Water Supply for Willingness to Pay and Affordability to Pay in Chennai City, Tamil Nadu, India

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ABSTRACT: Willingness to pay (WTP) andAffordability to pay (ATP) is an economic concept which aims to determine the amount of money a consumer is ready to pay if a product or service which is not currently available in the market is made available. This paper examines WTP and ATP for improved water Sustainability and water supply service at the level of household in Chennai city, India. For the study purpose Chennai city is divided into two residential Zones namely North and South. A Contingent valuationquestionnaire survey was conducted with a sample size of 320 for Chennai city. The questionnaire survey includes socio economic, life cycle of Human Attitude and current water source has variables. Methods of data analyses involved the use of Descriptive statistics and a Factor Analysis for the Households. The result of factor analysis shows that the most dominant factors are: Economic variables, social variables and life cycle of Human Attitudes.

KEYWORDS: Water Sustainability, Willingness to pay, Affordability to pay, Contingent valuation, Factor analysis.

I. INTRODUCTION

Water supply and sanitation have featured prominently on the International Development Agenda since the mid-1970s, in 1976, at the United Nations (UN) Conference on Human Settlement, Vancouver. The promise of the IDWSSD was that all people, whatever their stage of development and their social and economic conditions, have the right to have access to drinking water in quantity and of a quality equal to their basic needs (UNDSD 2001; UNICEF 1995). The main vision of 'water for people' is, "A clean and healthy world; a world in which every person has safe and adequate water and sanitation and lives in a hygienic environment" by the year 2025. The household is recognized as the prime catalyst for changing the existing water supply and sanitation conditions, whereby change demanded and achieved at the household leads to extended cooperation and action involving communities, local authorities, NGOs (non-governmental organizations), government and the international community (WSSCC 2000).This paper aim and object WTP and ATP for improved water Sustainability and water supply service at the level of household in Chennai city, India. For the study purpose Chennai city is divided into two residential Zones namely North and South. The result of factor analysis shows that the most dominant factors are: Economic variables, social variables and life cycle of Human Attitudes.

Study Area

Chennai is one of the major metropolitan in India. The average rainfall in Chennai is 1276mm. the metropolis receives about 600 million liters per day of water supply from various sources. Its surface water supplies are received from Krishna River, Veeranam Lake, Poondi Reservoir and Red hills Lake which are treated at different locations. Chennai metro water is responsible for collection, storage, treatment and distribution of water in Chennai city and in its peri-urban areas. (Figure 1).

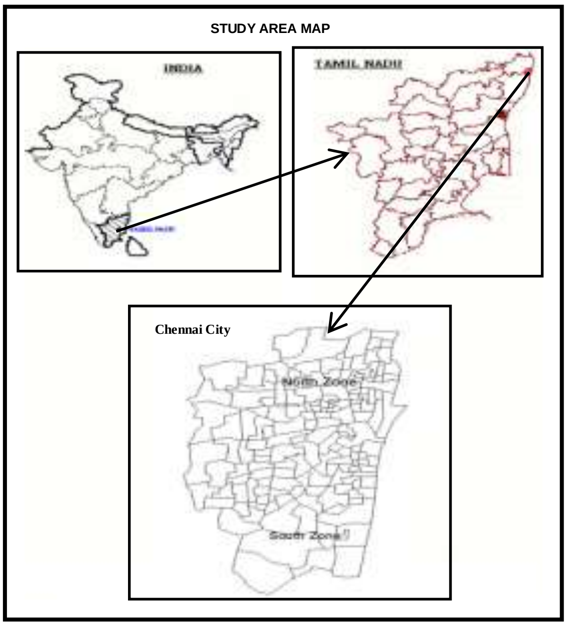

Figure 1. Study Area Map

The area selected for the study is the Chennai city. Chennai lies between 12^0 9' N to 13^0 9''N latitude and 80^0 12' E to 80^0 19' E Longitude and the covering a total area of 178.20 Sq.Km. The study area has been divided into North and South. The study areas North Zone Namely, Tondiarpet, Pulianthope and South zone Namely Adyar, Saidapet. It has a tropical climate with an average rainfall of 1200mm.

With respect to time and resource constraints it was decided to conduct the field study in Chennai city. Chennai city total 10 Zones and 155 Wards. This study has selected North and South part of Chennai city. North part is divided into 2 Zones Namely Tondiarpet and Pulianthope. South part is also divided into 2 zones namely Saidapet and Adyar. North part Tondiarpet zone, Pulianthope zone selected in 4 wards and south part selected in saidapet zone and Adyar zone selected in 4 wards. The Questionnaire survey taken for 320 samples and each ward consisting 21 samples. The survey is conducting in 3 group level of people High, Median and Low income. This level find the land value based in Chennai city. This satisfied sampling surveys.

II. Methodology

The study used primary data. The data were collected with the use of structure questionnaires. A stratified sampling technique was employed, for the first stage. The random sampling technique was used for the second stage. About 320 household were sampled from both the areas. The land value divided into three levels. i.e., High, Moderate and Low land value. Depends upon the levels of land value the questionnaires survey sampled are 106,106 and 108 respectively.

The collected data were analyzed using appropriate computer assisted and analytical procedures and using SPSS and Arc GIS software. Primary data collected through questionnaire survey were coded, tabulated and analyzed using SPSS software. The analyzed data were presented with the help of series of maps, Tables and graphs using digital cartographic techniques. This analysis to assessment of Household used is different source for water uses, asses of water, water quality and Willingness to pay. Descriptive statistics such as frequency distribution tables, mean and standard deviation were used to analyze the socioeconomic characteristics of the respondents. The factor analysis was also used to establish relationships between Willingness to pay and Affordable to pay the factor.

III. Results and Discussion

Factor Analysis of Water Sustainability and Water Supply, WTP and ATP

After factoring the correlation matrix by the principal components method, the five factors retained for the study togetherexplains about 80.93 per cent of the variations in the 15 water Sustainability andwater supply related variable measures entered in the analysis (Table 1). The communality estimate for each variable (Table 2) is the squared multiple correlation for predicting that metric from the five factors. There are no variables with low communalities and hence all are associated with the five factors retained in the analysis.

Table1.Water Sustainability and Water Supply: Total Variance Explained by 5-Factor Matrix Retained

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Factor	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.507	36.710	36.710	5.507	36.710	36.710	4.455	29.701	29.701
2	2.939	19.591	56.301	2.939	19.591	56.301	2.374	15.823	45.524
3	2.006	13.370	69.671	2.006	13.370	69.671	2.016	13.442	58.966
4	0.865	5.764	75.435	0.865	5.764	75.435	1.891	12.605	71.571
5	0.824	5.496	80.931	0.824	5.496	80.931	1.404	9.360	80.931
6	0.568	3.786	84.717						
7	0.488	3.252	87.968						
8	0.375	2.500	90.468						
9	0.331	2.207	92.676						
10	0.324	2.162	94.837						
11	0.275	1.835	96.672						
12	0.189	1.262	97.935						
13	0.173	1.154	99.089						
14	0.137	0.911	100.000						
15	1.036E-15	6.905E-15	100.000						
Extraction Method: Principal Component Analysis.									

Table 2.Water Sustainability and

Water Supply: Communalities Estimated for Variables in the Analysis

Variables entered in analysis	Initial	Extraction
Community (Caste category)	1.000	0.738
Educational status of respondent	1.000	0.771
Occupation of respondent	1.000	0.737
Monthly income of household	1.000	0.859
Size of household	1.000	0.849
Metro water cost	1.000	0.755
Distance to drinking water	1.000	0.864
Quantity of drinking water consumed	1.000	0.737
Distance to water for cooking	1.000	0.893
Quantity of cooking water consumed	1.000	0.748
Distance to bathing water	1.000	0.743
Quantity of bathing water consumed	1.000	0.787
Quantity of washing water consumed	1.000	0.662
Willingness to pay (WTP)	1.000	0.999

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Affordable to pay (ATP)	1.00 0	0.999
Extraction Method: Principal Component Analysis.		

The loadings of each variable on each of the five factors after varimax rotation are shown by the factor pattern in Table 3.

Factor Dimensions Retained for WaterSustainability andWater Supply in Chennai

The following are the factors extracted from the analysis of data pertaining to suitable water Sustainability andwater supply in Chennai, which has used 15 select variables that are considered relevant to the analysis as they are related to three major areas of action:

- 5socio-demographic variables including income of the households:
  - Community (Caste category);
  - Educational status of respondent;
  - Occupation of respondent;
  - Monthly income of household,
  - Size of household.
  -
- 8 metro water supply related variables such as cost, distances and quantities (for drinking, cooking, bathing and washing waters):
  - Metro water cost;
  - Distance to drinking water;
  - Quantity of drinking water consumed;
  - Distance to water for cooking;
  - Quantity of cooking water consumed;
  - Distance to bathing water;
  - Quantity of bathing water consumed; and
  - Quantity of washing water consumed.
  -
- 2 variables representing an attitude among the people of the city of Chennai in regard to:
  - Willingness to pay (WTP); and
  - Affordable to pay (ATP).

A rule-of-thumb for retaining factors is that the associated eigenvalue be greater than one. Whereas in initial solution of the factor analysis, the first 3 factors display eigenvalues greater than 1.0 and the other two less than 1.0. On the other hand, in the rotated solution, all the five dimensions are retained for interpretation because all of them have eigenvalues more than 1.0. Together, these three factors account for 59.97 per cent of the total variance, which is significant enough. The fourth and the fifth factors retained in the analysis have eigenvalues less than 1.0 but yet they have variables relating to distances to drinking, cooking and bathing water (fourth factor dimension) and quantities of drinking and cooking water (fifth factor dimension) and hence are retained for their significant loadings on the factors. Besides, the two together add common variances of 12.6 per cent and 9.4 per cent (an addition of 22 per cent) to make the 5-factor matrix quite relevant to explaining water supply in Chennai city, with 80.93 per cent as the cumulative variance explained by the five factors (Figure 2, scree plot).

As seen from Table 6.3, third factor has relatively high loadings for the two variables loading on the factor: WTP has 0.996 and so has ATP. This means that in the rotated metric state space, both the WTP and the ATP lie very near the third axis. Furthermore, because the signs are the same (both positive), the two metrics lie near the same end of the third axis with equal utility because their absolute values are equal. This is an example of how a metric pair with high positive correlation is treated by a factor analysis. Now it would be good to look at each the factor dimensions extracted and discuss their importance.

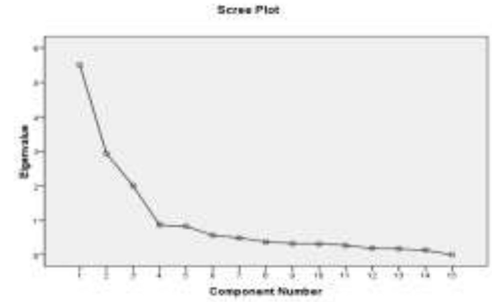

Figure 2. Scree Plot showing Eigenvalues against Factors Retained

Individual Dimensions of Water Supply, WTP and ATP

Let it be said that the people or rather the households of Chennai give a strong life cycle in human attitudinal inclination towards their willingness to pay for water, metro water supplied or private sector supplied through bottles and tankers, and intimate that they can afford to pay the water as well. Or maybe, their intentions come out so strong that they say through the survey that they can afford to pay and so they will pay for water. The very high, positive and significant loadings indicate that.

Factor I: Socio-Economic Dimension

Five items are found to load on Factor I, which is labelled as the '**socio-economic dimension**' because the five variables significantly loading on the first factor are social (3 variables) and economic (2 variables). Household income (loading: -0.898; variance explained: 85.9 per cent) loads with high negative loadings and is the first among the five on the factor. The negative sign of household income may be taken to mean the difficulty the people are going through in a period of escalating prices and costs, including that of water. Metro water cost (0.800; 75.5 per cent) loads high but is the last of the five variables. It does mean that the metro water is costing for the households and it would continue to do so. They are on the opposite ends of the first axis. On the social side of the dimension are three variables, all loading high and positive. Education (0.867; 77.1 per cent), community or caste category (0.841; 73.8 per cent) and occupation (0.820; 73.7 per cent) – all of them indicate that they are important in regard to water supply; particularly, caste categories are important because deprivation is by caste and access is limited by caste as well. While income of the household with a negative loading is on one end of the first axis, all other variables loading on the factor dimension is on the other end of the axis. The factor explains a total variance of 29.7 per cent, which in itself makes the first factor very relevant and significant dimension in the explanation of the nature ofwater Sustainability and water supply in Chennai. The eigenvalue of the factor is 4.455.

As monthly income has been identified as the most important variable governing the ATP and WTP, it is likely that Chennai with the increasing incomes even despite the economic slowdown can afford to pay and is also willing to pay as shown by the third factor. Their ability to pay for water is likely to go up in the coming years. Hence, the improved water supply schemes with the private as well as public participation is likely to succeed in the coming years. Adenike and Titus (2009) have also established a relationship between household income and willingness to pay for water in Osogbo metropolis which is very much similar to our findings in the study. Also, Asante et al. (2002) have established a relationship between household income and willingness to pay for water in Ghana.

Factor II: Household Size and Water Consumption Dimension

Only three variables are found to load on Factor II which is labelled, keeping in view the highly loading variables, as 'household size and water consumption dimension'. This factor accounts for a total variance of 15.82 per cent and with an eigenvalue of 2.374. Together, the first and the second dimensions account for a common variance of 45.52 per cent. As a social component, household size (0.885; 84.9 per cent) often determines the quantity of water consumed in the household: the larger the number, the greater is the volume of water consumed. In this sense that the quantity of bathing water (0.866; 78.7 per cent) and the quantity of washing water (0.796; 66.2 per cent) are the largest volumes in any household for bathing and washing of utensils, clothes, swabbing houses and cleaning vehicles used in travel takes much domestic water. At times of scarcity and staggered supply of water, it becomes necessary for the households to store water to meet the demands of bathing and washing in the households. Size of the family as well as type of the family are criteria that determine the willingness to pay and affordability to pay as well, for large size of household could mean a larger income and the size also indicates the type of family (nuclear, joint or extended households).

Table 3.Water Sustainability andWater Supply: Rotated Factor Matrix (Five Factors) for Chennai

	Rotated Factor				
Variables entered in analysis	I	II	III	IV	V
Monthly income of household	-0.898				
Educational status of respondent	0.867				
Community (caste category)	0.841				
Occupation of respondent	0.820				
Metrowater cost	0.800				
Size of household		0.885			
Quantity of bathing water consumed		0.866			
Quantity of washing water consumed		0.796			
Affordable to pay (ATP)			0.996		
Willingness to pay (WTP)			0.996		
Distance to drinking water				0.852	
Distance to cooking water				0.703	
Distance to bathing water				0.632	
Quantity of cooking water consumed					0.802
Quantity of drinking water consumed					0.771
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.					
a. Rotation converged in 6 iterations.					

Factor III: Life Cycle of Human Attitude Dimension

There are just two variables that are loaded with very high loadings, namely, Willingness to pay (0.996; 99.9 per cent) and Affordability to pay (0.996; 99.9 per cent). With very high positive loadings, the third axis has the two variables on one end of it. As indicated before, this represents a human attitude dimension and hence is so named. The inference from the factor dimension is that the households of Chennai can afford to pay for the water and so are willing to pay as well. Pearce et al (2008) have studied people's attitudes towards paying for water in five aboriginal communities in South Australia. They have also found that strategies such as communication and community involvement in the decision-making processes around water supply are necessary to facilitate cost recovery and to promote water conservation. The eigenvalue estimate of the third dimension is 2.02 and the total variance explained by it is 13.442 per cent.

Factor IV: Water Sustainability Potable and Bathing Water Dimension

The term 'water sustainabilityand potable water' means the water used for drinking and cooking. People invariably need good quality water for these two main purposes. While the distance to drinking water (0.852; 86.4 per cent) and distance to cooking water (0.703; 89.3 per cent) are found to load on this potable water dimension, distance to bathing water (0.632; 74.3 per cent) is also found to load on this factor. It must be pointed out that the distance to cooking and bathing water with their loadings are a bit in the middle of the axis and hence are not highly significant. The eigenvalue of the dimension is 1.89 and the total variance explained by it is 12.61 per cent. The four factor dimensions so far have explained a cumulative variance of 71.57 per cent.

As indicated in the previous chapter, there is not much distance involved in fetching or collecting the water for drinking, cooking, bathing and even washing, for water connections, bore wells and even taps are often within the house premises and in some households, especially in poor and marginal areas of the city, they may be outside the house premises. Even then, in the city, they are not very far away, as in rural areas, even though there may be several people at the collecting point competing for water. And the water supply may be for a limited time period that there is some difficulty in acquiring water. While metro water and water from the private sector such as bottled water are fairly good quality, groundwater sources and tanker water may be poor quality.

It is fairly certain also in the city of Chennai that the household's access and use good quality water for drinking and cooking, even though they may compromise on the quality of water for bathing. Yusuf (2005) in Indonesia has shown that households value access to safe and improved domestic water sources, which is definitely the case in Chennai as well. Yet again, the Chennai households are willing to pay for quality water for drinking and cooking as well as other domestic water if they could afford.

Factor V: Water Sustainability and Potable Water Dimension

This is indeed the water sustainability and potable water dimension, with the two important variables, and primarily the quantities consumed by the households. This last factor dimension retained has an eigenvalue of 1.404 and a total variance of 9.36 per cent. Together with all other dimensions, this account for a common variance of 80.93 per cent and hence the inferences drawn from the five dimensions are quite valid. Although the variables found in the last dimension extracted are quantity of drinking water consumed (0.802; 74.8 per cent) and quantity of cooking water consumed (0.771; 73.7 per cent), their implication for water supply in Chennai is that the emphasis is on quantity. Positive signs of the loadings and the relatively high loadings are to mean that the Chennai households do get to have their needs met by the metro water and the private sector suppliers, for a price they can now afford. If need arises, they are willing to pay for more of it and they are sure of their affordability to pay for the same.

IV. Conclusion

This paper examines WTP and ATP for improved water sustainability and water supply service at the level of household in Chennai city, India. The survey includes socio economic, life cycle of Human Attitude and current water source has variables. Methods of data analyses involved the use of Descriptive statistics and a Factor Analysis for the Households. The result of factor analysis shows that the most dominant factors are: Economic variables, social variables and life cycle of Human Attitudes.

This paper has dealt with a factor analysis of watersupply (15 variables) to extract 5 factors for an understanding of water supply and related aspects of the people of Chennai. The method of analysis in either context is common factor analysis with a principal component method of extraction. In both, the common set of variables belongs to the socio-economics and cultures of the Chennai households from a sample of 319 households.

As for Water Supply and related aspects (WTP and ATP), in Chennai, the factor analysis has used 15 variables in three major areas of action, namely: 5 socio-demographic variables including income of the households: Community (Caste category); educational status of respondent; occupation of respondent; monthly income of household; and size of household; 8 metro water supply related variables: Metro water cost; distance to drinking water; quantity of drinking water consumed; distance to water for cooking; quantity of cooking water consumed; distance to bathing water; quantity of bathing water consumed; and quantity of washing water consumed; and 2 variables representing attitudes among the people of the city: WTP; and ATP. The five factors retained have been labelled, based on the variables found to load significantly on the factors, as:

1. Socio-economic dimension
2. Household size and water consumption dimension
3. Life Cycle ofHuman Attitude dimension
4. Water Sustainability and Potable and bathing water dimension
5. Water Sustainability and Potable water dimension

The 5-factor matrix has been shown acquit relevant to explaining water sustainability water supply in Chennai city, with 80.93 per cent as the total variance explained by the five factors. The third dimension, which is Life Cycle ofHuman attitudinal, has shown that WTP has a very high loading 0.996 and so has ATP.

The households of Chennai have given out a strong Life Cycle ofHuman attitudinal inclination towards their willingness to pay for water, either public, metro water or private sector in bottles and tankers. They have also indicated very strongly that they could afford to pay the water. Their intentions have come out strong in that they categorically say that they could afford to pay and so they would willingly pay for water, even if this segment of the Chennai population is not a majority. The rotated factor scores have shown that in socio-economic (main), household size and water consumption (bipolar), Life Cycle ofHuman attitude (the third) and potable water dimensions (the fifth), the Chennai water consumers have not really been better placed. Only varying minorities of the households have been better placed, socio-economically (44.8 per cent), household size related water consumption (43.6 per cent), Life Cycle ofHuman attitudes (26 per cent) and water sustainabilityand potable water consumption (34.8 per cent).

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