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THE VALUE OF IMPROVED PUBLIC SERVICES: AN APPLICATION OF THE CHOICE EXPERIMENT METHOD TO ESTIMATE THE VALUE OF IMPROVED WASTEWATER TREATMENT INFRASTRUCTURE IN INDIA

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Abstract

In this paper we employ a stated preference environmental valuation technique, namely the choice experiment method, to estimate local public's willingness to pay (WTP) for improvements in the capacity and technology of a sewage treatment plant (STP) in Chandernagore municipality, located on the banks of the River Ganga in India. A pilot choice experiment study is administered to 150 randomly selected Chandernagore residents and the data are analysed using the conditional logit model with interactions. The results reveal that residents of this municipality are willing to pay significant amounts in terms of higher monthly municipality taxes to ensure the full capacity of the STP is used for primary treatment and the technology is upgraded to enable secondary treatment. Overall, the results reported in this paper supports increased investments to improve the capacity and technology of STPs to reduce water pollution, and hence environmental and health risks that are currently threatening the sustainability of the economic, cultural and religious values this sacred river generates.

Keywords: *choice experiment method, conditional logit model, River Ganga, sewage treatment plant, water quality, water quantity*

JEL Codes: *C25, C83,C87,Q5,Q53*

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1. Introduction

The Ganga is a major river in India, flowing east through northern India into Bangladesh. Its basin covers 861,404 km^2, which is approximately 26 percent of the total land area of India. There are numerous settlements (cities, towns and villages) located in the basin, comprising 45 percent of the country's population, i.e., approximately half a billion people. This figure is expected to double by 2030. Defined as the 'river of India' by Nehru, Ganga has important economic, social, cultural and religious values. It accounts for about 31.6 percent of India's annual utilisable water resources, providing water for agriculture, aquaculture, hydro-power generation, industry, and water supply for household consumption. The Ganga is a major input to agricultural production, as the soil in the river basin is very fertile, and the river provides a perennial source of irrigation to a large area, enabling cultivation of several crops.

Even though there are some industries which pollute the Ganga, most notably the leather industry, the main source of pollution is human waste. Untreated raw sewage discharged in the Ganga is estimated to be as much as one million M^3 per day (Murty *et al.,* 2000). The Ganga accumulates large amounts of human pollutants (e.g. *Schistosoma mansoni* and faecal coliforms) as it flows through highly populous areas. These pollutants carry significant health risks for humans, as well as environmental risks for the sustainability of the ecosystem services provides by the Ganga. Proposals have been made to reduce the amount of untreated raw sewage deposited in the Ganga. The most noteworthy of these is the Ganga Action Plan (GAP). Initiated in 1984 by the Indian Government, and supported by the Netherlands, UK and voluntary organizations, the aim of the GAP is to build a number of wastewater treatment facilities for the immediate reduction of sewage in the river. Even though over US$33 million has already been spent under the GAP, so far no great progress has been achieved.

The aim of this study is to investigate (i) whether and how much the Indian public values any efforts to reduce pollution levels in the Ganga via reduction of the amount of untreated raw sewage deposited therein through the improvement of the capacity and technology of the sewage treatment plants (STPs), and (ii) whether the public's aggregated willingness to pay (WTP) to this end is sufficient to offset the costs of improvements in the capacity and technology of the STP. The public's valuation is measured in terms of their WTP higher municipal taxes for improvements in wastewater treatment facilities, i.e., the local STP. To this end a stated preference environmental valuation technique, namely a choice experiment is employed to estimate the value of improved wastewater treatment to the residents of the case study municipality. Our case study is the Chanderganore municipality, located in West Bengal along the banks of the Ganga.

The choice experiment method was employed for two main reasons. Firstly, because revealed preference methods (e.g., hedonic pricing method) could not be used due to the lack of data on surrogate markets such as land prices which may vary depending on the quality and quantity of irrigation water from the Ganga it may have access to. Since there are missing markets for quality and quantity of treated wastewater, which are public or quasi-public goods, hypothetical, stated preference methods were preferred to capture the value of these. Among the stated preference methods the choice experiment method was deemed preferable to the contingent valuation method, since the former enables estimation of the various benefits that may be generated by different interventions, and their trade-offs (Bateman *et al.,* 2003). For example in this study we estimate the benefits that may be generated by the improvements in the technology of the STP to increase the quality of water deposited into the Ganga (from primary to secondary treatment) and the benefits that may be generated by the improvements in the overall capacity (i.e., amount of wastewater treated with primary treatment) of the STP to increase the quantity of treated water deposited into the Ganga.

A pilot choice experiment was implemented in November to December 2007 with 150 randomly selected households located in Chanderganore municipality. The data are analysed with the conditional logit model with interactions, allowing for possible differences in the residents' WTP due to their income and education levels. The results of this pilot experiment reveal that all households, regardless of their income levels, are WTP higher taxes to ensure higher quantity of wastewater is treated to a higher quality in the local STP before being discharged into the Ganga. There is however significant variation in the WTP of different education and income segments which should be taken into consideration for equity purposes.

A back-of-the-envelope cost-benefit analysis (CBA) is calculated by aggregating the average WTP over the population of the municipality and comparing this figure to the operating and upgrading costs of the STP. The result of this revealed that the annual taxes the residents are willing to pay are significantly below the actual costs. This finding may be due to two main factors: (i) the public's WTP is constrained by their ability to pay. The fact that despite their strict budget constraint the public is willing to pay for environmental improvement reveals that they value improved water quality in the Ganga, and (ii) the local public (residents) are one of many stakeholders who would benefit from the improvement of water quality in the Ganga, other stakeholders that may derive benefits from this improvement include, for example consumers of food produced by irrigation water from the Ganga; future generations, and the national or international public to name a few. A thorough cost-benefit analysis is warranted, nevertheless in the meanwhile the results of this study disclose that, despite their tight budget constraints the local public value improvements in the quality of the water in the Ganga and if the local government authorities would like to invest in infrastructure that would treat higher quantities of wastewater at a higher quality they could not completely rely on increased local tax revenues.

The contributions of this paper to the literature are threefold. First, this paper contributes to the scant although increasing number of choice experiment studies conducted in the developing country context (e.g., Scarpa *et al.* 2003a, b; Othman *et al.,* 2004; Bienabe and Hearne, 2006; Hope, 2006; Barton *et al.,* 2008; De Groote and Kimenju, 2008; Birol *et al.,* 2009c; Bush *et al.,* 2009; Bennett and Birol, 2010). Second, it adds to the studies on the demand (or preferences) of various stakeholders (e.g., user, or non-users) to improve the wastewater treatment services, most of which are from the engineering literature (e.g., Abelson, 1996; Idelovitch and Ringskog, 1997; Campbell, 2000; Showers, 2002). Third, it contributes to the increasing number of economic valuation studies which estimate the economic value of improved water quality in general (e.g., Fraas and Munley, 1984; Fernandez, 1987; Wang, 2002; Ha and Bae, 2001; Day and Mourato, 2002; Colombo *et al.,* 2005; Hanley *et al.,* 2005; Hasler *et al.,* 2005; Willis *et al.,* 2005; Hanley *et al.,* 2006a,b; Alvarez-Farizo *et al.,* 2007; Fischhendler, 2007; Birol *et al.,* 2009b), and the economic value of improved treated wastewater quality in particular (e.g., Desvouges *et al.,* 1987; Green *et al.*, 1991; Choe *et al.*, 1996; Murty *et al.,*2000, Markandya and Murty, 2004; Barton, 2002; Kontogianni *et al.,* 2003; Cooper *et al.,* 2004; Birol *et al.,* 2008; 2009a).

The rest of the paper unfolds as follow. Next section presents the case study of Chandernagore municipality. Section 3 explains the choice experiment method and survey design and administration. The results are presented in section 4 and section 5 concludes the paper with discussions of issues that arose when implementing the choice experiment study in a developing country context, and summary of findings and future research directions.

2. Case Study

Chandernagore municipality in West Bengal is situated along the banks of the River Ganga. This municipality hosts a conventional sewage treatment plant (STP) built in 1991 following the Ganga Action Plan (GAP). The total volume of wastewater generated by the Chandernagore municipality is estimated at 11,700 M^3 of raw sewage per day while the capacity of the local STP far surpasses this figure, at 22,500 M^3 of raw sewage which can be treated with primary treatment methods. Due to major financial constraints, the STP utilizes only a small fraction of its capacity, conducting primary treatment on only 2,800 M^3 of raw sewage per day, i.e., 24 percent of the sewage generated by the municipality.

The 2,800 M^3 of raw sewage treated daily is treated to permissible limit standards, which are 30 mgl for biochemical oxygen demand (BOD) and 250 mgl for chemical oxygen demand (COD), as set by the West Bengal Pollution Control Board in 1999. The current permissible limit standards, however, are not high enough to remove all the pathogens and hence after this primary treatment, significant health and environmental risks remain. The remaining wastewater generated by the municipality (i.e., the 8,830M^3 of raw sewage per day) is untreated by the STP due to the budget constraints. Less than half of the untreated water is used for the replenishment of the lake in the Wonderland Park, in which the STP is located, and for local agriculture (specifically vegetable farming) and aquaculture activities conducted in the surrounding areas. The use of the untreated wastewater for these purposes poses serious health risks to visitors of the park, as well as for the consumers and producers of fish and vegetables produced with this water. The remaining untreated wastewater is discharged to the Ganga, creating environmental pollution and negatively affecting the sustainability of the ecosystem functions of the river. There is therefore an urgent need to invest in the improvement of the STP of the Chandernagore municipality to ensure that it functions at its maximum capacity for primary treatment and treats higher quantities of wastewater and also to upgrade its technology to treat wastewater at a higher quality, i.e., secondary treatment.

3. Methodology

3.1 The Choice Experiment Method

The choice experiment method has its theoretical grounding in Lancaster's model of consumer choice (Lancaster, 1966), and its econometric basis in random utility theory (Luce, 1959; McFadden, 1974). Lancaster proposed that consumers derive satisfaction not from goods themselves but from the attributes they provide. According to the random utility theory, the utility of a choice is comprised of a deterministic component (*V*) and an error component (*e*), which is independent of the deterministic part and follows a predetermined distribution. This error component implies that predictions cannot be made with certainty. Choices made between alternatives will be a function of the probability that the utility associated with a particular alternative *j* (e.g., wastewater treatment programme option) is higher than those for other alternatives.

$$U_{ij} = V(Z_{ij}) + e(Z_{ij}) \qquad (1)$$

Where, for example in the case of the experiment presented here, for any resident *i*, a given level of utility will be associated with any wastewater treatment programme alternative *j*. Following Lancaster's theory of consumer choice, the utility derived from any of the wastewater treatment alternatives depends on its attributes (*Z*), such as the quantity and quality of wastewater treated in the STP and the regeneration of the Wonderland Park.

Assuming that the relationship between utility and attributes is linear in the parameters and variables function, and that the error terms are identically and independently distributed with a Weibull distribution, the probability of any particular wastewater treatment programme alternative j being chosen can be expressed in terms of a logistic distribution. Equation (1) can be estimated with a conditional logit model (CLM) (McFadden, 1974; Greene, 1997 pp. 913-914; Maddala, 1999, p. 42), which takes the general form:

$$P_{ij} = \frac{\exp(V(Z_{ij}))}{\sum_{h=1}^{C} \exp(V(Z_{ih}))} \tag{2}$$

where the conditional indirect utility function generally estimated is:

$$V_{ij} = \alpha + \beta_1 Z_1 + \beta_2 Z_2 + ... + \beta_n Z_n \tag{3}$$

where β is the alternative specific constant (ASC) which captures the effects on utility of any attributes not included in choice specific wastewater treatment programme attributes, *n* is the number of wastewater treatment programme attributes considered, and the vectors of coefficients β_1 to β_n are attached to the vector of attributes (*Z*).

The assumptions about the distribution of error terms implicit in the use of the CLM impose a particular condition known as the independence of irrelevant alternatives (IIA) property, which states that the relative probabilities of two options being chosen are unaffected by introduction or removal of other alternatives. If the IIA property is violated then CLM results will be biased and hence a discrete choice model that does not require the IIA property, such as random parameter logit model (RPLM), should be used. Another limitation of the CLM is that it assumes homogeneous preferences across households. Preferences, however, are in fact heterogeneous and accounting for heterogeneity enables estimation of unbiased estimates of preferences, enhancing accuracy and reliability of welfare estimates and enabling prescription of policies that take equity concerns into account (Greene, 1997). Information on who will be affected by a policy change or improvement in an infarstructure (e.g., the STP studied here) and the aggregate economic value associated with such changes is necessary for making efficient and equitable policies (Boxall and Adamowicz, 2002).

The RPLM can account for unobserved, unconditional heterogeneity in preferences across households. Formally:

$$U_{ij} = V(Z_j(\beta + \eta_i)) + e(Z_j) \qquad (4)$$

Similarly to the CLM, utility is decomposed into a deterministic component (*V*) and an error component stochastic term (*e*). Indirect utility is assumed to be a function of the choice attributes (Z_j), with parameters β , which due to preference heterogeneity may vary across households by a random component η_i . By specifying the distribution of the error terms e and η , the probability of choosing *j* in each of the choice sets can be derived (Train, 1998). By accounting for unobserved heterogeneity, equation (2) now becomes:

$$P_{ij} = \frac{\exp(V(Z_j(\beta + \eta_i)))}{\sum_{h=1}^{C} \exp(V(Z_h(\beta + \eta_i)))} \qquad (5)$$

Since this model is not restricted by the IIA assumption, the stochastic part of utility may be correlated among alternatives and across the sequence of choices via the common influence of η_i . Treating preference parameters as random variables requires estimation by simulated maximum likelihood. Procedurally, the maximum likelihood algorithm searches for a solution by simulating *k* draws from distributions with given means and standard deviations. Probabilities are calculated by integrating the joint simulated distribution.

Even if unobserved heterogeneity can be accounted for in the RPLM, however, this model fails to explain the sources of heterogeneity

(Boxall and Adamowicz, 2002). One solution to detecting the sources heterogeneity while accounting for unobserved heterogeneity is by including interactions of household characteristics with choice specific attributes in the utility function. When the interaction terms with household characteristics are included, the indirect utility function estimated becomes:

$$V_{ij} = \alpha + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_n Z_n + \delta_1 S_1 + \delta_2 S_2 + \ldots + \delta_l S_m \quad (3')$$

where, as before α is the ASC, *n* is the number of wastewater treatment programme attributes considered and the vector of coefficients β_1 to β_n are attached to the vector of attributes (*Z*). In this specification, *m* is the number of household specific characteristics employed to explain the choice of the wastewater treatment programme alternative, and the vector of coefficients δ_1 to δ_l are attached to the vector of interaction terms (*S*) that influence utility. Since household characteristics are constant across choice occasions for any given household, these only enter as interaction terms with the wastewater treatment programme attributes.

3.2 Survey Design and Administration

The first step in choice experiment design is to define the attributes of the wastewater treatment programme. Following extensive review of the published and gray literature on wastewater treatment in general and on River Ganga in particular; we conducted two focus group discussions with 12 residents of the Chandernagore municipality; as well as consultations with seven experts comprising managers and employees of the STP, who are civil and chemical engineers and hydrologists employed by the Kolkata Metropolitan Development Authority and Public Health Engineering Directorate. Through the focus group discussions, increased municipality tax was chosen as the payment vehicle.

Table 1: Wastewater Treatment Attributes and Attribute Levels used in the Choice Experiment

Attributes	**Definition**	**Levels**
Quantity of treated wastewater	Total volume of wastewater treated with primary treatment by the STP. At the moment the STP is working below its capacity, treating only a quarter of wastewater generated in the municipality. The capacity of the STP can however be increased to treat ALL the wastewater generated by the municipality with primary treatment. This would significantly reduce the discharge of untreated wastewater in the Ganga.	*Low**, High
Quality treated wastewater	Current capacity of the STP can only treat wastewater with primary treatment technology. The quality of wastewater treated with primary treatment is low, and when used for agri/aquaculture or discharged to the Ganga it would still create health and environmental hazards. Secondary treatment technology could be used to increase the quality of the treated wastewater to a higher level so as to minimize the health and environmental risks.	*Low*, High
Regeneration of the Park	Investment in the Wonderland Park to improve its use as a recreational site. At the moment there are no investments to sustain or improve the recreational services provided by the park, such as walking and picnicking.	*No*, Yes
A monthly increase in the municipal tax	Payment vehicle in Indian Rupees identified through the pilot open-ended contingent valuation survey (1 Euro = 59.85 Indian Rupees)	Rs. 1.5, Rs. 4.5, Rs. 12.5 and Rs. 20

* Levels in italics indicate the status quo level.

The focus group discussants felt this payment vehicle could ensure everyone contributes, though they strongly felt it was the authorities' role to improve the water quality in the Ganga, not the households'. Subsequently, we conducted an open-ended pilot contingent valuation (CV) study with 100 local residents to identify levels of the monetary attribute and to test the language and wording that should be used in the choice experiment. The levels of the monetary attribute (increased municipality taxes) were identified from the open-ended CV study and comprised the 5th, 25th, 50th (median) and 75th percentile figures of the local public's WTP distribution for improved water quality in the Ganga through investment in the local STP. Through these steps the following important wastewater treatment attributes, the monetary attribute and their levels were identified (Table 1).

Experimental design techniques (Louviere *et al.,* 2000) and SPSS Conjoint software were used to obtain an orthogonal design, which consisted of only the main effects, and resulted in 32 pair wise comparisons of alternative wastewater treatment programmes. These were randomly blocked to four different versions, each with eight choice sets. Each set contained two wastewater treatment scenario and an 'opt out' option which is considered as a status quo or baseline alternative whose inclusion in the choice set is instrumental to achieving welfare measures that are consistent with demand theory (Louviere *et al.,* 2000; Bateman *et al.,* 2003)

The pilot choice experiment survey was implemented in November and December 2007 with face-to-face interviews with a total of 150 randomly selected households located in Chandernagore municipality. The municipality population is 32,939 households according to the latest census conducted in 2001. Due to budget and time constraints a sample of 200 households (i.e., 0.6 percent of the population) was envisaged. Even though due to its small size the sample could not be representative of the population it is drawn from, it would generate some indication of the public's preferences with respect to improvements to the STPs and hence to the quality of the water in the Ganga.

The choice experiment survey was administered to be representative of the sample population in terms of income, social status, proximity to the River Ganga and the Wonderland Park. Households were sampled from four randomly selected wards (neighbourhoods in the municipality), chosen randomly from four lists of wards, which were stratified according to proximity to the park and income level. Each ward hosts about one thoudand households and 50 households (i.e. 5 percent of all households in each ward) was within the project budget and timeline of this pilot study. To select households a cross sampling method was used. That is, a cross "X" was drawn on the ward map and every nth household was asked to partake in the survey. Overall response rate was 75 percent with 150 households taking part in the survey.

In each household the household heads were interviewed. An introductory section explained to the respondents the context in which the choices were to be made and described each attribute, their present status and implications on public and environmental health. Respondents were reminded that there were no right or wrong answers and that we were only interested in their opinions. They were also told that the municipality did not have sufficient funds to improve the wastewater treatment facilities of the STP, and therefore it would be necessary to increase the monthly municipal taxes paid by the households. The respondents were also reminded of their budget constraints as well as other local public goods which could be funded through their taxes.

In addition to the choice experiment questions, data on the households' social, economic and demographic characteristics were collected. Descriptive statistics of the sample are reported in Table 2 below.

Table 2. Social, Economic and Demographic Characteristics of the Sampled Households

Characteristic	Sample Mean (std.dev.)
Household size	5.1 (2.4)
Household head age	58.8(13.1)
Monthly food expenditure (in Rs.)	3498.3(1618.4)
Monthly expenditure (in Rs.)	5839.6 (2397.5)
Share of income spent on food	60.1(12.3)
Number of years resident in the area	26(16.1)
Distance to the park (in minutes)	11.4 (3.7)
	Percentage
Household has a child < 18 years of age = 1, 0 otherwise	60
Household head female =1, 0 otherwise	8.7
Household head completed primary school or less =1, 0 otherwise	15.3
Household head has a university degree or above=1, 0 otherwise	33.3
Employment in service sector =1, 0 otherwise	26
Self-employed =1, 0 otherwise	40
Pensioner =1, 0 otherwise	22.7
Housewife =1, 0 otherwise	8.7
Manual worker =1, 0 otherwise	2.7
Visited the park =1, 0 otherwise	80

These statistics reveal that on average the households interviewed in this survey have been residents in the Chandernagore municipality for 26 years and they are located very near the Wonderland Park (a little over ten minutes walking distance). Average number of household members is 5 persons, which is similar to the West Bengal average of 4.7 members per household (Indiastat). Over half (60 percent) of the households have at least one child younger than 18 years of age. A great majority (91 percent) of the household heads are male and their average age is 59 years. About 15 percent of the household heads have completed (or dropped out of) primary school education, whereas 33 percent have technical school or university degrees and above. The average household monthly expenditure (proxy for disposable income in developing countries) is Rs. 5840 (97.8 Euro) and a great majority of the household expenditure is spent on food, followed by health and personal care, and transport. The average per capita expenditure (Rs. 1145) is similar to the average monthly per capita income for Hugli District (under which the Chandernagore municipality falls) which was estimated to be Rs. 1127 in 2005 (Bureau of Applied Economics & Statistics, Government of West Bengal, 2005).

The sample averages for household size and income per capita are therefore similar to the population averages for the Chandernagore municipality. The results reported in this paper however can not be generalised for the entire population of the municipality due to the small size of the sample. Though since some of the key characteristics of the sample are similar to those of the population, sample results presented in this paper do have indicative value regarding the preferences of the population.

4. Results and Discussion

4.1 Data Coding

The CE data were coded according to the levels of the attributes. Binary attributes, i.e., quantity and quality of treated water and the regeneration of the park, entered the utility function as binary variables that were effects coded (Louviere *et al.,* 2000). For quality (quantity) of treated wastewater, for example, the higher quality (quantity) level was coded as 1 and the low quality (quantity) level was coded as –1. Similarly for the regeneration of the park attribute, yes (i.e., investment in the regeneration of the park) was coded as 1 and no (i.e., no investment in the regerenartion of the park) was coded as –1. The levels for the attribute with four levels, i.e., (monthly increase in the municipal tax) were entered in cardinal-linear form, i.e. as 1.5, 4.5, 12.5, 20. The attributes for the status quo ""Neither wastewater treatment programme" were coded with 0 values for each attribute. Since this choice experiment involves generic instead of labelled options, the alternative specific constants (ASC) were equalled to 1 when either wastewater treatment programme A or B was chosen and to 0 when respondents chose neither alternative (Louviere *et al.,* 2000). In this choice experiment the ASC is specified to account for the proportion of participation in wastewater treatment programme. A relatively more negative and significant ASC indicate a higher propensity to choose to pay for improved wastewater treatment programmes.

4.2 Conditional Logit and Random Parameter Logit Models

The choice experiment was designed with the assumption that the observable utility function would follow a strictly additive form. The model was specified so that the probability of choosing a particular wastewater treatment programme was a function of the attributes and the ASC (equation (3) above). Using the 1500 choices elicited from 150 households the CLM was estimated with LIMDEP 8.0 NLOGIT 3.0. The results for the CLM are reported in the first column of Table 3.

The McFadden's ρ^2 value in CLM is similar to the R^2 in conventional analysis except that significance occurs at lower levels. According to Hensher *et al.* (2005, p. 338) values of ρ^2 between 0.2 and 0.4 are considered to be extremely good fits. According to this criterion the overall fit of the CLM (0.219) indicates an extremely good fit, and all the coefficients are statistically significant. Treated wastewater quantity and quality are significant factors in the choice of a wastewater treatment programme, and ceteris paribus, these two attributes increase the probability that a wastewater treatment programme is selected. In other words, households value those wastewater treatment programmes that result in higher quality and quantity of wastewater treated.

Table 3: CLM and RPLM estimates for wastewater treatment programme attributes

	CLM	RPLM	
Attributes	Coeff. (s.e.)		Coeff. Std. (s.e.)
ASC	-1.1***(0.174)	-1.1*** (0.189)	-
Quality of treated wastewater	0.665*** (0.071)	0.645***(0.087)	0.394*(0.259)
Quantity of treated wastewater	0.407*** (0.069)	0.422***(0.086)	0.178(0.233)
Regeneration of the park	-0.421*** (0.064)	-0.446***(0.098)	0.159(0.461)
Monthly increase in municipality tax	-0.147*** (0.012)	-0.155***(0.017)	-
Pseudo ρ^2	0.219	0.343	
Log-likelihood	-867.133	-866.05	
Sample size	1500	1500	

Source: River Ganga Wastewater Treatment Choice Experiment Survey, 2008.
*** 1percent significance; **5percent significance and *10percent significance level with two-tailed tests.

The coefficient on the wastewater quality is about one and a half times the magnitude of the coefficient on wastewater quantity. This result can be explained by the fact that even though residents recognize the need to increase the capacity of the current STP so that all of the wastewater generated by the residents of the Municipality can be treated with primary treatment, they are especially concerned about treating wastewater to a higher quality (secondary treatment) level before discharging in the River Ganga and/or before using it for irrigation or aquaculture. This result reveals that residents acknowledge that the quality of treated wastewater has implications for health and environmental risks. Therefore plans for improvements to the STP should not only include expansion (or full use of its current) capacity for primary treatment, but also upgrading of the current technology, from primary to secondary treatment, so that wastewater can be treated to a higher quality to minimize risks to public and environmental health.

Local households prefer those wastewater treatment programmes which do not propose additional investments in the regeneration of the Wonderland Park to improve its use as a recreational Park. This result is also not surprising given that 98.7 percent of the households interviewed agree that the Park is already an attractive recreational site and since its opening in 1999. In fact 80 percent of the respondents have visited the park for recreational purposes, an average of 6.8 times. The coefficient on ASC is negative and significant implying that there is some degree of status quo bias – all else held constant, respondents would prefer to move away from the status quo situation (Hanley *et al.,* 2005) and towards improved wastewater treatment programmes even if they would have to pay higher monthly taxes for these. Finally, the sign of the payment coefficient indicates that the effect on utility of choosing a choice set with a higher payment level is negative, as expected.

As explained above the CLM imposes the assumption of IIA that can be unrealistic in many settings. In case this assumption fails, the CLM is a misspecification. In order to test the assumption of IIA the Hausman and McFadden (1984) test for the IIA property is carried out. The IIA test involves constructing a likelihood ratio test around the different versions of the model where the choice alternatives are excluded. If IIA holds then the model estimated on all choices should be the same as that estimated for a sub-set of alternatives (Hensher *et al.* 2005, p. 519). The results of the test indicate that IIA property is rejected at the 1percent level for two cases while it is inconclusive in the third case. Therefore the CLM is may not the appropriate specification for the estimation.

Consequently the data are estimated by using the RPLM, which in addition to circumventing the IIA assumption, can also take into account the unconditional unobserved heterogeneity among the households. In order to investigate whether or not the data exhibit unobserved unconditional heterogeneity the RPL model is estimated using LIMDEP 8.0 NLOGIT 3.0. All choice attributes expect the monetary payment were specified to be normally distributed (Train, 1998; Revelt and Train, 1998). The results of the RPLM are reported in the second column of Table 3.

The Swait-Louviere log likelihood ratio test cannot reject the null hypothesis that the regression parameters of CLM and RPLM are equal at 10 percent significance level. The use of the RPLM model therefore does not result in an improved fit, even though the ρ^2 increases from 0.219 in CLM to 0.343 in RPLM. The estimated standard deviations of the RPLM are insignificant for the quantity of treated wastewater and regeneration of the park attribute. These results show that all respondents in the sample would derive higher utility from higher levels of former and lower levels of the latter attribute. The coefficient on the quality of treated water attribute is however significant although at 10 percent significance level. This implies that there is significant choice specific unobserved unconditional heterogeneity for this attribute. Even though the standard deviation for this attribute is significant, it is not large enough to affect the overall sign of the coefficient thus suggesting that the entire sample prefers higher quality treated water (Boxall and Adamowicz, 2002).

4.3 Conditional Logit Model with Interactions

Heterogeneity is often the result of differences of the social, economic, demographic and attitudinal characteristics of the respondents (Boxall and Adamowicz, 2002). In order to gain insight into the *sources* of heterogeneity and to identify the social, economic and demographic characteristics that may provide its foundations, a CLM with interactions was estimated. In this study, whether or not the households have visited the Park in the past, whether or not they have a university degree or above and household monthly expenditure (i.e., income) were considered to be important determinants of WTP and they were interacted with the monetary attribute. The results of the CLM with interactions are reported in Table 4.

Table 4: CLM with Interactions Estimates for Wastewater Treatment Programme Attributes

Attributes and Household Characteristics	Coeff. (s.e.)
ASC	-1.079***
	(0.175)
Quality of treated wastewater	0.673***
	(0.072)
Quantity of treated wastewater	0.416***
	(0.069)
Regeneration of the Park	-0.427***
	(0.064)
Monthly increase in municipality tax	-0.226***
	(0.031)
Monthly increase in municipality tax x household head	0.073***
had university degree	(0.016)
Monthly increase in municipality tax x household has	0.027*
visited the Park	(0.02)
Monthly increase in municipality tax x household	4.12×10^{-6}*
monthly income	(3.2×10^{-6})
Pseudo ρ^2	0.351
Log-likelihood	-855.8
Sample size	1500

Source: River Ganga Wastewater Treatment Choice Experiment Survey, 2008.
*** 1 percent significance; **5 percent significance and *10 percent significance level with two-tailed tests.

The Swait-Louviere log likelihood test suggests that the CLM model with interactions is an improvement over the basic CLM at 0.5 percent significance level. Furthermore, the explanatory power of the model increases relative to the basic CLM as indicated by the high ρ^2 of 0.351, which is considered to be an extremely good fit Hensher *et al.* (2005, p. 338).

The CLM with interactions results reveal that those households who have visited the Park in the past; those who have higher income levels and those with heads that have university degree or above are more likely to pay higher taxes for the wastewater treatment programme.

4.4 Estimation of Willingness to Pay

The choice experiment method is consistent with utility maximisation and demand theory (Hanemann, 1984; Bateman *et al.,* 2003), therefore the marginal value of change in wastewater treatment programme attribute can be calculated as

$$WTP = -2\left(\frac{\beta_{attribute}}{\beta_{localtax}}\right) \tag{6}$$

This part-worth (or implicit price) formula represents the marginal rate of substitution between payment (increase in monthly tax) and the wastewater treatment programme attribute in question, or the marginal welfare measure (i.e., WTP) for a change in any of the attributes. Since all three of the wastewater treatment programme have two levels, i.e., are binary, the WTP is multiplied by two (see, Hu *et al.,* 2004):

The best fitting model in this study is the CLM with interactions reported in Table 4. This model can be used to calculate the value assigned by the household to each wastewater treatment programme attribute (Scarpa et al., 2003), by modifying Equation (6):

$$WTP = -2\left(\frac{\hat{\beta}_{attribute} + \delta_{attribute} \times S_1 + ... + \delta_{attribute} \times S_3}{\hat{\beta}_{localtax} + \delta_{localtax} \times S_1 + ... + \delta_{localtax} \times S_3}\right) \tag{6'}$$

Variables $S_{1\text{-}3}$ are the three household specific characteristics under consideration (i.e., whether or not the household has visited the Park in the past, whether or not the household head has a university degree or above and the household's monthly income). Using Wald Procedure (Delta method) in LIMDEP 8.0 NLOGIT 3.0., households' valuation of wastewater treatment programme attributes are calculated for the best fit CLM with interactions and are reported in Table 6. The first row on Table 6 presents the WTP of the sample average for the three attributes, and the following rows report the valuation of six different households profiles which are presented in Table 5 below.

Table 5. Household Profiles used for WTP Estimates

Profile	Percent Visited the Park	Percent University Degree and Above	Mean Monthly Income (std.dev)
Average household	80	33.3	5831 (2390)
Profile 1: Park visitiors (Recreationalists)	100	30.8	5925 (2432)
Profile 2: Non-visitors (nonRecreationalists)	0	43.3	5452 (2172)
Profile 3: University education & above (Educated)	74	100	6227 (2549)
Profile 4: Below university education (Not educated)	83	0	5037 (1787)
Profile 5: Expenditure below 25th percentile of the sample (Poor)	71	16	3058 (625)
Profile 6: Expenditure above 75th percentile of the sample (Rich)	92	51.6	10030 (1685)

The estimated WTP values for the average household indicate that on average a household values the improvement in water quality the most, as they are willing to pay Rs. 5.82 more in monthly municipal taxes to ensure that the wastewater is treated with secondary treatment and the quality of the water discharged to the river is high. They are willing to pay about half as much to increase the treatment capacity of the STP to treat all the wastewater generated by the municipality with primary treatment. The households, however, derive negative values from investment in the regeneration of the park, given that they are already satisfied with the present facilities (status quo) provided.

Table 6. Marginal WTP for Wastewater Treatment Programme Attributes from the CLM with Interactions for the Average and Six Household Profiles (Rs./household/month) and 95 Percent C.I.

Profile	Quality of treated wastewater	Quantity of treated wastewater	Regeneration of the Park
Average household	5.82 (4.81-6.83)	3.54 (2.76-4.32)	-3.92 (-4.67- -3.2)
Profile 1: Park visitiors (Recreationalists)	5.81 (-4.79-6.83)	3.54 (2.76-4.32)	-3.93 (-4.66- -3.1)
Profile 2: Non-visitors (Non-recreationalists)	5.85 (4.85-6.85)	3.58 (3.08-4.62)	-3.89 (-4.63- -3.15)
Profile 3: University education & above (Educated)	5.87 (4.86-6.88)	3.59 (2.81-4.37)	-3.88 (-4.61- -3.15)
Profile 4: Below university education (Not educated)	5.73 (4.71-6.75)	3.46 (2.667-4.22)	-4.01 (-4.73- - 3.29)
Profile 5: Expenditure below 25th percentile of the sample (Poor)	5.82 (4.82-6.82)	3.55 (2.78-4.32)	-3.92 (-4.65- - 3.19)
Profile 6: Expenditure above 75th percentile of the sample (Rich)	5.81 (4.78-6.84)	3.53 (2.73-4.33)	-3.93 (-4.64- - 3.22)

When the six household types are compared, it can be seen that the marginal values for the three attributes are similar across households. In order to assess whether there are significant differences in the WTP values of these six household types, compared to the average household, following Rolfe & Windle (2005), a Poe *et al.* (1994) simple convolutions process was undertaken. After having calculated the WTP using the Wald Procedure (Delta method), differences between WTP values were calculated by taking one vector of WTP from another. The 95 percent confidence interval is approximated by identifying the proportion of differences that fall below zero. The results are reported in Table 7.

Table 7. Proportion of WTP Differences for Wastewater Treatment Programme Attributes Falling Below Zero

	Quality of Treated Wastewater	Quantity of Treated Wastewater	Regeneration of the Park
Average vs profile 1	0.7144	0.7144	0.7144
Average vs profile 2	0.6715	0.6715	0.6715
Average vs profile 3*	1	1	1
Average vs profile 4*	1	1	1
Average vs profile 5	0.0034	0.0034	0.0034
Average vs profile 6	0.4707	0.4707	0.4707

*significance at 1 percent level

The results of the Poe *et al.* test reported above reveal that, compared to the average profile, profiles 3 (educated and wealthier household) and 4 (poorer households without university degrees) are willing to pay more (3) and less (4) for the wastewater quality and quantity attributes, respectively. Therefore, less educated (and poorer) households are willing to pay the least for improvements in the quantity and quality of water treated, however stratification of households with respect to income (profiles 5 and 6) did not result in any significant differences compared to the average.

5. Discussions and Conclusions

5.1. Discussions

This paper contributes to the limited literature on the estimation of economic values generated by improved wastewater treatment by using the choice experiment method. There are to date very few albeit an increasing number of choice experiment studies carried out in developing countries. In accordance with the conclusions of these emerging number of developing country choice experiment applications (e.g., Scarpa *et al.* 2003a, b; Othman *et al.,* 2004; Bienabe and Hearne, 2006; Hope, 2006; De Groote and Kimenju, 2008; Birol *et al.,* 2009c; Bush *et al.,* 2009;

Bennett and Birol, 2010), this study reveals that the choice experiment method can be successfully employed in a developing country context with careful construction of the choice sets and effective field data collection.

There were some challenges faced when implementing this method in West Bengal, India. In general public in this locality are known to have a general apathy for answering survey-based questionnaires, especially those pertaining to the environmental issues such as improvements in the STP, as studied here, which they feel are under the responsibility of the state or of the local authorities. This was resolved partly by explaining to the households that their opinions might be used to inform the local authorities and also that the issue of improving the STP capacity and technology is important for public and environmental health.

Prior to conducting the choice experiment survey the five enumerators were trained thoroughly in a two workshop. They were coached in tackling various issues that may arise during the interviews, such as how to deal with illiterate or distracted respondents, or those that did not understand the choice exercise. Moreover in order to avoid strain on the enumerators, each one of them interviewed a maximum of ten households a day. Enumerators were monitored by a field supervisor who accompanied each enumerator to at least three interviews.

In each interview, the enumerators explained the attributes, levels they take and the status quo in detail and clearly both verbally and with the help of the simply written material in the local languages and printed in large font on laminated paper. Moreover the pilot contingent valuation survey (CV) conducted prior to the choice experiment informed a more efficient and effective choice experiment survey design. More specifically, the pilot CV was very lengthy which resulted in respondent fatigue. Consequently the choice experiment survey was designed to be as concise as possible. According to the authors' experience, for the choice experiment surveys to be successful in a developing country such as India, thoroughly trained enumerators and simple questionnaires are paramount.

5.2. Conclusions and Future Research

The average monthly expenditure (proxy for income) per capita in Chandernagore municipality is around 19.6 Euros, which is significantly lower than the monthly GDP per capita in India, which was estimated to be 49.2 Euros in 2006 (World Fact Book, 2007). The results of the pilot choice experiment study implemented in this municipality reveal that even though the residents of the Chandernagore municipality have lower disposable incomes compared to national standards, they are willing to pay higher taxes for improvements in the quality and quantity of the wastewater treated in their local sewage treatment plant (STP). Inclusion of the household and household head characteristics in analysis revealed that those households who are more educated (with university degree and above) and those with higher incomes are willing to pay significantly higher amounts for improvements in the quality and quality of wastewater treated, compared to the average households. Overall, these results confirm that even though constrained by tight budget constraints, the residents of this municipality value the quality and quantity of water in the Ganga, and derive positive benefits from the economic, religious and cultural values the river provides.

The benefit estimates reported in this study reveal that an average household in the sample would be willing to pay Rs. 8.36 per month (Rs. 4.82 for high quality of treated water plus 3.54 for high quantity of treated water) in municipal taxes, in order to improve the capacity and the technology of the STP to one that treats all the wastewater generated by the municipality at a high quality (secondary treatment) before discharging it into the Ganga. This would amount to Rs. 100.32 per annum in additional municipal taxes per household.

When aggregated over the entire population (32,939 households), Chandernagore municipality residents' WTP for increasing the capacity of the STP amounts to Rs. 3,304,441 per annum.

Currently the STP treats 24 percent of the wastewater generated by the municipality with running costs of Rs. 2,500,000 per annum. Assuming constant economies of scale, had the current STP treated 100 percent of the wastewater generated by the residents of the municipality, the running costs would amount to Rs. 10,416, 666 per annum. That is, the tax revenues would not be sufficient to cover the costs treating all of the wastewater generated by the municipality with primary treatment. Moreover, in order to be able to treat wastewater to a higher quality (i.e., secondary treatment), investment in the upgrading of the technology of the current STP is required. Therefore an increase in municipal taxes by a maximum of Rs. 8.36 per month may not be sufficient to cover the costs of both upgrading of the technology and maximising of the capacity of the current STP. This 'back-of-the-envelope' cost-benefit analysis (CBA) would suggest that even though the residents' welfare would increase as a result of an improvement of the current STP, tax revenues may not be sufficient to meet the costs and hence additional financial sources should be sought for the financing of this endeavour.

The results reported in this paper are indicative of local public's demand for higher quality and quantity of treated wastewater to minimize the high levels of environmental and health risks in the Ganga. It should however be noted that this study is a small pilot conducted to understand the significance and direction of the public's valuation of different attributes that may be generated by improved STP technology and capacity. In order to provide the policy makers with more accurate figures on the costs and benefits of improving STPs along the Ganga, a more comprehensive CBA study should be conducted. This proposed study should comprise economic valuation methods to estimate various benefits which may be generated by the cleaning up of the Ganga. These benefits may accrue to different stakeholder groups such as farmers, industry, tourists, local, national and international public etc. This proposed study should also gather more accurate estimates of upgrading and maintenance costs and should conduct a thorough CBA with long run discounting, since cleaning up of the Ganga have welfare implications for generations to come. Only such a thorough study could provide the policy makers with accurate information regarding the optimal STP investments to clean up the Ganga . This pilot case study is a small endeavour in that regard.

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