



Water Scarcity, Public Investment and Sustainability in Delhi Metropolitan Region: Identification, Challenges and Future Prospects

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Abstract— *Water is the most precious element on the earth. The tremendous increase in population has put intense pressure on all the available resources like land, forest and water etc. Among them, groundwater resources have been exploited the most. This divine component for all the living beings is facing the scenario of scarcity on the planet Earth. Indiscriminate and irrational use of water, its contamination, non-conservation of rainfall and the increasing pressure in the population are the main attributable reasons to be focused on. The spatio-temporal variations in the above-mentioned factors and many others over the last few decades show an increase in the trend of problems of water scarcity. The outcomes and results are being experienced in the everyday lives of the people in the Delhi Metropolitan Area. The present study is concerned with the increased level of water scarcity and low level of public investment in this prime sector. The study is based on both primary and secondary data sources collected from field survey. The result shows spatio-temporal variations as well as intra-regional variations in public investment with varying depths of groundwater in the study areas. The paper also suggests ways like rainwater harvesting, inculcating the ideal way of water flow, increase in vegetative cover, incentives for new irrigation techniques, modification in tile structure for footpath and adoption of green construction technologies etc. to ensure sustainability of the region.*

Keywords— *Identification, Assessment, Public Investment, Sustainability, Water Scarcity.*

I. INTRODUCTION

Water being the most important life-sustaining element of the earth system becomes indispensable for the well-being, welfare of living beings and their natural environment. Every resource on the earth plays an important role in the functioning of the environment, which over some time has been developed. The mismanagement, misuse, pollution, and scarcity of these life-sustaining resources pose a serious threat to the existence of living beings. The term 'water resource' is a broader concept and basically deals with the quality of available water. It is not limited to its physical measure of flows, and reserve, but encompasses

other more qualitative, environmental and socio-economic dimensions. However, estimation of groundwater focuses on the physical and quantitative assessment of the water resource.

Water is essential to the life of the earth surface either organic or inorganic life. About 71% of Earth's area has water bodies, of which oceans, seas, and bays constitute about 1,333,000,000 cubic kilometres of water volume, which is nearly 97% of the total water on Earth. The freshwater that is available i.e., 3% almost 2.5% of it is unavailable as it is locked up in glaciers, polar ice caps, atmosphere, and soil of which a huge amount of water is

highly contaminated, or lies too far under the earth's surface to be extracted at an affordable cost. As an example, we can say, if the world's water supply were only 100 litres (26 gallons), our usable water supply of freshwater would be only about 0.003 litres (one-half teaspoon). In actuality, that amounts to an average of 8.4 million litres (2.2 million gallons) for each person on earth. This supply is continually collected, purified, and distributed in the natural hydrologic cycle.

Population growth, urbanization, and expansion of economic activities lead to increasing demand for water. There are various uses of water for different purposes ranging from domestic, industrial, irrigational to hydroelectric powers, thermal power, recreational. The rising concern is the quantity of quality water being used. The growing scarcity of water due to negligence and insensitive shutting down of eyes while its use and management pose a danger to habitats. It is a growing peril to agriculture, food security, industrial development and the ecosystems on which living beings depend. Scarcity and poor quality of water can have a dramatic impact not only on agricultural production but also on all aspects of everyday life. It is adding to the burden of women very often. The competition for fresh water in the world is rising and thus as predicted the third world war is going to happen for the power of water. The demand for freshwater has skyrocketed with the whirlwind growth of population, agriculture, urbanization, and industrialization during this century. Global water use has more than tripled while per capita use has increased by almost 50 per cent since 1950. It has resulted in dire problems and competition among the various water users. The situation is exacerbated because of water being a common resource. Water is still largely a common property resource (CPR) in the world. Groundwater resources are sources of water that are potentially useful in a critical situation. Uses of groundwater have encompassed agricultural, industrial, household, recreational and environmental activities. All living things require water to grow, flourish and reproduce.

Water scarcity is one of the major issues threatening the sustainability of the world and the mega city of Delhi is no exception to this. Delhi, the capital of India, like other major metropolitan city is the facing the water crisis and the major culprit behind this are the uncontrolled population growth, concretization of land, low quality infrastructure, low water availability, inequitable distribution of water, etc. The population of the national capital is growing by leaps and bounds putting tremendous pressure on the available water resource in the capital. The total population of Delhi metropolitan region was 16.78 million which sharply increased to 20.25 million in 2021 and with a pronounced density of population being 11,312 persons per sq. km (UN

World Population Prospects, 2021). Keeping this scenario intact, the total requirement of water for drinking purpose is estimated to be 1200 Million Gallons per day (MGD) approx. and a deficit in water availability is observed. The scarcity in the drinking water supply is majorly due to due to the over-exploitation of groundwater resources and partly due to lack of public investments in this prime sector. Public investment is one of the best to fight to way to hold control over this silent crisis which is rapidly increasing its foot marks. It can be in form of legislation like mandatory rain water harvesting structure, using water percolation tiles, enforcing water guzzling sectors to adopt science and technology which would reduce their water consumption. It can be also done with direct engagement of people in form of afforestation drive, public camps, social awareness programme and activities, etc. and in other forms as well. Thus, the present study attempts to provide possible measures to reduce water scarcity and ways to increase public investments.

Depth of water in Delhi varies greatly from 1.2m (Yamuna Flood Plain) to more than 64m (in the southern part of Delhi Ridge). Groundwater management aspect emphasizes on augmentation of groundwater resources & improvement in groundwater quality through rainwater harvesting & artificial recharge etc (Shekhar et.al., 2009). In an article by 'Safe Water Network', Delhi Jal Board (DJB), is held responsible for production and distribution of drinking water in the NCT of Delhi. The ATMs, as implemented, have not been well received by residents; in areas without ATMs, there is low willingness to pay. USWEs can be an important part of the solution to address insufficient potable water supply in Delhi slums. Neglects the implementation part by the government (Safe Drinking Water, Dec 2016). The presence of groundwater has been reported in all the formations found in the Delhi region (Sett, 1964). This groundwater is controlled by hydrogeomorphic units in the regions such as the rocky tracts of the ridge, pediments, alluvial uplands, valleys, and floodplains (Bajpai, 2011). However, the alluvial floodplains of Yamuna is regarded as the most proficient area of subsurface fresh water resources in the city. In the business-as-usual scenario, problems of groundwater over-exploitation in India will only become more acute, widespread, serious and visible in the years to come. The frontline challenge is not just supply-side innovations but to put into operation a range of corrective mechanisms before the problem becomes either insolvable or not worth solving. This involves a transition from resource 'development' to resource 'management' mode (Moench, 1994). Throughout Asia—where symptoms of over-exploitation are all too clear—groundwater administration still operates in the 'development' mode, treating water availability to be unlimited, and directing

their energies on enhancing groundwater production. A major barrier that prevents transition from the groundwater development to management mode is lack of information (Shah,1993). The increased level of water shortage & the low level of public investment is leading to an increase in the trend of water scarcity. Indiscriminate and irrational use of water, its contamination, non-conservation of rainfall & the increasing pressure of population are the main attributable reasons. The rate of depletion of freshwater is alarming, yet, public sector is not doing sufficient investments to reduce or restrain Delhi from facing this problem. The spatial and temporal variations are also common in everyday geography of Delhi.

Based on the preceding discussion and reviews, the study will address gaps like the process and patterns leading to disappearance and shortage of water, water scarcity and the associated spatio-temporal variations as well as intra-regional variations in public investment with varying depths of groundwater. Developing the idea, the present research is an attempt to fill this gap by devising a suitable mechanism to facilitate and augment the need of water scarce regions, minimise the demand-supply gap of water and the policy formulation and measures adopted by government to boost public investments to ensure sustainability of the region.

II. OBJECTIVES OF THE STUDY

The underlying objectives of this study are:

1. to identify the water scarce regions in Delhi;
2. to explore and assess the role of public investment made;
3. to identify the potential zones responding to these investments; and
4. to analyse the level of developments based on exploration of irrigation facilities.

HYPOTHESIS

Higher the level of public investment & its proper management lower will be the water scarcity.

III. MATERIALS AND METHOD

3.1 Brief Description of the Study Area

A study area is a geography for which data is analysed in a report and for a map. Study areas are interdisciplinary fields of research and scholarship about particular geographical, national and federal regions. The present study is based on the world's one of the most urbanized cities, Delhi. Located in the North-Central part of India, the capital city of India sits astride primarily on the west bank of the Yamuna River.

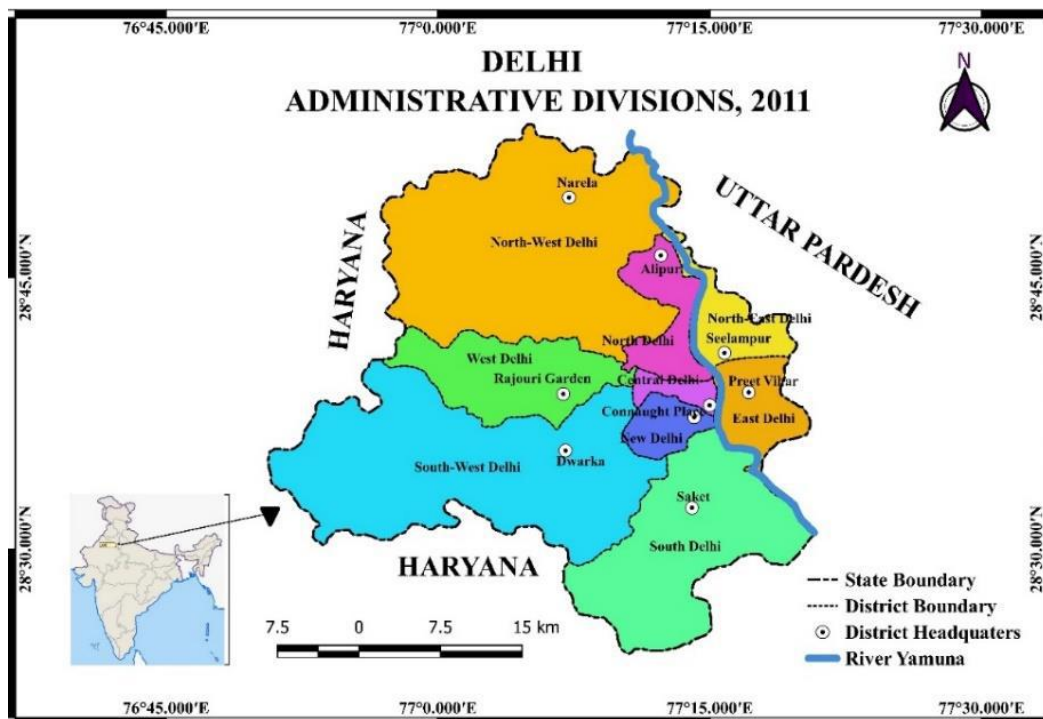


Fig.1: The Study Area

Source: Prepared by Author using QGIS, February-March, 2021

The latitudinal extent ranges from 28° 38' 41.2800' N to 77° 13' 0.1956' E. The climate remains generally dry and

receives an annual rainfall of less than 60 cm. The land use (sq. Km.) pattern is distributed as the Forest area is 16.31

hectares that too of very poor quality, Area as per village papers (Excluding Forest Area) is 1,47,488 hectares, Area Not Available for Cultivation is 92,701 hectares, Another Uncultivable land is 11,124 hectares, Fallow Land is 19,225 hectares, Net Area sown is 22,300 hectares, whereas the Total Cropped Area is 33,455 hectares in which the built-up area includes 3,72,370 Hectares. The Yamuna flood plain area is mainly covered with sandy and clayey soils spreading over a small area. The hydrogeology and aquifer group includes the Alluvium and Quartzite minerals.

Delhi is one of the fastest-growing urban centres in India, with a huge population base, and offering some of the best facilities to its people in terms of infrastructure, transport, health and education facilities consequently attracting a large number of people from all over the country. Delhi gradually developed as an education hub to facilitate quality education of students, who come from other states for pursuing their education here in the city. In the last few decades, the people of Delhi witnessed the emergence of one of the world's most extensive development of education centres like the University of Delhi, Jawaharlal Nehru University, Delhi School of Economics, Indian Institute of Technology, AIIMS etc. Along with the educational migrants, a huge chunk of immigration can be seen in the form of skilled and semi-skilled workers, in search of

employment as along with educational hub, it is also an IT hub, all major government offices, ministries have their headquarters set up here, hence it employs almost 1% population of India alone. Delhi, being the capital of the largest democracy in the world and seat of higher education in India as well as the centre of employment generation attracts immigrants in large numbers. In this rapidly urbanising city of Delhi, water availability thus becomes a necessity to accommodate large numbers of immigrants or such a huge amount of population. Population growth in Delhi has always been a critical factor for city planners and water supply organizations in the city. The earliest organized recorded census of the city was conducted in 1881 during the British era (Census of India, 2011). This practice was continued over the years as part of the decadal Census of India. Thus, the study in this area becomes very significant. A detailed description of the study areas taken for research purposes in Delhi is given below.

3.1.1 WAZIRABAD INDUSTRIAL AREA

The Wazirabad Industrial area is situated in North-East Delhi, near Delhi Jal board water treatment plant situated at 28°44' North latitude & 77°13' East longitude. The area is mostly unplanned and the Yamuna River flows along with a water treatment plant as over some time Yamuna's width has considerably reduced.

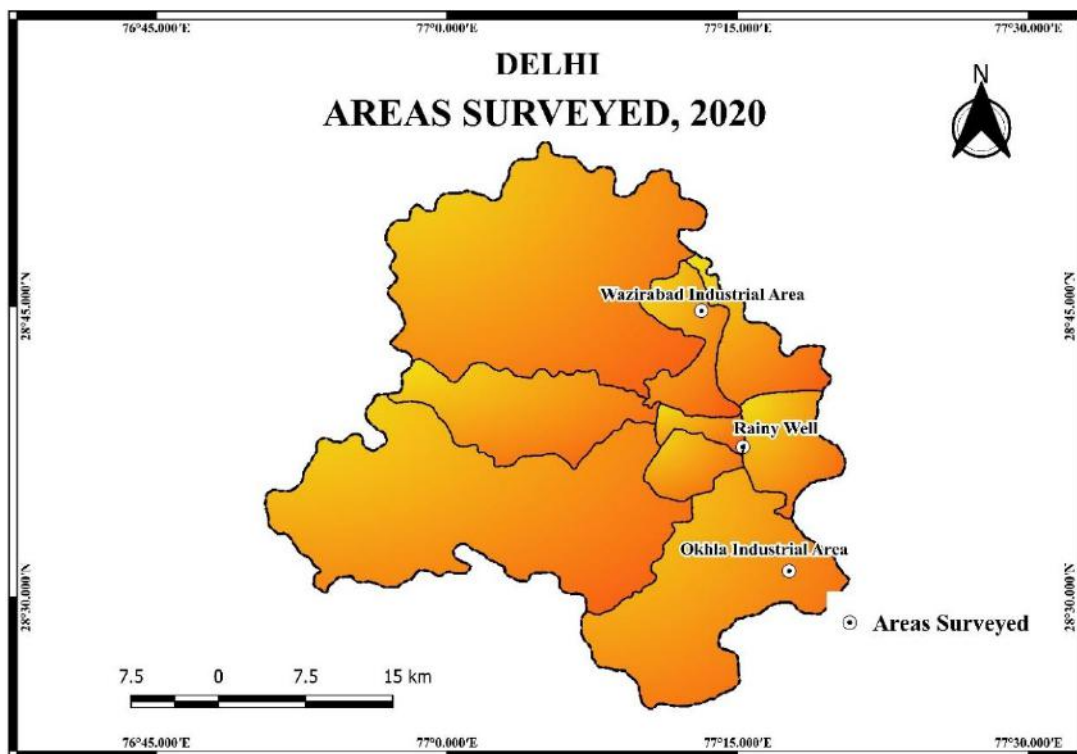


Fig.2: Areas Surveyed

Source: Prepared by Author using QGIS, February-March, 2021

3.1.2 OKHLA INDUSTRIAL AREA

It is situated near Abul Fazal Enclave, Kalindi Kunj, South Delhi at 28°32'8.75" North latitude & 77°16'35.16" East longitude at an elevation of 220.32 Meters (722.84 Feet). The area is mainly engaged in tertiary & primary activities. It is blessed with the Agra Canal for agricultural purposes which are serving it well. The area is having public investment but not getting the desired results.

3.1.3 RAINY WELL

It is located near Rainy well, ITO at 28.6308° North latitude and 77.2506° East longitude, in New Delhi. It is rich in farms and agro-based activities.

3.2 Sources of Data Collection

The present study is based on a combination of both primary and secondary sources of data collection. The major sources of primary data collected includes Questionnaire method, Observation survey, Personal Interview method and Field photograph. A Primary survey was conducted between September-October, 2019 by means of structured questionnaire consisting of 12 questions. Altogether three areas were surveyed across Delhi and a total of 80 respondents were chosen. The questionnaire was administered by the researchers personally via face-to-face interviews to understand the perceptions of the respondents about the role of public investments in their water usage strategies. During the survey, a few observations were made, especially while visiting the site, which gave us a discernment and helped in the better understanding of the theme of research. Field photograph authenticated the

reality. Apart from the primary sources, few secondary sources were also referred. Published Reports, Official Govt. Records, Library archives, Articles etc. relevant to the topic were reviewed and data gathered to validate and provide verity to the results obtained. Data on water resources and public investment was collected from Central Groundwater Resources Reports for various years viz, 2006, 2008, 2011, 2012, 2014, 2017-18, 2018-19 and 2019-20 and Delhi Jal Board Report 2019-20.

3.3 Analytical Techniques and Methodology

A reasonable combination of both quantitative and qualitative methods and techniques have been employed in tabulating, analysing and evaluating the data. As a methodological approach, both thematic and geostatistical techniques have been used like sampling plans, students' t-distribution, bar graph etc. QGIS 3.8.2 is used to map the spatial attribute and results obtained. Pie diagram is largely used to reflect the perception of respondents.

3.4 Z-Test and Hypothesis Testing

The study has used 'Z-test' which is a large sample parametric test with known arithmetic mean and standard deviation. The sample size is more than 30 being 80 for the surveyed areas. Results between 95% _(0.05) and 99% confidence level _(0.01) are accepted and anything falling below, is rejected (Rani, et. al., 2020). The test of proportions has been done for the two areas of Rainey well and Wazirabad Industrial area at 99% confidence level. The Okhla Barrage area has been excluded being a non-residential.

$$Z\text{-Test} = \frac{|p_1 - p_2|}{p^*q^* \left[\frac{1}{n_1} + \frac{1}{n_2} \right]}$$

Where;

p_1 and p_2 are probabilities of acceptance

$$p^* = \frac{x_1 + x_2}{n_1 + n_2}$$

$$q^* = 1 - p^*$$

For the two study areas, the calculated z-score of 1.17924 is less than the tabulated value of 1.96 _(0.05) and 2.58_(0.01). Hence, H_0 stands to be accepted. Thus, there is sufficient evidence to conclude that 'higher the level of public investment & its proper management, lower will be the water scarcity' and vice versa.

IV. RESULTS AND DISCUSSION

4.1 Water Scarcity in Delhi Metropolitan Region

Based on the data provided by Central Water Board Commission, 2019, the worst affected places in terms of water scarcity stands out to be Narela, Dwarka, Bawana,

Sangam Vihar and Burari. All these areas face the issue of water crisis either due to water contamination or lesser supply of water along with depletion of groundwater which escalates this problem. Figure 3 depicts the spatial location of these places in Delhi. The depletion of the water table poses a threat to life. It is a result of the changing land use land cover pattern of the Delhi over years due to developmental processes, where although the area under forest has increased the actual forest cover has reduced considerably, the land concretization for purposes of industrial setup and residential buildings. The change in the land use pattern of Delhi has led to a considerable loss in the depth of groundwater and the untreated effluent discharge

in the water is leading to contamination of limited water available for other purposes. It is during the survey when we explored the Delhi metropolitan area, we came across those people living in unauthorized colonies who have a severe water shortage, especially in summers. Even the places near water bodies like Agra Canal & Yamuna have depleted water table i.e., below 50 feet, that too not the freshwater. It was observed that water scarcity is not only due to depleted water level but also due to water contamination.

Lying above the bedrock beneath Delhi city are groundwater aquifers with alluvial deposits. The bedrock has an elevation ranging from about 190 to above 300 masl. The basement consists mainly of fractured and weathered quartzite hard rock (Bajpai, 2011). Wells sunk in the weathered and fractured aquifers of hard rock generally penetrate down to 80 mbgl but in some places they reach 150 mbgl (CGWB, 2012a). The DJB has estimated that about 115 MGD of groundwater is being exploited through their ranney wells and tubewells (Department of Planning,

2014). About 461,000 of the 3.34 million households in Delhi abstract groundwater, which helps bridge the gap between water demand and supply (Ministry of Water Resources, 2011). However, it has been observed that total annual groundwater draft has declined from 0.48 billion cubic meters (BCM) in 2004 to 0.4 BCM due to reduced groundwater abstraction for irrigation as well as domestic and industrial purposes (CGWB, 2006b; CGWB, 2011). The groundwater level contours of the Delhi region are controlled by a natural aquifer. The groundwater level in the alluvial plains ranges from 192 masl to 216 masl while the general groundwater level contour in the Delhi Ridge and its adjacent area is around 240 masl. The regional water trough near Kharkhari (west of the Najafgarh drain) and Pappankalan (east of the Najafgarh drain) is the result of heavy groundwater abstraction in the southwest district (Sarkar and Shekhar, 2015). These depressions have a strong influence on groundwater row, as can be seen by the convergence of groundwater toward the Najafgarh drain in the southwestern part of Delhi (Shekhar and Sarkar, 2013).

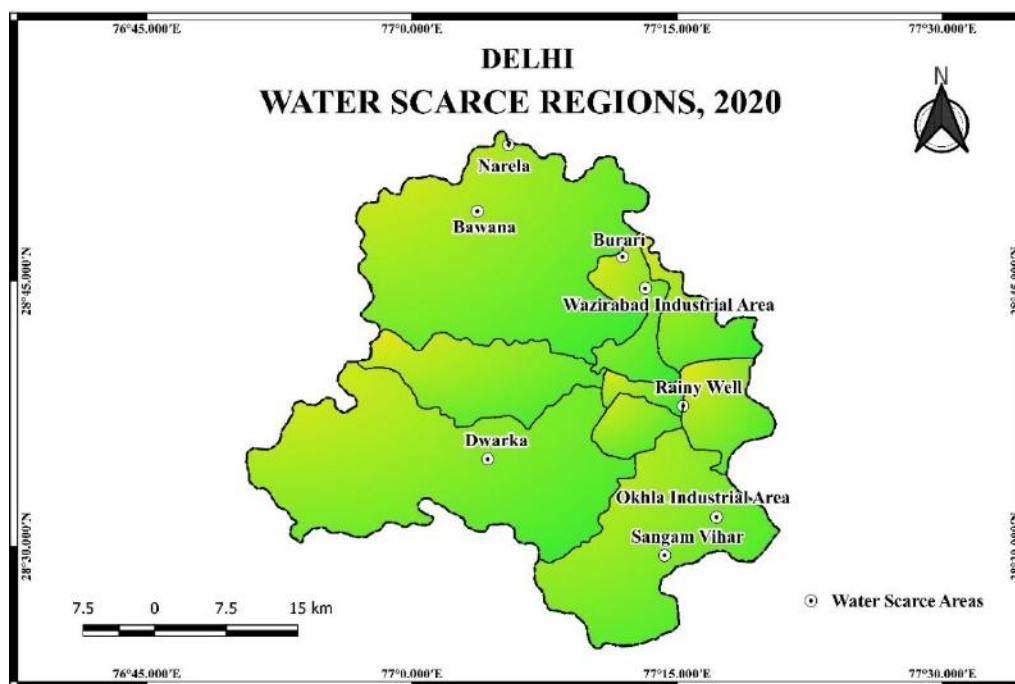


Fig.3: Worst Affected Places in Delhi (2020)

Source: Prepared by Author using QGIS, February-March, 2021

During the field survey, it was observed that the groundwater found at 35 feet was not even suitable for bathing purposes and the boring was done at 100 feet to get fresh water. It can be deduced that groundwater salinity emerged as a common problem in Delhi. The depth to the interface between fresh and saline water, which also varies with contours in the groundwater level, has been Xed on the

basis of varying electrical conductivity ranging from 1500 mS/cm to 2000 mS/cm for groundwater depth (Shekhar et al., 2005). The struggle for water is real and can be seen in the capital (Fig. 4). During the process of mapping the spatial variations concerning the availability of water in Delhi, it was quite discernible that South & South-Central Delhi receives more water than other parts of Delhi, but

there are exceptions (Fig. 3). Public investment in the areas having great potential of extraction of groundwater is quite low & it is likely to have negligible plans of investment shortly. This problem is widespread in nature but also varies over space like Delhi, Bangalore & Chennai on one side its various big-small cities are running out of water at an alarming rate. On the other hand, places like Bihar and Assam experience flood almost every year. It's very ironic that Mawsynram, the world's wettest place, is suffering from the drinking water crisis. At the places where public

investment was done the results were non-satisfactory as the implementation of the public policies was done but further maintenance was disregarded.

The water crisis in Delhi, as visible in the map that different areas in Delhi are water-deficient and the groundwater level has gone down considerably like in Mukherjee Nagar the groundwater level has gone down nearly by 30%, wherein Vasant Kunj and Chhatarpur have seen the depletion up to 100 and 200 per cent respectively (Fig. 5)



Fig.4: Drinking Water Crisis

Source: Primary survey, January,2021

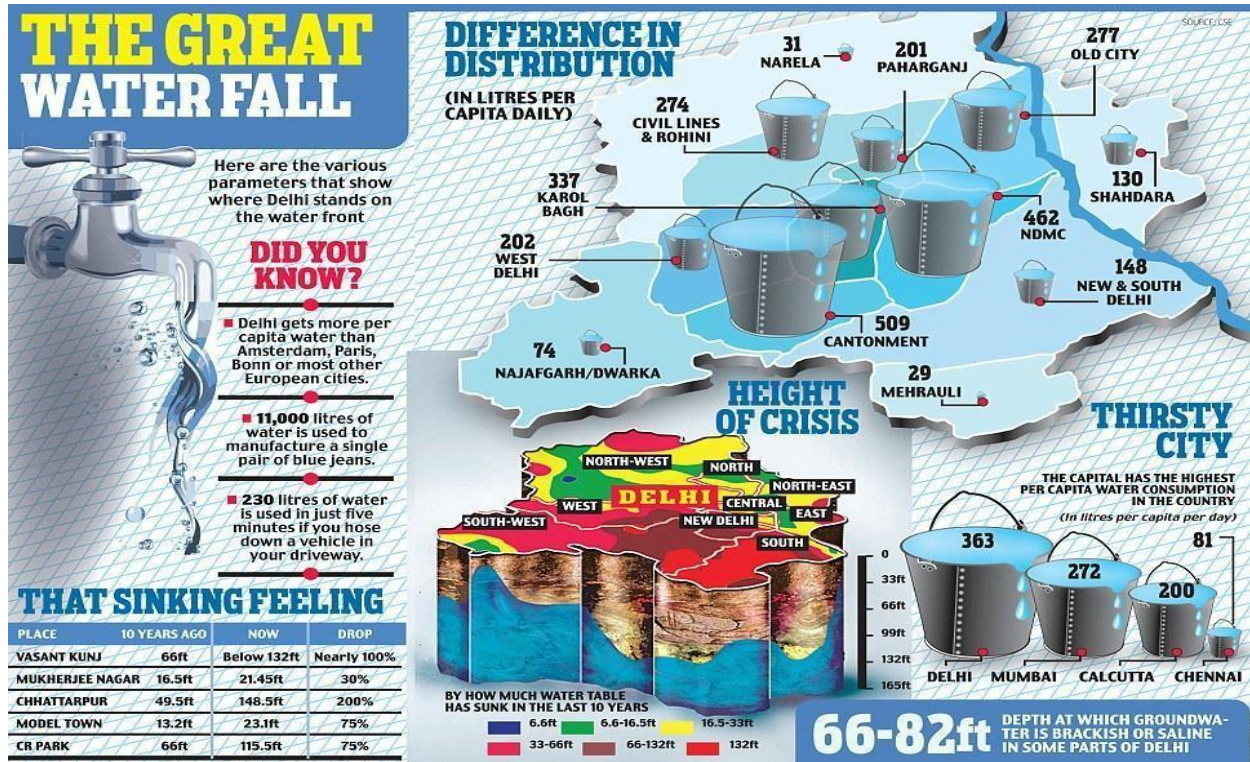


Fig.5: Water Crisis in Delhi Through the Eyes of Media

Source: www.cgwb.gov.in

4.1.1 Wazirabad Industrial Area

The residents of the Wazirabad Industrial Area told us that there is an erratic water supply that gets even worse in the summer season. They rely on tankers during that time. The

untreated sewage from Dhobi ghat and the domestic waste enters the Yamuna directly. The picture below reveals the pathetic conditions of the Yamuna and the people nearby (Fig. 6).



Fig.6: Untreated Sewage from Dhobi Ghat

Source: Primary survey (September-October, 2019)

The Najafgarh drain is the biggest drain in NCT Delhi, discharging 287.5 million litres per day (MLD) (0.2875 million m³/day) wastewater into river Yamuna (NEERI 2002). The Najafgarh drain contributes about 60% of the total wastewater that gets discharged from Delhi into river Yamuna (Kumar et al. 2006). The Najafgarh drain enters Delhi from Haryana from the south-west corner of Delhi. It traverses a length of 51 km before joining river Yamuna (INTACH, 2003). It was informed by an officer from Delhi

Jal Board that for surveillance of drinking water quality in the distribution network, six modern zonal laboratories have been set up in NCT of Delhi, who check the quality of water from Rainy Wells & Tube wells regarding Bacteriological & Chemical aspects in all parts of Delhi. Even though the water treatment plant was near, the region still faces water scarcity, be it in the form of freshwater or water for other purposes (Fig. 7).



Fig.7: Stretch of land along the Yamuna River

Source: Primary Survey (September-October, 2019)

4.1.2 Okhla Industrial Area

During our survey in the Okhla, in a Nursery named Anil Nursery, located about 20 m away from Agra Canal, the boring was done at 100 feet for watering the plant. Harilal, a Nursery worker told us that the water was available at 40

feet, but was highly contaminated, hence unfit to serve its purpose. A 'Barrage' has been constructed in Okhla but it wasn't giving desired results (Fig. 8 A, B & C).



(A)



(B)



(C)

Fig.8: (A). Survey in Anil Nursery, (B) Agra Canal, (C) Okhla Barrage

Source: Primary Survey (September-October, 2019)

4.1.3 Rainy Well

People were living in a very unhygienic and pathetic condition with lack water even for the basic amenities. Most of the people were dependent on agriculture either directly or indirectly, while others were masons. Rainey well is their prime source of drinking water and other domestic water needs. Hardly 100m away from the Yamuna, the average

depth of the boring was 80 feet which they used for irrigation. The water was also available at 40 feet, which was highly polluted and even unfit for bathing. The present state of Yamuna is highly vulnerable and it adversely affects the health of the people and their crops. People face acute water shortages in the months of May-June (summers). Public Investment in this area is nil & the worst sufferers are the locals (Fig. 9).



Fig.9: Survey near Rainey Well

Source: Primary Survey (September-October, 2019)

4.2 Land Use and Land Cover Change in Delhi

Over some time, the built-up area and fallow land in Delhi have increased considerably, wherein the width, quality and quantity of vegetation cover and water bodies have declined

sharply. This has in turn led to further aggravate the water scarcity to a major extent as the groundwater table has declined due to blockage of percolation of water because of concretization, waterlogging etc. (Fig. 10).

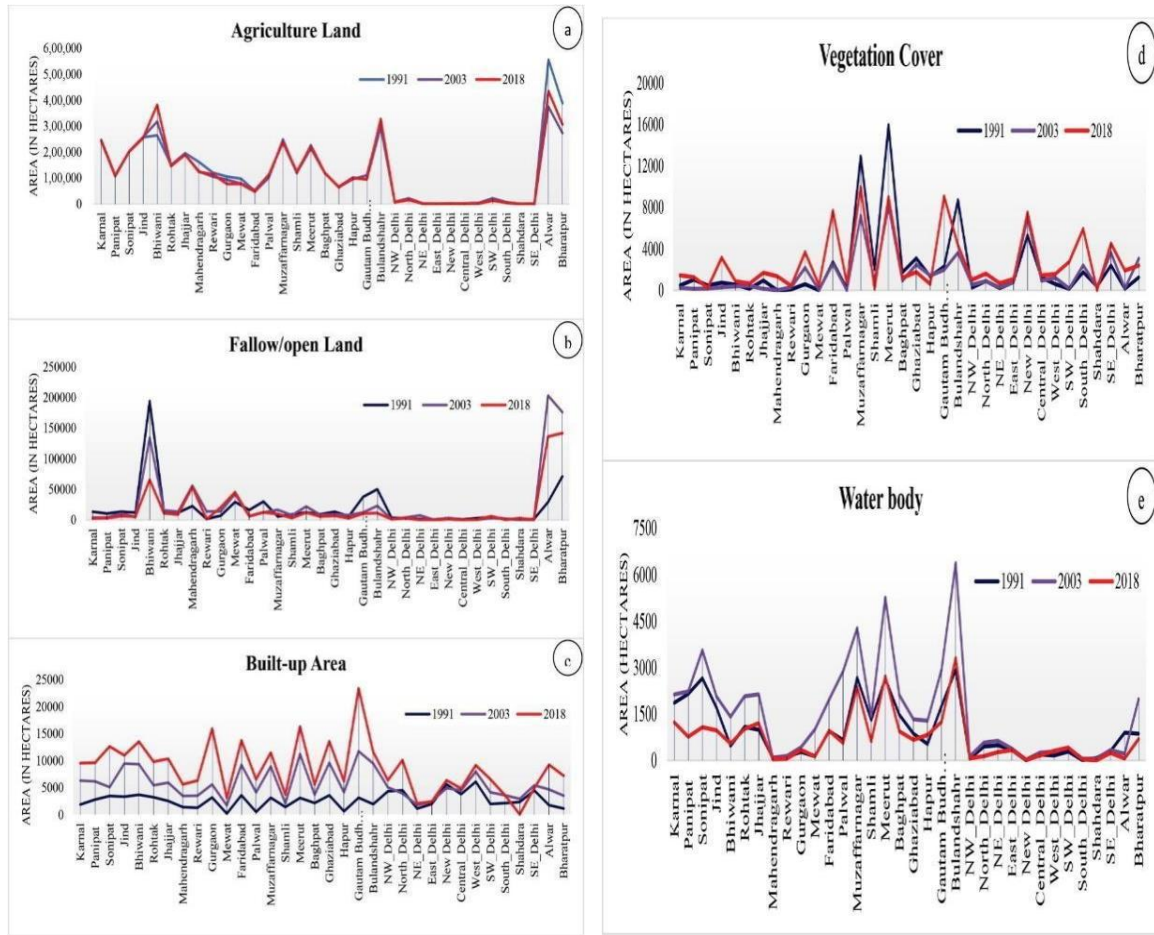


Fig.10: Land Use and Land Cover Change in Delhi

Source: Journal of Urban Management (2019)

4.3 Status of Ground Water Availability and Aquifer Management Plan

The Groundwater availability, draft and development (Fig. 11A & B) in Delhi varies spatially and temporally. In the rainy season, the availability of the groundwater rises as water seeps through the ground and thus the groundwater level rises, whereas in the summer season as the draft is far

more than the availability thus the water level falls deep below. The South Delhi district of Delhi has developed its groundwater resources the most followed by the South-West district and New Delhi district. North Delhi has the least developed groundwater resources suggesting less public investment thus relatively lesser developed areas and people suffering from the water crisis.

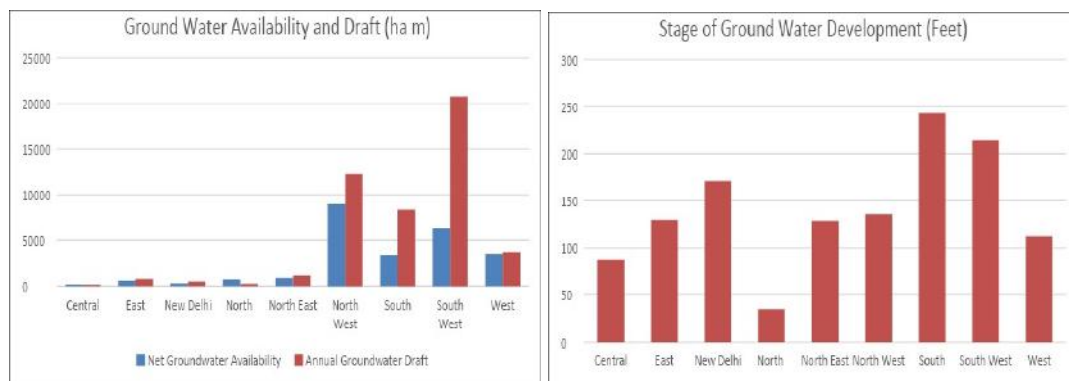


Fig.11(A) Groundwater Availability and Draft, (B) Stages of Groundwater Development

Source: www.cgwb.gov.in

Through the data we can see that most of the area of Delhi lies in the declining aquifer zone (Fig. 12), which shows that in most of the area the groundwater extraction exceeds the recharge rate, resulting in the declining water quantity. It is

also evident from the data that many places of Delhi have polluted groundwater mainly due to the low recharge leading to pollutant concentration.

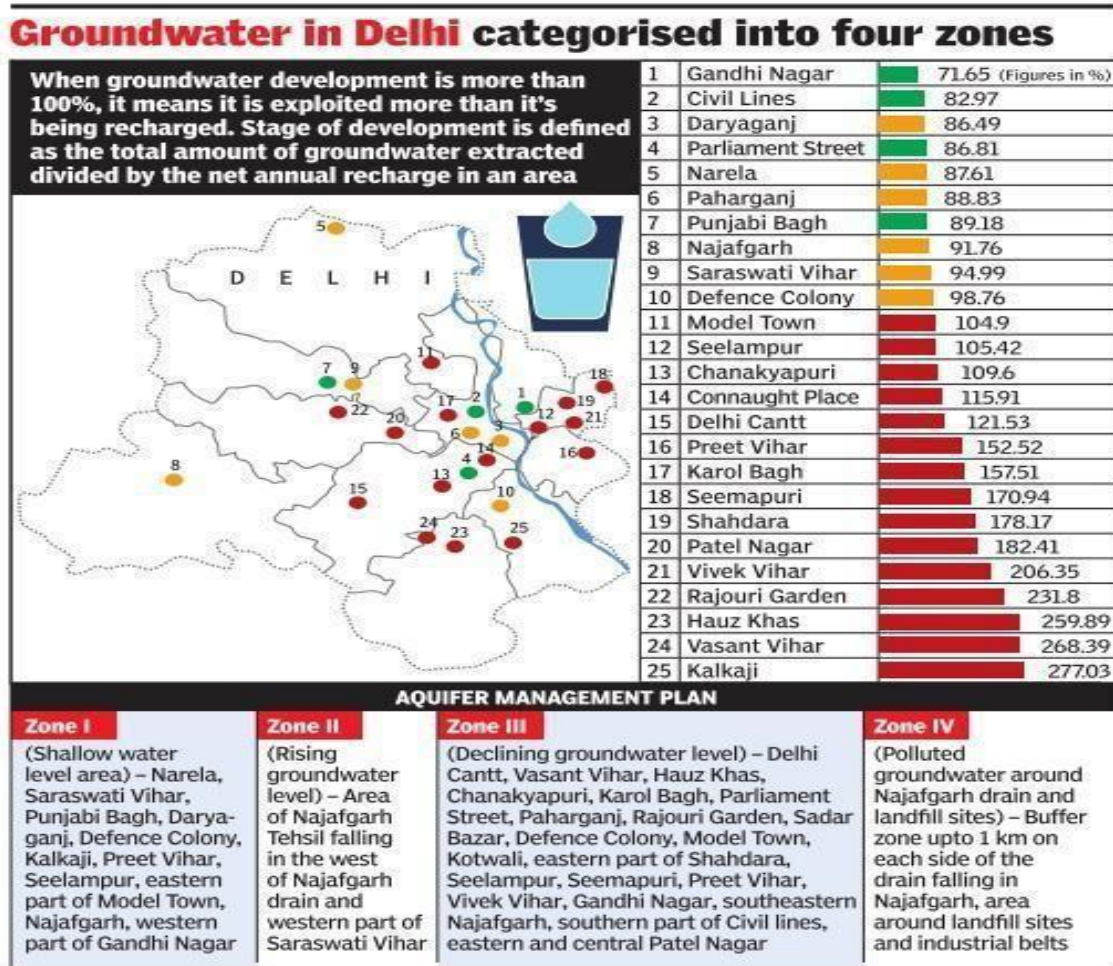


Fig.12: Zones in Aquifer Management Plan

Source: www.cgwb.gov.in

4.4 People’s Perception: Public Investment and Water Scarcity

During the survey, it was found that 71% of the people agreed that the increased level of public investment will lead to further betterment of their livelihood activities as well as reduce the prevailing level of water scarcity, wherein 12% of the people of the people said there is no relation between public investment and water scarcity.17% of the people were not even aware as to what does public investment means and clueless of its relation with the problem of water scarcity that they are facing (Fig. 13).

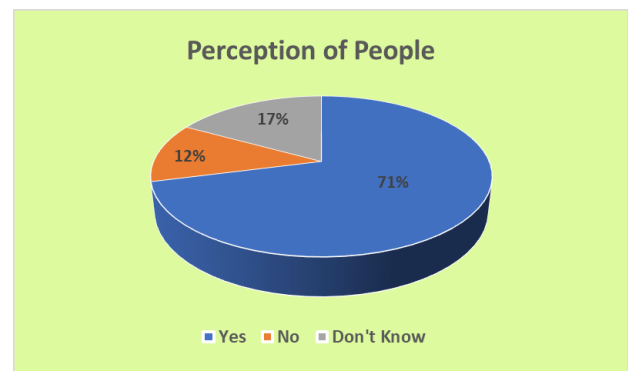


Fig.13: Perception of people regarding Public Investment and Water Scarcity

Source: Primary Survey (September-October, 2019)

4.5 Discussion

Based on the data collected through the primary survey and various secondary sources, it is established that that public investment in the selected areas is quite low, and it has shown a higher spatial variation due to varied investments. Through the calculations done using the Central Groundwater Board, Delhi Jal Board and primary survey, it was found that there is a negative correlation between public investment and water scarcity thereby sustainability i.e., the higher the level of public investment for water management, the lower is the water scarcity in that area thereby higher is the work done for sustainability. The survey was conducted in the Okhla Industrial Area, near Okhla barrage, the public investment made in the form of the Agra Canal is serving the purpose of agriculture and others very well. The motivation is needed for the purpose of further proper utilization of available resources thus their sustainable management. Contrary to this, in the Rainey Well area with Yamuna being less than 200 meters away, the boring at 100 feet to get freshwater for drinking purposes reveals the pathetic condition of the people living there and the level of groundwater degradation. With almost nil public investment, the area was performing very poorly in water availability and management, thus threatening the sustainability of the environment.

V. CHALLENGES

The major challenges observed in the present study include:

5.1 Concretization of the Land Area

Concretization refers to covering of soil surface with concrete. The problem with concrete is that it doesn't allow water to percolate. When compared to soil, it allows only 5% of water to percolate and the rest goes waste in the form of runoff while open soil allows percolation up to 45% which helps in recharging of groundwater. Hence it poses a great problem in recharging groundwater.

5.2 Economic [WATER MAFIA]

The difference between the total demand and the total supply gives rise to the water mafia. At present, the total demand is 1200 MGD while the supply by the DJB moves around the figure of 900 MGD. Hence there is a massive gap of 300 MGD. The water mafia exploits this gap and operates illegally by digging illegal bore-wells. These mafias operate without licence and supply water without any treatment.

With the help from the staff of water bottle companies, they get access to the plastic jars on which they apply the false name and false seals and sell at premium prices.

5.3 Uncontrolled population growth

Over a period, the population of Delhi has skyrocketed, from less than 20 lakhs in 1950 to over 20.25 million in 2021, Delhi is the second most populous urban agglomeration. Due to this high population, water consumption has increased tremendously in Delhi. It is also noteworthy to mention that despite the uncontrolled growth of population, Delhi still is the thirstiest city in the country with per capita consumption at 363 litres.

5.4 Inter-State Water disputes (Delhi-Haryana)

Delhi and Haryana for long now are indulging in the water dispute over the sharing of Yamuna River water. The total demand by the so called 'Delhite' generally exceeds the total water released by Haryana due to which dispute never ends. Despite several committees and tribunal, a mutually acceptable decision has not arrived.

5.5 Low-quality Infrastructure

According to the Delhi Committee of the Associated Chambers of Commerce and Industry of India (ASSOCHAM), Delhi loses 40% of its water due to the poor infrastructure mainly in the form of leakage. It is also noteworthy to mention that though DJB supplies around 3,000 million litres of water every day, but only 1,700 million litres reach the consumer due to the infrastructural losses.

VI. WHAT CAN BE DONE BY PUBLIC SECTOR?

6.1 Rainwater Harvesting at Community Level

Rainwater harvesting is a simple process or technology used to conserve the rainwater by collecting, storing, conveying and purifying it that runs off from rooftops, parks, roads, open grounds, etc. for later use. A Catchment is used to collect and store the captured rainwater, then via conveyance system, it is transported to the harvested water from the catchment to the recharge zone, then it is used to flush out the first spell of rain, further a Filter is used for filtering the collected Rainwater and remove pollutants (Fig. 14). Ultimately the tanks and the recharge structures used to store the filtered water which is ready to use. This process can be used for each house rooftops for the conservation and groundwater recharge process.

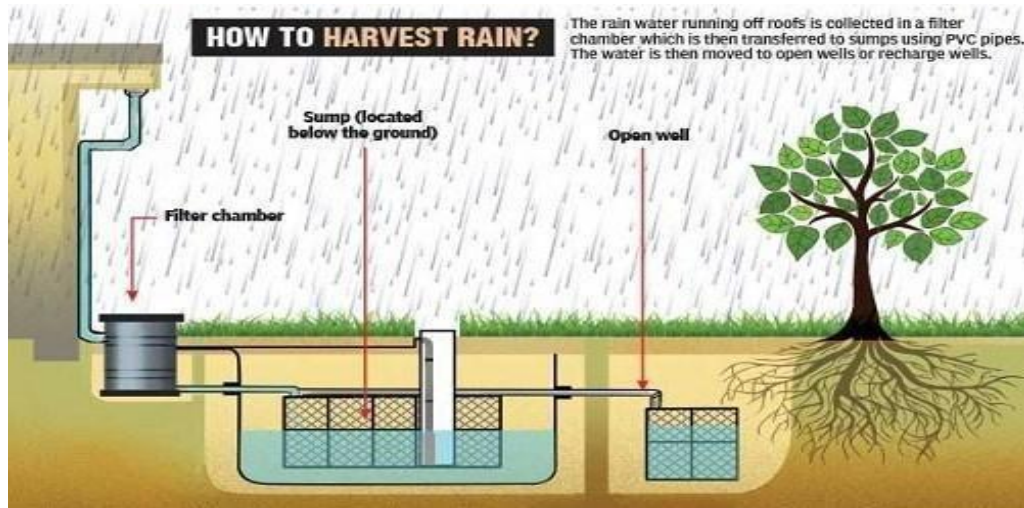


Fig.14: Rainwater Harvesting

Source: <https://orissadiary.com/manthan-rain-water-harvesting-roman-way/>

The Delhi Government has made rooftop water harvesting mandatory for a plot size of 100 square metres and above in the Building Bye-Laws for Delhi in 2012. While it is the responsibility of the societies to set up the RWH system themselves, the Jal Board provides support of up to Rs 50,000 to establish it. The cost of setting up the system costs around Rs 5-7 lakh. DJB also provides technical assistance, empanelled agencies and simplified designs. The strict implementation of the building by-laws is necessary as even after making laws there are only 1200 structures installed till now.

6.2 Following the Ideal way of Water Flow

Figure 15 depicts the ideal way to use water judiciously. Presently we see a disconnect between the residential and industrial usage of water. Hence, it is proposed that an integrated approach where instead of supplying fresh water to industries directly, the water first go to the residential area via treatment plants, from there it should be treated and send to industries and for horticulture and from industries it should be diverted again to the water plant before entering Yamuna. In this way we can fulfil our water needs and maintain the quality and quantity of water in the river.

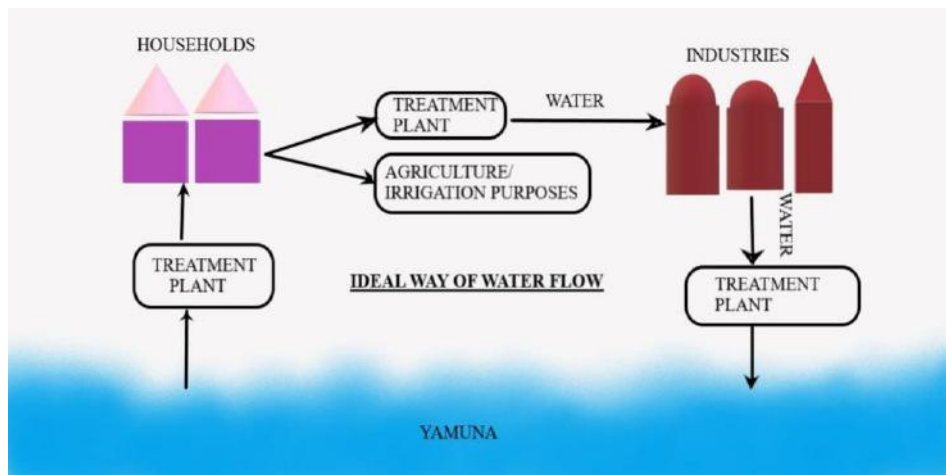


Fig.15: Ideal Way of Water Flow

Source: www.cgwb.gov.in

6.3 Increase in Vegetative Cover

Vegetation plays a vital role in regulating atmospheric moisture. The process of ET (evapotranspiration) is responsible for at least 40% of the total terrestrial rainfall. They not only help bring rainfall but also help in the intensification of rainfall by releasing various biological

particles in the air like pollen, bacterial cells, fungus spores etc. (Fig. 16). It is also important to mention that an increase of vegetative cover should be of native plants and not of alien species like eucalyptus, Kabuli kikar, vilayati kikar which uses a lot of water and does not allow native plants to grow.



Fig.16: Panoramic View of Vegetative Cover

Source: <https://unsplash.com/s/photos/vegetation>

6.4 Provision of incentives for new irrigation techniques

The provisions promoting the new water-efficient irrigation techniques reduces the use of water in the agriculture sector which contributes a major percentage of the total water usage. In the drip irrigation system, water is applied near the plant root through emitters or drippers, on or below the soil surface, at a low rate varying from 2-20 litres per hour. The soil moisture is kept at an optimum level with frequent irrigations.

6.4.1 Drip Irrigation

Being one of the most efficient irrigation techniques it can be practised for a large variety of crops, especially in vegetables, orchard crops, flowers and plantation crops. It reduces fertilizer and nutrient loss due to localized application and reduced leaching. The field levelling is not necessary and recycled non-potable water can be used. Water application efficiency increases. Soil erosion and weed growth are lessened (Fig. 17)

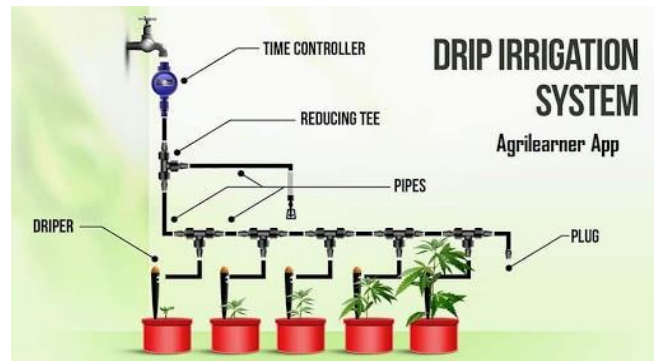


Fig.17: Drip Irrigation

Source: www.drishtias.com/to-the-points/paper3/different-irrigationsystems#:~:text=It%20is%20used%20in%20dry,fields%2C%20preventing%20soil%20consolidation%20etc

6.4.2 Sprinkler Irrigation

In this method, the water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. The spray is developed by the flow of water under pressure through small orifices or nozzles. It is a very suitable method for irrigation on uneven lands and on shallow soils

on which nearly all crops are suitable for sprinkler irrigation systems except crops like paddy, jute, etc. The dry crops, vegetables, flowering crops, orchards, etc. are all suitable and can be irrigated through sprinklers. It is suitable for all types of soil except heavy clay, a water-saving technique, increases the yield (Fig. 18).



Fig.18: Sprinkler Irrigation

Source: www.drishtiiias.com/to-the-points/paper3/different-irrigationsystems#:~:text=It%20is%20used%20in%20dry,fields%2C%20preventing%20soil%20consolidation%20etc

6.4.3 Ditch Irrigation

It is a traditional method, where ditches are dug out and seedlings are planted in rows. The plantings are watered by

placing canals or furrows in between the rows of plants. Siphon tubes are used to move the water from the main ditch to the canals (Fig. 19)



Fig.19: Ditch irrigation

Source: www.drishtiiias.com/to-the-points/paper3/different-irrigation-systems#:~:text=It%20is%20used%20in%20dry,fields%2C%20preventing%20soil%20consolidation%20etc

6.4.4 Sub Irrigation or Seepage Irrigation

It is a method where water is delivered to the plant root zone from below the soil surface and absorbed upwards. The excess water may be collected for reuse. It can be used for water and nutrient conservation, and as a labour-saving technique.

6.5 Change in Tile Structure for Footpath

The change in tile structure on the footpath is among one of the most successful ways for groundwater recharge, as the open tiles allow the percolation of water to the ground thus gradually, leading to a reduction in loss of rainwater through surface runoff (Fig. 20).

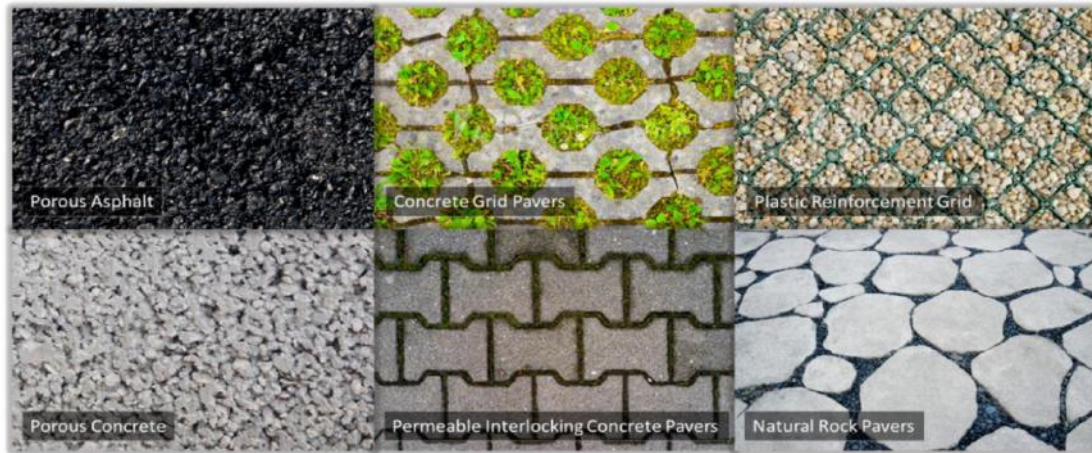


Fig.20: Glimpse of Permeable Pavements

Source: <https://www.mdpi.com/2071-1050/12/18/7422/htm>

6.6 Adopting new construction technologies

The old and traditional methods of construction are outdated and water demand. For constructing 1 sq m of wall 400-450 litres of water is required. With technology and science, modern methods of construction are present which eliminates the use of water significantly. These are known as green construction material. These materials are made up of pollutants and simplify the process of construction and reduce the construction cost. This green product comes in the form of ready to use wet mix hence it eliminates the use of water for the curing purpose and hence saves a lot of

water.

6.7 Steps to Reduce Water Scarcity

At individual level, many steps are required to reduce the scarcity of water. These are represented with the below flow diagrams (Fig. 21). Along with the public investment, the steps at the individual level are necessary to conserve water like rainwater harvesting, low flow of tap, use of buckets instead of showers etc. The small steps at the individual level and proper implementation of governmental policies can reduce the problem of water scarcity.

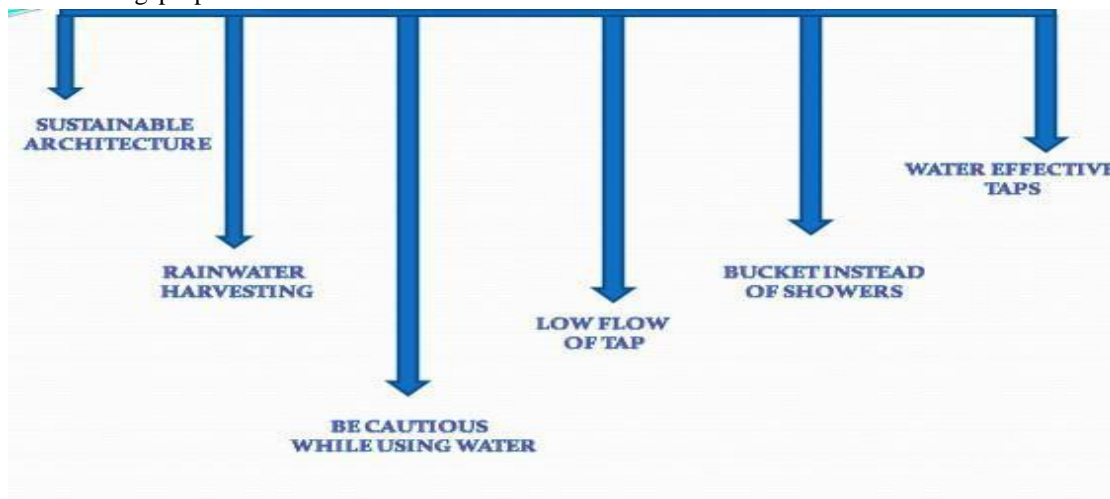


Fig.21: Steps to reduce water scarcity at individual level

VII. CONCLUSION

The preceding analysis reveals that there are widespread regional variations in the availability and distribution of water and levels of public investments made in the study area. It is due to the variations in population growth, urbanization, industrialization and expansion of economic

activities. Concretization of the land area hindering recharge of groundwater, unlicensed economic operation of *Water Mafia* to fill the demand-supply gap of water, uncontrolled population growth leading to a mammoth increase in water consumption and consequent pressure on its increased supply, low-quality Infrastructure like leaked and rusted water pipes leading to water loss both in quantity

and quality etc. are some of the major challenges observed in the study area. Water is essential for life and is increasingly getting scarce, which requires immediate attention from all facets of the society which includes government, NGOs, general public etc. Even the statistical tool of Z-test proved the hypothesis of the study, thus establishing the fact that “higher the amount of Public Investment, lower will be the Water Scarcity”.

There are some curative measures to overcome the challenges of water scarcity and low public investments such as rainwater harvesting structure, using water percolation tiles, enforcing water guzzling sectors to adopt science and technology which would reduce their water consumption. It can be also done with direct engagement of people in form of afforestation drive, public camps, social awareness programme and activities, etc. and in other forms as well. These steps will bridge the gap between demand and supply of water and thus will ensure sustainability of Delhi Metropolitan Region. It is our last and the best chance to tackle this problem on an equal footing, because if we will delay, then we will decay.

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