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Assessment of Groundwater Potential, Availability and Utilization in National Capital Territory of Delhi

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Abstract

This study seeks to assess the groundwater potential of National Capital Territory of Delhi, which is one of the fastest growing metropolitan areas of our country. Being the centre of political, social and economic activities, Delhi has attracted people from all over the country and consequently its population has grown more than nine folds in the last sixty years. With rapid urbanization, continuously increasing population in Delhi has created significant challenges to water resources of the city. Despite the best efforts made by the government, a severe shortage of raw water has hampered the adequate supply of water in Delhi. To maintain adequate water supply in Delhi, the availability of raw water in terms of quantity, quality and reliability is essential. Due to inadequate availability of surface water, groundwater has been extracted significantly in NCT Delhi to meet the increasing demand of water. This indiscriminate extraction has led to the decline in water table in the most parts of NCT Delhi. Adverse hydrogeological conditions especially in southern part have accelerated the gravity of this critical situation whereas Yamuna flood plain, which has potential aquifers are also depleting. Apart from overexploitation of groundwater, rapid pace of urbanization have resulted in reduced recharge of aquifers. This is of great concern that all these circumstances eventually reduced the groundwater potential in NCT Delhi. To meet the current water demand and to ensure adequate water supply in future, a careful management of groundwater in NCT Delhi is required including its different aspects such as augmentation and conservation.

Keywords: Aquifer, Groundwater recharge, Hydrogeology, Population growth, Urbanization, Water table.

Introduction

Twentieth century had seen an unprecedented growth in water consumption especially in metropolitan areas because of rapid pace of urbanization, explosive population growth and industrial requirements. Although water is a renewable resource, yet the supply of fresh water is steadily decreasing due to increased demand. The United Nations World Water Development Report also comments that 'the most important drivers - forces and processes generated by human activities- are demographics and the increasing consumption that comes with rising per capita incomes' (World

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Water Assessment Programme, 2009, p.14). National Capital Territory of Delhi (NCT Delhi), one of the fastest growing metropolitan areas of the world is facing the problem of water scarcity. However NCT Delhi receives raw water from surface and sub-surface sources but due to insufficiency of surface water, groundwater contributes to substantial quantity of water supply.

As per Economic Survey of Delhi: 2017-18 groundwater shares about nine percent of total water resources of NCT Delhi but this figure does not reveal the actual role of groundwater in water supply. A considerable part of territory, which gets only one to two hours water supply in a day largely rely on private tube wells, motor pumps and hand pumps etc. However, most of the private tube wells are legally registered, but it is much difficult to estimate the total volume of water abstracted through private tube wells, motor pumps etc. Due to rapid urbanization and high rate of population growth, the growing demand of portable water in NCT Delhi has resulted in overexploitation of groundwater. The gap between demand and supply of water is expected to widen further because our capital territory is growing rapidly and it is projected that the population will be 230 lakh in 2021 (MPD-2021) against 167.9 lakh in 2011 (Census of India 2011). This will put tremendous pressure on the groundwater to meet water demand of NCT Delhi. Upto 2021, it is expected that NCT Delhi will be complete built-up area and its consequences will be more drastic in terms of groundwater replenishment by decreasing surface area for infiltration of rainwater into ground. However, rapid urbanization in post independence period has already altered the permeability structure of land and destructed the environmental resources, such as wetlands.

Apart from this, unfavourable hydrogeological characteristics of NCT Delhi especially in rocky ridge area and Chhattarpur basin show a critical situation of groundwater resources whereas aquifers in Yamuna flood plain have large storage capacity. The depth to water table varies significantly and deeper water tables in southern part are in crucial condition. Groundwater is greatly utilized in domestic sector and situation of groundwater extraction becomes more critical in dry seasons and in the years of low rainfall. As a consequence, water table has declined alarmingly in most parts of NCT Delhi. As per Central Ground Water Board assessment, the total groundwater potential was only 280 million cubic meter (MCM) in 2008 in NCT Delhi against 428.07 MCM in 1983. It shows an overdraft and reduction of about 148 MCM in twenty-five years (State of Environment Report for Delhi, 2010).

Objectives

In this paper, an attempt has been made to evaluate the hydrogeological conditions, recharge and discharge components of groundwater with a view to work out the groundwater potential in terms of its volume in NCT Delhi. The objectives of this study are as follows:

1. To evaluate the hydrogeological characteristics of National Capital Territory of Delhi.
2. To analyze the groundwater availability and utilization in National Capital Territory of Delhi.
3. To study the fluctuations in water table in National Capital Territory of Delhi.

Methodology

The study examines the groundwater potential in terms of recharge, discharge and hydrogeological conditions of NCT Delhi. This study requires the authentic groundwater data for a long period. The

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study analyses the data mainly collected from the different reports of Central Ground Water Board, which observe the groundwater level four times in a year across NCT Delhi through observation wells. To maintain the uniformity of study, mainly pre-monsoon month data have been analyzed. The information and data are also taken from other secondary sources, such as the Government of India publications, books, handbooks, reports and journals. A field study has also been conducted to verify the data collected from different sources and to add some details.

Study Area

With 1483 sq. km. of sprawl NCT Delhi has almost central geographical location in India and extends between $28^0$23'17"N & $28^0$53'00"N latitudes and between $76^0$50'24"E & $77^0$20'37"E longitudes. Physiographically, NCT Delhi may be divided in to three parts - the plain, the Yamuna flood plain and the ridge. Its major part belongs to Indo-Gangetic alluvial plain, which is broadly between mountain ranges of the Great Himalayas and Aravallis. Thar, the Great Indian Desert is situated on the western side of the Territory in the state of Rajasthan. A strip of recent deposits adjoining the Yamuna River in eastern side is known as new Khadar. The Bangar, which is the region of earlier Pleistocene deposits and located in north-west of the ridge, is more fertile and productive of than those of Khadar whereas Dabar, a low-lying and rain-fed area lies to the west of the hills. The Ridge, locally known as Kohi is rocky and undulating constitutes the most dominating physiographic features in this region. The ridge forms principal watershed and act as groundwater divider between the western and the eastern parts. The Yamuna River, which is only perennial river in NCT Delhi, has a strong influence on drainage system of the area.

An extremely dry and hot summer and similarly an extremely cold winter are the best-known features of Delhi climate, which may be classified as semi-arid. Summer months are extremely hot and scorching while winters are severe. Extreme temperature in NCT Delhi ranges from -2.2^{0}C to 48.4^{0}C. The data of Indian Meteorological Department reveals that January with mean minimum temperature of 6.7^{0}C is the coldest month whereas May with mean maximum temperature of 40.5^{0}C is the hottest month in NCT Delhi. The extremity of climate is because of its inland position, close proximity to the Thar Desert and the Himalayas and the prevalence of air of continental type. Normally, monsoon arrives here in the end of June and months of July, August and September receive more than 80 percent of its annual rainfall. NCT Delhi receives its rainfall from both the branches of south-west monsoon, which penetrates here only during monsoon period. The monsoon air, which travels a long distance across the desert area of Rajasthan and Gangetic Plain of north India, becomes weaker and NCT Delhi receives comparatively less rain. The amount of rainfall during monsoon season varies significantly from year to year because the monsoon is very unpredictable and rainfall is very uncertain. With the cease of south-west monsoons NCT Delhi receives winter rains and thunderstorms rains during pre and post monsoon months. The normal annual rainfall of NCT Delhi is recorded approximately 612 mm. Heavy rainfall in the catchment areas of the Yamuna River often causes dangerous flood situation.

Despite the extreme climatic conditions, the twentieth century has witnessed phenomenal growth in the population of NCT Delhi. More than forty fold increase in its population has been noticed in a period of 100 years from 1911 to 2011. Delhi was a small town with an area of 43.25 sq. km. in 1911

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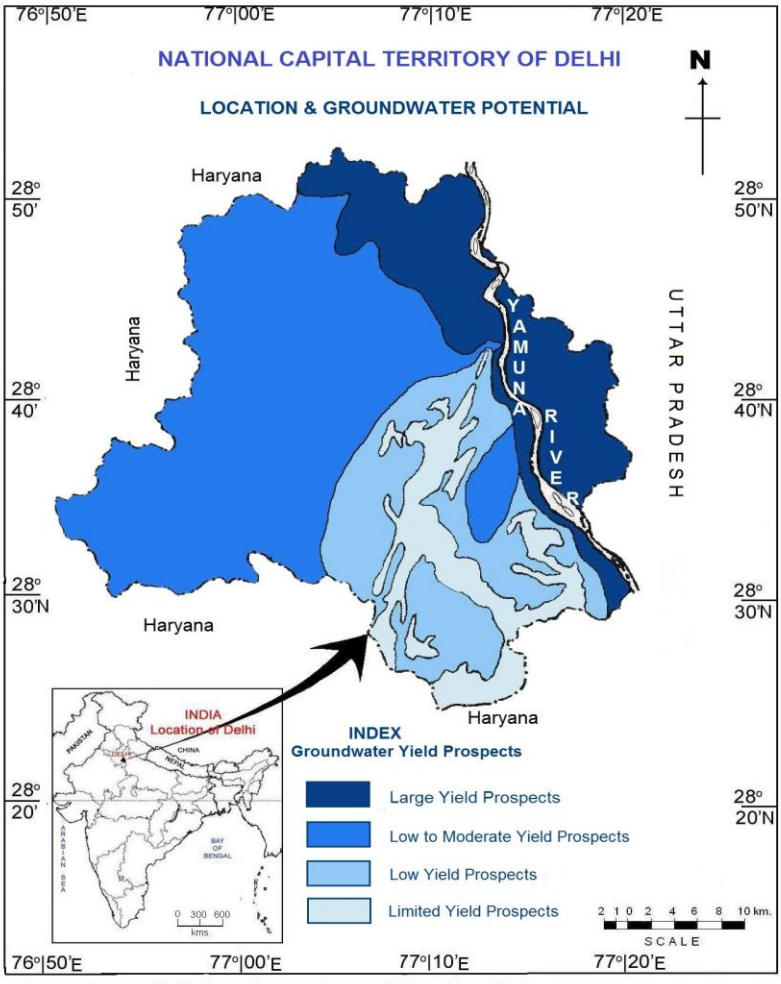
and its total population was a little over four lakh with an urban component of 57.50 percent. According to Census of India 2011, the total population of NCT Delhi is 16,787,941 which accounts for 1.39 percent of India's total population whereas in area it is only 0.05 percent of the total area of the country. The percentage decadal growth during 2001-2011 is 21.21, which has declined sharply compared to 47.02 percent during 1991-2001. It shows a tendency of population growth towards stabilization. Due to rapid increase in population, density has increased and it was 11320 people per sq. km in 2011. With 97.5 percent of its population as urban, NCT Delhi is the most urbanized state in the country. The rapid pace of urbanization has encouraged encroachment in rural areas and as a result, both the rural area and the population have declined sharply. The urban area was only 43.25 sq km in 1911 and it has increased to 1114 sq km in 2011, while in the same period the urban population has increased from 57.50 percent to 97.5 percent.



Source: Survey of India Toposheets and Ground Water Board Data

Figure 1

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NCT Delhi is a Union Territory, which shares its border with the states of Uttar Pradesh and Haryana and includes New Delhi, the national capital of India. With the formation of two more districts in 2012, it has total eleven districts. For civic services, Municipal Corporation of Delhi (MCD) was the single municipal body which covered approximately 94 percent of the area of NCT Delhi before its trifurcation in 2012. Now, it is divided into three parts, namely North Delhi Municipal Corporation, South Delhi Municipal Corporation and East Delhi Municipal Corporation for better civic administration and services. The rest area of 42.73 sq km and 43 sq km is in the jurisdiction of New Delhi Municipal Council (NDMC) and Delhi Cantonment Board (DBC) respectively.

Hydrogeological Characteristics

Hydrogeology is a complex science, which deals with occurrence, storage, movement, quality and quantity of groundwater in the soils and rocks of the earth's crust. The groundwater availability in NCT Delhi is largely influenced by the hydrogeological situation, which is characterized by occurrence of alluvial formation and quartzite rocks. The physiographic set-up also influences considerably the groundwater occurrence, quantity and quality. Structurally, a major portion of NCT Delhi is the part of Indo-Gangetic alluvial plain and includes older alluvium, newer alluvium and aeolian deposit. The alluvial formation overlays bedrock, depth of which significantly varies from few meters to more than 300 meter below land surface. The Chattarpur alluvial basin in the southern part of the area is covered with alluvium derived from the adjacent quartzite ridge. The most distinct physiographic feature of NCT Delhi is the Ridge, which consists of quartzite rocks. NCT Delhi may be divided into four distinct units on the basis of hydrogeological conditions.

1. Yamuna flood plain deposits or younger alluvium (large yield prospects)
2. Alluvial plains on eastern and western sides of the ridge or old alluvium (low to moderate yield prospects)
3. Isolated and nearly closed Chattarpur alluvial basin (low yield prospects)
4. Quartzite Ridge (limited yield prospects)

According to Central Ground Water Board (CGWB, 2016), the yield of exploratory tube wells drilled in the younger alluvium ranges between 100-310 m^3/hr, in older alluvium between 8-35 m^3/hr, in the Chhattarpur basin between 7-14 m^3/hr and in the quartzite ridge between 4-31 m^3/hr. Groundwater occurrence highly depends on the formation of the rocks. Unconsolidated formation such as alluvial sediment, which has substantial porosity and permeability, forms the most productive aquifers and yield significant amount of water.

In NCT Delhi, Yamuna flood plain deposits, which comprises a range of material from coarse to fine sand, gravel, silt and clay make good aquifer, which may store large amount of groundwater. Alluvial plains, situated on the eastern and western sides of the Ridge have low to moderate yield prospects of groundwater. The groundwater prospect of nearly closed Chattarpur basin is low whereas quartzite formation shows the most critical situation due to low or negligible primary porosity.

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Groundwater Availability and Utilization

The groundwater of NCT Delhi is mainly recharged from infiltration of rainfall; however significant attempts of artificial recharge to groundwater have also been made. Infiltration is a process by which surface water enters the soil and first it replenishes the moisture deficiency of soil, however a significant part of this water is returned to atmosphere through evapotranspiration. The further downward movement of the water through unsaturated zone is termed as percolation and the entry of water into saturated zone is known as groundwater recharge. Artificial groundwater recharge has become increasingly important in NCT Delhi where human activities have reduced recharge areas significantly. A significant amount of rainwater flows away unused and reaches a stream or other water body where it is evaporated into atmosphere. The rapid pace of urbanization in NCT Delhi further increases surface runoff by creating more impermeable surfaces. The recharge area has been reduced tremendously in NCT Delhi due to increased built-up area. It has significantly affected the replenishment of groundwater.

NCT Delhi is withdrawing more groundwater annually than annual replenishable groundwater resources. The net annual groundwater availability was 30649.61 hectare meter (ham) in 2013; however annual groundwater draft was 38776.79 ham. The total groundwater potential was 30649.61 ham in 2013 and about 28000 ham in 2008 in NCT Delhi against 42807 ham 1983. It shows an overdraft and reduction of about 12157 ham in thirty years.

In NCT Delhi, groundwater is one of the major sources of water supply and contributes significantly to fulfil the water requirements in domestic, industrial and agricultural sectors. Groundwater is largely utilized as drinking water especially in new developed areas of NCT Delhi. The agricultural irrigation has also threatened the groundwater resources because it mostly depends on groundwater. Table 2 reveals that a larger area is irrigated by wells compared to other sources of irrigation. A large number of tube wells, wells and ranney wells exhibit the indiscriminate extraction of groundwater. Private abstraction is another issue, which indicates the failure of the adequate water supply in NCT Delhi. Delhi Jal Board, an autonomous organization functioning under Government of NCT Delhi is responsible for water supply and distribution in most part of Delhi and for bulk supply to NDMC and Delhi Cantonment Board. As per 2017-18 edition of Economic Survey of Delhi, Delhi Jal Board had 4209 functional tube wells and 14 ranney wells in March 2017 compared to 2488 functional tube wells and 21 ranney wells in March 2008. In 2013, the total groundwater draft in NCT Delhi was 38776.79 hectare meter (ham) of which about 35.5 percent was for irrigation, and remaining 64.5 percent for domestic and industrial use (Table 1).

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Table 1

Groundwater Recharge, Availability and Draft in NCT Delhi in 2013 (Provisional)

			Amount of Water in ham
Annual Replenishable Groundwater Resource	Monsoon Season	Recharge from rainfall	8760.55
		Recharge from other sources	2203.94
	Non-monsoon Season	Recharge from rainfall	1366.34
		Recharge from other sources	21573.96
	Total		**33904.79**
Natural Discharge			3390.48
Net Annual Groundwater Availability			30649.61
Annual Groundwater Draft	Irrigation		13763.56 (35.5%)
	Domestic and industrial uses		25013.23 (64.5%)
	Total		**38776.79**
Stage of Groundwater Development			**126.52 %**

Source: Compiled from Central Ground Water Board (2016).

Table 2

Source-wise Irrigated Area in Delhi 2009-10 to 2016-17

(Area in hectares)

Source	2009-10	2011-12	2013-14	2015-16	2016-17 (Estimated)
Canals	2238	2225	2225	2218	2240
Wells	21205	19561	19561	19533	19727
Area Irrigated	23443	18581	21786	21751	21967

Source: Government of NCT Delhi, Planning Department (2018), Economic Survey of Delhi, 2017-18, New Delhi: Planning Department, Government of NCT Delhi.

The hydrogeological conditions and discharge and recharge components of groundwater strongly influence its availability in the different parts of NCT Delhi. In general, the Ridge and its neighbouring hilly areas including Chhatarpur basin are in critical condition whereas, the most part of the plain characterized by older alluvium is in semi critical situation. Despite having potential aquifers, some

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parts of the flood plain along the Yamuna River are also in critical and semi critical conditions due to overexploitation of groundwater resources. As per CGWB (2016) assessment, Out of 27 assessment units (tehsil) only five tehsils are in safe category on the basis of groundwater conditions, whereas seven and fifteen tehsils are categorized as overexploited and semi critical respectively in 2013. On the basis of groundwater recharge, availability and groundwater draft, the scenario of NCT Delhi, as per CGWB (2016) categorization is as follows.

- **Safe:**

As mentioned above, only five assessment units (tehsil) out of twenty seven are in safe category. The lowest stage of groundwater development is in Gandhi Nagar in eastern part followed by Sadar Bazar and Civil Lines in northern, Parliament Street in central and Punjabi Bagh in Western parts. The lower stage of groundwater development indicates higher groundwater potential. Despite the high population density and intensive commercial activities, these areas have higher groundwater potential.

- **Semi Critical:**

The seven tehsils, Darya Ganj and Pahar Ganj in Central, Kotwali in northern, Narela and Saraswati Vihar in north-western, Defence Colony in southern and Najafgarh in south-western parts of NCT Delhi come under semi critical category. A careful groundwater development is recommended in these areas because of moderate potential of groundwater. Excessive draft of groundwater in these areas is aggravated with irrigation draft especially in Najafgarh, Saraswati Vihar and Narela tehsils. Najafgarh, which has a significant part as arable land is the highest in groundwater draft for irrigation in NCT Delhi

- . **Overexploited:**

Most of the southern, central and eastern parts of the territory is in critical conditions and categorized as overexploited because of high population density, intense commercial activities and large scale industrial setup. As mentioned earlier, unfavourable hydrogeological conditions in ridge and its neighbouring hilly areas are another notable issue regarding the groundwater availability. The three units are Kalkaji , Vasant Vihar and Hauz Khas, all in the southern part of NCT Delhi are in the most critical conditions, which may be attributed to higher annual groundwater abstraction than replenishment. With high population density and commercial activities, the tehsils, namely Karol Bagh, Preet Vihar, Vivek Vihar, Seema Puri, Shahdra, Patel Nagar and Rajouri Garden are also in critical conditions whereas Chanakya Puri, Connaught Place, Seelam Pur, Model Town and Delhi Cantonment are in a slightly better condition.

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Table 3

Tehsil-wise Annual Groundwater Recharge, Groundwater Availability, Groundwater Draft, Stage of Groundwater Development and Category in NCT Delhi, 2013, (Provisional)

S.N.	Assessment Unit (Tehsil)	Total Annual Groundwater Recharge (ham)	Net Annual Groundwater Availability (ham)	Gross Annual Groundwater Draft (ham)	Stage of Groundwater Development (Percentage)	Category
1	Darya Ganj	331.3	314.73	257.88	86.49	Semi critical
2	Karol Bagh	42.48	38.23	60.22	157.52	Overexploited
3	Pahar Ganj	92.59	83.23	74.02	88.83	Semi critical
4	Gandhi Nagar	382.66	344.39	246.76	71.65	Safe
5	Preet Vihar	1095.76	986.18	1504.13	152.52	Overexploited
6	Vivek Vihar	248.25	223.42	461.04	206.36	Overexploited
7	Chanakya Puri	409.38	368.44	403.80	109.60	Overexploited
8	Connaught Place	200.00	180.00	219.80	122.01	Overexploited
9	Parliament Street	140.58	126.52	109.83	86.81	Safe
10	Civil Lines	1106.41	995.77	869.83	82.76	Safe
11	Kotwali	115.22	103.70	98.33	94.82	Semi critical
12	Sadar Bazar	63.92	60.72	46.09	75.91	Safe
13	Seelam Pur	966.26	869.63	916.72	105.41	Overexploited
14	Seema Puri	126.94	114.25	195.31	170.95	Overexploited
15	Shahdra	71.99	64.25	115.44	178.18	Overexploited
16	Model Town	994.80	895.32	939.17	104.90	Overexploited
17	Narela	6244.16	5619.74	4923.68	87.61	Semi critical
18	Saraswati Vihar	2821.71	2539.54	2412.41	94.99	Semi critical
19	Defence	812.80	731.52	722.41	98.75	Semi critical

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	Colony					
20	Hauz Khas	1974.64	1875.91	4618.72	259.89	Overexploited
21	Kalkaji	1291.48	1162.33	3219.96	277.03	Overexploited
22	Delhi Cantonment	1160.84	1044.76	1314.24	119.17	Overexploited
23	Najafgarh	8163.63	7347.27	6990.60	95.15	Semi critical
24	Vasant Vihar	1230.41	1107.37	2972.02	268.39	Overexploited
25	Patel Nagar	1847.84	1663.06	3033.53	182.41	Overexploited
26	Panjabi Bagh	1632.32	1469.09	1310.13	89.18	Safe
27	Rajouri Garden	336.42	319.60	740.82	231.80	Overexploited
	State Total	**33904.79**	**30649.61**	**38776.79**	**126.52**	

Source: Central Ground Water Board (2016), Aquifer Mapping and Ground Water Management Plan of NCT Delhi, New Delhi: Central Ground Water Board State Unit Office.

Depth to Water Table

The depth to water table in different parts of NCT Delhi varies significantly from few meters below ground level (mbgl) to more than 60 mbgl in different years and months. During the pre-monsoon period the depth to water table ranges from 1.61 to 63.97 mbgl in 2014, from 1.20 to 62.66 mbgl in 2015 and 1.84 to 58.39 mbgl in 2016. The deeper water tables are found in the southern part of NCT Delhi, especially in Pusp Vihar, Asola, Tughlakabad, Lado Sarai, and in Palam of the south-western part. According to CGWB (2016), depth to water table in 50 percent of the observation wells is more than 40 mbgl in south district, whereas shallow depth to water table is mainly found in the flood plains of the Yamuna River between 2 to 5 mbgl. About 57 percent of observation wells in New Delhi and 35 percent in South West district have water table depth between 10 to 20 mbgl. In North and North East districts, water tables are also not to a safe depth as they range between 5 to 10 mbgl for more than 40 percent of the observation wells.

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Table 4

Depth to Water Table and Annual Fluctuation in NCT Delhi: May 2014-May 2016

Part of NCTD	Location	Depth to Water Table (mbgl)			Annual Fluctuation (mbgl)	
		May 2014	May 2015	May 2016	May 2014 – May 2015	May 2015 – May 2016
Central	Rajghat	1.99	2.00	1.84	-0.01	0.16
East	CBD Shahdara	10.42	10.79	11.00	-0.37	-0.21
	Kondli	12.88	14.11	14.68	-1.23	-0.57
	Nangali Rajapur	3.16	3.99	4.13	-0.83	-0.14
New Delhi	India Gate	5.98	7.44	8.04	-1.46	-0.60
	Mahabir Vansth	26.97	27.08	27.80	-0.11	-0.72
North	Jagatpur Pz 2	1.68	1.82	2.26	-0.14	-0.44
	Majanu Ka Tila	8.27	8.17	9.44	0.10	-1.27
North East	Gokulpur E Pz	8.73	11.29	13.04	-2.56	-1.75
	Ushmanpur	2.89	4.77	8.43	-1.88	-3.66
North West	Balswa Lake	1.61	1.20	2.33	0.41	-1.13
	BBMB Narela	16.98	18.63	19.96	-1.65	-1.33
South	Asola	49.72	51.83	52.12	-2.11	-0.29
	Hauz Khas	33.37	34.54	35.03	-1.17	-0.49
	Madanpur Khadar	4.59	4.80	6.18	-0.21	-1.38
	Pusp Vihar	63.97	62.66	58.39	1.31	4.27
South West	Deorala	2.24	2.14	2.23	0.10	-0.09
	Palam Signal Camp	55.01	54.92	57.86	0.09	-2.94
West	Hiran Kudna	2.19	2.84	3.33	-0.65	-0.49
	Mayapuri	35.68	36.91	36.76	-1.23	0.15

Source: Central Ground Water Board (2016a), Ground Water Year Book 2015-16: National Capital Territory, Delhi, New Delhi: Central Ground Water Board, Ministry of Water Resources, Government of India, State Unit Office. mbgl = meter below ground level.

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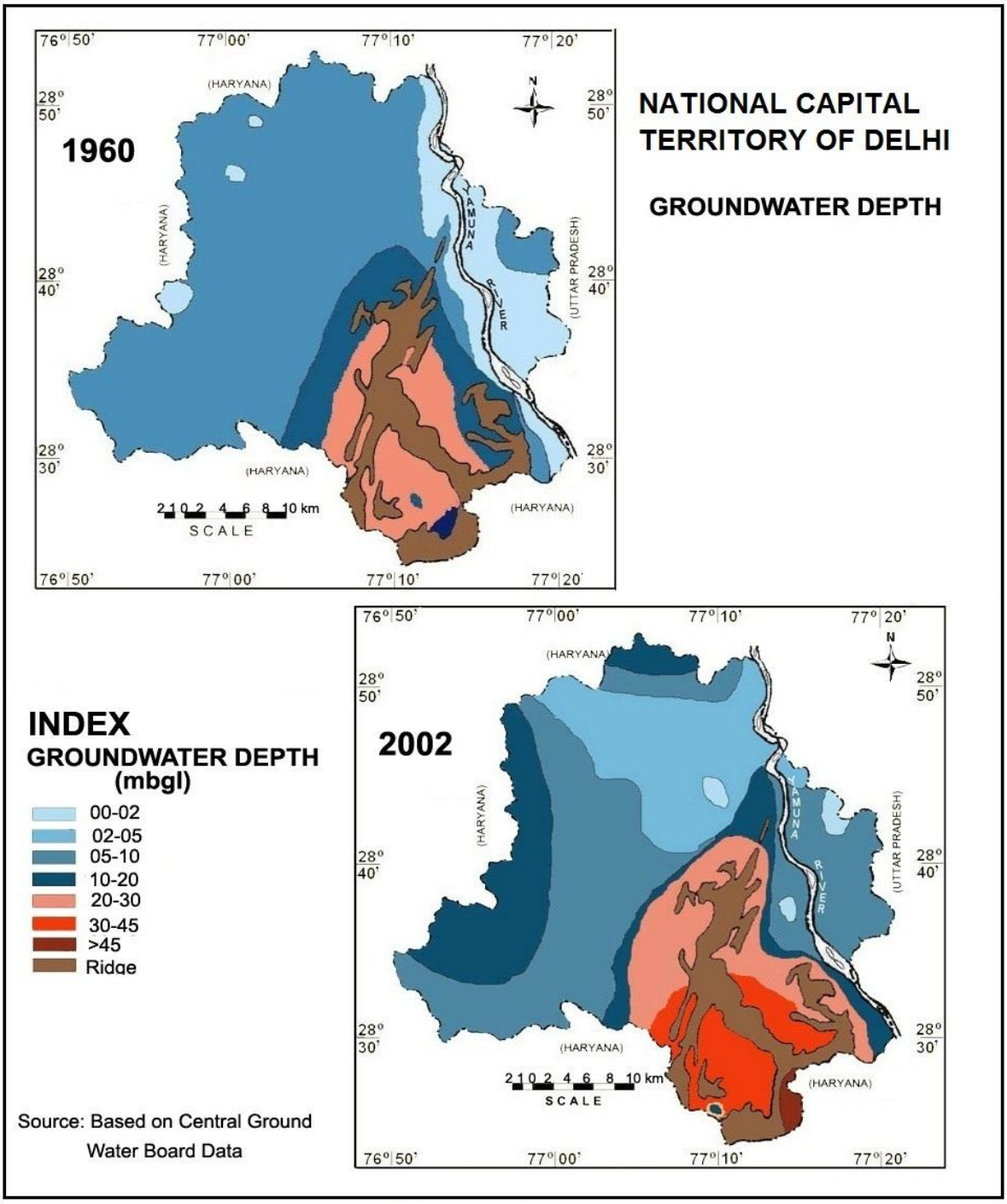

Figure 2

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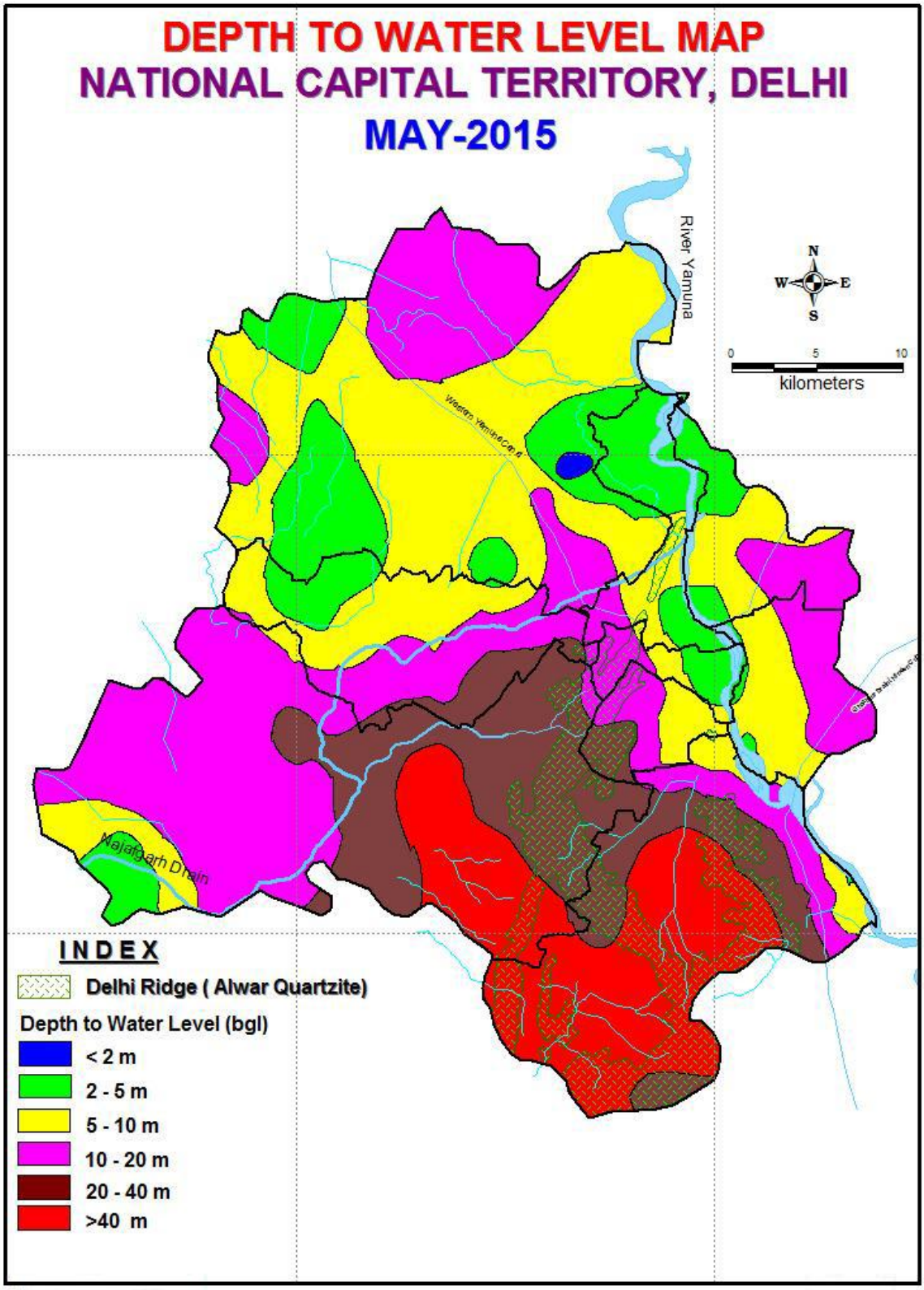

Source: Central Ground Water Board (2016), Aquifer Mapping and Ground Water Management Plan of NCT Delhi, New Delhi: Central Ground Water Board State Unit Office, p.49.

Figure 3

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- **Seasonal fluctuation**

Depth to the water table is influenced by various factors. Short-term seasonal variation is very obvious regarding the annual fluctuation in water table. Precipitation and evapotranspiration are the two important factors, which are directly responsible for seasonal fluctuation of water table in NCT Delhi. Central Ground Water Board monitors the groundwater level four times in a year in the months of May, August, November and January. In general the maximum depth to water table is recorded in the month of May whereas minimum depth is observed in the month of August. CGWB data reveals that most parts of NCT Delhi have registered the rise in water table between pre-monsoon and post monsoon periods whereas about 33 percent of observation wells have shown fall during the same period in 2015.

- **Decadal Fluctuation**

Due to intensive groundwater exploitation, water table in most parts of NCT Delhi has declined considerably while rise in water table is confined to small portion of the territory. Reports of CGWB exhibit a clear picture of water table decline in most parts of NCT Delhi. A comparison of depth to water table from 1960 to 2000 shows a decline about 4 to 8 meters in northern and more than 18 meter in southern part. The areas situated near Yamuna River and other water bodies show the minimum decline of water level. According to the studies of Centre for Science and Environment, the depth of water table was around 6 mbgl in major parts of NCT Delhi in 1977 and the deepest was 23 mbgl near Qutub Minar. In 1983, a significant decline in water table was observed in major parts of NCT Delhi and the deepest was recorded around 26 mbgl at Mehrauli. The depth of water table further declined significantly and the deepest water level was about 35 mbgl at Gadaipur (Mehrauli Block) in 1995.

Table 5
District-wise Fall in Groundwater Table: 2001-2010

District	Total No. of observation wells monitored	No. of wells showing fall in groundwater levels	Minimum fall (meter)	Maximum fall (meter)
Central	2	1	1.91	1.91
East	21	14	0.13	3.34
New Delhi	23	22	0.05	5.83
North	11	9	0.01	1.10
North East	7	5	0.07	0.91
North West	40	27	0.04	3.97
South	39	34	0.04	7.92
South West	46	39	0.05	9.25
West	12	9	0.16	2.36

Source: Central Groundwater Board (www.pib.nic.in)

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The district wise data for the 2001-2010 decade reveals a widespread fall in the groundwater table across the entire territory. The recent CGWB (2016) data (2005-2015) on decadal fluctuation shows the significant drop in groundwater table in all most all parts of NCT Delhi. On the comparison of groundwater table data of May 2015 with last ten year mean of the month of May, 63% of the observation wells have been reported decline in groundwater table range from 0.24 to 10.10 meter whereas only 32% wells show rise in water table upto 2 meter. The water table fall is more critical in highly urbanized districts of South and Southwest and it is recorded from 6.19 meter to 8.99 meter. Rise in water table is confined to limited areas, which include Yamuna flood plain, Northwest and Southwest districts and some parts of South and New Delhi districts. The main reason for rise in water tables in North West and South West districts is the limited withdrawal of groundwater due to poor quality while rise in some parts of South and New Delhi districts may be attributed to moderate extraction due to adequate water supply from other sources. As far as declining trend of groundwater table is concerned, CGWB (2016) calculated the rate of decline, which varies from 0.006 m/year at Alipur (Northwest) to 3.604 m/ year at Talkatora (New Delhi) for pre-monsoon period during decade of 2005-2014.

The important reasons, which are largely responsible for decline in water table may be summarised as:

1. Rapid pace of urbanization, which has significantly reduced natural recharge to aquifers.
2. Overexploitation of groundwater for domestic, industrial and agricultural purposes.
3. Lack of wetlands and water bodies.
4. Long dry season and uncertain rainfall.
5. Insufficient artificial recharge to groundwater.

Conclusion

On the basis of hydrogeological characteristics, Yamuna flood plain has good aquifers with large storage capacity of groundwater while aquifers under the older alluvial plains on both sides of the Ridge have low to moderate yield prospects of groundwater. Due to low porosity and permeability, a significant part of NCT Delhi, which is hilly or covered by quartzite formation and aeolian deposits have limited availability of groundwater.

Despite the less share of groundwater in total raw water of NCT Delhi, it is largely utilized in domestic, commercial, industrial and agricultural sectors. The extraction of groundwater is more than its replenishment in major parts of the territory. Due to rapid urbanization in post-independence period, substantial increase in built-up areas has taken place in NCT Delhi. Built-up area is an impermeable surface, which prevents the infiltration of water into the ground. Thus, substantial increase in built-up areas has resulted in reduced natural recharge of aquifers. Apart from these, lack of wetlands, long dry season, uncertain rainfall and insufficient artificial recharge system are also responsible for depleting groundwater resources in NCT Delhi.

Overexploitation of groundwater due to increased demand of water for various purposes consequent upon rapid urbanization is major reason for sharp decline in water table in almost every part of NCT Delhi with the critical conditions in highly urbanized areas. The decline of water table, which is measured during 2005–2014 for pre-monsoon month, shows an alarming situation. However rise in water table in some parts including New Delhi is also reported but this rise largely reflects the less abstraction of groundwater due to piped water supply and efforts of artificial groundwater recharge.

The increasing population and rapid urbanization threatens the sustainability of water resources. The further increase in the population, as projected in MPD 2021 may have drastic effects on the sustainability of groundwater resources. Apart from declining water table, overexploitation of groundwater may cause serious geo-environmental problems including land subsidence. To maintain the uninterrupted supply of water and to avoid geo-environmental problems associated with groundwater withdrawal, groundwater requires a careful management.

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