An assessment of the willingness to pay for reliable water supply in NCT-Delhi

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Abstract

Water is increasingly becoming a scarcer commodity, particularly in large cities of developing countries. Drinking water is an important use of water which has been catered for by most of the local governments. However, it is provided with a varying degree of reliability and the cost of this is not known. Consumers would like to pay for a reliable water supply besides what they pay for the normal water supply (both quantity and quality of water supplied). This paper presents an application of the contingent valuation method (CVM) for estimating the value of reliable water supply in National Capital Territory (NCT) – Delhi. The study implications and the lessons accruing from it are also summarized.

Keywords: Contingent valuation; Drinking water; Reliability; Willingness-to-pay

1. Introduction

Economic valuation of public goods and services, which often exist in non-market form, is increasingly being addressed by researchers in order to support local governments in realising the value of the services that they provide. The contingent valuation method (CVM) has been widely used for valuing non-market goods and services in developed and developing countries. It has become popular among both researchers and practitioners in eliciting the economic value of public goods and services because of the simplicity of its design and ease of execution. Besides the advantage of simplicity in elicitation, the CVM is useful in the measurement of both use and non-use values of the resource in question, as is evident by its application in various studies (e.g. Seller et al., 1985; Loomis et al., 1993; Johnson et al., 1990; Rollins et al., 1997). CVM has become popular recently in measuring the monetary value of public goods and services; only recently, it has been applied in the context of developing countries (e.g. Whittington et al., 1990a, 1990b, 1993; Altaf et al., 1993; Altaf & Hughes, 1994).

The application of CVM, however, has also raised questions of various kinds including those related to design and methodology, that is, questions of validity and reliability. The main drawbacks in the

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studies (Mitchell & Carson, 1989) include inadequate attention paid to substitutes, budget constraints of respondents, embedding effects and strategic bias. The method also received criticism owing to scepticism that the hypothetical nature of survey and question would result in biased estimates (Diamond & Hausman, 1994). Nevertheless, valuation methods like the CVM are quite useful because they provide first hand estimates of economic value, which are at least helpful in guiding decisions both at policy level and at execution level.

The endorsement of CVM as a useful method in the case of natural resource damage estimation studies by the Blue Ribbon panel of the National Oceanographic and Atmospheric Administration (NOAA) has led to the assertion about the utility of the method and the studies based on this method. However, the Blue Ribbon panel also made suggestions for improving the validity and reliability in order to bring confidence in the surveys conducted by researchers. It recommended that researchers draw attention to explanatory variables such as income, price of substitutes, use of site and substitute knowledge, environmental attitudes, distance to site, understanding, and belief and ability/willingness to perform task in their studies (Barton, 1998). Several studies subsequently carried out focussed on the effect of these variables in providing better estimates (e.g. Shultz et al., 1998; Kotchen & Reilling, 2000; Stevens et al., 2000). Yet, few CVM surveys have been conducted to measure the willingness to pay (WTP) for the various services (including ecological services) rendered by water resources (e.g. Carson & Mitchell, 1993; Navrud, 1995; Barton, 1998).

The current paper is an attempt redress the situation, aiming to elicit WTP for the reliability of water supply services rendered by water from the Yamuna river in NCT-Delhi. Moreover, there have been few studies of the application of CVM to aid decision making in resource allocation in the Indian context (e.g. Hadker et al., 1997; Saleth & Dinar, 1997; Markandya & Murty, 2000). These studies had a different focus and different methods from that of the current study, therefore, this study adds to existing CVM literature on application of water resources in the Indian context.

2. Background of the study and literature

Water resource falls into the class of public goods whose market price is much below the value of services rendered by it. Further, the wide variety of services provided by water, which range from basic needs like drinking water to aesthetics, render water resources with potential for experimentation in estimating its economic values using several approaches. Therefore, authors have taken different approaches to measure different services in order to elicit the economic value of the water resource; however, water quality received more attention than other aspects of water, as it is critically linked to several other uses. Turner (1978) provides a good framework for the valuation of water quality and lists various methods that can be used for measuring water quality services in the framework of public goods benefits – a damage costs method to assess industrial, domestic and agricultural uses; market methods to ascertain the demand for water quality and survey methods to measure aesthetics and recreation benefits.

Feenberg & Mills (1980) extended this approach by outlining measures of water quality conservation and depicted a benefit–cost framework in which they describe a methodology for valuing benefits and costs of water pollution control while considering water quality as a public good. They, however, do not lay emphasis on application of the valuation method, rather, they provide a valuation framework and discuss the policy implications. A somewhat similar approach but with different objectives and tools was attempted by Markandya & Murthy (2000) in the Indian context. In this broad framework, the
study of Carson & Mitchell (1993) distinguishes between demand for water quality for various uses to value demands for each use by conducting WTP surveys. However, the importance of water as a consumptive good has received attention in separate WTP surveys to assess the demand for public infrastructure goods like water supply in urban areas (e.g. Piper, 1996; Rollins et al., 1997), as well as in rural areas (e.g. Platt & Piper, 1994). Navrud (1995) also attempted to evaluate the benefits of water quality improvements in a lake affected by acid rain depositions through a contingent valuation survey; further, he also attempted to establish WTP, rather than willingness to accept, as an appropriate measure. Brox et al. (1996) made a more comprehensive contingent valuation survey that includes an assessment of WTP for water quality as well as quantity, which is appropriate and relevant to the current study.

3. The Study

The River Yamuna is an important river flowing through India’s national capital Delhi and it has a wide variety of “functional uses” ranging from those related to consumption to those related to heritage. The reduction in water quality and quantity, particularly along the stretch by the national capital, has led to the loss of its utility as a public good rendering various services; important among these is water supply to the citizen. A conservation programme aiming to improve the water quality needed to be formulated, requiring an estimation of the benefits of river water quality improvement in order to compare with the costs of the programme in a benefit–cost framework, for decision making with regard to the conservation programme. Here, it needs to be emphasized that as River Yamuna water is supplied for domestic use to the citizens of NCT-Delhi and its neighbouring districts, provision of water of appropriate quality is an important parameter of its reliability. Water service reliability depends both on the quality of service delivery measured in terms of service hours, coverage and quality, as well as the quantity and quality of water (sourced from river) provided.

Theoretically, Yamuna River water has several functional uses that involve the welfare of individuals. An improvement in water quality/quantity and the reliability of its supply would lead to an increase in the welfare of individuals without a concomitant increase in the price of water, in turn leading to an accrual of consumer surplus to individuals, while assuming that the income remains constant and that there is no close alternative. Since the price of water is almost equal to zero in a developing country like India, the WTP for water resource conservation corresponds closely to the economic value of river water services including that of the reliability of its supply to NCT-Delhi. WTP for reliable water supply is more important as the current water supply system does not provide a systematic schedule of water supply and the quality of water is also not reliable.

The utility of the WTP estimates lies in aiding decision making at the urban/regional level with regard to the provision of such a water supply service and recovering its cost. Earlier studies of WTP for water resources proved to be useful in public finance areas for improving water supply services (Rollins et al., 1997), and also in estimating reliable measures for water quality improvements benefits.

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1 The river water quality dipped well below the bathing quality (B level of the CPCB (Central Pollution Control Board)) throughout the stretch by NCT-Delhi. A detailed discussion can be found in Ramakrishna (2001).

2 The need for and nature of public intervention aiming at river water conservation through policy is emphasized by Ramakrishna (2001).
(Brox et al., 1996; Piper, 1996). The current study, in its estimation of benefits, utilizes the framework provided by Feenberg & Mills (1980) and follows the methodology of Navrud (1995), but has an extended scope from both studies. It comes closer to the studies of Whittington et al. (1990a, 1990b, 1993) but this exercise was not undertaken with any a priori decision of floating a project with funding support from multi-lateral/bi-lateral/domestic agency.

4. Methodology

A contingent valuation survey was carried out in NCT-Delhi to estimate the value of the services rendered by Yamuna River water by asking about WTP for the conservation of water quality, restoration of water quality and reliable water supply; and willingness to accept for stream flow depletion. The common methodology followed for eliciting the preference for all the above themes is detailed hereunder, although our concern in this paper is with the question of reliable water supply.

4.1 Questionnaire format

The format of questionnaire was planned to measure the benefits of river water resource conservation under the framework of CVM. A survey questionnaire was prepared to elicit the preference for river water quality, preference for regular and reliable water supply and preference for stream flows. The questionnaire consists of several other features that retrieve information useful in the analysis. A list of functional uses was provided at the beginning of the questionnaire in order to familiarize the respondent with the question; the respondent was then asked to identify those uses with which he or she perceived to be associated, for possible use as an index of attitude and knowledge as well as preference. In the subsequent part of the questionnaire, the respondent was confronted with direct questions pertaining to WTP for the above preferences. The questionnaire also sought information pertaining to the socio-economic characteristics of the respondent, which include age, sex, marital status, education, household income and size. It was also complemented by material pertinent to the study area, such as map, whenever was required for use and a translated copy in local language (Hindi).

4.2 Pre-test

A classroom pre-test survey was carried out before conducting the main survey to elicit WTP for water functions in the context of river water in another Indian city (Nagpur) by posing a similar question to a small sample. This was done to observe the behavioural responses of the respondents to the questionnaire and to overcome any defects in the design of questionnaire as well as the conduct of survey. The pre-test helped us in restructuring the questionnaire for better elicitation, particularly in the articulation of the problem before asking the WTP question. The pre-test also helped us in giving explanation about the payment vehicle, that is, money as well as equivalent labour and pay instrument, i.e. the bid structure; it also helped us in improving the conduct of the survey.
4.3 Questionnaire design

At the outset, the respondents were provided with information about River Yamuna water functions in the questionnaire, which also familiarised them with the background of the question, followed by a brief summary of water quality and its deterioration in River Yamuna (in addition, a provision was made for maps of the river and its stretches wherever required). In the next step, respondents were confronted with a WTP question about water quality for the prevention of further water pollution, which is possible through regulating wastewater discharges into the river water. However, this is not enough to rejuvenate ecological and aesthetic services as well as the other services provided by the river water, which require the restoration of water quality through water purification methods. The respondents were then asked about WTP for the restoration of river water quality to a desirable level, set by the Central Pollution Control Board (CPCB) and described in terms of dissolved oxygen (DO). The next question posed the maximum WTP for the same. The respondents were then provided information about the acute summer water shortage as well as water quality problems in the region and asked about WTP for a reliable water supply. Finally, anticipating river water works for storage and diversion in upstream areas, the respondents were asked if they would be willing to accept money as compensation for losses arising from stream flow reduction. In posing these questions, a combination of bid instrument and open-ended formats were used to elicit preferences. Adequate and relevant information was provided at all stages of the questionnaire to avoid non-specification bias as well as incomplete and inexact responses. Importantly, the translated copy of the questionnaire into the local language (Hindi) ensured that the respondents did not have any difficulty in understanding and responding.

4.4 Sampling

It was initially planned to choose a sample size of about 125 in a simple stratified method with a proportionate representation of the sample across upstream, middlestream and downstream contiguous areas of river, while resorting to random sampling within these areas. Ten such urban nodal centres around principle cities that are well distributed across space were selected (five in NCT-Delhi, three in downstream and two in upstream areas). The locations within these cities were selected such that there was an even spread of sample based on spatial, population and activity densities, while the respondents were chosen randomly. Hence, the survey method followed a combination of random and representative sampling. Further, care was taken to cover all income groups (low, middle and high) and social classes in the sample while executing the survey. The actual survey could only be done for a sample of 113 households.

5. Data analysis

A simple multiple linear regression model of WTP as an independent variable dependent upon the variables representing respondent characteristics, viz. household income (HHINC), size (HHSZ), age (HHAGE), sex (HHSEX), marital status (HHMAR) and educational qualifications (HHEDN), water consumption (WATCON) and perceived functional uses of water (PWURY) was conceived initially. However, a careful examination of data revealed that HHSEX and HHMAR were not significant
variables, as they were merely reflective of household status. The final model specified for use in the analysis has the following form:

\[ WTP = f(WATCON, HHINC, HHSZ, HHEDN, PWURY) \] or mathematically,

\[ Y = f(X_1, X_2, X_3, X_4, X_5) \]

where

- \( Y \)-WTP is the willingness to pay expressed in rupees
- \( X_1 \)-WATCON is water consumption expressed in litres per capita per day
- \( X_2 \)-HHINC is household annual income expressed in rupees
- \( X_3 \)-HHSZ is size of household expressed in units of individuals
- \( X_4 \)-HHEDN is the level of education expressed in number of years spent in education
- \( X_5 \)-PWURY is the perceived water uses of the River Yamuna expressed as numbers (units).

Although WTP is normally drawn based on the respondent’s acceptance of offered bid amount, recently, several authors used alternate function forms other than the linear regression form and included various supplementary measures and indexes to draw interesting conclusions (Shultz et al., 1998; Kotchen & Reiling, 2000). In a similar attempt, a logit model is used here to take into account the probability patterns of respondent to the bid structure. The probabilities of positive response – yes – for each bid amount were estimated using the following equation, which is fitted in logistic regression to account for the non-linearity in response pattern:

\[ Z_i = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4 + B_5 X_5 \]

where \( Z_i \) is equal to the logarithm of the fraction of the probability of a yes response divided by a no response to bid level (which is the select bid amount) \( i \), \( B_1 \) to \( B_5 \) are coefficients of the parameters \( X_1 \) to \( X_5 \) explained in the regression model and \( B_0 \) is a constant. Using this relation, the parameter coefficients for each bid level \( i \) were estimated using a logistic regression. Using these coefficients and the sample average values of parameters mentioned earlier, \( Z_i \) values for each bid level were generated. The \( Z_i \) values thus generated were then used to generate probabilities of acceptance of a bid. The probability of acceptance of a bid corresponding to the \( Z_i \) value was calculated using the following equation and was assigned as \( p(B) \), which is a variable dependent on bid amount \( B \), while the accumulation of probabilities of acceptance of bids gave rise to the cumulative probability \( P \).

\[ p(B) = 1/(1 + \exp^{-Z}) \]

The probabilities of acceptance were estimated using this function for all those bid amounts that fall below the accepted bid amount. However, the respondent might still accept higher bids, but the probability of this happening might be small. This is evident from the fact that the cumulative probability of accepted bids is less than one. Hence, there exists the probability for acceptance of bids beyond the last one accepted by the respondent, but it recedes at a faster rate beyond the last accepted bid. An
appropriate curve fitting, which reaches a cumulative probability plateau beyond the last accepted bid, was required for which logarithmic curve fitting forms a right choice, as it quickly reaches the upper bound after the threshold cumulative probability. For those bid amounts that fall beyond the maximum bid amount accepted, probabilities were derived from this logarithmic curve fitting of cumulative probabilities against bid amount. Using this relation from the curve fitting, probabilities of acceptance of higher bids were calculated using extrapolations of cumulative probability up to an accuracy of three decimal places. The probabilities and bid amounts were then used to derive the expected WTP for each bid level (tantamount to the expected value) and their sum gave rise to the mean expected WTP against the good/service in question.

6. Results and discussion

The responses to specific contingent valuation survey questions and the socio-economic characteristics of respondents have shown that the percentage of population that responded positively to the questions posed in the questionnaire varied between 64 and 66%. A summary of one characteristic of the respondents – educational profile – is given in Table 1. The observed mean characteristics of variables/descriptants of the sample are given in Table 2. The results of regression and response analysis using the methodology and approach to data analysis described in the previous sections are given in Tables 3 and 4. Also, using the same approach, the mean (or average) WTP for reliable water resource services in NCT-Delhi has been calculated at Rs 180.12 (at a price level prevailing in 1997) as shown in Table 4.

The primary objective of the exercise was to generate functional use values of river water in monetary terms and that of reliable water supply in monetary terms. Valuing people’s preference for water resource conservation is the method that was chosen for generating functional values and the value of reliability of water supply service. This WTP for reliable water supply is an important indicator of people’s preference for a reliable and regular water supply. Unfortunately, water supply systems in both urban and rural areas of developing countries are in a poor state in terms of parameters like quantity and quality supplied, as well as of service. Unreliable water supply not only renders a poor service level making it unattractive but also causes the spread of diseases (in the case of poor water quality, which is a common feature in several Indian cities) and also sporadic fights/tussles for control over it (also resulting

Table 1. Sample respondents’ educational profile*.

<table>
<thead>
<tr>
<th>Educational level</th>
<th>Proportion in sample (as %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Illiterate</td>
<td>10.62</td>
</tr>
<tr>
<td>Primary school</td>
<td>4.42</td>
</tr>
<tr>
<td>Secondary school</td>
<td>32.74</td>
</tr>
<tr>
<td>Higher secondary education</td>
<td>15.93</td>
</tr>
<tr>
<td>Graduates</td>
<td>22.12</td>
</tr>
<tr>
<td>Postgraduates</td>
<td>10.62</td>
</tr>
<tr>
<td>Doctorates and professionals</td>
<td>3.54</td>
</tr>
</tbody>
</table>

*The number of years of education spent by the persons in each category are 0, 0–5, 5–10, 10–12, 12–15, 15–17, >17 years of schooling, respectively.
in water mafias in some selected parts of cities in India). It has been found that consumers, in the absence of a regular and reliable water supply, also resort to several other security measures – they tend to store water in containers which imposes a burden on the women and children in fetching water; they spend on installing storage structures within household premises, which themselves are small in urban areas.

It is generally perceived by the policymakers that public water supply schemes are difficult to float as they provide a cost to the exchequer of the urban/regional local body and the general public is not willing to pay any money for the same. This delays the provision of a water supply for the community for years, unless a donor or lending agency comes forward to lend the service provision, only possible in the case of large schemes involving sizeable investment. The findings of the study suggest that the people living

Table 2. Mean characteristics of observed sample variables and descriptants data.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household size (units)</td>
<td></td>
<td>4.2</td>
</tr>
<tr>
<td>Education (no. of years of education)</td>
<td></td>
<td>10.5</td>
</tr>
<tr>
<td>Water consumption (in lpcd)</td>
<td></td>
<td>117.6</td>
</tr>
<tr>
<td>Annual household income (in rupees)</td>
<td></td>
<td>192,750</td>
</tr>
<tr>
<td>Perceived water uses of River Yamuna</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

Table 3. Regression outputs for the WTP bid offers to reliable water supply.

<table>
<thead>
<tr>
<th>Variable</th>
<th>$Z_{25}$</th>
<th>$Z_{50}$</th>
<th>$Z_{100}$</th>
<th>$Z_{150}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.1998</td>
<td>1.1394</td>
<td>3.2766</td>
<td>4.9812</td>
</tr>
<tr>
<td>HHINC</td>
<td>$2.56 \times 10^{-6}$</td>
<td>$3.4 \times 10^{-6}$</td>
<td>$8.3 \times 10^{-7}$</td>
<td>$1.5 \times 10^{-6}$</td>
</tr>
<tr>
<td>WSWTP</td>
<td>-0.014</td>
<td>0.0036</td>
<td>0.0112</td>
<td>0.0251</td>
</tr>
<tr>
<td>EDN</td>
<td>0.042</td>
<td>0.0293</td>
<td>0.0458</td>
<td>0.1952</td>
</tr>
<tr>
<td>HHSZ</td>
<td>-0.1085</td>
<td>0.0503</td>
<td>0.0778</td>
<td>-0.0448</td>
</tr>
<tr>
<td>WATCON</td>
<td>-0.01</td>
<td>-0.001</td>
<td>-0.0005</td>
<td>-0.0083</td>
</tr>
<tr>
<td>PWURY</td>
<td>-0.3677</td>
<td>-0.4063</td>
<td>0.0717</td>
<td>0.1141</td>
</tr>
</tbody>
</table>

Table 4. Response analysis of bid scores for a reliable water supply.

<table>
<thead>
<tr>
<th>Bid value (B)</th>
<th>Z score</th>
<th>Probability (p)</th>
<th>Cumulative probability (P)</th>
<th>p(B).B</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
<td>-1.374</td>
<td>0.2019</td>
<td>0.2019</td>
<td>5.0475</td>
</tr>
<tr>
<td>50</td>
<td>-2.4035</td>
<td>0.0829</td>
<td>0.2848</td>
<td>4.145</td>
</tr>
<tr>
<td>100</td>
<td>-1.8229</td>
<td>0.139085</td>
<td>0.423885</td>
<td>10.5</td>
</tr>
<tr>
<td>150</td>
<td>-2.5866</td>
<td>0.07</td>
<td>0.493885</td>
<td>13.9085</td>
</tr>
<tr>
<td>200</td>
<td>0.154995</td>
<td>0.64888</td>
<td>30.999</td>
<td></td>
</tr>
<tr>
<td>250</td>
<td>0.11048</td>
<td>0.75936</td>
<td>27.62</td>
<td></td>
</tr>
<tr>
<td>300</td>
<td>0.084109</td>
<td>0.843469</td>
<td>25.23</td>
<td></td>
</tr>
<tr>
<td>400</td>
<td>0.096691</td>
<td>0.94016</td>
<td>38.6764</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>0.03848</td>
<td>0.97864</td>
<td>19.24</td>
<td></td>
</tr>
<tr>
<td>600</td>
<td>0.01393</td>
<td>0.99257</td>
<td>3.409</td>
<td></td>
</tr>
<tr>
<td>700</td>
<td>0.00487</td>
<td>0.99744</td>
<td>1.344</td>
<td></td>
</tr>
<tr>
<td>Sum total</td>
<td>180.1194</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
in NCT-Delhi and closer to the River Yamuna are willing to pay for a reliable and regular water supply service, which is in addition to their willingness to pay for the improvement in the water quality of the River Yamuna. As a beginning, people’s value in monetary terms for a reliable water supply for drinking/domestic use indicates the economic importance attached to the resource in general and to its use in particular. While the functional use of water resources needs to be conserved through establishing institutions that can ensure good river water quality and quantity, water supply systems need to be geared towards an improved level of service delivery that ensures a regular and reliable water supply made available to citizens. A positive WTP clearly indicates that the people want delivery institutions responsible for water supply to come up with models (projects) that ensure a reliable and regular water supply and that they would be willing to pay for that particular purpose.

References


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