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Willingness to Pay for Water Quality Improvement: A Study of Powai Lake in India

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Abstract: The Powai Lake in Mumbai, India, spreading over 2.10 square kilometres, is in the heart of the most crowded India's premier metropolis. It consists of rich ecosystem of considerable value and interest, supporting wide variety of flora and fauna and a habitat for wild variety of aquatic animals. Now, it is increasingly being impacted by human activities, resulting in choking off the shoreline, and deteriorating water quality. In this context it is important to understand how to effectively protect the present status and to improve the water quality of the lake. Benefits of improvement as perceived by the users serves as a critical input for devising policy instrument based on economic principles. This paper attempts valuing improvement in water quality through 'Contingent Valuation Method' (CVM). Then the paper analyses the factors determining the WTP by the users for improvement in water quality using regression tool. A survey was conducted of about 300 samples, living in approximately five kilometres radius of the lake. The survey was done in two rounds, one in 2005 and another in 2007 to determine the changes that occur over time in terms of quality as well as perception of the users regarding the benefits of the lake. The results indicate that the average WTP have increased from 2005 to 2007 after adjusting for general price increase. Income, occupation and uses of the lake are the important attributes explaining WTP. On an average, salaried class is willing to pay 30% more according to 2007 survey. The respondents attach more values to the aesthetic benefits. The results are useful in designing policies based on market-based instruments such as charges or taxes for the purpose of improving the lake quality.

Key words: Non-market valuation, Powai Lake, CVM, water quality.

Introduction

The Contingent Valuation (CV) survey method is a widely used technique for valuing non-marketed environmental benefits and/or costs of any policy decision taken for the improvement/deterioration of environmental resources. It provides rough estimation at an extreme end of the exact value of natural resources so as to take appropriate policy measures to conserve and manage these resources. Some notable studies relied on CVM for non-market valuation are Carson and Mitchell (1993a), Cooper et al. (2004), Jorgensen et al. (2001), Huang et al. (1997) and Hadker et al. (1997), while many other studies questioned biases associated with strategy, design, information, hypothetical market condition, and operation (e.g. Kahneman and Knetsch, 1992; Diamond and Hausman, 1994; Zhang and Li, 2005).

Water resource is one of the environmental resources that exist as a public good in nature. Water pollution is a negative externality that effects all major users of water and thus in turn utility of consumer. This paper attempts to apply CV method to Powai Lake in Mumbai city of India to measure the benefits of improvement in the water quality. The paper has been organized as follows: Starting with a brief outline of Powai Lake, it discusses about relevant past studies on the CV approach. Subsequently,

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it also provides sampling methodology, followed by empirical analysis and the paper ends with a conclusion.

Powai Lake—A Profile

Mumbai has three major lakes: Tulsi, Vehar and Powai. Tulsi and Vehar lakes are located in the Sanjay Gandhi National Park and Powai Lake is located just outside in the south of this park. It is surrounded by India's two premier educational institutions, Indian Institute of Technology (IIT Bombay) in the south, and National Institute of Industrial Engineering (NITIE) in the north, Powai Gardens, Adi Shankaracharya Road and a host of housing colonies like Hiranandani and Raheja complexes.

Powai Lake was created by British in 1891 at an initial cost of ₹6.5 lakh, as an emergency measure to augment the drinking water supply for the city by recharging the area's underground water table and by constructing two stone dams of 10 metres high across two hillocks (BMC, 2006). The spread of the water body thus achieved was about 370 acres or 2.10 sq kilometres and the depth varied from about 10 ft (off periphery) to 40 ft at its deepest which is now reduced to 2 ft to 20 ft. Powai lake supplied two million gallons of water to Bombay. However, after Tansa Lake became a more viable option, in 1892, Powai was turned over to the picnickers due to its bad quality of water. The lake is about 17 miles from central Bombay and is situated 55 metres above the mean sea level. The population of the catchment area is 63,000. Average rainfall at Powai is about 2540 mm per year which makes the lake to overflow for about 60 days each year. The watershed area of the lake is 688 hectares. The volume of minimum water in summer is 440 lac litres and in monsoon the maximum water is 528 lac litres. It supports a very rich ecosystem with wide variety of flora and fauna. Earlier there were 37 different species of fishes but now only 10 varieties are left. Total silted area is 4,20,859 sq. metres[1]. Over the years, a wide variety of pollutants have rendered the lake's water unfit for drinking. Some of the problems that have been identified concerning Powai Lake are siltation, shallowness, pollution, reclamation, weed-infestation, quarrying and blasting in the catchment area, industrial activities within the catchment area, ecosystem degradation, encroachments along the lake, vehicular pollution, loss of aesthetic and recreational value.

Pollution on the banks of Powai Lake includes storm sewers, waste water drains, spots where clothes and vehicles are washed, area covered by weeds etc. In 1995, in response to community efforts to save the lake, the Government of India decided to undertake the Powai Lake Cleaning Project, the first project implemented under the Government's National Lake Conservation Plan. In order to recover the cost of the project and further to keep the lake from deterioration due to human activities, it is necessary to implement environmental charges/fees. The valuation of the benefits of the lake from the perception of users is a critical input for designing such a scheme.

An Overview of Literature on CVM

The CV method utilizes survey technique to obtain people's preferences in money terms. It asks what is the maximum amount that a person is willing to give up in exchange for a slated increase in the level of public good. This can be specified as follows:

$$\text{WTP} = [e(p_0,q_0,U_0)] - [e(p_0,q_1,U_0)]$$

It means if the minimum expenditure necessary to achieve a constant utility U_0 at set of prices p_0 of marketed goods and environmental quality q_0 is given by '$e(\ )$', then the maximum amount that a person would be willing to pay for an improvement in the quality from q_0 to q_1 is WTP.

Contingent Valuation (CV) method was first proposed by Ciriacy-Wantrup (1947) to generate prices when markets are missing for goods. It became popular in 1980 for valuing environmental damages and changes in environmental quality. Notable studies in the application of CV for water quality valuation are Carson and Mitchell (1993a) and Smith et al. (1986). Critical discussion of CV method were found in Hausman (1993), Hanemann (1994) and Diamond and Hausman (1994). Problems such as strategic answering and sensitivity of WTP estimates to changes in income distribution have been mentioned in the literature.

In the case of lake water quality valuation there is a very few number of studies. The study by Carson et al. (1993a) deals with lake water quality valuation using CV method for improvement from boatable to fishable and from fishable to swimmable and swimmable to drinkable. The study computed aggregate benefits of complying with the standards of U.S. Environmental Protection Agency. The study used CV approach where a national

[1] Silted area from Devi temple to Boat Club is 2,42,803 sq. metre (area of lake under IIT) and total silt quantity (excavation 3 ft) is 3,80,793 cubic metres. The silt quantity in other IIT area is 2,19,688 cubic metres. The silt quantity in remaining area is 1,61,104 cubic metres.

sample of American households was asked to value a set of water quality improvements. It estimates a Willingness To Pay as a function of water quality parameters, income and uses. The study has compared the willingness to pay with the cost of water quality improvement programmes and find that the benefits are large as compared to the costs currently but it predicts that costs are going to increase in the future and hence the net benefit of achieving a swimmable water quality level will not be positive. Hence it suggested policy changes from command and control to market-based instruments to cut down costs.

Smith et al. (1993) made a comparison of direct and indirect methods and concluded that even if the estimates are comparable, analysts' judgment played a crucial role in both the methods. Douglas (2003) made a survey of Maryland registered boat owners to value boatable water quality using CV method. The study revealed lower quality of water from the perception of the individual and the greater concern for the health effects from water quality increased the willingness to pay for improvement. In an interesting analysis, the authors attempted arriving at warm glow effect (payment for one's satisfaction of having an increased level of public good) treated as altruistic preference and showed that the total willingness to pay includes 'warm glow effect' (Carson, 2000) also. This may result in situation such as those who perceived the quality as excellent may still be willing to pay more just for the sake of 'warm glow' feeling.

Carson and Mitchell (1993b) questioned the argument of the critics of CV method that CV method is insensitive to change in the scope and size of the environmental good. The authors conclude that the issue of sensitivity to scope critically depends on survey design and administration and the kind of information provided to and perceived by the respondent. In a classic paper, Whittington (2002) explains why the CV studies conducted in the developing countries are below satisfactory. The author views that not only the CV survey is poorly designed and executed but also that very few studies conduct sensitivity test for robustness of the estimates.

The study by Wang et al. (2004) applied the concept of random valuation model introduced by Wang (1997). The study has developed a CV framework under uncertainty assuming WTP as a random variable which is specified as follows: $WTP = E\ (WTP) + \xi_i$. Three methods of value elicitation format—open ended, close ended and stochastic payment card (SPC)—were used. It shows that SPC approach yields higher mean WTP as compared to other methods. The study demonstrates that the individual's WTP is not a fixed number but rather has a distribution.

In the Indian context, there is no systematic study of lake water quality valuation using CV method. This study has addressed some of the criticism about CV, for instance about the scope, sensitivity and execution of survey, at the time of preparing the questionnaire and by giving the respondent the information set necessary to make the respondents reveal the correct values as close as possible.

Methodology and Sampling Design

The Powai Lake was purposively chosen for this study due to anthropogenic reasons of its degradation as mentioned earlier. To the best of authors' knowledge, there are no baseline estimates for WTP or WTA for Powai Lake. Therefore, it was a difficult task to design a survey instrument or questionnaire which in itself is accused of being responsible for creating biases. However, the questionnaire generated elsewhere (Hadker et al., 1997) has been referred for the same.

To be successful in eliciting the responses for WTP which is very close to their true willingness to pay (TWTP), the respondents should be provided with uniform information on the possible improvement/deterioration of the natural resource if a certain activity is undertaken. The interviewers carried with them a brief write up of Powai Lake highlighting its features and vital statistics, its diminishing quality in terms of flora and fauna, depth of lake, water quality etc. They also carried photographs depicting the improved quality of lake as well as further deterioration in an effort to narrow down the gap between stated preference and real preference. To a certain extent, hypothetical market was created as realistically as possible.

The respondents were asked to assign values for improvement in water quality from the present condition (q_0) to a boatable/fishable condition (q_1). Initially the researchers attempted putting questions that relate to varying degree of improvement in an objective manner. In the preliminary rounds of survey it was found, the values did not vary much between different levels of improvement. Hence the present study elicited single value from each user for a slated improvement.

The survey was done in two rounds at two different time points; one in 2005 and another in 2007. This helped us to compare the values which reflect the change in the quality between the years. Roughly the targeted sample point is 300. Few additional observations were selected to make the final sample around 300 after pruning. Due to time constraint, it was decided to interview residents in the nearby areas of Powai Lake (in the vicinity of 5 kms area). There were 13 interviewers and each of them interviewed 25-30 respondents at different locations such as IIT, Hiranandani, Raheja Vihar and other residential complexes, Sakinaka, NITIE and Powai Lake bank.

The questionnaire consisted of open ended and close ended questions. First few questions are related to the respondents' personal profile giving details of socio-economic and demographic features. Then, few questions were asked to judge their understanding on the existence of Powai Lake, the quality of water in it, their frequency of visit, and the purpose of use of the lake. Lastly, and most importantly, they were asked to give responses on their preferred mode of payment, payment is whose responsibility, and the WTP.

Empirical Analysis of Factors Influencing WTP

In this section, we attempt quantifying the extent of influence of various socio economic characteristics on WTP, and to compare between the two study years using the survey data. Regression tools are adopted to determine the extent of influence of various factors. Preliminary analysis with the help of bivariate classification of various attributes by WTP helped us select the relevant variables for the regression analysis.

Demographic Characteristics and WTP

Some of the demographic characteristics based on the data for the base year 2005 are as follows: Of the total of 298 respondents, 75% are males and the rest females. On the whole, 67% of the sample are willing to pay some amount for cleaning and 33% do not want to pay anything. In the latter year, viz. 2007, number of users willing to pay has marginally increased from 67% to 69%. There are no gender differences in the percentage of users willing to pay.

The average age of the respondents is 30 in the base year; it ranges from 15 to 70 years. The highest percentages of the respondent were in the age group of 24-25 years. It was observed that the respondents in the age-group 25-35 have a significant positive impact on WTP as compared to that of other age groups.

Regarding educational category, 46% are post graduates, 31% undergraduates and 12% Higher Secondary passed. More proportion of PG, UG and HSC qualified are willing to pay for cleaning of lake as compared to the proportion willing to pay among primary, vocational or illiterate. With reference to the occupational category, 43% belong to salaried class, 14% self-employed and 35% students, and the remaining are housewives and unemployed. There is no significant difference between the salaried and self employed groups in the proportion of respondents willing to pay. However the average annual willingness to pay is ₹445 for salaried group against ₹310 for self employed category. Classification by income category reveals that 22.15% of the respondents earn less than one lakh per annum, 35.23% earn between 1 and 3 lakhs, 24.5% earn from 3 to 5 lakhs and the rest earn more than five lakhs per annum. The average willingness to pay initially increases with income but sharply declines at the income level above five lakhs. The strong association between occupation and income could partially explain this phenomenon. In the salaried class only 20% are in the income category below one lakh whereas among the self employed, 30% falls in this income group. The larger willingness to pay of the salaried class explains this. If we analyse the data for the year 2007, the respondents' average income is relatively higher. The respondents in the lowest income class of below one lakh is only 17% and between 1 and 3 lakhs is 22%. The percentage of 3 to 5 lakhs category is higher at 31% and 30% of the respondents fall in the category above five lakhs. The significant positive association between income and WTP goes to show that environmental good is income elastic.

Regarding visitation rate, almost 40% of the respondents informed that they visit the lake frequently. About half of the sample lives in close proximity of the lake. However average willingness to pay does not differ significantly between respondents of close proximity or of no proximity. In terms of usage, about 44% preferred aesthetic reasons, and a mere 4 to 5% use it for earning income from activities like fishing and about 37% use it for recreational activity. Those who considered the quality of lake as poor, 75.41% of the respondents were willing to pay as against 50% of respondents who are of the opinion that the quality of the lake is good.

Willingness to Pay and Its Determinants

The aesthetics and recreational benefits were cited by maximum number of respondents as opposed to the economic importance, which indicates that in its present state, the lake provides more of direct non-consumptive use value of different types.

Table 1 presents WTP for different types of values perceived by the respondents. As is clear from the table, respondents give more importance to the lake's aesthetic and recreational values than to direct use value.

From the year 2005 to 2007, the average WTP has increased for those who use the lake for aesthetic purpose and it has declined between these two years for use of

Table 1: Average use and non-use values (samples exclude those who are not willing to pay)

Type of value	*Further classification of value*	*Average value (₹) - Annual WTP*	
		2005	*2007*
Direct consumptive-use value	Economic – Fishing	270	75
Direct non-consumptive-use value	Aesthetic – view particularly sun setting behind the hillocks	738	1113
	Recreational – boating, picnic, swimming, walk etc.	702	577
	Cold breeze, open and wide sky in front of crowded high rise buildings	440	487

Table 2: Frequency distribution by education category and WTP – Year 2007

Education	*Willingness to Pay (₹)*					
	Nil	*<100*	*100-200*	*200-500*	*Above 500*	*Total*
Illiterate, primary & vocational	33(62.3)	6(11.3)	2(3.8)	5(9.4)	7(13.2)	53
Higher secondary	19(46.3)	5(12.2)	7(17.1)	5(12.2)	5(12.2)	41
Under graduate	24(18.3)	11(8.4)	14(10.7)	28(21.4)	54(41.2)	131
Post graduate	19(25.0)	6(7.9)	13(17.1)	13(17.1)	25(32.9)	76
Total	95	28	36	51	91	301
χ^2 value for association of two attributes = 52.32* d.f = 812						

* Significant at 5% level.
Figures in the parentheses are percentages to row total.

Table 3: Distribution of sample by income category and WTP – Year 2007

Income category	*Willingness to Pay (₹)*					
	Nil	*<100*	*100-200*	*200-500*	*Above 500*	*Total*
< 1 lakhs	37(69.8)	9(17.0)	4(7.5)	2(3.8)	1(1.9)	53
1 to 3 lakhs	21(31.8)	4(6.1)	16(24.2)	11(16.7)	14(21.2)	66
3 to 5 lakhs	21(22.8)	10(10.9)	8(8.7)	20(21.7)	33(35.9)	92
> 5 lakhs	16(17.8)	5(5.6)	8(8.9)	18(20.0)	43(47.8)	90
Total	95	28	36	51	91	301
χ^2 value for association of the two attributes = 81.8* d.f = 12						

* Significant at 5% level. Figures in the parentheses are percentages to row total.

economic and recreational purposes (vide Table 1). About 70% of the respondents felt that the quality of the water is poor. The latter year data show that the average WTP varies inversely with the quality of water as expected. Those who feel that quality of water is bad or poor are willing to pay almost double of that of those who feel that the quality is good; viz. these figures were about ₹800 and ₹400.

Table 2 presents the distribution of sample by education category and WTP for the year 2007. Test for association between education group and WTP has shown significant positive association observed through 'χ^2' value. While 33% of the respondents qualified for PG are willing to pay above ₹500, only 13% of the sample household with less than higher secondary education are willing to pay above ₹500.

The association between Income and WTP is clearly visible in Table 3. About 70% of the respondents whose annual income is below one lakh are not willing to contribute anything for the lake improvement. This percentage is only 18% in the category of income above five lakhs. While only 5.7% of those with income below one lakh is willing to contribute above ₹200 for lake quality improvement, about 68% of those with income above ₹5 lakhs is willing to contribute above ₹200 for improvement in quality. The positive association is also confirmed by χ^2 test statistics.

It was expected that purpose of use of the lake will significantly influence the amount of contribution towards improvement of lake. But the bivariate classification of WTP and the uses and the associated χ^2 statistics have rejected the hypothesis of any correlation between the two attributes. However it is intended to analyse this further with the help of regression tool and hence this variable has been included as one of the explanatory variables in the analysis.

Determinants of Willingness to Pay

Regression model is used to find the determinants of willingness to pay as mentioned earlier. The econometric model for estimating the determinants of WTP is as follows:

$$\log(\text{WTP}) = \beta_0 + \beta_1 \cdot \text{Income} + \beta_2 \cdot \text{Education} + \beta_3 \cdot \text{Occupation} + \beta_4 \cdot \text{Uses} + \beta_5 \cdot \text{Opinion} + u$$

All the independent variables are dummy variables and are defined as follows:

Income: For 2005 data it is classified as (one lakh or above = 1) (Less than 1 lakh = 0)
For 2007, it is (3 lakh or above = 1) (Less than 3 lakh = 0)

Education: (PG and UG qualified = 1) (others = 0)

Occupation: (Salaried class = 1) (Self employed, unemployed and students = 0)

Uses: (Economic and Recreational = 1) (Aesthetic = 0)
Opinion about quality of lake: (Excellent, good or average = 1) (Bad or poor = 0)

Since all the variables are dummy variables, one can interpret the coefficients β's as follows; as compared to the reference category (the category which takes value '0' in each variable), on an average the respondents in the alternative category (the category which takes value '1' would be willing to pay β times more/less depending on the sign of coefficients.

The model has been tested for heteroscedasticity in the error term. The test confirmed presence of heteroscedasticity and hence weighted least square technique is used.

Table 4 presents mean values of the variables used in the regression. Average willingness to pay has increased in the latter year. After adjusting for inflation, it is ₹750 in 2007 against ₹670 in 2005. This can be attributed to the increasing deterioration of lake water and also to increasing awareness about the importance of cleaner environmental good. The occupational dummy average value indicates that in the total sample of those WTP, the salaried class percentage has declined from 44% to 30%.

Table 4: Mean values of the variables (samples exclude those who are not willing to pay)

Variables	*2005*	*2007*
WTP* (₹)	670.03	850.07 [a]
Ln (WTP)	5.43	6.05
Income#	0.79	0.70
Education	0.79	0.80
Opinion on quality of lake**	0.26	0.44
Uses	0.56	0.45
Occupation	0.44	0.30

Income dummy variable is revised for the latter year as only 8% of the sample were with income below one lakh as against more than 20% of the sample for the year 2005.
* WTP standard deviation is 1339, minimum is 5 and maximum is 12,000 for 2005 and the same figures were 1375, 20 and 13200 for the year 2007.
[a] ₹750 after adjusting for annual inflation rate of 6%.

The response coefficients with respect to income and education have increased over time (vide Table 5). However all the other coefficients are showing lesser impacts in the latter year. It is expected that the users who perceived water quality as poor would be willing to pay more for the improvement. Though this variable shows correct sign in the latter year, it is contrary to the expectation in the former period. It may also be the case that those who rated it as very poor may have less confidence in any attempt to restore water quality to higher standard. Hence it is difficult to hypothesize the relation between the perception of water quality and WTP. On an average the salaried class is willing to contribute 30% more as compared to the other occupational groups. But this percentage was 60% in the earlier year. This shows that those belonging to self-employed or other category are also increasingly willing to contribute more.

Table 5: Factors determining WTP – Logarithmic model
Dependent variable: log (WTP)

Variable	*Coefficient*	
	2005	*2007*
Income#	0.4116*	0.6123*
Education	0.2360	0.3155
Occupation	0.6019*	0.3027*
Uses	0.5243*	-0.4174*
Opinion on quality of lake	0.7950*	-0.0977
Intercept	4.0258*	5.5152*
Sample size	199	206

* Significant at 5% level.

Conclusion

In this study, the CV survey was carried out for valuing the benefits of Powai Lake in Mumbai. A random sample of about 300 respondents living around the lake was interviewed in two rounds, first in 2005 and then in 2007. Aesthetic and recreational purposes have been cited as two important uses of the lake. The average annual willingness to pay ranges from ₹500 to ₹1200 for these two uses. For economic use, average WTP varies from 75 to 270. The overall average WTP has increased from ₹670 to ₹850 between the years 2005 and 2007 indicating the further deterioration of the lake and increasing awareness and values attached to the environmental benefits of the lake. The analysis on the determinants of WTP revealed that income, occupation and types of use are the significant variables explaining the WTP positively. The policies based on market-based instruments can take insight from these attributes to design a suitable instrument of charges/taxes for use of the lake.

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