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Water Pricing, Affordability and Public Choice: An Economic Assessment from a Large Indian Metropolis

Venkatesh Dutta (Corresponding author)
Department of Environmental Sciences
Babasaheb Bhimrao Ambedkar University
Lucknow 226025 (UP), India
E-mail: dvenks@gmail.com
N M P Verma
Department of Economics
Babasaheb Bhimrao Ambedkar University
Lucknow 226025 (UP), India
E-mail: nmpverma@rediffmail.com

Abstract

The combined use of surface and groundwater that recognizes site-specificity and communities' preference structure can greatly determine the social and economic sustainability of communities in a growing metropolis. Utilizing both primary and secondary information pertaining to the water sector of India's capital city, this paper collectively looks at water demand, public choice and financial sustainability of water supply augmentations in both planned urban and unplanned peri-urban areas having differing levels of planning and resource availability. Households' preference heterogeneity for water supply scenarios differentiated by their 'quality' (potable or non-potable) and 'source' (surface or groundwater) has been examined through a carefully designed choice experiment (CE) using iterative bidding game. Household's choice and preference behaviour for dual quality water (decentralized municipal water for drinking and local groundwater for other purposes), single potable quality water and the 'business-as-usual' scenarios are assessed through utility function based multinomial logit (MNL) and nested logit (NL) choice models. The values resulting from the analysis are assessed in terms of water supply augmentation options and their practical limits incorporating the choice and preferences from the heterogeneous planning environments typical of a metropolis.

Keywords: Public choice, Water, Resource quality, Pricing, Willingness to pay

1. Introduction

When considering natural resource use in an economic sense, questions of both 'adequacy' and 'quality' levels available to the communities are of vital importance. Economics, the application of choice offers a means of understanding the nature of the choices people make and, through this understanding, researchers or policy makers decide upon a 'resource-conservative' approach that satisfies society's demands as well as improves resource sustainability (Kolstad, 2003). Adequate quantity of water meeting safety standards whether sourced from underground aquifer or streams has been increasingly viewed as an economic good fundamental to people's health, survival, growth and development (Note 1). Due to increasing demand from the society and the economy, water has become a scarce resource. The scarcity is deepening day-by-day due to limited availability and supply constraints. Additional quality deterioration further exacerbates water scarcity (Ahmad *et al.,* 2005). The scarcity scenario has undoubtedly changed people's perception and awareness about 'source limits' and economic realities of water supply made available by the government and public utilities. Many analysts argue that because water is increasingly scarce, it is increasingly valuable – and this value should be made evident by pricing water and allowing markets to establish the 'right' price for it. It has been observed by several researchers and development experts that both quality and quantity is compromised when it comes to providing water to communities in developing countries (Briscoe & Malik, 2006). The low level of social optimum resulting from services ensured by the public utility has led the urban and peri-urban communities to develop alternative strategies based on private groundwater augmentation. These alternative strategies might include direct use of groundwater from a private tubewell, development of a private small supply network fed with untreated groundwater, or supply by tanker, groundwater remaining the primary source of raw water in most of those private supply chains (Ramachandran, 2008; Maria, 2004; Llorente and Zérah, 2003; Saleth & Dinar, 2001).

This paper is structured as follows. First, we briefly set the context and describe the problem area both from the theoretical and empirical angle. Second, we explore the metropolis context and in particular, gather empirical evidence from a survey to see how scarcity is perceived in urban and peri-urban settlements with congregating determinant factors influencing the alternate choice behaviour of communities. Our discussion focuses on the source and quality aspects, mostly by assuming that two main sources groundwater and surface water with differing quality attributes are consumed having differing 'scope' of benefits and reach of its externalities. Third, the values resulting from the analysis are assessed in terms of water supply options and their practical limits incorporating the choice and preferences from the heterogeneous planning environments. The paper argues that more attention must be paid to diverging perceptions of the quality and availability of a natural resource and of how it should be accessed and delivered to maintain both the resource sustainability and public acceptability.

2. Setting the context

Reliable supply of a natural resource such as water in the wake of rising per-capita demand, declining resources as well as deteriorating quality levels require substantial financial resources to attain desired dependability. When a public water system is unavailable, insufficient, unaffordable, or inoperative, households pump groundwater privately to meet their needs. Many households either partially or totally substitute groundwater for water purchased from private vendors and the public supply, depending on the cost of extraction and the quality of the water. Groundwater has been exploited more and more widely and its consumption has increased dramatically in India's Capital city and its peri-urban communities, which is representative of the situation of many regions in developing metropolises. The main reason behind this situation is lack of a reliable water supply, which comes largely from surface water sources. As a result, major domestic chunk depend on groundwater, and because local authorities have historically not controlled withdrawals, the aquifers have been overdrawn. In spite of the public neglect of groundwater as a resource for urban water supply, groundwater plays a central role in meeting urban needs through a variety of private and uncontrolled systems (Maria, 2004) (Note 2). The inherent distinctiveness of urban environments was neglected in water supply considerations by planners in the past. While the planned urban settlements incorporate water design principles to some extent, the peri-urban settlements present unique resources attributes as a result of differing socio-economic values, flow asymmetries, and joint production potential (Tovey, 1998).

In the study area, despite the existence of a piped water system at least 36% of the planned urban population meets 90% of its water need from personal tubewells. Reliance on groundwater becomes almost 100% in many cooperative society flats who resort to deep drilling to withdraw groundwater. They have their own water distribution systems that often provide 24×7 water supply. The residential societies and real estate developers have in the past joined in a cooperative effort to devise an alternate management plan to augment the availability and improve the quality depending less on the public water supplies. The additional water is sought from the local bore wells due to the fact that groundwater is a more dependable water source than the surface water supplied from the water utility. In the unplanned peri-urban areas, very high proportion of population is outside the piped network and in such areas groundwater forms the main source of water. According to the study, the demand-supply gap in planned colonies is nearly 20 % less than the gap in unplanned peri-urban colonies. The households dig shallow wells fitted with handpumps or install motors and draw subsoil water. Owing to this situation of escalating population without a commensurate increase in the availability of raw water, the groundwater in many blocks has been over exploited. This has disturbed the hydrological balance leading to decline in the productivity of wells, increasing pumping costs and more energy requirement. Utilisation of groundwater in peri-urban settlements is very common which means that people consider this resource as potentially important. However, the quantity of fresh water is very marginal and most of the groundwater reserves consist of brackish or saline water.

The Delhi Jal Board acts as an autonomous body under the Government of the National Capital Territory (NCT, 1483 sq.km), and is estimated to serve around 14 Million people. Although the DJB has a production capacity of around 2900 Millions Liters a Day (MLD), non revenue water assessed by various studies quote it as high as 59% (Note 3). Therefore, although the per capita availability according to the production capacity is over 200 lpcd, the DJB is currently unable to provide a level of service matching the demand of the population. Allocation of water among the users is performed through scheduled intermittent supply, which leads to significant wastage of water due to the habit of emptying storage tanks before every new round of supply, as well as quality problems due to sewage infiltration in distribution pipes. The proper functioning of the distribution system is further jeopardized by the common practice by individual users of installing suctions pumps in order to increase the amount obtained during the limited period of supply. Various supply augmentation schemes that rely upon interstate water transfer would eliminate the demand-supply gap by 2021; however, such approaches are costlier and would remain to be financially non-viable in the long run due to inefficient water use as well as possibility of serious inter-sectoral and inter-state water allocation conflicts. Such schemes may also damage the incentive environment. Much of the future demand would be satisfied if the water losses in raw water transmission and treated supply can be drastically reduced. The pressure can also be reduced by promotion of multiple water sources augmented locally both by private and public means including in-house water use efficiency and conservation.

2.1 Theoretical construct: Public choice, social optimum and conjunctive use of groundwater and surface water

In an environment of constrained resource availability, choice of water supply options and preferences vary according to several factors including planning levels, local perception of water scarcity, individual water use requirements, and previous experience with irregularity in supply (Hanley *et al.* 2001, 2005; Louviere *et al.* 2000; Ryan & Wordsworth, 2000; Adamowicz *et al.* 1994). Due to diverse socio-economic status and heterogeneous customers' preference structure, public choice and economic values in decision-making transform into a site-specific problem. The policy choices regarding water supply reliability affect large numbers of people, making some better off and others worse off to varying degrees. The policy maker wishes to prefer policies that produce the largest possible increases in social wellbeing or welfare. When decision makers choose from alternative policies, they identify the favorable (beneficial) and adverse (costly) consequences associated with each alternative and choose the preferred option (Amador *et al.* 2005; Chesher & Santos-Silva, 2002; Huttala 2000). That is, if one scenario dominates the rest in the choice occasion, then it has more of all 'good attributes' and less of all the 'bad attributes'. In large metropolis, the current water supply system typically falls well short of offering customer classes a product that is a precise fit to the segment's needs. Solution may be reasonably acceptable to people in planned areas but at the same time totally unacceptable to customers in unplanned areas or vice versa. Given the social, economic and environmental externalities associated with unsustainable water use, it is important that the customer's 'preferred choice' informs the investment in infrastructure restructuring. The cost of infrastructure restructuring is influenced by the decisions of the utility with regard to reliability, quality and extent of supply. All decisions cannot be made in isolation and interaction with the customers is necessary to reach the correct balance and allocation of costs and benefits (Koundouri *et al.,* 2003; Foster *et al.,* 1998; Davis & Whittington, 1997).

Assume that water supply without source distinction is expressed by one variable Q and the supply function S_p is inelastic with monotonically declining demand D (Figure 1). The alternative supply with local groundwater augmentation by the communities has monotonically increasing demand with the alternative supply function S_A. The current scenario of single quality supply at service level Q_p is provided at price P_p; however, the actual service level would be lower than Q_p because customers use multiple alternatives at local levels, leading to lower cost recovery for the centralised service provider. At P_p the quantity demanded is $Q_{p'}$ ($>Q_p$), but this quantity cannot be provided by single quality public supply using surface water due to reliability constraints. Consumer surplus at P_p is P_pBCd', which does not reach its potential level P_pBE and producer surplus at this point is $AP_pd'Q_p$. Social surplus at P_p is $ABCQ_p$. Customers desire better quality and reliability and hence are willing to pay up to P_1 to improve the service level. In the absence of improved services, alternative options will be considered by the communities. An alternative supply using both local groundwater and municipal supply water, characterized by a supply function S_A will produce equilibrium values of P_2 and Q_2. Consumer surplus at P_2 is P_2BF and producer surplus is P_2FH. Social surplus at P_2 is HBF. The alternative supply will therefore be socially justified if $HBF - ABCQ_p$ is greater than zero, or if $CFD > AHdQ_p$.

Furthermore, with two alternative supplies having different quality attributes, S_A and S'_A, both going through point F and characterized by price elasticities ES_A and $\mathrm{E}S'_A$, it is observed that $\mathrm{E}S'_A < \mathrm{E}S_A \Rightarrow |CFd - AHdQ_p| < |CFd' - A'd'Q_p|$ Estimation of demand and supply elasticities make it possible to empirically calculate the areas under the demand and supply curves, and perform welfare comparisons. Let E_D be the price elasticity of demand, and E_{SP} and E_{SA} the price elasticities of single quality public and dual quality 'alternative' supply, respectively. Note that $\mathrm{E}_{SP} >> \mathrm{E}_{SA}$. Since all quantities are known, and if we assume that while changing supply arrangement quantities demanded will not change dramatically (or in other words, that the demand function remains intact), one can derive the equilibrium price and calculate areas under the supply and demand curves. Suppose that Q_p and Q_2 are observed at levels of q_P and q_2, respectively, with $q_2 > q_P$. Then $\Delta q = q_2 - q_P$. By using the price information in the same way, define $\Delta P = P_2 - P_P$. Let the 'alternative' supply curve be $q_A = \alpha + \beta P$, where α is an intercept and $\beta = \Delta q / \Delta P$. Note that $\mathrm{E}_{SA} = (\Delta q/q)/(\Delta P/P) = (\Delta q/\Delta P)(P/q)$. Since E_{SA}, P and q are known, $(\Delta q/\Delta P) = \mathrm{E}_{SA} / (P/q)$. This can be inserted into the 'alternative' supply equation which becomes $q_A = \alpha + [\mathrm{E}_{SA} / (P/q)]\, P$. A similar procedure can be used to specify public supply and the demand equation. Most groundwater aquifers are open access resources, and therefore these aquifers are characterized by divisibility and non-exclusivity. In other words, the amount of water extracted by one household affects the availability to others. As the height of the water table decreases, the additional unit cost of extraction for all other households increases who share the same aquifer. Under these conditions, no household has an incentive to conserve or reduce extraction to sustainable levels unless all households cease over extraction through joint action. Given that the quantity extracted by a household is private information, other households will tend to over extract. This behavior would threaten resource sustainability and lead to irreparable ecological damage to the aquifer.

Markets for public water supply may be subject to imperfections due to large economies of scale resulting in high investment cost, resource sustainability, physical and legal constraints to reach to all customer classes, complex institutional structures, and preferential concern for different user groups having varying cultural values (Bakker, 2003). Therefore, good policymaking requires sound assessment and evaluation of impacts in monetary terms to facilitate decision makers design need-based policies for taking appropriate location specific actions (Bateman *et al.* 2002; McFadden 2001). This places a challenge on estimating change in the water service provisions specially water quality. In the study area, resource availability as well as consumption between planned urban settlements and unplanned peri-urban settlements is uneven varying distinctly with property class. Even though affluent planned colonies receive far larger and even share of water than the poorer unplanned peri-urban colonies, they demand more hours of supply than the existing duration. It is observed that with increasing planning class and discretionary income, households spend higher amount of money to avert water supply unreliability both from quality and quantity angle. A high proportion of customers in both planned urban and unplanned peri-urban areas use 'point of use' treatment options for potable requirements. The usage of water purifiers is very high in planned colonies mainly due to perceived private health benefits in the safety and aesthetic qualities of purified water compared to the municipal water. Even in unplanned areas, many customers have designed their own point of use or point of delivery method for using dual quality water with different sources.

In this background, it is necessary to ask questions and provide answers to following pertinent questions concerning a very important natural resource – water:

- if it is necessary to develop different distribution systems for potable and non-potable water end-uses having heterogeneous customers' preference structure (which has become a reality, but nevertheless neglected in planning process). Also required is an understanding of how an alternative policy instrument of quality based pricing can modify water use pattern among households across different socio-economic and planning classes,
- if decentralized approaches are viable solutions for newer colonies and peri-urban settlements,
- if the key to the problems is a 'market solution' or rather an 'administrative solution' and that the needed investments will be generated by the private capital.

3. Methodology

As there is no perfect market for supplying a natural resource, either a stated-preference function or household health production function has to be estimated to find the value households place on it for getting private health benefits (Bateman & Willis, 1999). Accordingly, the well reviewed method of choice experiments (CE) are employed on a multistage-stratified random sample of 1100 households spread over planned urban and unplanned peri-urban residential units categorized by 'property-tax-class'. Property-tax-class is taken for stratification to introduce first level of preference heterogeneity. Water supply source with different quality and quantity attributes induce the second level of heterogeneity in preference behaviour. Iterative bidding game is used as the elicitation technique to find out households' stated amount in terms of willingness to pay (WTP) as described in Gloria *et al.* (2005), Wedgwood & Sanson (2003) and Carson (1991). The dependent variable, households' choice of water supply scenario is observed as a discrete variable and multinomial logit (MNL) and multinomial nested logit (NL) models are used for estimating households' WTP in both planned urban and unplanned peri-urban residential units using statistical package LIMDEP 8.

3.1 Survey design, scenario definition and analysis of public choice

The design of the questionnaire is based on research papers in valuation studies and available guidelines such as Wedgwood & Sanson (2003), MacDonald & Young (2002), the World Bank's Living Standard Measurement Survey (LSMS) manual (Grosh & Glewwe, 2000), DLTR's guidelines on WTP survey, ADB training manual on water sector, IWWA's manual on water demand assessment for urban water supply projects (2002). The final questionnaire consisted of the four sections: (a) section on socio-economic characteristics (b) preliminary attitudinal section (c) a section on water supply situation and (d) choice experiment with valuation section. The choice question format followed split bidding game in both planned urban and unplanned peri-urban residential units. The first question asked about the respondent's willingness to support (vote for) a supply option, i.e. choice; the second question asked about how much they would actually pay per kilolitre of water as well as maximum monthly water bill for a particular preferred choice with different choice-sets.

There are basically 3 broad choice-sets with different quality, quantity and reliability attributes in the choice experiment:

(1) Dual quality river and local groundwater – 20 to 25% potable water (36 lpcd) meeting WHO or EU standards (e.g., 80/778/EEC standard) and 75 to 80% non-potable water (129 lpcd) meeting extended limits of IS 10500

(2) Single quality river water (165 lpcd) meeting IS 10500 quality standards with increased hours of supply

(3) Business-as-usual (Note 4)

(a) Those who are willing to pay for the existing supply if the current supply is maintained as per notified timing with additional private investment on water purifiers or bottled water for potable needs

(b) Those who are not willing to pay anything and demand no improvements in supply attributes (opt-out)

Everything is common between these two treatment groups – 3(a) and 3(b) except that those opting for 3(a) also reveal their willingness to pay for the current supply. And interestingly, their stated willingness to pay is higher than their water bills implying that either they are not aware of water rates being charged or they want to pay higher to maintain existing supply. The valuation questions actually pose complex choices and require careful consideration on the part of the respondent who knows better his level of utility. Therefore he is able to state his true preferences and willingness to pay attached to the current supply. Those opting for 3(b) have zero wiliness to pay (or sometimes negative WTP).

Prior to designing the survey, a series of exploratory, qualitative group discussions were conducted with members of the research committee and small group of households to identify the salient aspects of the water services. 'Focus groups' were used which were assembled to discuss their reactions to the hypothetical market, following the pre-test prior to conducting the main survey. The focus group was comprised of researchers, statisticians, students and local representatives agreed on a sample size of around 100 to properly reflect the distribution of households in different income brackets and geographic locations. Four focus groups were conducted with residential customers and survey enumerators, each exploring customer's perceptions and experiences of water services. The information that was obtained during the focus groups was utilized to design the experiments, including which service attributes were included in the experiments, how the attributes were described, and the levels that each attribute could take. A total of 1100 interviews were completed spread over planned and unplanned settlements. Few of them were rejected due to non-response and missing data.

3.2 Modeling preference behaviour using discrete choice data

Preferences for change versus *status quo* and customer's willingness to pay are estimated through utility function based discrete choice multinomial logit and nested logit models using maximum likelihood estimation technique. The estimated parameters of the choice models define the utility functions for each alternative with different source and quality – groundwater or surface water. Multivariate regression analyses are employed to test hypotheses based on the statistical significance of coefficients, assess customer's preferences for water supply options, and finally estimate WTP. In this study, data generated from the field is modeled through:

(i) Multinomial Logit Model (conditional) for three supply choices for the entire sample (all classes) to show the importance of attribute-profile in explaining respondent' choice across scenarios; and

(ii) Nested Logit Model for three supply choices for the entire sample (all property classes from planned urban and unplanned peri-urban residential units).

In making a choice, individuals are assumed to evaluate 'alternatives' on the basis of their 'attribute profile' and then choose the alternative that maximizes utility.

The probability of choosing option *i* is given by

$$\Pr ob(i) = \frac{\exp(\mu V_{i})}{\sum_{J \in C} \exp(\mu V_j)} \tag{1}$$

where $V_i = V(Z_i, S)$ is the indirect utility function, Z_i is a vector of choice attributes, S is a vector of socio-economic characteristics, and μ is a scale parameter, which is usually assumed to be equal to 1 (implying constant error variance). The choice probabilities are estimated by means of a multinomial logit regression, which assumes that the choices are consistent with the IIA property. The most basic form of V_i is an additive structure, which indicates the attributes from the choice sets only, e.g.

$$V_i = ASC + \sum \beta_k Z_{ik} \tag{2}$$

where ASC is an alternative specific constant, β is a vector of coefficients, and Z are attributes from the choice sets. The effects of attributes in the choice sets are captured by the Z variables, while the ASC captures any systematic variations in choice observations that are associated with an alternative that are not explained either by the attribute variation or respondent's observed socio-economic characteristics. It is possible to include socio-economic as well as attitudinal variables into the utility functions by estimating the variables interactively, either with the ASC or with any of the attributes from the choice set, e.g.

$$V_i = ASC + \sum_n \gamma_n ASC * S_n + \sum_k \beta_k Z_k + \sum_{kn} \delta'_n Z_k \tag{3}$$

where S_n represents socio-economic or environmental attitudinal variables for the nth individual. Taking socio-economic variables without ASC interaction, the purpose of nested logit estimation procedure is not achieved. The nested logit Random Utility Model relaxes the restrictive IIA (Independence of Irrelevant Attribute) assumption to some degree. The choice probability under multinomial logit model for dual quality water supply options (Plan A) is given by:

$$\Pr(Y = Dual) = \frac{\exp(\beta'_{Dual} x_i)}{1 + \sum_{k=0}^{2} \exp(\beta'_k x_i)} \tag{4}$$

The probability that the person chooses dual quality supply *(Plan A)* instead of single quality supply *(Plan B)* is the probability that the unobserved factors for dual quality supply are sufficiently better than those for single quality supply to overcome the advantage that single quality supply has on observed factors. Specifically, the person will choose dual quality supply if the unobserved portion of utility is higher than that for single quality supply by at least 1 unit, thus overcoming the 1-unit advantage that single quality supply has on observed factors (Train, 2003, Chapter 2).

Once the parameter estimates have been obtained, a WTP welfare measure for a policy change that impacts on the environmental good which conforms to demand theory can be derived (Hanemann, 1984; Parsons & Kealy, 1992). Let U^0 represent the utility of the initial (for example, pre-project) state and U^1 represent the utility of the alternative (for example, post-project) state. The coefficient β_y gives the marginal utility of income and is the coefficient of the cost attribute:

$$WTP = \frac{1}{\beta_y} \ln \left[\frac{\sum_i \exp(U_i^1)}{\sum_i \exp(U^0{}_i)} \right] \tag{5}$$

Therefore, the WTP for dual quality supply is given by:

$$\text{E(WTP)} = \int_0^\infty \frac{1}{1 + e^{-(ASC + \sum_n \gamma_n ASC * S_n + \sum_k \beta_k Z_k + \sum_{kn} \delta'_n Z_k)}} d(\Delta y) \tag{6}$$

$$= \frac{1}{\beta_y} \ln[1 + \exp(ASC + \sum_n \gamma_n ASC * S_n + \sum_k \beta_k Z_k + \sum_{kn} \delta'_n Z_k) \tag{7}$$

We have selected the parametric method for two reasons (i) to know the effect of explanatory variables on the probability of selecting a particular scenario, and (ii) to introduce choice specific parameter, which varies across scenarios using more flexible models that use nested structure. "Parametric methods often work fairly well even when the distribution is contaminated or only approximately known, because, the central limit theorem shows that the sum of independent random variables with finite variance trends to be normal in large samples even when the variables themselves are not normal" (Systat Manual 2007: Chapter 2). In practical terms, such differentiation helps to calculate the mean or median WTP assuming that distribution of error is specified correctly to a large extent. This is reflected in the likelihood ratio test which is conducted by fitting two nested models (the restricted and the unrestricted) and comparing the log-likelihoods at the convergence. Most statisticians favour the likelihood ratio test as likelihood is the fundamental measure on which model fitting is based (Maddala, 2001).

4. Data analysis

In the first instance, choice responses are analyzed for planned urban settlements irrespective of any distinction of water quality based on source (groundwater or surface water). The sample population comes from those households who consider improvement in water attributes – quality, quantity and reliability is essential for making an alternate choice. Both multinomial logit and multinomial probit functions are employed to find out any large difference between the coefficients and significance of parameters. In case of planned urban settlements, groundwater dummy variable, household size, daily consumption, awareness level and price of water are found to be significant variables in explaining the difference in probability of selecting an alternative arrangement of water supply irrespective of source distinction. The coefficient on variables is large relative to their standard error and so they appear to be important predictor in explaining the higher choice probability (Note 5).

A positive coefficient on daily consumption and awareness levels means that an increase in these predictors leads to an increase in the predicted probability of choice occasion and paying behaviour, similarly negative coefficients on groundwater dummy, household size, and price of water means that an increase in these predictors leads to a decrease in the predicted probability of choice occasion and paying behaviour for alternate water supply (Table 2). Here, all of the coefficients except awareness level are significantly different from zero at the 99% confidence level. The null hypothesis is that the coefficients on parameters β and α_1 to α_5 are equal to zero. Here both the models contain a constant term; therefore, fitting the two models – restricted and the unrestricted, and comparing the log-likelihoods at the convergence conduct the likelihood-ratio test of the null hypothesis that all coefficients, except the constant are different from zero so that a decision can be made about the significance of the hypothesis. A lower value of likelihood ratio suggests that the observed result is less likely to arise under the null hypothesis. However, in most of the applications using discrete responses, the exact distribution of the likelihood ratio relating to the hypothesis in question is not easy to establish. A convenient way therefore is the distribution of –2log (LR) under certain regularity conditions, which is a chi-squared distribution for large sample sizes. Here, the model likelihoods are -52.25580 and -311.8557 for the MNP model measured using the cumulative distribution function of the standard normal, and twice the difference (519.1998) is chi-squared with six degree of freedom under the null hypothesis. This value can also be calculated by taking the difference of the LR test statistics reported below the parameter estimates. The chi-square is used to test the goodness of fit and test of independence, which indicates, if the observed frequency differs from the theoretically assumed distribution. A chi-squared probability of less than 0.05 is commonly taken as validation for rejecting the null hypothesis and accepting the alternate hypothesis that the explanatory variables are related to the dependent variable. Here the interpretation of coefficients used in MNP model is not as straightforward as used in other regressions. Unlike linear regression, coefficients in quality response models are confounded with residual variation or unobserved heterogeneity, which differs across choice (Williams, 2007). The increase on probability mass of respondents' willingness to pay due to one unit increase in the explanatory variable depends both on the values of the other explanatory variables and the starting value of the given variable. For example, if we hold other explanatory variables constant at zero, the one unit increase in the level of awareness from 1 to 2 has a different effect than one unit increase from 3 to 4 as the predicted probabilities do not change by a common difference (Green, 2003). This happens as variance differs across the respondents so it is rescaled differently. In both MNL and MNP models used here, the coefficients on parameters are standardized inherently, but not in the manner as it is done in OLS (standardizing by rescaling all variables to have a constant variance of one), the standardizing is done by rescaling the variables and error variance so that error variance is either one in probit or π^2/3 in logit. If error variances differ across respondents, the standardization will also differ, making comparisons of coefficients across respondents inappropriate for a particular variable (Williams, 2007). The slope coefficients reflect these differences. The MNP model results in WTP value of Rs 12.54/kL whereas the MNL model results in WTP value of Rs 12.98/kL for alternate water supply option irrespective of the source distinction between groundwater and surface water.

Table 3 shows the ratio of parameter estimates and preference behaviour of households in unplanned peri-urban areas without making any source distinction between groundwater and surface water. Education and awareness of the respondents is positively correlated with his preference behaviour implying that there is a positive relationship between a respondent's WTP and his number of education years as well as his level of awareness (Louviere *et al.,* 2000). Respondents with personal groundwater bore wells are less likely to pay more than the existing amount for an alternative water supply. This is because they have already invested a significant amount in securing a reliable water supply. The range of monthly bills likely to increase with alternate scenario significantly ($p<.001$) affected the price sensitivity (MacDonald *et al.,* 2005)

The coefficient of current monthly water bill is negatively signed – respondents getting higher water bills appear to be less likely to increase their payments for improvements in water supply. Alternatively, respondents who are getting lower monthly bills are more likely to choose the non-*status quo* option. The negative coefficients for households who have developed a large water storage capacity shows that they have already invested significant amount of money in storing water to avoid unreliable water supply, therefore, their additional WTP for an improved water supply system is actually lower. The results demonstrate that the culture of unreliability in the study area diminishes the willingness to pay for services. Respondents' household size is a significant variable with the negative coefficient meaning larger household sizes would have less likelihood of paying higher for improved water supply (Cai *et al.,* 1998; Hensher, 2004). Similarly coefficient for quantity of daily supply is a significant variable with negatively signed coefficient. In this context, a large majority of the customers receive water between 3 to 4 hours daily and it can be inferred that the level of satisfaction amongst customers in both planned and unplanned areas is very low. Probability of a respondent agreeing to pay higher decreases with increasing bid price (MacDonald *et al.,* 2005; Willis *et al.,* 2005; Raje *et al.,* 2002). Typically the difference between parameter estimates between MNL and MNP models are slight. Both distributions are symmetric and typically yield similar ratios of parameter estimates and likelihood functions (Table 2 and 3). Because each of the parameter estimates is normalized by the standard deviation of the distribution, the ratio of the parameters estimates would be roughly equal to the ratio of the standard logistic and standard normal distribution scales ($\pi/\sqrt{3}=1.814$). The test statistic is constructed from the value of log likelihood function under the null hypothesis and log-likelihood (unrestricted) indexes the unrestricted model. The model likelihoods are –261.119 and –402.584 for the probit, and twice the difference (282.92) is chi-squared with seven degrees of freedom under the null hypothesis. As the model employed here uses linear utility function and a symmetric mean zero error, the mean and median WTP with respect to random preferences are equal. Interestingly, the mean WTP in terms of Rs/kl of water supplied in both planned and unplanned areas is similar thereby indicating even in unplanned settlements, households would rather pay for good quality services than get low quality services at reduced price. The monthly bills that they would be willing to pay in these areas are different as their consumption structure is dissimilar – 19.8 kl/month in planned areas and 12.6 kl/month in unplanned areas.

4.1 Multinomial Logit Model (conditional) with source distinction for three supply choices for both the planned urban and unplanned peri-urban areas

Here conditional multinomial logit models have been used as preference behaviour among three alternatives is modeled both as a function of the characteristics of the alternatives, and the characteristics of the respondents making the choice keeping the *status quo* as the base case (0,1,2). The base case or *status quo* is one category of the dependent variable which is chosen as the comparison category. The negative sign on ASC in both the scenarios (dual and single quality supply) shows that choosing the *status quo* option would result in diminishing indirect utility (Table 4). The explanatory variables used here indicate the characteristics of the respondents as well as water supply situations that affect respondents' likelihood of being choosing a specific alternative. Log of income, cost of unreliability, planning class, awareness level, daily consumption, extra duration of water supply, monthly water bill, dummy for water quality, education level and environment dummy (1 if respondents think water quality is a major environmental problem, 0 otherwise) are included as predictors to see their sign and level of significance for both the improved scenario taking data from both planned urban areas and unplanned peri-urban areas. The variable 'planning class' is included to see how this affects in greater likelihood of choosing a specific alternative keeping *status quo* as the base case. Interestingly we get opposite sign for these two scenarios. The sign is negative when the choice is dual, and positive when the choice is single quality supply. This indicates as the level of planning increases, there is a greater likelihood of this alternative being selected as the best alternative. Cost of unreliability though not so significant for respondents choosing the dual supply option (t ratio 1.5728) has positive coefficients in both the scenarios, implying as the personal expenditure increases, the likelihood of choosing the improved scenarios increases. Similarly the level of education has a positive coefficient, but the magnitude of significance varies to large extent between the dual and single quality supply options. It becomes highly significant in choosing the dual supply options (t ratio 8.9353) as more educated people would like to go for better quality of water.

4.2 Modelling preference heterogeneity with source distinction using Nested MNL for three supply choices

The assessment of preferred choice behaviour is based upon estimated parameters and is a function of the random component assumed for preferences. The presence of two sources of uncertainty – parameters and preferences – and the additional source of variation between planned urban areas and unplanned peri-urban areas gives differing set of results. As the partial effect or interpretation of the slope coefficients depends upon the unobserved heterogeneity of the respondents, interpretation becomes useful when the endogenous explanatory variables interact with heterogeneity, in this case – the alternative specific constant. However, the attributes of the choice do not vary with the respondents, only the socio-economic characteristics vary. Therefore we cannot use the ASC to interact with the constant choice specific attributes. This is taken care of in the interaction effect using nested structure where two variables 'extra duration' and 'bid values' vary with respect to the alternatives chosen. In this case sources of heterogeneity are better modelled and controlled for using flexible form of specification such as nested models as determinants of heteroskedasticity can be better attributed.

The estimated results of customers' WTP show that changes in service attributes between dual quality and single quality is large enough to give differing estimates of benefits. As very few households opted for dual quality supply options in unplanned areas, the WTP estimated from MNL (Nested) from combined sample for dual quality shows preference for planned areas only. In planned areas, households are willing to pay Rs 295 per month for decentralized dual quality water. People in planned areas seek collective action to ensure cost minimization by a decentralized treatment option for high quality potable water. The WTP for centralized single quality improved water supply for both planned and unplanned areas put together is Rs 189 per month while the current average monthly bill paid to the Utility is Rs 89. This shows that households are willing to pay more then double their monthly bill for single quality improved water supply with assured reliability.

5. Conclusions and policy implications of the study

The signs on the coefficients under MNL and MNP models for both planned urban and unplanned peri-urban areas make intuitive sense. Overall, these multivariate model results are in accord with economic theory and prior expectations, and are robust with respect to estimation technique and model specification. The analysis is done for both planned urban and unplanned peri-urban areas segregated on the basis of property tax classification. A large number of households in planned urban areas favour decentralized dual quality water using both local groundwater and municipal surface water. However, single quality improved supply regardless of source distinction becomes the most preferred choice if planned urban and unplanned peri-urban households are modelled together. This preference variation across sampled households testifies 'scope effect', i.e., differential water quality and reliability provisions have differing value estimates between planned urban and unplanned peri-urban areas. By preserving the surface water-groundwater connection, conjunctive management is the preferred strategy for maintaining sustainable supply of a limited resource. However, the public utility must make adequate provisions to maintain safe-yield and control pumpage to prevent local water tables from experiencing long-term declines.

(a) Quality differentiated water with source distinction: The study has shown that it is promising to develop a differentially distribution systems for potable and non-potable water end-uses having heterogeneous customers' preference structure. Accordingly, it is desirable to consider water sensitive approach in the planning phase when developing a master plan for the cities and towns. The system may be desirable from both the customer's preference as well as resource sustainability point of view. With such a kind of system in place, the emergent alternative policy instrument of 'quality based pricing' can modify water use pattern among households across different socio-economic and planning classes. A perceptible heterogeneity in customer's preference provides remarkable lessons to policy makers on the distribution of costs and benefits related to a change in policy.

(b) Decentralized approaches: The study indicates that for a welfare-consistent outcome in water allocation, it is imperative to take decentralized approaches. Even though overall gain in welfare is positive, there exists a significant divergence among the respondents about the extent of these benefits between planned urban and unplanned peri-urban areas. The quality differentiated water supply with source distinction would be economically viable for newer colonies and urban extension due to obvious cost of retrofitting in the older settlements. People are able to support such decentralized options because they increase their wellbeing and hence they enlarge their ability to pay the required contribution from their discretionary income making them financially sustainable. Preference for dual quality water with source distinction between groundwater and surface water is almost negligible in the unplanned peri-urban areas implying that what they primarily need is better water supply. Rural and peri-urban areas adjoining the metropolis are often not well situated to imported surface water from the public water supply due to economies of scale. For communities residing in such areas, groundwater is the most accessible and secure water source. Such communities are concerned with having sufficient water supplies for future growth. If groundwater pumping is restricted because of its effect on adjudicated surface water, growth and development in such areas could be curtailed. The involvement of communities in the conception and the management of socially desirable alternative systems is very critical specially when the natural resource is in limited supply. Because groundwater is easier to access and costs less than water from piped systems, groundwater abstraction cannot be easily regulated. Groundwater management strategies by the local body and the residential society need to ensure sustainability of groundwater development in the future. Groundwater assessment, monitoring and regulation are key strategies for groundwater management in both planned and unplanned areas of a growing metropolis.

(c) Emergence of private capital and market solution: It has been observed from the study that people have deep understanding of water in their immediate environments and tend to cooperate in times of adversity to avoid high transaction costs that would result from limited resource availability. There are several instances of *reciprocal externality* wherein households themselves absorb the cost of over-extraction, in terms of higher pumping cost against declining water tables, and cost of salinity in terms of decentralized treatment cost. In several housing societies, the economies of scale act as externalities leading to an optimum investment in the decentralized treatment technology (such as reverse osmosis or ion exchange plant) and the emergence of a voluntary co-operation by the residents for good quality water. The ensuing economic approach of 'free market' for planned urban settlements generated by the private capital might lead to significant cost reduction as well as social welfare, but it is questionable, as to what extent a scarce resource would be conserved for future generations. Therefore, place for a regulator is strongly recommended.

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Notes

Note 1. Water is a contested resource: though it is often considered a common pool resource, it is rival and excludable in consumption. In many parts of the world, people no longer perceive it as a common good. Access to water reflects power asymmetries, socioeconomic inequalities, and other distributional factors such as land entitlements and planning status (Mehta, 2003).

Note 2. Although there are no comprehensive statistics on how many urban and peri-urban dwellers in Delhi rely on groundwater for their water supply, it is estimated that more than 80 percent of the total population depends partially or fully on groundwater. While 100,000 tube wells were officially registered in 2001, the actual number ranges from 360,000 to 400,000.

Note 3. The gross annual water demand for the city is projected to increase form 2050 million liters per day (MLD) to 4700 MLD in 2021, an increase of 75%, in order to cater for both the present deficiencies and future predicted population growth. Against this growing demand, the net water supply (i.e., excluding leakage and losses) from the 9 supply sources developed till today (2008 level) is only 696 MGD giving rise to a 33 per cent deficit in the net demand.

Note 4. Basically these two groups represent no improvement in quality or supply options, but giving them separately resulted in substantially (and statistically significantly) better estimates of mean willingness to pay than the widely used open-ended approach of allowing respondents to choose from a limited 'menu' of yes-no types without giving them a 'opt-out' choice. This approach reduces 'no response' or negative willingness to pay bias which presents a vexing problem in the contingent valuation studies increasing the number of 'free-riders' in the population.

Note 5. The interpretation is quite different from ordinary regression. Here, the MNL coefficients show how much the logit increases for a unit increase in the independent or explanatory variables, but the probability of a 'no' or 'yes' outcome is a non-linear function of the logit as it is a discrete variable.

Table 1. Difference in model specification as well as benefits of using nested logit model over MNL for reconciling preference heterogeneity

MNL	Elements of the choice sets are statistically independent of one another	$$P[(U_{ja} > U_{jb}) = \frac{\exp(\mu u_{ja})}{\sum_i \exp(\mu u_{jb})}$$
	The independent variables capture unobserved taste difference which could otherwise cause correlation across alternatives (a condition for homogeneous preference structure)	
	The error terms associated with the various alternatives follows a multivariate logistic distribution	
	The assumption of IID error terms in MNL leads to its infamous property. This restrictive assumption assumes identical error variances across individuals with no correlation in random components across choice occasions (Green, 2003) for people in planned and unplanned areas.	
NL	Flexible covariance structure/ more open	Prob$[U_{tk} > U_{tj}\ \forall\ j \neq k]$ = $$\frac{\exp(\alpha_k + \boldsymbol{\beta}'\mathbf{x}_{tk})}{\sum_{l=1}^{K}\exp(\alpha_l + \boldsymbol{\beta}'\mathbf{x}_{tl})}$$
	Differential variance for first and second stated choice preference data (covariance heterogeneous)	
	Non-independent errors	
	Inter-class level interactions (e.g. planned vs unplanned choice sets)	
	Non-constant correlation structure across observations	
	Choice based samples to obtain better information about alternatives	
	Clear interpretation of utility function parameters across alternatives	
	Application of the NL with the incorporation of choice specific attributes as explanatory variables as well as ASC induces heterogeneity in the preference structure of the respondents (Ziegler, 2005)	
	Nested logit specification outperforms the more basic MNL specifications with regard to reconciling preference heterogeneity across choice sets (Hensher & Greene, 2003; Louviere *et al.,* 2000)	

Table 2. Comparison of ratio of parameter estimates and other statistics for multinomial probit and multinomial logit models for planned urban areas irrespective of source distinction

Variables	**Coefficient (normal)**	**Coefficient (logistic)**	**Ratio of parameter+**
Constant	-12.6635990	-23.9773729	1.893409
	(-6.347)	(-5.498)	
GWATER_DUMMY	-.43905996	-.83643192	1.905052
	(-2.220)	(-2.351)	
HOUSEHOLD SIZE	-.28770614	-.51057004	1.774623
	(-2.391)	(-2.302)	
DAILY CONSUMPTION	.00134219	.00240689	1.793256
	(2.453)	(2.403)	
AWARENESS	.29084958	.41350775	1.421724
	(1.868)	(1.464)*	
PRICE/kl	-.00317678	-.00616994	1.942199
	(-6.010)	(-5.262)	
BID	-0.9945753	-1.8464431	1.856514
	(-6.754)	(-5.648)	
Log likelihood function (LogL)	-52.25580	-51.54004	
Restricted log likelihood (LogL$_0$)	-311.8557	-311.8557	
Estrella [1-(L/L$_0$)^(-2 L$_0$/n)]	.91127	.91127	
Chi squared	519.1998	520.6313	
Prob[ChiSqd > value]	.0000000	.0000000	
Hosmer-Lemeshow chi-squared	1.00699	.57132	
P-value	.60441	0.90297	
McFadden	.83244	.83244	
Mean WTP (Rs/kl)	12.540	12.986	
Mean WTP (Rs/month)	248.29	257.13	

Note: The ratio of estimated coefficient to standard error is asymptotically N (0,1) under the null hypothesis that the coefficients is zero and standard hypothesis testing applies. Here, all of the coefficients except this are significantly different from zero at the 99% level of confidence. The null hypothesis is that the parameters β and α_1 to α_5 are equal to zero.

+ The ratios of respective parameter coefficients indicate that the logit density is almost 1.8 times the probit density as expected for a well-behaved data set.

Table 3. Comparison of ratio of parameter estimates and other statistics for MNP and MNL models for unplanned peri-urban areas irrespective of source distinction

Variables	Coefficient (normal)	Coefficient (logistic)	Ratio of parameter
Constant	-1.83900467	-3.45269559	1.877481
	(-5.372)	(-5.442)	
EDUCATION	.03507168	.03144157	0.896495
	(2.046)	(1.010)	
HOUSEHOLD SIZE	-.17160736	-.32090264	1.869982
	(-6.592)	(-6.285)	
QUANTITY_DUMMY	-.30470228	-.51301725	1.683667
	(-2.070)	(-1.946)	
MONTHLY_BILL	-.00029037	-.00048517	1.670868
	(-1.858)	(-1.729)	
AWARENESS	.22016594	.33292274	1.512145
	(2.617)	(2.169)	
GWATER_DUMMY	-.37703663	-.64226197	1.703447
	(-2.570)	(-2.447)	
BELIEF	.00073714	.00079279	1.075494
	(2.108)	(1.255)	
BID	-.2688606	-.48991235	1.822181
	(-11.294)	(-9.928)	
Log likelihood function (LogL)	-261.119	-248.8049	
Restricted log likelihood ($LogL_0$)	-402.584	-402.584	
Estrella $[1-(L/L_0)^\wedge(-2 L_0/n)]$	.43476	0.46962	
Chi squared	282.9295	307.5594	
Prob[ChiSqd > value]	0.0000000	.0000000	
Hosmer-Lemeshow chi-squared	22.38609	49.94611	
P-value	.00425	0.00000	
McFadden	.35139	0.38198	
Mean WTP (Rs/kl)	11.4509	12.5011	
Mean WTP (Rs/month)	144.28	157.51	

Table 4. Estimation of parameter coefficients with source distinction using multinomial logit model (conditional)

	Coeff.	***Std.Err.***	***t-ratio***	***P-value***
Characteristics in numerator of Prob [Y = Dual Quality Supply]				
ASC+	-8.5938	0.9925	-8.6589	0.0000
Log (INCOME)	0.7349	0.0990	7.4228	0.0000
UNRELC	0.00001	0.0000	1.5728	0.1158
PLANNING CLASS	-0.2720	0.0447	-6.0857	0.0000
AWARENESS	0.5390	0.0800	6.7375	0.0000
DAILY CONSUMPTION	-0.0004	0.0002	-2.5779	0.0099
EXTRA DURATION	-0.0250	0.0136	-1.8406	0.0657
MONTHLY BILL	-0.0033	0.0011	-2.9422	0.0033
QUALITY_EC2	0.6298	0.1598	3.9425	0.0001
EDUCATION	0.2442	0.0273	8.9353	0.0000
ENVP_DUMMY	0.9125	0.1830	4.9870	0.0000
BID	-0.0572	0.0111	-5.1459	0.0000
Characteristics in numerator of Prob [Y = Single Quality Supply]				
ASC	-0.2035	0.4034	-0.5044	0.6140
Log (INCOME)	0.0004	0.0004	1.1931	0.2329
UNRELC	0.0001	0.0000	2.9481	0.0032
PLANNING CLASS	0.2419	0.0402	6.0172	0.0000
AWARENESS	0.6032	0.0728	8.2872	0.0000
DAILY CONSUMPTION	-0.0001	0.0002	-0.8334	0.4046
EXTRA DURATION	-0.0092	0.0124	-0.7416	0.4583
MONTHLY BILL	-0.0046	0.0011	-4.2482	0.0000
QUALITY_EC2	0.7882	0.1405	5.6106	0.0000
EDUCATION	0.0177	0.0152	1.1644	0.2443
ENVP_DUMMY	0.9423	0.1671	5.6386	0.0000
BID	-0.0936	0.0108	-8.6580	0.0000
Log likelihood function	**-2150.631**			
Restricted log likelihood	**-3022.157**			
Pseudo R-squared	**.28838**			

+ ASC is included in the specification to estimate the change in utility associated with choosing the *status quo* alternative when everything else is held constant (partial effect or *ceteris paribus*). It takes up any variation in choices that cannot be explained by either the attributes or socio-economic variables. The negative sign indicates that choosing the *status quo* option decreases indirect utility.

Table 5. Estimation of parameter coefficients for two scenarios using nested structure under multinomial logit model

Variables	Coefficient	Standard error	t-ratio
ASC_DUAL*	-3.88048620	1.03252163	-3.758
ASC_SINGLE	-2.76757203	.78471756	-3.527
EXTRA_DURATION	.16523668	.01391350	11.876
PAYMENT	-.00413130	.00062691	-1.760
Interaction effects			
ASC_DUAL			
DUA×PLANNING	-.33562158	.07616614	-4.406
DUA× AWARENESS	.56248998	.15107321	3.723
DUA× AGE	-.03886440	.01050529	-3.700
DUA× HEAD	.41415322	.29802436	1.390
DUA× ENV	1.04699051	.32747920	3.197
DUA× EDUCATION	.26606744	.04890373	5.441
ASC_SINGLE			
SIN× PLANNING	.22353802	.06939939	3.221
SIN× AWARENESS	.74980124	.13190306	5.684
SIN× AGE	-.03292063	.00887819	-3.708
SIN× HEAD	.60775243	.25175857	2.414
SIN× ENV	1.10176310	.28798764	3.826
SIN× EDUCATION	-.00066405	.02558244	-.0260
Pseudo R-square			0.449
Log likelihood function			-642.3527
E (WTP): SINGLE QUALITY			Rs. 189.32
E (WTP): DUAL QUALITY			Rs. 295.05

Note: *ASC_DUAL takes the value of one for Dual quality option and zero for Single and BAU options, similarly, ASC_SINGLE takes the value of one for Single quality options and zero for Dual and BAU options. Here BAU option is designated as the omitted level so that the parameter estimates on included levels represent the change from the *status quo* option.

Table 6. Cost and benefit spread of water supply options with source distinction among planned urban and unplanned peri-urban areas

COST SPREAD						
Water supply options	Likely cost (per 1000 L)		Monthly bill for a family of 5 at 165 lpcd (24.75kl)		Total monthly bill	
Centralized single quality water without source distinction	Rs 8.50 to Rs 15		Rs 210 to 371		Rs 210 to 371	
Decentralized dual quality water with source distinction	Rs 15 (potable) Rs 8.50 (non-potable)		Rs 81 (potable) Rs 159 (non-potable)		Rs 240	
BENEFIT SPREAD BETWEEN PLANNED AND UNPLANNED AREAS **Willingness to pay (Rs/month)**						
	Planned areas		**Unplanned areas**		**Planned and Unplanned put together**	
	MNL	MNP	MNL	MNP	MNL (Nested)	
Centralized single quality water without source distinction	257	248	158	144	189	
Decentralized dual quality water with source distinction					295	

Table 7. Inter-ward comparisons of water supply provision in the urban and peri-urban areas

Ward	**Saket** (urban)	**Ambedkar Nagar** (peri-urban)	**Vivek Vihar** (peri-urban)	**Shahadara** (peri-urban)	**Karampura** (urban)	**Janakpuri** (urban)
Zone	South	South	Shahadara (South)	Shahadara (South)	West	West
Population	150,000	125,000	75,000	150,000	100,000	200,000
Predominant land use	Residential & Commercial	JJ Clusters (10%) Resettlement Colonies (90%)	Residential (85%) Industrial (15%)	Mixed old area	Industrial & JJ Clusters	Residential (75%) Commercial (25%)
Access to piped water supply	100%	85%	100%	90%	100%	100%
Supply hours/day	3.5	4.2	5.5	5.2	4.5	3.5
Per capita supply (lpcd)	136	227	182	185	227	159
Monthly water bill paid to the DJB (Rs.)	92.80	66.50	85.60	70.48	53.25	98.50

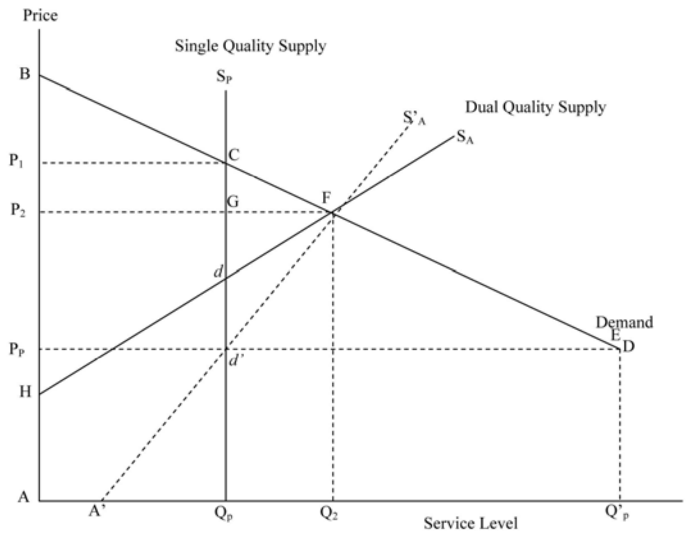

Figure 1. Social optimum and conjunctive use of groundwater and surface water vis-à-vis single quality supply (for a more detailed analysis, see Zekri & Dinar, 2003)

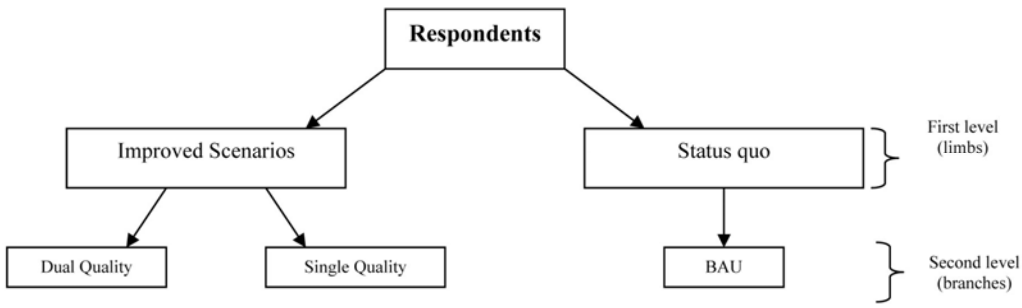

Figure 2. Choice path for the Nested MNLogit used in modelling preference behaviour

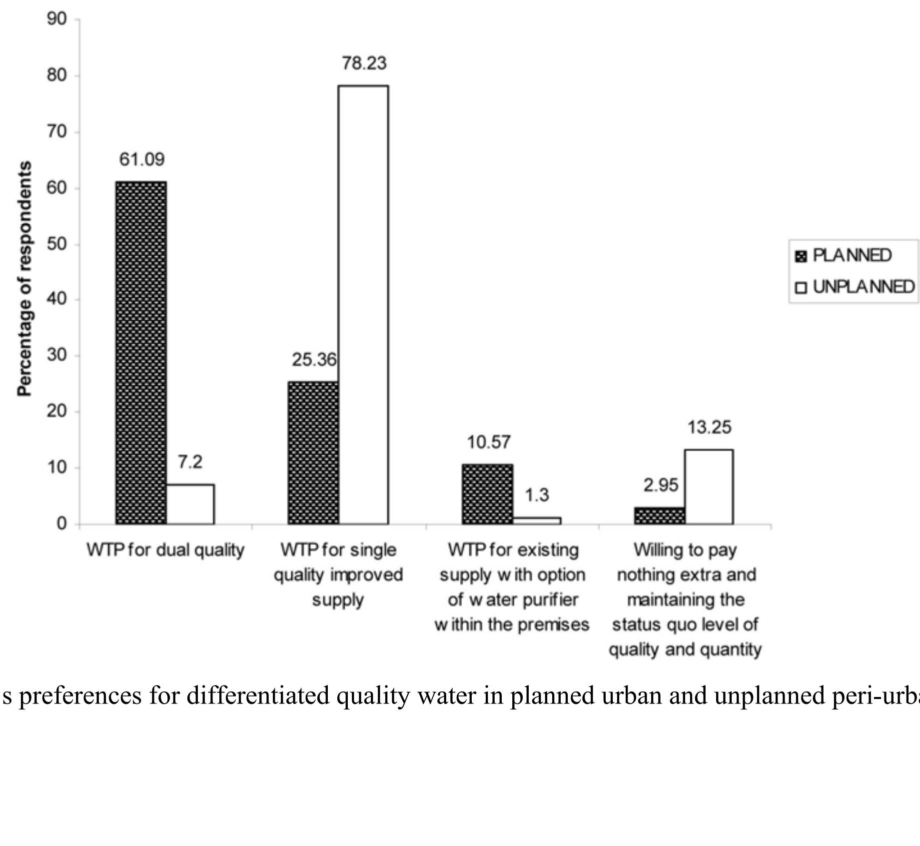

Figure 3. People's preferences for differentiated quality water in planned urban and unplanned peri-urban areas