Innovations

An Exploratory Study on Determinants of Water Scarcity in Delhi

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Abstract:

After oxygen, water is the important fundamental component of life. Anything that disrupts the availability and quantity of water tends to disrupt humanity's ability to survive. The scarcity of water puts the sustainability of the natural resource base in jeopardy, affecting all social and economic sectors. Since safe access to water is essential to peoples' diverse means of subsistence, the micro levels organisations such as local communities and households evidently experience water scarcity. Water resources in Delhi are under tremendous strain due to a combination of factors including a sharp rise in water demand, deteriorating water quality, groundwater depletion, inter-sectoral conflict and competition for water and system's bottlenecks. Despite Delhi's prominent position, it does not provide a fair representation of the supply and distribution of water. Many rural and urban areas do not receive water in accordance with prescribed norms. Even though hydrological and climatic statistics show no substantial change in the availability of water over the past fifty years, a sizable portion of both rural and urban areas nevertheless experience water shortage. People do not receive water that is of appropriate quality, in sufficient quantity or both, in a timely manner. In fact certain social, economic, political and institutional variables are accelerating and intensifying water shortage and inequality. The research work necessitated a wide range of primary and secondary data. The collected information has been analyzed and interpreted with the help of statistical technique and GIS mapping environment. This paper is a micro-level investigation that covers an entire city. This study therefore aims to investigate the determinants and nature of the water scarcity situation in Delhi. It also suggests pragmatic solutions and policy recommendations for ensuring access to affordable clean water to everyone.

Key words: 1.Water Scarcity, 2.Climatic Condition, 3.Water Resources, 4.Urban Area, 5.GIS Environment, 6.Non Revenue Water

Introduction

Water is regarded as the elixir of life, yet over exploitation of this vital resource and inefficient water usage across sectors as a result of poor policies has resulted in worldwide water shortages. All facets of society including people, enterprises, civil society and the government, must take prompt action to address the rapidly declining supply of precious and rare water resources caused by the expanding population. The water problem is one of the century's greatest challenge faced by different nations worldwide (World Economic Forum, 2019). There is strong global agreement that resource mismanagement is the only cause of the present water crisis. India is not an exception to this and is extremely accessible to water stress (Schleifer, 2017). As a result of India's rapid socio-economic expansion and, more specifically, its wasteful use of water, the country's per capita water attainability, a measure of water scarcity, continues to significantly decline. Along with population growth, it is anticipated that climate change will exacerbate the situation. For instance, the amount of water accessible per person has reduced from 1816 cubic meters in 2001 to 1588 cubic meters

in 2011. Additionally, to satisfy its demands as of 2011, India required getting 30 percent of its water from nearby nations (Levy and Sidel, 2011). Due to growth of population and urbanization, domestic water use is expected to increase almost double by the middle of the century despite the fact that agriculture uses more than 85 percent of freshwater resources (Amarasinghe et al., 2007). According to estimates, a total of 761 km^3 of water were extracted from India in 2010; of which 688 km^3 or 91 percent of the total was used for agriculture. 56 km^3 was used for municipal purposes while 17 km^3 were utilized for industries (FAO-UN, 2012).

The infrastructure and provision of different services in Delhi are overworked due to the growing population. The city is bordered by cities with a lot of people and significant functional connections to Delhi, including Gurugram, Faridabad, Ghaziabad and Noida. As a result, there is daily population movement for work and other reasons. Therefore, in addition to Delhi's population, a sizable daily migrant population needs basic services. According to UN demographic projections, by 2028, the Delhi region will have around 37.2 million people, surpassing the Tokyo region as the world's most populous metropolitan agglomeration (Economic Times, May 16, 2018).

Over the past few decades, Delhi's National Capital Territory has seen a tremendous increase in demand for fresh water. However, the city administration falls short in both providing inhabitants with drinking water and in the correct recycling of wastewater. There are still certain parts of the city where piped water and sewer services are not available. Areas with access to water services also have issues with supply frequency and quality. Therefore, a comprehensive understanding of the factors apart from increasing population and urbanization that influence water scarcity is necessary to design an adequate and effective planning and administration of water supply systems. Examining determinants of water scarcity in Delhi as well as the possible choices for guaranteeing water sufficiency in the future is crucial in one of the largest megacity of the world.

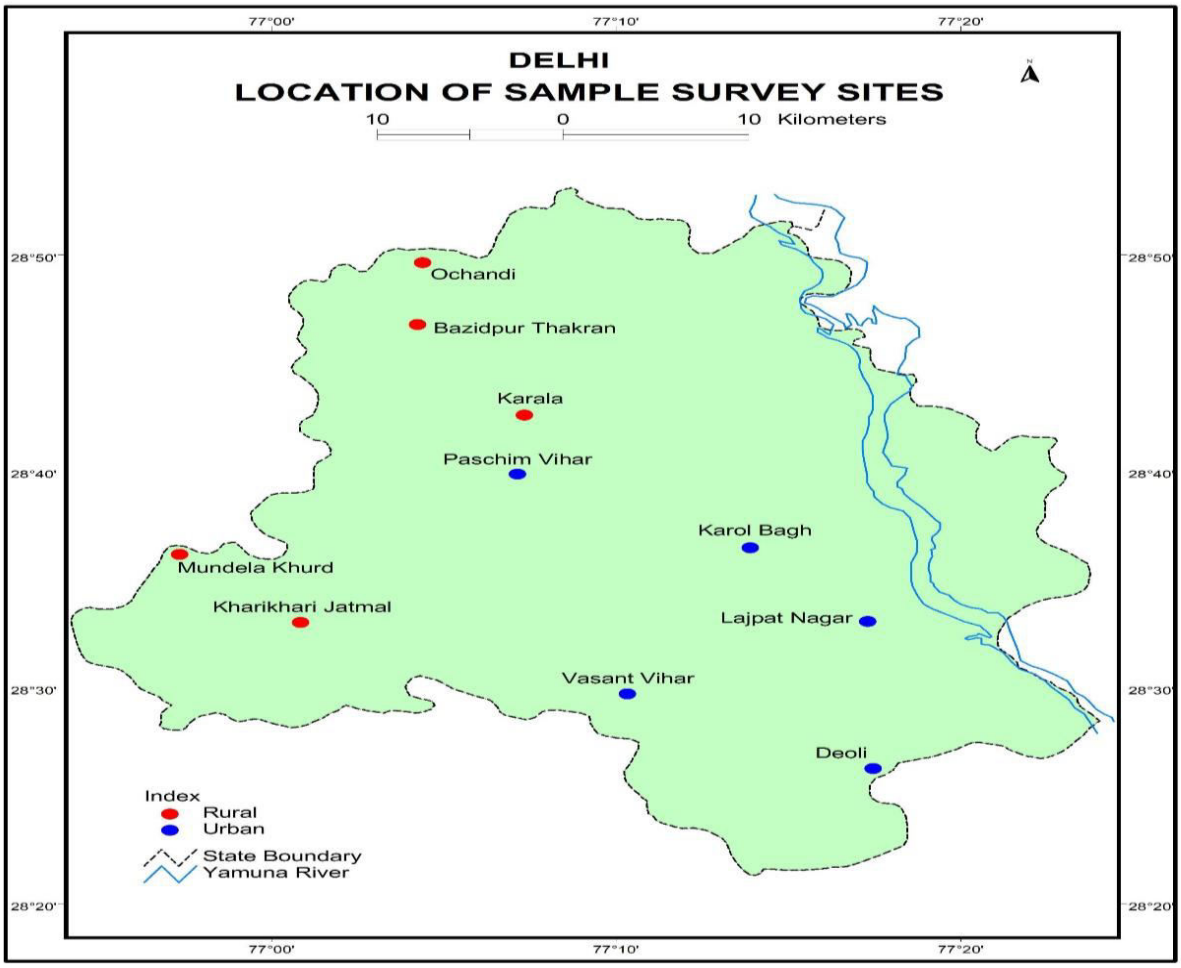
Study Area

In addition to being India's capital, Delhi is recognized for being a historical and ancient city. It is a division of the Indo-Gangetic Alluvial Plains and covers an area of 1483 sq. km. in northern India. Its elevation is between 198 and 220 meters above sea level. Delhi is located on the bank of river Yamuna between latitudes 28°24" and 28°53" north latitude and 76°50" and 77°23" east longitude. It averages 715 mm of rainfall annually, 75 percent of which falls in the months of July to September. The state of Delhi includes three municipalities and nine districts. The Government of Delhi and three Municipal Corporations jointly administer specific areas in the National Capital Territory. The New Delhi Municipal Corporation (NDMC) and the Cantonment Board are the other two, with the Municipal Corporation of Delhi (MCD) being the biggest. The city has experienced water issues in the past and these issues have gotten worse as a result of the city's surface and ground water contamination and ongoing population growth. The Delhi region's water supply supplies are always under severe stress as a result of population increase. The Delhi Jal Board (DJB) is in charge of overseeing the city's water supply. Around 1150 million cubic meters of water are available from surface water sources, including the Yamuna, Ganga and Bhakhara reservoir (MCM). Around 290 MCM of ground water is also available each year. The city needs 3324 MLD (million liters of water) per day, however it only receives around 2034 MLD. Hand pumps and private and municipal tube wells take care of the remaining portion of the demand. Delhi is experiencing a severe water deficit as a result of the declining groundwater level and growing population density.

Database and Research Methodology

The research work is the based on both secondary and primary data sources. Secondary data sources include journal publications, research papers, reports from government and other organisations, media stories and official documents addressing water scarcity concerns in the city whereas primary data was collected through a field survey. Field observation and a structured questionnaire are used to generate the primary data. The

information gathered covers a wide variety of topics, such as water sources, institutional problems, demographic information and additional time spent collecting water etc. 10 sample locations (5 urban and 5 rural) were used to gather primary data in order to determine the degree and determinants of the water shortage. The systematic sampling approach was selected for the household survey in a way that produced an equally dispersed sample. 5 km apart, regular east-west and north-south lines were drawn. to divide Delhi's entire city. For the household survey, the areas that lie on the first and fifth intersecting points were chosen. A total of 500 homes (250 rural and 250 urban) were surveyed and 50 sample households were randomly picked from each analytic unit that was chosen (Figure 1).



Source: Cencus of India, 2011

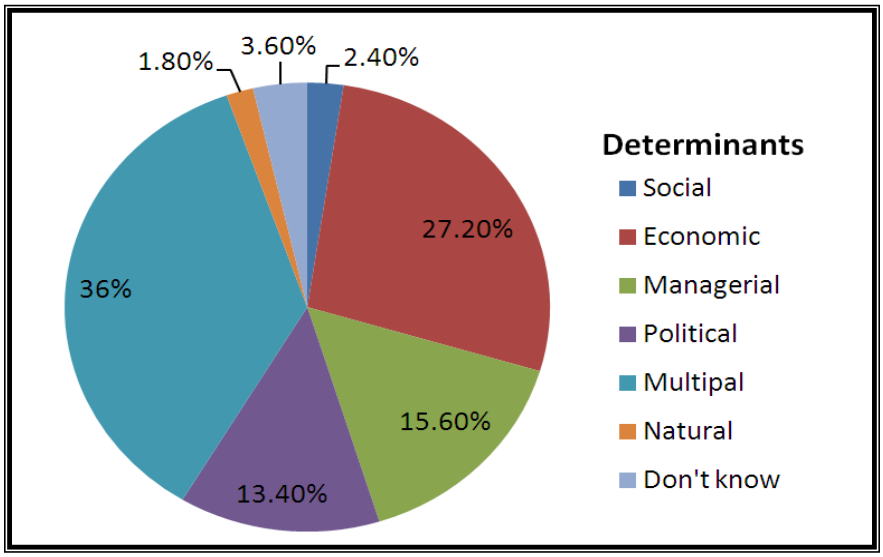
Figure 1 Location of Sample Survey Sites in Delhi

A comparison like this might highlight patterns and perceptions of regional water scarcity. A questionnaire was used to conduct an interview with the respondents and gather a wide variety of socio-economic data as well as details about various elements of water availability, accessibility and determinants of water scarcity. After the field survey, the main data was coded, sorted, and quantitatively analyzed using the appropriate statistical methods.

Analysis and Discussion

Variations in responses to the same situation may be brought on by differences in socio-economic status. Water shortage may also be caused by social and political actions. Political tendencies that result in specific laws and regulations may actually make it difficult for individuals to utilize their resources. The lack of water

might worsen in such a circumstance. Extreme water shortage for the impacted population may also be brought on by discriminatory and oppressive social practices. The results of the field study showed that the majority of respondents blamed a variety of issues for Delhi's water shortage. These elements include socio-economic, managerial and political elements that contribute to water shortage and exacerbate its issues (Figure 2).



Source: Primary Survey

Figure 2 Determinants of Water Shortage

Social Determinants (Caste)

Following the country's independence in 1947, the caste system was eliminated by the government. The Scheduled Castes and Backward Castes' economic circumstances have significantly improved due to incentives for education and employment reservation. Their financial standing secured their equality with the upper classes in society. Despite the fact that caste-based biases and rankings persist. Power and wealth are no longer as closely linked to caste. Caste plays a smaller role in people's day-to-day lives. It is likewise evident from the field review based outcome as just a small level of people (2.4 percent), mostly from rural areas, blamed their caste for the lack of water. According to the respondents caste is not a key factor in determining water shortage in Delhi.

Economic Determinants

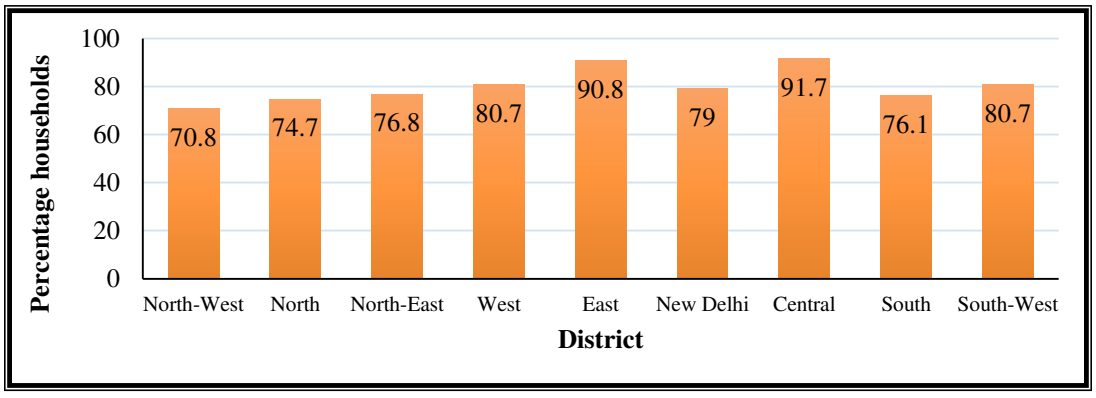
Economic factors for water scarcity include limited availability of water caused by inefficacy to pay for supplies or to provide labor or time for water collection. Money power has been the driving factor behind every resource usage, misuse and conflict (Mathur, 2002). According to Swyngedouw (1997), the locations where the wealthy and influential reside influence who has access to water in metropolitan settings. People with greater purchasing capacity have better access to protected water as a result of co- modification of water whilst the poor bear the brunt of the water issue. The bulk of the population with lower incomes lacks the purchasing power, receives a little part and as a result water becomes a limited resource for them. Of the overall sample of respondents, 27.2 percent said that money or income have a significant impact on the availability of water. Rural areas experience this strongly. Poor residents of J. J. clusters and surrounding regions are especially affected by the difficulties in obtaining water. Economic water shortage frequently relates to both "wasteful" water consumption and people's unmet expectations for water services.

Unprecedented water demand brought on by growing population leads to private water exploitation by the wealthy while impoverished people can not afford it. The availability of water impacts how households live their daily lives. Regardless of the quantity available, piped water is never provided for more than a few hours each day in Delhi whether in urban or rural regions. The majority of homes are compelled to deal with

inadequate water supplies and invest time and money to improve them. Economic disparities in access to water are made worse by the intermittent supply. Households have to create plans to meet demands in order to deal with water constraint. They either adopt compensating tactics by diversifying the availability to water and optimizing their capacity to receive water or they adjust to the circumstance (cutting consumption, reusing water, rescheduling household's activities etc.). Yet again it has to do with financial power. Some coping techniques include installing a filtration system to improve the water quality or using a water pump to aid with supplies when the pressure is low. Only wealthier homes may readily employ any of these solutions and experience reduced water shortages because they can pay for infrastructure, installation, and maintenance expenses (Plate 1).

Plate 1 Economic Variation in Water Storage Devices

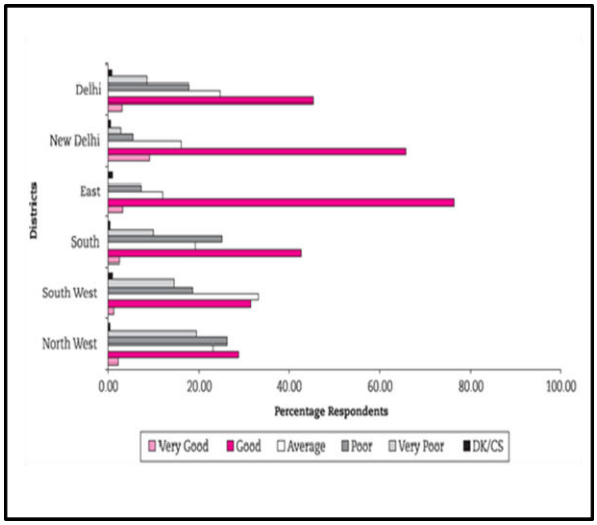
Due to the unreliability of piped water in rural regions as well, only wealthy individuals can afford to bore deeper tube wells as an alternate supply of water, allowing them to largely escape the effects of water shortage. The amount of water delivered to various districts in Delhi varies greatly. Government regulations often prohibit water utilities from installing water pipe networks in unofficial, unplanned housing zones, especially the poorest residents who do not receive water assistance from the government (Singh, 2006). While the majority of government aid goes to higher-income households in planned area. According to the Delhi Human Development Report, 2013, there is not an equitable allocation of water throughout the districts, with the periphery receiving less water per person, particularly in the north, north east, North West, and South district (Figure 3).

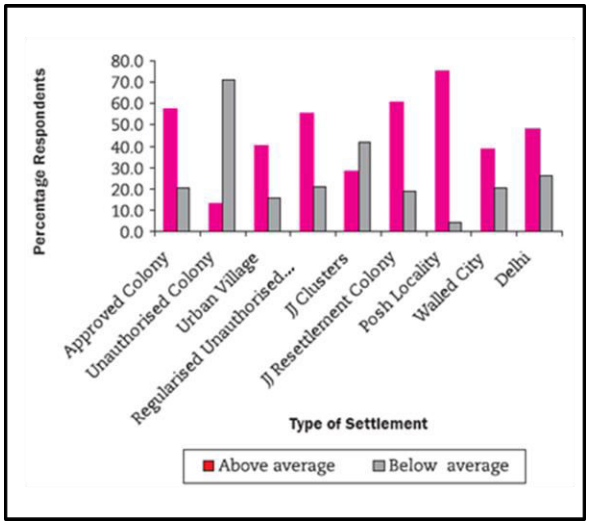


Source: Census, 2011

Figure 3 District wise Drinking Water Availability (in percent)

According to the Delhi Human Development Report's 2013 perception study, there are differences amongst districts in terms of how satisfied residents are with the supply of water (Figure 4). The least satisfied residents were found to reside in the South-West and North-West districts. Whilst those of the East and New Delhi districts gave the availability of water a high rating. Water is not distributed equally even among districts. This is evident from the large percentages of inhabitants who rate the supply of water as extremely low or poor in authorized colonies and J. J. Clusters, whereas respondents from settlements like posh localities and approved colonies appeared happier (Figure 5).





Source: Perception survey, Delhi Human Development Report, 2013.

Figure 4 Availability Rating of Water Supply in Different Selected Districts (percent respondent)

Figure 5 Availability Rating of Water in settlement types (percent respondents)

The Delhi Jal Board and private operators distribute water in addition to piped water for meeting the needs of the people. But even in this situation, a lack of money usually makes it difficult to acquire water. Naturally, the tendency of more affluent households to purchase water directly from water tankers demonstrated their ease of access to water. As a result, wealthy obtain more water than they require, even for their lawns, while the underprivileged must wait hours for a bucket of water (Dhaman, 2005). Although Delhi's underprivileged and needy receive free water, it still comes at a time and financial cost. Fights surrounding water tankers and hours-long lines at water stations are both regular sights in Delhi's slums (Plate 2 and 3).

Plate 2 A tanker keeping a house afloat during a water crisis, Plate 3 A Rigorous Effort to Fill Empty Cans

Therefore, it is evident from the preceding description that people's economic situations had a negative impact on them in many ways; as a result, lower or poorer-income groups of people are more likely to experience the water shortage crisis.

Managerial Determinants

Delhi's water shortage isn't caused by scarcity of water but by poor management. Systematic flaws include inadequate monitoring, institutional responsibility duplication, ineffective operation and management and unsustainable resource management techniques (Maria, 2006). Additionally, it is clear from the field study analysis that 15.6 percent of respondents believed that only management factors were to blame for water scarcity.

Service Delivery

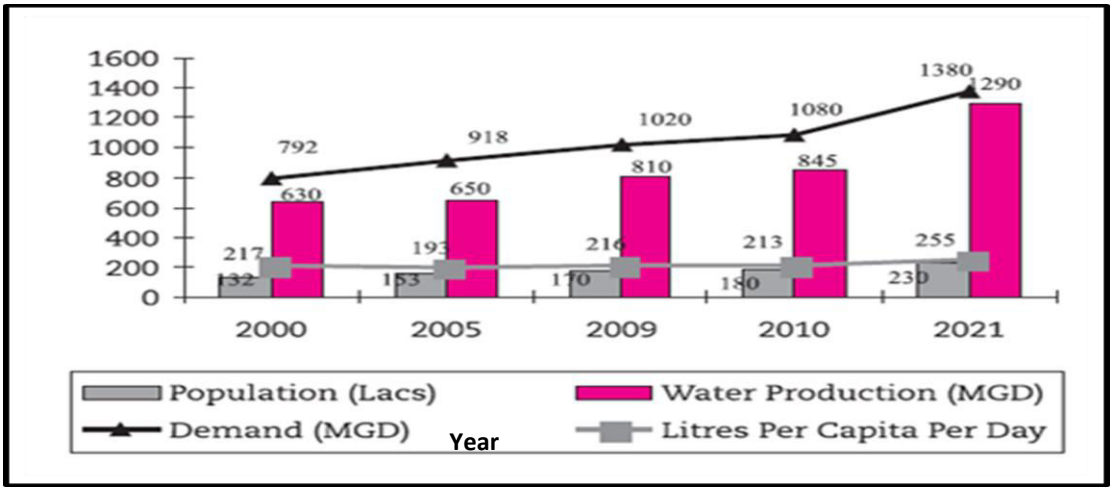
Due to the widening imbalance between supply and demand, the nation's capital is constantly experiencing water shortages from several years (Table 1).

Table 1: Year Wise Water Shortfall in Delhi

Year	Water requirement in MGD	Water production in MGD	Short Fall
2021	1380	1290	90
2010	1080	845	235
2009	1020	810	210
2005	918	650	268
2000	792	630	162

Source: DJB, 2013

Around 845 million gallons of water were produced daily from all sources in 2010, including 100 MGD of groundwater and 745 MGD of surface water. The total amount needed in 2010 was 1080 MGD, indicating a 235 MGD shortage (Delhi Human Development Report, 2013). According to Delhi govt. 2014, by the end of the 12th five year plan, the water supply demand is expected to reach roughly 1140 MGD based on an expected population of 19 million and the DJB's consumption standard of 60 GPCD (Figure 6).



Source: DJB, 2013.

Figure 6 Water Productions and Shortfall in Delhi

DJB has been unable to keep up with the city's growing urbanization. Despite government attempts to increase the production of drinkable water, the infrastructure for water delivery has not kept up with demand, which now ranges from about 25 to 34 percent.

5.3.2 Non-Revenue Water

Unaccounted water, often known as non-revenue water, is a significant issue in Delhi. The difference between the water supplied to the systems and the water sold to consumers is accounted-for water (World Bank, 1999). No revenue is earned by Non- revenue water. The allowable percentage of non-revenue water is 15%, according to the Ministry of Urban Development's manual on service level benchmarking, however in Delhi, DJB's non-revenue water usage over the past three years has exceeded the standard by more than four times (Table 2).

Table 2: Level of Non -Revenue Water in Delhi

Year	Produced water (MGD)	Billed water (MGD)	Non-Revenue water (MGD)	Non-Revenue water percentage
2011-12	818	306.0	512.0	62.6
2010-11	835	293.9	541.1	64.8
2009-10	800	264.2	535.8	66.9

Source: Water Management Thematic Audit Delhi, 2013.

Distribution losses, such as water theft through unauthorized connections and pipe leakage, cause the entire water supply to be lost by 40 percent. This was an extremely large loss of water the 1100 MLD of water that were lost could provide respite to 5.2 million people at a rate of 211 lpcd (Delhi Govt. Report, 2008).

Location of Water Treatment Plants

The water treatment facilities site station planning was flawed. Despite the fact that the majority of the population to whom this treated water is supplied is primarily concentrated in the north and south at a distance of about 30 to 35 kilometres, six of Delhi's eight water plants' main water treatment facilities are situated in an arch that runs from west to east (Figure 7). Leakage, seepage, and theft during shipment cause

the priceless cleansed water to be lost. Due to poor site selection, areas downstream of the distribution network receive less water and suffer from water shortages.

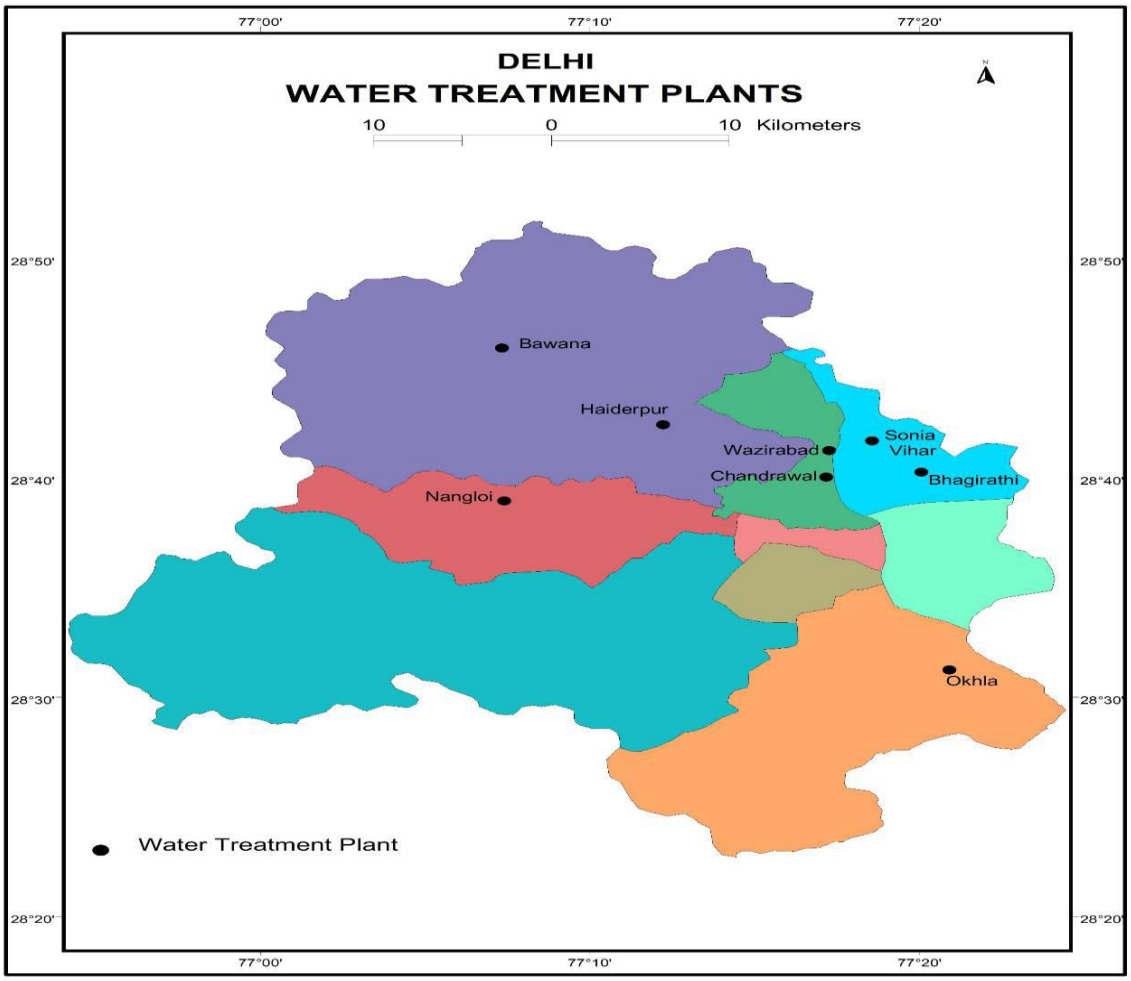


Figure 7 Water Treatment Plants in Delhi

Political Determinants

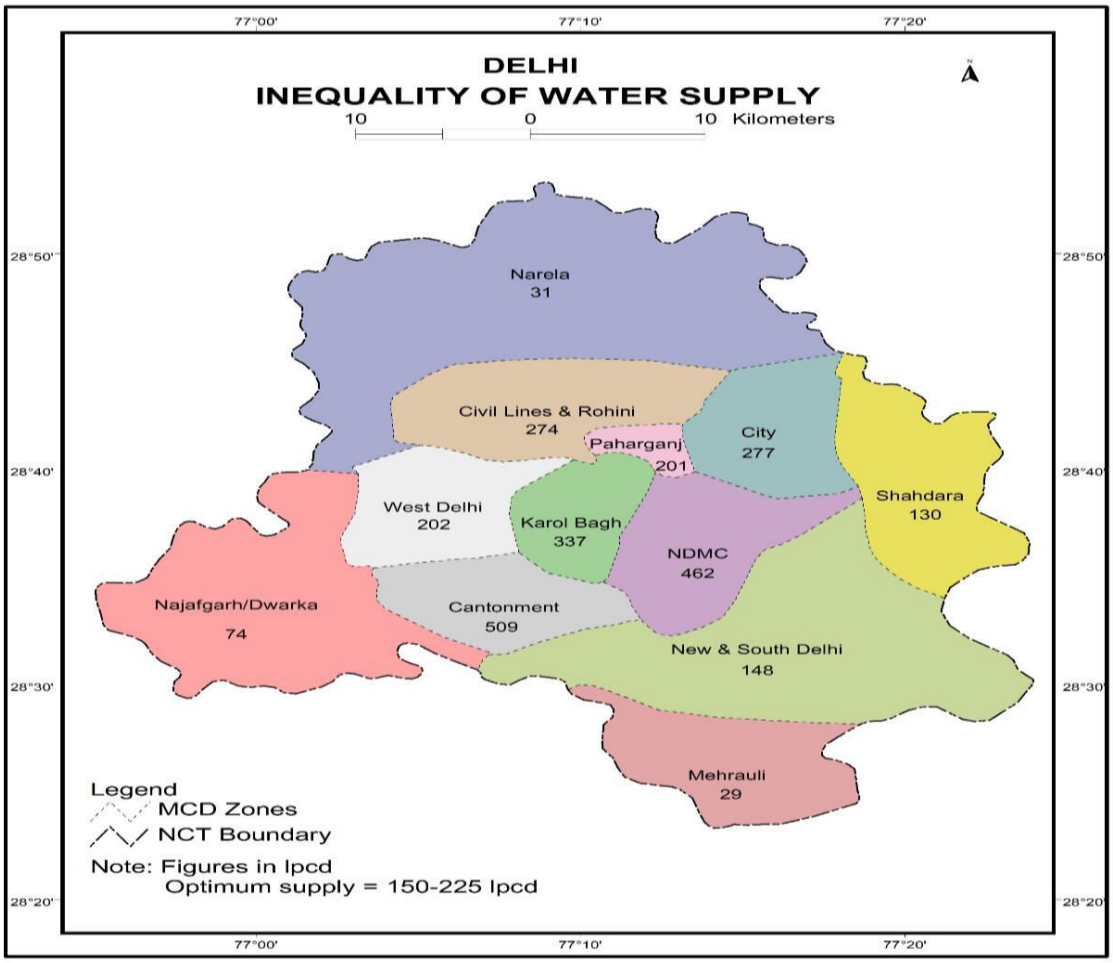
However, Delhi's water shortage is not just a result of physical or technological factors; rather, official policy has played and continues to play a significant role in denying approach to drinking water to some groups of the population. Additionally, it is clear from the field study that 23 percent of respondents believed political factors were to blame for water shortages.

Discriminate Distribution of Water Supply

Politics has a significant influence on water allocation. It is clear from the fact that the NDMC region makes up only around 2 percent of the city's area and receives roughly 30 percent of the water supply (NCW, 2005). Politicians and officials occupy most of this area. While Delhi's outer Delhi, North, West, and North-West Delhi receive less than 5% of the city's water supply, Delhi villages that cover 50% of Delhi's area (Rohilla et al.) 1999). The area outside the MCD boundary is partially surrounded by the water distribution system. According to Delhi Jal Board, urban customers who are connected to the planned water delivery network use 96 percent of the water generated compared to 4 percent for rural users (Govt. of India, 2003). About 30

percent of those living in slums are estimated to have legal access to 7.5 percent of Delhi's water supply (Sanjeev, 1997).

The distribution system in Delhi is biased because many areas do not receive enough water supply (Figure 7).These locations includes several slum settlements as well as periphery districts, both rural and newly built homes. This is brought on by uneven spatial development and an increase in the urban population. Therefore, a lack of infrastructure or an inadequate supply affects both the wealthy and the poor, but obviously not equally.

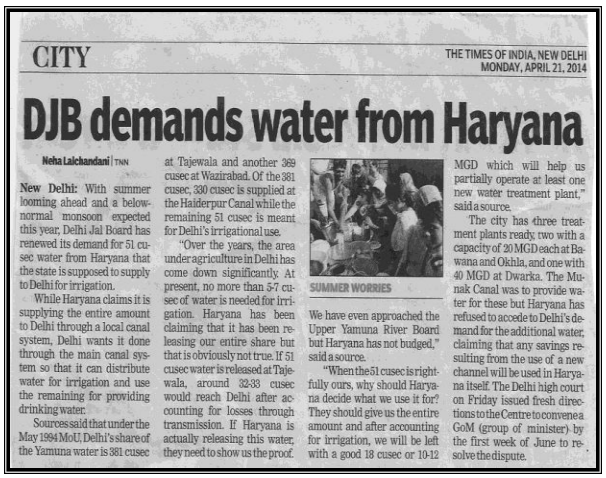


Source: Fact Sheet Delhi, 1999

Figure 7 Inequality Water Supply, Delhi

Dispute over Raw Water Supply

Only 425 cusec of the daily 725 cusec of water that Delhi is supposed to get from Haryana according to their bilateral agreement-actually makes it to Delhi. The water is let out of Haryana into an open channel, where it goes to the city. Over half of this discharged water is lost in visible and physical losses as it travels into Delhi. Evaporation, seepage, leakage,, purposeful canal breaching by farmers to water their agricultural areas, etc. are some of the elements that contribute to this. In order to resolve the issue, the Delhi Government petitioned the Central Government in 2012, but it's not resolved yet completely (Comptroller Auditor General, 2013). With the population increase in Delhi, demand for more water will be also increased automatically (Plate 4 and 5).



CITY

THE TIMES OF INDIA, NEW DELHI
MONDAY, APRIL 21, 2014

DJB demands water from Haryana

Neha Lalchandani | TNN

New Delhi: With summer looming ahead and a below-normal monsoon expected this year, Delhi Jal Board has renewed its demand for 51 cusec water from Haryana that the state is supposed to supply to Delhi for irrigation.

While Haryana claims it is supplying the entire amount to Delhi through a local canal system, Delhi wants it done through the main canal system so that it can distribute water for irrigation and use the remaining for providing drinking water.

Sources said that under the May 1994 MoU, Delhi's share of the Yamuna water is 381 cusec at Tajewala and another 369 cusec at Wazirabad. Of the 381 cusec, 330 cusec is supplied at the Haiderpur Canal while the remaining 51 cusec is meant for Delhi's irrigational use.

"Over the years, the area under agriculture in Delhi has come down significantly. At present, no more than 3-7 cusec of water is needed for irrigation. Haryana has been claiming that it has been releasing our entire share but that is obviously not true. If 51 cusec water is released at Tajewala, around 32-33 cusec would reach Delhi after accounting for losses through transmission. If Haryana is actually releasing this water, they need to show us the proof.

SUMMER WORRIES

We have even approached the Upper Yamuna River Board but Haryana has not budged," said a source.

"When the 51 cusec is rightfully ours, why should Haryana decide what we use it for? They should give us the entire amount and after accounting for irrigation, we will be left with a good 18 cusec or 10-12 MGD which will help us partially operate at least one new water treatment plant," said a source.

The city has three treatment plants ready, two with a capacity of 20 MGD each at Bawana and Okhla, and one with 40 MGD at Dwarka. The Munak Canal was to provide water for these but Haryana has refused to accede to Delhi's demand for the additional water, claiming that any savings resulting from the use of a new channel will be used in Haryana itself. The Delhi high court on Friday issued fresh directions to the Centre to convene a GoM (group of minister) by the first week of June to resolve the dispute.

Plate 4 Demand of Water by Delhi from Haryana water

वॉटर पर स्टेट वॉर

मेरे घर में भी कम करो पानी की सप्लाई : शीला

एक ही बार नहाएं लोग : हुड्डा

कोई झुकने को तैयार नहीं

Plate 5 Dispute between Delhi and Haryana over water

Inter Departmental Debate

The situation in Delhi is quite complex in many ways. There is a frequent conflict between the federal government and t he state legislature for keeping control on the city's growth. New Delhi housing planning projects are developed by the Delhi Development Authority (DDA), which also acts as an implementing body and is in charge of writing the Delhi Master Plan. The Delhi Jal Board is the only organization in responsibility of delivering water to Delhi residents. The residents have experienced severe harassment as a result of the DDA and DJB's lack of cooperation. There is hardly any water in the Dwaraka housing complex that the DDA built to house 1.4 million people (Plate 7).

www.delhi.nbt.in

द्वारका सब सिटी के लोग परेशान, सप्लाई किया जा रहा है बोरवेल वाला पानी

खरीदकर पीना पड़ रहा है पानी

Plate 7 Watery Woes of Dwarka in Delhi

The two official organisations have openly blamed one another for the city's current dilemma. DDA claimed that DJB was responsible for providing water, while DJB asserted that "DDA cannot continue on building dwellings indefinitely." They should provide a source of water before beginning any plan, and then do so (Shukla and Singh, 2005). The National Capital Region Planning Board (NCRPB), in addition to the DDA, is in charge of creating a master plan and comprehensive strategy for the entire National Capital Region, including neighboring towns as well as latent growth towns in Uttar Pradesh, Rajasthan and Haryana in the future. As

the Delhi Administration seeks to lessen the stream of migrants into Delhi by providing enough facilities and stimulus to adjacent cities, the NCRPB's function must be carefully coordinated with that administration. However, the most current data on immigration into Delhi makes it very evident that the Board has failed to address regional issues.

Water Mafia

Water mafia has emerged in Delhi as a result of the city's ongoing water shortages throughout the summer and DJB's failure to satisfy customers. This witness a 400 crore rupees business, derived primarily from DJB water (Saroha, 2013). In Delhi, there are over 250 private water operators who deliver water by tankers (Daga, 2003). The water tankers don't guarantee about the quality of the untreated potable water they provide. These suppliers drill bore wells and tube wells to obtain the water they sell. They rely largely on groundwater for their operations. When demand for water is highest in summer season, private water providers become more significant. The water mafia supplies the majority of Delhi's 45 crore liters of water needed during the summer. Water is put into plastic jugs, bottles, jars, pouches, and other containers and sold by sellers. This generates a sizable daily profit of 1.5 to 2 crores of rupees. The tankers primarily operate in South Delhi. These tankers utilize ground water that is free to extract yet sell each tanker for 1000-2500 rupees for domestic use (CSE, 2012). People are compelled to drink it since there is no other alternative even though it is clearly stated on these trucks that "This water is not drinkable water." Because of this, tankers break all laws and engage in illicit operations like water theft and pilferage while working closely with local officials. For the tankers, shortage is equivalent to a gold rush. The water mafia problem demonstrates how poorly managed and currently insufficient Delhi's water delivery system is to suit the requirements of the populace. The inability of DJB to meet the city's water demands benefits the private water providers. They contribute significantly to closing the gap but at a hefty cost. Delhi's citizens have to depend on them unwillingly or willingly.

Conclusion

Despite being replenished by nature, fresh water is a finite resource. The primary objective of society today, especially the affluent, is to consume more which puts further strain on this finite natural resource. The present paper discussed the causes of water scarcity in Delhi. Economic status, management inefficiency and governmental policies are the main elements that contribute to and aggravate Delhi's water scarcity. The complicated interaction between resources and society is assessed in part by all three factors (economic, managerial, and political). Although water shortage is a physical phenomenon, it is made worse by a number of socio-economic and politico-administrative reasons. The appropriate distribution, management, and conservation of water resources are key components of the solution to the problem of water. The government has taken a number of actions to manage Delhi's water resources including attempts to increase water supply, reduce pollution and save water. To address the issue of water shortage, all water sector stakeholders must work together to resolve the problem of water shortage.

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