack of information on household preferences regarding water services is a major impediment to implementing sustainable public water supply systems and identification of such household preferences may help in appropriate policy making (Vásquez, 2011). This highlights the importance of assessing the household's willingness to pay (WTP) for water improved services.

In Indian cities, water supply situation is very bleak and water is available for a few hours per day with a questionable water quality. No Indian city has a 24-hour supply of water, with 4 to 5 hours of supply being the norm, which is very poor as compared to the Asia-Pacific average of 19 hours per day supply (McKenzie and Ray, 2009). The main problems that the Indian cities face is that of operations and maintenance (O&M), low water pressure, ill designed transmission and distribution systems and unequal distribution within cities. It is estimated that by 2050, 50% of Indians will reside in urban areas (Assessment, 2002) which will further escalate the demand for water services.

This paper uses Contingent Valuation (CV) methodology with a Double Bounded Dichotomous Choice (DBDC) format to estimate the willingness to pay (WTP) and its determinants. The CV method is the most preferred and used method (Mitchell and Carson, 1989) which allows a researcher to measure the total value of the commodity in question (List, 2001). CV has been successfully implemented by the US Environmental

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Protection Agency (USEPA), National Oceanographic and Atmospheric Administration (NOAA) and the US Fish and Wildlife Service. This method is used either as Single Bound Dichotomous Choice (SBDC) or the Double Bound Dichotomous Choice (DBDC) format. The Double Bound Dichotomous Choice (DBDC) model was first proposed by Hanemann in 1985 and subsequently shown that the statistical efficiency of dichotomous choice CV can be improved by asking the respondent to engage in two rounds of bidding. Since then, the DBDC format has emerged as a tool to improve statistical efficiency in CV applications.

The findings from most of the CV studies reveal that in most cases at least fifty percent of the surveyed households is willing to pay for improved water quality and reliability of supply (Mofatt et al., 2011; Olanrewaju and Omonona, 2012). In one of the first evidence from South Asia, Whittington et al. (2002) show that the households' WTP for improved water in higher Kathmandu, Nepal was much more higher than their current water bills and there was a substantial support for a privatization plan that would improve the water services and also require all the households' to pay regularly and higher monthly bills. Tussupova et al. (2015) employed CV method to estimate WTP for piped water supply in Pavlodar Region, Kazakhstan and found that more than 90% of the consumers were willing to pay for better quality and regular supply. If we look into the CV findings on the determinants of WTP, distance to water source, location (urban/rural), age of the head of the household, education, gender, average monthly income, prices charged by vendors and water treatment practices are among the important variables (Bogale and Urgessa, 2012).

Description of Study Area

Darjeeling is an urban hill town in northern India and faces major problems in water services provided by the local municipality. Darjeeling is located in the Mahabharata Range or Lesser Himalaya at an average elevation of 6710 ft (2050 m). Established in 1850, the Darjeeling municipality (the local water body) is one of the oldest city administrative bodies in India and maintains the civic administration of the town, covering an area of 10.57 sq. km (4.08 sq mi). Water is tapped from about 26 natural springs which originate in the catchment area of Senchal Forest and Wildlife Sanctuary located about 15 km away from the main town. The water from the springs are collected in an Arrestor tank fed to the Masonry conduit line (about 8 km in length) which brings water on gravity to twin Senchal lakes (see Figure 1). The twin Senchal lakes, which were built in 1910 and 1932 respectively, have a storage capacity of 125 million litres. Water from these lakes are filtered and distributed to numerous subsidiary tanks located at various places of the town.

The existing water infrastructure, which was laid during the period 1910–1915 (before India's independence in 1947) and was meant for a population of about 15,000, is unable to cater to the needs of current population which has increased to 132,016 as per 2011 census. As per the figures provided by Darjeeling municipality, the total demand for water in the town is 75 lakh litres per day while total supply is 24 lakh litres per day with a deficit of 50 lakh litres per day. Out of 21,782 households in 32 wards of the town, only 2689 households (i.e. 12%) have municipal water connections and pay INR 500.00 annually as water bill to the municipality.

The rest of the paper is organised as follows. The second section discusses the survey methodology with a sub-section on model and estimation methods. Results are discussed in next section, and the paper concludes with some policy implications in the last section.

Survey Methodology

The questionnaire used in the study was designed especially keeping in mind the nature of problem that is persistent in Darjeeling which includes poor water infrastructure and supply constraints. Hence, a scenario formulation was made on the lines that there are "insufficient water supply", "poor infrastructure" and "acute water shortages" which becomes more acute during the dry season, and therefore, the vision plan would be to provide "improved water services (qualitative and quantitative)" in the town. A pre-test with a set of questions on socio-economic and demographic characteristics, housing, health, water use profiles and open ended questions on willingness to pay were asked to a randomly selected group of 40 households to gain initial insights and make necessary changes in the questions that were being asked before going for the main survey. The sample size of the main survey (and this study) consisted of 500 households and the descriptive statistics of the variables used are shown in Table 1. Based on the pre-test survey three bids INR 300.00, 500.00 and 600.00, were used as bids in the main survey.

The survey was administered with the help of college students from Government College in Darjeeling.

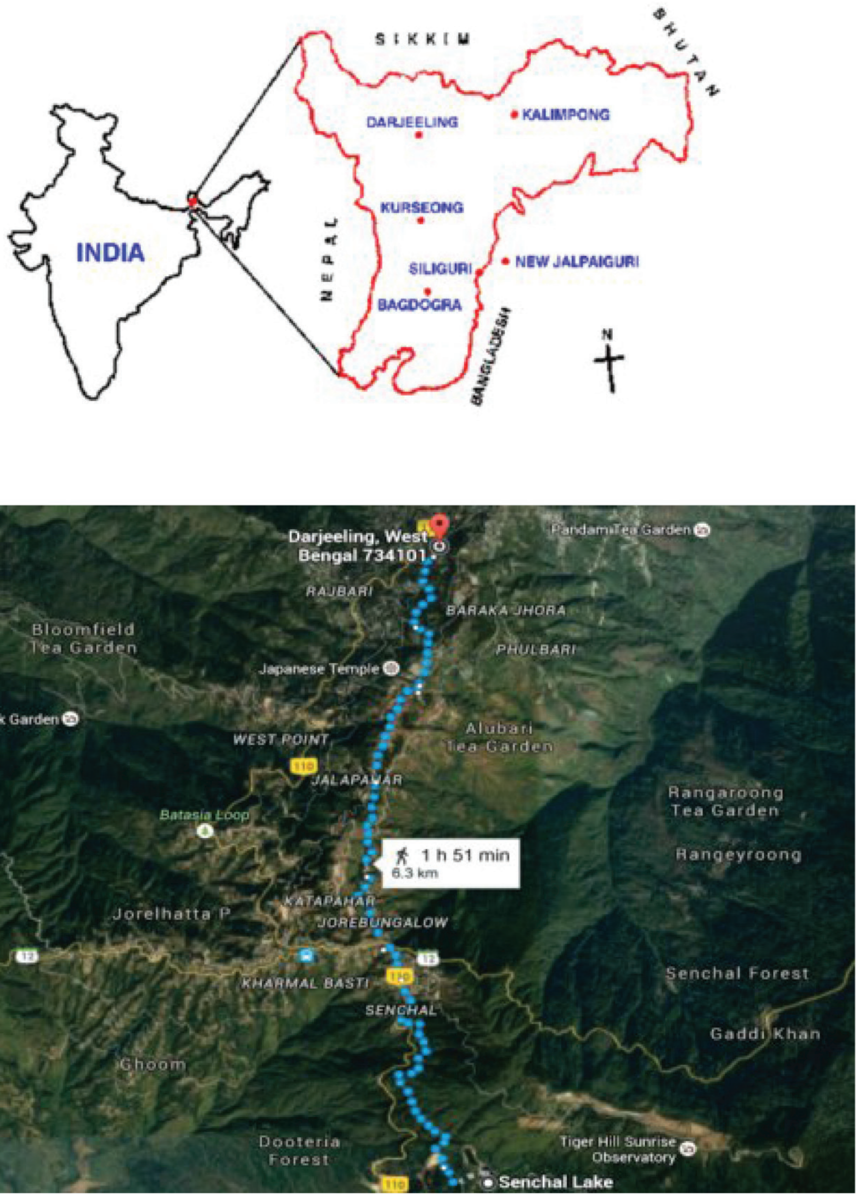

Figure 1: Maps of Darjeeling showing location and water source.
***Source:* Google maps**

The students were properly trained with classroom instructions followed by mock interviews within the group members. Almost all the students belonged to the town and they themselves had experienced the water problem in one-way or the other and they could understand the situation better which helped a lot during the field work. The questionnaire for the main survey was divided into five main sections. The first section contained questions on socio-economic and demographic characteristics. The main focus was to gather information on gender, age, education level, marital status, employment and the income of the household. The second section had questions on characteristics of housing, for example the ownership status of house, roof material, ground material, monthly expenses of the household and the ownership of physical assets. The third section focused on health and hygiene related to water use. The fourth section was based on the water use profile of the household and had questions on time taken to collect water, volume of water collected, the costs associated with water use and the perceived physical quality of water. This section

Table 1: Descriptive statistics

Variable	*Description*	*Obs*	*Mean*	*Std. Dev.*	*Min*	*Max*
Femalehead	Whether the head is female (1 = female, 0 = male)	500	0.144	0.3514413	0	1
Agehead	Age of the head of the family (in years)	500	48.15	13.53047	14	95
Eduhead	Educational status of the head (1 = literate, 0 = illiterate)	500	0.264	0.4412407	0	1
ttime	Total time taken to collect water (minutes/day)	500	44.471	36.749	2	300
Watsrce	Water source (1 = Kiosk selling water, 2 = Shared Yard Tap, 3 = Individual House Connection)	500	2.542	0.699439	1	3
Hhinc	Income of the hosehold per month (2014 INR)(0 = 0 to 10,000, 1 = 10001 to 30,000, 2 = 30001 to 50,000, 3 = above 50,000)	500	3	1.046387	0	3
Nworkers	Number of workers in the household	500	1.752	0.8671793	1	7
Treat	Water treatment before drinking (1 = treat, 0 = do not treat)	500	0.99	0.0995984	0	1
Female	Gender of the respondent	500	0.234	0.4237962	0	1
Married	Marital status (0 = unmarried, 1 = married)	500	1.25	0.790411	0	1
Employ	Employment status[#]	500	4.976	2.560574	1	10
Tyresid	Type of residence[##]	500	1.738	0.8214045	1	4
Ownership	Ownership of house (1 = owned, 2 = rented, 3 = others)	500	1.306	0.4825243	1	3
Distance	Distance from main road/town	500	2.5844	1.852085	0.2	17
Logexp	Log values of monthly expenditure per month (in 2014 INR)	500	3.85244	0.2535576	3.02	4.61
Col	Perceived colour of water (1 = colourless, 2 = clear, 3 = dirty)	500	1.72	0.7061142	0	3
Taste	Perceived taste of water (1 = good, 2 = bad)	500	1.024	0.1532023	1	2
Odour	Perceived odour of water (1 = good, 2 = bad)	500	1.074	0.2620331	1	2

[#]Choices: 1 = Unemployed, 2 = Vendor/Small informal business, 3 = Shop attendant/employee of a small business, 4 = Sells food in the market, 5 = Govt employee, 6 = Works for a large private company, 7 = Casual worker, 8 = Retired with pension, 9 = Farmer, 10 = Others (Specify)
[##]Choices: 1 = pucka, 2 = semi-pucka, 3 = kutcha, 4 = others.

also contained questions on water storage, treatment and consumption patterns of the households. The last section contained the Double Bound Dichotomous Choice WTP questions. Before the last section, scenario formulation/ introduction to CV scenario and a cheap talk script were included in the questionnaire which were read out to the respondents at the time of survey before the WTP questions were asked.

Over-estimation of willingness to pay is common and a major concern in CV studies with hypothetical markets (Mitchell and Carson, 1989). Cheap talk usually consists of scripts of varying lengths which explicitly inform respondents of the existence of hypothetical bias, and also ask them to respond as if they were in a real and not hypothetical situation (Cummings et al., 1995). The cheap talk script was read out to the respondents so that hypothetical bias is kept in check.

The WTP questions for the main survey were provided with the bid options obtained from the pre-test and were of Double Bound Dichotomous Choice (DBDC) type. The DBDC version was chosen as it improves statistical efficiency in contingent valuation studies (Jeanty et al., 2007a). The sample for the study was chosen by simple random sampling technique. Stratified random sampling could not be used in this case because of unavailability of households' information in advance. As per Census of India (2011), there were 21,782 households in 32 wards of Darjeeling town. Hence, a table of random numbers was used to select 500 random numbers that lie between 1 and 21,782, and the random numbers were assigned to the corresponding households.

Model and Estimation Methods

In this paper, bivariate probit is used to estimate the WTP values for the double bounded models because it provides a way of dealing with two separate binary dependent variables and estimates them together allowing for a correlation between the error terms of the two equations which in-turn helps recognize any unobservable characteristics (Jones, 2011). The essence of a double-bounded model is that the respondents are presented with initial bid prices and following their initial responses, they are provided with new prices (which may be higher if the initial response was yes and a lower price if the initial response was no). The answer sequences yes-no or no-yes yield clear bounds on WTP. In a general form the bounds on WTP are as follows:

1. $t^1 \leq WTP < t^2$ for the yes-no responses
2. $t^1 > WTP \geq t^2$ for the no-yes responses
3. $WTP \geq t^2$ for the yes-yes responses
4. $WTP < t^2$ for the no-no responses.

Following Habb and McConnell (2002), the basic econometric model for a double bounded question format is:

$$WTP_{ij} = \mu_i + \varepsilon_{ij}$$

where WTP_{ij} represents the j^{th} respondent's willingness to pay and $i = 1, 2$ denoting the first and the second question. And μ_i's are the means of the two responses. The probability of observing each of the possible two-bid response sequences is given by:

$$\Pr(\text{yes, no}) = \Pr(\mu_1 + \varepsilon_{1j} \geq t^1, \mu_2 + \varepsilon_{2j} < t^2)$$
$$\Pr(\text{yes, yes}) = \Pr(\mu_1 + \varepsilon_{1j} > t^1, \mu_2 + \varepsilon_{2j} \geq t^2)$$
$$\Pr(\text{no, no}) = \Pr(\mu_1 + \varepsilon_{1j} < t^1, \mu_2 + \varepsilon_{2j} < t^2)$$
$$\Pr(\text{no, yes}) = \Pr(\mu_1 + \varepsilon_{1j} > t^1, \mu_2 + \varepsilon_{2j} > t^2)$$

The j^{th} contribution to the likelihood function becomes:

$$L_j(\mu|t) = \Pr(\text{yes, no}) \times \Pr(\text{yes, yes}) \times \Pr(\text{no, no}) \times \Pr(\text{no, yes})$$

If the errors are assumed to be normally distributed with means 0 and respective variances of σ_1^2 and σ_2^2, then WTP_{1j} and WTP_{2j} have a bivariate normal distribution with means μ_1 and μ_2, variances σ_1^2 and σ_2^2 and correlation coefficient ρ. Since the choice response is dichotomous in nature, this normally distributed model is known as the bivariate probit model. The j^{th} contribution to the likelihood function of this bivariate probit model becomes:

$$L_j(\mu/t) = \Phi_{\varepsilon_1\varepsilon_2}\left(d_{1j}\left(\frac{t^1-\mu_1}{\sigma_1}\right), d_{2j}\left(\frac{t^2-\mu_2}{\sigma_2}\right), d_{1j}\, d_{2j}\,\rho\right)$$

where $\Phi_{\varepsilon_1\varepsilon_2}(.)$ = the standardized bivariate normal cumulative distribution function with zero means, unit variances and correlation coefficient ρ; and $d_{1j} = 2y_{1j} - 1$ and $d_{2j} = 2y_{2j} - 1$; $y_{1j} = 1$ if the response to the first question is yes and 0 otherwise and $y_{2j} = 1$ if the response to the second question is yes, 0 otherwise.

The WTP for each equation is calculated by the formula $\hat{\mu} = (\hat{\alpha} + \bar{X}\hat{\beta})/\hat{\beta}_0$, where $\hat{\beta}_0$ is the coefficient of the bid amount. The econometric analysis is carried out in STATA 13.0 which uses maximum likelihood (under the assumption of normality) to estimate the double bounded dichotomous choice model for contingent valuation. The details can be found in Lopez-Feldman (2012).

Results and Discussion

The survey design was made after a pre-test/pilot survey was conducted. A total of 40 households were surveyed during the pilot survey and the findings were used to get *a priori* bid values for the final survey. Based on the pre-test, the sets of bids used were: (300, 150, 600), (500, 250, 750) and (600, 300, 900) where the first element of each set represents the first bid, the second element is the lower bid for a "no" answer and the third element is the higher bid for a "yes" answer. A total of 500 households were surveyed and used in the analysis.

The majority of the heads of the household (about 79%) were in the age group 20 to 60, which means the majority were a working cohort and very much willing to contribute for better water services. Within this cohort about 27% of the heads were in the age cohort 20-40 which composed of newly married couples and independently living singles. The majority (38%) of the households earned between INR 10,000 to 30,000 and only 17% earned above INR 50,000. Therefore, the majority of the households do not belong to a very high earning class which has impacted their current water expenditure patterns. As seen in Figure 2, about 80% of the households were currently paying a little above INR 500.00 per month for water and 19% paying in the range INR 500.00 to INR 1000.00.

As far as access to urban amenities is concerned, the distance of the household from the town or main road was considered. In hilly terrains access to main road is one of the main factors because roads leading to each household or areas are very small and people can only commute by walking. So we wanted to know whether this factor has any effect on WTP. In the survey area, almost 96% of the households were within 5 km of the main road and the others in the range of 5 km to 15 km. At present, the main sources of the water in the area include individual house connection, shared tap yard, natural springs (wherever available) and kiosks and private vendors. The respondents were given all the above choices (excluding natural springs because they are a very few in numbers and sparsely distributed and they dry up every year after the monsoons are over) and asked which source they would prefer. More than 66% voted for individual house connections while a meagre 12% still wanted to buy from water vendors. So there is still a strong demand for water in the region which is in the form of a better service provided by the municipality or any water body as people prefer them over kiosks and vendors. Also, this stark demand for a provision of better infrastructure and the preference of the water body (municipality) over private vendors can be attributed to the total time that households in the region spend in collecting water. As seen in Figure 2, more than 80% of the households spend an hour per day or more collecting water and 17% spend two hours per day, and a majority of these households currently use shared water taps and buy water from water trucks.

The households were also asked about their perception of water quality and whether they treat water in any way before drinking. The majority of the households reported a bad taste (90%) and colourless water (70%) and they basically resorted to treat water by boiling (87%) and using water filters (9%). People in the hills mostly prefer hot water because of the weather, and one can also find that hotels and restaurants serve hot water with meals. Therefore, irrespective of the water quality people boil water and the observation from Figure 2 may not be fully attributed to water treatment. However, it may also be perceived that boiling may serve both these purposes of drinking hot water and treating it too. The description and descriptive statistics of the variables used in the model are summarized in Table 1.

Table 2 reports the results from the bivariate probit model. It can be seen that the coefficient of *femalehead* (the head of the family is female) is significant and positive indicating that WTP for improved water services is high if the head of the household is female. Also the older heads in the household tend to have higher WTP as suggested by a positive and significant coefficient of the variable *agehead*. The other significant variables are *ttime, watsrce, nworkers, treat, married, distance* and *odour*. Collecting water in hilly terrain is very time consuming as people have to wait in long queues and is also very difficult to manually carry large containers over steep slopes. The regression result shows that households are willing to pay more as their time spent in collecting water increases. Also it can be seen that if the choice of source of water is an "individual house connection" type, the households are willing to pay more. This would of course save more time and energy because you don't have to travel long distances and spend long hours collecting water.

The *distance* variable was used to get an idea of how far the household was from the town, indicating how much urban facilities like roads, bus and taxi services etc. the household enjoyed. The coefficient is significant and negative indicating that the less distant households are willing to pay more because if a household has to buy water from a private vendor it will have to pay the same price irrespective of the distance from the main

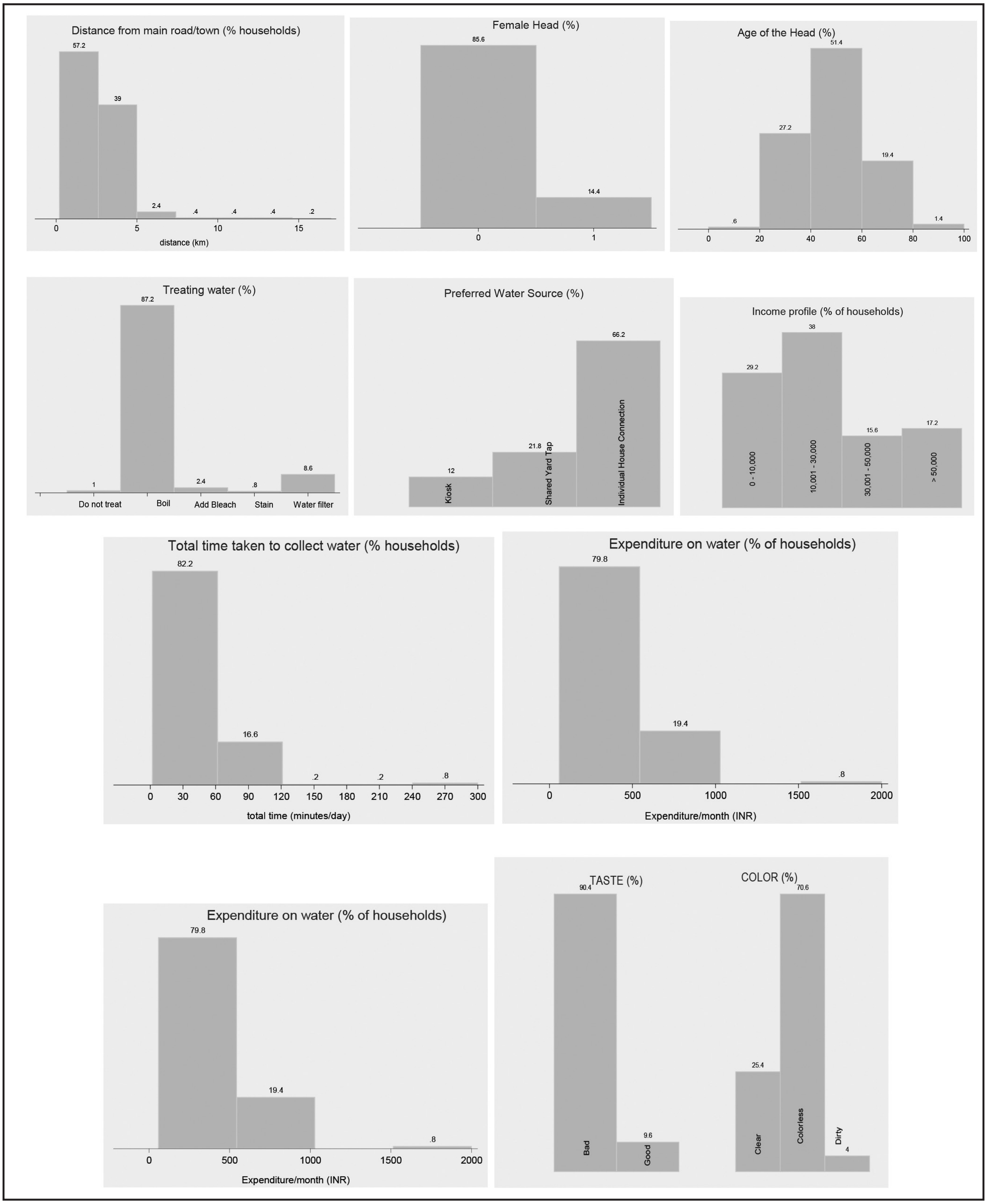

Figure 2: Socio-economic and water use profile.

Note: **USD 1 ~ INR 60.00 as of March 2014 when the responses were taken.**

Source: **Field Survey**

Table 2: Results from bivariate probit model

Variables	*Coef.*	*Std. Err.*	*z*	*P>z*	
Femalehead	108.4241	46.1798	2.35	0.019	**
Agehead	141.3248	47.24647	2.99	0.003	***
Eduhead	45.73169	34.75752	1.32	0.188	
Ttime	72.5089	29.25755	2.48	0.013	**
Watsrce	118.424	44.45062	2.66	0.008	***
Hhinc	25.80485	16.29763	1.58	0.113	
Nworkers	-35.4777	19.20071	-1.85	0.065	*
Treat	-290.054	160.3771	-1.81	0.071	*
Female	56.90759	37.69942	1.51	0.131	
Married	-36.1264	18.64736	-1.94	0.053	*
Employ	6.22066	5.758197	1.08	0.280	
Tyresid	-13.9052	18.12007	-0.77	0.443	
Ownership	-44.3623	31.4649	-1.41	0.159	
Distance	-13.7833	7.963043	-1.73	0.083	*
Logexp	82.44812	60.82728	1.36	0.175	
Col	-13.8442	22.62608	-0.61	0.541	
Taste	-69.3773	95.37123	-0.73	0.467	
Odour	-139.269	57.50439	-2.42	0.015	**
_cons	668.6154	301.9264	2.21	0.027	**
No of observations	500				
Wald chi2(18)	53.52				
Prob> chi2	0.0000				
Log likelihood	-714.444				

***significant at 1% level, **significant at 5% level, *significant at 10% level.

road. In Darjeeling, a household 5 km away from the main road pays the same as the household which is a meagre 500 metres from the main road. The price varies only with quantity and not distance; therefore a household in the main town will be willing to pay more for an improved municipal water service which means being near to the main road does not provide any incentive to the household for better water services.

Among the variables which were included to seek the perception of water quality, only the *odour* variable is significant and negative. The other variables *taste* and *col* used to understand the taste and colour preferences are insignificant and negative, which shows that households who are less satisfied by the water quality are willing to pay more for improved water quality. This is also the same for the *treat* variable which is negative and significant which means those households who treat water are willing to pay more.

The WTP estimated using the delta method is about INR 494.00 per month as reported in Table 3. This is not very surprising because the households now pay INR 41.66 as monthly water bill to the municipality, and incur an average additional cost of INR 500.00 per month for buying water from private vendors. This result shows that the households are willing to pay more than what they are now paying to the service provider (municipality).

Table 3: Results from DBDC models

	Coef.	*Std. Err.*	*z*	*P>z*	*[95% Conf.Interval]*	
mean WTP	494.0327	16.87045	29.28	0	460.9672	527.0981

Conclusion and Policy Implications

This study uses a double bounded dichotomous choice CV method to elicit WTP for improved water services and also estimate its major determinants. The questions were carefully designed considering the demographic and geographical profile of the region. Since Darjeeling is a hill station in India at an altitude of 6700 ft, use of underground water as a water source is not feasible. Due to old and unplanned building structures, rain water harvesting is also not viable (although Darjeeling has high annual precipitation of 2,812 mm). Therefore, the town basically has to depend on the municipal water services. This study focuses on the demand side and tries to understand the water perceptions by conducting a CV survey. The survey was conducted with the help of local students who were able to understand the scenario and the nature of the problem. The students were given proper training and mock surveys were conducted before the main survey. For econometric estimation, a bivariate probit model was used for estimating the WTP and its determinants. The findings reveal that gender of the head of the family, age of the head, total time taken to collect water, water treatment, water source and distance were among the significant and major determinants of WTP for improved water services.

An important policy implication of this study is that the households are willing to pay more for an improved water service and it has to be provided by the municipality or any agency. Therefore, essentially the local water body seems to be a priority because the private water vendors are not very reliable and often do not deliver water in time. The vendors mostly deliver water in trucks and households have to make prior intimations and the delivery/supply is scheduled as per the time slot available with these vendors. The problem here is that the process itself is very time consuming and sometimes the water trucks even fail to deliver if the demand is very high.

It is important that the water infrastructure in the town is improved. The regression results too confirm that households are willing to pay more for better water source i.e. individual house connections, which means people look forward for a better means of water infrastructure. Also, the service provider should have a proper water management system in place taking due care of malpractices in paper works and water theft along the pipelines, which are more rampant and prevalent in the region. The findings on the WTP also indicate that there is a huge potential for investment in water projects in the town because the households are willing to pay much higher than what they are now paying. Policy makers can also look into alternative sources of water, like rainwater harvesting coupled with planned urban planning policies, for the town as the water in the springs which feed the reservoirs are gradually drying up. As far as the applicability of the findings of the paper is concerned, the findings can be applied in other smaller towns like Kalimpong and Kurseong which share a similar socio-economic, demographic and geographical profile to Darjeeling.

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