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RESEARCH PAPER

Estimating Willingness to Pay for Wastewater Treatment in New Delhi: Contingent Valuation Approach

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Abstract: Given the increasing demand pressure on water resources coupled with supply holdups and institutional failures, fresh-water resources are increasingly susceptible to depletion and could potentially add to water stress in India. A vast demand-supply gap necessitates water conservation, including recycling measures. India has a great potential in wastewater treatment, and one of the ways to address it is decentralisation of wastewater treatment given its environmental benefits. Based on the Contingent Valuation Method (CVM), this study assesses Delhi urban households' willingness to pay for the Operation & Maintenance (O&M) costs of a local Wastewater Treatment Plants (WWTP) that supplies residential complexes treated water for toilet-flushing. The study found that if freshwater prices rise sufficiently for consumers, they may be willing to subsidise a decentralized WWTP to cover at least their non-potable water uses. In addition, the co-provision of such public goods can become an important supplement to urban municipal finance.

Keywords: Community Participation, Contingent Valuation, Willingness To Pay, Wastewater Treatment, Double Hurdle Model.

1. INTRODUCTION

Global water resources are vulnerable to climate change and population growth and are affected by rising water demand, worldwide. In India, as also in the entire sub-continent, the rising population has reduced per capita

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average freshwater availability by about 65% in the latter half of the 20th century and is expected to reduce further over the next 30 years (Kaur *et al.* 2012). Overall, water demand is projected to increase by about 55% by 2050 causing worldwide depletion of water resources (Mountford 2011). While India might not be critically water scarce at present, in terms of the Water Stress Index,[1] some parts of northern and southern India (e.g., Uttar Pradesh, Andhra Pradesh, Telangana, and Odisha) are 'critically' water scarce (Rijsberman 2006).

The emerging groundwater problem in South Asia and the Middle East and their increasing populations are causing demand for water (for domestic uses, irrigation, and industries) to rise, leading to depletion of fresh-water aquifers on one hand and rising salinity and contamination of usable groundwater on the other (Barker, Koppen, and Shah 2000). India is no exception and hence needs to critically examine supply augmentation options by reusing treated wastewater to bridge the demand-supply gap. Municipal bodies are caught in a downward spiral of disrepair and are unable to meet demand or maintain effluent standards for treated wastewater. Inefficiency, low investment levels, financial unviability, and absence of customer orientation means customers face inadequate and unreliable low-quality water supply (Dutta, Chander, and Srivastava 2005). About 70-80% of domestic water use translates into wastewater production. According to Central Pollution Control Board (CPCB), in 2007, the combined wastewater generation from cities and towns was 38,354 million litres daily (MLD) whereas sewage treatment capacity was only 11,786 MLD—a gap of about 26,568 MLD. In 2017, the gap, although lower, was still about 22,939 MLD. Presently, the average utilisation of the eight sewage treatment plants (STP) owned by Delhi Government is 52% of total installed capacity, which is rated as gross underutilization (Gautam *et al.* 2017).

In developed nations, treated wastewater is used for agriculture and industrial purposes, however, avenues for its use in urban areas are rising. Often, scarcity is caused due to mismanagement in the distribution of water resources (CSE 2013). The city water-excreta survey[2] portrays a succinct picture of demand-supply gap and leakage losses in metro cities and other classifications. Based on water supply norms of Central Public Health and Environmental Engineering Organisation (CPHEEO), water demand is in

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[1] According to this index, a country is defined as being water scarce when its water resource availability is less than 1000 cubic metres per capita (Sengupta 2011).

[2] The survey was published in 2005-06 by Centre for Science and Environment (CSE). It depicts the water supply scenario of 71 cities in India.

excess of supply in 35% of the 71 cities surveyed with the highest shortfall and demand-supply gap in metropolitan cities (Narain 2012).

In India, according to CPCB, urban areas generate 22,900 MLD of domestic wastewater, which has surpassed industrial wastewater generation (13,500 MLD). However, the treatment capacity for domestic wastewater is only 25% (Sengupta 2011). Water recycling and reuse have proved to be a feasible and sustainable way of water management (Anderson 2003). This is demonstrated by Chennai Metro Water Supply & Sewage Board's (CMWSSB) zero-water discharge programme in which all wastewater generated is treated and fully reused. As of 2018, 15% of Chennai's water demand is met from recycled water (International Water Association 2018). About 40% of domestic water demand of newly built houses and 8% of industrial water demand is met from the treated wastewater (International Water Association 2018). In Bengaluru, recycled water is used for toilet flushing and landscaping in apartment buildings. In a recent study, 67% of survey respondents in Bengaluru city expressed willingness to buy recycled water (Ravishankar, Nautiyal and Seshaiah 2018). Wastewater treatment has great potential, and it may be feasible for the users and governments to co-sponsor setting up Wastewater Treatment Plants (WWTP). In fact, WWTPs are a pre-requisite to the overall development of urban metropolises as they internalise the negative environmental externalities of urbanisation.

The primary objective of this study is to find out urban residents' willingness to pay (WTP) for the maintenance of a decentralised WWTP that treats domestic wastewater ("grey" water) for non-potable reuse. The study identifies main factors that affect monetary participation as measured by WTP and environmental attitude of individuals. Contingent Valuation Method (CVM) was used for valuation of a non-market environmental good i.e. treated wastewater and its reuse. The survey responses were elicited through an individual Contingent Valuation questionnaire using payment card format for the WTP bids, and econometric analysis was undertaken to determine the impact of household perceptions, socio-economic and demographic characteristics on the WTP bids of urban households. Subsequently, the average WTP and net benefits were computed. The water saving potential was computed in monetary terms as a reduction in the freshwater bill[3] when recycled water was reused by households.

3 The new freshwater bill is the original bill less the water-savings based on water consumption level plus the share of O&M cost of the treatment plant that is payable by the residents.

The paper contributes to (1) the existing contingent valuation literature in a developing country context with respect to wastewater treatment; (2) a novel econometric identification strategy; and (3) providing the numerical value of water saving potential for urban households in Delhi and its potential benefits for the households. The next section describes various technical options to treat domestic wastewater and some examples from the Indian context. Section 3 focuses on description of CVM, theoretical framework and related literature. Section 4 depicts the present study area, survey data and empirical strategy. Section 5 discusses salient findings, and section 6 describes study limitations. The last two sections conclude the paper and highlight policy implications.

2. TREATMENT OPTIONS

In order to be reused, domestic wastewater is treated with specific processes determined based on the level of effluent standards and reuse purpose. Wastewater reclamation involves various levels of treatment including primary (bar screens, grit chambers, skimming tank followed by a primary sedimentation tank), secondary (trickling filter, activated sludge process, secondary settling tank, oxidation ponds and sludge treatment) and tertiary treatment i.e. removal of residual organic matter (Tchobanoglous and Burton 1991). Each treatment level is associated with a certain level of water pollution as well as purpose, and pollution level decreases with an increase in the level of treatment. Benefits of wastewater reclamation include conservation of fresh-water resources, prevention of over-extraction and pollution reduction of water bodies.

Recently, there has been a paradigm shift with studies demonstrating wastewater treatment to its reuse, especially for industrial and agricultural purposes. Some metropolitan cities in India like Chennai and Bengaluru are working on tapping the potential for wastewater treatment and reuse. In Chennai, it is compulsory for every community to treat wastewater. The water balance study for wastewater reuse (toilet flushing and irrigation) in Sangamam, Tamil Nadu shows that potable fresh-water demand reduced by 120 litres per capita daily (LPCD) (CPCB, 2008). For non-potable purposes, secondary treatment like Activated Sludge Process (ASP), Sequencing Batch Reactor (SBR), Moving Bed Biological Reactor (MBBR) and Membrane Bioreactor (MBR) are preferred to achieve the required effluent standards. Table 1 provides processes[4] and their effluent standards, that is Biological Oxygen Demand (BOD) and Suspended Solids (SS). MBR is a popular

[4] Detailed description of processes is provided in Table A6 in annexure.

technology given its capacity to treat wastewater to prescribed river water quality levels but is costly (Kamyotra and Bhardwaj 2011). The costs are calculated for 1 MLD, hence, there are limitations in scaling down the costs due to the presence of scale economies (Sugam, Jain and Neog 2017). In terms of scale economies for centralized versus decentralized plants, there are cost differences, however, decentralized plants are designed to operate at a smaller scale as compared to centralized ones (Massoud, Tarhini and Nasr 2009).

Table 1: Output Water Quality

Technology	BOD (mg/L)	SS (mg/L)
ASP	<20	<30
SBR	<10	<10
MBBR	<30	<30
MBR	<5	<5

Source: Sugam, Jain and Neog (2017)

The benefit of decentralized plants is the feasibility of community involvement in sharing Operation & Maintenance (O&M) costs that reduces monetary burden for government budgets. Since this is on a need basis, it will also not lead to wasted potential as opposed to centralised treatment plants. In the end, the assessment of centralised plants often indicates wasted potential as well as issues of improper piping that lead to mixing of treated and untreated water hence wasting the entire effort of treatment in the first place (Narain 2012). Although devoid of scale economies, the decentralised plants are better suited in the urban as well as rural context.

3. CONTINGENT VALUATION METHOD

The contingent valuation method (CVM) accounts for necessary scenario change for which valuation is done i.e. treatment of domestic wastewater through construction of WWTP and subsequent improvement in water quality from q^0 to q^1. The method assesses total consumer welfare from the utility through improved water quality. This utility benefit can be measured using the Hicksian Compensating Variation (CV) (Weldesilassie *et al.,* 2009).[5]

$$CV_h^{01} = e_h\left(p^1, q^1, U_h^1\right) - e_h\left(p^1, q^0, U_h^0\right) \quad (1)$$

where, e_h (p, q, U_h) is household's expenditure function, p is price vector, q is the level of public good and the household's utility i.e. U_h. The superscript 0 refers to the current scenario (no provision of public good) and superscript 1 refers to improved scenario (with the provision of public

[5] The Contingent Valuation framework helps to determine what amount of income change would be required to compensate the consumer for the payment. For a "good" change, wherein utility is higher than before (an assumption), CV correctly measures the WTP (Varian, 1992).

good). The compensating variation is equivalent to the maximum amount of money that can be appropriated from the consumer, that is shadow price or WTP of an individual (Weldesilassie *et al.* 2009). "Willingness to pay is defined as the maximum price a buyer accepts to pay for a given quantity of goods or services" (Gall-Ely 2009).

Equation (1) can also be written as the integral of the shadow price of the environmental good:

$$CV_h = e_h \int_{q^0}^{q^1} \pi\left(p^1, q, U_h^0\right) dq \qquad (2)$$

where, due to unobservable nature of the shadow price function π_h (p, q, U_h) = $-\partial e$ (p, q, U_h) / ∂q**,** the willingness to pay is elicited through CVM.

If individual's income in the utility function is Y_i and the payment for the environmental good is h_i for an individual i, in the context of Random Utility Model, a respondent will be willing to pay h_i (which raises the quality of the environmental public good, that is treated wastewater, from q^0 to q^1) if:

$$U_1(y_i - h_i, z_i, \varepsilon_i) > U1(y_i, z_i, \varepsilon_i) \qquad (3)$$

where, z vector contains socio-economic and demographic characteristics.

Equation 3 simply states that an individual will be willing to pay a certain bid if they are better off with the payment and the public good provision (Dutta, Chander and Srivastava 2005). This gives rise to the probability of an individual saying yes, expressed as:

$$\Pr(yes_i) = \Pr\{U_1(y_i - h_i, z_i, \varepsilon_i) > U_1(y_i, z_i, \varepsilon_i)\} \qquad (4)$$

The utility function of an individual is additively separable into a deterministic and random component.

$$U(y_i, z_i, \varepsilon_i) = U(y_i + z_i) + \varepsilon_i \qquad (5)$$

Let the deterministic part (non-stochastic) of the utility function be as follows:

$$U_i = \alpha_i z_i + \beta(y_i - h_i) \qquad (6)$$

The stochastic part is the error term i.e. ε. The utility difference is calculated as:

$$U_i^1 - U_i^0 = (\alpha_i z_i + \beta h_i) \qquad (7)$$

$$\Pr(\text{yes}_i) = \Pr(\alpha_i z_i - \beta h_i + \varepsilon_i) > 0 \tag{8}$$

where, α is the difference of vector of coefficients to respective socio-economic and demographic variables between two scenarios i.e. $\alpha_i = \alpha_1 - \alpha_0$.

The behaviour assumptions for error term necessitate independent and identical distribution (IID) with zero mean (Dutta, Chander, and Srivastava 2005). Usually, logit (logistic CDF) or probit (standard normal CDF) models are used depending upon the choice of the cumulative distribution function (CDF) for the data obtained. However, WTP calculation is not derived from the Random Utility Model for payment card format. Prior CVM studies have measured WTP both for setting up a common treatment plant as well as improving the capacity of an existing plant (Rollins *et al.* 1997; Tziakisa *et al.* 2009). A recent study in Bengaluru states that decentralized wastewater treatment plants are an attractive solution to the rising water scarcity problems in urban India (Kuttuva, Lele and Mendez 2018). They distinguish between the voluntary role of the public in adopting the system versus incentives used to gain compliance and conclude that even though such systems are a partial solution to addressing the scarcity issue, voluntary adoption is quite challenging, and consumers must be incentivized for adoption. The study highlights prior arguments made against centralized wastewater treatment as a non-optimal solution as compared to the decentralized treatment that leads to larger environmental benefits (Kuttuva, Lele, and Mendez 2018). Given that other cities in urban India face similar constraints in terms of water scarcity and sub-optimal performance of centralized wastewater treatment plants, the present study offers a potential solution.

The framework proposed here requires an institutional setting where a government-sponsored public good is made available to people and they pay a monthly subscription, so it fits into the literature that measures benefits of decentralization of treatment plants. A global overview depicts the advantages of reusing wastewater, for instance, in Australia, wastewater reuse decreased energy consumption and demand for fresh water. In places like Lebanon and Palestine, the grey water is used to irrigate crops rather than domestic reuse, however, it also has shown positive impacts for demand reduction (Madungwe and Sakuringwa 2007). A study in Greece elicited residents' willingness to pay for the provision of a central wastewater treatment plant using CVM through a questionnaire on their socio-economic, demographic background and valuation concerns. The study found that about 97% of the residents agreed to pay for construction and their mean WTP was about 93% of the fresh-water price (Tziakisa *et al.* 2009).

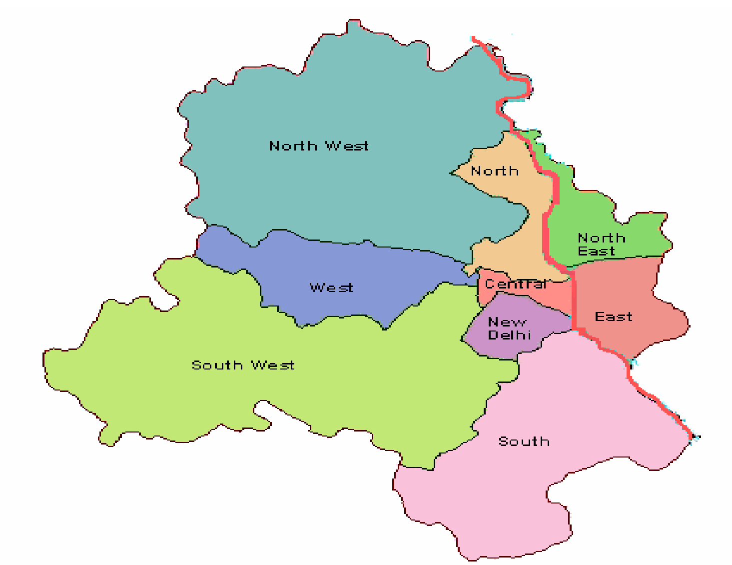
Another study in Greece ensured the full operational capacity of an existing treatment plant and concluded that about 69% of respondents were willing to pay, and the total amount contributed by respondents covered the amount required for the full operational capacity of the existing plant (Kontogianni *et al.* 2003). These studies follow a similar methodology; however, they look at individual households rather than a community. In communities, the mindset of respondents is different and often leads to comparatively lower zero responses. Loomis *et al.* (2000) estimate the total economic value of restoring selected ecosystem services in a river basin and estimate WTP and other total economic value measures using CVM. Rollins *et al.* (1997) elicited WTP by implementing the CVM and concluded a significant willingness to pay. The studies that focus on wastewater treatment and reuse have implications for water demand, that is, the provision of such public goods and perceptions about them have implications for water demand by respondents.

4. PRESENT STUDY

The study is based in New Delhi, which is not only the capital of India but is also becoming a hub for activities causing pollution. There are 4 major districts i.e. North, South, East and West Delhi as is visible in Figure 1. The Population of West Delhi (about 25 lakhs) and South Delhi (about 27 lakhs) is highest among all major divisions which correspond to high water demand and usage relative to other divisions (District Census 2011). Delhi's colossal water shortage problem coupled with massive population growth has led to groundwater exploitation. The water demand-supply gap was estimated at 173 MLD (million litres per day) and rose up to 2,149 MLD after accounting for leakage loss (Narain 2012). Groundwater resources cater to about 12% of the city's water needs, however, it is underestimated given unaccounted use of alternatives (hand pumps, illegal tube wells etc.). This has led to groundwater salinity and a fall in water tables up to 30-45 meters below the ground level in West, North West and South West Delhi (Economic Survey 2014-15). India's per capita water availability is decreasing and is expected to fall from a level of 5177 cubic meter per year in 1951 to 1140 cubic meter by 2050 which warrants need for efficient water management (Kaur *et al.* 2012).

Domestic sewage is about 80% of the household water supply,[6] which contributes to more than 80% of the pollution load (Narain 2012). CPCB estimates 4,426 MLD wastewater generation in Delhi. This wastewater needs to be treated in a Municipal Wastewater Treatment Plant (MWWTP) to remove harmful chemicals and waste. Although the number of treatment plants and capacity has increased over time; as of 2008, the treatment capacity was 3,250 MLD at 100% capacity utilization. In other words, only about 70% of the wastewater generated in Delhi could be treated (Narain 2012). There was no domestic reuse and the treated water was dumped into drains that nullified the whole process. As of 2018, the installed capacity is only 75% of the total wastewater generated in Delhi, and the utilization rate is about 75% (Gupta, Singh and Gandhi 2018).

Figure 1: Districts in New Delhi



Source: Wikipedia (2019)

This raises a question about improvement in centralised wastewater treatment plants and disposal process and their complementarities with decentralized plants (Libralato, Ghirardini and Avezzù 2012). This study

[6] Domestic Sewage consists of black water (containing faecal matter) as well as greywater (coming from household activities but not containing faecal matter); this study focuses on reuse of domestic greywater.

focuses on decentralised STPs as the focus is on domestic wastewater reuse within households. In addition, effects of improvement in centralized (government-owned) STPs have been widely studied in the literature. Although economies of scale may not hold with decentralized STPs, it is important to recognize that decentralized STPs do not always correspond to small scale.[7] However, the decentralized approach is helpful in inducing wastewater reuse at a lower cost[8] through savings in the cost of piping for supplying the treated water as compared to centralized STPs. Moreover, decentralised STPs favour reuse instead of discharge into the environment (Libralato, Ghirardini and Avezzù 2012). Given the economy, efficiency and utility, Decentralized Wastewater Treatment Systems (DEWATS) jointly set up by community and municipality are becoming popular for greywater treatment (including wastewater from kitchen, washing machine and bathwater, etc.). Vigyan Vijay, an NGO based in New Delhi, has set up a wastewater treatment plant in Vasant Vihar [capacity: 45 KLD (Kilo Litres Daily); reuse available: 40 KLD] as well as a kitchen waste biogas plant with funding from the residents and the Municipal Corporation of Delhi in order to scale up micro-sized plants (Seshadri 2011). Hence, co-funding is not only a proposed strategy for decentralized treatment plants, but it has also already been implemented in India.

4.1. Study Specifications

This study is based on a primary survey of 167 urban households in eight group housing societies (GHS) in New Delhi.[9] Households were identified based on stratified random sampling, where a stratum is defined as urban households living in group housing societies (each GHS has a common Resident Welfare Association (RWA)). The societies were chosen given their proximity to municipal WWTP that treated their domestic wastewater. Within each society, households were randomly chosen.[10] As much as possible, the choice of households was random, but it is still subject to a sampling error. The households were surveyed from December 2015 – February 2016 and one representative from each household who was involved in household decisions was interviewed.[11] The survey questionnaire[12] was designed to elicit responses in three information

[7] The scale (in KLD or MLD) will depend on a society if the study is to be generalized to relatively larger societies as compared to our sample.
[8] The additional capital and maintenance costs for decentralized STPs have been discussed under cost estimates. The dual piping is not initiated in Delhi; hence no reasonable estimate may be utilized as per Indian Institute of Technology, Roorkee experts.
[9] This represents 6.1 % of total households in 8 societies as of 2016.
[10] On average, less than 10% of households within each society refused to be interviewed.
[11] The 8 survey areas and number of respondents is included in the annexure.
[12] The instructions for questionnaire are included in the annexure.

categories: (a) Attitudes, knowledge and behaviour, (b) Economic valuation questions and (c) Socio-economic characteristics. The pilot survey took place in December 2015 in Punjabi Bagh (West Delhi), where seven households were surveyed to test and, if need be, amend the questionnaire in order to obtain all required information. The scenario structured for CVM in the context of Delhi was quite similar to a study that was conducted in Chennai to elicit consumer willingness to pay for wastewater management and reuse (Das, Bouzit and Cary 2016). After ensuring the appropriateness of the survey questionnaire, the rest of the households (160) were surveyed during January – February 2016. The survey was conducted by way of a personal interview with a Payment Card Format Questionnaire in which a set of bids was provided, and the respondents chose their maximum WTP. There was only one scenario change[13] that was provided to the respondents along with its characteristics.

Before the pilot study was implemented, the following steps were taken in reducing CVM biases. To begin with, as all households in the survey sample pay the water bill according to consumption levels, they were familiar with water use cost. Further, all survey interviews were conducted by the same interviewer in order to minimize bias. All respondents were briefed that their freshwater bill would reduce by a certain proportion depending on their consumption levels. The interviewees were also told that there was no increased monetary burden, in case they "dislike" the payment vehicle (Whittington 2010). It was taken care that the time spent in asking the questions was more and less same for all interviewees and that the interviewer did not indulge in any personal talk in order to avoid anchoring or influencing the answers of the participants. Also, for all societies, the individual households were chosen randomly, and the survey was completed on the same day to avoid survey information being passed on by neighbours. The remaining biases are discussed in the limitations. The bid amounts[14] used for economic valuation were calculated using time series data on per capita water consumption in Delhi for the past 10 years. The payment vehicle is a tax over and above the existing monthly water bill and can be thought of as a monthly payment to the RWA to financially support the O&M costs of the treatment plant.

4.2. Survey data and Econometric Framework

During the survey period (January – February 2016), the data entry was done manually and cross-checked after survey was completed to avoid data

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[13] The scenario change (in the questionnaire included in annexure) has been constructed after consultations with field experts, hydrologists, municipal officials and academicians.

[14] Assuming a 4-person household, the final water bill was Rs. 950.

entry errors. The data being of categorical nature required transformations to facilitate data analysis using Stata.[15] In terms of outliers and errors in reporting, data was not always consistent. It was observed that two households with same water consumption had a slightly different bill amount, but the analysis results are robust to that.

Given that the data had many zero responses that depicted people's unwillingness to pay, an empirical model that accounts for the meaning of zeros fits the data well. With such data, heckit type 2 or "hurdle" models were suitable as they assumed a 2-step decision. In addition, the model assumed that factors affecting consumer participation have a different impact on consumption/payment hence a two-step process is followed (Humphreys, 2013). It also allowed for covariates to be different for two processes i.e. participation and payment. These models were a less restrictive version of the Tobit Model, which assumes one process explains both decisions. According to Jones' Alternatives, hurdle models are best suited for "genuine zero" responses when the participation and payment decision is taken simultaneously. Hence, the Double Hurdle Model was employed (Humphreys 2013). In the first step, a probit regression is run for the participation decision, where a dummy for whether the respondent is willing to participate in the contingent market is regressed on explanatory variables (Jones 2000). The second step is a truncated Ordinary Least Squares (OLS) regression to model the payment decision by those individuals that choose to participate in the contingent market. Since a part (116 respondents) of the total sample population (167 respondents) was modelled for the second decision, the truncated OLS is used instead of a simple OLS regression model.

The econometric representations given below characterize participation (9) and payment (10).

$$Y_1 = \varphi(SEC_i, HC_i, DEM_i, Z_i) \tag{9}$$

$$Y_2 = f(SEC_i, HC_i, DEM_i, Z_i) \tag{10}$$

where, Y_1 is participation dummy, Y_2 is WTP, φ standard normal CDF, f is truncated regression CDF, SEC is socio-economic characteristics, HC is household characteristics, DEM is demographic characteristics and Z is environmental characteristics. The Z vector includes awareness dummy (regarding wastewater disposal and treatment) and pollution dummy (opinion about pollution due to uncovered sewer drains).

[15] Stata, a statistical package, has also been used for the entire estimation of the empirical model described in this section in order to obtain findings.

5. SURVEY FINDINGS

5.1 Empirical Results

A total of 167 urban households from 8 societies across 4 districts of Delhi participated in the survey. All societies had an existing MWWTP responsible for treating the domestic wastewater, 70% of which were found to be grossly underutilized, and those that were fully utilized had a very low treatment capacity as compared to others. Reasons for such poor performance have been documented in studies by CPCB as well as others (Kaur *et al.* 2012). Improper design, power cuts and lack of maintenance have been highlighted as the main reasons behind the neglect of STPs. Due to the lack of proper functioning of the facilities, most STPs remain closed or underutilised (Kaur *et al.* 2012).

Table 2: Summary Statistics

Name	Mean (Std. Dev)
Age (years)	45.4 (17.0)
Monthly Income (Rs.)	72997.0 (28591.5)
Monthly Expenditure on Food (Rs.)	17481.0 (8758.6)
Total Monthly Expenditure (Rs.)	40304.9 (16419.5)
Monthly Water Bill (Rs.)	583.9 (371.8)
Monthly Water Consumption (KL)	21.4 (8.6)
Children	1.5 (0.8)
Household Members	3.9 (1.4)
Toilets	2.4 (0.9)

Source: Authors' calculations based on field survey data

Of the respondents surveyed, 60.5% were males. About 54% of the respondents possessed an undergraduate degree, 38% were post-graduates and 8% stated higher secondary level as their highest educational qualification. About 67% of the respondents were aware of wastewater disposal and treatment as well as the existence of an STP nearby. Overall, 69% of the respondents were willing to pay for wastewater treatment in a contingent improved scenario and reuse of treated wastewater. Of those who stated motivation behind the willingness to pay (51 respondents), 49% said it was for the environmental protection for future generations. These specific questions in the survey directly translated into economic variables of interest in order to employ the econometric strategy. The description of the variables is presented in annexure. Table 2 provides summary statistics. The average age of the respondents was 45 years and they played a role in household decision-making. Majority of the households had a single child, and some had more than 3. On average, the survey households had four members each and at least two toilets, and they came under a high tax bracket.

To reiterate, 69% of the respondents were willing to pay for improved wastewater treatment services and reuse. This directly corresponds to whether they were aware of improper wastewater disposal and its negative environmental consequences. Of the respondents who were unwilling to pay (31% of the total sample), about 52% believed the government should pay for such improvements. During the interview, many respondents said that they did not believe that the municipality put the resources to correct use, although it was not formally captured. Hence, it is speculated that this belief was triggered due to a trust deficit of consumers in the municipalities given their opaque management system. A double-hurdle model for participation and payment decision was employed and results for both tier 1 and 2 are specified in Table 3.

Table 3: Regression Results of the Survey

Variables	Tier 1: Probit Coefficient (Standard Error)	Tier 1: Probit Marginal Effects (at mean)	Tier 2: Truncated OLS Coefficient (Standard Error)
Age of respondent	0.0152 (0.0154)	.0019 (.001)	-1.841** (.838)
Education dummy	0.236 (0.638)	.0305 (.083)	99.362 (136.792)
Pollution	1.747*** (0.486)	.2258*** (.086)	111.81** (48.757)
Awareness dummy	3.010*** (0.480)	.3891** (.161)	40.590 (37.493)
Female	0.756* (0.438)	.0977 (.071)	-46.435** (23.99)
Monthly income	0.0000645*** (1.76e-05)	0.00000834*** (2.79e-06)	.001229* (.0006)
No. of Children	-0.156 (0.270)	-.0202 (.037)	-
No. of Toilets	-	-	39.727*** (11.976)
Constant	-7.397*** (1.787)	-	-100.222 (159.502)
Observations	167	167	116

Source: Authors' calculations based on field survey data
Note: Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Female respondents were more likely to pay for wastewater treatment, however, their WTP bid was significantly lower than that of male respondents. There were some contradictory results obtained in the literature with respect to the gender of the respondent (Genius &

Tsagarakis 2006). However, Bilgic (2010) found that female respondents in Turkey were willing to pay lower than their male counterparts given a greater role of males in decision making, which is consistent with the present study. Household income was also an important and significant factor in determining participation and WTP amounts. Some studies use food expenditure as a proxy for income, given the inherent problem of underreporting; food expenditure has a positive impact on WTP estimates (Bilgic 2010). Whittington et al. (1993) had similarly observed that higher income has a causal link with higher willingness to pay. Awareness level of the individual regarding wastewater treatment is also a key determinant. Level of education showed no significant effect on WTP for improved wastewater infrastructure in a study in Canada (Rollins *et al.* 1997). Result of the present study is consistent with that and it is possible that correlation[16] between awareness and education level may be high or it could also be a direct result of low variation in education level in the sample.

Another important factor that contributes towards participation is the respondents' knowledge and perceptions of pollution caused by sewage (positive and significant). Groundwater pollution and coastal pollution have been used in drinking water improvement studies and results are in line with economic theory as groundwater is a major source for drinking in Greece (Tziakisa *et al.* 2009). In line with mainstream literature, the payment decision in this survey is influenced by perceived pollution level. In addition, gender and income have a significant impact on the amount that a respondent is willing to pay for wastewater treatment. The number of toilets (a proxy for water usage) is a significant determinant of the WTP bids chosen by respondents. The economic rationale being that those who consume more water and pay higher monthly water bill are the ones who can afford to do so; they have a high probability of choosing a higher bid than low consumption households. Any reduction is beneficial to high consumption households and leads to a large potential freshwater and monetary saving.

Usually, it is expected that respondents having high water consumption have a higher contribution to the treatment of used water. The analogy is similar to the Kyoto Protocol for climate change—the countries that emit more carbon must abate at a higher rate. Other measures of water usage identified in the literature are the water bill and water consumption. Those who pay water bill that is inclusive of wastewater or sewerage charges would usually like to pay less for wastewater treatment (Rollins, *et al.* 1997).

[16] To ensure problem of multicollinearity is dealt with, if any, correlation between education and awareness is evaluated and it is not high as well as a joint F-test shows significance.

A Study done in Greece on wastewater improvement concludes that consumers who consume more water are willing to pay a higher amount; these are cases of larger families with more no. of children and a high willingness to pay for their wellbeing (Tziakisa *et al.* 2009). The salient findings from the survey are listed below.

1. Relatively high level of awareness among people of wastewater treatment and disposal: As many as 69% of the total respondents were aware of wastewater treatment concerns in contrast to 44% reported by a similar study in Bengaluru (Ravishankar, Nautiyal and Seishaiah 2018). However, this awareness is lower in comparison to Australia and Florida, possibly because recycled water is already being reused in those countries (Po, Nancarrow and Kaercher 2003).

2. A majority of respondents distrust government's fund management: More than half (53%) of total respondents were not willing to pay government directly, consistent with a similar choice-experiment study of WTP of local people near the Ganges that found that even though people valued the improvement in wastewater quality, most of them were not willing to pay due to a substantial amount of distrust in the fund management of authorities (Birol and Das 2012).

3. Nearly half (48.5%) of the respondents felt that wastewater treatment was important regardless of cost. Also, 36.2% (42) of the total respondents (116) who were willing to pay for wastewater treatment stated their motivation as protection of the environment for future generations, while 76% of the respondents (89) felt that wastewater treatment was very important regardless of the cost.

5.2. Willingness to Pay

The average willingness to pay varies across the survey respondents due to the existence of heterogeneity in awareness levels, socio-economic characteristics and environmental attitudes. The average WTP varies within a range of Rs. 100 – Rs. 200.[17] The potential benefits from scenario change are constructed using reduction in freshwater bill, water saving potential and approximate cost constructed based on estimated cost regressions (Starkl et al. 2018), which is compared to water bill in business as usual scenario. The comparison is systematically provided in section 5.3. The net benefits are calculated while accounting for operating and maintenance costs based on the premise that residents are responsible for O&M

[17] Table A5 in annexure captures average WTP for each society.

expenditure. The capacity[18] of 200 KLD was chosen to minimize the sub-optimal use, achieve cost efficiency and overcome the inherent problem of inefficiency in government-owned plants.

5.3 Water Saving Potential

The activity-wise water consumption was calculated by a study done in all major cities in India, including New Delhi (Shaban and Sharma 2007). In an urban household, bathing accounts for the highest proportion of water usage, followed by toilets flushing, and utensil washing (Shaban and Sharma 2007). Based on this study, percentage of water consumption in toilets per month in Delhi (16.5%) was computed for all the households. This study computes the water saving potential that equals the volume of water used in toilets in line with its premise that replacement of freshwater with treated water is channeled towards non-potable household use.[19] The absolute figure depends on total household consumption. Therefore, the households were categorized based on their consumption levels. To maintain congruity, we followed water consumption categories similar to those provided by Delhi Jal Board in their tariff order for domestic consumers. The tariff rates used in the calculation are the revised rates for the year 2015.

Table 4: Household Water Saving Potential

Consumer Category	Water Consumption (KL/month)	Average water saving (KL/month)	Average water saving (Rs./month)	Potential Saving (percentage of average monthly water bill)
1 (Low)	0-20	2.09	14.68	6.1%
2 (Medium)	20-30	4.04	142.10	21.0%
3 (High)	Above 30	6.27	367.27	26.6%

Source: Authors' calculations based on field survey data

The average water saving for three consumer categories (in volume and monetary value) are provided in Table 4. The interpretation of the results is quite straight-forward in that saving is proportional to consumption category: households in high consumption category had higher saving potential than those in low consumption category. For a medium category water consumer, average water saving was Rs. 140 per month; which is, to say the least, not insignificant compared to the average bill in that category (i.e. Rs. 675). Similarly, high usage category households on average save

[18] Although the technology has been scaled down, costs cannot always be scaled down given scale economies hence, the scaled down costs from CEEW estimates are compared with cost functions estimated by Starkl *et al.* (2018).

[19] Please note that although non-potable includes a wide variety of uses, toilet reuse was not mentioned in the survey.

Rs. 367 on the average bill of Rs. 1378 (i.e. average monthly saving of 26% of the average water bill for the category). Users who are quite close to the upper threshold of categories have an incentive to reduce consumption[20] and save a lot on the water bill, that is, say a household uses 22 Kilo Litres (KL) of water per month, by reducing even 2 KL consumer would jump down to the lower category thus saving on the water bill.

Based on these categories, if the average WTP is compared to average water saving in monetary terms, it gives a rough idea as to whether households are better off[21] with the new scenario or not. For low and medium category users, the average WTP is higher than the average water saving per month whereas for the high category[22] users, the potential water saving is much higher than average WTP. In Table 6, similar findings by Tziakisa *et al.* (2009) demonstrate WTP as a percentage of average water bill, which is 40.5%, 24.5% and 9.2% for low, medium and high users, respectively. The reason that this figure is relatively low as compared to the finding in Greece (93%) may be because the fixed charge is also included in the original water bill instead of just comparing by the volumetric charge. Also, the fact that low consumption households are not really low income users is also important here. High users were quite less relatively in the sample and gave zero responses, which drives down the average WTP. This, however, does not correspond to a comparison of the two scenarios which is done later in this section.

5.4 Cost Estimates

There are different technologies for the secondary treatment of wastewater, some[23] of these are listed in Table 5 along with their per KLD costs as estimated by Starkl *et al.* (2018). Council on Energy, Environment & Water (CEEW) computations for input cost[24] of wastewater treatment technologies provide another comparison, however, it is subject to scale issues (Sugam, Jain and Neog 2017). These cost estimates take into consideration the following specific characteristics of a wastewater

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[20] This reduction can stem from various sources i.e. lower absolute consumption of freshwater without any increase in alternative sources or reusing treated water such that it displaces freshwater consumption.

[21] Table A2 in annexure provides comparison of average WTP based on consumer category (low, medium or high) and average water saving (in Rs.).

[22] The Average WTP of the high user category is less than that of the medium due to lower number of high users being in the sample and a higher percentage of them were not willing to pay as compared to the medium category users.

[23] There are many more technologies that exist, however, this study depicts some of the more commonly used ones across India.

[24] The reference values for the capital expenditure are obtained from CPCB; see table A4 ijn annexure for estimates scaled down for 200 KLD plant.

treatment plant: (1) Capacity of 200 KLD (for 350-400 households); (2) secondary treatment along with secondary sludge handling; (3) 100-150 m^2 land area requirement; (4) gardening and toilet flushing reuse; (5) BOD and SS standards.

Starkl *et al.* (2018) estimated cost functions based on actual observed capital and maintenance costs of over 50 STPs all over India using all widely available treatment technologies, including the four described in this study. Starkl *et al.* (2018) calculated the capital expenditure and the O&M expenditure for different technologies per KLD in order to account for scale economies.[25]

Table 5: Technology Input Cost

Technology	Total Capital Expenditure (Rs. '000)	Total Annual Operating Expenditure (Rs. '000)
SBR	644.4 – 5118.8	317.8
MBBR	410.6 – 6256.4	24 – 92.6
MBR	12200 - 13530	477.8

Source: Starkl *et al.* (2018)

Membrane Bioreactor requires much higher capital and operating expenditure; however, it provides a higher output water quality. As per CPHEEO guidelines,[26] BOD must be less than 10 mg/L and SS must be nil in order to reuse water for non-potable purposes (toilet flushing, surface irrigation). There exist trade-offs with respect to water quality standards and costs between MBR and MBBR, hence, there is no ideal technology that can be justified as the best for all criteria, and this fact is well-supported in the literature (Starkl *et al.* 2018). Giving higher preference to effluent standards, this study uses O&M costs for SBR and MBR that are borne by the beneficiary community, while the governing agency incurs capital costs as infrastructure investment.

The total freshwater cost for community members after the scenario change has been portrayed for each consumer category in comparison to their average original freshwater bill (before scenario change) to assess the benefits (Refer Table 6). O&M costs were calculated for all societies based on total resident population. As the number of residents differs across societies, a range of O&M shares is provided (Table A3). The new freshwater bill is calculated using two components, original freshwater bill less the reduction i.e. average water saving and O&M cost share for recycled water.

[25] The values are time adjusted as per changes in Indian Rupee (Rs.).

[26] The analogous standards as per US EPA (Environmental Protection Agency) are less than 10 mg/L for BOD and SS.

Table 6: Comparison of Scenario A and B in Terms of Freshwater Bill				
Consumer Category	Avg. water saving (Rs./month)	Avg. Original Freshwater Bill (Rs./month)	New Freshwater Bill SBR (Rs./month)	New Freshwater Bill MBR (Rs./month)
1(Low)	14.68	241.14	285.31 – 358.87	314.94 – 425.54
2 (Medium)	142.10	675.32	592.07 – 665.63	621.7 – 732.3
3 (High)	367.27	1378.57	1070.15 – 1143.71	1099.78 – 1210.38
Source: Authors' calculations based on field survey data; O&M costs based on calculations by Starkl *et al.* (2018).				

Based on the above comparison, it can be concluded that low category users do not benefit (the new bill is higher). However, it must be noted that here the division among residents is equal,[27] whereas the water bill reduction isn't. The medium and high consumption users benefit more from the scenario change based on the SBR technology as their total cost of water reduces even assuming the higher range value. High category users particularly get a sizeable reduction in their freshwater bill, that is Rs. 367, and benefit the most from such a decentralized STP construction and water reuse.

6. STUDY LIMITATIONS

The contingent valuation method, a stated preference approach, is prone to certain biases given its very nature. Some of those are mentioned in section 4 along with efforts to minimize the same. Other plausible biases include hypothetical bias, that is an overestimation of WTP given that consumers do not make choices subject to a budget constraint (Whittington 2010). CV studies may also be prone to an enumerator bias, that is people expressing positive willingness to pay in order to satisfy the interviewer (Whittington 2010). Prior literature finds that these biases do not exist at least at a statistically significant level, that is the revealed and stated preferences are quite similar for the context of developed countries (Carson *et al.* 1996). However, there are mixed findings with respect to developing countries.

Whittington (2010) points out that there are two scenarios wherein the revealed preferences could deviate from the stated ones, that is in case of voluntary contributions. However, in this study, the participants were explained potential savings in the water bill, so contribution does have some future benefit which could reduce the bias to an extent. The other

[27] There exist alternatives for proportional contribution based on water consumption and saving.

scenario is a hypothetical choice in laboratory settings, which does not apply to a field setting. The study is based on a small sample size; however, it does not cause any statistical significance issues. It seems large enough to obtain mean effects for WTP and its determinants. Although respondents were told about non-potable reuse of recycled wastewater, the questionnaire did not specifically mention toilet flushing to avoid any misgivings. Also, there were some households for which data was not consistent, that is even with same water consumption for two households, they had a slightly different bill, which points out potential inconsistencies with water meters that measure consumption. With respect to CEEW cost estimates, it is subject to the issue of scaling down due to the presence of scale economies. However, to overcome that cost estimates provided by Starkl *et al.* (2018) for a plant as small as 1 KLD are employed. Since these cost estimates are fitted regressions based on a sample of 50 STPs, these are not free from the errors of fitted cost regression lines.

The study is largely focused on the computation of benefits. However, costs provide a good perspective in terms of assessment of net benefits. The scope of this study far exceeds the calculation of net present valued benefits and payback period, which are interesting future research avenues. Based on a similar survey, the study can be replicated for the entire Delhi region and other states. This study may be generalized, to an extent, to residential societies in Delhi with common trends with respect to different socioeconomic characteristics such as income, education, etc. The societies that were surveyed for this study also contained a mix of middle-income and high-income households. It may not, however, be generalized at the state or national level given the different socio-economic characteristics of residents as well as differences in cooperation levels within societies.

7. CONCLUSION

Wastewater reclamation has been a subject of considerable attention especially with respect to industries and agricultural reuse. However, this study aims at extending it to the domestic sector. The study utilized primary field data that was beneficial in raising awareness about water reuse and wastewater treatment among individuals. This was essential given awareness is a direct determinant of contribution towards a cleaner environment. This result is in line with studies done in major districts of Canada, where prior awareness contributes to a higher WTP for a wastewater infrastructure project (Rollins *et al.* 1997). As economic theory dictates, socio-economic and demographic characteristics (gender, income) significantly determine whether a household will choose to participate in the contingent market.

Overall, the survey reveals that 30% of the urban population living in residential colonies of New Delhi is still unaware of wastewater treatment. The analysis concludes that medium and high usage consumers benefit the most based on technology choices. However, for low and medium users paying for expensive technology, that is MBR, the government must offer some subsidy in order to make them at least as better off as before. For low usage consumers, the study recommends a subsidy of at least Rs. 73 a month considering the lower threshold of range for freshwater with MBR technology (Table 6), and for medium usage consumers, a subsidy of at the most Rs. 57 a month considering the higher threshold. Hence, co-financed decentralized STPs will benefit[28] the urban residential colonies in Delhi. This analysis is based on adapted suitable cost estimates that may be subject to error and whether the households adopt the practice voluntarily or otherwise is not the focus. However, it is another way forward for any extensions to the context of urban cities in India.

8. POLICY IMPLICATIONS

Awareness of all individuals must be augmented in order to tackle environmental problems with suitable incentives. In fact, as mentioned in the paper, Delhi Government could think about replicating a mandatory framework used in the context of Chennai. In addition, in Kerala, the newly built residential buildings also include the construction costs of the WWTP within the cost of the house, therefore ensuring the residents finance the public good. To deal with lack of trust in local bodies, transparency and effective policy implementation can be targeted. The government can introduce a subsidy scheme for households that participate in water conservation such that they can be incentivised, and possibly other households can be motivated to invest in environmental protection. Given that co-funding leads to some reduction in spending by the government, it would be interesting to try and assess whether a subsidy can be constructed that leaves everyone at least as better off as before. This gives way to potential savings in water bill and environmental benefits from cleaner drains. This study suggests a possible way of creating environmental and monetary benefits not only for the new apartment buildings but also for existing residential colonies. This, of course, depends on additional safeguards that treatment plants run at full capacity and are economically viable. Although the study might inform policy, it is far from providing a well-structured policy, for which further research is encouraged on

[28] These results are based on cost estimates that may change overtime and hence, are subject to dynamics of freshwater price changes and changes in O&M costs.

consumer attitudes, awareness and social acceptance that may be helpful while designing policies.

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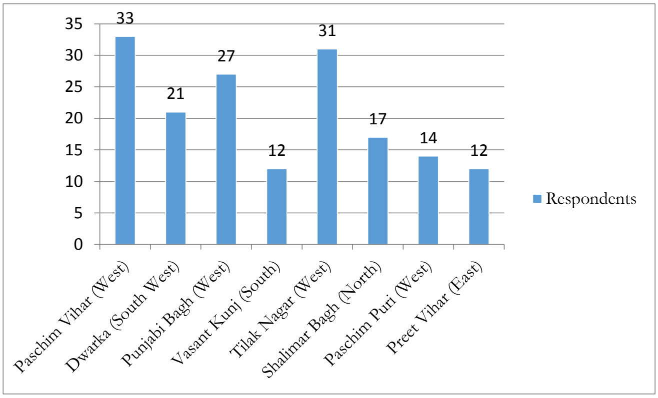
ANNEXURE A

Figure A1: Survey areas in New Delhi



Source: Authors' calculations based on field survey data

Table A1: Description of Variables		
Name of Variable	Definition	Type
Age	The age of a person in completed years that relates to his / her last birthday prior to the date of enquiry.	Discrete
Education	The highest general and technical education levels attained by the person determine what is known as educational standard.	Categorical
Occupation	The nature of economic activity performed by a person is his/her occupation.	Categorical
Female	Identifies the gender of the respondent. The dummy = 1 if respondent is a female, 0 otherwise.	Binary
Monthly Income	The monthly income includes all income accruing from economic activity i.e. wage/salaried employed.	Continuous
Awareness Dummy	= 1 if the respondent is aware about wastewater disposal and related services, 0 otherwise.	Binary
Children	Equal to the no. of children born to the respondent.	Discrete
Sewer Drain Pollution	=1 if the respondent faces pollution from uncovered sewer drain, 0 otherwise.	Binary
Toilets	Equal to the no. of toilets/washrooms that are used in a respondent's household.	Discrete
Source: NSSO (2001) for first three variables, and authors' own compilation for the rest.		

Table A2: Comparison of Average WTP, Average water saving & Average Water Bill

Consumer Category	Water Consumption (KL / month)	No. of Observations	Average water saving (KL/month)	Average water saving (Rs./ month)	Average WTP (Rs./ month)	Average Freshwater Bill (Rs. / Month)
1(Low)	0-20	57	2.09	14.68	97.89	241.14
2 (Medium)	20-30	88	4.04	142.10	165.85	675.32
3 (High)	Above 30	14	6.27	367.27	127.5	1378.57

Source: Authors' calculations based on field survey data
Note: The average freshwater bill is based on full consumption quantity, however, average WTP is based on the use of treated water for non-potable purposes, majorly toilet flushing, as freshwater saving potential measured in KL. The average saving is through the *reduction* in water bill as a result of reduced consumption of freshwater.

Table A3: Computation of O&M cost

Consumer Category	Water Consumption (KL)	Average water saving (KL)	Average water saving (Rs.)	Average WTP (Rs.)	Average Freshwater Bill (Rs.)	O&M – SBR (Rs.)	O&M – MBR (Rs.)
1 (Low)	0-20	2.09	14.68	97.89	241.14	58.85 – 132.41	88.48 – 199.08
2 (Medium)	20-30	4.04	142.10	165.85	675.32	58.85 – 132.41	88.48 – 199.08
3 (High)	Above 30	6.27	367.27	127.5	1378.57	58.85 – 132.41	88.48 – 199.08

Source: Authors' calculations based on field survey data; O&M costs based on calculations by Starkl *et al.* (2018).
Note: All figures are per month.

Table A4: Technology Input Cost (based on CEEW estimates)						
Techno-logy	Total Capital Expenditure* (Rs. '000)	Annual Operating Expenditure (Rs. '000)				Total Annual Operating Expenditure (Rs. '000)
		Power	Repairs	Chemical	Manpower	
Activated Sludge Process (ASP)	2000	80.8	30	17	13.4	141.2
Sequencing Batch Reactor (SBR)	1800	66.8	23.2	17	8.2	115.2
Moving Bed Biological Reactor (MBBR)	1800	97.4	24.4	17	9.8	148.6
Membrane Bioreactor (MBR)	6400	132.4	44	132	24	332.4
Source: Sugam, Jain and Neog (2017) **Note**: * signifies including land cost						

Table A5: Average WTP by society		
Area	Average WTP (Rs./month)	Total population of the society (no. of households)
Dwarka	181.61	400
Paschim Vihar (two societies)	152.18	400
Paschim Puri	165.5	250
Punjabi Bagh	196.85	200
Tilak Nagar	200.83	350
Preet Vihar	173.25	300
Shalimar Bagh	182.11	400
Vasant Kunj	101.25	450
Source: Authors' calculations based on field survey data		

Table A6: Description of Technologies	
Technology	Description
Activated Sludge Process (ASP)	The first process requires aeration tank that uses oxygen to break down the BOD components and a clarifier in the secondary process in order to separate sludge.
Sequencing Batch Reactor (SBR)	Involves three processes in a sequence—fill-aeration, settling and decantation to remove organic matter.
Moving Bed Biological Reactor (MBBR)	Like ASP, it uses aeration tank in order to treat the wastewater.
Membrane Bioreactor (MBR)	Amalgamation of activated sludge process and microfiltration in order to treat wastewater.
Source: Kamyotra and Bhardwaj (2011)	

ANNEXURE B

1. Instructions/Introduction for each respondent (before the survey questionnaire)[29]

Hello, my name is Vasudha Chopra and I am a master's student at TERI University pursuing M.Sc. Economics. I am working on a study for my master's thesis that focuses on wastewater treatment. This is a field experiment in the economics of decision making.

Would you like to participate for a short interview?

I have a short questionnaire form with me for you to fill based on your true preferences in wastewater treatment and reuse (for non-potable purposes i.e. gardening, toilet flushing, cleaning of cars etc.). Some of the information is also contained in the questionnaire. If there are any questions or confusions while filling it out, please feel free to ask me to explain.

Before starting, I would like to stress on the fact that I want you to answer in line with your true preferences as re-use of recycled water leads to monetary saving in freshwater bill.

Thank you.

2. Questionnaire

A. HOUSEHOLD PROFILE

1.Name and address of respondent: Name (optional); Address; Residing Area; Mobile/Telephone (optional)

[29] While this script was written out initially, it was made sure that the interviewer memorizes the same and speaks out loud while quickly introducing himself/herself to the respondent and asking for permission to be interviewed. If the permission wasn't granted, then another random household was picked and so on.

2.Age (in years) of the respondent: __

3.Gender of the respondent: choose from — Male; Female

4.No. of members in the household (including you): __

5.Caste affiliation of the Respondent: choose from — General; Scheduled Tribe; Scheduled Caste; Other Backward Caste

6.Education status of respondent: choose from — Illiterate; Higher Secondary (up to age of 18); Up to Primary education (up to the age of 11); Graduate; Secondary School education (up to the age of 16); Post Graduate and above

7.Education status of decision maker: choose from — Illiterate; Higher Secondary (up to age of 18); Up to Primary education (up to the age of 11); Graduate; Secondary School education (up to the age of 16); Post Graduate and above

8.Main occupation of respondent: choose from — Service; Student; Self-employed; Worker; Pensioner/Retiree; Unemployed; Other (if, specify __)

9.Main occupation of decision maker: choose from — Service; Student; Self-employed; Worker; Pensioner/Retiree; Unemployed; Other (if, specify __)

10. Which class best describes your total monthly household income? choose from — Less than Rs. 10,000; Rs. 20,000 - Rs. 30,000; Rs. 40,000 - Rs. 50,000; Rs. 10,000 - Rs. 20,000; Rs. 30,000 - Rs. 40,000; Higher than 50,000

11. How much is your approximate monthly household expenditure on food items?__

12. Number of children in your home, if any? __

13. Since how many years have you been living in your home? __

14. Do you own or rent your home? choose from — Own House; Rented House

15. Provide the no. of toilets in the house? __

B. HOUSEHOLD PROVISION OF EXISTING SEWERAGE AND WATER SERVICES:

16. What are the sources for potable water (drinking/cooking)? choose from —Piped water connection; Rainwater; Public Tap; Bottled/Canned Water; Bore well/Tube well/Dug well; Surface Water (river, pond, canal etc.)

17. What are the sources for non-potable water (bathing/washing/cleaning etc.)? choose from —Piped water connection; Rainwater; Public Tap; Bottled/Canned Water; Bore well/Tube well/Dug well; Surface Water (river, pond, canal etc.)

18. How much is your monthly household consumption of water (in kilolitres or units)? __

19. How much is your average monthly water bill (in rupees)? Rs. __

20. How much was the water consumption last year? __KL

C. WARM UP AND AWARENESS QUESTIONS

21. Do you know where the household wastewater is being disposed? choose from — Central Sewerage System; Groundwater Seepage; River; Roadside Drains / Sewer Drains; Canal; Do not know

22. Are you aware that the domestic wastewater is being treated in a Sewage Treatment Plant? choose from — Yes; No; Do not know

23. Are you aware of existence of STPs owned by the government in order to treat wastewater in your society? choose from — Yes; No; Do not know

24. Is there a sewer drain nearby your area? choose from — Yes; No; Do not know

25. How would you describe water quality of sewer drain in your area? choose from — Very poor; Poor; Adequate; Good; Very good; Do not know

26. How are the sanitation facilities in your society? choose from — Excellent; Adequate; Very poor; Good; Poor; Do not know

27. If you answered poor or very poor to the previous question, then how many times have you suffered from illness in the last 5 years? __

28. Are you suffering from pollution due to the sewer drain? choose from — Yes; No; Do not know

29. If a sewer drain exists nearby then have you experienced any illness due to its pollution in the last 5 years? choose from — Yes; No; Do not know.

D. PERCEPTION ABOUT ENVIRONMENTAL QUALITY

30. Which statement do you agree with the most? choose from — Wastewater treatment is very important regardless the cost; Wastewater treatment is important while holding the current cost; Wastewater treatment is sufficient and we should cut down on cost.

31. Cleaning of the nearby sewer drain may have various benefits, which among the following are the most important for your residing area? express your preference in order from 1 to 6 (1 signifies most important; 6 signifies least important) — Eliminates odor; Eliminates insects and mosquitoes; Avoid groundwater contamination; Reduce pollution; Reduce health problems; Lower the degradation of the environment

32. Treatment of domestic wastewater may have various benefits, which among the following are the most important according to you? express your preference in order from 1 to 5 (1 signifies most important; 5 signifies least important) — Water recycling and reuse; Lower water pollution; Improving health situation; Conservation of scarce freshwater; Protection of the environment

33. In order for conserving the scarce freshwater in India, treatment and reuse of domestic wastewater would be: choose from — Very Important; Somewhat Important; Not important; Important; Less Important

E. CONTINGENT VALUATION

- Huge wastewater generation from households in Delhi
- Only 55% of this wastewater is treated currently
- Causes enormous environmental and water pollution, groundwater contamination as well as health problems
- There is a need for treatment of the remaining untreated wastewater

Current Scenario (A): There is no treatment plant set up near your society. The STPs by the government only partially treat the wastewater.

- There is an environmental degradation involving *groundwater depletion*.
- The untreated wastewater and poorly managed sewer drains cause *health problems*.

Improved Scenario (B): A treatment plant is set up near your society which treats the wastewater and this can be reused for non-potable purposes like cleaning of cars and gardening.

- *Water bill reduces* since now fresh water is not being used for a few non-potable purposes.
- There is an *environmental improvement* and due to better management of water in sewer drains there are lower health problems in your area.

34. Suppose that Wastewater plant were to be constructed, this will result in an improvement in the quality of environment from Scenario A to B. Would you be willing to pay higher water and sewage taxes for environmental improvement? choose from — Yes; No; Do not know

35. If you answered yes to Q34, what amount are you willing to pay per month? choose from — Rs. 95; Rs. 114; Rs. 142; Rs. 161; Rs. 190; Rs. 237; Rs. 256; Rs. 285; Rs. 304; Rs. 332; None of the mentioned; if any other amount, Rs. __.

36. If you chose none of the above for Q35, would you be willing to pay a lower amount per month for the improvement of the environment? choose from — Rs. 47; Rs. 66; Rs. 95; Rs. 114; Rs. 142; Rs. 161; Rs. 190; Rs. 209; None of the above

37. Would you be willing to pay a higher amount for environmental improvement than the ones offered before? choose from — Yes; No; Do not know

38. If you answered yes to Q37, how much are you willing to pay for environmental improvement? choose from — Rs. 190; Rs. 285; Rs. 380; Rs. 475; Rs. 237; Rs. 332; Rs. 427

39. If you are willing to pay for environmental improvement then please state your motivation to do so: choose from — Wastewater management problem is important; Enjoy contributing for a cleaner environment; Protection of environment for future generations; Water is being over-utilized and its

conservation is important; Enjoy contributing for other reasons; Other reasons if any

40. If you are NOT willing to pay for environmental improvement then state your reasons: choose from — The government should pay for water conservation rather than introducing new taxes; Cannot afford to pay more taxes; Not interested in paying for wastewater management; Not interested in paying for a cleaner environment; This problem is not a priority; Water is not being over-utilized and there is no need for water conservation