SUSTAINABLE WATER PRICING AND TARIFF DESIGN: A STUDY OF RESIDENTIAL WATER DEMAND IN DELHI

Dissertation submitted to Jawaharlal Nehru University

in partial fulfillment of the requirements

for the award of the degree of

MASTER OF PHILOSOPHY

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2011

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DECLARATION

I hereby affirm that the work for this dissertation, **"Sustainable Water Pricing and Tariff Design: A Study of Residential Water Demand in Delhi"**, being submitted as a part of the requirements of the **M. Phil Programme** of the Jawaharlal Nehru University, was carried out entirely by myself. I also affirm that it was not part of any other programme of study and has not been submitted to any other university for the award of any degree.

25th July, 2011

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CERTIFICATION

We recommend that the dissertation be placed before the examiners for evaluation.

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Dedicated to Maa, Babuji

Acknowledgement

First and foremost, I owe my deepest gratitude and profound sense of indebtedness to my esteemed supervisor, **Dr. Jaivir Singh**, for his expert guidance, moral encouragement, and constructive criticisms which have played an instrumental role in the completion of this dissertation. No words can express the feelings I have for him for his patience and painstaking supervision with which he guided me throughout the completion of this dissertation.

I would like to express my sincere thanks to **Dr. Ramaswamy R. Iyer** (Centre for Policy Research, New Delhi), **Ms. Marie-Helene Zerah, Prof. Meera Mehra** (CITD/JNU), **Mr. Arvind Kejriwal, Mr. Alankar** (CSDS, New Delhi) for providing me valuable inputs on urban water governance in Delhi in particular, and India in general. I would also like to thank the librarian and the staff of the Central Ground Water Authority, New Delhi. Also, I duly acknowledge my sincere thanks to **Prof. Amita Singh** (CSLG/JNU) for giving me candid support.

My thanks are also due to invaluable contributions to my work by my friends and colleagues. I would like to name Awadhesh, Jatinder Singh, Nilotpal Bal, Lull and Ajit for their methodological support. No words can express heartfelt thanks to my dear friend **Mr. Mohit K. Gupta** (CILS/JNU) for keeping me always motivated towards my work. My loving friend Promila who acted as a catalyst in my work deserves mentioning.

Family always plays a significant role in the making of a human being. My loving brother **Dhananjay Singh**, Asst. Prof. at JNU, kept on encouraging me all throughout the work. My beloved **parents and sisters** who counted on me will definitely be pleased with my work. Last but not the least, my mentor SGI President, **Daisaku Ikeda** to whom this all work is credited has been a source of deep inspiration.

Rakesh Kumar Singh

CONTENTS

List of Abbreviations

B P S	**Booster Pumping Station**
C D P	**City Development Programme**
C E T P	**Common Effluent Treatment Plant**
C P H E E O	**Central Public Health Engineering**
C S E	**Centre for Science and Environment**
D C B	**Delhi Cantonment Board**
D D A	**Delhi Development Authority**
D J B	**Delhi Jal (Water) Board**
D W S S P	**Delhi Water Supply and Sewerage Project**
D U E I I P	**Delhi Urban Environment and Infrastructure Improvement Project**
I G I	**Indira Gandhi International**
J N N U R M	**Jawaharlal Nehru National Urban Renewal Mission**
N C T D	**National Capital Territory of Delhi**
M C D	**Municipal Corporation of Delhi**
N D M C	**New Delhi Municipal Corporation**
T E R I	**Tata Energy Research Institute**
M G/ D	**Million Gallons per Day**
M L/ D	**Million Litres per Day**
G P C/ D	**Gallon Per Capita per Day**
L P H/ D	**Litre Per Hectare per Day**
N C R P B	**National Capital Region Planning Board**
D U S S D U	**Delhi Water Supply and Sewage Disposal Undertaking**
N I U A	**National Institute of Urban Affairs**
S T P	**Sewerage Treatment Plant**
U L B	**Urban Local Body**
J J	**Jhuggi Jhopri**
U W S S	**Urban Water and Sewerage Services**
U C	**Unauthorised Colonies**
I I R	**India Infrastructure Report**

W T P	**Water Treatment Plant**
M P D	**Mater Plan Delhi**
U G R	**Under Ground Reserviour**
D W S & S S R P	**Delhi Water Supply and Sewerage Services Research Project**
C G W A	**Central Ground Water Authority**
H H	**Household**
G P S	**Geo Positioning System**
I B R	**Increasing Block Rate**
L D C	**Less Developed Countries**
J N U	**Jawaharlal Nehru University**
C P W D	**Central Public Work Department**

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Abstract

With the rapid pace of urbanisation and growing population, it has become a Herculean task for the authorities to provide safe and adequate water supply to the residents of Delhi. There are instances of serious water shortages in many zones or areas in Delhi. It is predicted that, in coming years, the threat of water 'crisis' is only going to aggravate, with the present limited water resources to the service of the citizens in the capital city. It is maintained that, the Delhi Jal Board (DJB) as the nodal agency of public water system and water resource management in the city, fails to deliver satisfactory customer services on several grounds. There is inequitable water availability in many parts of Delhi. There is acute mismanagement of water resources, like groundwater over extraction in the city. There is a serious case of under pricing of water resources in Delhi. As a consequence, the groundwater level has been depleted fast over the years. There are instances where, in some parts of Delhi, residents are availing abundant water supply making them hardly care about the judicious consumption of it. In this direction, it is felt that, altering or rationalising water tariffs could play an instrumental role in minimising water wastage and rationalise consumers for the optimal use of this increasingly scarce and valuable resource. It has been witnessed that, mostly the water inadequacy is visualised as a 'supply deficit' problem, which is often met by augmenting existing supply through tapping new distant and often 'cost ineffective' water sources. The important concern is that, the demand side of domestic water consumption is often ignored, making the system partially viable in its service delivery. *The present work is an earnest attempt to determine empirically, the residential demand for water, thus estimating the demand function to derive price and income elasticities. The coefficients of price and income elasticities are taken as key policy variables in determining effective water demand management compatible with the available water supply.*

The basic premises for the advocating rationale water pricing in the present work is to presuppose the fact that 'sustainable water pricing' from all perspectives, plays a significant role in mitigating the institutional inefficiencies on one hand, and meeting the adequate water requirement for all categories of water consumers in Delhi on the other hand. The present work emphasises the need for effective urban water governance in Delhi, taking into consideration all the pillars of water governance like law, policy, and importantly the water governing institutions.

Chapter 1

An Overview of Water Supply Governance in Delhi

Outline of the Chapter

1.1 Public Water Delivery System in Delhi: An Appraisal of Delhi Jal (Water) Board

Water supply and sewerage services are essential component of the basic infrastructure of urban settlement (Economic Survey of Delhi, 2008-09:151), and so is the case with the Delhi city. The present section focuses, primarily, on the *institutional* framework surrounding the public water provision, and management water resources in the Delhi city. This section also attempts to expose, though in an elementary fashion, some of the underlying issues pertaining to different facets of the residential water supply and demand in Delhi. The household water in the city is provided to the citizens by the state government through the agency of the Delhi Jal Board (DJB). Preliminary investigation into the various roles, functions, and powers assigned to DJB would, surely provide the platform to seek deeper insight into the issues that confronts the household water management in Delhi.

The total geographical/political territory of Delhi is referred as the National Capital Territory of Delhi (NCTD), which has a total area of 1483 km^2, and comprises of three jurisdictions or constituents: Municipal Corporation of Delhi (MCD) having an area of 1297.29 km^2, New Delhi Municipal Corporation (NDMC) at the core having an area of 42.74 km^2, and the Delhi Cantonment Board (DCB) area between the Indira Gandhi International Airport (IGI) and the NDMC, having an area of 42.97 km^2 respectively (CDP, JNNURM Delhi, 2006:8-1). This means MCD covers the maximum (about 94 percent) of the total area of the city. As per the 2001 Census of the Government of India, the population of Delhi stands at 137.83 lakh. The decennial population growth from 1991 to 2001 was 46.31 percent, and with this growth rate, it is projected to have reached 195.1 lakh in 2011 (Daga, 2007:181). The central public utility meant for meeting the water demand of vast and ever increasing Delhi citizens leading to management of water resources is the DJB.

> DJB is the sole agency of the Government of NCTD responsible for procurement, treatment, transportation and distribution of potable quality water in the MCD areas. It also supplies treated bulk water to NDMC and DCB for distribution in their respective areas (CDP, JNNURM Delhi, 2006:8-1).

The water supply infrastructural development in the NDMC and the DCB territories is not the responsibility of DJB, and hence only the MCD area is in control of DJB (Economic Survey of Delhi, 2008-09:154). The DJB is also responsible for all wastewater collection, conveyance, treatment and disposal facilities except in the NDMC and the DCB areas, where it acts as an agency for treatment and waste water disposal (DWSSP Part B, 2008:1-1). Water supply and sewerage disposal in urban areas usually go in conjunction is true in the case of DJB also. However, the aim in the present work is exclusively to focus on the residential water demand for water, keeping in mind the water supply segment of the DJB.

The history of DJB as the *nodal* agency for water provision in the city can be acknowledged from the following briefs:

(i)In colonial times, the Delhi Water Works was constructed at Chandrawal with a capacity of 1 Million Gallon per Day (MG/D) or 4.5 Million Litre per Day (ML/D) in the year 1890 and the source of water supply was a row of wells sunk along the river Yamuna. By the year 1912, the water demand had exceeded the capacity and recourse was taken to drawing water directly from the river and this necessitated the installation of settling tanks and slow sand filters (CDP, JNNURM Delhi, 2006:8-1).

(ii)In the water supply sector, till 1998, the public undertaking responsible for water production and distribution in Delhi was the Delhi Water Supply and Sewage Disposal Undertaking (DWSSDU). It became the Delhi Water Board or Delhi Jal Board in 1998, by an enactment of Delhi Water Board Act, promulgated on 2 April, 1998 (Zerah 2000:64).

(iii)The Delhi Water Board is an autonomous body directly under the Delhi government and benefits from extended powers and greater autonomy. Its board is constituted by ex-officio members and elected representatives. The Delhi Jal Board, like the DWSSDU previously, is responsible for the production of water, control of water quality, water pollution monitoring, water resource management and treatment of waste water (Zerah 2000:64).

The National Institute of Urban Affairs (NIUA), in India Infrastructure Report (IIR, 2006:136) presents a schematic framework of the institutional set up for urban water supply as outlined below. This scheme shows how the modern urban water utility functions at different hierarchies of governance.

Activities				
Source Development	Conveyance	Storage/Treatment	Distribution Network	Operation and Maintenance
Municipal Government				
State Department			Municipal Government	
State Department		Parastatal Agency	Municipal Government	
↓Metropolitan Agency → State Department or Agency				

Source: NIUA *cited* in IIR 2006.

At this point it is to be noted that 'water' in India, is constitutionally a 'state' subject and the role of the 'central' government is limited to defining norms for the 'sector', providing guidelines and technical assistance to the states (IIR, 2006:134). Further in the context of the urban water supply and sewerage services, the IIR (2006:134) informs that,

> The Central Government also intervenes through some centrally funded special programmes of the Ministry of Urban Development such as the megacity schemes or programmes on sanitation. Similarly, the Planning Commission plays a role in evaluating financial requirements for the quinquennial plans and has an advisory role in policymaking. However, the states are responsible for Urban Water and Sewerage Services (UWSS) while Urban Local Bodies (ULBs) operate and maintain water supply and sewerage services. The role of ULBs towards operation and maintenance is now reinforced with the 74th Constitutional Amendment Act, 1992.
>
> Water supply for domestic, industrial and commercial purposes as well as public health, sanitation, conservancy and solid waste management are part of the Twelfth Schedule of the Constitution, which clearly spells out the functions of an ULB. In this context, management of the distribution network, operation, and maintenance and revenue collection is the responsibility of the ULB and source development and capital investment in the network system remain with a state department or a parastatal agency.

The scheme presented above, clearly shows that for large metropolises like Delhi, parastatal agencies at the state level or at the city level constitute the third kind of institutional arrangement (IIR, 2006:135). The parastatal agency or board is financially more autonomous, which enable it to raise larger amount of investments

(IIR, 2006:135). Therefore, DJB acts as the *parastatal* authority for all the capital work, operation and maintenance and revenue functions (revenue billing and collection) related to water supply within the NCT of Delhi (TERI Report, 2009:32). The following (Table 1) summarizes the various functions of the DJB as per the different areas of the NCTD.

Table 1: Responsibilities of DJB with Provision of Water Services in Delhi

Geographical Area	Water Supply Functions		
	Capital Works **(CW)**	Operation and Maintenance **(O & M)**	Revenue Function **(RF)**
MCD	Yes	Yes	Yes
NDMC	Yes	Bulk Supply only	Bulk Payment from NDMC
DCB	Yes	Bulk Supply only	Bulk Payment from DCB

Source: Delhi (Water) Jal Board Act, 1998, *cited* in TERI, Report No. 2009IA02.

While describing the institutional arrangements for supplying water in the city, it is worthwhile to note here that the DJB, besides carrying the cited functions also alter and/or hike the water tariff rates, but at the approval of the Government of Delhi. This is clear from the following information.

> As per Section 55 of the DJB Act, 1998, the board has the power of levying fees, charges, including development charges, rentals etc. and recovering them by the services rendered by it. However, the board members of DJB comprise of elected representatives of government and therefore the state government has a major say in decisions relating to tariff fixing and tariff revision (TERI Report, 2009: 32).

This important issue of water pricing and tariff setting mechanism of DJB will be treated in detail in later sections/chapters. But for now, a brief account of the **water production system** existing in the capital city seems significant in order to understand the overall framework of water supply. The major surface water sources for the city is (i) the river Yamuna, on which the city's water supply heavily depends upon, (ii) the Western Jamuna Canal - a carrier of Yamuna waters as also Bhakra waters, and (iii) the Upper Ganga Canal. Around 446 tube wells are drilled in Yamuna bed and areas within the city to meet the water demand (CDP, JNNURM Delhi, 2006:8-2). Altogether DJB has 2,300 functional tube wells (Daga, 2007:173) and as on March 2008, the number reached 2488 and 21 ranney wells (Economic Survey of

Delhi, 2008-09:156). Hence, surface water contributes to over 86% of Delhi's water supply.

For the **water treatment system,** DJB is equipped to treat 790 MG/D of water inclusive of about 100 MG/D of ground water abstraction, however, it should be noted that the actual production is 735 MG/D with a *shortfall* of 255 MG/D at production point (CDP, JNNURM Delhi, 2006:8-2). The following (Table 2) shows the water treatment capacity indicating source of raw water.

Table 2: Water Treatment Capacity of DJB indicating Source of Raw Water

Source of Raw Water	Name of the Water Treatment Plant	Installed Capacity (MG/D)	Production by Optimisation(MG/D)
River Yamuna	Chandrawal I and II	90	105
River Yamuna	Wazirabad I, II, III	120	124
Bhakra Storage/Yamuna	Haiderpur I and II	200	210
Bhakra Storage	Nangloi	40	21
River Yamuna	Bawana	20	0
Upper Ganga Canal	Bhagirathi	100	110
Upper Ganga Canal	Sonia Vihar	140	65
Ground Water (Sub Surface Water)	Ranney Wells and Tube Wells	100	100
All Sources→→→	**Total**	**790**	**735**

Source: CDP, JNNURM, City Water Supply System, Dept. of Urban Development, Govt. of Delhi, 2006.

The water treatment and supply capacity was raised to 810 MG/D in 2007-08, 830 MG/D in 2009 and the target for the 11th 5-Year Plan (March, 2012) is kept at 915 MG/D by the DJB (Economic Survey of Delhi, 2008-09:151). So far as groundwater is concerned, the hydrogeological situation characterised by occurrence of alluvial formation and quartizitic rocks controls the availability of groundwater in the NCTD (Daga 2007:172). The quality of the groundwater in the hard rock formation in Delhi is generally potable, whereas in the alluvial formation groundwater, the water quality deteriorates with depth (Economic Survey of Delhi, 2003-04:157). The Delhi region receives on *average* normal rainfall and rainwater contributes a minimal amount to total water supply, of course after treatment, in rainy days. Delhi receives a normal precipitation of 611.8 mm in 27 rainy days (Daga

2007:172). The water treatment consists of the following processes or stages before it gets supplied.

> Raw water is lifted from the river/canal. The water is pre-chlorinated to destroy the algae and bacteria present in it and then taken to clarifloculators. In clarifloculators, water is cleaned through a process of sedimentation. After that, water is passed through a series of filters in order to remove remaining impurities. Once that is over, water is chlorinated again to kill any remaining germs. This treated water reaches all parts of the city through a network of about 9,000 kilometers of water mains/lines. Water from tube wells and ranney wells is just chlorinated and notfiltered because groundwater in naturally filtered (Daga, 2007:173).

The quality aspect of the available water is itself a highly objectionable subject in context of household water in Delhi. However, the quality issue takes a back seat as we go along talking about the sufficiency of water per capita demand/requirement in Delhi. The next important component in supplying water is the **transmission and distribution system.** By and large, water supply system is through piped water network, hand pumps and private motorised wells/tube wells in urban areas, and in areas without planned water supply through water tankers (CDP, JNNURM Delhi, 2006:8-4). Water delivery is supplemented by water tankers (managed both by DJB and private suppliers) to meet unforeseen and contingent increase in demand in the unorganised as well as in urban areas. However, the conditions for water provision differ significantly with either provider of tanker waters especially the price at which they sell to the citizens (see section 1.3). The following (Table 3) indicates the transmission and distribution network in Delhi.

Table 3: Water Transmission and Distribution Network in Delhi

Sl. No.	Item	During 2001	As on 01. 04. 2006
1.	Length of Water Mains (kms)	8363	More than 9,000
2.	No. of Water Connections	13, 33,833	About 15.52 lakhs
3.	No. of Water Stand Posts (Public Water Hydrants)	11,533	*Figure Not Available*

4.	No. of Water Tankers by DJB	493	1100 (as per revised budget estimate 2005-06)
5.	No. of Private Tubewells	2,00,000 (estimated)	*Figure Not Available*
6.	Capacity of Existing Underground Reserviours	175 MG/D (corresponding to 6-7 hours of production)	Proposed to build 35% of average demand as storage capacity

Source: CDP, JNNURM, City Water Supply System, Dept. of Urban Development, Govt. of Delhi, 2006.

In order to rationalise the distribution of water (Daga, 2007:173), DJB had drawn up an elaborate plan for the construction of Under Ground Reserviours (UGRs) and Booster Pumping Stations (BPSs) initiated back in the year 2000-01. The following major UGRs/BPSs have been completed and commissioned during 2000-01. These are G T Road Shahdara and Yamuna Vihar (Daga 2007:173).

It is to be noted that there is considerable **spatial inequity** of water supply in different parts of the city. In some parts, availability of water is 2 to 3 hours a day, in general, and in some areas (mostly in North Delhi) directly on the main line gets 24 hours water indicating inequitable distribution of water in different parts of Delhi (CDP, JNNURM 2006:8-4). It can be observed from the Table 4 below, that there is a lot of inconsistency in the level of water supplied to different areas of Delhi (CSE, Govt. of NCT of Delhi 2010:56). The figures mentioned in the table fluctuates to a great extent and are not compatible to either the DJB norms of 270 Litres per Capita per Day - LPC/D or Delhi Master Plan – 2021 by DDA, of 80 Gallons per Capita per Day - GPC/D (CSE, Govt. of NCTD, 2010:56). Please see (Table 4) below (Daga, 2007:174).

Table 4: Inequity in Water Supply in Different Parts of Delhi

District	Water Supply (LPC/D)
Mehrauli	29
Narela	31
Najafgarh/Dwarka	74
Shahdra	130
New/South Delhi	148
Paharganj	201
West Delhi	202
Civil Lines and Rohini	274

City	277
Karol Bagh	337
NDMC	462
DCB	509
Total Allocation of Water	**2674 (LPC/D)**

Source: NCRPB, Delhi Fact Sheet in DUEIIP 2004 *cited* in Daga 2007:174. [1 gallon = 3.785 litres. 1 litre = 0.2642 US gallons or 1000 cubic centimetre].

The significant inequity in the water availability in different zones in Delhi region is quite evident from the (Table 4) above. This could be interpreted in the following manner (Economic Survey of Delhi, 2001-02:115):

(a) The level of supply in the DCB area is the highest and is almost eighteen times the level of supply in the Mehrauli area. If NDMC and DCB areas are excluded, being bulk supplies, the level of supply is highest in Karol Bagh and is twelve times level of supply in Mehrauli and eleven times of Narela.

(b) The level of supply in South and New Delhi is extremely low of 148 LPC/D as per National Capital Region Planning Board (NCRPB) considering the high demand expected from a largely medium/high income residential area.

(c) All water production centres – Haiderpur, Wazirabad, Nangloi and Chandarwal are located in the North of Delhi and thus the trunk mains carry water long distances resulting in low pressures and flow losses. Illegal tapping is also very common.

(d) 10 percent of Delhi's population has no piped water supply and 30 percent population has grossly inadequate water supply. Even planned areas of MCD with house connections have a shortfall of 42 percent. This demands serious overhaul of supply management.

(e) A very low supply level of 29 and 31 LPC/D cannot be justified for any part of Delhi.

According to Zerah (2000: 46), the existing water supply in the city is highly non-uniform having seasonal variations from zone to zone, within zones, within colonies and from floor to floor. Others like Rohilla (*cited* in Datta, Rohilla and Tyagi, 2001:68) maintain that,

> Unplanned growth of the city also upsets the hydraulics of the water supply distribution system. The cantonment area in the central southwest

> part which has a lower population density gets 509-650 LPC/D, while some northwestern and northern areas with high population densities receive as little as 25-31 LPC/D. Delhi's villages, spread over 50 per cent of the area, covering outer Delhi, west, northwest and north Delhi, get less than 5 percent of the water consumption for the city.
>
> Distribution is also affected due unauthorised use of considerable part of drinking water supply for horticulture/watering lawns and for washing a large numbers of vehicles. Distribution losses between the treatment plant and the point of consumption can be taken to 30 to 40 per cent.

Now an account of the **supply side shortcomings** is presented below with an objective to articulate the inherent problems DJB is facing. It is also important to take into account that a good amount of treated water goes unaccounted.

> Unaccounted for water is in the range of 40 to 45 per cent. Water loses through accounted flow comprises of (i) Unbilled un-metered consumption @2 per cent, (ii) Leakage in transmission mains @16 per cent, and (iii) Leakages in distribution mains @24 per cent. Thus, in reality 58 per cent of water produced (58 per cent of 735 MG/D = 426 MG/D) is available for meeting water demands leading to water shortages in tail end areas and inequitable distribution of water. This is one reason why people have to resort to high abstraction of ground water in the city (CDP, JNNURM, 2006:8-5).

A study by Pricewater House Coopers funded by the World Bank reveals that the Authorised Consumption @ 58% break-up is thus (CDP, JNNURM, 2006:8-5).

(i) Billed Meter Consumption i/c Water Supply in Bulk @13 per cent

(ii) Billed Un-metered Consumption @37 per cent

(iii) Unbilled Un-metered Consumption @8 per cent

However, Non-revenue Water is 42 + 8 per cent = 50 per cent. The unaccounted for water is calculated as: **(Total Annual Production in Million Litres minus Total Annual Consumption in Million Litres) / Total Annual Production in Million Litres.** It should be noted at this outset that water wasted imply not only the physical loss of water but also economic losses which obviously incur economic cost (Zerah, 1995:3). From another aspect, precisely from the financial viability aspect of the DJB, unaccounted for water is calculated thus: **(Total Annual Production in Million Litres minus Total Annual Consumption Billed in Million Litres) / Total Annual Production in Million Litres** (Zerah, 1995:3).

Thus far, an insight into the water supply related issues have highlighted in some detail, at the same time reflects, the inherent problems facing DJB, often culminates into acute supply shortages in the city particularly during the peak summer months, when DJB seems totally inefficient in delivering water services for all purposes. In this connection, it is important to note the **supply side bottlenecks** (DWSSP, Part B, 2007:2-9) leading to severe supply shortages and hence generating inefficiency in water management as listed below:

(a) High Non Revenue Water or Unaccounted Water.

(b) Supply Shortages.

(c) Intermittent Supplies and Low Pressures.

(d) Inappropriate and Inadequate Operation and Management (O&M) of Water Distribution.

(e) Shortcomings at Water Treatment Plants - WTPs.

(f) Inadequate System Asset and Operation Data (in particular No Flow and Pressure Measurement and No Records of Laid Pipelines.

(g) Quality Control Deficiencies (Lack of Laboratories).

(h) Problems with Equipment at Booster Pumping Stations.

(i) Inefficient Equipment (High Energy Consumption).

(j) Transmission Main Damage due to Power Failures.

(k) Poor House Connection Quality.

(l) Customer Connection Ownership not fully in the hands of DJB.

(m) Inadequate Meter Repair Arrangements.

Apart from these supply side inadequacies, inefficiency in terms of **institutional incapacity and constraints** pose serious limitations to the city's water supply delivery mechanism. The IIR (2006:135-136) maintains that,

> The public water provider (DJB) function with a nonintegrated information system, very poor delegation of power to lower ranked (despite their wielding strong discretionary powers for approval of new connections, for instance), and a very technical approach favouring end of the pipe technologies, even in the case of the most autonomous of board. Overall, the failure of the public sector to provide adequate services has often been simply described as a result of public monopoly, organisational inefficiency (lack of accountability, bureaucratic procedures, low tariffs), technical flaws (unaccounted for water, absence of preventive maintenance, high leakage, and old piping system) as well as overstaffing and lack of autonomy.

To summarise the present section, it can safely claimed that there are myriad factors of various nature and dimensions responsible for ineffective and inefficient water supply delivery in Delhi. These factors have been better described in the report of Delhi Water Supply and Sewerage Services Research Project (DWS & SSRP), presented by DJB with the aid from the World Bank. These can be categorised in three main groups, as we have been actually doing so far. These are:

- **Gaps in Service Delivery**

(i)The actual water supply available to the residents is intermittent and inequitable. Despite concerted efforts the demand-supply gap is on the rise. This imbalance is further exacerbated by the high level of non revenue water – including both technical and commercial losses estimates of which range around 40-50 per cent.

(ii)The ability to identify the losses is further constrained due to lack of bulk metering for transmission and distribution systems except for supply to NDMC and DCB. The present zoning arrangements are not conducive for effective monitoring and control. Customer metering is ineffective under the prevailing condition of intermittent supply.

Under these conditions, there is little incentive to economise the use and wastage of water. There are shortcomings at treatment works and the equipment is inefficient. *The obvious manifestation of the poor supply situation is high customer coping costs and low level of customer satisfaction* (DJB, DWS & SSRP, 2004:7).

- **Institutional Loopholes**

(i)DJB's institutional arrangements are not geared to promote managerial autonomy and accountability. The role of the government is significant as reflected in the current composition of the board. DJB is mandated to frame its own regulations (with approval from the government) with respect to tariffs and service quality and enforcing them, thereby reflecting an inherent conflict. The management responsibility is diffused leading to lack of accountability. The organization is overstaffed as reflected in the high ratio of staff per thousand connections compared to the industry norms.

(ii)There is little use of information technology and there is a lack of a modern management information system, both essential for effective management. The customer interface is a clear weak link. *DJB is clearly a supply oriented body whereas a service should be demand oriented, recognizing the importance of the customer and of good relations with them* (DJB, DWS & SSRP, 2004:7).

- **Financial Sustainability**

(i)With respect to the financial situation, even though Delhi has the highest national per capita income, it has the lowest water tariffs among all metros in India. There is a persistent deficit on the revenue account over the years. Despite the fact that the DJB Act mandates full cost recovery, this philosophy has not been reflected in the tariff setting decisions taken by the DJB.

(ii)In addition to the average monthly bill of Rs 50, the present coping costs already range between Rs 200-350 per month for the residents of Delhi. Contrary to the common perception, a recently conducted willingness to pay survey in Delhi indicates a positive response with respect to a willingness to pay for enhanced service quality.

(iii)Operation is inefficient and maintenance is at far lower levels than is needed - with energy and establishment costs accounting for 42 per cent and 45 per cent of the operation and management costs (excluding debt charges) respectively. Presently, the revenue deficit is being funded through loans from the government (approx. Rs 350-400 crore annually).

(iii) However, given DJB's envisaged pipeline of projects, funds required (Rs 5000 crore) for system rehabilitation, as well as limited capacity of the government as the sole funding source, there is a need to progressively revise water charges accompanied with improved services whilst gradually phasing out the government subsidy, with the objective of achieving full recovery of costs of efficient operation and management (DJB, DWS & SSRP, 2004: 7-8).

Therefore, it can be said that DJB fails to secure the efficient provision of water supply due to inherent loopholes embedded in its very functioning. Again to correct these shortcomings is important in the sense that, to attain a best functioning public utility, the DJB has to reconsider and scrutinise its policies as well as make reform of certain instruments, one of course is the water tariffs the citizens' are paying and that too with a definite objective for improvement in the water sector. It is easier to highlight the problems DJB is not able to yield solutions to; however, what is desirable is a long term sustainable solution to the growing problem of water insecurity among the residents of Delhi.

1.2 Pattern of Water Consumption in Delhi

This section talks about the different pattern of water consumption observed in Delhi from the end water users. Broadly, it is an exercise in order to know how the water distribution meets its end users. The objective here is also to explore the kind of preferences the citizens' pursue in order to get water. It is self explanatory that water is demanded for multiple uses, like, in domestic or residential (highest share), industrial and commercial, institutions and other uses. At present DJB is serving a total population of around 25.54 lakh households in Delhi through 19.24 lakh water households through piped water supply connections (Economic Survey of Delhi, 2008-09:151). DJB also provides water supply through public water hydrants (also for fire fighting, though in principle), water tankers and handpumps to about 20 lakh people settled in *Jhuggi Jhopri* (JJ) Cluster with water demands of about 270 ML/D. DJB is able to meet about 60 to 65 per cent of water requirement of slum dwellers (CDP, JNNURM, 2006:8-5). The other sources such as handpumps, water tankers of DJB and water trollies contribute to 25 to 30 per cent of remaining water demand (CDP, JNNURM, 2006:8-5).

Based on a norm of 60 GPC/D as per the Central Public Health and Environmental Engineering Organisation (CPHEEO) norms prescribed in the Master

Plan of Delhi – MPD:2021, the water requirement for 2007-08 stood at 990 MG/D. This norm of 60 GPC/D is followed by the DJB. So, following the CPHEEO manual, the per capita per day water requirement is 60 GPC/D (Economic Survey of Delhi, 2008-09:151). The details are given in (Table 5) below:

Table 5: Per Capita per Day Water Requirement of Water – CPHEEO Norms

Category	Water Requirement (in LPC/D)
Domestic (Residential)	172
Industrial, Commercial, Community Requirement based on 45,000 Litre per Hectare per Day	47
Fire Protection based @ 1% Norm	3
Floating Population and Special Uses like Hotels/ Embassies	52
Total	**274 (60 GPC/D)**

Source: Economic Survey of Delhi, 2008-09:152.

At the same time in the MPD – 2021 by the Delhi Development Authority (DDA) proposed water requirement with the norm of 80 GPC/D, out of which 50 GPC/D is for domestic requirement and 30 GPC/D for non domestic purposes. Again, the domestic water requirement of 50 GPC/D comprises of 30 GPC/D for potable needs and 20 GPC/D for non-potable water (Economic Survey of Delhi, 2008-09: 152). The details are given in (Table 6) below:

Table 6: Break Up of Water Requirement as Proposed in MPD -2021

Norm	**Quantum (in GPC/D)**		**Source of Non-Potable Water**
	Potable	Non-Potable	
Domestic @ 50 GPC/D (a) Residential	30	20	Recycling and Permissible Ground Water Extraction at Community Level.
Non-Domestic @30 GPC/D	5	25	Recycling from STPs and Permissible Ground Water Extraction.
(a) Irrigation, Horticulture, Recreational, Construction, Fire @ 6.65 LPC/D	0	10	
(b) Public/Semi-Public, Industrial, Commercial	5	15	Recycling from CETPs.
Total @ 80 GPC/D	**35**	**45**	—

Source: Economic Survey of Delhi, 2008-09:152.

On the other hand, with the MPD – 2021 norm of 80 GPC/D estimated by DDA, water supply requirement, for projected population of 23 million in 2021 in Delhi, will be 1840 GPC/D (Economic Survey, 2008-09:153). It will be interesting to know how DJB would be achieving this target with so much of supply mismanagement. As mentioned earlier, DJB provides piped water supply system to 19.24 lakh households out of the total 25.54 lakh households. About 5.6 lakh households are provided water supply through tubewells/deep bore handpumps/public hydrants. In other words, about 75.33 per cent households meet their water requirement through piped water supply and about 21.91 per cent households through tubewells/deep bore handpumps/public hydrants. Remaining 2.76 per cent households depend on other sources like wells, river, tanks, canal, ponds etc (Economic Survey of Delhi 2008-09:151). The following (Table 7) shows an exhaustive account of the sources of water and its distribution to households categorised into rural and urban Delhi:

Table 7: Source of Household Water (Census 2001)

	Number of Households (HHs)		
Source	Total	Rural	Urban
Tap	19,24,140 (75.33%)	87,417 (51.56%)	18,36,723 (77.02%)
Hand Pump/ Tube Well	5,59,518 (21.91%)	65,290 (38.51%)	4,94,228 (20.73%)
Well	1,019 (0.04%)	612 (0.36%)	407 (0.02%)
Others (River/Canal/Tank/Spring)	69,472 (2.72%)	16,209 (9.57%)	53,263 (2.23%)
All Sources	**25,54,149 (100%)**	**1,69,528 (100%)**	**23,84,621 (100%)**

Source: Delhi Statistical Handbook 2004 *cited* in Economic Survey of Delhi 2008-09.

The National Sample Survey Organisation - NSSO Report (2003a:135) gives the figures for the access to water supply to urban households living in slums, through various sources in the Delhi city as presented in the following (Table 8).

Table 8: Access to Water for Urban Households (HHs) Living in Slums (%) in Delhi in 2002

% of HHs Living in		Modes of Water Access (%)					
		NS			NNS		
NS	NNS	Tap (%)	Tubewell (%)	Other (%)	Tap (%)	Tubewell (%)	Other (%)
20.5	79.5	100	0	0	71	29	0

Source: NSSO (2003a) *cited* in IIR 2006.

{*A note on Table 5: According to NSS data, a 'slum' is a compact settlement with a collection of poorly built tenements, mostly of temporary nature, crowded together in unhygienic conditions usually with inadequate sanitary and drinking water. Such an area is considered 'Non Notified Slum' or NNS, if at least 20 households lived in that area, while NS stands for 'Notified Slum' is that area notified as 'slum' by an ULB or development authorities* (IRR, 2006:135)}.

For the sake of elementary exposition, the following (Table 9) depicts the pattern of consumption of water in Delhi for a seven year time period. The purpose here is to see the trend in per capita consumption of water in GPC/D, broadly categorised into domestic/residential and commercial consumption.

Table 9: Consumption of Water in Delhi

Description	Year						
	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09
(a) Domestic	9,624	9,770	9,842	9,770	10,976	11,102	11,997
(b) Commercial	1,312	1,332	1,343	1,332	955	1,160	1,260
Per Capita Consumption of Water (in GPC/D)	**39.5**	**39**	**48.20**	**47.50**	**48**	**48**	**50**

Source: Economic Survey of Delhi, 2007-08:155.

It is clear that per capita consumption of water has shown an upward trend over the seven year time period. Growing population and shift in the level of urbanisation and also emerging new demands for water the per capita availability might be the reasons assigned for this increase which it seems inevitable. It has been said before that DJB has always devised new ways/sources to augment the water supply to meet the growing demand during these seven year time period. Infact DJB every five year, increases its water treatment and supply capacity, however the average per capita capacity of water remains at 48 GPC/D in 2007-08 (Economic Survey of Delhi, 2008-09:155).

1.3 The Problem of Supply Deficit: Alternate Sources of Household Water

With the rapid urbanization added with unchecked population growth, there is ever increasing pressure on the water resources in Delhi. Due to unplanned and uncontrolled growth of unauthorised colonies and annual influx of migrants, water supply infrastructure has come under severe pressure (Daga, 2007:174). According to Daga (2007:175),

> Different segments of population demand different amounts of water for consumption. However, the DJB fails to supply these segments adequate water, whether we talk about people living in slums or people living in bungalows, or we talk about supply of water in residential areas or in industrial areas.

It is maintained by the same author that, inspite of augmentation of water supply by considerable volume of treated water incurring large public investments (mentioned earlier also in the paper), 10 per cent of Delhi's population has no piped water supply, and 30 per cent of population has grossly inadequate water supply. This demands serious overhauls of the supply management. Even planned areas of MCD with house connections have a shortfall of 42 per cent (Daga: 2007:175). This is evident from the following (Table 10):

Table 10: Demand and Supply of Water in Different Settlements in Delhi

Type of Settlement	Population (in lakhs)	Demand (in ML/D)	Supply (in ML/D)	Deficit/Excess (in %)
JJ Cluster, NS and UC I	13.96	59.33	No Piped W/S	**(-) 100**
JJCluster, NS and UC II	40.80	173.40	20.43	**(-) 88**
Planned Areas (MCD)	75.50	1,698.75	990	**(-) 42**

Source: Status Report for Delhi 21: DUEIIP. UC – Unauthorised Colonies, NS – Notified Slum.

As per the DJB, the following (Table 11) is about the projection of total water demand upto the year 2021:

Table 11: Projection of Total Water Demand in Delhi 2021

Category of Demand	Water Demand (LPC/D)		
	2006	2011	2021
Residential	3,099	3,689	3,673
Commercial & Inst.	178	248	367
Industrial	813	1,244	2,232
Total	**4,090**	**5,181**	**6,272**

Source: Delhi Jal Board *cited* in Economic Survey of Delhi, 2008-09.

Now in order to compensate this supply deficit (Table 10), citizens have been employing other means (both legal and illegal) to cope up with the rising demand for water for many years now. **Broadly, residents of Delhi have been completely engaged in three major alternatives sources of procuring water due to the failure of DJB to meet the growing demand for water.** These sources (Daga, 2007:175) are: (a) Boring Private Tubewells and Borewells, (b) Purchasing Water from Private Water Tankers/DJB Water Tankers and, (c) Purchasing Bottled Water either from DJB or elsewhere. It must be noted that these practices are not area specific across Delhi and citizens' bear remarkable cost to get these services. It is important to know the implications of these alternatives sources of water the residents of Delhi have learnt to cop up with time.

So far as boring private tubewells and borewells are concerned, invariably, almost every colony or complex in Delhi has a borewell or a tubewell to agument private water supply (Daga, 2007:175). The excess demand of water is met through two lakh private tubewells drilled by owner in their premises (CDP, JNNURM, 2006:8-6). Legally any such source (tubewell/borewell) of water has to be registered with the Central Ground Water Authority (CGWA) of India, but seldom registered (Daga, 2007:175) and this practice is common in South Delhi where there is acute shortage of water. Residents are relying more on groundwater than on the DJB water supply. Interestingly, the CGWA has no information about the number of tubewells or borewells in the city, predominantly because of illegal drilling and hardly any registration of it with the CGWA (Daga, 2007:176).

It is of course the case that there is no mechanism to price or restrict the groundwater use in the city, because of which groundwater is often overused, and thus the level of groundwater in many parts of the city is declining fast. As mentioned earlier, water provided through private water tankers and DJB offers different prices based on certain conditions of distance and time of the place from the nearest DJB or private water vendor. The private water suppliers provide untreated or non potable and hold no responsibility of the quality of water. These private suppliers get water for sale by drilling borewells and tubewells and therefore rely heavily on the groundwater for their business (Daga, 2007:176) which is unaccounted for price by the government. Even DJB hires private water tankers in times of emergency. Private water tankers have come into existence precisely due to failure of the government to meet the growing water demand of the city (Daga, 2007:176).

Private suppliers of water also supply water on behalf of DJB in slum areas, and rural Delhi, colonies under DDA, regularised colonies and upcoming societies and to places where DJB does not reach due to low pressures and repair works in supply lines and many institutions like government hospitals, central jail, congested colonies and metro projects (Daga, 2007:176). These private water suppliers often seen as water *mafia* make huge profits throughout the year, mostly during summer months. They have made supplying water as a profiteering venture. This is evident from the following fact.

> It does not take much to venture into this business. Cost of installing a simple borewell varies from Rs. 30,000 - 40,000 to Rs. 2.5 lacs. One can bore borewells in any part of Delhi without many hassles. In order bore a tubewell/borewell in a Notified Area (NA), one has to acquire permission from the CGWA. Given the laxity in enforcement of the laws by the CGWA, the private water suppliers are able to bore tubewells in NAs as well as Un-notified Areas (UNAs) with equal ease. Fleet size of a water supplier varies from 2-25-50 tankers depending upon the size of his business (Daga, 2007:176).

Apart from these sources, consumers buy packaged drinking water at a market price widely available everywhere. Even the DJB also supplies packaged water under the brand name of 'JAL' in different volumes and at different prices. In case of production of packaged water too, there is no concrete price mechanism to check the unwarranted use of groundwater. For instance, most brand companies like Bisleri, use borewells and tubewells to pump out groundwater, purify it and sell in the market (Daga, 2007:177). A comparison of prices citizens' are paying in order to avail water both by DJB and private suppliers as well as packaged water becomes inevitable to reach a concrete foundation for sustainable pricing of water from the conservation point of view in the city in the present and future. This is explained in section 1.4.

It is apparent that in such a grim situation of water supply deficit, the residents of Delhi have sought to multiple preferences for obtaining potable as well as non-potable sources of water; the pricing factor cannot be simply overlooked. The citizens' are paying an exorbitant price for water in the present time. Therefore, the pricing of alternate sources of household water demand has to dealt carefully and logically so as to arrive at the exact policy recommendation at all levels for this precious resource and should not be based merely on the traditional tool of supply-demand or benefit-cost analysis. Since households in Delhi have preferred different sources of water and it has a price, and therefore water pricing and optimal tariff design must be an important consideration in sustainable provision of public water. The present study focuses on this very important instrument of sustainable water pricing in context of residential water demand in Delhi along with other sub-ordinating pillars of effective water supply governance in Delhi.

1.4 Water Tariff Regimes/Structure by DJB and Other Agencies

This section attempts to look into the tariff water tariff structure being followed by the DJB, as well as prices of domestic water by alternate sources. As mentioned earlier, the DJB in exercise of powers conferred under the Section 55 of the Delhi Water Board Act, 1998, revise, restructure or rationalise the water rates in every five year. However, the basis for the revision or restructuring water rates periodically is not clear through the secondary sources.

It is important to review the different tariff plans the DJB has been engaged in enforcing over time, as well as the different prices the residents are paying for other means of meeting water demand, so that a comparative study of tariff rates could be arrived at. However, for the present study, water prices that the households have been paying can be categorised in three broad headings: (i) Tariffs levied by DJB (ii) Prices paid by residents for private water tankers services and (iii) Prices of packaged drinking water. Therefore, a set of prices can be constructed using the information for consumption of water in units.

The study reveals that the DJB has been engaged in the revision and/or rationlisation of the water rates at certain interval of time, and hence different water/ tariff rates in different regimes. Presently, the DJB follows the following **tariff design** (TERI, 2009:32-33) last revised in 2009 (No.DJB/DOR/Tariff/2009) for water provision. There are four components of water/sewerage bill as follow: Water charge is based on a **Two-part Pricing Model (Increasing Block Rate - IBR)** operating on a cost-plus basis. The total water bill (B) is calculated as: $B = M + 1.5X$, where, M is the minimum fixed access charges, and X is the units of water consumption in kilolitre. These charges are elaborated as follows:

(a) **Fixed Access Charge or Service Charge,** is payable by all registered consumers to meet the cost of access to the network, operation and maintenance (O&M) costs. It depends on type of dwelling and category of consumer.

(b) **Water Volumetric Consumption Charge** is levied based on the block tariff rate, therefore, depending upon the actual consumption and category of consumer from metered users of the system.

(c) **Sewerage Maintenance Charge** from all consumers.

(d) **Additional Sewerage Maintenance Charge** for the category of consumers engaged in intensive water use.

DJB has classified four categories of consumers in the new water tariff w.e.f 01.01.2010. These are: (a) Domestic (Category I) – Residential (b) Commercial/Industrial (Category II) (c) Mixed Use (Category IA) and, (d) Government Institutions (Category IIA). The Mixed Use Category is applicable to such premises where a part of the premises under residential use is also used for commercial purposes provided the water use is for non-intensive purposes. For example, residences having some portion under such as *kiryana* shop, stationery shop, barbar shop etc. The focus exclusively is to look at the domestic category consumers including the mixed category users, so the other categories of end water users will be exempted from the present study. The water tariff rates for Domestic (Category I) is as given in (Table 12):

Table 12: Water Tariff Rates for Domestic Category I by DJB

Monthly Consumption (in Kilolitre)	Service Charge (in Rs.)	Volumetric Charge (Rs. per Kilolitre)	Sewerage Maintenance Charge (60% of water volumetric charge)
0 – 10	50.00	2.00	1.20
10 – 20	100.00	3.00	1.80
20 – 30	150.00	15.00	9.00
Greater than 30	200.00	25.00	15.00

Source: DJB website: www.delhijalboard.nic.in accessed on 12/02/2011.

In the Mixed Use Category IA, Service Charge plus Sewerage Maintenance Charge remain same; the Volumetric Charge however becomes twice that of the rates under the Domestic Category I. The Additional Sewerage Maintenance Charges per month for Intensive Water Use is applicable to residential premises pertaining to commercial purposes like hotels, guest houses, banquet, hospitals, nursing homes, malls, cineplex etc. This additional sewerage maintenance charge is applicable to the units using alternate source of water such as groundwater, tankerwater supply etc. in addition to the DJB piped water/using DJB's sewerage system.

As mentioned earlier that, at the time of acute shortages of water in the city or if the DJB plans to supply water free of cost to the needy.

> Potable water is supplied through tankers, in the event of non availability/short supply of water, within 3 hours of the complaint subject to availability of tanker at a particular location. This service is free of cost (Source: delhijalboard.nic.in/djbdocs/about us/charter.htm accessed on 12/02/2011).

DJB hires private water tankers to deliver water on its behalf, in addition to its own fleet of water tankers meant to meet demands of critical points in rural and unauthorised areas. Apart from DJB water tankers rates fixed by DJB depending on the distance and filling time, DJB also fixes prices for the service delivery for the private water tankers depending on the tanker capacity which are as follows in (Table 13):

Table 13: Private Water Tankers Rates Fixed by DJB for its own Services

Water Capacity (in Litres)	Water Rates during 2006 (in Rs.)	Water Rates as on 01. 01. 2010 (in Rs.)
2,000 – 3,000	577.00	651.00
8,000 – 10,000	823.00	894.00
Greater than 10,000	856.00	916.00

Source: www.indianexpress.com accessed on 15/02/2011.

In addition to the payment of daily charges, the DJB also reimburses diesel bills for the private tankers and tractors. However, it is not certain what is standard on which the private tankers/suppliers provide water to the citizens. Since there are transaction costs associated with the DJB own water tankers such as advance booking, especially for private functions it needs 15 days advance booking for water tankers. Therefore people prefer private water tankers supplies. According to Bhandari and Khare (2004:110),

> The private tankers charge a standard fee according to the quantity of water supplied and do not require an advance booking and they have generally a capacity of 3, 000 to 6, 000 litres of water. The prices they charge is not necessarily related to the distance the tanker must travel.

The households, generally low-income or lower-middle income share the cost of water by paying for the quantity that they individually consume. The packaged drinking water or popularly known as mineral water is widely available in market at a very high price and it is difficult to mention all prices at the moment, however, it is worth mentioning here that DJB also provides packaged drinking water in two different volumes: The cost of 1 cartoon of 250 ml packaged drinking water JAL glasses (containing 24 glasses) is Rs. 31. The selling price for one 20 litre filled JAL bottle is Rs. 25 and the security deposit for one empty bottle is Rs. 160 (Source: DJB).

1.5 Statement of the Problem

Leaky infrastructure, managerial inefficiency along with underpricing of water services by the DJB are the major factors that could be accounted for severe water shortages in Delhi. Apart from these, a plethora of other factors are at work for water mismanagement in present times *(some of these have already been discussed at length in this chapter)*. What is evident till far is: Inefficiency in urban water supply, as a consequence of underpricing of urban water utilities in Delhi accompanied with managerial constraints do not allow for the state municipal water board (DJB) to cover even their operation and maintenance costs generated out of the revenues from the tariffs and hence brings inefficiency in all parts of its operations.

At the household level, it might be the case theoretically, that because of the 'unideal' price being paid by the residents for the water services being availed in the city from municipal supply results in great loss in the physical volume of water. Contrary to this observation, residents in some zones are getting very less water, not enough to meet their daily consumption demand. Interestingly, residents are paying high prices for obtaining water through private water suppliers. In this connection, Zerah (IIR, 2006:140) maintains that 'simple economic calculations demonstrate the spiralling costs of relying on water tanker to provide services in the city.' According to Raghupati and Foster (2002) (IIR, 2006:140),

> The cost of private water tankers is very high both for industrial or domestic use, ranging from at least Rs. 33 to Rs. 88 per cubic metre while the average price charged for domestic consumption in urban India is Rs. 1.5 per cubic metre.

DJB makes often an excuse of 'demand supply' gap because, of poor infrastructure in all its part of operations may be because of inability to recover costs, economists could argue that optimal pricing for the available volume of water is the only alternative with us to deal with this crisis situation and to make the water utility viable in its operations. There is no justification in saying that a huge public investment in water sector would bring 24 x 7 water supplies for the residents of Delhi. The real problem is how to devise correct pricing mechanism in such a fashion which impresses citizens on one of the most crucial part, that is, the conservation of water aspect. There is a serious demand management initiatives lacking in the case of unchecked use of groundwater resources. It is interesting to know that,

> It just takes 2, 600 handpumps running for 10 hours to suck Delhi dry of all of its groundwater. Delhi's 3, 000 unauthorised colonies, which do no receive municipal water supply, sink deep borewells. In the Sainik Farms area, for example, borewells have caused the water table to drop to 250 feet. And people spend Rs. 20, 000 every year to deepen the borewells.

> Some residents said that ten years ago they got water at 50 feet. The decline in the water table is alarming. Groundwater is one of the most important sources of water (CSE *cited* in Daga, 2007:177).

The problem also identified here is to carefully categorise 'residential water' as a 'public' good or an 'economic' good, knowing the fact that residents of Delhi have become accustomed to consume domestic water from diverse sources and how to bring sustainable pricing into the picture for an equitable distribution of water among residents across Delhi. The positive impact envisioned through optimal and sustainable pricing of water resources in Delhi would be the emphasis on the conservation of water and optimal use of water for all purposes at the residential level in the areas having fair and adequate water supply. The problem is seen as the re-allocation of water distribution in areas having sufficiency of water to areas having deficient water supply.

On another front, the problem with the present mechanism of water pricing/tariff structure is that it needs to be self-sustainable and atleast meet operation and maintenance costs in full (CDP JNNURM, 2008:8-10), and is the most common reason assigned for service delivery failure. However, this is the half of the story relating to the inadequate water provision in the capital city. A tariff regulatory commission is noticed absent in the present context, so that the tariff set by the DJB is acceptable to all people (CDP JNNURM, 2008:8-10). Moreover, a proper price regulatory mechanism is not constituted so far, in order to regulate the charges of private water tankers supplying water. Therefore, the problem is identified as the determination of sustainable price of water resources economically and enforcing it so that reckless consumption of water in Delhi can be put to halt and to bring equitable allocation of water among residents, apart from reducing the non-revenue loss for the DJB.

1.6 Objectives for the Study of Water Pricing as Instrument for the Water Demand Management in Delhi

Granted for the fact that the municipal water supply in Delhi is unreliable, intermittent and inequitable, the real issue confronts today is how to manage residential water demand effectively keeping in view the available quantum of water and inherent institutional failure in the urban water sector. It is questionable whether unreliability of water supplied by DJB is really a product of water scarcity or a product of supply mismanagement (Zerah, 1995:2). In this situation, correct pricing decision can be understood as an effective tool in an attempt to conserve water or minimise water wastage in areas having sufficient water availability. The objective in the present study is not to favour any move by the government for privatistion of water services in the capital city, but how to manage water consumption through adjusting prices and enforcing acceptable pricing all those alternative resources of water which are due to be priced.

Pricing of a public good and service like municipal water in the first place is a highly controversial subject more so in case of developing societies (Whittington and Nauges, 2007:6). It is a difficult task; at same time many contradictory objectives are set to achieve, like efficient allocation of water resources and equity considerations because of district socio-economic characteristics of the population under study. On the other hand (Zerah, 1995:4) maintains that,

> It cannot be denied that underpricing of water resources has led to different vicious circles such as (i) Wastage of water and water resources depletion (ii) Failure in the objective of equity, as a consequence poor households end up paying more than richer households relatively to their income and because they have to get water from other sources at a more expensive price than the municipal supply and, (iii) Inefficiency as tariff is not linked to the cost of production and leads to low revenue collection. Thus, public utilities face financial difficulties and are indeed unable to invest in improving the system. Regarding all these aspects, Delhi is a typical example of underpricing of water.

There is also the emergence of 'new entrepreneurs' in low income areas across Delhi. According to Raghupati (IIR, 2006:140),

> Delhi is witnessing new modes of service delivery in slums where enterprising inhabitants dig tubewells, install power motors and set up a small network to supply water to a few lanes. Such arrangements can serve an average of 200 households whose up front cost is limited to the plumbing work. However, once the connection is given, the households pay a hefty monthly contribution that is six to seven times the cost on

municipal water. This shows that supply is provided and there is a reliable service as the 'owner' of the network is a close neighbour.

This fact clearly bears testimony for the different feasible preferences citizens are prepared to reveal over the municipal water supply. It is to be noted that the above report was an outcome of the study carried in slum areas where we presume low paying capacity of households. On that basis, it can be argued that residents have revealed preferred alternative reliable sources of water over DJB supply, at least in principle. But this in turn incurs huge personal as well as environment costs upon society, it is not actually the viable option. The objective in the present study is to propose remedial alternatives for growing mismanagement in the water supply sector by bringing and specifically targeting the sustainable water pricing to the forefront of the entire analysis. The overall objective in the present study is to examine as well as scrutinise the institutional role of DJB in achieving the effective urban water governance in Delhi.

1.7 Research Methodology: Nature and Kind of Data and Empirical Analysis

Research methodology broadly includes a primary household sample survey of families across five different areas/pockets in Delhi, exclusively on the basis on the spatial inequity in the water availability (discussed in section 1.1). The areas chosen for the primary survey are: Mehrauli, Vasant Kunj, DCB, Munirka DDA Flats and Munirka Village, Vasant Vihar (posh and slum). The primary survey will include collecting samples through framing intended questionnaire to get households responses. Apart from the primary survey, secondary sources will be relied upon to encompass most of the study and research. In the preliminary effort to obtain secondary data based on household survey seems futile except a few aggregate data on the study area. There is no well set data source or database for the purpose of doing empirical estimation of residential demand function. There is data inadequacy on the subject chosen for study and research.

It has repeatedly been maintained in the present study that data insufficiency in terms of household demand for water at the utility level is very much lacking which do not permit to execute a complete estimation of residential water demand in Delhi. At the same time there is no other reason to believe that the empirical estimation of the demand function at the city level is possible in the present study with the kind of data in hand. According to Whittington and Nauges (2007:2-3, emphasis added),

> In studies of household water demand functions in industrialised countries, data for the model estimation typically come from water utility records. Analysis of demand for water in LDCs, on the other hand, is complicated by abundant evidence that, contrary to what is observed in most developed countries, households in LDCs have access to and may use more than one of several types of water sources, such as in-house tap connections, public or private wells, public (or someone else's) private taps, water vendors or resellers, tank trucks, water provided by neighbours, rainwater collection, or water collected from rivers, streams or lakes. The choice set as well as the condition of access varies significantly across households.

The real issue in the present study is to extract some disaggregated data on households' responses on pricing and consumption of water and to obtain certain econometric results pertaining to residential water demand. However, the dearth of data on household demand in Delhi is the greatest obstacle in the entire process of the study. To be positive, the small survey taken in hand can meet the purpose of empirical work to certain extent and, the secondary information from the DJB Annual Reports will prove helpful in gaining insights on the subject.

Interestingly, water treatment capacity is used to calculate supply, often assuming a 100 per cent yield, which is usually far from the truth (IIR, 2006: 141). Percentage of leakage is underestimated. Demand assessment is flawed as well. Further, in the IIR (2006:141), it is mentioned that,

> First of all, the demand is simply measured by multiplying the population with per capita demand as per norms established. Norms applied are excessive. In Delhi, the DDA in its MPD applies a norm of 363 LPC/D, close to consumption levels seen in the United States while European consumption levels are much lower (and have followed a decreasing trend in the last decade).
>
> Projections on future demand are calculated applying the same growth trend factor to all population categories and no detailed survey is carried out to get a better idea of differences between household and

> industrial demand. The combination of all these factors results in an overestimation of the demand-supply gap, which is recurrently used as an excuse to promote costly, large scale water projects.

This is true but there is no information on the overuse of groundwater in the city. It is unfortunate that DJB has no data on the zonal division of demand for water in Delhi. There are no details regarding residential water demand and also the distribution of demand across districts (Daga, 2007:174). Nevertheless, with the available data and household survey, the exercise is to frame an economic model to study the trends of different variables in context of residential water demand in Delhi. The major objective will, however, be the estimation of residential water demand from the data gathered from the primary survey with the aid of software packages like SPSS etc.

1.8 Research Hypotheses: Null Hypotheses

- Residents' current coping costs (domestic capital investment in water storage and treatment) exceed or at least as much as the DJB's water bills.
- Sustainable water pricing *institutionally* from all socio-economic and political considerations plays a significant role in minimising water wastage, eventually rationalise consumers for judicious use of water.
- Equitable distribution of municipal water across residents of Delhi is feasible in the present water scenario.

These hypotheses are built on the basis of the approach to the study of empirical estimation of households (HHs) demand for water, and the elasticity coefficients that would be obtained through the econometric exercise in the subsequent chapters.

1.9 Research Question

- How the water supply 'augmentation inefficiency' paradox can be visualised in 'water pricing' policy prescription in the context of DJB city's water management?

- Whether 'sustainable water pricing' from all perspectives could reduce the lack of trust of the residents of Delhi towards the public water utility/DJB for any improvement in current status of water supply reliability?

1.10 Subsequent Chapters

The present study and research is structured in three broad chapters. The second chapter 'Statistical exercise on the residential water demand in Delhi' is subdivided into two major sections: (i) Empirical estimation of residential water demand per capita in Delhi: Database – primary survey to be executed for a few selected areas of Delhi, and (ii) Economic interpretation of the empirical results with conclusion. The empirical work in the next chapter will form an important aspect of analysis in the subsequent chapter.

The third and final chapter will be an attempt to give a feasible solution to the ongoing water management deficiencies in Delhi. The third chapter is intended to answer all the research questions raised in the present study. The first section in this chapter will be devoted to the major aspect of water pricing, that is, 'The debate over optimal water pricing cum inefficiency' and to put forth remedial policy measures to mitigate the inefficiency as well as unreliability in water provision in the city with concluding remarks. The real task in hand is to break the logic of low tariff, low revenue, high public infrastructure and inefficiency in urban water utility (DJB). Therefore, the third chapter will be a policy prescriptive work.

Apart from the core three chapters, an introductory note in the beginning gives an impression of the issued dealt in throughout the thesis. A summary and conclusion part is added in the end of chapters with an objective to highlight the major issues raised in the present work, and the same time presents the inputs derived from the work, presupposed to provide vital for the future endeavour of the work.

....

Chapter 2

Statistical Exercise on Residential Water Demand in Delhi

►A Case-Study Based Approach◄

Outline of the Chapter

2.1 A Prelude to the Previous Chapter

In the previous chapter (1), the underlying reasons for the inefficient urban water delivery mechanism in Delhi have been identified. It has also been recognised that the constraints responsible for the cropping up of the deficient public water supply across the areas, is manifold in structure and nature, such as *institutional* failure, both at the managerial and at the operational standards. As a result there are water shortages in many areas. This is in addition to the great wastage of public water, from the frequent discharge of huge quantity of municipally supplied water on streets. The major cause accountable for such wastage of water is the non maintenance or replacement of old rusted water main pipes. The leaky and poor urban water infrastructure does not permit the DJB in bringing efficiency in water service delivery system. Apart from these factors, ratio of metering to non metering connections is not significantly low (Economic Survey of Delhi, 2007-08:34), and non replacement of the defective meters, at the level of end users (consumers) often results in huge non revenue water loss to the DJB resulting in the huge revenue deficit (chapter 1) etc. All these inefficiency factors in one way or the other ultimately contribute in delivering persistent *inequitous* water distribution or water allocation among residents across the various areas/zones/localities/colonies across the Delhi city.

At the household level, unreliability of water supply through the in-house water connection and public taps is the greatest problem Delhi citizens' are facing, institutionally speaking. It is a proved reality now that there is spatial discrimination in water use pattern per person as per the norms established by DJB or CPHEEO etc. (chapter 1) throughout the Delhi metropolitan.

> Delhi does not have water shortage but the management needs to account for the huge quantum of water that is lost in transit. DJB does not even have a network map to fall back on. While that may not be its fault entirely, it should now have Geo-Positioning System (GPS) mapping which may be an expensive exercise but necessary," said Ashok Jaitley, director of water resources at the Energy Resource Institute. *Source:* http://articles.timesofindia.indiatimes.com/delhi/treatment-1plants-water-shortage-supply, accessed on 15/03/2011].

It is better to recollect the highlights of the previous chapter so that the sequence of the arguments can prove useful for the further work. The three major causes accounted for the grim situation of water crisis in Delhi are (i) Non-revenue losses for DJB (ii) Inadequate supply/distribution network and (iii) Wide disparity in the spatial availability of municipal tap water to the households. The last of these, apparently becomes the platform for the field survey being carried out for a few selected areas in Delhi in the present study.

On the methodological front, with the lack of disaggregated (household) level utility data on water 'quantity consumed/demanded-price' of Delhi's' residents, water prices and household income, the objective of doing any empirical work related to the *direct* estimation of residential demand for water in Delhi, and hence knowing the price-elasticity of water demand, can be only partially achieved. Another important specific issue related to demand estimation is the specification of the 'price' variable. Generally, water rate schedules in Delhi include combinations of a fixed fee with IBRs and/or non-metered rates (fixed fee only). The estimation of residential water demand is complicated by an administered rate schedule, if a block rate structure is employed; price is endogenous, varying with the amount of water consumed (Young, 2005:252).

The *indirect* estimation of demand function (see following sections) as will be obtained from the primary survey data could be thought as the representative of the whole of Delhi for granted, as the survey has been carried on with the issues of uneven distribution of water and unreliability in supply as major concerns of the whole of the residents of Delhi. In the present chapter the intention purely is to seek insights into the problems stated above using the statistical techniques and to give logical arguments, for advocating 'sustainable water pricing' from the viewpoint of the residents, as a tool in mitigating the city's water crisis as a future course of study.

Therefore, the present chapter deals with statistical exposition of the residential water use in Delhi through a case study orientation. In this direction, a primary survey has been done, though for a few colonies/residential areas in the stipulated time frame, precisely to know the responses of residents on a wide variety of issues relevant to municipal water demand in their respective residing areas/colonies in Delhi. The survey results would also be crucial in terms of looking at the hypotheses that have been constructed in the study. The additional exercise in the present chapter is the look at the some of the preliminary theoretical background on municipal water pricing applicable in the present chapter (to be followed in detail in the next chapter) in order to determine the *pros and cons* of a sound pricing policy keeping in mind the current water situation in Delhi. Henceforth, the present chapter attempts to study the socio-economic and behavioural aspects of HHs in the sampled areas and to derive the fact that could guarantee the sustainable management of public water system in Delhi.

2.2 **Analysis of the Field Survey Report**

The macro-level data/aggregate data from various secondary sources, (mentioned in chapter 1) indicating abundant water availability with uneven per capita availability in Delhi has no dearth, however, periodic water scarcities that eventually culminates into perennial water shortages in most of the areas in Delhi calls for the need for disaggregated analysis of the household level data which in turn could reveal seasonal as well as spatial variations in water availability and households' demand/preferences of DJB's sponsored water supply and other sources of water procurement. This would also incorporate public reactions, if any, for any price alterations made in the current water pricing structure, that could make the water accessibility to needy residents a better, reliable and universally acceptable one. In this regard, under the 'contingent valuation method', generally used to determine the people's 'willingness to pay' for a good or service viewed as economically valuable or environmentally scarce, is also considered in the primary survey, but because of the subjective nature of the 'willingness to pay' criterion, it cannot become the sole standard for arriving at any concrete answer to the optimal provision of water to all households at a price for the purpose destined to in the present work.

(a) **Methodology: Data and Survey Design**

The primary household survey being carried out was primarily targeted at obtaining information for a selected set of parameters such as average amount of water consumption per HH per day, source(s) of domestic water, water accessibility, cost of coping alternative means of water and other water conservation costs, costs associated with making impure water safe for drinking – averting cost, user charges for water, water usage patterns etc. considered vital for the present study and research. The analysis is based on a case study of a household survey of 148 HHs in five selected pockets of Delhi. The sampled areas are - DCB area, Vasant Vihar (Posh and Non-Notified Slum – *Kara Camp*), Vasant Kunj, Mehrauli and Munrika (DDA Flats and Munirka Village). Except the DCB area, all the rest areas are located in South Delhi, where acute shortage of water is a common problem more so in the summer season. The basis for choosing these specific areas in Delhi is solely attributed to the fact that these areas have spatial variation in the accessibility/availability of municipal water, that is, from the least (Mehrauli) to the moderate (Vasant Kunj etc.) to the highest availability (DCB).

As mentioned before (chapter 1), quantity in terms of availability of municipal water, the notion we build up at the moment is that DCB region is comparatively better off in terms of receiving supplied water from DJB as per the various institutional norms of per capita water availability, while areas like Mehrauli is very much deficient in getting DJB water on the same ground. This is supported by a press release as mentioned below:

> According to DJB's estimate, its network covers 72 per cent of the city, a figure some say is highly exaggerated, though many new areas have been brought under the distribution network in the last few years. "Earlier, there was a massive difference in the per capita distribution in various areas. NDMC and Cantonment (DCB) areas have conventionally had a better supply than most other areas. Around the year 2000, distribution varied between 35 LPC/D (areas like Mehrauli) to 450 LPC/D (areas like DCB). Though the gap has been brought down significantly East Delhi and NDMC still get most of the water," said DJB sources.
> [Website: http://articles.timesofindia.indiatimes.com/delhi/treatment-plants-1 water-shortage-supply on 15/03/2011].

Hence, the broad objective that has been attempted to address in the primary survey was to examine the influences of socio-economic and demographic factors as well as institutional factors on the household water demand because of the ununiformity in water distribution in these areas, and importantly people's reaction to the growing unreliability of municipal water being provided to them either through in-house water connection or through public taps/standposts by DJB. The survey done begins with a randomly representative sample survey of households in the stated areas. The survey was carried out through intended 'questionnaire based interviews' from the residents *(questionnaire designed for the purpose has been attached at the end of the chapter 2 as annexure)* with an objective of seeking the following desirable information as enlisted below:

(i) To obtain data on residents' existing sources of domestic water supply.

(ii) To obtain data on residents' average monthly expenditure in percentage terms on water consumption, both for the DJB in-house piped water *plus* monthly expenditure on all other sources of household water demand. This will act as the *proxy* variable for the composite 'prices' residents' are paying for water in Delhi.

(iii) To obtain data on estimated household consumption of water per HH per day.

(iv) To know the water usage pattern of households.

(v) To obtain information about households' coping strategies for meeting alternate sources of water, in case of unreliability of municipal water.

(vi) To seek information about the awareness about the water scarcity in Delhi.

(vii) To obtain information on residents' 'willingness-to-pay' for improved, reliable and better water supply.

(viii) To obtain information about the educational status of the head of the family.

(b) Survey Details

The total number of HHs surveyed was 148 in all from the areas chosen for the study. The response rate was almost 90 percent. The respondents in the surveyed areas were randomly selected for seeking information on the issues highlighted in the questionnaire. The pocket wise distribution of the respondents is as given in the below (Table 14):

Table 14: Distribution of Total Samples Taken from Different Areas

Sl. No.	Areas/Pockets Surveyed	No. of HHs
01.	Mehrauli	24
02.	DCB	26
03.	Vasant Vihar (Non-Notified Slum – *Kara Camp*)	16
04.	Vasant Vihar (Posh)	22
05.	Vasant Kunj (LIG, MIG and HIG Flats)	20
06.	Munirka (DDA Flats)	20
07.	Munirka (Village)	20
08.	**Total No. of HHs Surveyed →**	**148**

Source: Primary Survey.

The descriptive statistics for the survey done is summarized in the tabular forms below: (i) Residents were asked about their **present sources of household water** in different categories of sources, areawise, and the results obtained are tabulated in percentage terms of HHs in the following (Table 15):

Table 15: Water Supply Sources Used by the Sampled HHs - Areawise (In % of HHs)

Sl. No.	Area	Domestic Water Sources (codes below↓)									
		1	2	3	4	5	6	7	8	9	0
01.	Mehrauli	64.5	3	8.4	6.1	11.8	0.8	0.1	3.5	1.7	0.1
02.	DCB	90	2.1	1.2	2.1	1.2	0.2	0.1	3.1	0	0
03.	Vasant Vihar (Non-Notified Slum – *Kara Camp*)	0	0	65.8	0	0	26.2	0.4	3.1	0	0.2
04.	Vasant Vihar (Posh)	64.2	4.1	8.0	13.3	14	1.1	0	16.2	2.1	0
05.	Vasant Kunj	66	1.1	7.1	9.2	6.7	2.3	0	7.1	0.5	0
06.	Munirka (DDA Flats)	67.6	2.2	8.3	12.1	3	1.5	0	4.3	0	0
07.	Munirka (Village)	68.6	2.6	7.8	6.4	5.8	3.1	0	3.9	1.5	0.3

Source: Primary Survey. [Please note that the other sources of procurement of domestic water may be employed when the DJB pipe in-house water supply is in short supply and however, it may not be a regular feature, except the Kara Camp where the DJB tank water supply is the major option].

Codes – 1 – DJB Piped Household (in-House) Water Connection

2 – Public Taps/Standpipes

3 – DJB Tank Water

4 – Private Tank Water/Vendor

5 – Private Tubewell/Borewell

6 – Water from Neighbours

7 – River/Lakes/Ponds

8 – Packaged Marketed Drinking Water Bottles/DJB Water Bottles

9 – Private Water Supply/Small Community Water Enterprises

0 – Others

Observation on Table 15: It has been observed during the survey that, though most areas (except *Kara Camp,* having no DJB piped water connections) have the higher percentage of DJB piped in-house water connections, the residents were not satisfied with water being supplied to them. Majority of the residents were found complaining about the intermittency of the water being supplied to them. Especially, this problem was felt in areas like Mehrauli and Vasant Kunj. One of the residents residing in LIG flats in Vasant Kunj complained,

> "We the residents are facing an unsustainable water situation. But there is no relief from the intermittent water supply of the DJB tap water, and that too with very low pressure every time. In summer months this problem is only going to aggravate. When water comes, it comes for just 30 to 40 minutes a day and we hardly manage to fill up our buckets. We are bound to spend extra money on packaged water bottles for drinking water and on private tank water for the rest of the uses."

Such similar stories are also prevalent in the Meharauli areas. The respondents were not happy with the present water services in their areas. Through the survey, it has been realised that the 'unreliability' of water supply is the biggest problem the residents are facing mainly in Vasant Kunj and Mehrauli areas. On the other hand, DCB areas have fairly good municipal water supply, even though sometimes residents resort to other means of water also. On average, the residents in DCB region get 5 to 6 hours of water every day, most of the days in a year. Areas like Munirka and Vasant Vihar (Posh) has moderate water supply with 1 to $1^{1}/_{2}$ hour of water supply per day with occasional interruptions in supply. It is interesting to observe the other sources of water in these areas from the Table 15. For instance, the highest percentage of private tubewell/borewell is found in areas like Mehrauli and Vasant Vihar (Posh). These sources of water are unaccounted for any price, as the primary survey suggests the fact that the residents were quite reluctant in revealing any information about the legality of such a source. However, as per the DJB's notification no. DJB/DOR/TARIFF/01-01-2004 dated 28/29-01-2005; the DJB imposes a levy on extraction of ground water. The notification says that:

> To regulate the ground water extraction being done through tubewells, DJB will charge Rs. 1500.00 per HP, as one time charge, from tubewell owners for ground water extraction, subject to clearance from the Central Government (DJB: Citizen Charter, accessed from the website: http://www.delhijalboard.nic.in/ on 18/04/2011).

In the *Kara Camp* – a Non-Notified Slum near to JNU North Gate, people have no fixed source of water, so they have to depend heavily on the DJB free of cost tanker water supply, which is unpredictable in its timings and slots in a day/month. A resident of *Kara Camp* informed that,

> "Every morning we wake up fighting for water, and since DJB tankers are not at all reliable, we have no other option than going to nearby JNU premises to take some water. Nowadays, even the JNU guards have become hostile and as they do not allow us to enter JNU gates. Even if the DJB tanker arrives, there is no space for its parking except the main road. DJB water tankers stop for less time in order to avoid any traffic jam and it results in great rush often ends in public brawl and fighting. Recently a woman got injured while taking water. We somehow mange to get drinking water here and there, we cannot afford to buy those expensive bottled water."

Undoubtedly, these responses of residents have great significance for any policy recommendations pertaining to water allocation to slum areas where people are heavily depended on uncertain sources of water for their use.

(ii) Data on **HHs' monthly income** was categorised into different class-size of the total HHs in all the areas during the study. The below (Table 16) presents the HH income and related figures for the areas in the present study:

Table 16: Data on HH Monthly Income and Related Statistics

Items ↓ Areas*(see codes)***→**	**A**	**B**	**C**	**D**	**E**	**F**	**G**
No. of Sampled HHs	*24*	*26*	*16*	*22*	*20*	*20*	*20*
Mean Monthly Income(Rs.)	15,485	10,183	6,000	32,387	18,225	12,416	8,714
Standard Deviation (σ)	0.68	0.56	0.81	0.47	0.9	0.53	0.64
Median Income	12,200	8,300	4,900	24,000	16,500	11,600	7,120
(%) of HHs per Income Bracket↓							
< 10,000	1.8	0.9	64.8	0.1	2.4	2.2	4.8
10,001-20,000	21.3	11	13.2	8.3	6.7	9.8	17.2
20,001-30,000	38.7	34.1	11.6	16.7	17.4	17.1	23
30,001-40,000	15	22	10.4	17.6	23.3	26	32.2
> 40,000	23.2	32	0	57.3	50.2	44.9	22.8
Total →	*100*	*100*	*100*	*100*	*100*	*100*	*100*

Source: Primary Survey [**Codes – A** – Mehrauli, **B**- DCB, **C**- Vasant Vihar (NNS), **D**- Vasant Vihar (Posh), **E**- Vasant Kunj, **F**- Munirka (DDA Flats), and **G**- Munirka (Village)].

Observation on Table 16: The **average monthly income** of the head of the family of all the HHs in all the areas was calculated at Rs. 21,635.81 (regression data). Though a few residents were not in agreement to yield their monthly income, however, most of the residents informed about their monthly incomes. Table 16 confirms the fact that there exists variations between the incomes levels of residents in the areas reported. It has been observed that the lowest the and highest percentage of income per HH in the respective income brackets are found among the Vasant Vihar (Posh) residents. Atleast 10% of the HHs have monthly income less than Rs. 10,000 and about 57 per cent residents have monthly income more than Rs. 40,000.

(iii)The next issue of interest in the primary survey was to obtain data on the **average monthly expenditure** (in percentage terms) of 148 HHs on household water consumption. It was found that different HHs have different income levels and also, total members in different HH, that is, family size vary, accordingly the average monthly expenditure on household water consumption varies per HH in each locality.

The percentage average monthly expenditure given in (Table 17) below is inclusive of all prices residents pay today for water consumption: (a) monthly water bills paid for DJB in-house water supply (on metered connections), except in the *Kara Camp* area (b) costs pertaining to purchase of water storage tanks, electric motors/pumps etc. (c) expenditure on packaged drinking water (both on DJB packaged water bottles 'JAL' and marketed drinking water bottles) and, (d) expenditure incurred on water filters for making water safe for drinking (e) expenditure on private tank water services, except DJB free of cost tanker water for which separate rates are there for purely private use like water demanded for private functions, construction work etc. (DJB: Citizen Charter, accessed from the website: http://www.delhijalboard.nic.in/ on 17/04/2011).

It should be noted that the above household investment on domestic water management ranging from (b) to (e) are the prices residents are actually paying for coping up with the alternate strategies for meeting residential water demand, which are broadly found to be accounted for in the survey, though it vary from season to season in sampled regions and mostly depended upon the income level of the household surveyed. This information is tabulated areawise in the following (Table 17):

Table 17: Average Monthly Expenditure of Residents on Water (in % per HH of Income)

Sl. No.	Area	Average Monthly Expenditure on Water per HH (in % of Total Income)
01.	Mehrauli	4.64
02.	DCB	2.67
03.	Vasant Vihar (Posh)	4.25
04.	Vasant Vihar (Non-Notified Slum – *Kara Camp*)	0.50
05.	Vasant Kunj	3.29

06.	Munirka (DDA Flats)	2.84
07.	Munirka (Village)	2.32

Source: Primary Survey

Observation on Table 17: The exact proportion of monthly expenditure on all other commodities households consume within various income groups of the 148 HHs is not exactly known. However, information provided in (Table 17), in percentage terms, is only suggestive of the households' average monthly budget allocation on water consumption. It can be observed that there is a great variation in the percentage average monthly expenditure of HHs across the sampled areas on water, encompassing all sources. The highest average monthly expenditure share of the total household expenditure is seen in Mehrauli and Vasant Vihar (Posh) areas and the least is observed in the Vasant Vihar (Non-Notified Slum).

A relevant question worth investigating is: can there be a correlation between the average monthly expenditure on water per household and the spatial inadequate water supply among these sampled areas. Mehrauli receives only 30 to 35 LPC/D of the DJB municipal water which is far below the prescribed DJB norm of 60 GPC/D or 80 GPC/D by DDA, MPD: 2021 (chapter 1). This is the lowest of all areas receiving DJB piped water not only among the sampled areas, but across all areas in Delhi. So far as (Table 17) reveals, HHs in Mehrauli residents spend a larger proportion of their income on water per month next only to Vasant Vihar (Posh) residents may be of the fact that Vasant Vihar (Posh) residents pay more for the services of private water tankers as well as on packaged drinking water (Table 15). In areas like Munirka (Village), mixed responses were observed in terms of expenditure on water. A resident living in Munirka Village informed that,

> "Sometimes we spend some money on packaged drinking water, or when we call a private tanker. This happens in hot summer days, when we suffer the most, because there is cut short of the timings of the piped water, and even it comes for less number of days in a week. Moreover, we have to store water as there is no surety of municipal water to come the next day. Since most residents here keep tenants in their houses, they need to store more water by

employing electric motors for longer hours. This entails more of our expenditure on water."

(iv) Regarding the **average consumption of water** per HH daily is investigated, which is observed to be depended on multiple factors like the family size (number of adults, children etc.), water usage pattern, habits of residents related to water conservation etc., it was acknowledged from the primary survey that, on average, per HH (family size of four – 2 adults and 2 minors), water consumption stands 243.58 litres daily in summer months and 214.55 litres daily in winter months (for bathing, laundry, drinking and cooking purposes) comprehensive of all the areas surveyed. For simplicity, the seasons are broadly classified into winter and summer seasons. The average quantity of 214.55 litres daily in winters goes up in summer months because of the increase in the frequency of bathing habits of residents. This is tabulated in the following (Table 18):

Table 18: Estimated Average Daily Water Consumption per HH in the Sampled Regions with respect to Seasons*

Region	**Average Water Consumption (in Litres per HH per Day)**	
	Winter Season	***Summer Season***
Mehrauli	216.43	244.12
DCB	214.32	264.09
Vasant Vihar (Posh)	227.11	251.89
Vasant Vihar (Non-Notified Slum *Kara Camp*)	165.23	200
Vasant Kunj	235.67	260.10
Munirka (DDA Flats)	223.80	250.32
Munirka (Village)	218.91	234.54
Average of all HHs →→	**214.55**	**243.58**

Source: Primary Survey.

[*Please note that the Winter Season in Delhi in the primary survey include months starting from Mid- October till Mid-March, and the Summer Season include the rest of the months in a year. Also, the figures given include water consumption on bathing, laundry, drinking and cooking purposes.]

(v) Information was collected on the question of **sufficiency of the availability of household** water throughout the year (based on information contained in Table 17) – a qualitative aspect important for arriving at any argument pertaining to policy formulation. The survey indicates that except the DCB region and in the Vasant Vihar (Posh) areas, other remaining areas have no sufficient availability of tap water and that too perennially. People's responses to water sufficiency in different regions are given below in (Table 19):

Table 19: Water Sufficiency/Availability in the Sampled Areas with respect to Total Water Demand per HH Daily *(summer + winter months)*

Area	**Water Demand per HH (LPC/D) *in Winter Months***	**Whether Sufficiency (1-Yes/ 0-No)**	**Water Demand per HH (LPC/D) *in Summer Months***	**Whether Sufficiency (1-Yes/ 0-No**
Mehrauli	216.43	0	244.12	0
DCB	214.32	1	264.09	1
Vasant Vihar (Posh)	227.11	1	251.89	1
Vasant Vihar (NNS)	165.23	0	200	0
Vasant Kunj	235.67	0	260.10	0
Munirka (DDA Flats)	223.80	1	250.32	0
Munirka (Village)	218.91	0	234.54	0

Source: Primary Survey

(vi) The **water usage pattern** of the sampled HHs was taken into account. It was observed that a typical household (family size of four – 2 adults and 2 minors) in the sampled areas uses about 30% of the total water on toilet flushing, 35% for bathing and showering, 15% for laundry, 8% for drinking and cooking, 5% for dishwashing, 3% for gardening, 2% for car washing and 2% on cleaning homes (personal hygiene).

(vii) Almost all the residents regardless of their residing areas in the sampled survey agreed to the growing **problem of water scarcity** in Delhi. Majority felt that the DJB is highly inefficient in terms of water service delivery to households. Some residents of Mehrauli area showed their 'willingness to pay' for a bit higher price for municipal water, but at the same time they did not hesitate in complaining that,

> "We do not get sufficient water in the first place, so why to pay higher prices for the DJB piped water. Yes if the DJB is going to give us reliable water supply for atleast 2 to 3 hours a day, we are able to pay higher monthly water bills because we are already paying an unaccounted price for other sources of water."

This attitude was also observed in other areas except the DCB residents. About 40 per cent of the respondents in DCB and Vasant Vihar (Posh) areas disagreed with the idea that increased water tariffs are going to help in the improvement of current water situation. The basic reason accounted for this response was the fact that most residents lack trust in the autonomy of DJB as nodal water agency in the city or because some of the residents are indifferent to the changes in current water rates as they are getting sufficient water in their homes. This is an interesting outcome of the primary survey.

(c) <u>Interpretation of the Survey Details</u>

What becomes visible in all the responses was, except DCB and Vasant Vihar (Posh) areas, there is no sufficient water available to the residents in other sampled areas. In this situation mere 'willingness to pay' for improved or reliable water services would be a misleading proposition, because 'willingness to pay' for the provision of a good or service, is an individualistic approach and public choices differ from individual to individual and from region to region receiving the benefits of a public or merit good/service. This proposition directly comes through the Arrow's Impossibility Theorem which states that:

> A social welfare function cannot be derived by democratic vote, that is, preferences of all the individuals in society without violating at least one of the given conditions: (i) social welfare choices must be transitive (ii) social welfare choices must not be responsive in the opposite direction to changes in individual preferences (iii) social welfare choices cannot be dictated by any one individual preferences, and (iv) social welfare choices must be independent of irrelevant alternatives; for example, if society prefers A to B

and B to C, then society must prefer A to B even in the absence of alternative C (Salvatore, 2003:595).

Therefore, the 'willingness to pay' standard has been discarded in the present study. Any concrete pricing policy formulation/alteration in current pricing policy cannot be impulsively arrived at, on the basis of such a loose criterion. So far as the water prices are concerned, it is evident that the residents are in the persistent practice of paying different categories of prices for meeting household water demand in terms of coping alternate strategies of household water demand and thus the hidden costs intrinsically paid for, by the residents for securing other feasible sources of water demand in the regions sampled. One resident of the Central Public Works Department (CPWD) colony (government flats) in Vasant Vihar informed that,

> "Since the water tariffs are administratively determined and the monthly bill is often deducted as imputed rent from my salary, I do not have any sure shot idea about how much amount I exactly pay to DJB. There is a water meter installed in my house and I believe I pay the correct amount to the DJB for the water I use."

This statement is an indicative of the level of general awareness about water tariff/ rates prevalent in the city. On the other hand, in some areas, residents feel that private tubewell/borewell is more reliable source of water than the DJB piped water supply. Residents believe that the piped groundwater supply of water by DJB is generally impure and hence cannot be used for drinking purpose and hence residents have to bear additional costs for the domestic purification of water. Yet on another side, people living in NNS area are quite uncertain about water accessibility. They have an implicit demand for water for which there is no provision so far. It has also become clear through the survey that different HHs have employed various means to obtain safe and pure drinking water. The survey done is qualitatively informative in the sense that residents realise the fact that there is acute water crisis in Delhi and the government seem helpless in this direction to mitigate or atleast lessen the crisis in the near future.

(d) Estimation of Residential Water Demand Function of the Sampled HHs: A Case Study

- **Using Alternate Water Coping Strategies for the Unreliable DJB Water**

Literature on water unreliability facing residents from a public utility is formulated in terms of coping costs. According to Choe and Varley (Osei-Asare, 2004: 68),

> Explicit costs and opportunity costs should feature in the estimation of water price in case household employ water storage tanks and water treatment equipments on a daily basis. Explicit costs and opportunity costs determine the coping costs of water insecurity among urban consumers.

This is expressed as: **Coping Costs of HH** = Explicit Costs [HH Investment in Water Storage Facility] + Domestic Water Treatment Costs + Opportunity Costs [Time Spent by HH in Collecting Water, e.g. from public taps/standposts, neighbours, utility sponsored tanker water etc.]. Further it is maintained in the literature that,

> Coping Costs could serve a good *proxy* for water price since it incorporates both opportunity costs and explicit costs in its calculations. Moreover, coping costs are more likely to reflect the reality of daily household water coping mechanisms in securing water (Osei-Asare, 2004: 69).

It has been observed during the survey that residents have their own strategies of meeting with the intermittent water supply, and therefore the economic and behavioural changes of residents associated with the unreliable water supply could lead to an *indirect* estimation of residential water demand in the areas of interest in the study. The underlying assumption made for the *indirect* estimation of water demand was that the residents' demand for water is not met in the current supply and thus they have to make a huge domestic capital investment in storage facilities or have to depend upon additional/alternate sources of water, in addition to many other costs discussed below, collectively termed as *total* coping costs which embeds the total *price* the residents are paying for converting unreliable water supply to a reliable one. The major strategies adopted by the residents in the sampled areas for coping up with the unreliable municipal water supply at the household level, as revealed through the primary survey were found to be:

(i) Increased households' water conservation capacity through purchase of water storage tanks of various capacities (1000/500/200 litres) and expenditure incurred on the built of underground and on surface cemented water storage tanks. The storage tanks need frequent cleaning which has a time element.

(ii) Enhancing water pressure through mechanical improvements by incurring the plumbering costs etc.

(iii) Water purification costs like purchase of water filters, aquaguard etc.

(iv) Residents' expenditure on purchase of electric motors/pumps for enhancing the flow reliability and improved pressure of water supply to the storage tanks placed on the roof of the houses. The running of electric motors also adds to the appreciable electricity bills residents pay monthly. Occasional maintenance of electric motors incurs costs to residents. Expenditures on private tank water are also taken into account.

The survey study in the sampled areas points out the fact that the percentage of HHs who employs **domestic water related durable equipments** vary significantly with respect to the income level of the household and the standard of living of the households. In order to reduce intermittency of municipal water, the multiple ownership pattern of the equipments HHs use in order to compensate lack of availability of DJB's water along with improvement in the quality of domestic water mainly for drinking and cooking, with respect to residents' income level is presented in the (Table 20) below:

Table 20: Water Related Equipments Owned by HHs w. r. t. HHs Income Level

Equipments Owned by HHs (in %) ↓	**Monthly Income of the Head of the HHs (in Rs.)**				
	< 10, 000	**10,001-20,000**	**20,001-30,000**	**31,001-40,000**	**>40,000**
Water Storage Tanks, Electric Motor/Pump, Water Filters	1	3	6	10	10
Water Storage Tanks, Electric Motor/Pump	2	5	8	11	12

Water Storage Tanks, Water Filters	4	8	11	13	17
Water Storage Tanks/Buckets	9	10	19	21	23
Water Filters Only	5	13	23	24	26
None of the Above	**79**	**61**	**33**	**21**	**8**

Source: Primary Survey.

Table 20 is self-explanatory, not every HH can afford to own all the durable equipments in various income groups, meant to cope with the intermittent supply of water and hence to enhance the water reliability and improved water quality of municipal water. A brief summary of the socio-economic profile of sampled HHs is tabulated below in (Table 21):

Table 21: Summary of the Socio-Economic Profile of the Sampled HHs

Sl. No.	Variables	Figure
01.	Average HH Size	4
02.	Average HH Monthly Income of the Head of the Family (Rs.)	21,635.81
03.	Average Years of Education	12
04.	Average No. of Working People per HH	2.1
05.	Average Monthly Electricity Bill (Rs.)	1,121.62
06.	Average Monthly Water Bill (Tax + User Charge) per HH(Rs.)	321.60
07.	Average DJB in-House (Metered) Piped Water Connection	55.7%
08.	Average Total Coping Costs on Alternate (Compensatory) HH Strategies Towards meeting the monthly per HH Water Demand (Rs.) [*inclusive of both the seasons*]	727.53
09.	Average Water Storage Capacity per HH per Day (in Litres)	200
10.	Average Water Consumption per HH per Day (in Litres)	471.30
11.	Average Number of Hours of Water Supply per Day across Areas	3.21

Source: Primary Survey.

❖ **Model Specification and Choice of Model Variables: The Demand Side**

The Economic Model designed/formulated for the purpose of estimating water demand function with respect to its determinants facing residents in all the respective areas is given as follows: **Quantity of Water Consumption per HH per Day = f**

(Prices in terms of Coping Costs, Water Bills, HH Water Holding Capacity, Income of the Head of the HH, Standard of Living, Size of HH, Educational Status of HH, Number of Hours of Water Supply, Opportunity Cost of Collecting Water).

A cross-sectional data derived from the survey data has been used at the level of municipal water supply in the surveyed areas in order to estimate an aggregate demand function of the sampled residents. The following econometric model has been formulated in order to estimate residential water demand function of all the residents in the areas surveyed in the present study. The description/identification of dependent and independent variables in the model are explained as follows:

Dependent Variable

(i) **Demand for Residential Water per HH per Day (Q):** Proxy - Water Consumption per HH per Day (in Litres). This is because, in the present study, quantity of water consumption per HH per day is taken as a *proxy* to an estimated demand for HH water per day. However, the water supplied to residents might not be adequate to meet the projected demand across the areas. Here, water demanded is meant both for the necessities and non-necessities domestic uses.

Independent Variables (Explanatory)

(i) Demand Factors: **Proxy variable for Price (P)** – *(Average) Coping Costs on Alternate (Compensatory) HH Strategies* towards meeting the monthly per HH Water Demand in monetary terms. In the model, this has been taken equivalent to HHs' average monthly expenditure on domestic water.

(ii) **Sufficiency (S)** of Municipal Water supplied to HHs with respect to HH Demand – Dummy.

(iii) Water Holding Capacity of HHs – This variable is taken as *average water storage capacity daily of residents* based on water tank storing capacity, and other containers used for conserving water like buckets, small drums etc. It is important to know that water cannot be stored for a longer time and therefore needs fresh water collection almost every day. However, this variable has *not* been included in the model because it was not certain in the entire survey that how much quantity of water residents would like to hold, and at the same time it was realised that HHs would like to hold as much water they could, if provided.

(iv) Standard of Living: **Proxy variable** – *Average Monthly Electricity Consumption Bill* **(EB)** *per HH.* It is assumed that HHs consuming more electricity have better standard of living as they may be using various costly electric/electronic appliances.

(v) Average HH Monthly Income **(M)** of the Head of the Family.

(vi) Time Spent in Water Collection **(T)** – Dummy: HHs spend a considerable time in collecting water irrespective of water sources, by running electric motors (and therefore, incur monetary cost included in monthly electricity bills) or manual collection of water coming through public taps/standposts, in-house water supply etc. This is taken in the model because of the fact that water pressure through taps varies considerably across the areas. The time element has incorporated in the model as an opportunity cost of the DJB unreliable water supply. This has been done by calculating mean time spent by HH in collecting a 15 litre water capacity bucket.

(vii) Average Number of Hours of Water Supply per Day **(N)** – Dummy.

(viii) HH Size of Residents **(D)** – Dummy.

(ix) Education Status **(E)** – Dummy: Since the residential water demand is a composite demand (necessities and non-necessities), it is assumed in the economic model that residents having comparatively better educational status would be using less water because of the fact that they might know the importance of water as a scare resource by reducing increased use of water consumption on non-necessities like gardening or car-washing etc. and on the opposite; residents having less number of years of education use more water. The water consumer is assumed to be rational water user. Here, the educational status of the head of the family has been taken into account.

The qualitative regressors or dummies in the explanatory variables of the model are defined as follows:

D1 = 1 if the HH size is greater than 6; 0 if the HH size is otherwise.

D2 = 1 if the HH size is between 2 and 6; 0 otherwise.

E1 = 1 if the head of the family is primary school pass; 0 otherwise.

E2 = 1 if the head of family is between middle school pass and intermediate; 0 otherwise.

E3 = 1 if the head of the family is graduate; 0 otherwise.

N = 1 if the HH spends more than 5 hours a day; 0 otherwise.

❖ The Model

A log-linear specification model is considered in the present set of data because of the fact that the log-linear functional form model allows the coefficients to be directly interpreted as elasticities. The Ordinary Least Squares is used to estimate the log-linear functional form of the model given as:

$$\ln Q = a + b_1 \ln P + b_2 \ln EB + b_3 \ln M + b_4 \ln WB + e_1 D_1 + e_2 D_2 + g_1 E_1 + g_2 E_2 + g_3 E_3 + kN + u$$

Where, 'u' is the error term.

The statistical results based on the regression of the model using the survey data from a sample of 148 HHs, are presented in the following Table 22:

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.743[a]	.552	.511	.29604

a. Predictors: (Constant), Sufficiency , E2, E1, D2, E3, ln_EB, ln_M, N1, ln_WB, ln_P, D1

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	12.967	11	1.179	13.451	.000[a]
	Residual	10.517	120	.088		
	Total	23.484	131			

a. Predictors: (Constant), S, E2, E1, D2, E3, ln_EB, ln_M, N1, ln_WB, ln_P, D1

b. Dependent Variable: ln_Q

Table 22: Regression Results

Coefficients[a]					
Model	Unstandardized Coefficients	Std. Error	Standardized Coefficients	t	Sig.
	B		Beta		
a (Constant)	1.567	0.848		1.849	0.067
ln_P	-0.127	0.1	-0.186	-1.274	0.205
ln_EB	-0.146	0.124	-0.138	-1.179	0.241
ln_M	0.295	0.077	0.291	3.821	0
ln_WB	0.479	0.101	0.602	4.744	0
D1	1.097	0.161	1.186	6.822	0
D2	0.773	0.157	0.859	4.911	0
E1	-0.42	0.305	-0.086	-1.378	0.171
E2	-0.134	0.304	-0.028	-0.442	0.66
E3	-0.039	0.054	-0.046	-0.725	0.47
N	-0.128	0.068	-0.147	-1.889	0.061
S	-0.048	0.069	-0.057	-0.694	0.489

Dependent Variable: ln_Q

Number of Observations: 148.

Here, P is the Price, *proxy* for Coping Costs/Expenditure.

EB is the HHs Average Monthly Electricity Bills, *proxy* for Standard of Living.

M is the Average Monthly Income of the Head of the Family.

WB is the Monthly Water Bills. S is the Sufficiency of Water Demand.

$$\ln Q = 1.567 - 0.127 \ln P - 0.146 \ln EB + 0.295 \ln M + 0.479 \ln WB + 1.097\,D1$$

(1.85) (-1.27)* (- 1.18)* (3.82) (4.74) (6.82)

$$+ 0.773\,D2 - 0.420\,E1 - 0.134\,E2 - 0.03\,E3 - 0.128\,N - 0.048\,S$$

(4.91) (-1.38) (-0.44)* (-0.73)* (-1.89) (-0.7)*

$$R^2 = 0.552$$

[Figures in brackets show the **t**-statistic and * shows statistically insignificant result. R^2- the 'coefficient of determination' of 0.55 is acceptable as the data collected within a short time from the residents and also the number of observations is 148 only. The statistic of Fisher F is significant at 100 percent. This enables to validate the model].

(e) Interpretation of the Statistical Results

The parameter estimate of (- 0.127) for the **price elasticity** of water demand in absolute terms (in the model, prices are set to approximately cover the coping costs), indicates that residential water is fairly *inelastic* in its demand. The coefficient (- 0.127) of the price elasticity refutes the general proposition that residential water demand is unresponsive to any changes in its price. In this connection, according to Renwick and Archibald (1998, 2-3),

> It is maintained that residential water demand is price inelastic, making price a relatively ineffective demand-side policy variable. The argument is like the use of price as an allocation mechanism is constrained by the fact that water is generally regarded as a basic necessity, even a right, not an economic good.

There is a difference between price-inelastic demand and no price responsiveness (Renwick and Archibald, 1998: 3-4). According to Renwick and Archibald (1998: 3-4),

> The point that residential water demand is price inelastic or to say in other words that residential consumers do not respond to higher water prices is not true. Economics say that residential water demand should be price inelastic for three reasons: First, there exists no close substitute for water in most of its uses and hence more price inelastic in demand. Second, the amount of money spent on water is generally a relatively small share of the typical HH budget.

Third, water is frequently demanded jointly with some other complementary goods.

The price inelasticity is a technical definition when it comes to residential water demand. It simply means that a one percent increase in the price will result in a less than one percent decrease in water consumption. In other words, residential consumers respond to higher prices but at less than proportionate to the price increase. Therefore, the serious flaw in the general perception that residential water demand is unresponsive is not acceptable, as the above empirical result shows that residents in fact response to changes in prices, constructed in terms of their monthly coping costs in the present study.

The estimate for the **income elasticity** of water demand of 0.295 (statistically significant) confirms the fact that residential water demand is a normal good – as income increases consumption demand for water go up and vice-versa. HHs with increased income may like to divert their expenditure from the consumption of water on necessities towards non-necessities or consume more of the complementary goods associated with water use like more water use on gardening, car washing, private swimming pool (as in Vasant Vihar posh, residents having relatively higher average monthly income have swimming pools and tub bath facility, car washing), and thus increases the indirect demand for HH water.

It is important to note here that, as income increases consumption of water increases but disproportionally, because even if residents have increased income, water availability is unreliable in most of the areas surveyed, which does not allow the residents to consume more water *(as evident from the survey that residents are 'willing to pay' more for reliable water supply in areas like Mehrauli)* or may the coping costs are so high for some income brackets of residents that even if they are willing to consume more water they have to limit demand, because it add to the costs to residents like higher electricity bill or higher domestic water treatment for drinking and cooking purposes and other occasional extra expenditure on managing HH water demand.

The negative coefficient of (– 0.146) of **electricity bill** (EB) suggests that there exists an inverse relationship between the quantity of daily water consumption and the electricity bills residents are paying. From the model result it is clear that the more the electricity bills residents are paying the higher the standard of living they are enjoying, and lower will be expenditure on water, other things remaining constant. It is because higher electricity bills imply that residents are consuming more electricity on various other electric/electronic appliances or gadgets/devices like many air conditioners, refrigerators etc. they are using in their homes apart from a small proportion of their monthly budget is being allocated on water storage and treatment. So there stands no perfect correlation between the standard of living and the consumption of water. From the survey it is clear that residents in the Vasant Vihar Posh, on average pays the highest electricity bills and have better standard of living (average income is highest among all the areas). These residents have more or less reliable source of water supply also at the same time *(sample data).*

The parameter estimate of **water bill** (WB) of 0.479 is statistically highly significant, which establishes a positive relationship between the quantity of water demanded/consumed and the water bill is being paid for that consumption. It is also true hypothetically, that since for the metered connections, the increasing block/volumetric consumption would lead to a rise in the monthly water bills as consumption per block increases. Residents having higher income definitely would like to consumer more water. Since the percentage of metered connection in the total connection stands around sixty per cent in the present survey, undoubtedly no residents has any hesitation in paying as per the metered bill or would like to constrict their consumption so as to avoid paying more. Also the domestic water if behaves as a normal good, 'more is better' always prevail as per the consumer's preferences at the given consumer's income level.

- Explanation of the Dummies: (i) If D1 = 1, then $\ln Q = 1.567 + 1.097 = 2.664$. $\ln Q = 2.664 \rightarrow Q = e^{2.664} = 14.35$ litres. Therefore, on average, a HH size of more than 6 consumes around 15 litres of water per day other things remaining constant.

If D1 = 0, other things remaining constant. Then, $\ln Q = 1.567 \rightarrow Q = e^{1.567} = 4.8$ litres. Therefore, on average, all other HH sizes consumes approximately 5 litres of water per day.

(ii) If D2 = 1, then ln Q = 1.567 + 0.773 = 2.340. ln Q = 2.340 → Q = $e^{2.340}$ = 10.4 litres. Therefore, on average, HH lies between 2 and 6 consume approximately 10 litres of water daily. If D2 = 0 → Q = 4.8 litres other things remaining constant. There is a positive correlation between the **HH size** and the level of HH consumption of water per day. It is proved by the positive coefficient of 1.097 and 0.773 of the dummy variables D1 and D2 respectively, of the HH size used in the model. Water consumption is an increasing function of the size of the HH.

(iii) If E1 = 1, then ln Q = 1.567 + (-0.420) = 1.147. ln Q = 1.147→ Q = $e^{1.147}$ = 3.15 litres. If E1 = 0, then Q = 4.8 litres. This implies that primary pass resident use 3.15 litres of water per day, other things remaining constant. All other categories of educational status of residents consume 4.8 litres of water per day.

(iv) If E2 = 1, then ln Q = 1.567 + (-0.134) = 1.433. ln Q = 1.433 → $e^{1.433}$ = 4.19 litres. If E2 = 0, then Q = 4.8 litres.

(v) If E3 = 1, then ln Q = 1.567 + (-0.03) = 1.537. ln Q = 1.537 →$e^{1.537}$ = 4.65 litres. If E3 = 0, then Q = 4.8 litres. **Educational status** of the head of the families has no major impact on the level of consumption of municipal water supply among the residents.

(vi) If N = 1, then ln Q = 1.567 + (-0.128) = 1.439. ln Q = 1.439 → $e^{1.439}$ = 4.22 litres. If N = 0, then Q = 4.8 litres. There is a negative correlation between the **number of hours of water supply** (N) and the per capita HH consumption per day (Q). The negative coefficient estimate of (– 0.128) suggests that number of hours of supply does not affect the level of consumption per HH. It may be due to the fact that even if there is increased hours of water supply, low pressure and intermittency of water supplied are the factors causing not appreciable impact on the consumption of municipal water.

(vii) **Sufficiency** (S) of water has no significant impact on the consumption of water. It is obvious from the parameter estimate of (– 0.048) reveals the fact that the demand for additional quantity of water would decrease as the sufficiency standard increases. Hence empirically, there exists an inverse relationship between the sufficiency of water and the HH demand for water.

2.3 Concluding Remarks on the Survey (Empirical) Results

The primary survey, on one hand, encompasses all the relevant issues of water availability, accessibility, and water usage pattern and water quality related to household water security among sampled residents of Delhi, which calls for a fresh thinking about the water demand management policy prescription. The survey envisages availability of water in the areas surveyed as the central focus in the entire study, although it is now clear that 'availability' alone does not ensure household water security at a given point in time. Residential water is viewed as a natural resource that has to managed and sustainably used (Osei-Asare, 2004:3). The managerial factors influencing water availability in Delhi are not upto the household's expectations of adequate and reliable water flow. We can safely infer at this stage that water accessibility must be seen in context of municipal water as 'commodity' and the residents must have full accessibility of the available water. By access to water as commodity therefore depends on its physical location of water source and timely availability and certainty in service (Osei-Asare, 2004:3).

On the other hand, the survey quantitatively suggests that the residential water demand is infact responsive to changes in prices and income of households, rejecting the notion that prices have no effect on domestic water demand. The empirical result validates the fact that increased reliability of household water consumption comes at an increased costs. Residents in such a situation have shown a 'willingness to pay' for water reliability in several ways of reducing unreliability in terms of above calculated coping costs as compared to the amount households are paying for the current water bills. It could be figured out from the survey data that the value of 'reliability' can be measured in terms of 'prices' household pay for domestic water demand management. The statistical results conform the fact that residents have the capacity or willingness to pay a higher water bills for improved water supply. Tariff rationalisation seems justifiable as suggested by the findings of the survey results based on the households' 'ability to pay' and 'willingness to pay'. How much the residents would like to bear the increase in the current tariff rate sustainable from both the consumer satisfaction and institutionally viable, is yet another dimension to the present research, however limited effort is put in this direction in the ongoing work. Undoubtedly, a comparison between the coping costs borne by the household and a price increase of water is not totally inappropriate in reaching an optimum pricing of domestic water. The inequalities in household average expenditure on water is dependent on the individual household strategies rather than to the question of access to water.

Therefore, it is necessary to understand the factors that influence household choice for improved water sources among available alternatives and the quantities consumed. It calls forth that sustainable pricing for the residential water demand must acknowledge the determinants that affects the household expenditure on water. The primary survey conducted facilitates, in terms of collectively looking at three main issues emanating from the management crisis in DJB water supply mechanism, namely, water demand management – sustainable pricing policy, public choices related to water sources and, sustainability of water supply augmentation projects in the wake of water scarcity in Delhi. The survey findings pose challenges in framing pricing policy taking into account the quantum of social and economic cost of inadequate and unreliable public water delivery in Delhi.

The next chapter is devoted in understanding the mechanism of reducing the cost of unreliability from the residents' welfare point of view on one hand, and the minimising managerial inefficiencies of the DJB on the other, in terms of designing a 'sustainable' water tariff structure that could take care of the fact that water is a valuable natural resource and needs optimal distribution to all residents irrespective of income standards of water consumers. The next chapter also attempts to see in what aspect the pricing of water resource like groundwater could be taken into account into the water tariff design, so that judicious utilisation of all other water resources could be arrived at eventually.

Chapter 3

The Economics of Water Pricing in Optimal Urban Water Allocation in Delhi

►What Fits Best for the DJB◄

Outline of the Chapter

3.1 Conceptual Framework of Urban Water Pricing

The aim of the present section is to bring out the practical problems of 'pricing' household water. In the view of Goetz and Berga (2003:73) too, pricing of household water with regard to current and future quality, quantity and access to all citizens with the maximum possible efficiency at the utility level is the serious most problem. This is unearthed first, by exploring the concepts of water pricing in theory, and later, by discussing pragmatic solutions to the ongoing area specific water shortages in Delhi. In the light of this, the empirical results in hand from the previous chapters shall form an important aspect.

In common terminology, '*water price* is a volumetric price placed on *metered* water' (Griffin, 2006:244). 'Water *rate* is coterminous with water *price*' (Griffin, 2006:244). 'Water *rates* are the charges for the measured delivery of a valued commodity' (Griffin, 2006:244). The term 'water *rates*, expressed plurally, typically refer to the entire package of *charges* applied by a water supplier' (Griffin, 2006:244). This entire package of different water charges can broadly be put into various categories similar to the case of DJB's 'two part pricing' model, mentioned in the previous chapters.

According to the Organisation of Economic Cooperation and Development (OECD),

> A *tariff* is a whole set of procedures and elements that determine the 'total water bill' paid by the consumer; a *tax* is that part of the total bill measured in money per unit of time or in money alone; *price* is that part of the total bill measured in money per volume. Thus in this context, the *cost* of water is a broader concept than the notion of *price* alone. However, we refer to the *total bill paid* by the consumer as the *price* of the water (Goetz and Berga, 2003:73).

Normally, it is considered that the 'two part pricing' model, or increasing block rate (IBR) pricing model, which the DJB follows for the metered connections, the tendency is toward 'volumetric pricing' combined with a 'fixed access charge'. Goetz and Berga (2003:73) state that, 'the size of the fixed access charge is subject of discussion regarding equity and access.' They further emphasise the point that 'experience has shown that higher fixed charges tend to reduce access and the consideration of social criteria.' The same authors maintain that 'current pricing practice is to take into account the marginal cost of supply related to volumetric consumption and fixed cost related to infrastructural investment.' Further, it is assumed by Goetz and Berga (2003:73), that,

> The effect of this practice of pricing on equity and access depends on the proportion of the fixed share compared to the price of the water per cubic meter. If the fixed share is set too high, equity and access are reduced whereas if it is too low, the maintenance of existing or construction of new infrastructure is neglected.

The 'two-part pricing' model or the 'non linear pricing' model is presently being used by the DJB. This kind of pricing gives some freedom to redistribute the 'social surplus' (Goetz and Berga, 2003:75). The objective of such pricing is relatively simple. The consumer pays a fixed charge *plus* the bill of its effective consumption. If 'F' is the fixed amount and 'p' the unit price, the total bill 'B' for consumption 'Q' is: $B = F + pQ$. According to Goetz and Berga (2007:75), 'the "two part pricing" can insure a *first order* optimum (see sections below) if the fixed charge is set to offset the spread between marginal cost and average cost, which involves a deficit (D) when pricing to the marginal cost under increasing returns to scale.'

The DJB acting as a natural monopoly *(a natural monopoly is a monopoly firm that exists because the average cost of production are declining beyond the level of output demanded in the market, thus making entry unprofitable and making it efficient for there to be a single firm.* Salvatore, 2003:710), if specifies its charges, and the government acting as a monopoly regulator, then , the regulator can redistribute towards the weak demand consumers in the following way: the fixed charge (F) could be adjusted to the deficit (D) for a given number of 'n' metered connections, or, $D = nF$. This kind of set up procedure could be easily employed, as the natural monopoly differentiates between the 'F' according to the expected quantities' to be consumed (Goetz and Berga, 2003:75). Goetz and Berga (2003:75), further assumes that,

> The problem of inequality in payment can be overcome by charging a higher fixed charge to the larger consumers and hence adjusting the 'D' factor. The fixed charge increases with the expected quantity of water to be consumed by the individual consumers. In this way, the pricing takes into account of the social criteria. A kind of equity is then restored. The low quantity consumers pay a lower fixed charge (price) than the high quantity consumers.

Given the multiplicity of residential water demand (necessities and non necessities), residential water use could be appropriately classified as a final consumption good in a consumer utility bundle, available at a certain administratively determined price (Young, 2005:246). It has been stated in the previous chapters that the municipal supply of water with high 'uncertainty' in provision is an important component of 'willingness to pay' for the procurement of domestic water by the sampled residents in Delhi.

This is supported by the empirical results based on the primary survey in the previous chapter. This is further validated by the fact that the economic 'value' most often desired for residential water investment and allocation appraisals is *at source* value (Young, 2005:247). The *at source* value is the derived demand for raw or untreated water in a stream or other body, a measure comparable to derived demands from other sectors such as agriculture, industry or the environment. In contrast, the most readily observable value of water is *at site value*, the 'willingness to pay' at the point of use – in this case, the household (Young, 2005:247). The willingness to pay for improved and reliable domestic water comes directly from the bulging 'coping costs' on the part of the consumer residents. The same has been witnessed in primary survey results too.

On the other front, in order to reduce over use and/or mis use of water consumption by the households abundance in water supply, correct water pricing signals would be considered as a far reaching instrument in effective water demand management (Griffin, 2006:243, The Economic and Social Commission for Asia and the Pacific, 1997:4). The Economic and Social Commission for Asia and the Pacific (ESCAP) (1997:4) suggests that one strategy towards effective water demand and management 'is to establish and implement appropriate water pricing policy that encourages judicious use, discourages water wastage and to protect the quality of water resources by reducing the waste water discharge.' The Economic and Social Commission for Asia and the Pacific (ESCAP) (1997:4) says that,

> Realistic water prices, when properly introduced and administered can help ensure efficient use of water, meet operation and maintenance costs, recover capital investments, generate funds for extension of water supply services to other areas and protect the environment by reducing the quantity of waste water.

As generally being observed that all agents pay a 'price' for the water they consume, the price of water is 'statistically' strong determinant of water demand even when the price elasticity of demand is low (Griffin, 2006:243). Further, Griffin (2006:243) maintains that,

> Although it (price of water) is not the only determinant, it is the only administratively controlled factor consistent with freedom of choice by water users. As a consequence, pricing is a serious tactic for combating scarcity, and it is a prime demand management strategy.

The main objective of *rational* water pricing of public water would be to bring the public water utility, in the present case – DJB, a financially viable institution on one hand, and economically efficient in service delivery raising water consumers to a higher social welfare function on the other hand. At this stage, it is worthwhile to know the underlying principles of urban water rate setting. Griffin (2006:151), presents the customary objectives of water rate setting practice. According to Griffin (2006:251), addressing the contributions of Boland (1993), Ernst and Young (1992), Herrington (1987), pertaining to water rate setting, states that 'multiple goals are identified and pursued while framing the water rates.' The commonly observed goals are as follows:

(i)Revenue Sufficiency or Cost Recovery: Enough revenue should be collected to offset all costs. Revenue sufficiency is paramount in the mindset of water supplier (Griffin, 2006:152). The public utility management is interested in 'breaking even' and running a financially solvent operation (Griffin, 2006:152). An emphasis on revenue sufficiency promotes the idea of average cost pricing. Naturally enough, if everyone pays exactly the average cost for every unit of water they consume, the collected revenue will equal total costs, making the system financially sustainable. However, average cost pricing is not the same as marginal cost pricing, so there will be *efficiency* loss (Griffin, 2006:152). Ordinarily, average costs are less than marginal costs, so the quantity demanded will be too high with the average cost pricing. Yet revenue sufficiency is a compelling goal for a water utility (Griffin, 2006:152). Any system of economically efficient water rates may have to be adjusted to produce a balanced budget for water suppliers. Some loss in efficiency is a possible outcome, however, revenue sufficiency and highly efficient water rates need careful attention (Griffin, 2006:152).

(ii)Economic Efficiency: Water rates should maximise water consumers' net benefits or maximise net present value across all water consumers.

(iii)Equity and Fairness: Consumers with equivalent *characteristics* should pay equivalent *rates,* and rates should be perceived as *fair* by customers. However, there cannot be general agreement on equity and fairness of water rates as water rates may be perceived differently by different customers.

(iv)Simplicity: Water rates should be easily understood by consumers. Simplicity in rate design is commendable from an economic perspective. The idea behind efficient rates is to motivate all consumers to behave efficiently to consume water upto the point where price is same as marginal benefits. However, rates must be properly understable enough by the consumers to know what the price of water is. Griffin (2006:252) maintains that 'most urban water consumers do not understand more about their bills than what is expressed by the idea that higher consumption causes a higher bill. Thus consumers could not contribute to the true purpose of economic rate setting.'

(v)Legality: Water rates should be rightfully enforced legally.

However, satisfying all these objectives in a modern urban water economy will invite ample opportunities for conflicts between the decision makers and the beneficiaries. Griffin (2006:253), while *citing* Boland (1993) maintains that, 'pursuing these objectives jointly will entail trade offs and compromises.' Griffin further holds the opinion that,

> In the end, some measure of efficiency will often be sacrificed, and water will be systematically underpriced. That is, an important reason for the underpricing is the wide range of goals that are blended into the rate-making process.

On the other hand, 'equitability' in the allocation/distribution of water, to a larger extent supports the 'efficiency' criterion of the public water system. This factor, however, is very much interrelated to the institutional infrastructural arrangement subordinating the water utility services *viz-* connection maintainability, coverage of metering, periodic replacement of defective meters and proper metering etc. The important objective of this regulatory procedure is to achieve efficiency factors so as to determine sound water demand management of the urban water utility.

In a situation where there is lesser probability of bringing 'equity and fairness' in the water pricing structure due to inherent institutional bottlenecks (chapter 1), it is proper to consider supply shortages or even inadequate supply of municipal water as the problem that requires prime attention. However, the *sine qua non* determinant in constructing optimal water prices or tariff design compatible with simultaneous attainment of efficient and equitable outcomes in residential water delivery is to well maintain the delivery system. Often, the supply shortage dominates over the other efficiency factors resulting in overall policy in determining the optimal water rates. Therefore, it becomes plausible to revisit the objectives of water rate settings before making uncongenial reasons for the service failure by the water utility. Hence, a sound institutional requirement becomes mandatory in determining sustainable pricing for the residential water demand.

In the case of DJB, none of the objectives mentioned above seem to have been achieved. It typically follows the 'accounting' pricing practices/measures so that the system becomes functionally viable and operational. Usually, a rate setter uses accounting costs and tries to set rates to recover some of these accounting costs using a rate that will be politically acceptable (Shaw, 2003:102). A common example of non economic accounting is the average cost pricing. Average cost pricing is only economically acceptable when it well approximates the signaling performed by marginal cost pricing (Griffin, 2006:254). Griffin (2006:256) further adds to his argument that,

> It is important to determine marginal costs as well as to incorporate scarcity values in price signal to consumers.

This kind of proposition seems valid from the supply side considerations. However, it is not clear through the secondary information the standard for deciding water rate/tariffs by the DJB. In deciding the water rate structure, the DJB has categorically ignored the demand side factors equally important as the supply side determinants so as to reach any sustainable pricing situation. The DJB cannot be visualised as a true market for urban water, it is simply a public utility functioning on no-profit/loss principle.

The term 'sustainable' in the present context means, that a situation is an improvement where the sum of the utilities of the consumer residents in terms of quantity and quality of domestic water is maximised, and the efficiency of the public utility – DJB in terms of the above defined set of goals of water rate setting is optimally achievable. In the present context of household water situation in Delhi, the elimination of operational and managerial inefficiencies of the DJB on one hand, and making inequitous availability of water to residents an equitable one, on the other, are the decisive factors in framing sustainable water pricing structure.

In 1992 the Dublin Water Principles claimed 'water as an economic good' (Rogers, et al., 2002:1). To promote all the customary objectives of equity, efficiency and sustainability in the water sector, water pricing is probably the simplest conceptually, but may be the most difficult to implement politically (Rogers, et al., 2002:1). Proper pricing of a 'public' good could lead to gains in the economic efficiency. However, for this situation to occur requires the necessary condition that the water resources are managed in an integrated fashion where the economics, legal, environmental aspects complements each other, then increased prices could satisfy the customary objectives of water rate settings (Rogers, et al., 2002:2).

It is maintained in the conventional literature that the typical price and income elasticities for household water demand and the typical income distributions encountered, raising prices is regressive and therefore reduces equity, is actually not true (Rogers, et al., 2002:1). Raising water prices based on the estimates of price income/elasticity coefficients could actually reduce certain inefficiencies associated with the public utility functioning, by altering household demand when the price is allowed to truly reflect the true cost of water. This would occur when the resource (water) will be put to its most valuable use mainly by the residents who do not adequate supply water compensates often, by spending extra money on additional water. This must also be accompanied by the willingness on the part of management of the utility to improve the supply mechanism.

It is important to highlight the definitions of the concepts such as the cost of water, the value of water, and the price of water emanating from the discipline of water economics (Rogers, et al., 2002:3). According to Rogers and others (2002:3), the literature on water pricing often confuses with these concepts:

> (i) Cost of water service means operation and maintenance costs, capital costs, opportunity costs, costs of economics and environmental externalities.
>
> (ii) Value of water is defined as the benefits to users, benefits from returned flows, indirect benefits and intrinsic values.
>
> (iii) Price of water is the amount set by the political and social system to ensure cost recovery, equity and sustainability of the resource.

Often, it is the case in the water sector is that prices and tariffs are almost universally below the full cost of supply, which results in large inefficiencies (Rogers, et al., 2002:3), and to sustain the use of the resource in the long run, prices need to be increased to reflects scarcity of water on one hand, and to mitigate the supply constraints on the other.

The objective in the present study, however, is not to go into the detail of the different aspects of 'water' as a natural resource. The thesis attempts to put forth the simple idea that, given the supply conditions, the 'best' tariff design for any water using population, will be one which balances and reconciles the preconditions of water demand in existence in time and space.

For the residents in Delhi, the 'sustainable' pricing will be one at which reliable quality water is available at affordable and at stable prices, and more importantly, water should be evenly available among the users. Therefore, it takes to look at the water allocation part of the water service delivery, at the same time revisiting the conceptual framework surrounding the financial feasibility of the DJB. Because the delivery of water is closely tied up with infrastructure to deliver it, so the water availability cannot be seen independent of financial viability of DJB. It is important for the utility to identify and locate the objectives most common to all residents and relevant to any situation demanding changes in tariff rates.

3.2 Literature Survey on Urban Water Pricing

Literature on urban water pricing is flooded with empirical work mainly in context of the developed countries taking into account the respective price and/or income elasticity of residential water demand as the key policy variable for the effective demand management. The literature on urban water pricing mainly consider water as an 'economic' good or sometimes a scarce 'environmental' good which needs valuation, and thus proceeds methodologically to attain economic efficiency in production and consumption through optimal pricing. Such literature has less applicability in the context of specific countries, where the water utility is gripped with institutional failures. There is dearth of literature on the inequitable distributional aspect of urban water, a fundamental concern of the urban water consumers, more so in a developing country.

The economic interpretation of public water as an 'economic' good seems vital to understand the production side of urban water demand. What follows is the different perspectives of looking at the urban water pricing. In this regard, a wide range of contextual based methods of pricing water has been developed over time. According to Easter (1997:23), 'efficient water distribution is one that which maximises the total net benefit ability to be obtained using existing technologies and available quantities of that resource.' 'In an economically efficient resource allocation, the marginal benefit from use of the resource (water) should be equal across user sectors in order to maximise social welfare' (Dinar, 1997:3-1).

According to Johansson (2005:14), 'under certain conditions (full information, no externalities, perfect competition, complete certainty and nonincreasing returns to scale), markets would achieve *first best* allocations.' Allocation maximising the total net benefit is called Pareto efficient or *first best.* When trades are free from government constraints and high transactions costs, the resulting price will be equal to that determined under marginal cost pricing methods and the resulting allocation will be Pareto efficient (Mohayidin, *et al.*, 2009:1536).

Further, the allocation is termed *second best* efficient when maximisation occurs under constraints like institutional, informational or political constraints (Mas-Collel, 1995; Johansson, 2000). According to Dinar (1997:3-2) and Johansson (2000:14), 'equity of water distribution concerns with the "fairness" of distribution across time or economically disparate groups in a society and may not be appropriate with respect to efficiency purposes.' The public good nature of the urban residential water provision calls for the *second best* theories of water allocation. Among economists (Mohayidin, *et al.*, 2009:1537), the debate rests on whether to price water by its average cost (financial reasons of cost recovery) or by its marginal cost (economic reasoning of promoting an efficient use of the resource).

There exists a consistent debate in the literature on water pricing whether to price pubic water by the *first best* pricing rule or the *second best* pricing rule. Garcia and Reynaud (Mohayidin, *et al.*, 2009:1537), argues that, 'maximising social welfare leads a public utility to use marginal cost pricing. Maximising aggregate net surplus leads to the famous "law of equality of price and social marginal cost".' Symbolically, $\mathbf{P = \partial C (Q)/\partial Q + \Omega}$, where, '$\Omega$' is the marginal *shadow* price of water, and 'Q' is the volume produced by a water utility. The *shadow* price is positive when water withdrawals have environmental impacts or when water is scarce (Mohayidin, *et al.*, 2009:1537).

The same author further argues that, 'due to a number of criticisms against marginal cost pricing or the *first best* water pricing, the "revenue recovery principle" will play the primary rule in design of water prices, thus the "price" usually used by water utilities corresponds to average cost pricing or the *second best* water pricing.' This may due to the reasoning that marginal cost pricing is technically not feasible. 'An advantage of the marginal cost pricing is that it is theoretically efficient, and the most important result from the existing water pricing literature is that efficiency calls for marginal cost pricing' (Mohayidin, *et. al.* 2009:1538).

Carrying out the analysis of the *second best* pricing principle, the same authors maintain that, 'in a *second best* world, where the budget of a water utility must be balanced, an alternative to average cost pricing is "Ramsey-Boiteux" pricing. Under a budget constraint, it ensures a maximal economic welfare.' Symbolically, the Ramsey-Boiteux equation is given as: $\{P - \partial C(Q)/\partial Q\} \div P = \mu/(1 + \mu).(1/\varepsilon)$, where 'ε' is the price elasticity of the water demand, and the term, $\mu/(1 + \mu)$, reflects the cost of the budget constraint.

This is a *second best* optimum where prices are higher than the effective individual 'willingness to pay' (Goetz and Berga, 2003:73). Here the fundamental variable is the price elasticity of demand. The 'Ramsey-Boiteux' marginal cost pricing seeks the price compatible with pubic welfare and the production constraints (Goetz and Berga, 2003:74). This pricing obviously requires information about the marginal cost and the estimate of the price elasticity of water demand.

Related to the demand management policies, many researchers have investigated the relationship between the price of water and the consumption level (Qdais and Nassey, 2001:208). Qdais and Nassey (2001:208) mention scholars like Babbit, Donald and Cleasby (1962) for their contribution in establishing the following relationship:

$C = 21 - 10 \ln Q$, where, C is the cost (in monetary terms), and Q is the rate of water used in thousands of gallons per year.

Qdais and Nassey (2001:208) also acknowledge the contributions of scholars like Walski, Richards, McCall, Deb, and Morgan (1985) for developing a model for evaluating the effectiveness of water conservation measures. According to this model

(Qdais and Nassey, 2001:208), 'a reduction factor in water use was calculated as a function of water price elasticity' as follows:

$R = 1 - (P_1/P_2)^{\varepsilon}$, where, R is the reduction factor, P_1 is the initial price and P_2 is the final price, and 'ε' is the elasticity of demand.

Qdais and Nassey (2001:208) maintain that (Walski et. al., 1985) do not give the potential reduction factor that may be achieved by increasing the water price, they indicated that 'price has a higher coverage value than other non price conservation measures' like water conservation devices, public education about water conservation etc. They meant to say that, 'the number of consumers that will react to price change is higher than those who will react to non price measures.'

Qdais and Nassey (2001:208) recognise the contribution of Twort, et. al., (1994), in establishing the following formula:

$Q = kP^{\varepsilon}$, where, Q is the demand at the price 'P' per unit of consumption, 'k' is the constant, and 'ε' is the elasticity of demand.

The economists have long held that the rule to achieve efficiency in consumption and production, that the price of a good must equal its marginal cost, has another dimension. According to Moncur and Pollock (1988:63), 'for natural resources, this rule incorporates marginal cost of extraction and scarcity rent (on the marginal unit) of drawing down the available stock of the resource so that: $\mathbf{P = MC_{Extraction} + Scarcity\ Rent}$.' Extraction costs include any environmental loss due the extraction of the resource. The same authors maintain that,

> Most water utilities adhere to costing and pricing policies that not only ignore scarcity rents but also base price on average, instead of marginal, explicit extraction cost (Moncur and Pollock, 1998:63).

In continuation to the above views, in another instance, Moncur and Pollock (1998:1) argue that,

> *Scarcity rents* are completely ignored while framing water pricing. We typically cover cost of extraction, treatment, transmission and distribution in

the conventional pricing, in terms of cost recovery, since profit-making is not the aim of public utilities. The *scarcity rents* reflects purely the scarcity of the water itself, given present sources and the prospect that higher cost sources will have to be used in the foreseeable future.

The econometric work in the previous chapter could be interpreted in a sense of 'scarcity rents' people are willing to pay to get water and its valuation thereof economically becomes inevitable for pricing policy. The coping costs incurred by the households may be thought of imputed value of domestic water procurement, forgone by the DJB while recommending price rationalisation.

It is clear that, there is an unsustainable situation of water distribution in Delhi, which no other work, except Zerah, Marie-Helene (2000), has brought out in her book: 'Water – Unreliable Supply in Delhi'. She has attempted to deal with the critical issue of 'unreliability of urban water supply' in Delhi, taking into account a number of household water consumption indicators. Though not much have been talked about the analytical presentation of what ought to be the optimal pricing structure of household water, it, however, brings insight into the water situation in Delhi and the households' responses on the issue. Her thesis tries to draw attention to the policy makers, in the light of unreliability, the fact that the households' expenses on alternate means to procure domestic water exceed the cost of urban water provision by the DJB.

The work is primarily prescriptive in content and character. The incredible work done by the author has proved an asset for the present study, and for providing platform for creating new ideas relevant to the current situation of household water supply in Delhi.

3.3 Demand and Value of Residential Water Uses in Delhi: In Theory and Practice

In Delhi, it seems that the 'water crisis' is actually the 'crisis of availability' of water and as Iyer (2007:29) maintains that, 'the "crisis of availability" theory assumes that water scarcity is a natural phenomenon, that there in not enough water to meet the projected demand, and that we must somehow enhance the availability of water for use.' To quote Iyer (2007:29) further,

> 'Demand' is a crucial factor here, and this will inturn depend crucially on how we use water. 'Demand' is therefore what we should look at first, and very carefully, before we even begin to think of supply-side answers.

Yet in another instance, Iyer (2010) advocates that,

> At the heart of the numerous water-related conflicts lies a competitive, unsustainable demand for water. We are asking for water does not exist. How are we to deal with those demands? The tendency in the past to accept the demands as given and find supply-side answers (dams, reserviours-canals, drilling for groundwater, etc.).
>
> It is only in recent years that we have begun to recognise that there are limits to the augmentation of supplies; that even augmentation that is technically feasible has economic, environmental, social and human costs; and we must try to minimise or atleast reduce the need for such augmentation by limiting the growth of demand for water in every kind of water use. Unfortunately, that recognition is not widespread.

The opinion of Iyer is significant as it points out the crucial issue of supply augmentation of water by tapping new distant source(s) to mitigate water shortages. There are diverse kinds of costs associated with it including additional huge public expenditure in raising the desired infrastructure. Therefore, mere increase in the volume of stock of water would not automatically solve the water shortage problem Delhi and hence, the water 'augmentation inefficiency' paradox remains. The point in question is also, not establishing mere norms for per capita consumption of water availability. For instance, what has become evident from previous analysis is that, in Delhi, the actual supply by the DJB is upwards of 200 LPC/D, which is higher than the current norm and higher than the supply in other Indian cities (Iyer, 2007:39). This is an average figure. The problem is that it is unevenly and inequitably distributed (chapter 1). In this connection, Iyer (2007:39) while talking about the question of inequitable distribution of municipal water in Delhi opines that,

> There are areas in Delhi where people – poor people – have to manage with 30 LPC/D or less, and other areas where people – the middle classes and the rich – use 400 to 500 LPC/D or more.
>
> What we need to do is to enforce economies on those that use too much water, and improve availability to groups or areas that receive too little. If this were done, it might not be necessary to raise the average. While the poor might have to be provided with a certain quantum of water at affordable prices, and the very poor might have to be given some free water, there is no reason why the middle and affluent classes should not be charged the full economic price.

The Centre for Science and Environment (CSE) (Iyer, 2007:40), points out the fact that 'Indian cities generate huge quantities of waste water, the citizens (including the very rich) not merely pay low prices for water, but practically pay nothing at all for the disposal of their waste water.' Accordingly, domestic water will be valued according to its availability and accessibility, not necessarily on the 'economic' value of water as a scarce resource. For the poor, the value of water could be the most, though they may be consuming less water, paying a nominal price or even free of cost, while for the rich who avail better water supply conveniences, from diverse sources and regardless of paying excessive unaccounted prices for water.

The last of the four Dublin Principles (African Water Development Report, 2006:278) reads: 'water has an economic value in all its competing uses and should be recognised as an economic good.' Recognising water as an 'economic' good will mean the right choices about the utilisation of water in the broadest socio-economic context, whereas, water pricing has to do with cost recovery and demand management. At the same time it must also be recognised 'water is also a "social" good and that it should be affordable to the poor' (African Water Development Report, 2006:278). To argue for the case of water as an economic good does mean that water is scarce and valuable resource and that should not be wasted by those having plenty of it and that proper pricing (valuation) will ensure efficient utilisation (African Water Development Report, 2006:279). This will provide a powerful decision and management tool.

The question is about the practicability of such idealistic theories of demand management in context of Delhi. What looks disturbing is how would the municipal water be 'economically' valued, and through what mechanism. There is dearth of opinion on this issue. Water as a 'social' good is often justifiable and generally unobjectionable in the type of societal and economic structure built inherently. So far as defining water as an 'economic' good and prescribing demand management remedies for the judicious use of water, taking into account the empirically estimated price elasticity of demand for water is liable to be controversial. In this connection, it is to be noted that, water rates are the result of a political economic process and not purely an economic process (Shaw, 2003:103). Therefore, the 'economic valuation' of water takes a backseat and the 'availability' of water to all residents becomes the prime focus in the 'supply cum demand' management strategy in the present context of Delhi.

3.4 Survey (Empirical) Results: The Sustainability of Water Tariffs in Delhi

The empirical results derived from the *indirect* estimation of the residential water demand function (chapter 2) of the sampled HHs in Delhi, along with the conceptual framework advocating 'rational' water pricing calls forth two main and straightforward propositions: (i) Firstly, residential demand for water municipal (DJB) water is responsive to any price change or change in the tariff structure in effect in Delhi, evident from the coefficient of price-income/elasticity of (-0.127) and (0.295) respectively. Prices can play a crucial role in demand management as long as the elasticities are different from zero (Arbues, et. al., 2003), and secondly,

(ii) Managerial and operational inefficiencies have to be corrected to attain the equitable and reliable supply of water to residents. The second proposition is the deciding one factor for the first one, because if the condition of inefficiency on the part of DJB persists like what is appeared in the current scenario, the price and income elasticities could no longer be used as significant policy variables.

The empirical results concluded in the last chapter, clearly indicate the fact that the residents are paying the 'cost of inefficiency' of the service delivery failure institutionally, culminated eventually into the 'unreliability of water supply with low water pressure' at the households' end. Hence, the cost of services of the DJB and the price being paid by the residents to avail those services may not be compatible, in the sense, that if the DJB improves its services, the prices actually borne by the residents will lie somewhere between the range of cost of services and the residents' coping cost for obtaining that quantity of water, indicated by the price elasticity coefficient.

The residents are willing to pay higher prices. They are finding themselves capable to pay enough for improved water system. Therefore, the 'cost price' linkages are essential to reach correct water pricing. The empirical study in the previous chapter suggests, that there are host of determinants to look at the urban water demand. These determinants when applied to a municipal water system demand a very high degree of reliability and availability of water. Therefore, the 'cost price' linkages of sustainable water pricing would include the issues of water quality and quantity cost, water reliability cost, affordability cost etc.

The tools employed in the econometric exercise, in the earlier chapter, are designed to understand the preferences of water accessibility among Delhi's residents in the light of water shortages. The elasticity coefficients derived from the estimation of demand function would prove useful in judging the correct policies for good governance in the urban water sector. The results clearly show that the residents do response to the current water situation in Delhi. It impresses upon the water administrating agency to rethink abut the people's perception and responsiveness towards water demand in the city.

Empirically speaking, certain policy changes in the 'pricing' mechanism, making it more suitable for a 'differential' pricing fulfilling atleast the minimum criterion of providing equitable availability of water to all residents in Delhi is the need of the hour. This 'differential pricing' would depend in turn, on whether the policy makers include the income standard of the residents into account while framing any policy recommendation. It is the economists, the managers, the engineers to bring certain institutional changes in order to make the public water system trustworthy by removing inconsistencies associated with the DJB.

The improved situation could materialize if it necessitates the willingness on the part of the government to improve the water delivery system. Unless the managerial bottlenecks are corrected, altered pricing could only be partially successful in achieving the sustainable use of the water resource which might bring controversies in return.

3.5 Need for Effective Public Water Governance in Delhi: Lessons for the DJB

Water governance refers to the range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society (Rogers and Hall, 2003:7). Governance *per se* covers the manner in which *allocative* and *regulatory* politics are exercised in the management of resources (natural, economic, and social) and broadly embraces the formal and informal institutions by which authority is exercised (Rogers and Hall, 2003:7). At the 2000 World Water Forum in The Hague, the Global Water Partnership Framework for Action stated that, 'water crisis is often a crisis of governance' (Rogers and Hall, 2003:15). The 2000 Hague Ministerial Declaration reinforced this view and called for governing water wisely to 'ensure "good" governance, so that the involvement of the public and the interests of all stakeholders are included in the management of water resources' (Rogers and Hall, 2003:15).

Precisely, these views put forth the basic idea that good governance in the public water sector indicates policies directed towards stopping the unsustainable use of water resources by developing effective demand management strategies which promotes both equitable access and adequate supplies of water to all. However, the management of water resources in an area is a function of or is determined by the complex interaction among engineering approaches and growth in productivity of the resource, stability in water production and equality in distribution of water, institutional arrangements, and operation and maintenance resources (Datta, et al., 2001:70).

Urban water management issues are inextricably linked to 'population density, settlement pattern, HHs income level, reliable assessment of available water, and its scope for augmentation, distribution, reuse/cycling, its protection from depletion and degradation, and most important knowing the demand for the resource from the consumption point of view' (Datta, et al., 2001:70, emphasis added).

The main pillars of the water governance institutions are the law, policy and administration (Shah, 2005:2-1). These pillars are collectively called the New Institutional Economics of the water economy, which is distinguished from the institutional arrangements (Shah, 2005:2-1). According to Shah (2005:2-1),

> Institutional arrangements are humanly imposed 'rules in use' that govern the behaviour of water users and suppliers, and dealings between them. Water Users Associations, urban tank water markets are examples of institutional arrangements. Institutional arrangements have therefore a performance enhancing role to play in changes in the improvement in the water economy.
>
> New Institutional Economics' central concern about 'why economies fail to undertake appropriate activities if they had a high payoff' is of great interest to actors in the Institutional Economics - Governments, Non Governmental Organisations, donors, policy makers, legislators, local administrators.

Hence, the key (policy) instruments evolve from the New Institutional Economics of the water economy are the institutional changes, regulatory measures and price rationalisation. In context of urban water sector in India, according to Iyer (2007:28), 'failure in the water sector is the failure of the "governance".' Iyer (2007:28) further maintains that,

> Water governance issues cannot be separated from water policy or water management issues. Two are interrelated. To the extent that corruption, inefficiency and non performance in water related institutions are merely reflections of the general state of affairs in the country, this does not tell us much about water *per se*.

The whole paradigm of sustainable water pricing needs a revamp of the urban water reforms. The institutional mechanisms in dealing water management require a strong regulatory framework for checking illegal tapping of groundwater within the city. The government should become vigilant, and make citizens aware about the consequences of over extraction of groundwater in the city. The government should price the groundwater too. In a pubic notice no. 6 of 2000, issued by the Central Ground Water Authority (CGWA), states the grim situation of groundwater use in Delhi. It says,

> .....has declared Najafgarh block, Mehrauli block and Vasant Vihar and Vasant Kunj areas of the National Capital Territory (NCT) of Delhi as 'Notified Area' on block/area wise basis vide public notice dated 1.4.1998, 24.12.1999 and 25.4.1999, respectively, in view of depletion in groundwater resources due to over development/incidence of upconing of saline groundwater (Daga, 2007:180).

The groundwater resources are at threat due to their fast depletion and hence need protection and preservation to ensure future security of water availability in Delhi. It is interesting to find that most of the areas mentioned in the notice have been selected during the primary survey. Areas like Mehrauli, Vasant Kunj are found deficient in DJB's water supply in the survey, and hence citizens are bound to utilise groundwater by drilling private wells. The CGWA notice is compatible with the survey results. This situation is an explicit outcome of inadequate municipal water in these areas. This further gives scope for the private suppliers of water and packaged water suppliers for the profiteering venture of selling water by extracting groundwater by boring private tubewells in the region (Daga, 2007:181).

As mentioned before, because of its specific features and structural organisation, the public water utility (DJB) service works as a *natural* monopoly, hence, the service is often managed and supplied by government: municipalities under the authority of the government (Clark and Mondello *in* Goetz and Berga, 2003:69, emphasis added). The distribution of water obeys the theoretical rules of a natural monopoly. As an analytical consequence, knowing that water management is a natural monopoly does not automatically solve the management problems. In the case of water, Clark and Mondello (*in* Goetz and Berga, 2003:72), argues that,

> The key questions are allocation and distribution with respect to regulatory constraints, pricing, current output and investment that will determine future output.

The same authors maintain that, 'the answers to these questions are complicated by ethical considerations related the special status of water as indispensible to life itself.' Further it is maintained in the water literature that,

> The special status of water limits the role of water as a purely economic good and implies a special set of conditions for the water monopoly that recognise that no one can be excluded because of price (Goetz and Berga, 2003:72).

This is true because there may be instances, say for example; certain sections of the society may not be able to pay for water or 'have sufficient financial resources to pay the economic price for scarce water' (Goetz and Berga, 2003:72), for example, people dwelling in the *slum* areas of Delhi. The important concern in the true spirit of water governance should be that poor must not excluded in terms of accessibility of water. While framing any policy for the sound water governance, it is worthwhile to note that quality, quantity, accessibility etc. are relative terms, and it varies across households, time and space. Therefore, a deliberate pricing policy which diverts the resources from those who can really pay more, towards the poor who would be paying less, should become the prime element of the 'good' water governance in Delhi.

At the household level, it is felt that, 'the price of water is too low for people to care about its conservation' (Dasgupta, 2010:33). According to some residents, 'it is water shortage, and not their water bill that set them thinking about reducing water wastage' (Dasgupta, 2010:33). Others view that, 'to promote water efficiency, it is needed to introduce a law that makes use of water efficient fixtures mandatory. In this direction, a bureau of water efficiency might work (Dasgupta, 2010:33).

DJB is undertaking measures to increase the water supply capacity (Daga, 2007:181) in coming times. Major water treatment plants are under construction. To be optimistic, the city's water supply will improve, and reliability of water supply will be better than before. The proposed long term water augmentation projects will definitely prove beneficial in this direction (Daga, 2007:181). However, keeping into the consideration the failure of the DJB on many grounds, it is important to reconsider the factors attributable to the city's water supply delivery system. It needs careful scrutiny of the current policies and the future prospects of these policies on effective water governance in Delhi. Estimation of residential demand for water in Delhi, in the light of inequitable water allocation, shall prove a milestone in designing sustainable water prices. This will enhance DJB to make supply compatible with the estimated demand. Mitigating the inherent institutional bottlenecks within the DJB shall of course be the priority.

Summary and Conclusion

It can be safely concluded that from the analysis, that residents demand water at a 'sustainable' price. This 'sustainable' price should satisfy all major social, economic, and environmental issues at the policy formulation level. However, politics in determining water tariff should not outweigh other indicators of water demand. The analysis of the present work would suggest some 'state of the art' measures to improve household water both qualitatively and quantitatively. The work would suggest institutional reforms in the area specific to pricing of water consumed by the residents in Delhi. The econometric work tries to establish the fact that household water demand is responsive to certain changes in policy variables like price or income elasticity coefficients. It is important then to consider valuation of water based on criterion like, coping costs, which the residents are paying for domestic water.

The entire work would suggests that, governance in the urban water delivery system in Delhi urgently needs capacity as well as capability building on the part of water governing institutions, residents and other stakeholders for equitable and adequate availability of water across areas and residents. The work also mandate the idea that residents having excess water for necessary and non necessary consumption needs should curtail consumption and use water judiciously. It is where the economic valuation of water is important. This could only be achieved if there is revision in prices that suit consumer's demand as well as retain the financial sustainability of DJB. There is clear indication in the present work that the city's water supply system is unable to cope with the demand of the residents. A structural change in the form of pricing water, keeping in view the weaker sections of the society seems need of the time. It is theoretically true in the analysis, that 'uneconomic' price being paid by the residents for water is actually implausible for the preservation and conservation of water resources from the environmental perspectives in times to come. Keeping this in mind, the 'sustainable' water pricing requires influential role of the decision makers in the formulation of policies destined to bring efficiency in the service delivery mechanism of the DJB, and on the other side, satisfaction among residents availing utility's services.

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Household Survey on Water Consumption in Delhi

Area/District/Location: ______________________________

Type of Colony: ____________________________________ Date: __________

{Note: Please fill up the following information}

01. Name ______________________________________.
02. No. of members in family (i) Adults____________. (ii)Minors____________.
03. No. of working members in family _________________.
04. Monthly income of the head of the family ____________.
05. Educational qualification of the head of the family_______________________.
06. Source(s) of household water (e.g. DJB piped water, private sources etc.). If the source is private one, please mention the particular source.

    ____

    ____
07. Average number of hours of water supply per day _______________________.
08. Pressure of supply (defined in terms of time required to fill a 15 litre bucket) __________.
09. How much is your average daily consumption of municipal water? _______________________.
10. How much water you roughly consume in winters and summer months? (i) Winters _____________. (ii) Summers__________________.
11. Sufficiency of water (Yes/No) _________________________.
12. Are you satisfied with the present supply services being rendered from the present source of water supply _________ (Yes/No)? Could you please account the reasons for your response?

    ____

    ____

    ____
13. Do you feel that DJB is inefficient in water service delivery to residents in your area in Delhi? (Yes/No) _________.
14. Do you think that there is water scarcity in Delhi? (Yes/No) _______________.

15. What is the monthly water bill you pay to DJB? ________________________.

16. What is your average monthly electricity bill? ___________________________.

17. What is your monthly expenditure on water from other sources like Private Water Tankers, Packaged Drinking Water, Storage Tanks, Water Filters, etc.? ____

18. Do you feel that you are actually paying less for water and unaware of water wastage, at times when the population of Delhi is rapidly increasing and limited water resources to fulfill the growing water demand in present and in future? (Yes/No).

____

____

19. Do you think that if you pay more, DJB will be able to improve the water supply system; hence you get enhanced and reliable supply? (Yes/No)_________. Could you please account the reasons for your response?

____

____

____

If you have anything else to share on water situation in Delhi, please do write to me at: rakeshks.jnu@gmail.com. Thank you.

Data from Primary Survey

Area	HH	HH_Size	Adult	Minor	Water Consmp. Per HH (Q Lt/Day)	Sufficiency	Average Monthly Coping Cost (Rs.)	Average Monthly Water Bill (Rs.)	Average Monthly Electricity Bill (Rs)	Average Monthly Income (Rs.)	Average No. of Hrs of Water Supply Per Day	Educational Status of Head of the family
Mehrauli	1	3	2	1	550	0	900	376	1400	18000	2	Grad
	2	5	3	1	475	0	850	370	1250	17500	2	PG
	3	4	2	2	360	0	900	362	1350	12000	2.5	PG
	4	2	2	0	350	1	750	256	1500	15000	1.4	Grad
	5	6	3	1	580	0	750	351	1300	16000	1.5	Inter
	6	3	2	1	450	0	600	237	1250	13000	1	PG
	7	6	4	2	329	0	700	320	1100	18000	1	PG
	8	7	4	3	328	0	850	329	1350	20000	2	Grad
	9	5	3	2	325	0	900	300	1200	16000	1.5	Inter
	10	4	2	2	350	0	800	345	1900	17500	1.3	Grad
	11	4	2	2	330	0	900	296	1600	25000	1	PG
	12	2	2	0	360	0	700	303	1780	10000	1.4	PG
	13	4	2	2	400	0	750	340	1500	17000	1.2	PG
	14	6	3	3	350	0	600	325	1450	15000	2	Grad
	15	3	2	1	330	1	900	320	1600	12000	1	Grad
	16	3	3	0	325	0	700	315	1200	18000	1	Inter
	17	5	2	3	350	0	600	314	1350	30000	1.5	Grad
	18	4	2	2	440	1	650	378	1200	14000	2	PG
	19	8	5	3	400	0	800	351	1350	16000	1	Grad
	20	7	4	3	326	0	650	279	1400	22000	1.4	Inter
	21	2	2	0	200	1	900	202	1700	10000	1	PG

	22	6	2	4	300	1	700	357	1900	9500	6	PhD
	23	8	4	4	500	0	600	340	1800	9500	6	PG
	24	4	3	1	450	0	700	325	1350	10000	5	PG
DCB	25	3	3	0	250	1	350	110	600	25000	6	PG
	26	8	5	3	450	1	200	123	740	20000	5.5	PhD
	27	3	2	1	280	1	275	102	750	26000	6	PhD
	28	4	4	0	250	1	270	98.5	930	30000	6	Grad
	29	4	2	2	320	1	200	113	800	25000	5	Grad
	30	4	2	2	400	1	250	123	750	36000	7	Grad
	31	5	3	2	500	1	200	125	650	40000	6	Grad
	32	2	2	0	450	1	200	127	760	20000	6	PG
	33	2	1	1	300	1	250	112	700	18000	6	PG
	34	8	5	3	900	1	250	203	550	16000	5	Grad
	35	7	3	4	850	1	200	190	650	20000	6	Grad
	36	8	6	2	800	1	250	178	900	21000	6	PG
	37	6	3	3	740	1	270	157	460	25000	7	PG
	38	6	4	2	624	1	250	134	760	36000	5	PhD
	39	4	4	0	500	1	350	139	550	35000	5	Mphil
	40	5	2	3	675	1	400	136	675	16000	7	Grad
	41	5	4	1	625	1	500	127	650	17000	6	Grad
	42	5	5	0	600	1	350	130	755	18000	5	PG
	43	3	2	1	500	1	430	132	800	20000	5	Grad
	44	2	2	0	400	1	300	122	550	22000	6	PG
	45	7	5	2	800	1	200	178	650	34000	6	Grad
	46	2	2	0	300	1	450	119	750	25000	6	Grad
	47	8	5	3	800	1	300	184	950	40000	6	PG
	48	7	4	3	750	1	250	167	900	16000	5	PG

	49	7	6	1	700	1	300	158	800	13000	7	Grad
	50	3	2	1	400	1	250	137	600	18000	6	PG
V. V. NNS	51	2	2	0	150	0	200	0	200	6000	0	Matric
	52	2	1	1	100	0	200	0	200	5000	0	VIIth
	53	4	3	1	200	0	250	0	200	7000	0	Inter
	54	5	3	2	300	0	200	0	200	5500	0	Primary
	55	7	4	3	350	0	230	0	200	5000	0	Primary
	56	8	4	4	300	0	250	0	200	7000	0	Primary
	57	3	3	0	200	0	300	0	200	6500	0	VIth
	58	2	2	0	150	0	200	0	200	7500	0	Middle
	59	5	3	2	300	0	250	0	200	8000	0	Inter
	60	6	4	2	200	0	300	0	200	7500	0	Primary
	61	6	3	3	200	0	350	0	200	5500	0	Primary
	62	4	4	0	300	0	200	0	200	7600	0	Matric
	63	2	2	0	200	0	200	0	200	8000	0	Grad
	64	1	1	0	100	0	150	0	200	9000	0	Primary
	65	4	2	2	150	0	250	0	200	5000	0	Primary
	66	6	4	2	100	0	300	0	200	6500	0	Grad
V. V. Posh	67	2	2	0	600	1	1500	655	2200	45000	2	PG
	68	3	2	1	650	1	1600	668	2300	40000	3	PG
	69	3	2	1	650	1	1500	651	2000	50000	3	Grad
	70	3	3	0	700	1	1700	720	2500	40000	3	PG
	71	5	2	3	600	1	1200	655	2700	35000	3	PG
	72	4	2	2	500	1	1500	569	2950	55000	3	PG
	73	1	1	0	600	1	1000	700	1400	39000	2.5	PhD
	74	4	2	2	750	1	1200	776	2000	38000	2	PG
	75	4	2	2	700	1	1500	756	1550	40000	2	PG

	76	5	4	1	900	0	1500	701	1700	25000	3	Grad
	77	6	4	2	800	1	2000	676	2200	70000	2	Grad
	78	7	5	2	900	0	2000	712	2500	50000	3	Grad
	79	1	1	0	300	1	1000	445	2300	45000	4	Grad
	80	7	4	3	800	0	2000	770	2100	35000	4	PG
	81	8	4	4	1100	0	2000	712	1900	60000	3	PhD
	82	8	6	2	1000	1	2500	700	1800	50000	4	PhD
	83	2	1	1	400	1	1000	423	2000	30000	2	Grad
	84	3	2	1	500	1	2000	450	1400	28000	4	PhD
	85	3	2	1	400	1	2000	401	1300	55000	3	PG
	86	3	3	0	500	1	1500	445	1500	60000	3	PG
	87	4	2	2	550	1	2000	451	1500	40000	3	PG
	88	7	5	2	800	0	2000	681	2200	35000	4	Grad
V. Kunj	89	5	3	2	500	0	1000	441	1300	22000	3	Grad
	90	8	4	4	800	1	1200	650	1600	18000	3	Grad
	91	2	2	0	300	0	600	376	900	15000	3	Grad
	92	2	2	0	400	0	700	350	1000	20000	3	Grad
	93	4	3	1	500	0	1000	375	1100	18000	4	Grad
	94	6	3	3	700	0	1200	550	1500	13000	4	Grad
	95	2	2	0	400	0	800	350	800	20000	2.4	PG
	96	3	2	1	450	0	1000	365	1000	16000	2.5	Grad
	97	4	4	0	500	0	850	371	1300	13000	3.5	PG
	98	4	3	1	500	0	1000	365	1300	15000	4	PG
	99	4	2	2	400	0	1200	346	1400	18000	3	PG
	100	7	3	4	700	0	1500	450	1700	17000	3	Grad
	101	6	4	2	750	0	1000	455	1800	22000	4	PhD
	102	6	3	3	800	0	800	675	1500	16000	2.5	Mphil

	103	5	2	3	600	0	800	565	1500	23000	3	Mphil
	104	4	2	2	500	0	750	410	1400	21000	3	PhD
	105	5	3	2	650	0	900	400	1700	18000	3	PhD
	106	2	2	0	200	1	600	245	1200	12000	3	PG
	107	2	2	0	250	1	600	250	1400	23000	4	PG
	108	2	2	0	250	1	500	255	1000	21000	2	PG
Munk. DDA	109	5	2	3	540	0	700	346	900	18000	3	PhD
	110	7	4	3	500	0	800	391	1050	17000	35	PhD
	111	3	3	0	300	0	600	440	800	18000	4	PG
	112	5	3	2	500	0	800	350	1000	20000	2.5	PG
	113	4	2	2	550	0	750	356	1000	25000	2.5	PG
	114	4	2	2	480	0	700	340	1100	18000	3	PG
	115	3	2	1	300	1	700	300	900	21000	3	PG
	116	7	5	2	800	0	1000	451	1400	21000	3	PG
	117	6	4	2	750	0	800	500	1200	19000	3	PG
	118	3	2	1	300	0	750	368	1200	20000	4	Grad
	119	1	1	0	100	1	250	200	700	18000	4	PG
	120	2	2	0	250	1	500	346	800	22000	4	Grad
	121	2	2	0	200	1	600	230	800	25000	4	Grad
	122	5	3	2	450	1	800	344	1200	20000	3	Grad
	123	8	6	2	800	0	1200	700	1500	30000	4	Grad
	124	3	2	1	300	1	600	250	1100	18000	3	PhD
	125	3	2	1	340	1	600	256	1200	20000	4	Mphil
	126	4	2	2	350	1	800	260	1300	22000	3	PhD
	127	7	4	3	600	0	1000	651	1500	20000	3	PG
	128	1	1	0	140	1	300	175	700	20000	3	Grad
V. k	129	4	2	2	340	0	400	246	750	15000	2	Matric

	130	5	4	1	530	0	550	355	950	18000	2	Inter
	131	4	2	2	440	0	500	300	860	20000	3	Inter
	132	6	4	2	650	0	600	356	1000	17000	2	Grad
	133	3	2	1	320	1	300	340	640	15000	2	Grad
	134	4	2	2	550	0	400	350	550	17500	3	Grad
	135	4	2	2	540	0	500	400	900	18000	2	Inter
	136	4	2	2	450	0	400	355	890	12000	2.5	Inter
	137	2	2	0	200	1	400	166	750	17000	2.5	Inter
	138	2	2	2	220	1	300	170	700	16500	3	Primary
	139	8	6	2	600	0	700	350	1000	18000	2.5	Grad
	140	7	4	3	850	0	800	500	1200	20000	3	Grad
	141	6	3	3	640	0	750	451	1300	22000	2.5	Grad
	142	3	2	1	420	1	300	430	600	17500	3	Inter
	143	5	4	1	500	0	500	400	1000	14000	2	Inter
	144	5	2	3	450	0	650	375	1000	15500	2	Grad
	145	4	2	2	400	0	450	430	850	17500	3	Grad
	146	6	4	2	430	0	500	300	900	19000	2	Grad
	147	4	2	2	400	1	350	350	800	20000	3	PG
	148	5	2	0	800	0	400	450	1000	15000	2	PG