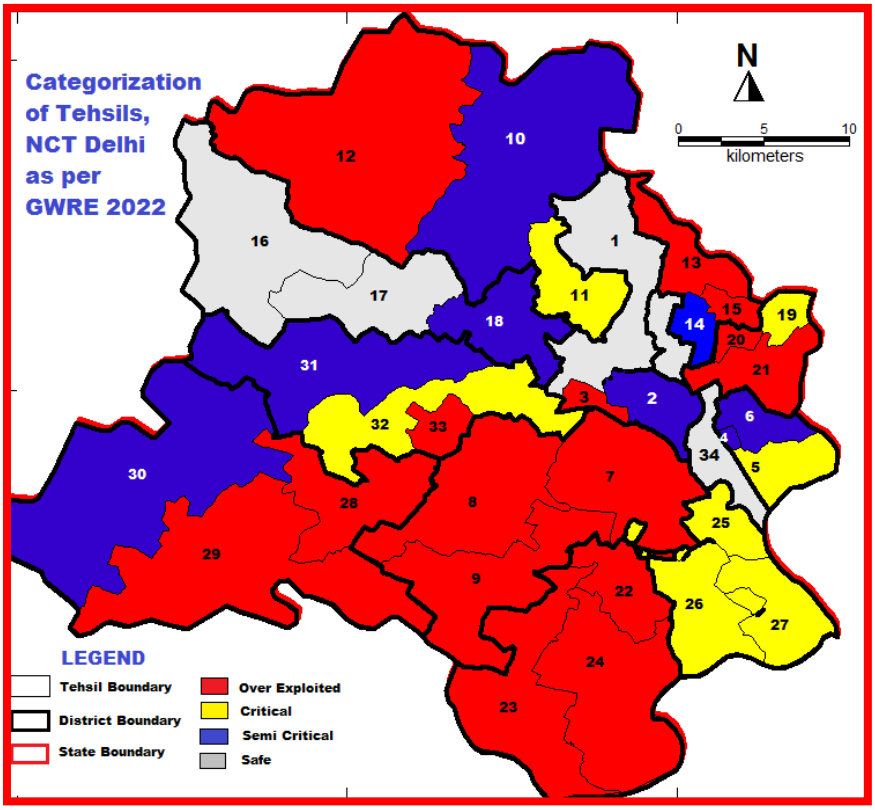
REPORT
DYNAMIC GROUND WATER RESOURCES OF NCT, Delhi As on March 2022



Central Ground Water Board
State Unit Office, Delhi

Department of Water Resources, River Development & Ganga Rejuvenation
Ministry of Jal Shakti

March 2022

केन्द्रीय भूमि जल बोर्ड,
राज्य एकक कार्यालय,
जल शक्ति मंत्रालय,
जल संसाधन, नदी विकास एवं जल संरक्षण विभाग,
भारत सरकार , नई दिल्ली

CENTRAL GROUND WATER BOARD,
STATE UNIT OFFICE-DELHI,
MINISTRY OF JAL SHAKTI
DEPARTMENT OF WR, RD & GR,
GOVERNMENT OF INDIA, NEW DELHI

PREFACE

Groundwater has emerged as an important source of water in the NCT, Delhi. In order to precisely estimate the ground water resources available for various uses and judiciously plan the development of water supply programmes as well as to ensure food security, there is a need to assess the ground water resources periodically. In view of this, Central ground Water Board and Department of Urban Development, Government of NCT, Delhi take up the task of estimating the dynamic ground water resources of NCT, Delhi periodically based on GEC 2015 methodology.

The re-estimation of ground water resources as on 2022 has been carried out using the methodology recommended by Ground Water Estimation Committee (GEC-2015) and the updated data which was provided by various State and Central Government agencies. The present estimation has been done considering each Tehsil (Revenue) Sub-division as assessment unit to have more refined and accurate estimation. The current status of ground water development is reflected in the category of various Tehsils, which are assigned taking into consideration both the stage of ground water development and the trend of ground water levels. The report on "Dynamic Ground Water Resources of NCT, Delhi as on 2022" contains very useful data pertaining to ground water resources and its development in the State. I sincerely, hope this report will be of immense help not only to planners administrators, researchers and policy makers but also to the stakeholder in need of such information to make himself aware of the availability of ground water and help in formulating development and management strategy.

This report will serve as useful tool for administrators, planners and government authorities in decision support and planning of ground water development schemes and management and regulation of this precious resource.

(S.K. MOHIDDIN)
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DYNAMIC GROUND WATER RESOURCES OF NCT OF DELHI

As on March, 2022

AT A GLANCE

1.	Total Annual Ground Water Recharge	41051.17 (ham)
2.	Annual Extractable Ground Water Resources	36946.51 (ham)
3.	Annual Ground Water Extraction	29032.77 (ham)
4.	Stage of Ground Water Extraction	98.16 %

CATEGORISATION OF ASSESSMENT UNITS (TEHSILS)

S. No.	Category	Assessment Units
1.	Safe	4 (11.8%)
2.	Semi Critical	8 (23.5%)
3.	Critical	7 (20.6%)
4.	Over Exploited	15 (44.1%)
	Total	**34**

CONTRIBUTORS

Assessment of ground water resources of NCT Delhi is based on the hydrogeological data collected during the field investigations carried out by the scientists of Delhi State Unit Office, CGWB and extraction & artificial recharge data gathered from State Government Agencies. Main Contributors are – Directorate of Economics and Statistics, Govt. of NCT Delhi; Irrigation and Flood Control Department, Govt. of NCT Delhi; Delhi Jal Board; Census of India, 2011; Indian Meteorological Department; New Delhi Municipal Corporation; Delhi Cantonment Board; DMRC, Delhi Parks & Garden Societies; Delhi Pollution Control Committee. NWIC (National Water Informatics Centre, Ministry of Jal Shakti has also extended great help in spatial distribution of geo referenced extraction data. However, Indian Railways & CPWD has not provided any data and have been used in this report on pro rate basis.

The computation of the dynamic ground water resource of NCT Delhi and preparation of the report has been done by the team lead by Sh. Saidul Haq, Retd. Scientist-D in association with Smt. Shilpi Gupta, Scientist-B, Sh. Faisal Abrar, AHG & Sh. V. Praveen Kumar, STA (HG) under the active supervision and guidance of Sh. S.K. Mohiddin, Officer In-charge, CGWB, SUO-Delhi.

This year CGWB is using online software IN-GRES to assess Dynamic Ground Water Resource as on 31 March 2022 using all input data of 2021.

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1. INTRODUCTION

Ground water Resources Estimation plays a pivotal role in effective implementation and monitoring of various guidelines issued by Govt. of India & State Governments. In view of the substantial changes observed in ground water resource scenario throughout the country, there is an emphasis has been laid in National Water Policy on periodic reassessment of ground water resources of the entire country for quantification, sustainable development and management.

The 'National Water Policy 2012 adopted by the Government of India regards water as a scarce natural resource, fundamental to life, livelihood, food security and sustainable development. It emphasizes that the efforts to develop, conserve, utilize and manage this resource must be guided by the national perspective. Correspondingly, safe water for drinking and sanitation is considered as pre-emptive needs, followed by high priority allocation for other basic domestic needs including needs of animals, achieving food security, supporting sustenance agriculture and minimum eco-system needs.

NCT Delhi being urban area wherein space for natural recharge is reducing abreast with infrastructural development both over the surface & under the surface posing challenges to planners and scientist to accurately assess Dynamic Ground Water Resource of NCT Delhi. The subsurface infrastructure developments (construction of double/triple basements, underground metro tunnel, Station, roads etc.) are also causing imbalance in natural sub surface flow of ground water.

1.1. Background of Ground water Resources Estimation

As early as in 1972, guidelines for an approximate evaluation of ground water potential were circulated by the Ministry of Agriculture, Government of India to all the State Governments and financial institutions. The guidelines recommended norms for ground water recharge from rainfall and from other sources. The first attempt to estimate the ground water resources on a scientific basis was made in 1979. A High-Level Committee, known as 'Ground water Over Exploitation Committee', was constituted by then Agriculture Refinance and Development Corporation (ARDC). This Committee recommended definite norms for ground water resources computations. In the year 1982, Government of India constituted "Ground water Estimation Committee" (GEC) with the members drawn from various organizations engaged in hydrogeological studies and ground water development. In 1984 this Committee, after reviewing the data collected by central and state agencies, research organizations, universities, etc., recommended the methods for ground recharge estimation. This is popularly known as GEC 1984. This was the first methodology which dealt with the subject exhaustively and assessed the resources on a fool proof method. This methodology was in practice for next 12 years. In the year 1996, Government of India again constituted "Ground water Estimation Committee" (GEC) with the members taken from various organizations engaged in hydrogeological studies and groundwater development. In 1997 this Committee, after reviewing the data collected by central and state agencies, research organizations, universities, etc. recommended the methods for ground water recharge estimation. This is popularly known as 'GEC 1997'. Subsequently, GEC 1997 was revised and present methodology in vogue is 2015. GEC 2015 recommends aquifer wise Ground Water resource assessment to which demarcation of lateral as well as vertical extent and disposition of different aquifers is pre-requisite. Keeping in view of the rapid change in ground water extraction, GEC-2015 recommends resources estimation once in every three years.

1.2. Previous Ground Water Resource Estimation of NCT Delhi

The Ground water Resources of NCT Delhi was estimated first time in year 1991 as per GEC 1984 methodology taking into consideration then 9 districts area as 'Assessment Unit' and then in year 2004 as per GEC 1997 methodology. Tehsil wise ground water resources estimation was undertaken during 2009, 2011 and 2013 for then 27 Tehsils of 9 district of NCT Delhi and for 34 tehsils of 11 districts and 1 non- revenue district during 2017. The summarized details of all such previous resource estimation of NCT Delhi is presented in Table 1 and depicted graphically in Figure 1.

Table 1: Previous Ground Water Resource Estimation of NCT Delhi

Methodology	1991	2004	2009	2011	2013	2017	2020
	GEC 1984	GEC 1997				GEC 2015	
Total Annual Recharge (ham)	29154	29710	31501	31050	34192	30090	31811.76
Total Ground water Extraction (ham)	16840	47945	39619	39215	38785	35990	36267.14
Stage of Ground water Development (%)	58	161	125	126	113	119	98

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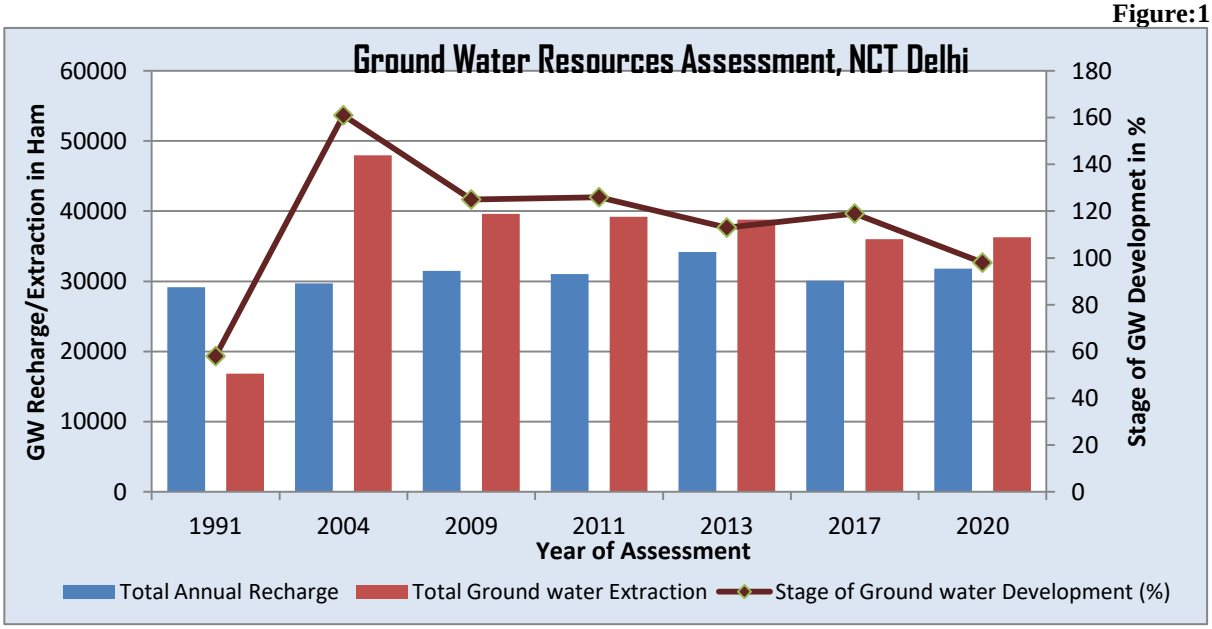
Figure:1



1.3. Constitution of State Level Ground Water Coordination Committee

Department of Water Resources, River Development & Ganga Rejuvenation, Ministry of Jal Shakti, Govt. of India constituted a Central Level Expert Group (CLEG) for overall re

assessment of ground water resources of the country as on 31st March 2022 vide Resolution dated 08 Febraury, 2022. Accordingly, a State Level 'State Ground Water Coordination Committee' (SGWCC) was constituted by the Government of NCT, Delhi vide order no. 16 F-16 (554)/UD/W/2015/Vol-II/2079-281 dated 29th March, 2022 for re-estimation of ground water resources as on March 2020 with 17 members under the Chairmanship of Principal Secretary, Urban Development, GNCTD (Annexure-1). The list of members of the Committee constituted at the State level for re-estimation of ground water resources is given in the Table 2.

Table 2: Composition - State Ground water Coordination Committee, NCT Delhi

1	Pr. Secretary, UPr. Secretary, Urban Development, GNCTD Development,	CHAIRMAN
2	Commissioner, Dept. of Industries, GNCTD	MEMBER
3	Chief Executive Officer, Delhi Cantonment Board	MEMBER
4	Member (Water Supply), Delhi Jal Board	MEMBER
5	Member(Engineering), Delhi Development Authority	MEMBER
6	Chief Engineer(Civil-I), NDMC	MEMBER
7	Chief Engineer, Zone-I, Irrigation and Flood Control Department, GNCTD	MEMBER
8	Chief Engineer, Zone-II, Irrigation and Flood Control Department, GNCTD	MEMBER
9	Chief Engineer, North Delhi Municipal Corporation	MEMBER
10	Chief Engineer, South Delhi Municipal Corporation	MEMBER
11	Chief Engineer, East Delhi Municipal Corporation	MEMBER
12	Director, Department of Environment, GNCTD	MEMBER
13	Joint Director(Agriculture), Development Department	MEMBER
14	General Manager (NABARD)	MEMBER
15	Superintending Engineer(RWH), Delhi Jal Board	MEMBER
16	Garrison Engineer(Utility), Water Supply, MES	MEMBER
17	OIC, State Unit Office, Central Ground Water Board	MEMBER SECRETARY

1.4. Brief outline of the meetings of the SGWCC, NCT Delhi

First meeting of the State Level Committee (SLC), NCT Delhi was held on 25 April, 2022 under the Chairmanship of Sh. Sanjeev Khirwar, Principal Secretary, Urban Development, Govt. of NCT, Delhi. During the meeting CGWB gave background information on groundwater resource estimation and its importance and it was agreed that authenticated information about revised administrative units (33 tehsils/11 districts) in terms of its boundary, geographical area, population and related land use data may be obtained from concerned District Magistrate offices of NCT, Delhi. It was decided that Ground water Resource Estimation for the year 2022 would be taken up in these 33 Tehsils of 11 districts & one non-revenue unit (Nazul land) of NCT Delhi. Further, it was agreed that Ground water Resource Assessment 2022 would be taken up as per revised methodology of GEC, 2015. CGWB highlighted that the assessment of the Ground water Resources requires multiple data pertaining to groundwater Extraction & recharge from various department / agencies of GNCT Delhi. In this respect, numbers of departments /agencies of GNCT Delhi, namely DJB, NDMC, North, South & East MCD, DDA, DMRC, PWD, I&FC, Delhi Cantonment, Department of Industries etc were identified for providing the requisite input data.

Principal Secretary,Urban Development advised that all the concerned state govt. departments must co-operate to provide the necessary data to CGWB in the format provided by CGWB. The minutes of the first meeting are annexed at Annexure (I).

Second meeting of the SGWCC was held on 31st May,2022 under the Chairmanship of Sh. V.S. Rawat, Special Secretary, Urban Development, Govt. of NCT, Delhi. Brief account of status of data provided by various state departments to CGWB was deliberated. During the meeting, data gap pertaining to ground water Extraction and artificial recharge was presented by CGWB. It was also decided to include CPWD and Railway representative as co-opted member of SGWCC for providing Extraction and recharge data because of NCT, Delhi have large area under control of these two departments. Chairman of SGWCC again requested all departments to provided geo-reference data to CGWB before 15th June 2022 so that Ground Water Estimation process could be initiated and finalize the Ground water Resources report of NCT, Delhi as per the data/information provided to CGWB. The minutes of the 2nd meeting is annexed at **Annexure (II).**

Third & final meeting of SGWCC (State Level Groundwater Coordination Committee) held on 28th July 2022 for approval of dynamic ground water resource as on March 2022. Officer In charge, CGWB, Delhi State Unit Office made a presentation regarding methodology adopted, processing of ground water extraction & recharge data and outcome of INGRES. Tehsil wise Category as Safe, Semi-critical, Critical and Over Exploited as on March 2022 was also presented. The Committee approved the Dynamic Ground Water Resource 2022 estimated by CGWB unanimously. The minutes of the 3rd meeting is annexed at **Annexure (III)**.

2. NCT DELHI: BACKGROUND INFORMATION

The National Capital Territory (NCT) of Delhi is spread in an area of 1483 Sq.km and lies between 28°24'15'' & 28°53'00'' *North Latitudes* and 76°50'24" & 77°20'30" *East Longitudes*, covered under Survey of India Toposheet Nos. 53D and 53H. It is surrounded on three sides by two States, i.e., on North, West and South by Haryana and in the East across the river Yamuna by Uttar Pradesh.

2.1. Administrative Setup of NCT Delhi

NCT Delhi is divided in 11 Revenue District and one non-revenue unit, Nazul Land along river Yamuna (Table 3 & Figure 2). Each district is headed by a Deputy Commissioner and assisted by Additional District Magistrate & Sub Divisional Magistrates. The District Administration in Delhi is the *de-facto* enforcement department for all kinds of Government policies and exercises supervisory powers over numerous other functionaries of the Government. As per District Census Hand Book, 11 districts of NCT of Delhi are further subdivided into 3 Tehsils for each district and there are total 33 Tehsils, with 112 villages, 110 Census Town and 3 Statutory Towns. Administrative map of NCT of Delhi is shown in Figure 2 and list of districts and its tehsils are presented in Table 3a.

Figure: 2

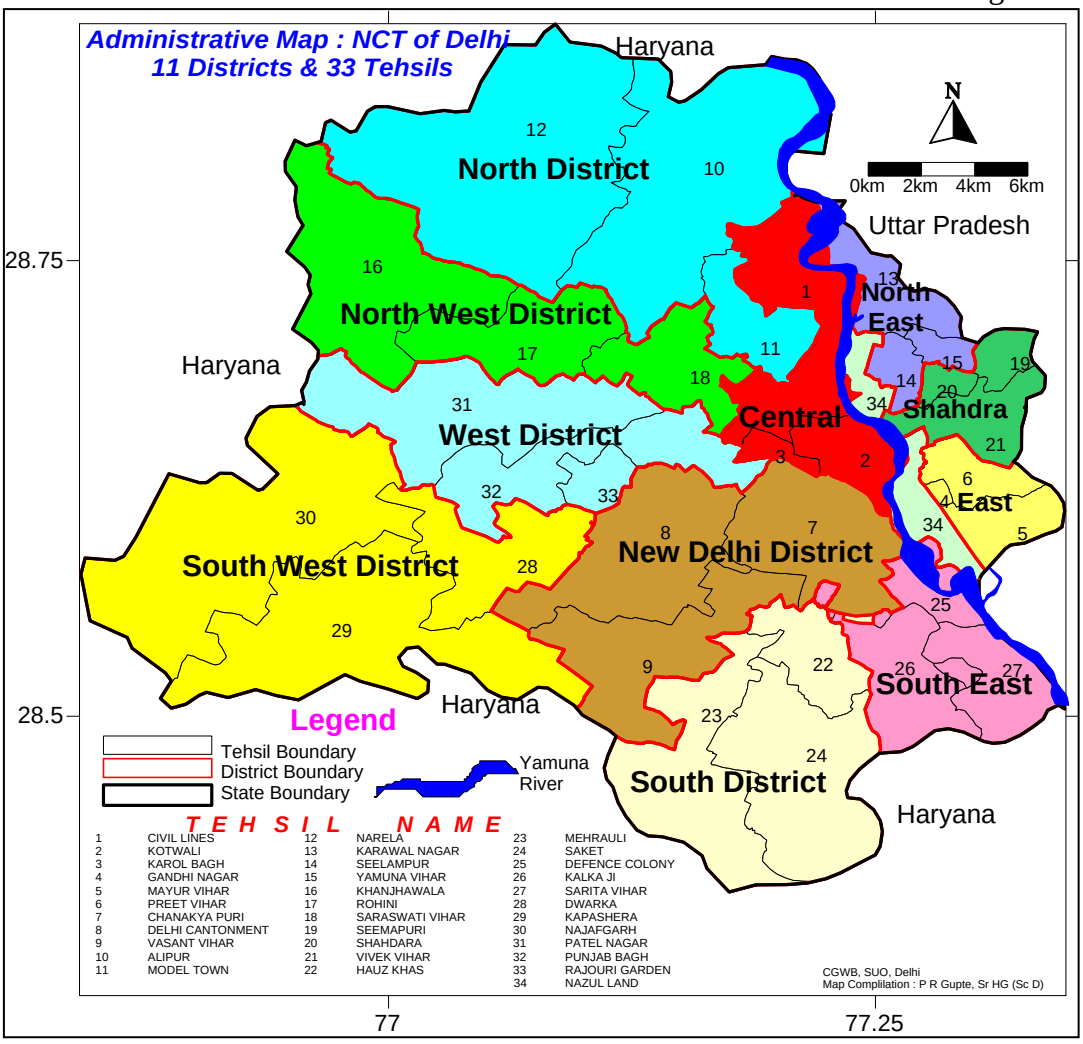


Table 3a: Details of Administrative Units - NCT of Delhi

Sr.No.	District Name	Tehsil Name
1	CENTRAL	CIVIL LINES
		KOTWALI
		KAROL BAGH
2	EAST	GANDHI NAGAR
		MAYUR VIHAR
		PREET VIHAR
3	NEW DELHI	CHANAKYA PURI
		DELHI CANTONMENT
		VASANT VIHAR
4	NORTH	ALIPUR
		MODEL TOWN
		NARELA
5	NORTH EAST	KARAWAL NAGAR
		SEELAMPUR
		YAMUNA VIHAR
6	NORTH WEST	KHANJHAWALA
		ROHINI
		SARASWATI VIHAR
7	SHAHDARA	SEEMAPURI
		SHAHDARA
		VIVEK VIHAR
8	SOUTH	HAUZ KHAS
		MEHRAULI
		SAKET
9	SOUTH EAST	DEFENCE COLONY
		KALKA JI
		SARITA VIHAR
10	SOUTH WEST	DWARKA
		KAPASHERA
		NAJAFGARH
11	WEST	PATEL NAGAR
		PUNJAB BAGH
		RAJOURI GARDEN
Non-Revenue Unit Area		NAZUL LAND

2.2. Population & Land use

As per 2011 Census of India Report total population of NCT Delhi is 167,87,944 persons. Out of total 1483 Sq.km areas, only 25 % constitute rural areas spread in 112 villages, which is sparsely populated having population density of 1135 persons / Sq.km, whereas rest 75 % is urban areas spread in 110 Census Towns and 3 Statutory Towns and it is densely populated with population density of 14,698 persons / Sq.km. Details of villages & towns and its area & populations and land use pattern is given in table 3b & 3c respectively. Population of Delhi has increased at a rate of 2.1% per annum during the decade 2001-2011. Considering the same growth rate for the present decade, it is estimated that the population of Delhi in 2021 would be about 188 lakhs and 208 lakhs by 2031.

Table 3b: Area, Population & Details of Towns and Villages: NCT of Delhi

Area & Population

- Total Area: 1483 Sq.km Total Population: 167,87,941 persons
- Urban Area: 1114 Sq.km (75%) Urban Population: 163,68,899 (98 %)
- Rural Area: 369 Sq.km (25 %) Rural Population: 4,19,042 (2 %)

Details of Towns - Urban Area

- ✓ Statutory Towns: 3
- ✓ New Delhi Municipal Council: Area 42.74 Sq.km; Population: 2,57,803
- ✓ Delhi Cantonment Board: Area 42.97 Sq.km; Population: 1,10,351
- ✓ Delhi Municipal Corporation
- ✓ Census Towns: 110 - (List – Details Annexure I)
- ✓ DMC & Census Town Area: 1028 Sq.km Population: 160,00,745

Details of Villages - Rural Area

- Villages: 112 List – Details Annexure I)
- Village Area: 363.35 Sq.km Population: 4,19,042

Source: Delhi Statistical Handbook-2021: www.delhigovt.nic.in

Land utilization data for year 2020-21 reveals that out of 1474.8 sq.km areas accounted for Land Records in NCT of Delhi, more than 57 % area is not available for cultivation whereas only 192.25 sq.km is available for cultivation and nearly 435 sq. km is gross cropped / agriculture areas. Nearly 6 % of total area is under forest, cover mostly notified ridges and other forest pockets under DDA & government forest land. Break up of land utilization is presented in Table 3b&3c and depicted graphically in Figure 3.

Table: 3c Utilization of Land in Delhi (2020-21) Area in Hectares

Area according to Land use Records (Exclude Forest)		147488
Area not Available for Cultivation		92700
(a) Land Put to Non-Agriculture Use -	76218	
(b) Barren and Uncultivated Land	16482	
Other Uncultivated Land		11124
(a) Permanent Pasture & Other Grazing Land	61	
(b) Land Use Under Miscellaneous Uses	1170	
(c) Cultivable Waste Land	9893	
Fallow Land		19225
Net Area Sown		29241
Area Sown more than once		14328
Total Cropped Area		43569
Area Under Forest		9453
(a) Forest Under DDA	1281	
(b) Notified Ridge Forest	7784	
(c) Other Forest Area	388	

Source: Joint Director of Agriculture, Govt of NCT Delhi

Table: 4 Sources of Irrigation and Irrigated Area 2020-21

Source		Area Irrigated (in Hectare)	
Canals			2235
Tanks			
Wells	TWs	21477	22465
	Others	988	
Net Area Irrigated			24700
Area Irrigated More Than Once			14328
Gross Area Irrigated			39028

Source: Joint Director of Agriculture, Govt of NCT of Delhi

Main source for irrigation in NCT of Delhi is groundwater whereas surface water is also available from Trans Yamuna Canal Network. Details about sources of irrigation and areas under irrigation is presented in Table 4 and Figure 4.

Figure: 3

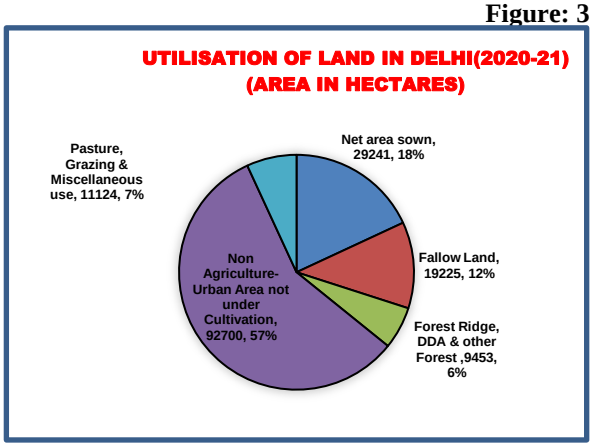
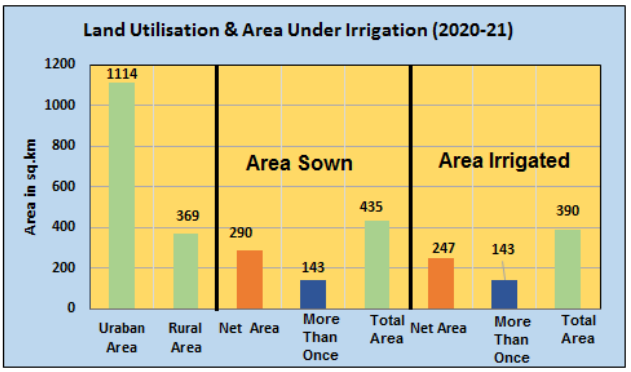


Figure: 4



2.3. Hydrometeorology

Climate

The climate of NCT Delhi is mainly influenced by its inland position and the prevalence of air of the continental type during the major part of the year. Extreme dryness with the intensely hot summer and cold winter are the characteristics of the climate. Only during the three- monsoon months July, August, and September does air of oceanic origin penetrate to this state and causes increased humidity, cloudiness and precipitation. The year can broadly be divided into three seasons (Table 5). Data on long-term average climatologic parameters covering monthly maximum / minimum temperature, relative humidity, evaporation and rainfall for NCT of Delhi is given in Table 6 and presented graphically in Fig 5.

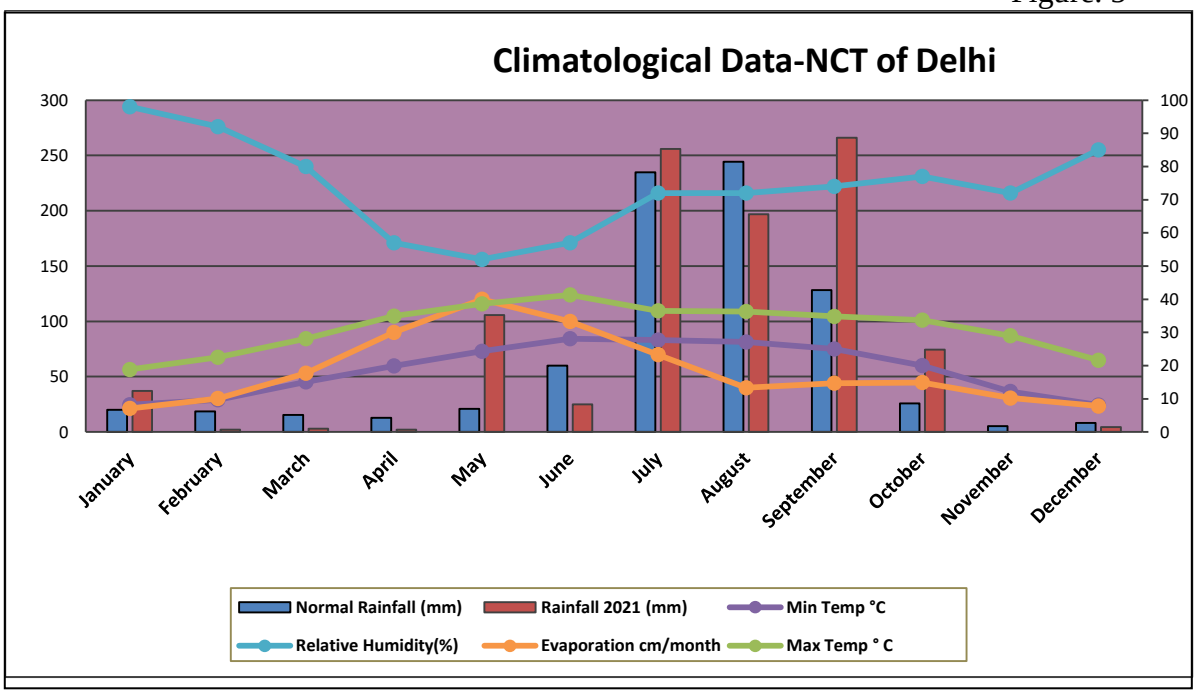
Table 5: Climate Seasons in NCT of Delhi

Season	Begin	End
Cold/Winter	End of November	Middle of March
Summer	Middle/End of March	End of June
Rainy season	Early July	September

Table: 6 Climatological Parameters – NCT of Delhi

Month	Max Temp (°C)	Mini Temp (°C)	Relative Humidity (%)	Rainfall (mm) Normal	Rainfall (mm) 2021	Rainy Days	Eto (mm/d)
January	18.8	8.2	98.0	19.9	37.11	4.0	7.1
February	22.5	9.7	92.0	18.6	2.18	0.0	10.1
March	28.1	15.1	80.0	15.5	2.93	6.0	17.7
April	34.9	19.9	57.0	12.7	2.16	2.0	30.0
May	38.6	24.3	52.0	20.8	105.62	0.0	40.0
June	41.3	28.1	57.0	59.9	24.88	4.0	33.3
July	36.5	27.7	72.0	234.7	255.94	10.0	23.3
August	36.3	27.1	72.0	244.2	196.74	9.0	13.3
September	34.8	25.0	74.0	128.3	265.95	1.0	14.7
October	33.7	20.0	77.0	25.9	74.34	0.0	14.9
November	29.0	12.2	72.0	5.3	0	0.0	10.2
December	21.6	8.1	85.0	8.2	4.49	0.0	7.8
Total	**-**	**-**	**-**	**794**	**972.34**	**36.0**	**222.4**
Average	**31.3**	**18.8**	**74.0**				

Figure. 5



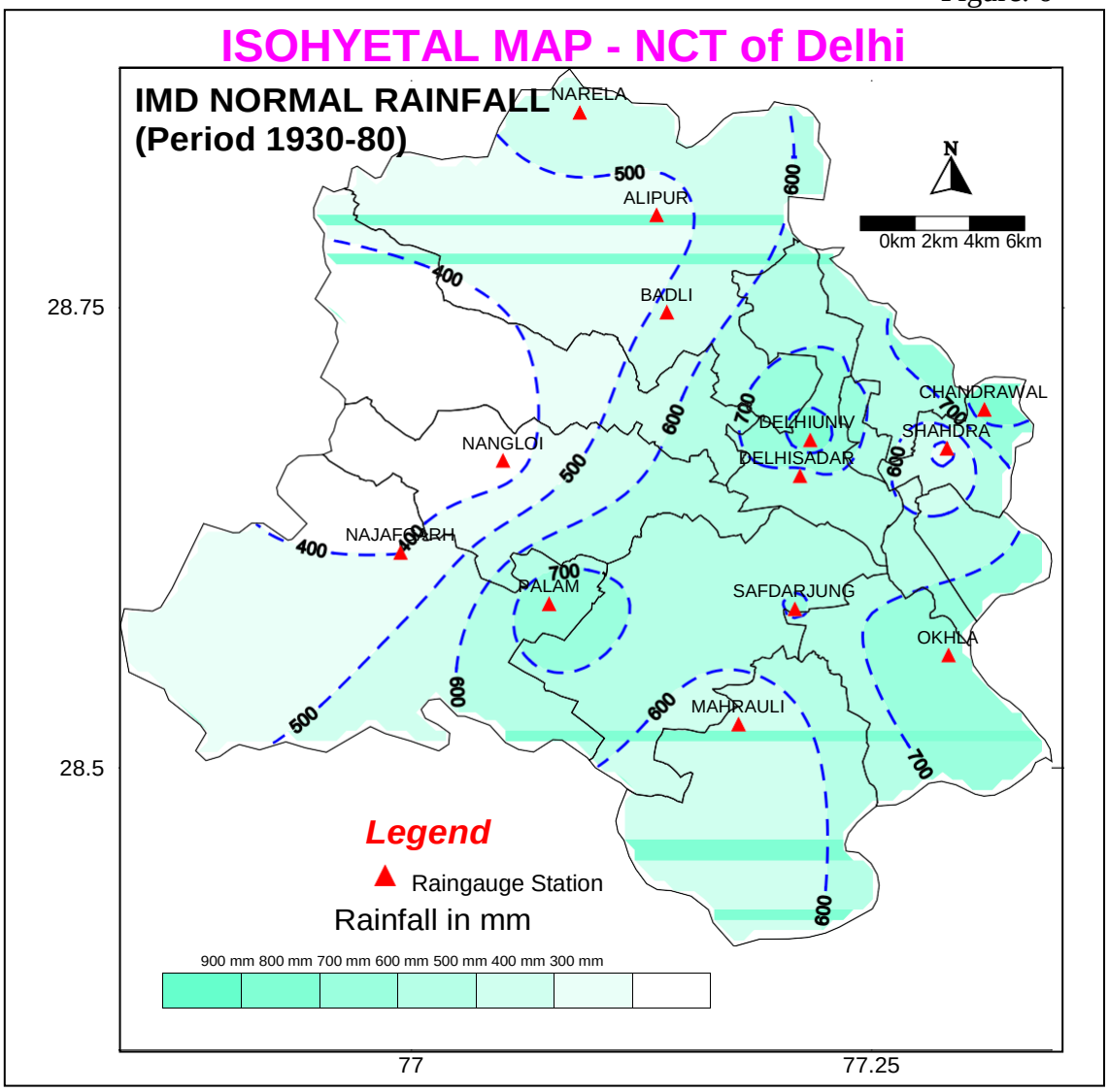
Rainfall

The normal rainfall in NCT Delhi is 794 mm. The rainfall in NCT Delhi increases from the southwest to the northwest (Fig. 4). About 81% of the annual rainfall is received during the monsoon months July, August and September. The rest of the annual rainfall is received as winter rains and as thunderstorm rain in the pre and post monsoon months. The variation of rainfall from year to year is large.

Rainfall Analysis

Rainfall analysis of 34 years annual rainfall of data and probability analysis data is plotted in figure 7 & 8 and its finding, about probability of occurrence of quantum of rainfall with various probability is presented in Table 7.

Figure. 6



Plot of Annual Rainfall, Departure & Cummulative Departure

Figure.7

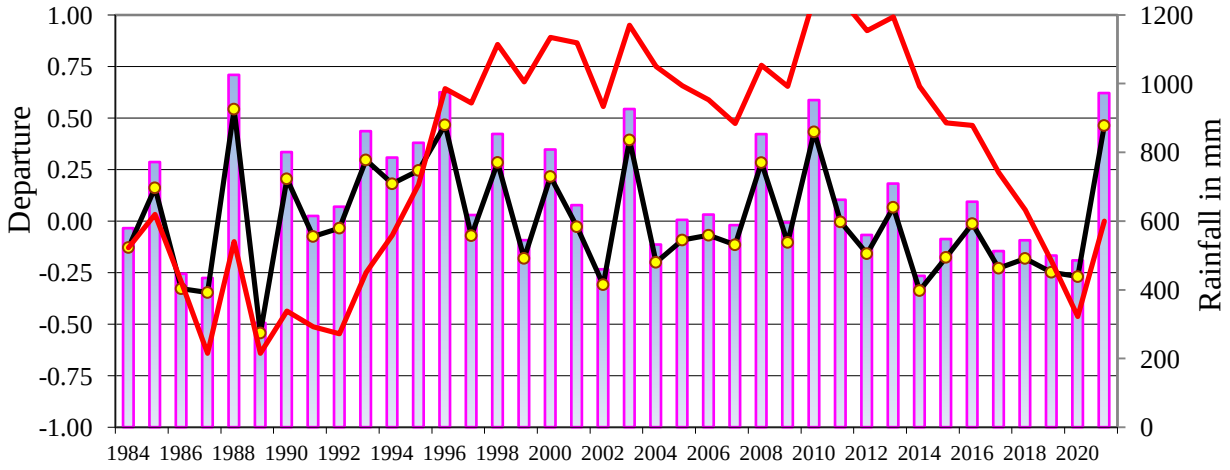


Figure.8

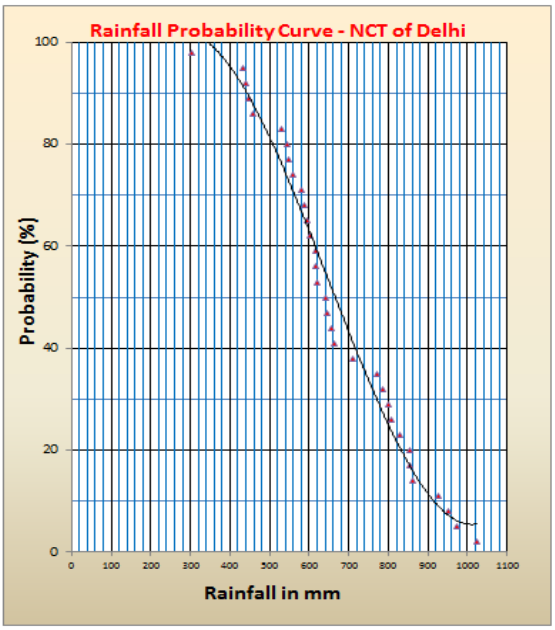


Table 7: Rainfall Probability	
Probability %	Annual Rainfall in mm
10%	922
20%	840
30%	778
40%	718
50%	664
60%	618
70%	562
80%	520
90%	476
Probability of exceeding of Normal RF	58%

A perusal of rainfall data from 1984 to 2021 shows that NCT Delhi received deficient rainfall during last 21 years corresponding to mild to severe drought conditions (Annexure-II). Severe drought with departure of 50% was experienced in the year 1989. Normal drought, departure 25 to 50 % was experienced during year 1986,1987, 2002 and recently during 2014. Whereas, Mild drought, departure up to 25%, was experienced during the year 1984, 1991, 1992, 1997, 1999, 2001, 2004 to 2007, 2009, 2010, 2012 and 2015 to 2021. The probability analysis shows that probability of rainfall exceeding normal rainfall of 669 mm is up to 48 % whereas there are 90 % chance that rainfall would limit to 476 mm. Overall, the rainfall in Delhi is highly variable and which in turn affects the natural recharge to ground water from year to year. The effect of climate change is visible since 2019 onwards. The rainfall events are intense & more frequent during monsoon months with less no. of rainy days.

Other Climatic Parameters

- Temperature:

The cold season starts after second week of November when both day and night temperature drop rapidly with the advance of the season. January is the coldest month during which mean daily maximum and minimum temperature varies between 21.3°C to 7.3°C. In the winter months when western disturbances pass over North India, minimum temperatures may sometimes go down to the freezing point of water. From about the middle of March, temperature begins to rise rapidly. May and June are the hottest months. While day temperature is higher in May the nights are warmer in June. From April the hot wind known locally as *'loo'* blows and the weather is unpleasant. In May and June maximum temperature may sometimes reach 46°C or 47°C. With the advance of the monsoon into the area towards the end of June or the beginning of July day temperatures drop appreciably while the night temperatures remain high. In October the day temperatures are as in the monsoon months, but the nights are cooler.

- Humidity:

The air over Delhi is dry during the greater part of the year. Humidity is high in the monsoon months. April and May are the driest months with relative humidity of about 30% in the morning and less than 20% in the afternoons.

- Cloudiness:

During the monsoon especially in July and August skies are heavily clouded and often overcast. In the rest of the year skies are clear or lightly clouded. But in the months January, February and early March skies become cloudy by western disturbances.

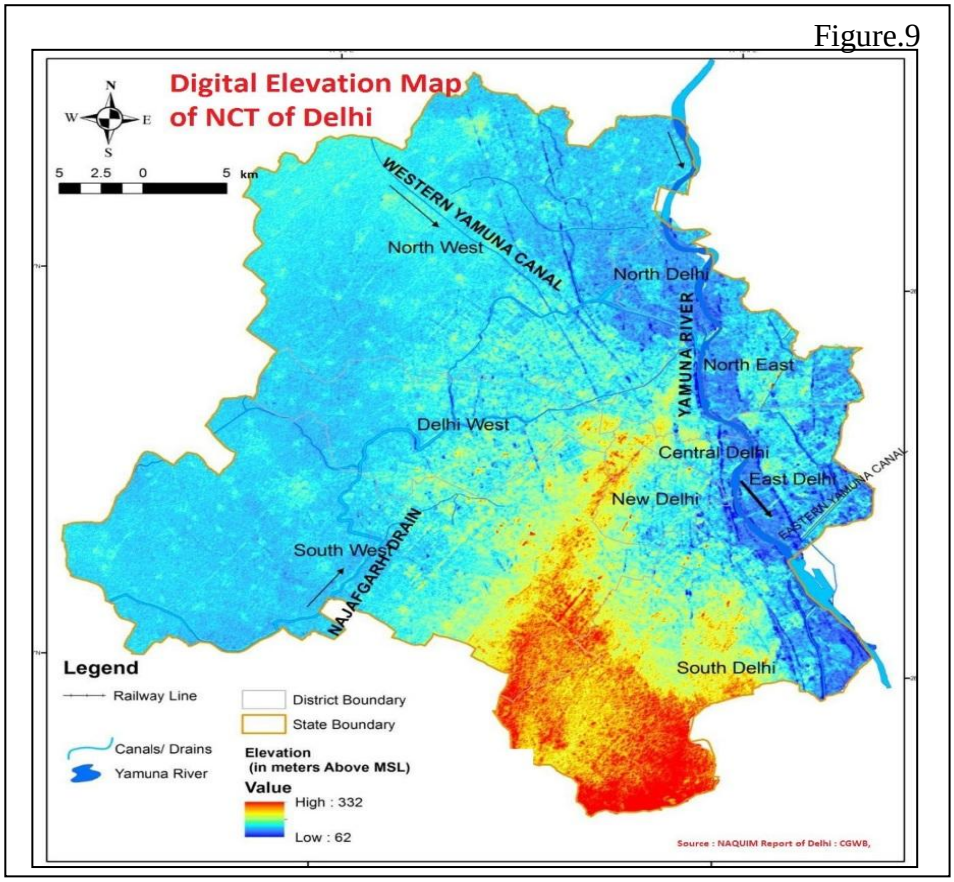
- Winds:

Winds are generally light during the post monsoon and winter months. They strengthen during the summer and monsoon months. Except during the monsoon months, winds are predominantly from a westerly or northwesterly direction and tend to be more northerly in the afternoon. Easterly and southeasterly winds are more common in the monsoon months.

2.4. Physiography & Drainage

NCT of Delhi represents a mature topography with vast, gently undulatory plains dominated by Yamuna River, low linear ridges and isolated hillocks. Physiography of Delhi is dominated by the Yamuna river, the Aravalli range, and the plains in between formed by alluvium deposits of Recent age. The SSW- NNE trending Aravalli Ranges are designated as *Delhi Ridge*, occupy the South-Central part of Delhi and extend up to western bank of Yamuna River near Okhla in the south and Wazirabad in the north-east. Ecologically, the Aravalli Ridge acts as a barrier between the Thar desert and the plains and slows down the movement of dust and wind from the desert. In NCT Delhi, the ridge area is covered with forests, acts as city's lungs and help maintain its environment. This green belt, a natural forest, has a moderate influence on temperature, besides bestowing other known benefits to the people.

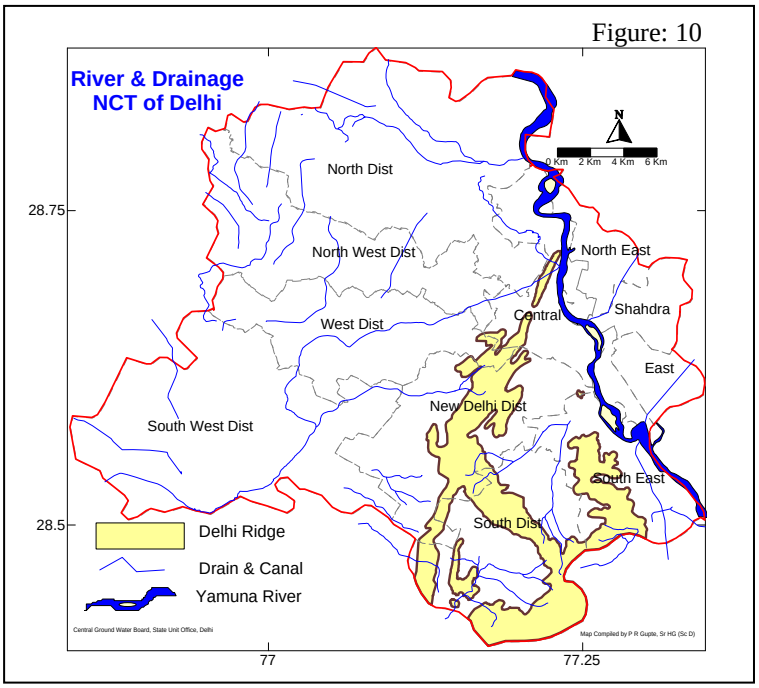
Figure.9



The area towards east of ridge has a gentle slope of 3.5 m/km towards Yamuna. The area towards west of ridge representing Older Alluvial Plain is mostly covered by sand dunes and has a westerly slope. Yamuna River flows across Delhi in a south- southeasterly direction with vast flood plain, marked by a bluff of 3 to 4 m on either bank. Digital Elevation Model Map of Delhi is presented in Fig. 9. Surface elevation varies from 332 m above mean sea level at the ridge to 62 m above mean sea level at river Yamuna. The low-lying Yamuna flood plains, with an elevation as low as 198 m amsl, provide fertile alluvial soil suitable for agriculture but are prone to recurrent floods.

The Yamuna River flowing in a southerly direction in the eastern part of the NCT of Delhi is the only perennial river in the area besides the number of micro watersheds originating from the

Figure: 10



quartzite ridge. The drainage on the East of the ridge enters river Yamuna, whereas on the West, it enters natural depressions located in Najafgarh Tehsil of South-West district. The NCT of Delhi can be divided into seven sub basins, ultimately discharging into the Yamuna (Fig. 10), namely (i) The Najafgarh Drain is about 39 Km long, flows North-Easterly and joins Yamuna River at Wazirabad in North Delhi. (ii) Supplementary drain, (iii) Barapullah drain (iv) Wild life sanctuary area, (v) Drainage of Shahadra area, (vi) Bawana drain basin, (vii) Other drains directly out falling into river Yamuna on right bank. Swamp areas are common along the flood plains of Yamuna.

2.5. Geomorphology

The ground water availability in NCT of Delhi indirectly relates with its distinct landform units, which in turn represent underlying intrinsic geological features. Map showing these landforms of NCT of Delhi are presented in Fig. 11. All these landforms of NCT, Delhi can be grouped into three broad geomorphic units: namely Rocky surface, Older Alluvial Plain and Flood Plain of Yamuna River.

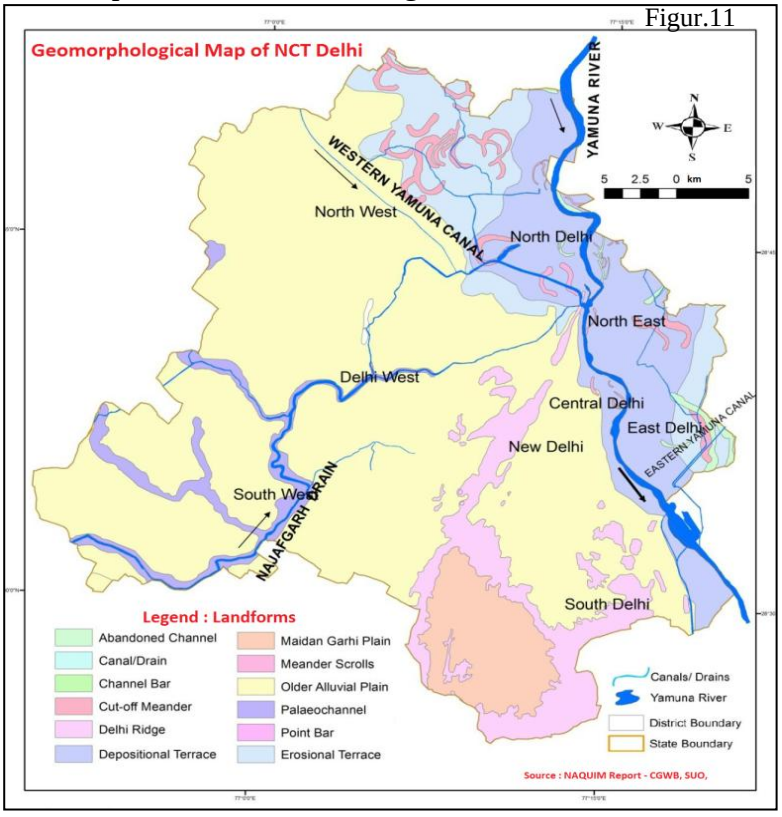
Rocky Surface: The rocky surface represents structurally controlled relict linear ridges and isolated hillocks comprising of rocks of Delhi Supergroup. This distinct landform comprising of isolated hills is most prominent in the South- and South-Central parts, extends from Mahipalpur to

Wazirabad in the north. Towards south of Mahipalpur the ridge gets bifurcated, one arm extends towards Mandi and further south while the other arm takes a turn towards southeast and extends uptoTughlakabad- Greater Kailash-Nehru Place and Okhla. It attains a maximum elevation of 362 m amsl which gradually diminishes towards north where rocks are exposed on the western bank of Yamuna near Wazirabad.

Older Alluvial Plain: The gently undulatory terrain on either side of the rocky surface is described as Older Alluvial Plain. This surface is separated from the Yamuna Flood Plain by a bluff. Depending upon the morphological expressions / features, this unit is further divided into different subunits: namely, (i) Najafgarh Older Alluvial Plain, (ii) Delhi Older Alluvial Plain and (iii) Maidan Garhi Plain. Najafgarh Older Alluvial Plain occupying western and southwestern part of the region is partly covered by sand dunes and sandy sheets. The gently sloping surface including the covered pediment along the eastern flank of the ridge represents the Delhi Older Alluvial Plain. Maidan Garhi Plain is a relatively higher plain surface and forms part of Chhatarpur Basin. A narrow zone of badland has formed mostly along the western margins of structural ridges due to intense development of gullies and rills.

Flood Plain of river Yamuna: The low-lying flat surface representing the Flood Plain of river Yamuna occupying northern, northeastern and eastern parts of the NCT is an important geomorphic unit. North of Narela, the width of flood plain varies from 15 to 17 km. The wider Older Yamuna flood plain indicates lateral migration of river Yamuna over large areas. This belt has good potential for ground water development. It forms the erosional terrace. The Yamuna Active Flood Plain represents the wide belt bounded on both the sides by Eastern and Western bunds and is naturally prone to annual / periodic floods being in the flood way and flood fringe zone of river Yamuna. It forms depositional terrace and is characterized by abandoned channels, cut-off meanders, meander scrolls, point bars and channel bars. Presence of number of cut- off meanders in the Yamuna Flood Plain suggests oscillatory shifting of river. The lakes near Bhalsawa, Kondli and Khichdipur are remnants of large meanders.

Figur.11



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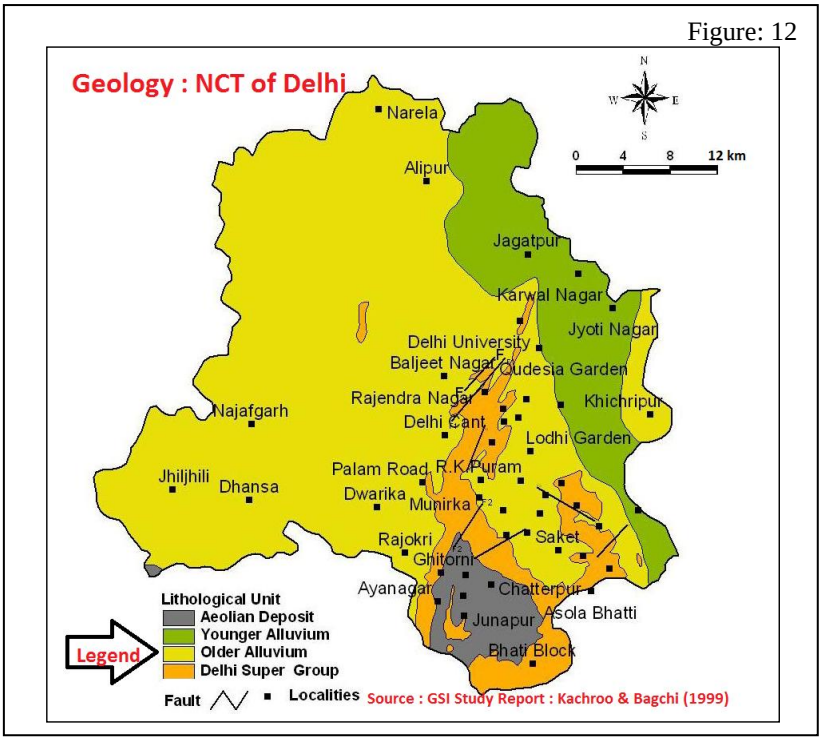
2.6. Geology

The rock formations exposed in the National Capital Territory of Delhi are mainly quartzite interbedded with thin bands of micaceous schist. These Proterozoic age rocks occur along the ridge, extending from Harchandpur (Haryana) in the South to Wazirabad (Delhi) in the North. Quaternary sediments consisting alluvium deposit directly overlie the Proterozoic rocks. Systematic geological and geomorphologic studies carried out by the Geologists of Geological Survey of Indiahas revealed three Stratigraphic horizons and underlying three distinct lithostratigraphic units of NCT Delhi. The highest of these is the erosional surface forming the top of denudational hills. The second surface is Older Alluvial plain and the third is depositional Younger Alluvial plain (Yamuna). All three lithostratigraphic units corresponding them have undergone changes due to widespread and uncontrolled urban activity over the period. The geological map of Delhi after Kachroo and Bagchi (1999), showing these main units is shown in Fig. 12 and generalized stratigraphy of NCT of Delhi is presented in Table 8.

Table 8: Generalized Stratigraphic Units of NCT Delhi (compiled after GSI Study)

Alluvium	Newer Alluvium	Unconsolidated, inter-bedded lenses of sand, silt gravel and clay confined to narrow flood plains of Yamuna river and Aeolian deposit of South Delhi.
	Older Alluvium	Unconsolidated thickness varies upto 300m. Interbedded, inter-fingering deposits of sand, clay and kankar, poor to moderately sorted.
Delhi Super Group	Alwar Quartzite	Well stratified, thick bedded, brown to buff colour, hard and compact, intruded locally by pegmatite and quartz veins interbedded with mica schist.

Figure: 12



In NCT Delhi region, exposures of the oldest litho-stratigraphic unit, the Delhi Quartzite ridge acts as main recharge zone to subsurface aquifer system. The Quaternary deposits in the form of aeolian and alluvial deposits are the major repository of ground water in the area. These two main hydrogeological units constitute main aquifer system for NCT Delhi.

2.6.1. Alluvium Aquifer

In NCT Delhi region, exposures of the oldest lithostratigraphic unit, the Delhi Quartzite ridge acts as main recharge zone to subsurface aquifer system. The Quaternary deposits in the form of aeolian and alluvial deposits constitute the major repository of ground water in the area. In the East of the ridge, the thickness of unconsolidated sediments gradually increases away from the ridge, with the maximum reported thickness being 170 m. In the Southwestern, Western and Northern parts of the area, the thickness of sediments is more than 300 m except at Dhansa where the bedrock has been encountered at 297 m below land surface. In Chhattarpur basin, the maximum thickness of sediments is 116 m. The aeolian deposits of South Delhi are mainly comprised of loam, silty loam and sandy loam. The bedrock is overlain by these deposits. Older alluvial deposits consist mostly of interbedded, lenticular and inter fingering deposits of clay, silt, and sand along with kankar. These deposits are overlain by the newer alluvium, which occurs mostly in the flood plains of river Yamuna.

2.6.2. Hard Rock Aquifer

Quartzite is one of the most physically durable and chemically resistant rocks found in NCT of Delhi. The suits of quartzite and associated mica schist /phyllite bands of Delhi system have undergone multiple folding and different phases of metamorphism. When the mountain ranges are worn down by weathering and erosion, less-resistant and less-durable rocks are destroyed, but the quartzite remains. This is why Delhi Quartzite is so often the rock found as linear ridges ranges and covering their flanks as a litter of scree. One of the research study on weathering of Proterozoic quartzite in the semi-arid conditions around Delhi suggested that Quartzite being a resistant rock, dissolution of small amount of pyrites presence, by moving water produced a sulphate-bearing acidic solution and ferrous iron which reacted with aluminosilicate minerals and quartz respectively and has made the Delhi Quartzite porous and subsequent friable. The coupled weathering mechanism, from the core outward and also proceeded initially from fractures towards the inside, produced weathering rinds and subsequent physical erosion of loose sand, produced during rind development in the outermost zones, has given rise to features like tors, spheroids, gullies, cavities and small-scale caves on these quartzites. Thus, the terrain has acquired ruggedness in semi-arid conditions.

In one of the studies of GSI, it is reported three generations of folding in the rocks of Delhi. The fold axes of first-generation folds follow the trend of main ridge i.e. NNE-SSW, the second-generation folds trending NE-SW are observed at Tughlaqabad - Mehrauli area, and third generation fold trending NW-SE is observed at Anand Parbat. The rocks are highly jointed and two sets of conjugate vertical to sub-vertical joints have been reported. Another study of GSI has inferred a number of faults trending NNE-SSW, NE-SW and WNW-ESE.

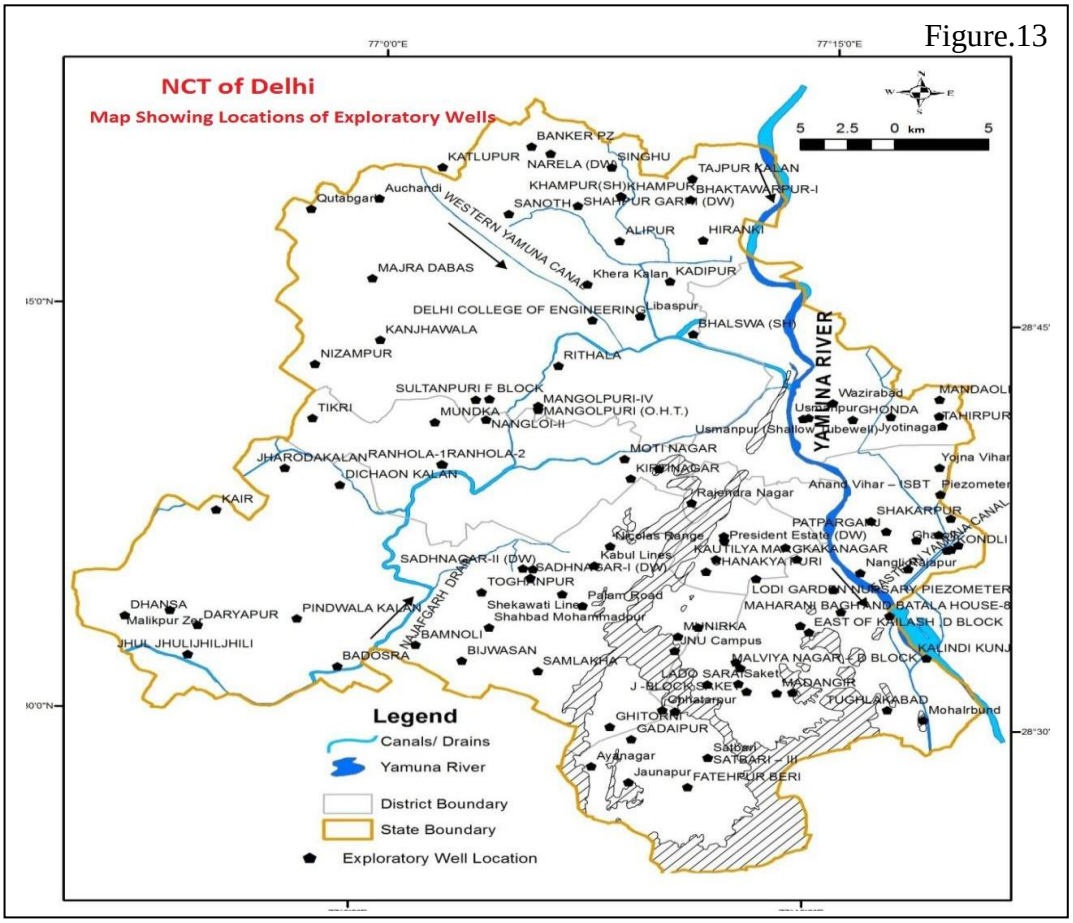
2.7. Hydrogeology and Subsurface Aquifer Dispositions

Central Ground Water Board had been engaged in Ground Water Exploration in National Capital Territory of Delhi since its inception in 1972 and till date more than 327 boreholes are drilled out of which 151 are Exploratory Well (EW), 176 are Observation Well (OW) / Piezometers (Pz) / Slim holes. Locations of exploratory boreholes are shown in Fig. 13. All these boreholes were electrically logged to identify granular zones with fresh ground water and other lithological characteristics of subsurface litho units. All these studies have revealed that there is distinct variations in sub surface lithology characteristics and thickness of individual subunits of the main aquifer zone, within the Younger and Older alluvium deposits of NCT Delhi (refer Fig. 12) which make the aquifer geometry of Delhi complicated and complex. Younger Alluvium confined to the flood plains of Yamuna River and also along the courses of major streams, comprises of clay/silt mixed with small mica flakes, and medium to coarse-grained sand and gravel whereas Older Alluvium comprises interbedded and

lenticular deposits of clay, silt and sand ranging from very fine to very coarse with occasional kankar. In general, the Younger alluvium, the disposition of different sediments particularly the pervious layer constituting the unconfined aquifer is well delineated in the Yamuna flood plain area while in the older alluvium, the disposition of different lithological units is not well defined, and they are heterogeneous in nature, making it difficult to identify the deep aquifer zones which are regionally extensive, both vertically and laterally. In the Yamuna flood plain, Younger Alluvium thickness is about 40m thick and underlain with silty clay with kankar whereas the thickness of the Older Alluvium, mainly west of Delhi Ridge is highly variable and is dependent mainly on the configuration of the basement; at Shahbad Mohammadpur near IGI airport the thickness of the older alluvium is 560 meters overlying the bed rock. Whereas in areas underlain by hard rock units, mainly South, South East, Parts of New Delhi and Central district of NCT of Delhi, the aquifers are defined by the presence of fractured zones at different depths. These fractured zones at places are locally well defined but not regionally extensive.

The subsurface configuration of aquifers, in entire NCT of Delhi has been deciphered on basis of available lithological and geophysical logs of exploratory wells drilled by Central Ground Water Board under the Ground Water Exploration Programme. To mark the aquifer geometry, on the

Figure.13

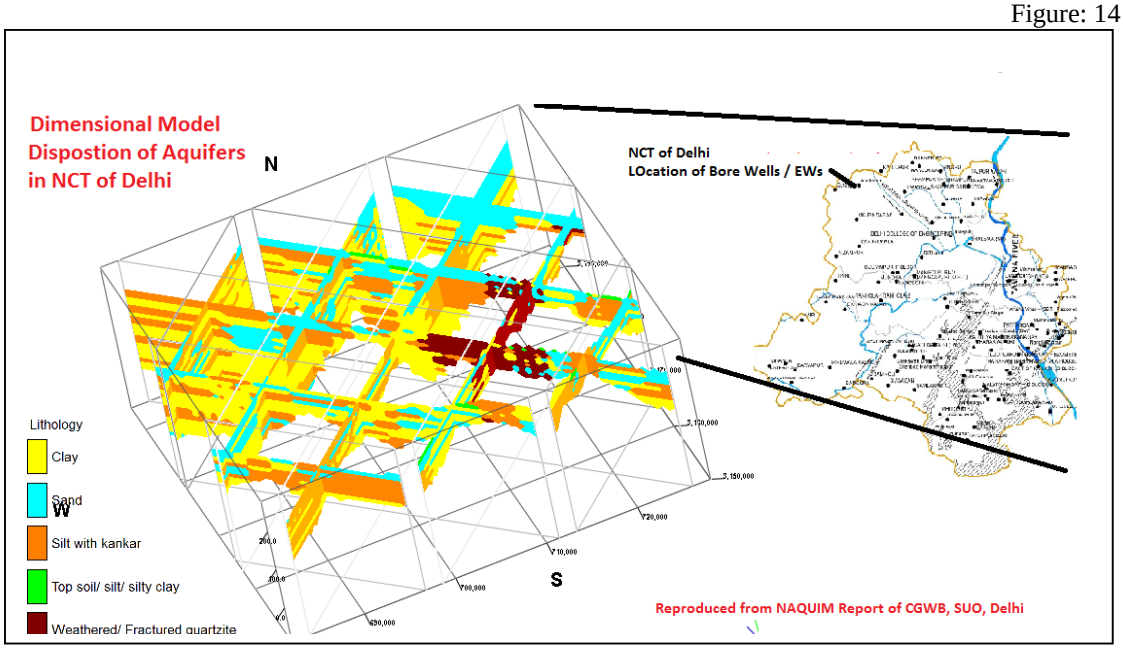


basis of these litholog data, the different sediments i.e. clay, silt, kankar and different grades of sand, and their admixture has been categorized as pervious (silt + kankar + sand) and impervious (mostly clay with some silt + kankar). In the areas underlain by hard rock formation, upper most wreathed regolith and quartzite with fractured zones at different depths and associated mica schist band constitutes unique hard rock aquifer system.

In recent study taken by CGWB under NAQUIM Project, the detailed aquifer geometry on regional scale has been established in the NCT, Delhi. All available information about subsurface aquifer configuration, deciphered on basis lithological and geophysical logs of exploratory wells drilled by Central Ground Water Board under the Ground Water Exploration Programme along with interpreted records of various geophysical studies etc., are integrated to prepare the aquifer

map. From the geological sections and fence diagrams prepared, principal aquifers in the area have been delineated by grouping the fine, medium, coarse sand and sand with gravels as sand. Top soil and silty clay or silt at the surface have been grouped together. Weathered and fractured quartzite and the massive quartzite/ bedrock have been grouped together as weathered/ fractured quartzite (Fig.14).

Figure: 14



2.8. Fresh –Saline Ground Water Interface

Various hydrogeological and groundwater exploration studies in NCT of Delhi by CGWB has revealed that the thickness of fresh water in major part of the State varies from 20 to 40 m. It is also observed that no fresh water is available in a few pockets in Narela and Alipur tehsils of North District, Saraswati Vihar tehsil of Northwest district, Punjabi Bagh and Patel Nagar tehsils of West District, Najafgarh tehsil of Southwest district and Kalkaji tehsil of Southeast District. (Fig. 15).

In one of the recent studies undertaken under NAQUIM projects by WAPCOS, the granular zones (the aquifers) with varied resistivity were picked up from the combined interpretations of electrical resistivity (64 inches Normal) and gamma radioactivity logs of the boreholes drilled in the area. It shows that resistivity values greater than 10 ohm m to 50 ohm m represents predominately sand with fresh ground water. Resistivity less than 10 ohm m indicates predominately clay and kankar with saline water. Further lowering of resistivity values to 1 ohm m indicates further deterioration of water quality with depth. Resistivity of the order of 50 to 500 ohm m in hard rock (quartzite) area is represented by weathered/ fractured/ jointed quartzite which forms potential aquifer with potable water. In general, it is clear that fresh water sediments are followed by the saline water sediments in all over NCT of Delhi. The thickness of fresh water sediments is limited in major parts of NCT, Delhi. The depth to fresh-saline water interface varies from 10 m bgl to 80 m bgl. Ground water quality below fresh saline water interface is saline all through up to the bedrock. At a few locations like Dhansa, Qutabgarh and Bankner, saline ground water is present at a very shallow depth. Panel diagram showing fresh-saline ground water interface in subsurface aquifer system of NCT of Delhi, is presented in Fig. 16.

Figure.15

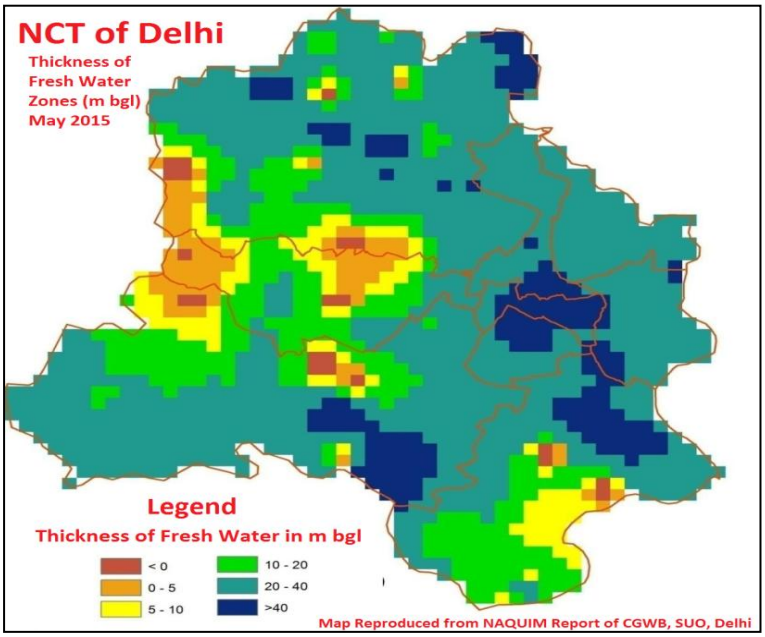
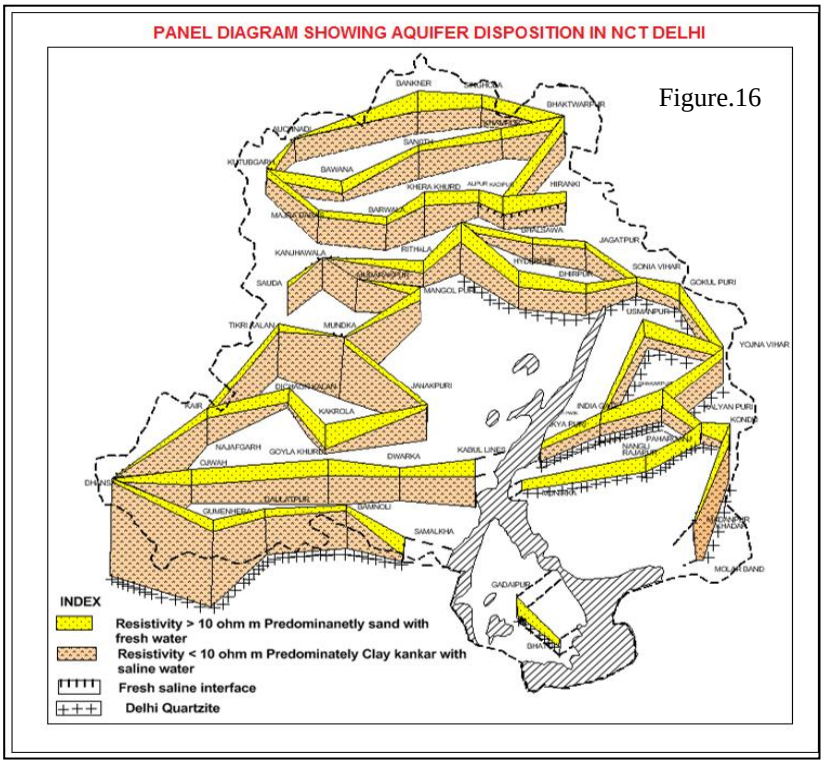


Figure.16



Perusal of Fig. 16 shows that in the South West district of NCT Delhi, bedrock is encountered at many places i.e. in Dhansa, Samalkha, Kabul lines, Jhuljhuli where fresh/saline water interface also varies greatly in entire area. All along the Najafgarh Drain and two depressions i.e., Gummanhera & Pindwalan Kalan, fresh water layer is somewhat deeper i.e. up to 35 m bgl but rest of the area is having thin layer of fresh water i.e. up to the depth 25 to 28 m bgl only. In the western parts of the district, the thickness of fresh water zone is limited. At a few locations like Dhansa, the saline ground water is present at a very shallow depth and as we move towards areas in the eastern part of the district, where hard rock is present, the thickness of fresh water aquifers is more, and fresh-saline water interface occurs at deeper depth i.e. generally around 80 to 90 m bgl. At Rajokri, the depth of fresh-saline water interface has been observed to be 150 m bgl.

In West district, the depth of fresh-saline interface varies from 25 to 50 m bgl. The depth of fresh water zone varies from 10 to 45mbgl. The thickness of fresh water aquifers is more at places like Dichaon Kalan and Kakrola and fresh-saline interface is at deeper depths. While in the areas around Janakpuri, Mundka, the saline water is present at shallow depths.

In South district, depth of fresh-saline water interface varies from 75 to 100 mbgl. The thickness of fresh water zone varies from 30 to 85 m. At locations like Gadaipur, Bhatti and Munirka, fresh water aquifers are followed by hard rock (Delhi quartzite). In Southeast district, at places around Madanpur Khadar, the thickness of fresh water zones is limited. Here, fresh water aquifers are followed by saline water zone and bedrock is encountered at depth of around of 300 m.

In North West district, the depth of fresh-saline water interface varies greatly. The thickness of fresh water aquifers is limited in this district. At locations like Auchandi, Qutabgarh&Bankner, the saline water is present at shallower depths. In areas along Yamuna Flood Plain, fresh-saline water interface is at deeper depth i.e., around 40 to 70 m bgl, whereas in rest of the area it is 22 to 40 m. No bedrock has been observed up to the depth of 250 mbgl.

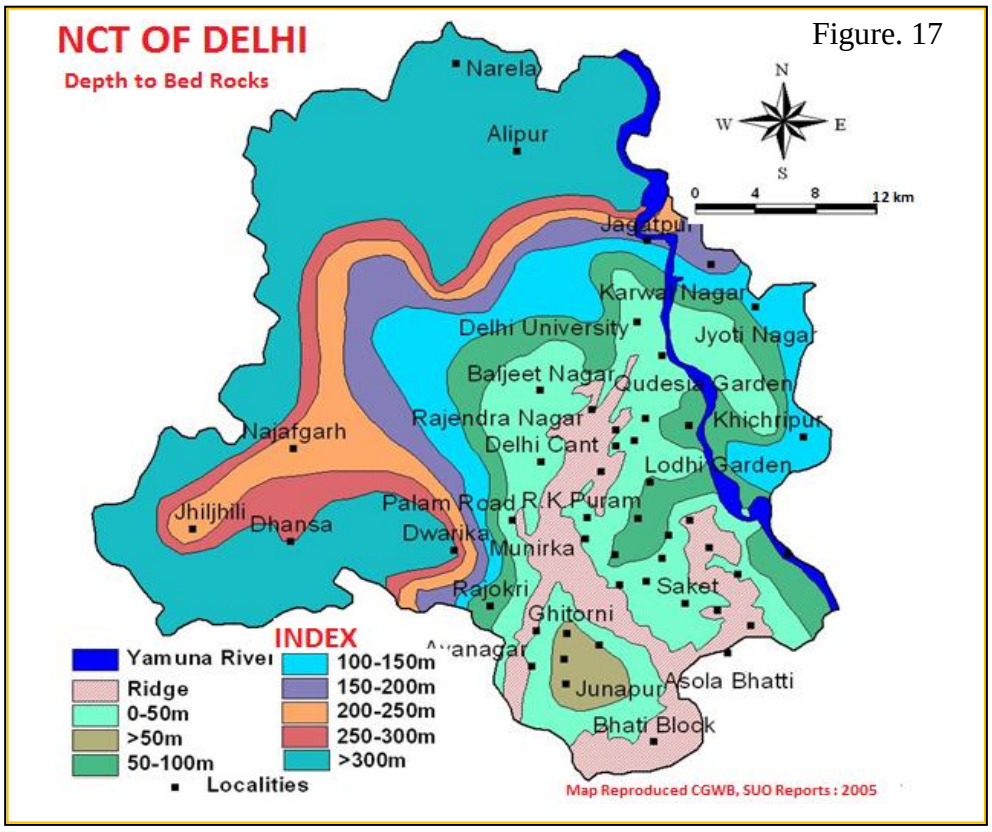
In Northeast district, thickness of fresh water aquifers is more in areas around Yamuna Flood Plain. The depth of fresh-saline water interface in Yamuna Flood Plain ranges between 32 and 50 mbgl whereas in rest of the area, it ranges from 25 to 38 m bgl.

In New Delhi and Central Districts, fresh water sediments are followed by saline water and then by quartzites (Delhi Ridge). In East & Shahdara districts, thickness of fresh water aquifers is more at locations like Kalyanpuri, Kondli and Shakurpur up to 60 mbgl.

2.9. Basement Topography

The configuration of the basement rock topography, below variable thickness of alluvium of NCT of Delhi, worked out based on subsurface geological data generated from exploratory drilling and supplementary geophysical data input revels its uneven basement topography in NCT Delhi area (Figure 17).

Figure. 17



3. DEPTH TO WATER LEVEL

The analysis of number of monitoring wells in the different categories of the water levels for all four monitoring periods of year 2021-22 (January, May, August & November) reveals that zone (shallow aquifer) having depth to water level up to 5 meters bgl varies considerably over two monitoring periods which shows that upper zone (shallow aquifer) is actively responding to stresses on ground water system. The changes in water levels in the depth range of 5mbgl to 10mbgland 10mbgl to 20mbgland> 20 mbgl, during 3 monitoring period as compared to May is not prominent. This may be interpreted as stressed water level conditions suppressing dynamic changes in water levels. Whereas number of monitoring stations showing water level below 40 m remain almost same in all four-monitoring period, indicating very high stressed water conditions in deep aquifers (Hard Rock Aquifer) of NCT Delhi.

Figure. 18

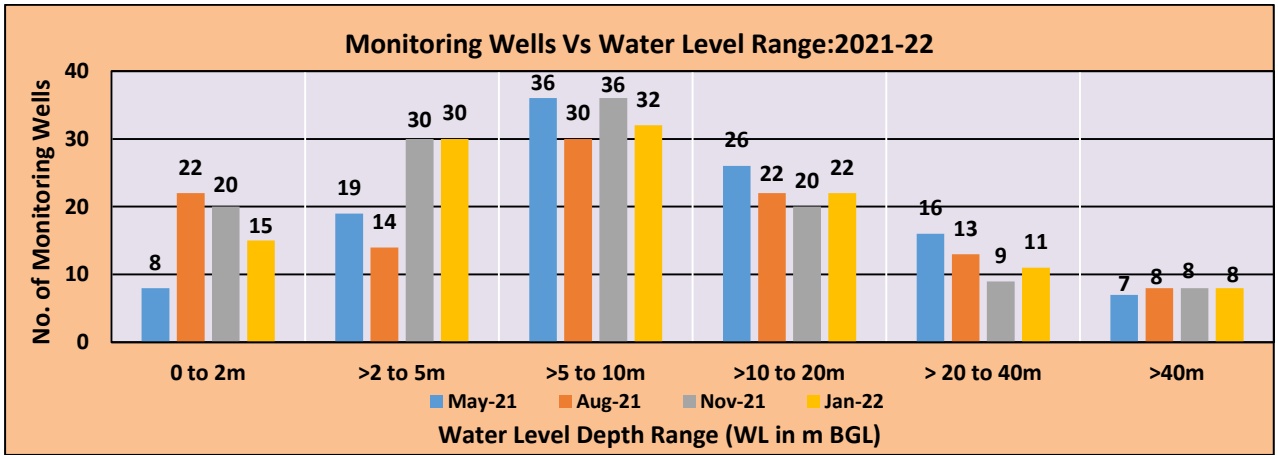
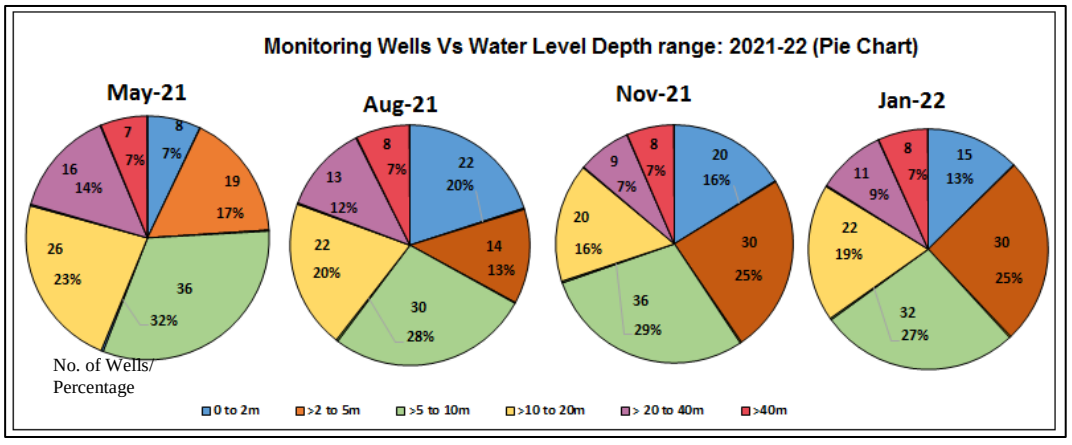


Figure.19



3.1. May 2021

The Depth to water level recorded in NCT Delhi during **May-2021** ranges from 0.5mbgl at Deorala to 64.85m bgl at Gadaipur. A map showing May 2021 ground water levels in NCT of Delhi is given in Fig. 20 and areas under various depth zones is presented in Fig. 21. Around 11% of NCT Delhi have shallow water level up to 5 m bgl which falls in parts of North, North West, West, South West & Central districts. Deep water levels of 20m bgl to 65mbgl is observed in around 24% of NCT Delhi, which falls mainly in South & New Delhi districts & small pockets of South West, South East, North districts. In rest of NCT Delhi i.e. 65% of areas have water level ranging between 5m bgl to 20 m bgl.

Figure. 20

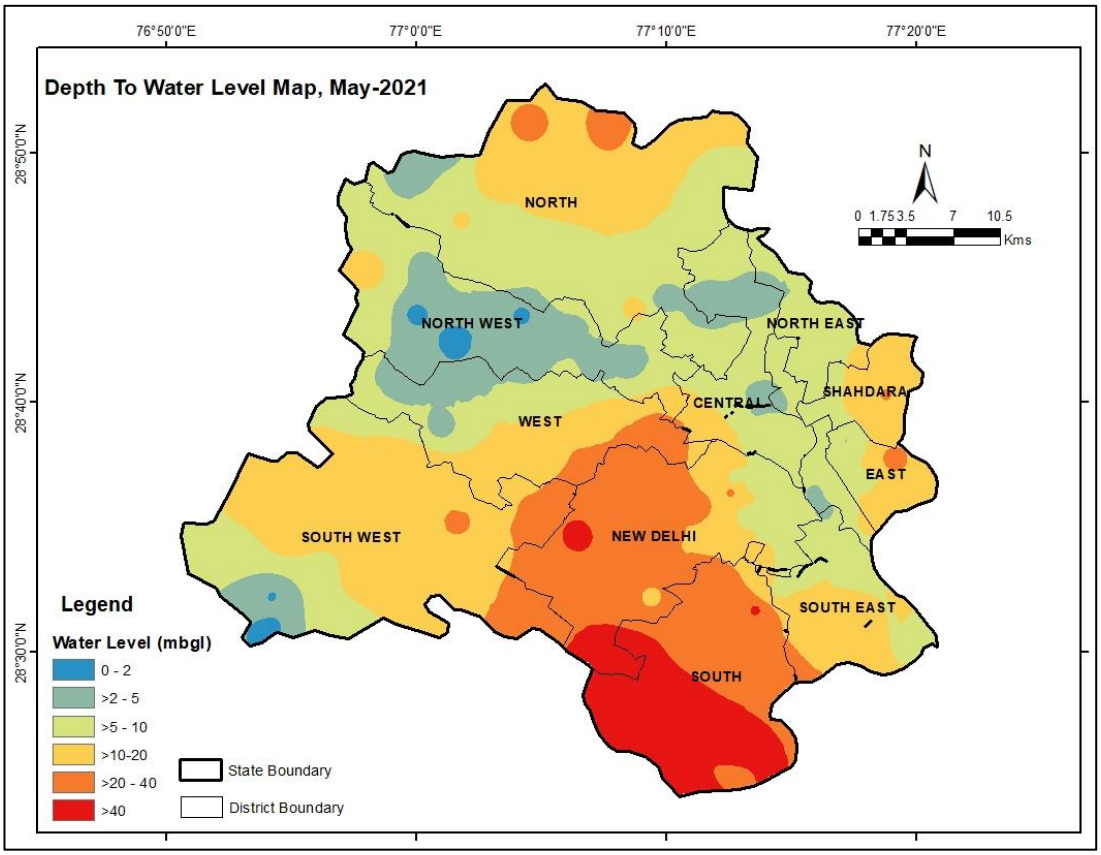
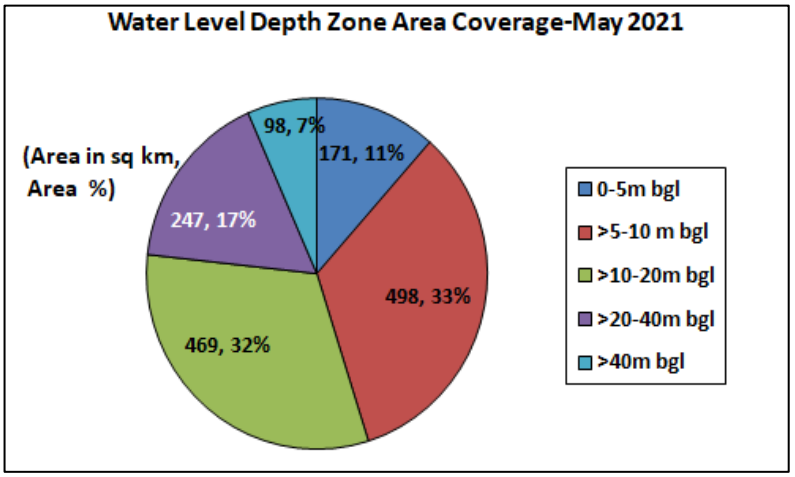


Figure.21



3.2. August 2021

The Depth to water level recorded in NCT Delhi during **August-2021** ranges from 0.12mbglat Asthakunj Park to 65.48mbgl at Gadaipur. A map showing August 2021 ground water levels in NCT of Delhi is given in Fig. 22 and areas under various depth zones is presented in Fig. 23. Around 22% of NCT Delhi areas have shallow water level up to 5 m bgl which falls in parts of North, North West, North East, Central and South West districts. Deep water levels of 20 to 66 mbgl observed in around 23% of NCT Delhi, which falls in South, South East, New Delhi, North & South West districts. In rest of NCT Delhi, 55 % areas have water level in range of 5 to 20 mbgl.

Figure.22

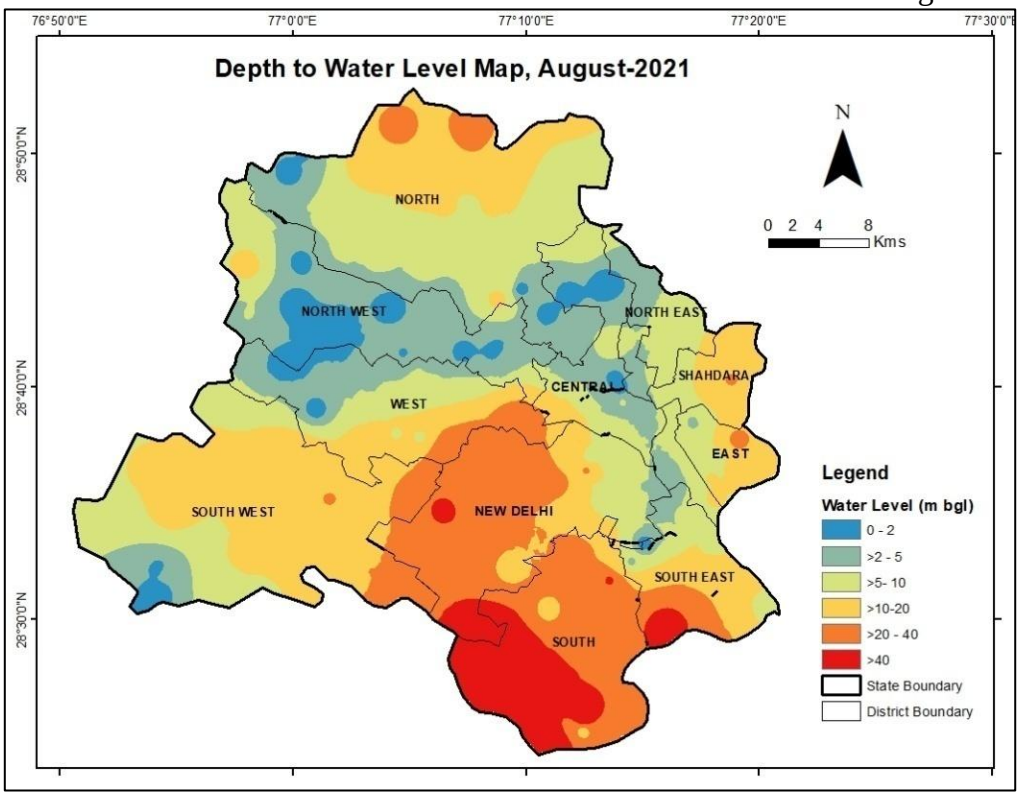
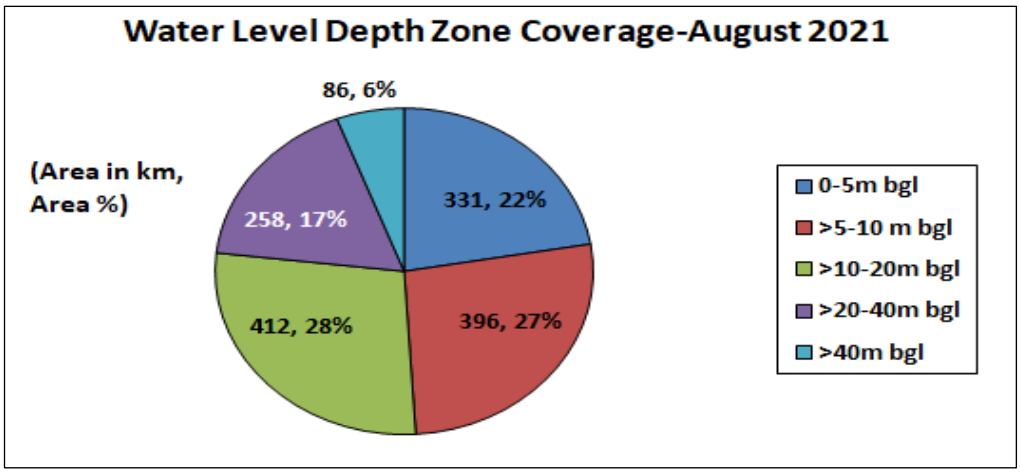


Figure.23



3.3. November 2021

The Depth to water level recorded in NCT Delhi during **November-2021** ranges from 0.19m bgl at Asthakunj Park to 65.67mbgl at Gadaipur. A map showing November 2021 ground water levels in NCT of Delhi is given in Fig. 24 and areas under various depth zones presented in Fig. 25. Around 26% of NCT Delhi, which falls in parts of North, North West, Northeast, South East, Central, West and Southwest districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 66 mbgl observed in around 18% of NCT Delhi, which falls in South, South East, New Delhi & South West districts. In rest of NCT Delhi, 56 % areas have water level in range of 5 to 20 mbgl.

Figure.24

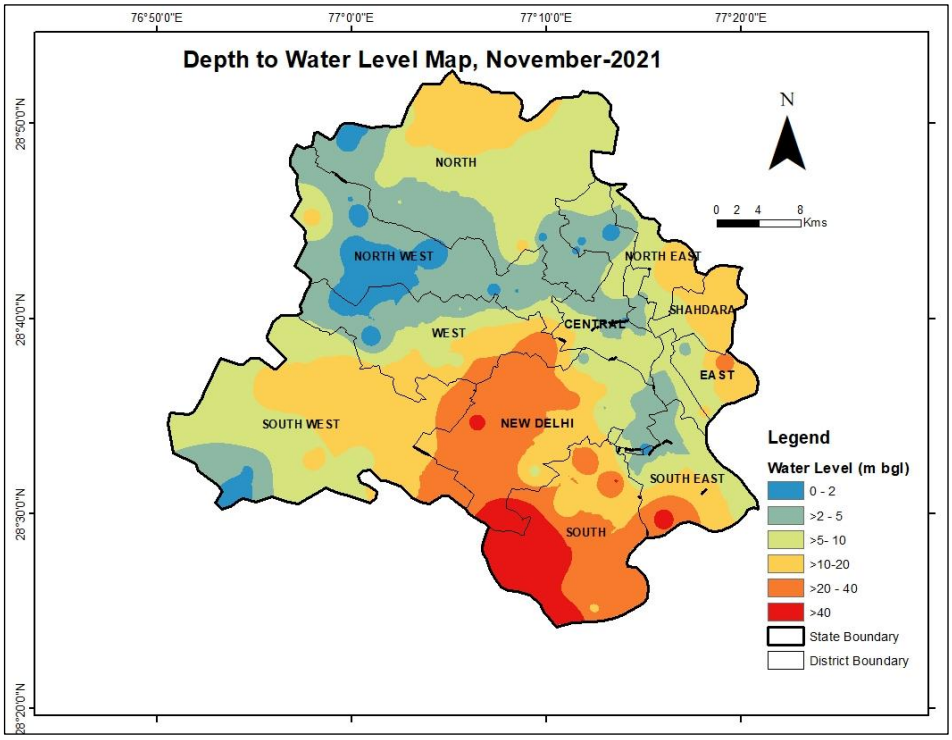
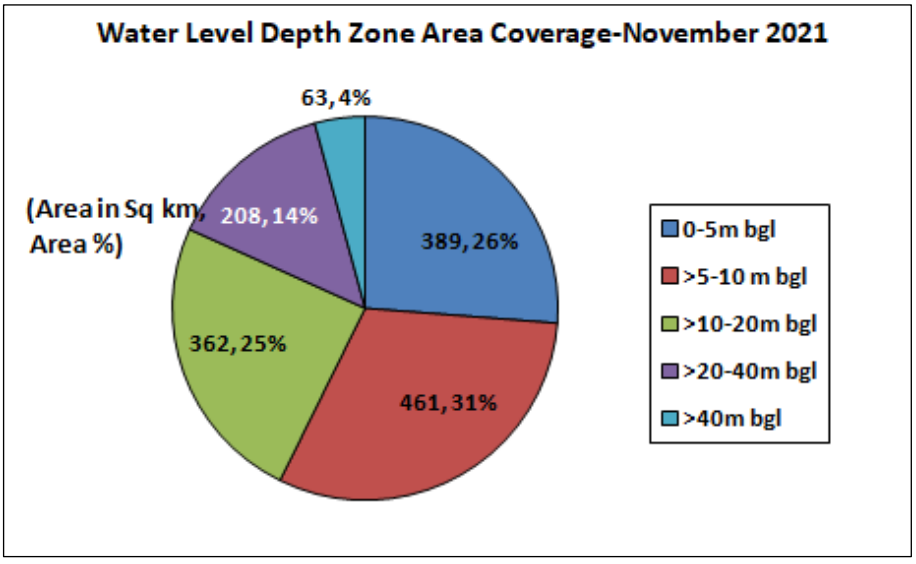


Figure.25



3.4. January 2022

The Depth to water level recorded in NCT Delhi during **January-2022** ranges from 0.6 mbgl at Hiran Kudna to 67.64mbgl at Jheel Khoh. A map showing January 2022 ground water levels in NCT of Delhi is given in Fig.26 and areas under various depth zones presented in Fig. 27. Around 24% of NCT Delhi, which falls in parts of North, North West and some small pockets of South East Central & Southwest districts have shallow water level up to 5 m bgl. Deep water levels of 20 to 68m bgl observed in around 19% of NCT Delhi, which falls in South, South East, New Delhi, West, North, East & South West districts. In rest of NCT Delhi, 57 % areas have water level in range of 5 to 20 m bgl.

Figure. 26

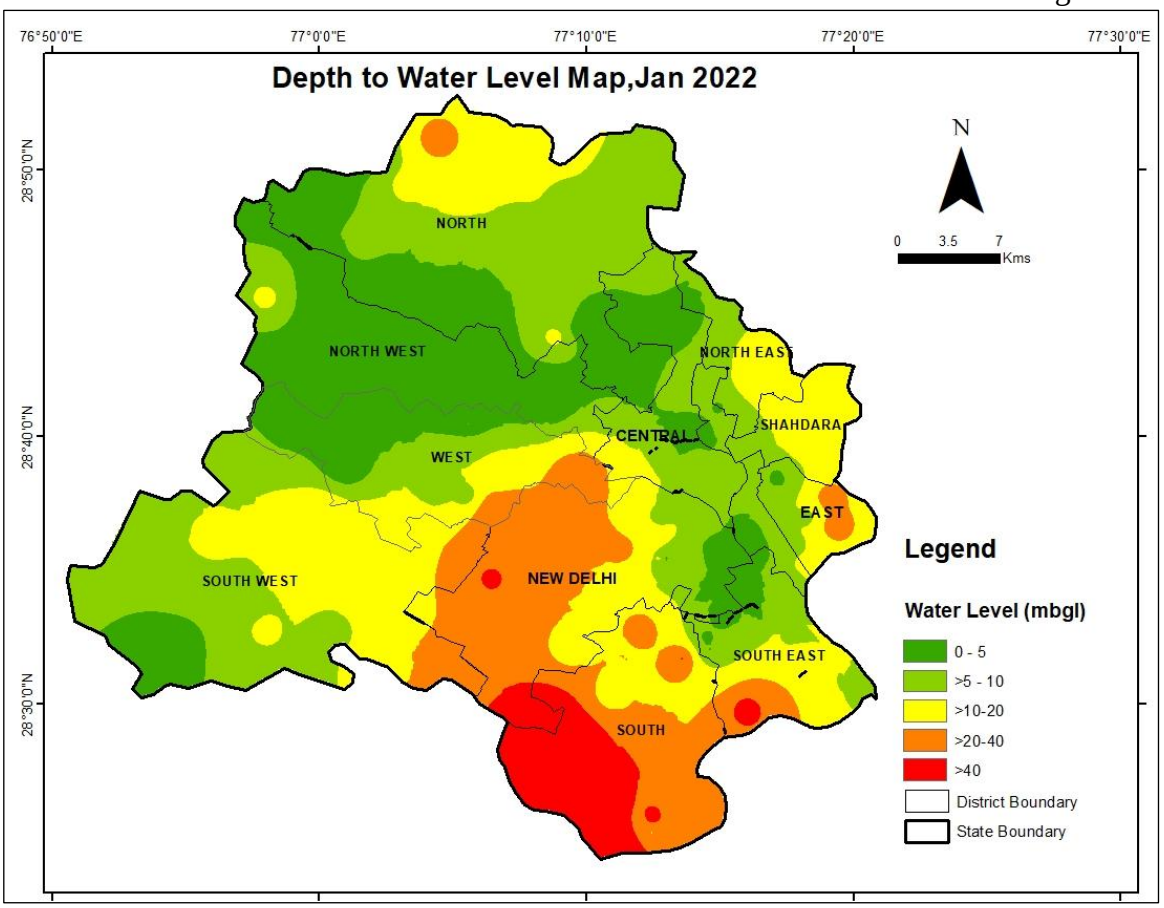
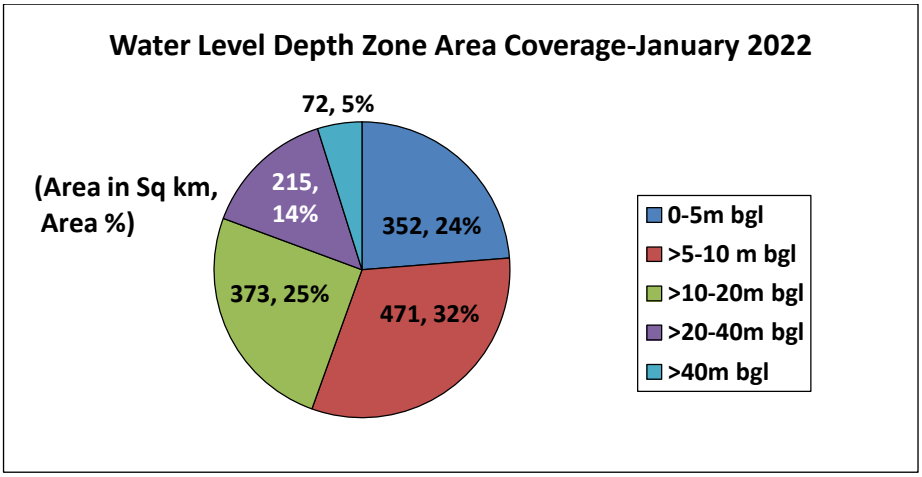


Figure. 27



3.5. Seasonal Water Level Fluctuation: 2021-22

The seasonal water level fluctuation, i.e. the changes in depth of water levels of August 21, November 21 and January 22 with respect to May 21 water level reveals the effect of subsequent utilization of groundwater for various needs like Industrial, Irrigation, Domestic etc., on overall groundwater regime of the area. Number of wells showing change in groundwater levels in the region over different periods is presented in Fig. 28 (a,b & c) and Table 9.

Figure: 28 a

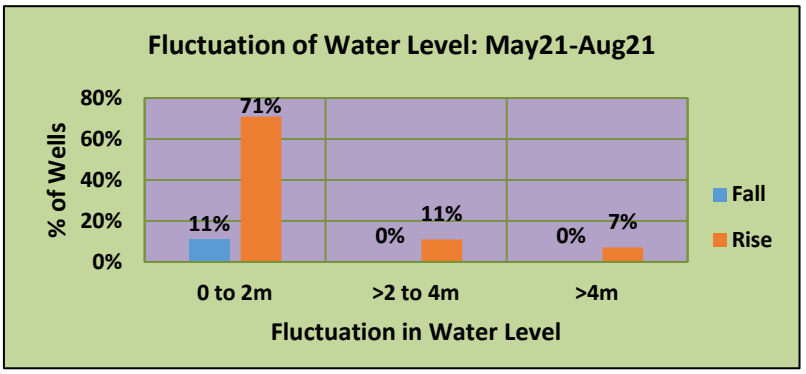


Figure 28b

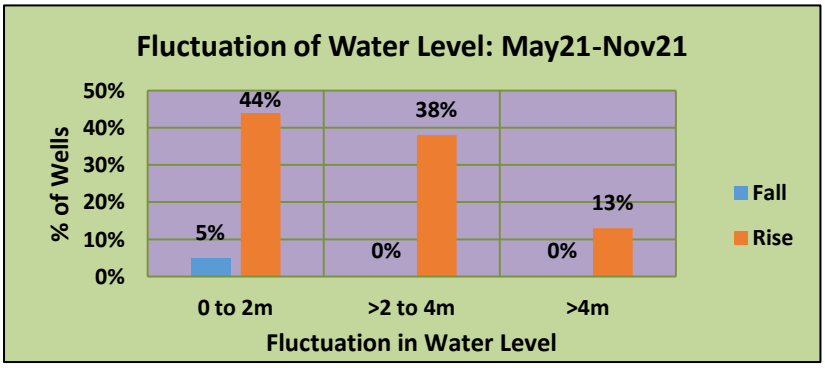


Figure: 28 c

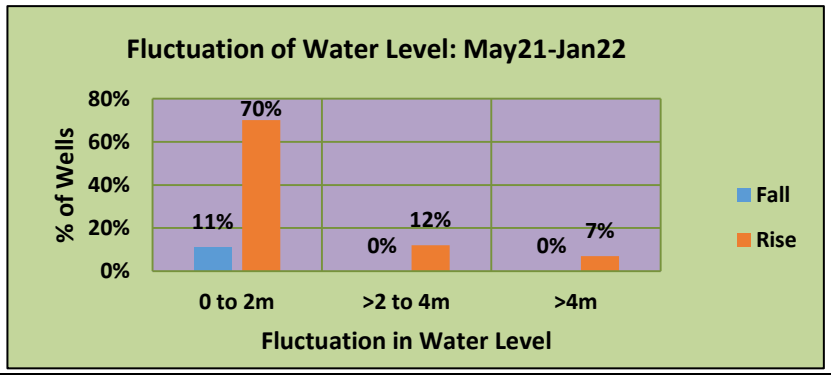


Table: 9 Monitoring Wells Showing Seasonal Fluctuation in Water Level

Water Level Fluctuation Range	May 21 -Aug 21		May 21-Nov 21		May 21 - Jan22	
	Rise	Fall	Rise	Fall	Rise	Fall
0 to 2 m	75	12	48	6	75	12
> 2 to 4 m	12	0	41	0	13	0
>4 m	7	0	14	0	7	0
Total	94	12	103	6	95	12
	106		109		107	

3.5.1. May 2021 to August 2021

A perusal of Fig. 28a and Table 11 reveals that comparing water levels of May 21 to August 21, total 94 (89%) of monitoring wells of the NCT Delhi show a rise in water level whereas rest 11% shows declining water level. The extent of rise and decline in water levels is shown in map presented in Fig. 29 and in pie chart (Fig.30).

Figure. 29

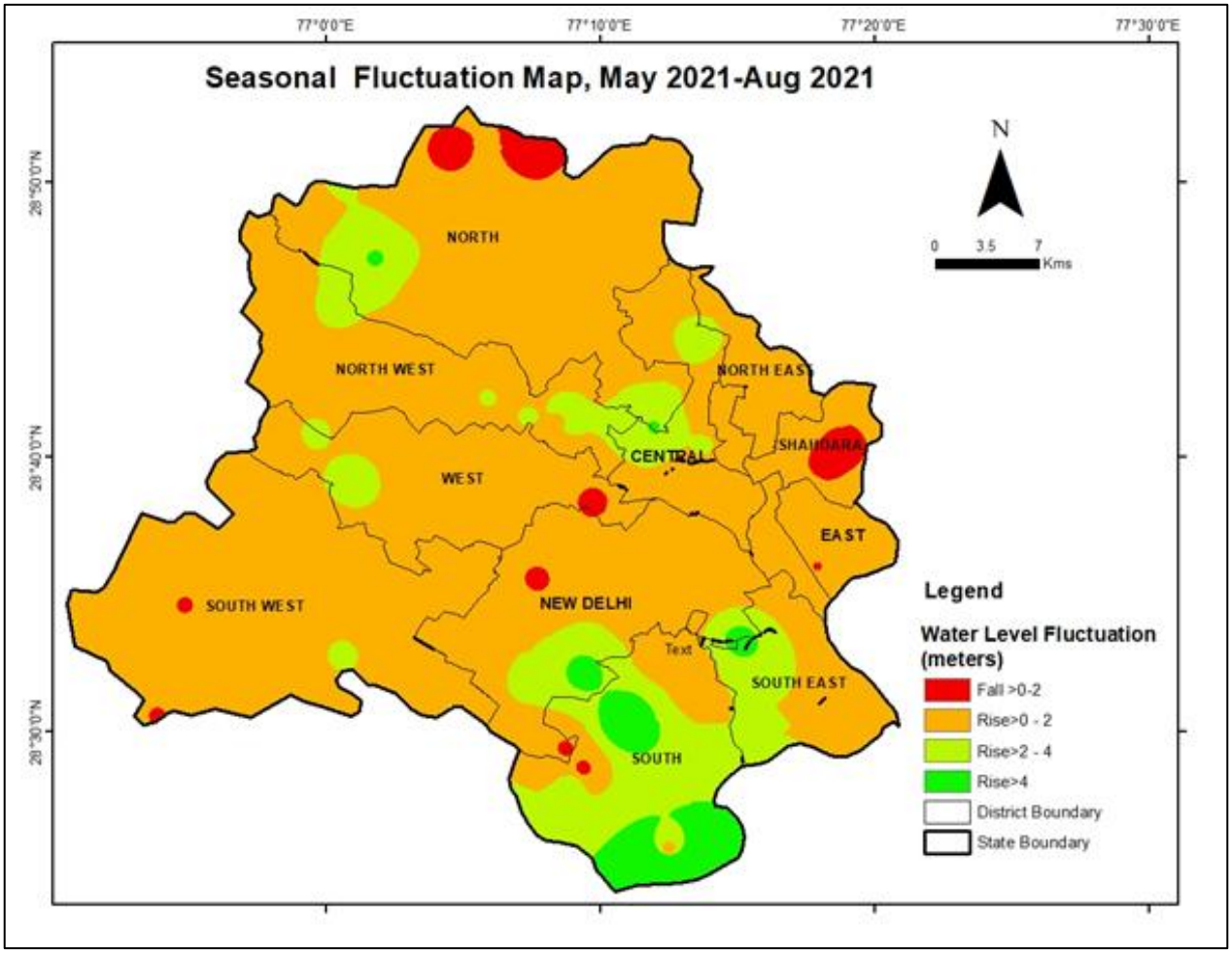
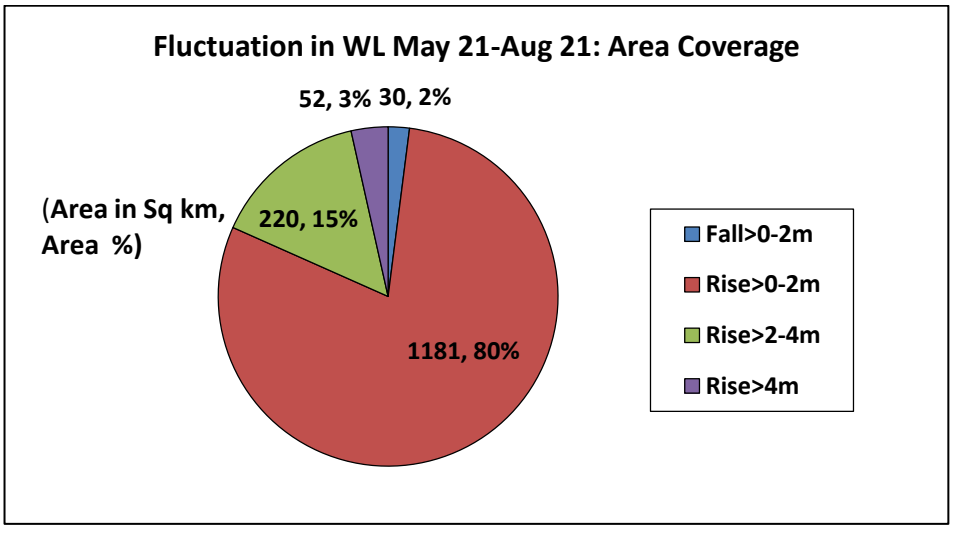


Figure. 30



3.5.2. May 2021 to November 2021 (Pre & Post Monsoon)

A perusal of Fig. 28(b) and Table 11 reveals that comparing water levels of May 21 to November 21, total 103(95%) of monitoring wells of the NCT Delhi show a rise in water level whereas rest 5% shows declining water level. The extent of rise and fall in water levels is shown in map presented in Fig. 31 and in pie chart (Fig. 32).

Figure. 31

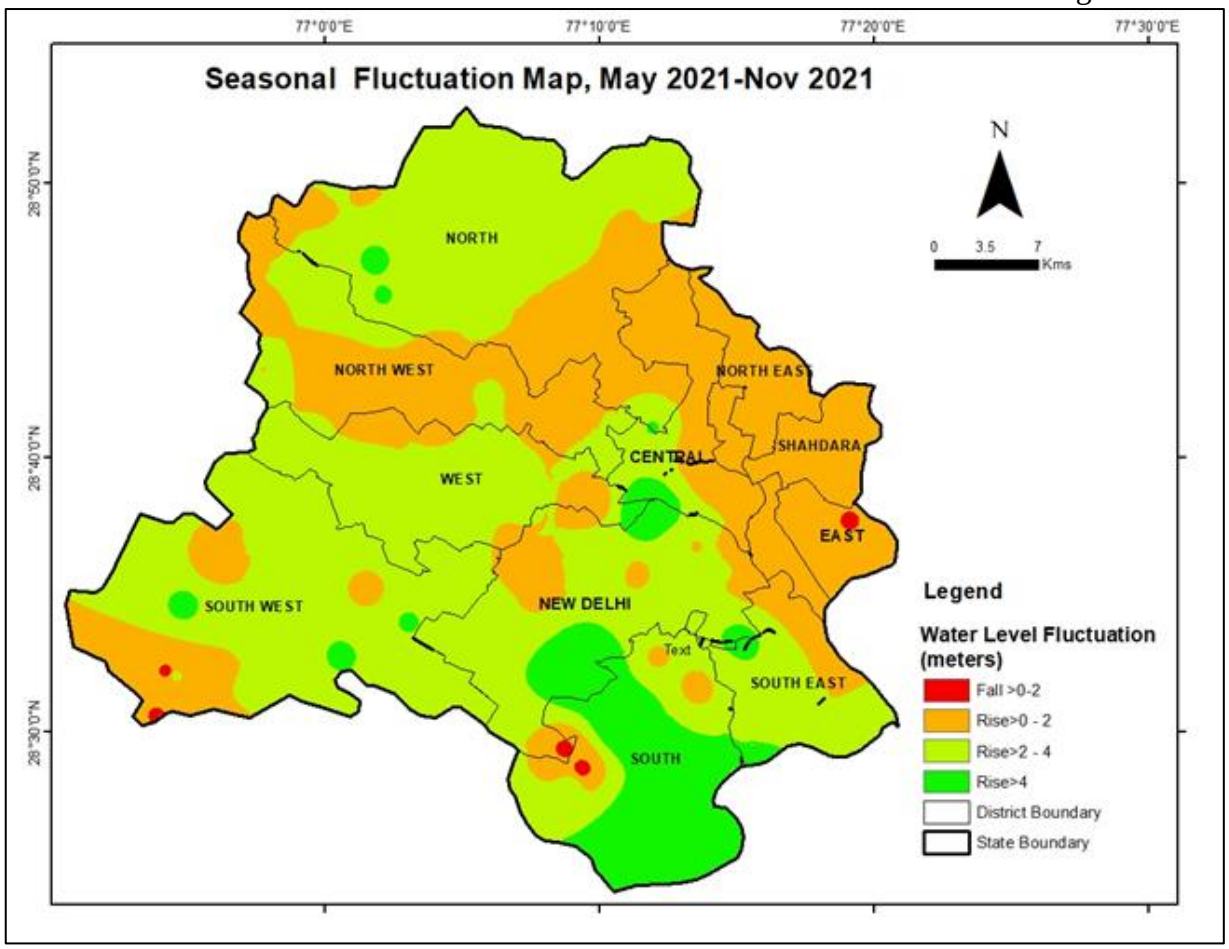
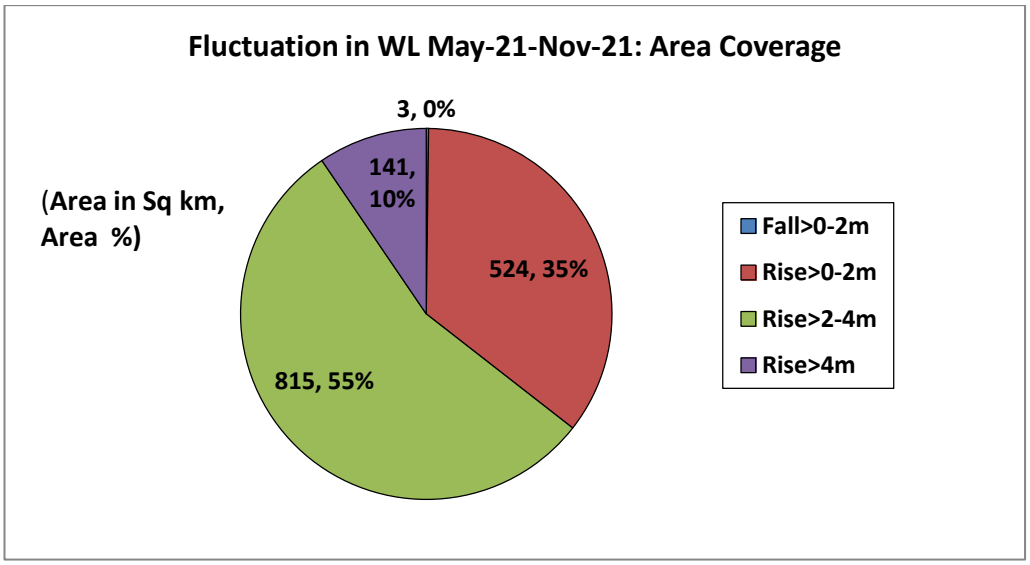


Figure. 32



3.5.3. May 2021 to January 2022

A perusal of Fig. 28(c) and Table 11 reveals that comparing water levels of May 21 to January 22, total 95 (89%) of monitoring wells of the NCT Delhi show a rise in water level whereas rest 11 % shows fall in water level. The extent of rise and fall in water levels is shown in map presented in Fig. 33 and in pie chart (Fig.34).

Figure. 33

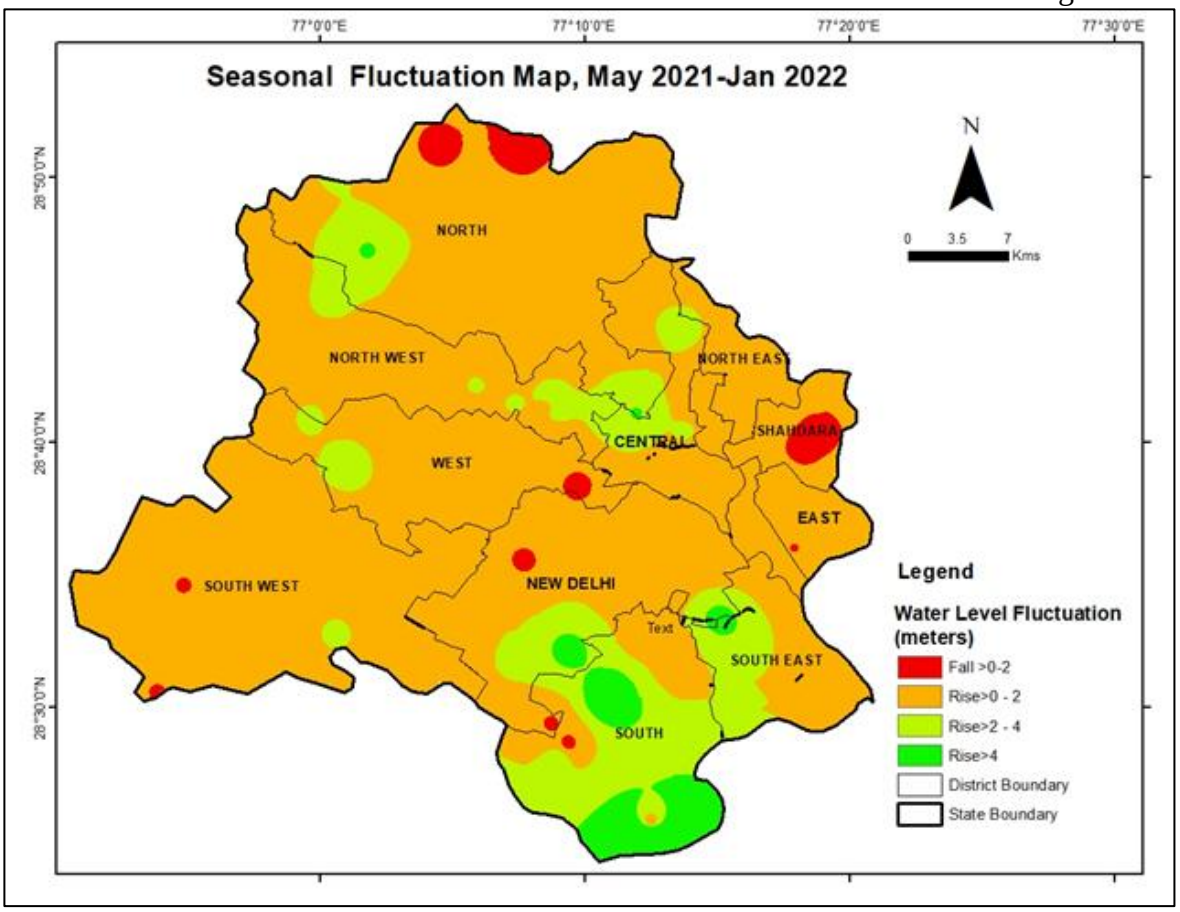
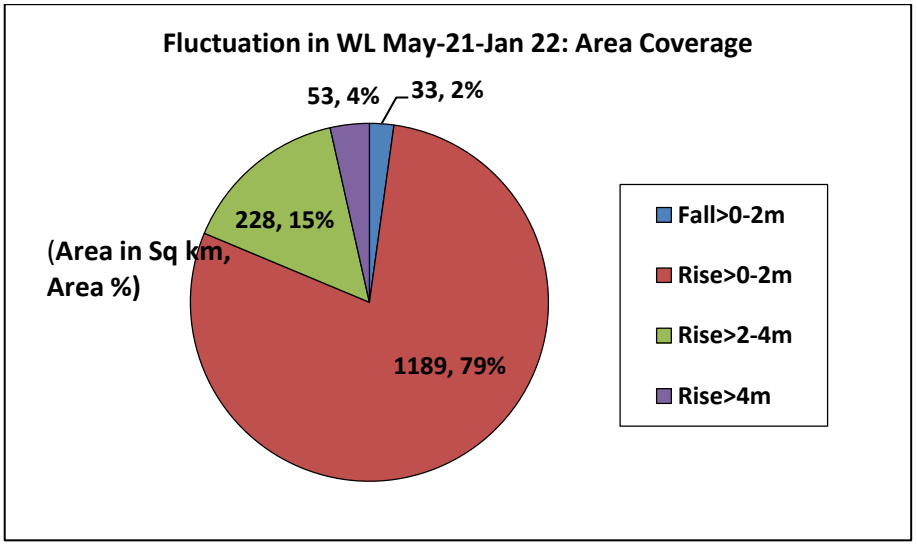


Figure. 34



4. GROUND WATER QUALITY IN NCT DELHI

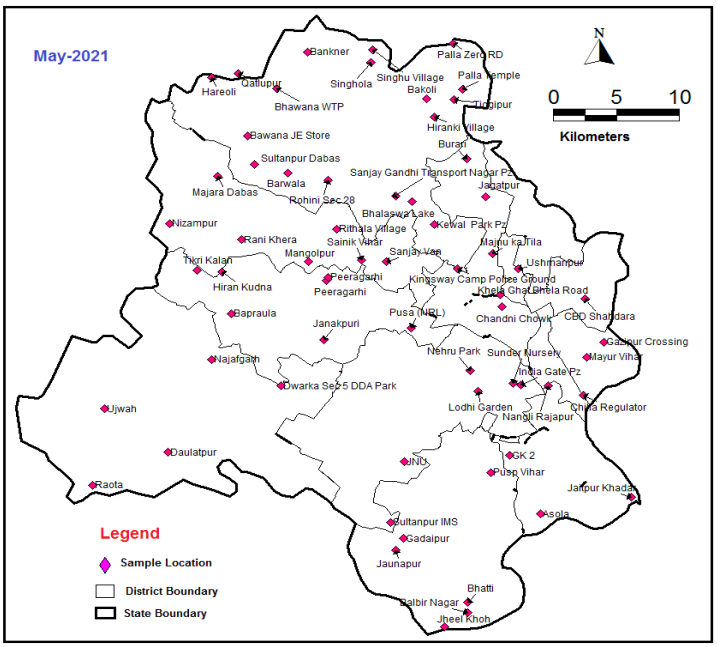
Groundwater situations and groundwater quality of NCT of Delhi and it varies with depth and space. It is mainly influenced by local geology and inherent salinity, and uneven development of groundwater.

In alluvial formations, in general, the quality of ground water deteriorates with depth, which is variable in different areas. The fresh ground water aquifers mainly exist up to a depth of 25 to 35 m in North West, West and parts of South west districts and in minor patches in North and Central districts. In South, Southeast & Southwest district, especially in Najafgarh *Jheel* area the fresh water occurs up to a depth of 30 to 45 mbgl. A localized area located just north of Kamala Nehru Ridge (part of Delhi ridge falling in Central District) covering area of Dhirpur, Wazirabad and Jagatpur are characterized by shallow depth of fresh water aquifers that is in the range of 22 to 28mbgl, regardless of proximity to River Yamuna. In the flood plains of Yamuna, in general, fresh water aquifers exist down to depth of 30-45mbgl and especially in Palla it reaches to the depth of 60 to 75mbglbelow which brackish and saline water exists. The ground water is fresh at all depths in the areas around the ridge falling in Central, New Delhi, South and eastern part (Ridge Area) of South-West districts and also in Chattarpur basin. In the areas west of the ridge, in general, the thickness of fresh water aquifers decreases towards North-West, the thickness of fresh water zone is limited in most parts of west and southwest districts.

4.1. Groundwater Quality Monitoring

Monitoring of groundwater quality is an effort to obtain information on chemical quality through representative sampling in different parts of NCT Delhi. Groundwater is commonly tapped from phreatic aquifers through representative dug well / bore wells or hand pump located nearest to the monitoring station. A total number of 66 water samples were collected from NCT of Delhi, as part of groundwater quality monitoring work, during May 2020. List of locations and result of chemical analysis for its basic parameters such as pH, EC, TDS, CO3, HCO3, Cl, NO3, SO4, F, Ca, Mg, TH. Map showing locations of water sample locations is presented in Fig. 35.

Ground Water Quality Samples, NCT Delhi Figure.35



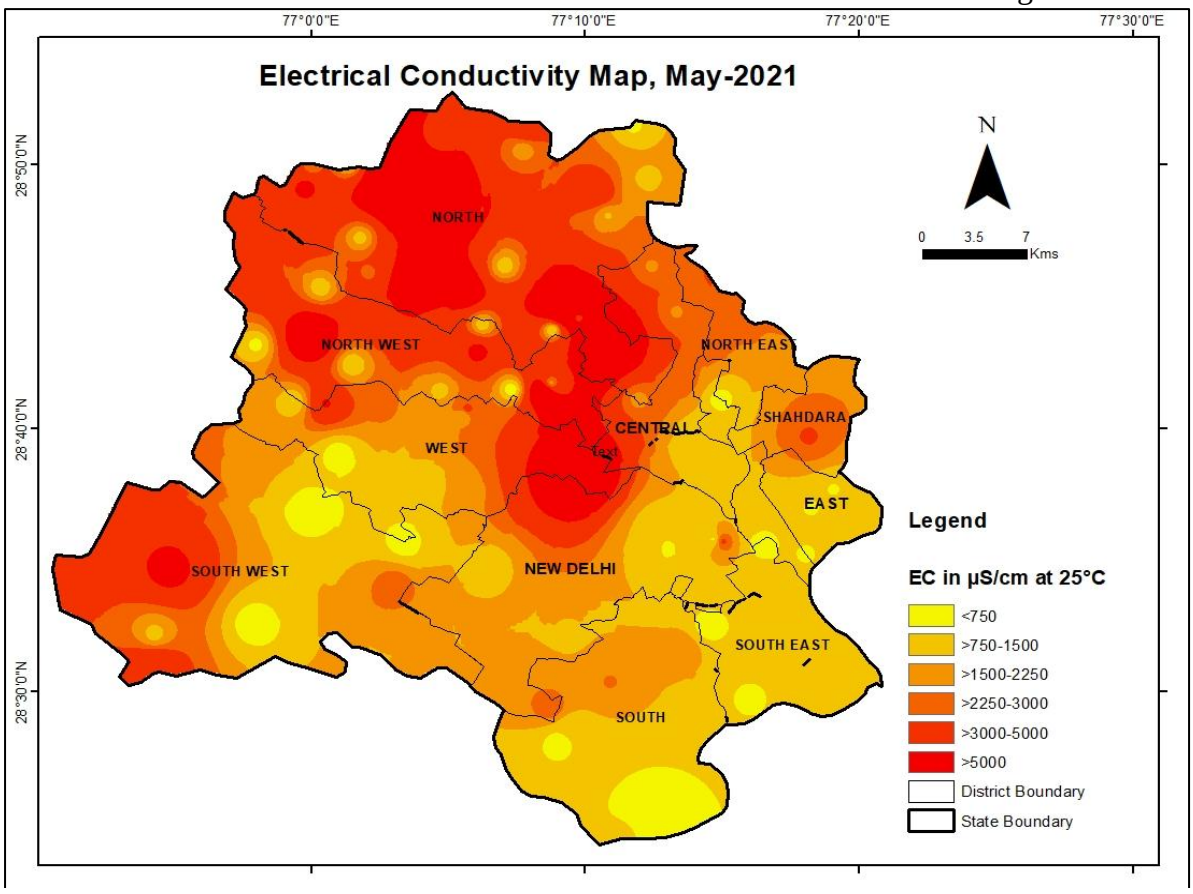
The overall results of hydro chemical analysis are attached in Annexure VI(a) and Annexure VI(b) whereas distribution of major groundwater quality parameters in NCT of Delhi are described as under.

4.2. Electrical Conductance

Electrical conductivity represents total number of *cations* and *anions* present in groundwater, indicating ionic mobility of different ions, total dissolved solids and saline nature of water. Electrical Conductivity (EC) is a measure of salinity of the groundwater in terms of saltiness, calculated as Micro Siemen / cm at 25°C. Similar expression is Total Dissolved Solid (TDS), a measure of total dissolved salt contents in mg / liter of groundwater. Different substances dissolve in groundwater giving it taste and odour. In fact, human beings have developed senses, which are able to evaluatethe potability of water. In general water having EC < 1500 uS/cm, is considered as fresh water, EC 1500 – 15000 uS/cm is considered as brackish water and EC > 15000 uS/cm is considered as saline water.

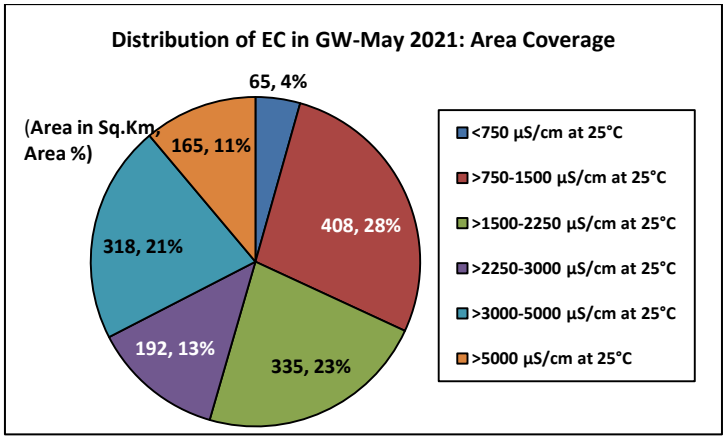
Map showing distribution of electrical conductance in groundwater of NCT Delhi is presented in Fig.36. Most of eastern part of NCT Delhi, in areas around Yamuna in district of Central, North East, East, South East, New Delhi, South Delhi and few parts of North Delhi and South West Delhi districts has EC within permissible range, upto to 2250 µS/cm at 25°C. The area of Tagore Garden, Nizampur, Jharoda Kalan, HiranKudna and some pockets of Shahdara are showing exceptionally high EC Values, even in shallower depth. It is also observed that deeper aquifer water has greater EC value than the shallow aquifer, value increases with increase in depth. The major part of the area underlain by Delhi quartzite ridge has EC values in range of 600 µs/cm to 2000 µs/cm.

Figure. 36



It is observed that nearly 39.3% areas of NCT Delhi falling in North, North West, West and South West districts show EC more than 3000 µS/cm at 25°C whereas rest 60.7 % area has EC in range from 0 to 3000 µS/cm at 25°C. Nearly 3.8% (55.96sqkm) areas of North, New Delhi, South East & South district has EC of 0 to 750 µS/cm at 25°C (Fig. 37).

Figure:37



5. "INDIA-Groundwater Resource Estimation System (IN-GRES)"

Assessment of 'Dynamic Ground Water Resources of India' is carried out at periodical intervals jointly by the Central Ground Water Board (CGWB) and State/UT Ground Water Departments under the guidance of State Level Committee at State levels and under the overall supervision of Central Level Expert Group. Last assessment was carried out in 2020 and re-assessment of Dynamic Ground Water Resources of India, 2022 has been carried out based on the norms and guidelines of Ground Water Resource Estimation Committee (GEC-2015) methodology.

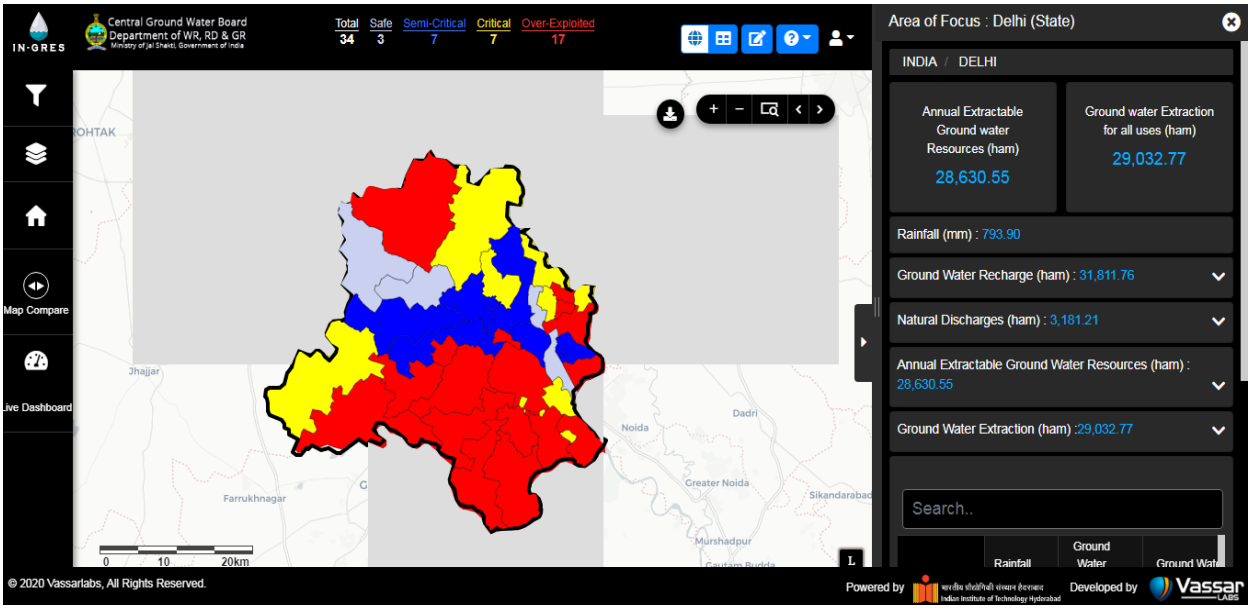
The assessment involves computation of Annual Ground Water Recharge and Annual Extractable Ground Water Resources, Total Annual Ground Water Extraction (utilization) and the percentage of utilization with respect to Annual Extractable Ground Water Resources (Stage of Extraction). The assessment units (blocks/taluks/mandals/tehsil/firkas etc.) are categorized based on the Stage of Extraction (SoE) i.e 'Safe' if SoE < 70 %; 'Semi-critical if SoE> 70 and <= 90 %; 'Critical' if SoE>90 and <=100 % and 'Over-exploited' if SoE> 100 %.

"INDIA-Ground Water Resource Estimation System (IN-GRES)" is a software/web-based application developed by Central Ground Water Board (CGWB) in collaboration with Indian Institute of Technology-Hyderabad (IIT-H) for assessment of ground water resources.

Objectives

1. To provide common and standardized platform for Ground Water Resource Assessment for the entire country based on Ground Water Resource Estimation Committee-2015 (GEC-2015) methodology.
2. Pan-India operationalization (Joint assessment by CGWB and State Ground Water/ Nodal Departments).
3. Visibility dashboards allowing user to view the data/map and download reports (Figure 38).

Figure: 38



6. GEC 2015 METHODOLOGY

Present Ground water Resource Estimation 2022 (GWRE 2022) has been carried as per revised methodology, known as Ground water Estimation Committee 2015 (GEC 2015). The foremost recommendations of revised GEC 2015 methodology are summarized as follows. Detailed report on GEC 2015 is available on CGWB web site (http://cgwb.gov.in/).

6.1. Concept of Aquifer Wise Assessment

GEC 2015 recommends aquifer wise ground water resource assessment for Replenishable ground water resources or Dynamic ground water resources and for In-storage ground water resources or Static ground water resources for both Unconfined and Confined aquifer. Wherever the aquifer geometry has not been firmly established for the unconfined aquifer, the in-storage ground water resources must be assessed in the alluvial areas up to the depth of bed rock or 300m whichever is less. In case of hard rock aquifers, the depth of assessment would be limited to 100m. In case of confined aquifers, if it is known that ground water extraction is being taken place from this aquifer, the dynamic as well as in-storage resources are to be estimated. If it is firmly established that there is no ground water extraction from this confined aquifer, then only in-storage resources of that aquifer must be estimated.

6.1.1. Periodicity of Assessment

GEC 2015 methodology recommends that the ground water resources should be assessed once in every three years as per the present practice such that time lag between assessment and publication of the results is minimized.

6.1.2. Ground water Assessment Unit & Sub Units

GEC 2015 methodology recommends aquifer wise ground water resource assessment. However, until aquifer geometry is established on appropriate scale, it recommends that the existing practice of using watershed in hard rock areas and blocks/ mandals/ firkas in soft rock areas may be continued. In case of NCT Delhi, Tehsil Subdivision boundary has been considered as assessment unit. In all it is 33 Tehsils plus one Nazul Land has also been considered as assessment unit. Hence, there are 34 assessment units in NCT, Delhi.

Like earlier GEC methodology, out of the total geographical area of the assessment unit, hilly areas wherever slope is greater than 20%, are to be identified and subtracted as these areas have more runoff than infiltration. No such area is identified in Delhi where slope is more that 20%.

The ground water resource beyond the permissible quality limits in terms of the salinity has to be computed separately. There is a small patch in NCT, Delhi where Salinity in ground water is reported from ground level. However, saline ground water occurs at very shallow depth. GEC 2015 methodology recommends that after the assessment is done, a quality flag may be added to the assessment unit for parameters salinity, fluoride and arsenic. It is proposed to have all these areas of an assessment unit in integer hectares to make it national database with uniform precision.

6.1.3. Ground Water Resources of Assessment of Unit

The ground water resources of any assessment unit are the sum of the total ground water availability in the principal aquifer (mostly unconfined aquifer) and the total ground water availability of semi-confined and confined aquifers existing in that assessment unit. The total ground water availability of any aquifer is the sum of Dynamic ground water resources and the In-storage or Static resources of the aquifer.

GEC 2015 advocate that the development planning should be on dynamic resource only as it gets replenished every year. Changes in static or in-storage resources reflect impacts of ground water mining. Such resources may not be replenishable annually and may be allowed to be extracted only during exigencies with proper recharge planning in the succeeding excess rainfall years.

6.2. Assessment of Annually Replenishable or Dynamic Ground water Resources

The elementary concept of GEC 2015 methodology for ground water resources estimation is based on basic principle of water balance as given below –

Inflow – Outflow = Change in Storage (of an aquifer) **1**

Equation 1 can be further elaborated as -

ΔS= Rrf+RSTR+RC+RSWI+RGWI+RTP+RWCS±VF ± LF -GE-T-E-B **2**

Where,

ΔS –	Change is storage
Rrf –	Rainfall recharge
RSTR-	Recharge from stream channels
Rc –	Recharge from canals
RSWI –	Recharge from surface water irrigation
RGWI-	Recharge from groundwater irrigation
RTP-	Recharge from Tanks & Ponds
RWCS –	Recharge from water conservation structures
VF –	Vertical flow across the aquifer system
LF-	Lateral flow along the aquifer system (through flow)
GE-	Groundwater Extraction
T-	Transpiration
E-	Evaporation
B-	Base flow

GEC 2015 has observed that although above mentioned components of water balance equation are imperative, the present status of database available with Government and non-government agencies is not adequate in most of the assessment units. Therefore, it is proposed that at present the water budget may be restricted to the major components only taking into consideration certain reasonable assumptions. The estimation is to be carried out using lumped parameter estimation approach keeping in mind that data from many more sources if available may be used for refining the assessment.

6.2.1. Rainfall Recharge

GEC 2015 recommended that monsoon rainfall recharge should be estimated on ground water level fluctuation and specific yield approach. This, however, requires adequately spaced representative water level measurement for a sufficiently long period. It is proposed

that there should be at least three spatially well distributed observation wells in the assessment unit, or one observation well per 100 Sq.km. Water level data should also be available for a minimum period of 5 years (preferably 10 years), along with corresponding rainfall data. Regarding frequency of water level data, three water level readings during pre and post monsoon seasons and in the month of January/ May preferably in successive years, are the minimum requirements. It would be ideal to have monthly water level measurements to record the peak rise and maximum fall in the ground water levels. In units or subareas where adequate data on ground water level fluctuations are not available as specified above, ground water recharge may be estimated using rainfall infiltration factor method only. The rainfall recharge during non-monsoon season may be estimated using rainfall infiltration factor method only.(Annexure IV & V)

- **Water Level Fluctuation (WLF) Method**

Under this method the change in storage is computed by multiplying water level fluctuation between pre and post monsoon seasons with the area of assessment and specific yield.
Change in Storage = $\Delta S = h * Sy * A$ …… (i)
Where,
h = rise in water level due to monsoon (fluctuation between pre-monsoon and post-monsoon water level),
A = area for computation of recharge, and
Sy = specific yield of aquifer formation

The Specific yield of a soil or rock is the ratio of the volume of water that, after saturation, can be drained by gravity to its own volume (Todd & Mays, 2005). The Specific yield data have either been arrived through field studies, including long-duration pumping tests and dry season ground water balance (in hard-rock areas) or adopted from the norms recommended by GEC-1997, which were derived from the various water-balance studies carried out by CGWB, SGWDs and academic/research institutions. The range of specific yield recommended by GEC 2015 for different formations of Delhi is presented in Annexure IV**.**

Substituting the expression in equation 1 for storage increase ΔS in terms of water level fluctuation and specific yield, rainfall recharge in non-command will be as follow:

$$R_{RF} = h \times Sy \times A - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \quad 3$$

and considering another term Rc as Recharge due to canals, rainfall recharge equation in command will be as follows:

$$R_{RF} = h \times Sy \times A - R_{C} - R_{STR} - R_{SWI} - R_{GWI} - R_{TP} - R_{WCS} \pm VF \pm LF + GE + T + E + B \quad 4$$

The recharge calculated from equation 3 in case of non-command sub units and equation 4 in case of command sub units and poor ground water quality sub units gives the rainfall recharge for the particular monsoon season. However, it may be noted that in case base flow/ recharge from stream and through flow have not been estimated, the same may be assumed to be zero. The rainfall recharge obtained by using equation 3 & equation 4 provides the recharge in any particular monsoon season for the associated monsoon season rainfall. This estimate is to be normalized for the normal monsoon season rainfall as per the procedure indicated below.

- **Normalization of Rainfall Recharge**

The recharge from rainfall estimated as per the above is for the particular monsoon season. It should be normalized for estimating recharge corresponding to the normal monsoon rainfall.

The methodology for normalizing monsoon recharge, is summarized below.

The computational procedure to be followed is as given below:

$$\boldsymbol{Rrf(normal) = \frac{\Sigma_{i=1}^{N}\left(R_i \frac{r(normal)}{r_i}\right)}{N}}$$

Where,
Rrf (normal) = Normalized Rainfall Recharge in the monsoon season.
$\mathbf{R_i}$ = Rainfall Recharge in the monsoon season for the i^{th} year.
r(normal) = Normal monsoon Season rainfall.
$\mathbf{r_i}$ = Rain fall in the monsoon season for the i^{th} year.
N = Number of years data is available.

- **Rainfall Infiltration Factor (RIF) Method**

Like earlier GEC methodology, GEC 2015 recommended to compare the rainfall recharge obtained from Water Level Fluctuation approach with that estimated using Rainfall Infiltration Factor Method.
Recharge from rainfall is estimated by using the following relationship -
Rrf = RFIF * A* (R – a)/1000
Where,
Rrf = Rainfall recharge in ham
A = Area in Hectares
RFIF = Rainfall Infiltration Factor (in fraction)
R = Rainfall in mm
a = Minimum threshold value above which rainfall induces ground water recharge in mm

GEC 2015 suggest that 10% of Normal annual rainfall be taken as Minimum Rainfall Threshold and 3000 mm as Maximum Rainfall limit. While computing the rainfall recharge, 10% of the normal annual rainfall is to be deducted from the monsoon rainfall and balance rainfall would be considered for computation of rainfall recharge. The same recharge factor may be used for both monsoon and non-monsoon rainfall, with the condition that the recharge due to non-monsoon rainfall may be taken as zero, if the normal rainfall during the non-monsoon season is less than 10% of normal annual rainfall. In using the method based on the specified norms, recharge due to both monsoon and non-monsoon rainfall may be estimated for normal rainfall, based on recent 30 to 50 years of data.

- **Percent Deviation**

After computing the rainfall recharge for normal monsoon season rainfall using the Water level Fluctuation method and Rainfall Infiltration Factor method these two estimates have to be compared with each other. A term, Percent Deviation (PD) which is the difference between the two expressed as a percentage of the former is computed as

$$PD = \frac{R_{rf\ (normal,wlfm)} - R_{rf\ (normal,rifm)}}{R_{rf\ (normal,wlfm)}} \times 100$$

where,

Rrf (normal, wlfm) = Rainfall recharge for normal monsoon season rainfall estimated by the water level fluctuation method

Rrf (normal, rifm) = Rainfall recharge for normal monsoon season rainfall estimated by the rainfall infiltration factor method

The rainfall recharge for normal monsoon season rainfall is finally adopted as per the criteria given below:

- If PD is greater than or equal to -20%, and less than or equal to +20%, Rrf (normal) is
- taken as the value estimated by the water level fluctuation method.
- If PD is less than -20%, Rrf (normal) is taken as equal to 0.8 times the value estimated by the rainfall infiltration factor method.
- If PD is greater than +20%, Rrf (normal) is taken as equal to 1.2 times the value estimated by the rainfall infiltration factor method.

During the period 2020 – 2021, above calculation, normalization, estimation of PD and consideration of rainfall recharge is taken care by INGRES software. Basic data pertaining to Rainfall, Water level, Specific Yield, Infiltration faction factor, Paved area, Buildup area and open area have been provided to Software. The NCT Delhi being urban area which have more than 60% build up area do not support rainfall recharge at all places.

6.2.2. Recharge from other Sources

Recharge from other sources constitute recharges from canals, surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures in command areas where as in non-command areas the recharge due to surface water irrigation, ground water irrigation, tanks & ponds and water conservation structures are possible (Annexure V).

- **Recharge from Canals**

Recharge due to canals is to be estimated based on the following formula:

RC = WA * SF * Days

Where:

RC = Recharge from Canals
WA = Wetted Area
SF = Seepage Factor
Days = Number of Canal Running Days.

The NCT Delhi have very small length of Canal that too lined, support very little recharge.

- **Recharge from Surface Water Irrigation**

Recharge due to applied surface water irrigation, either by means of canal outlets or by- lift irrigation schemes is to be estimated based on the following formula:

RSWI =AD*Days*RFF

Where:

RSWI = Recharge due to applied surface water irrigation
AD = Average Discharge
Days = Number of days water is discharged to the Fields
RFF = Return Flow Factor

The NCT Delhi use treated water and canal water for irrigation in small area which is existing only in North & North West district, so impact of recharge is limited to this area only

- **Recharge from Ground water Irrigation**

Recharge due to applied ground water irrigation is to be estimated based on the following formula:

RGWI = GEIRR*RFF

Where:

RGWI = Recharge due to applied ground water irrigation
GEIRR = Ground water Extraction for Irrigation
RFF = Return Flow Factor

The ground water used by Horticulture department, Forest department, PWD and State & Central agencies of NCT Delhi for green belt development have been used as irrigation by ground water.

- **Recharge due to Surface Water Bodies**

Recharge due to surface water bodies, like tanks & ponds etc is to be estimated based on the following formula:

R_{TP} =AWSA*RF

Where:

R_{TP} = Recharge due to Tanks & Ponds
AWSA = Average Water Spread Area
RF = Recharge Factor

Data provided by DJB & wetland authority of NCT Delhi have been used by averaging water spread & recharge factors for each Tehsil.

- Recharge due to Water Conservation Structures

Recharge due to Water Conservation Structures is to be estimated based on the following formula:

R_{WCS} =GS*RF

Where:

R_{WCS} = Recharge due to Water Conservation Structures
GS = Gross Storage (Storage Capacity multiplied by number of Fillings).
RF = Recharge Factor

Delhi Jal Board, being the Nodal Agency to keep account of water conservation structure, has provided comprehensive data pertaining to water conservation structure spread all over Delhi. Many authorities such as CPWD, Indian Railway & PWD has failed to provide data regarding Water Conservation Structures created by them during 2017 – 2019, hence, there is scope for refinement of estimation of recharge from water conservation structures.

The NCT Delhi, being urban area, have very dense network of piped water supply and sewer system. The piped water supply is only 80% efficient and remaining 20% is leaking and recharging to ground water. This has been used while estimating recharge from other sources depending on tehsil wise status of water supply & source of water supply.

6.2.3. Recharge During Monsoon Season

The sum of normalized monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into the sub unit and stream inflows during monsoon season is the total recharge during monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

6.2.4. Recharge During Non-Monsoon Season

The rainfall recharge during non-monsoon season is estimated using Rainfall Infiltration Factor method only when the non-monsoon season rainfall is more than 10% of normal annual rainfall. The sum of non-monsoon rainfall recharge and the recharge from other sources and lateral and vertical flows into the sub unit and stream inflows during non-monsoon season is the total recharge during non-monsoon season for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

6.2.5. Total Annual Ground Water Recharge

The sum of the recharge during monsoon and non-monsoon seasons is the total annual ground water recharge for the sub unit. Similarly, this is to be computed for all the sub units available in the assessment unit.

6.2.6. Annual Extractable Ground Water Recharge (EGR)

The National Water Policy, 2012 stresses that the ecological flow of rivers should be maintained. Accordingly, GEC 2015 recommends that ground water base flow contribution limited to the ecological flow of the river should be determined which will be deducted from Annual Ground water Recharge to determine Annual Extractable Ground water Resources (EGR). The ecological flows of the rivers are to be determined in consultation with Central Water Commission and other concerned river basin agencies. In the assessment units, where river stage data are not available and neither the detailed data for quantitative assessment of the natural discharge are available, present practice (GEC 1997) of allocation of unaccountable natural discharges to 5% or 10% of annual recharge may be retained. If the rainfall recharge is assessed using Water Level Fluctuation method this will be 5% of the annual recharge and if it is assessed using Rainfall Infiltration Factor method, it will be 10% of the annual recharge. The balance will account for Annual Extractable Ground water Resources (EGR).

6.3. Estimation of Ground water Extraction

GEC 2015 recommends various available methods for estimation of ground water extraction in each assessment sub unit, as described below. Moreover, GEC 2015 also recommends that the ground water extraction obtained figures from different methods need to be compared and based on field checks, the seemingly best value may be adopted. At times, ground water extraction obtained by different methods may vary widely. Moreover, unit Extraction adopted needs to be normalized as per annual rainfall of period for which assessment is being carried out. In general, the value matching the field situation should be considered. It is also suggested that the storage depletion during a season where other recharges are negligible can be taken as ground water extraction during that particular period.

6.3.1. Normalization of Ground water Extraction

GEC-1997 recommended to use well census method for computing the ground water extraction. The norm used for computing ground water extraction is the unit Extraction. The unit Extraction can be computed by field studies. This method involves selecting representative abstraction structure and calculating the discharge from that particular type of structure and collecting the information on how many hours of pumping is being done in various seasons and number of such days during each season. The Unit Extraction during a particular season can be computed using the following equation:

Unit Extraction m^3 / hr = discharge in m^3 / hr X number of pumping hrs X numbers of days

GEC 2015 recommends normalization of unit Extraction figures as either of following two simple techniques, as per available data. If the unit Extraction values for one rainfall cycle are available for at least 10 years following equation second method is to be followed or else the first method shown in equation may be used.

$$\text{Normalised Unit Extraction} = \frac{\text{Unit Extraction} \times \text{Rainfall for the year}_{\text{all}}}{\text{Noramall Rainfall}_{\text{all}}} \quad 1$$

$$\text{Normalised Unit Extraction} = \frac{\sum_{i=1}^{n} \text{Unit Extraction}_i}{\text{Number of Years}} \quad 2$$

Although GEC-1997 methodology recommends a default value for the unit Extractions and each State is using its own values, generally after conducting field studies, even though without a documentation. GEC 2015 recommends that this norm may be computed by the state agency after conducting field studies before commencement of the assessment and should be documented and submitted along with the results of the assessment.

6.3.2. Components of Ground water Extractions

Ground water Extraction or extraction is to be assessed as follows.

GEALL = GEIRR + GEDOM + GEIND

Where,

GALL = Ground water extraction for all uses
GEIRR = Ground water extraction for irrigation
GE**DOM** = Ground water extraction for domestic uses
GEIND = Ground water extraction for industrial uses

- **Ground Water Extraction for Irrigation (GEIRR)**

Unit Extraction Method: – In this method, season-wise unit Extraction of each type of well in an assessment unit is estimated. The unit Extraction of different types (eg. Dug well, dug cum bore well, shallow tube well, deep tube well, bore well etc.) is multiplied with the number of wells of that particular type to obtain season-wise ground water extraction by that particular structure. It is recommended that a single source of well census should be maintained for resources computation at all India level. Minor Irrigation Census of MoWR, RD, GR would be the preferred option.

- **Ground water Extraction for Domestic Use (GEDOM)**

Unit Extraction Method: – In this method, unit Extraction of each type of well is multiplied by the number of wells used for domestic purpose to obtain the domestic ground water Extraction.
Consumptive Use Method: – In this method, population is multiplied with per capita consumption usually expressed in litre per capita per day (lpcd). It can be expressed using following equation.
GEDOM= Population X Consumptive Requirement X Lg
Where,
Lg = Fractional Load on Ground water for Domestic Water Supply
The data about load factors on ground water sources can be obtained from the concerned water supply agencies / departments in urban areas.

- **Ground water Extraction for Industrial use (GEIND)**

Unit Extraction Method: - In this method, unit Extraction of each type of well is multiplied by the number of wells used for industrial purpose to obtain the industrial ground water extraction.
Consumptive Use Pattern Method: – In this method, water consumption of different industrial units are determined. Number of Industrial units which are dependent on ground water are multiplied with unit water consumption to obtain ground water Extraction for industrial use, as suggested below.

GEIND= Number of industrial units X Unit Water Consumption X Lg
Where,
Lg = Fractional load on ground water for industrial water supply
The load on Ground water for Industrial water supply can be obtained from water supply agencies in the Industrial belt.
Data Base of Industry: -Other important sources of data on ground water extraction for industrial uses are - Central Ground Water Authority, State Ground Water Authority, National Green Tribunal and other Environmental Regulatory Authorities.

6.4. Stage of Ground water Extraction

The stage of ground water extraction is defined by,

$$Stage\ of\ GW\ Extraction = \frac{Existing\ Gross\ Ground\ water\ Extraction\ For\ All\ Uses}{Annual\ Extractble\ Ground\ water\ Resources} \times 100$$

The existing gross ground water extraction for all uses refers to the total of existing gross ground water extraction for irrigation and all other purposes. The stage of ground water extraction should be obtained separately for command areas, non-command areas and poor ground water quality areas.

6.4.1. Validation of Stage of Ground water Extraction

Taking into consideration of inherent uncertainties associated with various component of both extracted and extractable ground water resources, GEC 1997 has recommended to validate the “Stage of Ground water Extraction (SGE)” with long term trend of ground water

levels for a minimum period of 10 years for both pre-monsoon and post-monsoon period. GEC 2015 refine these concepts further and suggest that if the pre and post monsoon water levels show a fairly stable trend, it does not necessarily mean that there is no scope for further ground water development. Such a trend indicates that there is a balance between recharge, extraction and natural discharge in the unit. However, further ground water development may be possible, which may result in a new stable trend at a lower ground water level with associated reduced natural discharge. If the ground water resource assessment and the trend of long-term water levels contradict each other, this anomalous situation requires a review of the ground water resource computation, as well as the reliability of water level data. The mismatch conditions are enumerated below Table 10.

Table 10: Validation Criteria for Stage of GW Extraction (SGWE)

Stage of GW Extraction	Ground water Level Trend	Remarks
≤ 70 %	Decline in trend in both pre-monsoon and post-monsoon	Not acceptable and needs reassessment
> 100 %	No significant decline in both pre-monsoon and post-monsoon long term trend	Not acceptable and needs reassessment

In case, the category does not match with the water level trend given above, a reassessment should be attempted. If the mismatch persists even after reassessment, the sub unit may be categorized based on Stage of Ground Water Extraction of the reassessment. However, the sub unit should be flagged for strengthening of observation well network and parameter estimation.

6.4.2. Categorization of Assessment Units

Present categorization of assessment units, as per GEC 1997 methodology takes into account long term ground water level trends and stage of ground water extraction of period under consideration. The National Water Policy, 2012 emphasis a convergence of quantity and quality of ground water resources while assessing the ground water extraction status in an assessment unit so as to aid appropriate management decisions. Therefore, GEC 2015 recommends to separate estimation of resources where water quality is beyond permissible limits for the parameter salinity. Moreover, if any of the three quality hazards in terms of Arsenic, Fluoride and Salinity are encountered in the assessment sub unit in mappable units, the assessment sub unit may be tagged with the particular Quality hazard. Accordingly, GEC 2015 recommends that each assessment unit, in addition to the quantity based categorization (safe, semi-critical, critical and over-exploited) should bear a quality hazard identifier (Table 11). Such quality hazards are to be based on available ground water monitoring data of State Ground Water Departments and /or Central Ground Water Board.

Table 11: Criteria for Quantity & Quality Based Categorization

Stage of Ground water Extraction	Category	Quality Tag
≤ 70 %	Safe	Tag for sub unit / unit in terms of Salinity, Arsenic, Fluoride, if any
> 70 % and ≤ 90 %	Semi Critical	
> 90 % and ≤ 100 %	Critical	
> 100 %	Over Exploited	

6.4.3. Allocation of Ground water Resource for Utilization

The Annual Extractable Groundwater Resources are to be apportioned between domestic, industrial and irrigation uses. Among these, as per the National Water Policy, requirement for domestic water supply is to be accorded priority. This requirement has to be based on population as projected to the year 2025, per capita requirement of water for domestic use, and relative load on ground water for urban and rural water supply. The estimate of allocation for domestic water requirement may vary for one sub unit to the other in different states. In situations where adequate data is not available to make this estimate, the following empirical relation is recommended.

Alloc = 22 X N X L_g mm per year

Where

Alloc = Allocation for domestic water requirement
N = population density in the unit in thousands per sq. km.
Lg = fractional load on groundwater for domestic and industrial water supply (≤ 1.0)

In deriving equation above, it is assumed that the requirement of water for domestic use is 60 lpd per head. The equation can be suitably modified in case per capita requirement is different. If by chance, the estimation of projected allocation for future domestic needs is less than the current domestic extraction due to any reason, the allocation must be equal to the present-day extraction. It can never be less than the present-day extraction as it is unrealistic.

6.4.4. Net Annual Ground Water Availability for Future Use

The water available for future use is obtained by deducting the allocation for Domestic use and current extraction for Irrigation and Industrial uses from the annual extractable ground water recharge. The resulting ground water potential is termed as the Net Annual Ground Water Availability for future use.

The net annual ground water availability for future use should be calculated separately for non-command areas and command areas. As per the recommendations of the R&D Advisory committee, the ground water available for future use can never be negative. If it becomes negative, the future allocation of domestic needs can be reduced to current extraction for domestic use. Even then if it is still negative, then the ground water available for future uses will be zero.

6.5. Ground water Assessment in Urban Areas

GEC 2015 propose to have a separate ground water assessment for urban areas with population more than 10 lakhs. Taking note of difficulties to have ground water Extraction data in most of the urban areas and constraints to natural recharge, by rainfall infiltration and recharge due to other sources on account of urbanization, GEC 2015 has suggested the following few points are to be considered for Urban Areas Ground Water Resources Estimation.

- The difference of the actual demand and the supply by surface water sources as the withdrawal from the ground water resources.
- Consider 30% of the rainfall infiltration factor for urban areas as an adhoc arrangement till field studies are done and documented.

- The 50 % percent losses reported by piped water supply may be taken as recharge to the ground water system.
- The seepages from the sewerages, which normally contaminate the ground water resources with nitrate also contribute to the quantity of resources and hence same percent as in the case of water supply pipes may be taken as norm for the recharge on the quantity of sewerage when there is sub surface drainage system.
- Recharge on account of seepage from open drainage system / open channels, (like lined / unlined canal) may be considered, till further documented field studies are done.
- If estimated flash flood data is available, the same percent can be used on the quantum of flash floods to estimate the recharge from the flash floods.

6.6. Ground water Assessment in Water Level Depletion Zone

In some of assessment unit there may be areas where ground water level shows a decline even in the monsoon season. The reasons for this may be genuine depletion in the ground water regime, with ground water extraction and natural ground water discharge in the monsoon season (outflow from the region and base flow) exceeding the recharge.

GEC 2015 suggest that, if it is concluded that the water level data is erroneous, recharge assessment may be made based on rainfall infiltration factor method. If, on the other hand, water level data is assessed as reliable, the ground water level fluctuation method may be applied for recharge estimation. In such cases, the estimated recharge will be less than the gross ground water extraction in the monsoon season. It must be noted that this recharge is the gross recharge minus the natural discharges in the monsoon season. The immediate conclusion from such an assessment in water depletion zones will be that the area falls under the overexploited category which requires micro level study.

7. GROUND WATER RESOURCE ESTIMATION 2022

The Ground water Resource Estimation 2022 (GWRE 2022), NCT Delhi has been carried out broadly following GEC-2015 methodology. In absence of requisites data or inadequacy if any, the constraints and the procedure followed in the present assessment are described below.

7.1. Data Sources and Constraint for Various Data Elements

All efforts are made to collect the data from the respective State Government Departments. However, it is felt necessary to mention that due to non-availability of data from some departments, certain assumptions have made while making the computations. Essential data sets were generated by approximate methods by fitting a relationship with the existing data elements and the required data elements wherever both are available and used the equation for rest of the area. The data sources for the various data elements used in the present exercise are presented in Table 12.

Table 12: Data Sources Used in the Ground Water Resource Estimation 2022

S. No	Data Element	Used in the Computation of	Data Source
1	Areas of Various sub units	Assessment unit wise recharge & Extraction component	List and maps of new administrative Units of 11 Districts of NCT Delhi: Revenue Dept, GNCT Delhi. web site & Geospatial Delhi Limited
2	Irrigation Well Census	Ground water extraction for irrigation	IV Minor Irrigation Census & Agriculture Dept of GNCT, I&FC
3	Population Census / Agriculture Area / Industry Census /	Ground water extraction for domestic, agriculture and industrial use	Census of India, Agriculture statistics of GNCT Delhi, List Industries on Industry Dept DPCC web site. DJB, Horticulture, Delhi Cantt, DMRC, DMC etc
4	Canal/Drains Details	Return Seepage Recharge due to Canals / Drains	I&FC Dept, GNCT of Delhi
5	Cropping Pattern	Return Seepage Recharge due to Surface Water Irrigation and Ground Water Irrigation.	IV Minor Irrigation Census & Agriculture Dept of GNCT Delhi
6	Details of Tanks & Ponds	Recharge due to Tanks & Ponds: ad-hoc basis	Statistical Book of GNCT Delhi / web link Parks & Garden, GNCT Delhi, DJB
7	Details of Water Conservation Structures	Recharge due to Water Conservation Structures	Delhi Jal Board (DJB)
8	Rainfall	Recharge due to Rainfall / Normalization of Rainfall Recharge	IMD, Govt of India web site
9	Ground Water Monitoring: Pre-monsoon and Post-monsoon groundwater levels & trends and GW quality monitoring data of last decade (2008-19).	Water Level Fluctuation method and validation of SGE; GW Quality data for identification of poor-quality area.	GEMS Database of SUO, New Delhi, Central Ground Water Board
10	Population Details	Provision for Future Domestic and Industrial Requirement.	Growth rate data of NCT Delhi as per Census of India, 2011 report.

Long term 10 years (2010-21), pre-monsoon (May) and post-monsoon (November) water level data of observation wells monitored by CGWB, SUO Delhi are considered for

calculating estimating zone of dynamic fluctuation and Water Level Trend. Water level fluctuations between pre-monsoon and post-monsoon have been calculated for hard rock and alluvial terrains separately. State agencies in NCT Delhi do not have any program for ground water monitoring and therefore recharge estimation relied on available data of CGWB. Monitoring station having data set pair, pre-monsoon and post-monsoon period, for more than 5 years considered. Some of the assessment units don't have sufficient representation for water level data. For such assessment units, monsoon recharge estimated by Rainfall Infiltration Factor, as suggested in GEC 2015 methodology is adopted.

For estimation ground water extraction for domestic water supply, data provided by different agencies were disseminated assessment unit wise based on coordinates. The cumulative ground water Extraction for drinking water for entire NCT Delhi cross checked with DJB data on difference in total water demand and supply from surface water source in NCT Delhi. Agriculture Extraction data was provided by I & FC and Agriculture department. The Extraction data provided by Horticulture & Forest department has been considered as Extraction for agriculture. The agriculture Extraction data provided by Agriculture department & I & FC department have been subsumed with that of Horticulture and Forest department to estimate agriculture Extraction. The Extraction due to Industry is worked out as per area wise Industries /data available on web sites of Industry and DPCC site of GNCT of Delhi.

7.2. Assessment Unit Area

The ground water resource assessment of the NCT Delhi has been carried out considering tehsil as a unit assessment area. In total there are eleven (11) districts with three tehsils in each district of NCT Delhi, accounting for 33 assessment units and parts flood plain area around Yamuna River, which is demarcated as a Nazul land. The Nazul land area is also considered as additional assessment unit. First time Ground water Resources Assessment had been attempted for these new administrative sub-units of NCT, Delhi in 2017. The Geospatial Delhi Limited, an undertaking under Department of Revenue of NCT Delhi has been requested to provided Tehsil wise area and GIS layer of NCT Delhi. The cumulative area for entire NCT Delhi worked out is 1486.67 Sq.km which nearly matches with total NCT area of 1483.00 Sq.km given in District Census Book of Delhi and accordingly, ground water resources assessment has been done for each of 33 tehsil and Nazul land areas considering total 1486 Sq.km of NCT Delhi. Some assessment units of NCT has surface water irrigation, constitute as a Canal Command Area. It is observed that such command has less than 100 ha in respective assessment units and therefore treated as Non-Command Area for resources estimation as per GEC 2015 methodology. The districts of South East, South, New Delhi and Central are covered with alluvial aquifers are fringed with hard rock aquifers viz. Delhi Quartzite occurring around Delhi ridge. Rest of the districts have alluvium aquifers only. Basic details of all 34-assessment units are presented in Table 13.

Table 13: Basic Details of Assessment Units of NCT Delhi – GWRE 2022

District	Assessment Unit	Predominant Rock Formation	Total Area (ha)	Hilly Area (Ha)	Recharge worthy area (Ha)	Poor Ground water quality (Ha)			Command Area (Ha)	Non Command Area (Ha)
						As	Salinity	F		
1	2	3	4	5	6	7	8	9	10	11
CENTRAL	KAROL BAGH	Alluvium & HR	512.5	0	512.5	0	0	0	0	512.5
CENTRAL	KOTWALI	Alluvium	1964	0	1964	0	0	0	0	1964
CENTRAL	CIVIL LINES	Alluvium	5454	0	5454	0	0	0	0	5454
EAST	PREET VIHAR	Alluvium	1344	0	1344	0	0	0	0	1344
EAST	MAYUR VIHAR	Alluvium	1677	0	1677	0	0	0	0	1677
EAST	GANDHI NAGAR	Alluvium	138.9	0	138.9	0	0	0	0	138.9
NAZUL LAND	NAZUR LAND	Alluvium	2579	0	2579	0	0	0	0	2579
NEW DELHI	VASANT VIHAR	Alluvium & HR	5721	0	5721	0	Saline	0	0	5721
NEW DELHI	DELHI CANTONMENT	Alluvium & HR	6580	0	6580	0	Saline	0	0	6580
NEW DELHI	CHANAKYAPURI	Alluvium & HR	3508	0	3508	0	0	0	0	3508
NORTH	MODEL TOWN	Alluvium	2538	0	2538	0	Saline	0	0	2538
NORTH	ALIPUR	Alluvium	11818	0	11818	0	Saline	0	0	11818
NORTH	NARELA	Alluvium	14758	0	14758	0	Saline	0	0	14758
NORTH EAST	YAMUNA VIHAR	Alluvium	557.3	0	557.3	0	0	0	0	557.3
NORTH EAST	SEELAMPUR	Alluvium	895.9	0	895.9	0	0	0	0	895.9
NORTH EAST	KARAWAL NAGAR	Alluvium	2114	0	2114	0	0	0	0	2114
NORTH WEST	SARASWATI VIHAR	Alluvium	3299	0	3299	0	Saline	0	0	3299
NORTH WEST	KANJHAWALA	Alluvium	8039	0	8039	0	Saline	0	0	8039
NORTH WEST	ROHINI	Alluvium	4098	0	4098	0	0	0	0	4098
SHAHDARA	SHAHDARA	Alluvium	490.2	0	490.2	0	0	0	0	490.2
SHAHDARA	VIVEK VIHAR	Alluvium	2244	0	2244	0	0	0	0	2244
SHAHDARA	SEEMAPURI	Alluvium	724.3	0	724.3	0	0	0	0	724.3
SOUTH	SAKET	Alluvium & HR	7197	0	7197	0	0	0	0	7197
SOUTH	HAUZ KHAS	Alluvium & HR	2472	0	2472	0	0	0	0	2472
SOUTH	MEHRAULI	Alluvium & HR	6116	0	6116	0	0	0	0	6116
SOUTH EAST	SARITA VIHAR	Alluvium	3020	0	3020	0	0	0	0	3020
SOUTH EAST	DEFENCE COLONY	Alluvium & HR	3938	0	3938	0	0	0	0	3938
SOUTH EAST	KALKAJI	Alluvium & HR	3394	0	3394	0	0	0	0	3394
SOUTH WEST	KAPASHERA	Alluvium	10879	0	10879	0	Saline	0	0	10879
SOUTH WEST	DWARKA	Alluvium	6784	0	6784	0	Saline	0	0	6784
SOUTH WEST	NAJAFGARH	Alluvium	12853	0	12853	0	Saline	0	0	12853
WEST	RAJOURI GARDEN	Alluvium	1048	0	1048	0	Saline	0	0	1048
WEST	PATEL NAGAR	Alluvium	2646	0	2646	0	Saline	0	0	2646
WEST	PUNJABI BAGH	Alluvium	7360	0	7360	0	Saline	0	0	7360

7.3. Norms Followed in the Assessment GWRE 2022

The GEC 2015 recommends that the state agencies should be encouraged to conduct field studies for various norms and use such computed norms in the assessment. In absence of such computed norms by the field study, GEC 2015 suggests an average of the range of norms to

be used as the recommended by GEC-1997. Detail of such norms are presented in GEC, 2015 report. The recommended norm values are to be used for assessment, unless sufficient data based on field study are available to justify the minimum, maximum or other intermediate values. Following are the range of norms suggested in GEC 2015 methodology (Table 14 & 15).

7.3.1. Specific Yield

The Specific Yield values are used for the assessment units of NCT Delhi are as per its two main hydrogeological formation, alluvium as soft rock unit and Aravalli Group Quartzites and related meta-sediment units, as mapped in NAQUIM project of CGWB. The portion of the specific yield norms recommended by GEC 2015, for aquifers underlain in NCT Delhi, is given in Table 14.

Table 14: Specific Yield Norms: GEC 2015 Methodology

Sl.No	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	6	4	8
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	16	12	20
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	10	8	12
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	16	12	20
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay)	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	16	12	20
7	Alluvium	AL07	Glacial Deposits	Quaternary	16	12	20
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.5
41	Schist	SC02	Phyllite	Azoic to Proterozoic	1.5	1	2
42	Schist	SC03	Slate	Azoic to Proterozoic	1.5	1	2
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	1.5	1	2
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	0.3	0.2	0.4
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	1.5	1	2
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	0.3	0.2	0.4

7.3.2. Rainfall Infiltration Factor

GEC 2015 recommends that Rainfall Infiltration Factor (RIF) values are to be used for assessment as per norm (Table 15) unless sufficient data based on field study is available to justify the minimum, maximum or other intermediate values. GEC 2015 recommends

Table 15: Rainfall Infiltration Factor: GEC 2015 Methodology

Sl.No	Principal Aquifer	Major Aquifers		Age	Recommended (%)	Minimum (%)	Maximum (%)
		Code	Name				
1	Alluvium	AL01	Younger Alluvium (Clay/Silt/Sand/ Calcareous concretions)	Quaternary	22	20	24
2	Alluvium	AL02	Pebble / Gravel/ Bazada/ Kandi	Quaternary	22	20	24
3	Alluvium	AL03	Older Alluvium (Silt/Sand/Gravel/Lithomargic clay)	Quaternary	22	20	24
4	Alluvium	AL04	Aeolian Alluvium (Silt/ Sand)	Quaternary	22	20	24
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) -East Coast	Quaternary	16	14	18
5	Alluvium	AL05	Coastal Alluvium (Sand/Silt/Clay) - West Coast	Quaternary	10	8	12
6	Alluvium	AL06	Valley Fills	Quaternary	22	20	24
7	Alluvium	AL07	Glacial Deposits	Quaternary	22	20	24
39	Schist	SC01	Schist - Weathered, Jointed	Azoic to Proterozoic	7	5	9
40	Schist	SC01	Schist - Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3
41	Schist	SC02	Phyllite	Azoic to Proterozoic	4	3	5
42	Schist	SC03	Slate	Azoic to Proterozoic	4	3	5
43	Quartzite	QZ01	Quartzite - Weathered, Jointed	Proterozoic to Cenozoic	6	5	7
44	Quartzite	QZ01	Quartzite - Massive, Poorly Fractured	Proterozoic to Cenozoic	2	1	3
45	Quartzite	QZ02	Quartzite - Weathered, Jointed	Azoic to Proterozoic	6	5	7
46	Quartzite	QZ02	Quartzite- Massive, Poorly Fractured	Azoic to Proterozoic	2	1	3

conducting field studies and strengthen the database norms. Moreover, for urban area assessment, GEC 2015 recommends adopting 30 % values of RIF norms on account of apparent reduction in rainfall infiltration due to urbanization. It is observed that, although most of the NCT Delhi is considered as Urban City, most of the assessment units have open space and green zones, which accommodate major part of rainfall infiltration like other non-urban areas. Therefore, except few assessment units of East Delhi and Central district, for major parts of NCT Delhi RIF value as per GEC 2015 norms and field observations of CGWB are adopted in GWRE 2022 is presented in Table 16. IMD Rainfall data adopted for GWRE 2022 is presented in Table 17.

Table 16: Norms adopted GWRE 2022, NCT Delhi

District	Assessment Unit Name	Normal Annual Rainfall (mm)	Normal Monsoon Rainfall (mm)	Specific Yield (%)	Method adopted for computing rainfall recharge during Monsoon recharge (WLF/RIF Method)	RF Infiltration Factor (%)
Central	Civil Lines Tehsil	794	667.1	3%& 15%	RIF	20%
Central	Karol Bagh Tehsil	794	667.1	3%&15%	RIF	20%
Central	Kotwali Tehsil	794	667.1	10%	RIF	15%
East	Gandhi Nagar Tehsil	794	667.1	15%	RIF	22%
East	Mayur Vihar Tehsil	794	667.1	12%	RIF	22%
East	Preet Vihar Tehsil	794	667.1	15%	RIF	22%
New Delhi	Chanakyapuri Tehsil	794	667.1	3% &10%	RIF	20%
New Delhi	Delhi Cantonment Tehsil	794	667.1	15%& 3%	RIF	20%
New Delhi	Vasant Vihar Tehsil	794	667.1	3%&15%	RIF	20%& 22%
North	Alipur Tehsil	794	667.1	15%	RIF	20%
North	Model Town Tehsil	794	667.1	15%	RIF	22%
North	Narela Tehsil	794	667.1	14%	RIF	22%
North East	Karawal Nagar Tehsil	794	667.1	15%	RIF	22%
North East	Seelampur Tehsil	794	667.1	15%	RIF	22%
North East	Yamuna Vihar Tehsil	794	667.1	15%	RIF	22%
North West	Kanjhawala Tehsil	794	667.1	13%	RIF	22%
North West	Rohini Tehsil	794	667.1	10%	RIF	22%
North West	SaraswatiVihar Tehsil	794	667.1	12%	RIF	22%
Shahdara	Seemapuri Tehsil	794	667.1	15%	RIF	22%
Shahdara	Shahdara Tehsil	794	667.1	15%	RIF	22%
Shahdara	Vivek Vihar Tehsil	794	667.1	15%	RIF	22%
South	Hauz Khas Tehsil	794	667.1	10%& 3%	RIF	20%
South	Mehrauli Tehsil	794	667.1	3%&15%	RIF	20%& 22%
South	Saket Tehsil	794	667.1	3%&15%	RIF	20%& 22%
South East	Defence Colony Tehsil	794	667.1	10%	RIF	22%
South East	Kalkaji Tehsil	794	667.1	15%&3%	RIF	20%
South East	Sarita Vihar Tehsil	794	667.1	15%	RIF	22%
South West	Dwarka Tehsil	794	667.1	10%	RIF	22%
South West	Kapashera Tehsil	794	667.1	12%	RIF	22%
South West	Najafgarh Tehsil	794	667.1	12%	RIF	22%
West	Patel Nagar Tehsil	794	667.1	3% &10%	RIF	22%
West	Punjabi Bagh Tehsil	794	667.1	13%	RIF	22%
West	Rajouri Garden Tehsil	794	667.1	15%	RIF	22%
Nazul Land	Nazul Land Tehsil	794	667.1	16%	RIF	25%

Table: 17 Month & Season wise IMD Rainfall Data – NCT Delhi

Year	January	Febraury	March	April	May	June	July	August	September	October	November	December	Annual
2017	38.8	0	8.7	22.8	16	103.8	109.7	117	112.1	0	0.1	4.7	533.7
2018	4.8	0	0	12.2	18.6	57.4	247.6	185.8	148.7	0	3.8	0.5	679.4
2019	34.8	23.1	5.1	7.9	13.5	6.6	167.4	149.2	57.4	13.5	4.5	22.6	505.6
2020	23.8	2.2	69.4	14.6	15.5	30.5	166.2	233.1	37.9	0	0.6	0.2	678.5
2021	37.11	2.18	2.93	2.16	105.62	24.88	255.94	196.74	265.95	74.34	0	4.49	972.34
Average	27.862	5.496	17.226	11.932	33.844	44.636	189.368	176.368	124.41	17.568	1.8	6.498	673.908

Year	Winter	Pre-Monsoon	Monsoon	Post Monsoon	Annual
2017	38.8	47.5	442.6	4.8	533.7
2018	4.8	30.8	639.5	4.3	679.4
2019	57.9	26.5	380.6	40.6	505.6
2020	26	99.5	467.7	0.8	678.5
2021	39.29	110.71	743.51	78.83	972.34

7.3.3. Norms for Canal Recharge

GEC 2015 recommends the norm in ham/million m^2 of wetted area for computing the recharge due to canals. In the absence of any field studies to refine the norms, it is recommended to continue with the same adhoc norms as of earlier GEC 1997. The committee strongly recommends that each state agency must conduct one filed study at least one in each district before completing the first assessment using this methodology and where specific results are available from case studies in some states, the adhoc norms are to be replaced by norms evolved from these results. In absence any field study, the norms adopted in earlier estimation are adopted in resent GWRE 2020 (Table 18).

Table 18: Norms for Recharge from Canals and Other Water Bodies

Parameters	Sources of Recharge	Range of Parameters
Canal Seepage Factor	Unlined Canals	15 to 30 ham / m sqm of wetted area
	Lined Canals & Canals in Hard Rock Terrain	20 % of above values suggested for lined canals
Seepage from Tanks & Ponds	1.4 mm / day over the average Water Spread Areas	
Recharge from Water Conservation Structures	40 % of the Gross Storage. Out of 50% during monsoon season and the remaining 50 % during non-monsoon season.	

7.3.4. Norms for Recharge Due to Other Sources

GEC 2015 has observed that the data on the field studies for computing recharge from other sources like tanks & ponds, Water Conservation Structures are very limited. It is recommended to follow the norms as per methodology when area specific field studies are not available. Accordingly, for recharge due to tanks & ponds, norm of 1.4 mm / day and for seepage recharge from Water Conservation Structures, norms of 40% of gross storage during a year which means 20% during monsoon season and 20% during non-monsoon season is adopted (Table 18).

7.3.5. Norm for Future Allocation for Domestic Use

Per capita water requirement norm recommended by the GEC 2015 is 60 lpcd for domestic needs. It also suggested that it can be modified as per norm followed for domestic water supply agency in assessment unit if any for specific case. As per information made available from one of GNCT of Delhi report Economy Survey of NCT Delhi, same norm is considered by Delhi Jal Board, a water supplying agency in NCT Delhi. Future allocation for Domestic Use for 2025 has been estimated considering the said norms and dependency on ground water in respective Tehsil of NCT Delhi.

7.3.6. Norm for Natural Discharges

GEC 2015 recommends computing the base flow for each assessment unit. Wherever, there is no assessment of base flow, earlier norms recommended by GEC 1997 i.e. 5% if Water Table Fluctuation method is used or 10% if Rainfall Infiltration Factor method is used for assessing the rainfall recharge may be continued. Accordingly, the assessment unit component of Natural Discharge estimated, as per above norm corresponding WLF or RIF methodology adopted for estimating monsoon recharge is presented in Table 19.

7.4. Results of Groundwater Resources Estimation 2022

7.4.1. Annual Groundwater Recharge

The annual groundwater recharge includes the components of rainfall recharge and recharge from other sources like canal/drain seepage, return flow from irrigation, seepage from domestic water supply and recharge from water conservation structure. The Annual Groundwater Recharge for NCT Delhi 2022 is estimated as 41041.17 ham. Assessment unit wise details of estimation are presented in Table 19 (column 4 to 8).

7.4.2. Annual Extractable Groundwater Recharge

The annual extractable groundwater recharge as defined in GEC 2015 methodology, involving component of monsoon & non-monsoon recharge and excluding component for natural discharge for the environment, following GEC 2015 norms has been estimated for NCT Delhi is 36946.51 ham. Assessment unit wise details of estimation are presented in Table 19 (column 10).

7.4.2. Annual Groundwater Extraction

During the year under report, almost all departments & Institutions of NCT Delhi have provided geo-referenced extraction data which has been further distributed over Tehsil layer by CGWB to find out tehsil wise extraction. The running hour and discharge have been averaging out as demand of Software. Industrial extraction data was not provided and have been considered on pro rata basis.

The total ground water extraction as defined in GEC 2015 methodology, involving component of domestic ground water extraction, irrigation extraction and industrial extraction has been estimated for NCT Delhi is 36267.14 ham. Assessment unit wise details of ground water extraction is presented in Table 19 (Column 11 to 14).

7.5. Stage of Groundwater Extraction and Categorization of Assessment Units

The Stage of Ground Water Extraction as on 2022 in NCT Delhi varies from 63% in Rohini Tehshil to 135% in Yamuna Vihar tehshil of North West Distrct. The overall Stage of Groundwater Extraction in NCT Delhi as on 2020 is 98%. The information on Stage of Ground Water Extraction is given in table 19 (column 17).

As per recommendation of GEC 2015 methodology, the Dynamic Groundwater Resources (fresh quality) be planned for future ground water management. Out of 34 new assessment units of NCT Delhi, 4 are categorized as *'Safe'*, 8 as *'Semi Critical'*, 7 as *'Critical'* and rest 15 as *'Over Exploited'*. A summarized data on categorization all 34 assessment units of NCT Delhi is presented in Table 19 (column 18). A map showing categorization of assessment units (Tehsils of NCT Delhi) is presented in Figure 39.

7.6. Annual Allocation for Domestic use and Net Ground Water Availability for future use

Annual Allocation for Domestic use for 2025 has been estimated as 28780.55 ham, for entire NCT Delhi. The Assessment unit wise Annual Allocation for Domestic Use as on 2025 is presented in Table 19, column 15. The Net Ground Water Availability for future use in NCT Delhi is 2876.15 ham (Table 19, column 16).

Figure: 39

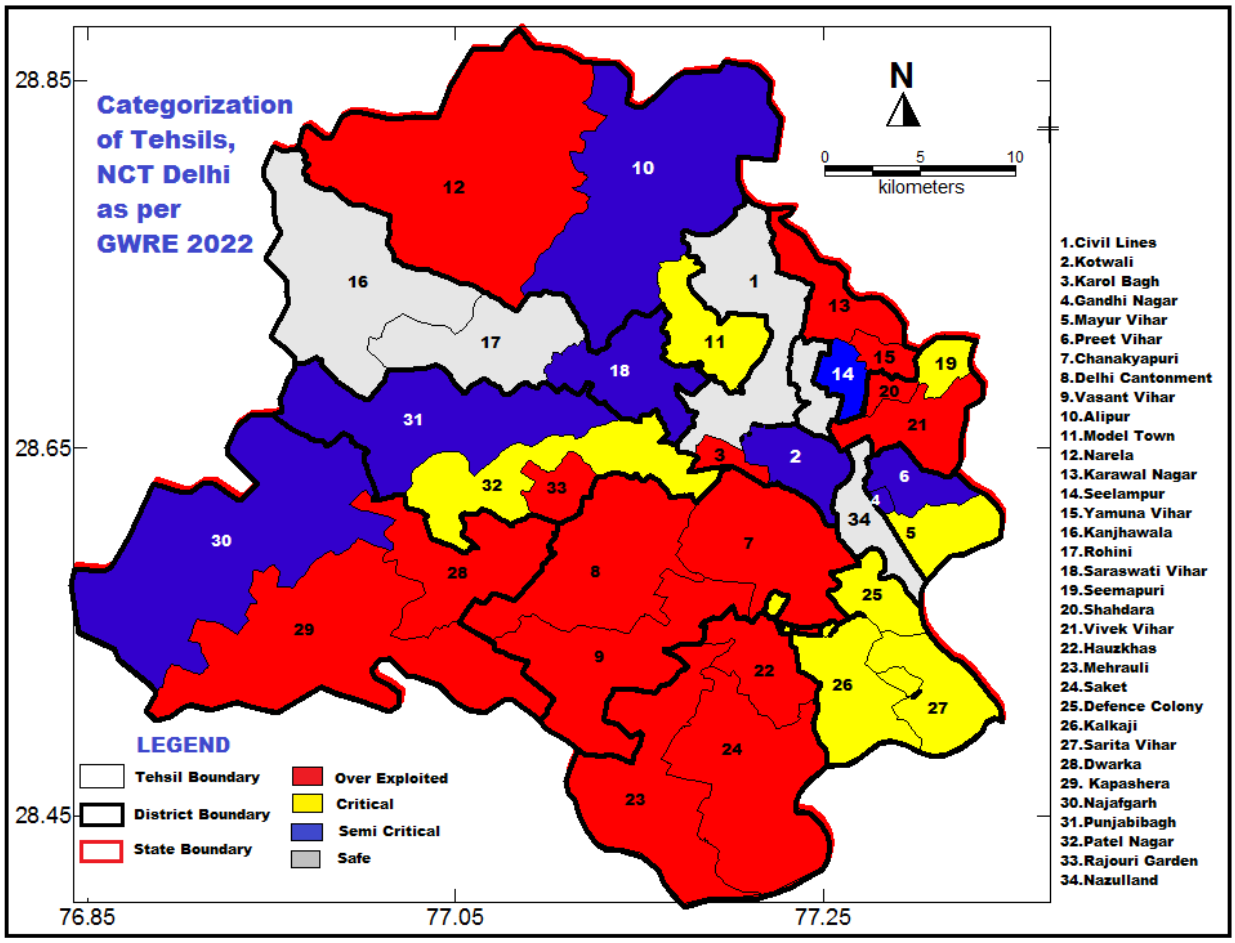

Categorization of Tehsils, NCT Delhi as per GWRE 2022
N
0 5 10
kilometers
28.85
28.65
28.45
76.85
77.05
77.25
LEGEND
Tehsil Boundary
District Boundary
State Boundary
Over Exploited
Critical
Semi Critical
Safe
1.Civil Lines
2.Kotwali
3.Karol Bagh
4.Gandhi Nagar
5.Mayur Vihar
6.Preet Vihar
7.Chanakyapuri
8.Delhi Cantonment
9.Vasant Vihar
10.Alipur
11.Model Town
12.Narela
13.Karawal Nagar
14.Seelampur
15.Yamuna Vihar
16.Kanjhawala
17.Rohini
18.Saraswati Vihar
19.Seemapuri
20.Shahdara
21.Vivek Vihar
22.Hauzkhas
23.Mehrauli
24.Saket
25.Defence Colony
26.Kalkaji
27.Sarita Vihar
28.Dwarka
29. Kapashera
30.Najafgarh
31.Punjabibagh
32.Patel Nagar
33.Rajouri Garden
34.Nazulland

Table 19: Assessment Unit Wise Dynamic Groundwater Resources Estimation 2022 , NCT Delhi (Fresh Component)

S.No	District	Assessment Unit	Area (Sq.Km)	Ground Water Recharge (ham)					Total Natural Discharge (ham)	Annual Extractable Ground Water Resource (ham) (8-9)	Annual Ground Water Extraction (ham)				Allocation of Ground Water Resource for Future Domestic Utilisation (ham)	Net Annual Ground Water Availability for future use (ham)	Stage of Ground Water Extraction (%) (14/10) * 100	Category	Quality Tagging (if any) As/F/Salinity
				Monsoon		Non-Monsoon													
				Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources	Total Annual Ground Water Recharge			Domestic	Industrial	Irrigation	Total (11+12+13)					
1	2	3		4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	Central	Civil Lines Tehsil	54.54	408.01	448.82	27.48	888.50	1772.81	177.28	1595.53	833.69	0.00	207.13	1040.82	833.69	554.71	65.23	Safe	
2	Central	Karol Bagh Tehsil	5.13	31.22	46.89	2.10	88.03	168.24	16.82	151.42	151.70	0.00	18.65	170.35	744.35	0.00	112.50	Over Exploited	
3	Central	Kotwali Tehsil	19.65	85.89	221.14	5.78	441.77	754.58	75.46	679.12	575.40	0.00	19.01	594.41	575.4	84.72	87.53	Semi Critical	
4	East	Gandhi Nagar Tehsil	1.39	7.21	30.71	0.49	54.86	93.27	9.33	83.94	71.04	0.00	2.40	73.44	227.56	10.5	87.49	Semi Critical	
5	East	Mayur Vihar Tehsil	16.77	89.27	245.89	6.01	487.09	828.26	82.83	745.43	663.53	0.00	66.30	729.83	663.53	15.6	97.91	Critical	
6	East	Preet Vihar Tehsil	13.45	70.72	233.85	4.76	465.11	774.44	77.44	697.00	564.92	0.00	41.85	606.77	564.92	90.02	87.06	Semi Critical	
7	New Delhi	Chanakyapuri Tehsil	35.09	322.94	162.50	21.75	283.37	790.56	79.06	711.50	419.63	0.00	398.31	817.94	419.63	0.00	114.96	Over Exploited	
8	New Delhi	Delhi Cantonment Tehsil	65.81	410.58	281.14	27.65	549.53	1268.90	126.89	1142.01	1099.78	2.20	171.25	1273.23	1,099.78	0.00	111.49	Over Exploited	Salinity
9	New Delhi	Vasant Vihar Tehsil	57.21	513.44	270.14	34.58	520.45	1338.61	133.86	1204.75	1476.61	0.00	145.35	1621.96	1,476.61	0.00	134.63	Over Exploited	Salinity
10	North	Alipur Tehsil	118.19	1079.51	287.57	72.71	559.75	1999.54	199.95	1799.59	1351.60	0.00	237.76	1589.36	1,351.60	210.22	88.32	Semi Critical	Salinity
11	North	Model Town Tehsil	25.39	142.45	156.49	9.59	310.89	619.42	61.94	557.48	456.51	0.30	77.32	534.13	472.7	7.16	95.81	Critical	Salinity
12	North	Narela Tehsil	148.08	1398.64	302.22	94.20	571.23	2366.29	236.63	2129.66	2192.40	50.01	174.69	2417.10	2,192.40	0.00	113.50	Over Exploited	Salinity
13	North East	Karawal Nagar Tehsil	21.15	132.17	203.99	10.68	402.52	749.36	74.94	674.42	619.16	0.00	73.95	693.11	619.16	0.00	102.77	Over Exploited	
14	North East	Seelampur Tehsil	8.96	55.75	257.19	3.75	522.19	838.88	83.89	754.99	573.17	0.00	39.81	612.98	573.17	142.01	81.19	Semi Critical	
15	North East	Yamuna Vihar Tehsil	5.57	28.98	95.88	1.95	182.97	309.78	30.98	278.80	314.54	0.00	63.00	377.54	314.54	0.00	135.42	Over Exploited	
16	North West	Kanjhawala Tehsil	80.4	1001.94	46.65	67.48	78.76	1194.83	119.48	1075.35	647.08	0.00	85.40	732.48	1,007.38	342.87	68.12	Safe	Salinity
17	North West	Rohini Tehsil	40.98	284.13	608.68	19.14	1222.98	2134.93	213.49	1921.44	940.51	0.00	259.65	1200.16	940.51	721.28	62.46	Safe	
18	North West	Saraswati Vihar Tehsil	32.99	191.13	127.12	12.87	246.13	577.25	57.73	519.53	283.38	0.56	156.75	440.69	331.38	30.83	84.83	Semi Critical	Salinity
19	Shahdara	Seemapuri Tehsil	7.24	41.23	225.55	2.78	452.34	721.90	72.19	649.71	585.19	0.00	60.00	645.19	585.19	4.52	99.30	Critical	
20	Shahdara	Shahdara Tehsil	4.9	24.23	172.95	1.63	343.70	542.51	54.25	488.26	514.10	0.00	28.65	542.75	514.1	0.00	111.16	Over Exploited	
21	Shahdara	Vivek Vihar Tehsil	22.44	123.54	237.08	8.32	452.43	821.37	82.14	739.23	534.03	0.50	315.70	850.23	534.03	0.00	115.02	Over Exploited	
22	South	Hauz Khas Tehsil	24.72	133.76	336.91	9.01	651.17	1130.85	113.09	1017.77	1082.40	0.00	216.85	1299.25	1,082.40	0.00	127.66	Over Exploited	
23	South	Mehrauli Tehsil	61.16	481.50	281.59	32.43	558.93	1354.45	135.45	1219.01	1299.53	0.00	92.23	1391.76	1,299.53	0.00	114.17	Over Exploited	
24	South	Saket Tehsil	71.98	733.70	542.51	49.42	1065.43	2391.06	239.11	2151.95	1963.05	0.00	447.76	2410.81	1,963.05	0.00	112.03	Over Exploited	
25	South East	Defence Colony Tehsil	39.39	233.82	266.65	15.75	526.13	1042.35	104.24	938.12	824.81	1.60	90.52	916.93	824.81	21.18	97.74	Critical	
26	South East	Kalkaji Tehsil	33.95	302.46	295.50	20.37	588.65	1206.98	120.70	1086.28	1047.05	7.50	31.07	1085.62	1,047.05	0.66	99.94	Critical	
27	South East	Sarita Vihar Tehsil	30.2	202.56	163.91	13.64	314.03	694.14	69.41	624.73	501.78	3.64	107.92	613.34	501.78	11.38	98.18	Critical	
28	South West	Dwarka Tehsil	67.84	552.55	575.97	37.22	1116.08	2281.82	228.18	2053.64	1458.45	0.00	854.25	2312.70	1,458.45	0.00	112.61	Over Exploited	Salinity
29	South West	Kapashera Tehsil	108.8	1259.67	401.46	84.84	720.49	2466.46	246.65	2219.81	693.18	0.00	1788.56	2481.74	821.21	0.00	111.80	Over Exploited	Salinity
30	South West	Najafgarh Tehsil	128.54	1514.87	499.96	102.03	825.37	2942.23	294.22	2648.01	462.69	0.00	1730.60	2193.29	777.59	139.82	82.83	Semi Critical	Salinity
31	West	Patel Nagar Tehsil	26.46	402.14	391.18	27.09	774.00	1594.41	159.44	1434.97	1103.40	0.50	287.63	1391.53	1,103.40	43.44	96.97	Critical	Salinity
32	West	Punjabi Bagh Tehsil	73.06	1116.39	284.62	75.19	539.58	2015.78	201.58	1814.20	1156.27	0.10	404.92	1561.29	1,156.27	252.9	86.06	Semi Critical	Salinity
33	West	Rajouri Garden Tehsil	10.49	62.73	175.56	4.23	346.75	589.27	58.93	530.34	588.78	0.00	39.43	628.21	588.78	0.00	118.45	Over Exploited	Salinity
34	Nazul Land	Nazul Land Tehsil	25.79	444.95	75.24	29.97	125.99	676.15	67.62	608.54	114.60	0.00	301.60	416.20	114.6	192.33	68.39	Safe	
	Total		1487.71	13884.08	8953.51	936.89	17277.20	41051.68	4105.17	36946.51	27163.96	66.91	9036.27	36267.14	28780.55	2876.15	98.16	Critical	

Table 20: District Wise Dynamic Groundwater Resources Estimation 2022 , NCT Delhi (Fresh Component)

DYNAMIC GROUND WATER RESOURCES OF NCT, Delhi, 2022															(in Ham)
S. No.	Name of District	Ground Water Recharge					Total Natural Discharges	Annual Extractable Ground Water Resource	Current Annual Ground Water Extraction				Annual GW Allocation for for Domestic Use as on 2025	Net Ground Water Availability for future use	Stage of Ground Water Extraction (%)
		Monsoon Season		Non-monsoon Season		Total Annual Ground Water Recharge			Irrigation	Industrial	Domestic	Total			
		Recharge from rainfall	Recharge from other sources	Recharge from rainfall	Recharge from other sources										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	CENTRAL	525.12	716.85	35.36	1418.3	2695.63	269.56	2426.07	244.79	0	1560.79	1805.57	2153.44	639.43	74.42
3	EAST	167.2	510.45	11.26	1007.06	1695.97	169.61	1526.36	110.55	0.2	1299.5	1410.24	1456.01	116.12	92.39
4	NAZUL LAND	444.95	75.24	29.97	125.99	676.15	67.62	608.53	301.6	0	114.6	416.2	114.6	192.33	68.39
5	NEW DELHI	1246.96	713.78	83.98	1353.34	3398.06	339.8	3058.26	714.92	2.2	2996.02	3713.14	2996.02	0	121.41
6	NORTH	2620.6	746.28	176.5	1441.87	4985.25	498.53	4486.72	489.77	50.31	4000.51	4540.58	4016.7	217.38	101.2
7	NORTH EAST	216.9	557.06	16.38	1107.67	1898.01	189.8	1708.21	176.76	0	1506.88	1683.63	1506.87	142.01	98.56
8	NORTH WEST	1477.2	782.45	99.49	1547.87	3907.01	390.7	3516.31	501.8	0.56	1870.97	2373.33	2279.27	1094.98	67.49
9	SHAHDARA	189	635.58	12.73	1248.46	2085.77	208.57	1877.2	404.35	0.5	1633.32	2038.17	1633.32	4.52	108.58
10	SOUTH	1348.96	1161.01	90.86	2275.53	4876.36	487.64	4388.72	756.84	0	4344.97	5101.82	4344.98	0	116.25
11	SOUTH EAST	738.84	726.06	49.76	1428.81	2943.47	294.36	2649.11	229.51	12.74	2373.64	2615.89	2373.64	33.22	98.75
12	SOUTH WEST	3327.09	1477.39	224.09	2661.94	7690.51	769.04	6921.47	4373.41	0	2614.33	6987.74	3057.25	139.82	100.96
13	WEST	1581.26	851.36	106.51	1660.32	4199.45	419.95	3779.5	731.98	0.6	2848.46	3581.03	2848.45	296.34	94.75
	Total(Ham)	13884.08	8953.51	936.89	17277.16	41051.64	4105.18	36946.46	9036.29	67.11	27163.97	36267.34	28780.55	2876.15	98.16
	Total(Bcm)	0.14	0.09	0.01	0.17	0.41	0.04	0.37	0.09	0.000671	0.27	0.36	0.29	0.03	98.16

Table 21: Category wise Assessment unit Percentage

S.No	Name of District	Total No. Of Assessed Units	Safe		Semi-Critical		Critical		Over-Exploited		Saline			
			No.	%	No.	%	No.	%	No.	%	No.	%		
1	NORTH	3	-	-	1	33.33	1	33.33	1	33.33	-	-		
2	SOUTH EAST	3	-	-	-	-	3	100	-	-	-	-		
3	SOUTH WEST	3	-	-	1	33.33	-	-	2	66.67	-	-		
4	EAST	3	-	-	2	66.67	1	33.33	-	-	-	-		
5	NAZUL LAND	1	1	100	-	-	-	-	-	-	-	-		
6	SOUTH	3	-	-	-	-	-	-	3	100	-	-		
7	CENTRAL	3	1	33.33	1	33.33	-	-	1	33.33	-	-		
8	NEW DELHI	3	-	-	-	-	-	-	3	100	-	-		
9	NORTH WEST	3	2	66.67	1	33.33	-	-	-	-	-	-		
10	WEST	3	-	-	1	33.33	1	33.33	1	33.33	-	-		
11	NORTH EAST	3	-	-	1	33.33	-	-	2	66.67	-	-		
12	SHAHDARA	3	-	-	-	-	1	33.33	2	66.67	-	-		
	Total	34	4	11.76	8	23.53	7	20.59	15	44.12	-	-		

ANNUAL EXTRACTABLE GROUND WATER RESOURCE OF ASSESSMENT UNITS UNDER DIFFERENT CATEGORIES IN NCT, DELHI (2022)

S.No.	Total Annual Extractable Resource of Assessed Units (in Mcm)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
		Total Annual Extractable Resource (in Mcm)	%	Total Annual Extractable Resource (in Mcm)	%	Total Annual Extractable Resource (in Mcm)	%	Total Annual Extractable Resource (in Mcm)	%	Total Annual Extractable Resource (in Mcm)	%
1	369.46	52.01	14.08	89.96	24.35	60.37	16.34	167.13	45.23	-	-

Table 22: District wise Annual Extractable Resource of different Categories

DYNAMIC GROUND WATER RESOURCES OF NCT, DELHI, 2022												
S.No	**Name of District**	**Total Annual Extractable Resource of Assessed Units (in Mcm)**	**Safe**		**Semi-Critical**		**Critical**		**Over-Exploited**		**Saline**	
			Annual Extractable Resource (in Mcm)	**%**	**Annual Extractable Resource (in Mcm)**	**%**	**Annual Extractable Resource (in Mcm)**	**%**	**Annual Extractable Resource (in Mcm)**	**%**	**Annual Extractable Resource (in Mcm)**	**%**
1	**NORTH**	44.87	0.00		18.00	4.87	5.58	1.51	21.30	5.77		
2	**SOUTH EAST**	26.49	0.00		0.00		26.49	7.17	0.00			
3	**SOUTH WEST**	69.21	0.00		26.48	7.17	0.00		42.73	11.57		
4	**EAST**	15.26	0.00		7.81	2.11	7.45	2.02	0.00			
5	**NAZUL LAND**	6.09	6.09	1.65	0.00		0.00		0.00			
6	**SOUTH**	43.89	0.00		0.00		0.00		43.89	11.88		
7	**CENTRAL**	24.26	15.96	4.32	6.79	1.84	0.00		1.51	0.41		
8	**NEW DELHI**	30.58	0.00		0.00		0.00		30.58	8.28		
9	**NORTH WEST**	35.16	29.96	8.11	5.19	1.40	0.00		0.00			
10	**WEST**	37.80	0.00		18.14	4.91	14.35	3.88	5.30	1.43		
11	**NORTH EAST**	17.08	0.00		7.55	2.04	0.00		9.53	2.58		
12	**SHAHDARA**	18.77	0.00		0.00		6.50	1.76	12.28	3.32		
	Total	369.46	52.01	14.08	89.96	24.35	60.37	16.34	167.12	45.23		

Table 23: Category wise Recharge worthy area of Assessment Units

DYNAMIC GROUND WATER RESOURCES OF NCT, DELHI, 2022												
S.No	Name of District	Total Recharge Worthy Area of Assessed Units (in sq.km)	Safe		Semi-Critical		Critical		Over-Exploited		Saline	
			Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%	Recharge Worthy Area of Assessed Units (in sq.km)	%
1	NORTH	291.1	-	-	118.2	7.95	25.4	1.71	147.6	9.92	-	-
2	SOUTH EAST	103.5	-	-	-	-	103.5	6.96	-	-	-	-
3	SOUTH WEST	305.1	-	-	128.5	8.64	-	-	176.6	11.87	-	-
4	EAST	31.6	-	-	14.83	1.00	16.8	1.13	-	-	-	-
5	NAZUL LAND	25.8	25.8	1.73	-	-	-	-	-	-	-	-
6	SOUTH	157.9	-	-	-	-	-	-	157.9	10.61	-	-
7	CENTRAL	79.3	54.5	3.66	19.6	1.32	-	-	5.1	0.34	-	-
8	NEW DELHI	158.1	-	-	-	-	-	-	158.1	10.63	-	-
9	NORTH WEST	154.4	121.4	8.16	33	2.22	-	-	-	-	-	-
10	WEST	110.5	-	-	73.6	4.95	26.5	1.78	10.5	0.71	-	-
11	NORTH EAST	35.7	-	-	9	0.61	-	-	26.7	1.79	-	-
12	SHAHDARA	34.6	-	-	-	-	7.2	0.48	27.3	1.84	-	-
	Total	1487.6	201.7	13.56	396.7	26.67	179.4	12.06	709.8	47.72	-	-

Table 24: Categorization of Assessment units, GWRE 2022

CATEGORIZATION OF ASSESSMENT UNITS, 2022							
S. No	**Name of District**	**S. No**	**Name of Semi-Critical Assessment Unit**	**S. No**	**Name of Critical Assessment Unit**	**S. No**	**Name of Over-Exploited Assessment Unit**
1	**CENTRAL**	1	KOTWALI			1	KAROL BAGH
2	**EAST**	1	GANDHI NAGAR	1	MAYUR VIHAR		
		2	PREET VIHAR				
3	**NAZUL LAND**						
4	**NEW DELHI**					1	DELHI CANTONMENT
						2	CHANAKYAPURI
						3	VASANT VIHAR
5	**NORTH**	1	ALIPUR	1	MODEL TOWN	1	NARELA
6	**NORTH EAST**	1	SEELAMPUR			1	YAMUNA VIHAR
						2	KARAWAL NAGAR
7	**NORTH WEST**	1	SARASWATI VIHAR				
8	**SHAHDARA**			1	SEEMAPURI	1	VIVEK VIHAR
						2	SHAHDARA
9	**SOUTH**					1	HAUZ KHAS
						2	MEHRAULI
						3	SAKET
10	**SOUTH EAST**			1	KALKAJI		
				2	DEFENCE COLONY		
				3	SARITA VIHAR		
11	**SOUTH WEST**	1	NAJAFGARH			1	KAPASHERA
						2	DWARKA
12	**WEST**	1	PUNJABI BAGH	1	PATEL NAGAR	1	RAJOURI GARDEN

ABSTRACT			
Total No. of Assessed Units	**Number of Semicritical Assessment Units**	**Number of Critical Assessment Units**	**Number of Over Exploited Assessment Units**
34	8	7	15

Table 25: Improved List of assessment units from GWRE 2020

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2022 AND 2020)						
NCT DELHI						
S. No	Name of District	Name of Assessment Unit	Stage of Ground Water Extraction (%) in 2020	Categorization in 2020	Stage of Ground Water Extraction (%) in 2022	Categorization in 2022
Improved (7 assessment units)						
1	Central	Civil Lines	76.01	Semi Critical	65.23	Safe
2	East	Mayur Vihar	107.12	Over-exploited	97.91	Critical
3	North	Alipur	97.9	Critical	88.32	Semi Critical
4	North-East	Seelampur	99.27	Critical	81.19	Semi Critical
5	South-East	Kalkaji	113.85	Over-exploited	99.94	Critical
6	South-East	Sarita Vihar	114.23	Over-exploited	98.18	Critical
7	South-West	Najafgarh	94.18	Critical	82.73	Semi Critical

Table 26: Deteriorated list of Assessment Units from GWRE 2020

COMPARISON OF CATEGORIZATION OF ASSESSMENT UNITS (2022 AND 2020)						
NCT DELHI						
S. No	**Name of District**	**Name of Assessment Unit**	**Stage of Ground Water Extraction (%) 2020**	**Categorization 2020**	**Stage of Ground Water Extraction (%) in 2022**	**Categorization 2022**
Deteriorated (2 assessment units)						
1	**North East**	**Karawal Nagar**	**98.69**	**Critical**	**102.77**	**Over Exploited**
2	**West**	**Patel Nagar**	**84.35**	**Semi-Critical**	**96.97**	**Critical**

7.7. Comparison of GWRE 2022 with Previous GWREs of NCT Delhi

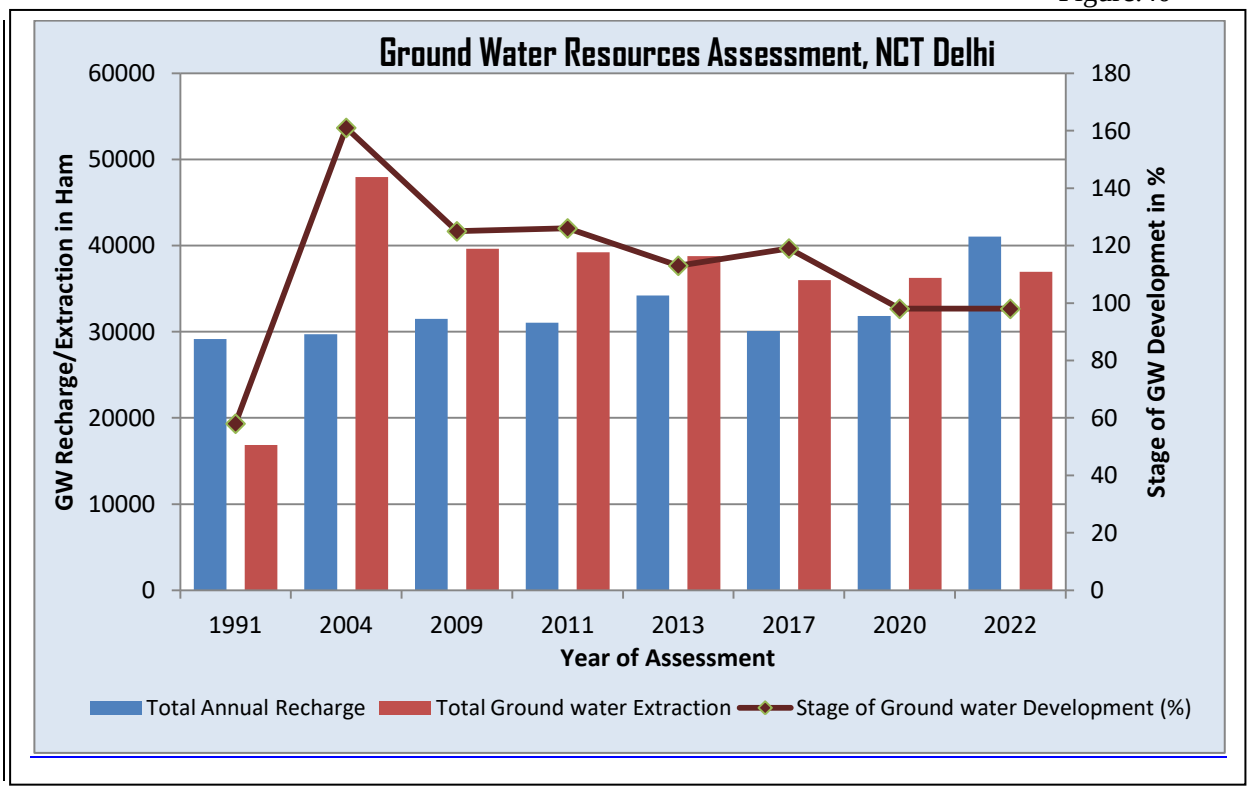
The comparison of GWRE 2022 with the previous estimates of 1991, 2004, 2009, 2011, 2013, 2017, 2020 has been presented in the Table No. 27 shows a decline trend. This is on account of more refined methodology and refined database over the period. From year 2004 onward more refined GEC 1997 methodology was in vogue for next three assessments. Moreover, the database on which computation were carried out was updated continuously. In year 2013, data pertaining to canals / drains were updated which reflected as positive impact on the total ground water recharge. Further, there was reduction in domestic Ground Water Extraction which was attributed to the increased piped (surface) water supply by DJB during the period of assessment. The regulation on drilling of new bore wells in whole NCT Delhi has also contributed to lesser dependency on ground water and all these factors led of slight lower development compared to previous two estimates.

Comparison of present GWRE 2022 with earlier estimates is presented in Table 27 and Figure40.

Table 27: Comparison of GWREs of NCT Delhi

Methodology	1991	2004	2009	2011	2013	2017	2020	2022
	GEC 1984	GEC 1997				GEC 2015		
Total Annual Recharge (ham)	29154	29710	31501	31050	34192	30090	28490	41051
Total Ground water Extraction (ham)	16840	47945	39619	39215	38785	35990	29032	36947
Stage of Ground water Development (%)	58	161	125	126	113	119	102	98

Figure.40



Perusal of above, table 27 and figure 40 reveals that the stage of ground water extraction for NCT Delhi, from year 2009 onward when refined GEC Methodology is adopted for tehsil wise resource estimation, has remained changing (more improvement). Compared to estimate of year 2009, 2011, 2013, 2017 and 2020 there is less annual replenishable recharge in present (GWRE 2022) estimate. The reduced ground water recharge compared to the earlier estimation can be corroborated with diminishing average annual rainfall over last five years and extreme climate events despite refinement of data pertaining to recharge from water conservation structure. This can further be collaborated with the significant decreasing trend

in annual rainfall in NCT Delhi areas, as per analysis of rainfall data study report of IMD[1]. Similarly, reduced ground water extraction compared to the earlier estimate can be attributed less dependency on ground water resources over the period of assessment, for drinking water supply in NCT Delhi by implementation / coverage of large additional pockets by piped water supply of DJB. Moreover, increased urbanization also resulted less ground water extraction for agriculture uses. However, overall development status remained around 102 %, i.e., more extraction than annual replenishable recharge, resulting in mining of static ground water resources of the NCT Delhi. This has reflected in decreasing ground water levels in major part of NCT Delhi.

8. CONCLUSION AND RECOMMENDATION

It can be concluded that Dynamic Ground Water Resource of NCT Delhi is improving in certain districts of NCT Delhi because of implementation of interventions suggested by Hon'ble NGT, CGWB, use of treated water for Irrigation, improvement of water supply of Delhi Jal Board and less dependency on groundwater.

It was recommended during 4th & final meeting for approval of Dynamic Groundwater Resource 2020 and during Workshop that Estimation for 2022 may be undertaken by considering wards as smallest assessment units. It is also recommended to consider intense water conservation activities in South & South East districts of NCT, Delhi especially in south of Shahjahan Reserved Forest up to Chattarpur & further south.

As far as geo-referenced data of ground water extraction & water conservation structures is concerned which is most vital input to INGRES for groundwater estimation, all departments of NCT Delhi & Govt. of India, are recommended to maintain meticulous records of ground water extraction & water conservation to be used in GWRE 2022.

Annexure I: Minutes of the first meeting of State Groundwater Coordination Committee

Government of NCT of Delhi
Department of Urban Development
10th Level, 'A' Wing, Delhi Secretariat
IP Estate, New Delhi – 110002

F. No. 16(554)/UD/W/2015/Vol-II/472-491 Dated: 05/05/2022

Minutes of the 1st Meeting of State Level Committee for Ground Water Resources Assessment, 2022 under the Chairmanship of Principal Secretary (UD), in Delhi Secretariat, Govt. of NCT of Delhi.

First Meeting of State Level Committee for Ground Water Resources Assessment, 2022 for NCT, Delhi was held on 25.04.2022 at 03.30 P.M. under the Chairmanship of Principal Secretary, Urban Development Department, Govt. of NCT of Delhi. At the outset Principal Secretary, Urban Development Department welcomed all the participants, thereafter he requested Shri S.K. Mohiddin, Head of Office, Central Ground Water Board, State Unit Office, Delhi & Member Secretary of the Committee to initiate the Agenda Item wise discussion. The list of officer attended the meeting is enclosed as Annexure-'A'.

Shri Mohiddin briefed the members about the Ground Water Resource Assessment (GWRA) methodology and he informed that as per the last GWRA 2020, out of 34 Assessment units of NCT, Delhi 17 Assessment units are **over exploited**, 07 are **critical**, 07 are **semi critical** and 03 are in safe category. The Chairman of the committee enquired about need of repeat resource assessment when already it has been done in 2020. Shri S.K. Mohiddin, CGWB apprised about recommendations of various committees constituted by Govt. of India on this issue. He also explained the members regarding the necessity to do the repeat Resource Assessment in 2022 & thereafter every 2 years same exercise is to be undertaken. Then he requested Shri Saidul Haq, Scientist 'D', Hydrogeologist, CGWB to give brief presentation on Ground Water Resource Assessment Methodology. Shri Saidul Haq, first thanked all members present in the meeting for their active cooperation during GWRA 2020 in providing Extraction & Recharge Data.

Thereafter, agenda wise discussions were taken up for GWRA, 2022.

Agenda 1:- Extraction Data

(A) Drinking & Domestic Water supply through Ground water

Ground water is being used by various govt. & non-govt. agencies in NCT of Delhi to meet out their daily domestic water demand. There are institutions like Schools, Universities, Collages, Coaching Institutes, Hostels, Hotels, Malls etc., in each tehsil (Revenue sub-division) of NCT of Delhi. These institutions are either getting supply from DJB or using their own tube wells for their water demand.

It is necessary to estimate total ground water extraction in one Hydrological Cycle by all stakeholders.

All agencies to provide data in following format:

10/5/22
Sh. Saidul Haq, Sc-D

डायरी सं. / Diary No. 92
दिनांक / Date 11.05.2022
के.भू.ज.बो. / C.G.W.B.

Name of Department:						
S.No.	Detail Location of Tube well & Revenue Subdivision	Longitude	Latitude	Monsoon Running Hour/day	Non-monsoon Running Hour/day	Discharge in M3/hr

(Action: All govt. departments including MES & Cantonment Board, Central Government Departments)

Chairman of the Committee directed the Deputy Secretary (UD) to write letters on his behalf to all the concerned departments to furnish the data as per the time schedule so that the process can be concluded in time. He also instructed DJB representative to compile the data for the last 10 years to whom permissions were issued for extraction of ground water.

(B) Irrigation Water Demand & Supply

Irrigation is also an important input which contributes to recharge as return seepage. Irrigation & Flood Control Department of GNCT of Delhi & All Municipal Corporations, Forest Department & DDA are using ground water for green belt development which is also considered as irrigation by ground water for the purpose of GWRA 2022.

Data may be provided in following format for Agriculture area:-

There is very less agriculture land in NCT of Delhi but still contributing supportive farm produce by using ground water & surface water.

(B)1 Irrigation by Surface Water

Sr.No	Tehsil (Revenue sub division)	Crop Area in Hac (hectare)	Area Irrigated	Monsoon	Non Monsoon

(B)2 Irrigation by Ground Water

Data may be provided in following format for Parks & Forest area:

S.No	Tehsil (Revenue sub division)	Crop Area/ Park Area/ Forest Area in Hac (hectare)	Area Irrigated	Detailed Location of Tube Wells	Unit discharge of Tube wells in M^3/Day	Monsoon running hour	Non Monsoon running hour

(Action: All Municipal Corporations, Forest Department, DDA, DJB, I& FC, CPWD, Railways, DMRC & PWD)

(C) Ground Water Extraction by Industries

There are only three industrial areas in GNCT of Delhi viz., Narela, Alipur & Okhla. Department of DSIIDC has failed to provide ground water extraction data during GWRA 2020 despite several requests. Finally CGWB considered industrial ground water withdrawal on pro-rata basis during estimation exercise. Data may be provided in the following table-

Sr/No.	Name of the industrial Area	Total No. of Tube Wells	Running Hour/day	Discharge in M^3/hr	Type of Industries e.g. Packaging, Manufacturing, Processing, Machioning etc.,

DSIIDC and DPCC have been requested to provide the industrial draft as per the proforma attached above.

(Action: DSIIDC & DPCC)

Agenda 2:- Recharge Data

The chairman of the committee enquired regarding methodology of estimating total ground water recharge from all sources including rainfall. Sh. Mohiddin, OIC, CGWB informed that during Aquifer mapping of NCT of Delhi, CGWB has conducted infiltration test at various locations. He also explained regarding rate of infiltration in different lithostratigraphic units and how this facilitates rainfall percolation.

Indian Meteorological Department (IMD) maintains historical record of daily rainfall data of all rain gauge stations in NCT of Delhi which they either sell or share on institutional arrangement. It is necessary to obtain last 10 year monthly rainfall data and 50 year normal rainfall for ground water resource estimation 2022. In this regard, chairman of the committee is requested to send a letter to DGM, IMD at dgmmet@gmail.com.

(Action: Urban Development Department)

2 (A) Canal Bed Recharge

Irrigation department informed the committee that no canal water is used for irrigation. I& FC is to provide dimension details and map for canal.

(Action: I & FC)

2 (B) Recharge through Drains

CGWB briefed regarding contribution of open drains in recharging ground water. Therefore, it is necessary to compile data regarding perennial drain caring effluent and rainwater drains active during monsoon only.

I& FC was requested to provide dimension details of each drain, number of days water remains in each drain and map for drain.

(Action: I&FC Department and Agriculture Department, Govt. of NCT Delhi)

2 (C) Recharge through Water Bodies

CGWB received locations of 1001 water bodies and same has been used during GWRA 2020 with assumed dimension. The actual dimension and revenue sub division wherein these water bodies existing were not provided and geo tagging was not very accurate. Therefore data pertain to water bodies may be provided in following format:

S.No	Tehsil (Revenue sub division)	No. of Tanks & Ponds	Avg. Spread Area (Hactares)	Monsoon Spread Area	Non Monsoon Spread Area	No. of Days Water Is Available	
						Monsoon	Non Monsoon

(Action: DJB, Forest, Revenue & DDA etc)

2 (D) Recharge through Conservation Structures

CGWB received data pertaining to 10780 water conservation structures (RWH). In absence of dimension data of each structure, recharge from each structure has been considered from pro-rata basis during GWRA 2020 by CGWB.

It is necessary to have Tehsil (Revenue Sub-division) wise average dimension and numbers of water conservation structures in following format:

S.No	Tehsil (Revenue sub division)	Type of structure	No. of Recharge structures	Avg. Volume of Recharge Structures

(Action: DJB, Municipal bodies, PWD and all other Govt. agencies)

2 (E) Recharge from Shallow water level Area

There are local spots/areas in NCT of Delhi which have been reported to have very shallow water level i.e. < 5 meter in post monsoon period, this also constitutes as ground water resource available for development.

(Action: CGWB, SUO Delhi)

2 (F) Ground Water Recharge by Leakage from Delhi Jal Board Supply Line

Delhi Jal Board is supplying 900 MGD of water to 85% population of Delhi through complicated & dense network of water supply line of various dimensions. It is assumed that 15% to 20% of supplied water goes back to ground water system every day as **Leakage** thereby recharging ground water and become a part of resource.

Data may be submitted in the following format:

S.No	Tehsil	Length of Supply Line	Average Dia of supply line	Quantum of Water supplied	Monsoon	Non-Moonsoon

(Action: DJB, CPWD, NDMC, GE, Delhi Cantonment & Railways including DMRC which have their own water extraction & distribution System.)

Agenda 3:- Nodal Officers for providing Data

The data requirement as detailed in Agenda Point 1& 2 would only be possible if each department designate one responsible officer as **Nodal Officer** for gathering information from their field offices in required format and provide to CGWB within stipulated time for further processing. The chairman of the committee agreed to communicate with head of each department for nominating one officer as nodal officer.

(Action: CGWB will prepare draft letter)

Agenda 4:- Time Line for Ground Water Resource Assessment

Time line of GWRA 2022 were discussed and agreed by most of the members that including chairman of the committee to complete the process (data collection & Analysis) by 31st May 2022. There will be 2nd meeting of this committee in the first week of June, 2022 to discuss outcome of the exercise.

Agenda 5:- Ground Water Resource Assessment technical working Group

The need of a working group for analysing gathered information as detailed above was discussed and chairman of the committee agreed to form a working group.

CGWB proposed representative from following department to constitute a working group-

1. Three Scientists from CGWB, SUO Delhi
2. One officer from DJB
3. One Technical officer from GSDL
4. One Junior level officer from Cantonment board/MES

(Action: Urban Development Department)

Agenda 6:-Any other item with the permission of the Chair

Issue of Permanent committee in NCT of Delhi with specific TORs which need to be constituted for addressing the ground water issues in NCT, Delhi was also discussed.

The meeting ended with the Vote of thanks to the Chair.

(Rajesh Kumar)
Deputy Secretary (Water)

F. No. 16(554)/UD/W/2015/Vol-II/472-491 Dated: 05/05/2022

1. The Commissioner, Department of Industries, 419, Udyog Sadan, FIF, Patparganj, Delhi-110092.
2. The Managing Director (IAS), Geospatial Delhi Ltd., Govt. of NCT of Delhi, 3rd Level, 'C' Wing, Vikas Bhawan –II, Civil Lines, Delhi -110054.
3. The Managing Director (IAS), Delhi Metro Rail Corporation Ltd., Metro Bhawan, Fire Brigade Lane, Barakhamba Lane, New Delhi – 110001
4. The Chief Executive Officer, Delhi Cantonment Board, Sadar Bazar, Delhi Cantt.-10.
5. The Member (Water Supply), Delhi Jal Board, Varunalaya, Phase-II, Jhandewalan, New Delhi.
6. The Member (Engineering), Delhi Development Authority, Vikas Sadan, INA, Delhi.
7. The Chief Engineer (Civil-I), NDMC, Palika Kendra, Sansad Marg, New Delhi.
8. The Chief Engineer, Zone –I, I&FC Deptt. L.M. Bund, office complex, Shastri Nagar, Delhi-31.
9. The Chief Engineer, Zone –II, I&FC Deptt. L.M Bund, office complex, Shastri Nagar, Delhi-31.
10. The Chief Engineer, South DMC, Dr. S.P.M. Civic Centre, JLN Marg, Minto Road, New Delhi.
11. The Chief Engineer, North DMC, Dr. S.P.M. Civic Centre, JLN Marg, Minto Road, New Delhi.
12. The Chief Engineer, East DMC, Patparganj Industrial Area, Delhi.
13. The Director, Environment Deptt., 6th level, C-Wing, Delhi Secretariat, New Delhi.
14. The Joint Director (Agriculture), Development Department, 11th level, MSO Building, ITO, New Delhi.
15. The General Manager, NABARD, NABARD Tower, 24 Rajender Place, New Delhi.
16. The Superintending Engineer (RWH), Delhi Jal Board, Varunalaya, Phase-II, Jhandewalan, New Delhi.
17. The Garrison Engineer (Utility), Water Supply, MES, Delhi Cantonment Board, Delhi.
18. The Office In charge, State Unit Office, Central Ground Water Board, West Block-2, Wing-3, Sector-1, R.K. Puram, New Delhi-110066.

Copy for information to: -

1. PS to Pr. Secretary, UD, 9th Level, C-Wing, Delhi Secretariat, New Delhi.
2. PA to Special Secretary, UD, 9th Level, C-Wing, Delhi Secretariat, New Delhi.

Dy. Secretary (Water)

Meeting on 25/04/2022 at 03:30 PM regarding First Meeting on Ground Water Resources Assesment-2022

.).	Name & Designation	Department	Email & Contact No.	Signature
.	H. S. Sidhu SE/Project/DDA	DDA	SEPLC1DDA@GMAIL.com 8130012805	
.	Harish Chander Addl CE (GW) DJB	DJB	ace gwc8@gmail.com & rain water harvesting 2013@gmail.com	
.	VIMAL Y BELANI Ex. ER	DJB.	-- do --	
.	VIKASH SINGHAL Sr DGM/Engr	DMRC	vikass.singhal@gmail.com 9953786027	
.	SACHIN KUMAR. Junior Engineer	DCB	7042491406	
.	Faisal Abrar	CGWB	fabrar71@gmail.com	
.	V. Sathish Kumar	DDH/Horticulture North DMC	9711787577	
.	Dr Chetna Anand Environment		dr.chetnaanand@gov.in 9717593542	
.	H. S. Singh	EDMC	sesshahn2@gmail.com 9717788343	
0.	SAIDUL HAQ Sc D	CGWB	7275059345	
1.	S.K Mohiddin OIC	CGWB	9560599977	
2.	Subhash Chandra	UD		
3.	Jai Singh, AE (Engg)	NDMC	jaisingh1210@gmail.com, 9968116987	
4.				
5.				
6.				
7.				

Annexure II: Minutes of the Second meeting of State Groundwater Coordination Committee.

Government of NCT of Delhi
Department of Urban Development
10th Level C-Wing, Delhi Sachivalaya
I.P. Estate, New Delhi
Ph-011-23392343

F.No. 16 (554)/UD/W/2015/Vol-II/726-732 Dated: 13/07/2022

Summary Record of Discussion held on 31.05.2022 during Second Meeting of GWRA - 2022 under the chairmanship of Special Secretary, UD, Govt. of NCT Delhi

The 2nd Meeting of GWRA – 2022 was held in the conference room of Urban Development Department, Govt. of NCT of Delhi under the chairmanship of Special Secretary at 3 pm on 31.05.2022. After formal introduction of all the participants, the Special Secretary, UD, desired to form a **Whatsapp Group** of all the Nodal Officer from member departments participating/contributing data for assessment of ground water resource as March 2022. List of participants annexed herewith.

Shri S K Mohiddin, Officer In Charge of Central Ground Water Board thanked Special Secretary, UD for promptly issuing letters to all the members of the committee for providing necessary/ desired data to CGWB in the format designed by CGWB.

Sh. Saidul Haq, Scientist 'D' of Central Ground Water Board, Delhi informed that IMD, Govt of India has provided rainfall data of all Rain gauge stations of NCT of Delhi up to 2019 only. He also informed to the committee that IMD, Pune communicated that Rain fall data of 2020 & 2021 is still with IMD, Lodhi road, Delhi therefore requested the Chair for again issuing a letter to Director General, Indian Metrological Department, Delhi for providing rainfall data for the year 2020 & 2021 for NCT, Delhi. He also informed that the data received for last study of GWRA, 2020 has already been forwarded to GSDL for further processing & blending with data available with them. GSDL was also requested to expedite the process.

Sh. Saidul Haq, Scientist 'D' of Central Ground Water Board, Delhi also apprised to the committee that an **Online Training Program** on INGRES was also organized on 25-05-2022 and attended by Nodal officers from DJB & GSDL.

Deputy Secretary, UD informed that Technical Coordination Group comprising of Nodal Officers have been formed for better coordination to carry out the study of GWRA, 2022 in NCT of Delhi.

CGWB requested that letters may also be issued to following Departments by Urban Development Department, Govt. of NCT Delhi for providing data of

Wearing Mask, Washing Hands and follow Social Distancing

Shri S K Mohiddin, OIC, CGWB, Delhi also raised the issue of CGWA latest Guidelines issued on 24-9-2020 and available on CGWA website at nocap-cgwa.gov.in. Delhi government need to notify the guidelines issued during 2010 based on these revised guidelines of CGWA. The notification need to be broughtout with the approval of Hon'ble LG of Delhi because NCT of Delhi is still following LG's Notification issued in 2010 based on then Guideline of CGWA. Sh. S.K. Mohiddin also raised the issue of constitution of Ground Water Cell in DJB or renaming the Rainwater Harvesting Cell of DJB as Ground Water Cell with proper strengthening and more powers and responsibilities to address the ground water related issues.

The Chair again desired to put up a note along with copy of Guideline and necessary modification required in relevant para & section of LG's Notification of 2010.

(Action: CGWB & DS, UD)

It was also decided that 3rd meeting of this committee would be held on last week of July, 2022 to discuss draft Ground Water Resource as proposed to be estimated by CGWB in coordination with

The meeting ended with vote of thanks to the chair.

(Rajesh Kumar)
Deputy Secretary (Water)

F.No. 16 (554)/UD/W/2015/Vol-II/726-732 Dated: 13/07/2022

Copy forwarded to the following for information please:-

1. The Chief Executive Officer, Delhi Cantonment Board, Sadar Bazar, Delhi Cantt. – 110010.
2. The Chief Engineer, Zone – I, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
3. The Chief Engineer, Zone – II, Irrigation & Flood Control Department, L.M. Bund Office Complex, Shastri Nagar, Delhi – 110031.
4. The Member (Water Supply), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
5. The Superintending Engineer (RWH), Delhi Jal Board, Varunalaya, Phase – II, Jhandewalan, New Delhi – 110005.
6. The Garrison Engineer (Utility), Water Supply, MES, Delhi Cantonment Board, Delhi – 110010.
7. The Office-in-Charge, State Unit Office, Central Ground Water Board, Ministry of Jal Shakti, Department of WR, RD & GR., GoI, West Block – 2, Wing – 3, Sector – 1, R.K. Puram, New Delhi – 110066.

Deputy Secretary (Water)

ground water extraction and rain water harvesting being done by these departments –

(i) Delhi Pollution Control Committee Govt. of NCT Delhi
(ii) DSIIDC, Govt. of NCT Delhi
(iii) Public Works Department Govt. of NCT Delhi
(iv) Irrigation & Flood Control Department, Govt. of NCT Delhi
(v) Municipal Corporation of Delhi, Govt. of NCT Delhi.
(vi) New Delhi Municipal Corporation
(vii) DUSIB
(viii) Delhi Transport Corporation
(ix) Delhi Development Authority
(x) Railways

(Action: CGWB to prepare draft letter)

Shri Belani from Delhi Jal Board clarified that the data of DJB tube wells mapped with GSDL are of individual users who gave information under Voluntary Disclosure Scheme. These tube wells are not that of DJB Domestic supply tube wells.

Addl Chief Engineer from Delhi Jal Board also ensured that data of DJB domestic wells would be made available in desired format by 2nd week of June 2022

Sh. Sachin Kumar, JE, Delhi Cantonment Board informed that Cantonment Board has provided their data and for remaining data, a letter to Garrison Engineer, MES, Delhi Cantt is to be written for providing data required for GWRA-2022.

(Action: CGWB to prepare draft letter)

Sh. KJVS Prasad, from GSDL informed that they have geo-referenced all the water bodies in NCT, Delhi and remaining data provided by CGWB & other agencies are under processing.

It was suggested by the Chair that MI census data is maintained Agriculture department, Govt of NCT of Delhi therefore they should also be requested to provide all data in desired format.

(Action: CGWB to prepare draft letter & format)

Shri S K Mohiddin, OIC, CGWB, Delhi raise the issue of Permanent Committee in NCT of Delhi for discussing the ground water related issues and taking up the management aspects of ground water in NCT, Delhi. Chairman has requested to prepare detailed note for constituting an Umbrella Permanent Committee in NCT of Delhi to look into issues & concerns of ground water in NCT of Delhi.

(Action: CGWB to prepare draft note)

MEETING ON GROUND WATER RESOURCE ASSESSMENT, 2022 ON 31.05.2022 UNDER THE CHAIRMANSHIP OF SPECIAL SECRETARY, URBAN DEVELOPMENT, GOVT. OF NCT DELHI

S.No.	Name & Designation	Department	Contact No.	Email
1	Gopinder Jeet Addl CE P-IV	DJB	9868127408	addlcep4@gmail.com
2.	Vimal. V. Belani	DJB	9650291229	RainHatka harvesting@gmail.com
3.	Rajesh Kumar, DS	UD Dept	9953010617	deputy secretaryud@gmail.com
4.	Vijendra Singh Rawat	Spl. Secy. UD		
5.	DR VARUN PRAKASH	AGM-GIS	9350718330	agm.gsdl@gmail.com
6.	KJVS Prasad Geospatial Executive	GSDL	8586869053	kjvsprasad@gmail.com
7.	Faisal Akhter	CGWB	9811868445	Akhtar789-cgwb@nic.in
8.	SADDUL HAQ	CGWB	7275099345	faisal.haq@gmail.com
9.	S. K. Mohiddin	CGWB	9540599927	S.K.M.
10.	Sachin. Kumar. JE(El.)	Delhi Cantt. Board	7042491406	OIC2d-cgwb@nic.in SKS Kumar790@gmail.com
11.	R. Gangadhar EE[P&D]	IGFC	9830435590	ceitcd@gmail.com

Annexure III: Minutes of the third meeting of State Groundwater Coordination Committee

Government of NCT of Delhi
Department of Urban Development
.10th Level C-Wing, Delhi Sachivalaya
I.P. Estate, New Delhi
Ph-011-23392343

F.No. 16 (554)/UD/W/2015/834-854 Dated: 3/08/2022

Sub:- MINUTES OF THE 3RD MEETING OF STATE LEVEL COMMITTEE ON GWRE - 2022 HELD ON 28/7/2022 UNDER THE CHAIRMANSHIP OF SPECIAL SECRETARY (UD), GOVT. OF NCT, DELHI.

The 3rd meeting of State Level Committee on GWRE – 2022 was held on 28/7/2022 in the chamber of Special Secretary under his chairmanship. After formal introduction of all the participants, Special Secretary welcomed all the participants from different organisations of Government of NCT, Delhi and Central Ground Water Board. The list of participants is attached as Annexure-I.

Agenda 1 : Approval of GWRE, 2022 of NCT, Delhi

Shri S.K. Mohiddin, Head of Office, CGWB gave a brief presentation on the final studies done for GWRE-2022 by CGWB. He has explained that the GWRE, 2022 has been carried out through InGRESS Software and based on the data supplied by all the participatory departments. During the course of discussion, Special Secretary advised that all the departments of GNCTD to direct the concerned officer to give exact data of groundwater extraction from all the tubewells along with coordinates when the next studies to be carried out in 2023.

Special Secretary opined that the recharge measures to be taken up on a large scale for areas fall under OE category. He also said we should plan for sustainable development of groundwater. He also emphasised as per vision 2041 and 2047, the main emphasize will be on development of Groundwater resources as the availability of surface water sources is very limited.

Shri S.K. Mohiddin said that as per the study of GWRE – 2022, the OE assessment units have been reduced from 17 in 2020 to 15 in 2022. He also said that as per the data received from all the participatory departments and field observation of CGWB, the study of GWRE-2022 has been done precisely within the time frame given by Central Ground Water Board, Central Head Quarter, Faridabad. Shri Mohiddin conveyed thanks to all the participatory departments by saying that we have received proper data because of their excellent coordination and timely cooperation and accordingly GWRE-2022 has been prepared by the committee members well advance in time. As per GWRE-2022, the total groundwater recharge is 41,051.64 Ham and annual extractable groundwater resources are 36,946.46 Ham.

groundwater extraction for all purposes is 36,267.34 Ham. The stage of groundwater extraction is 98.16%.

The district-wise GWRE-2022 is as follows:

District	Annual Extractable Ground Water Resource (ham)	Annual Ground Water Extraction (ham)				Stage of GW Development(%)
		Domestic	Industrial	Irrigation	Total	
Central	2426.07	1560.79	0	244.79	1805.58	74.42
East	1526.36	1299.49	0	110.55	1410.04	92.39
New Delhi	3058.26	2996.02	2.20	714.91	3713.13	121.41
North	4540.58	4000.51	50.31	489.77	4540.59	101.2
North East	1683.63	1506.87	0	176.76	1683.63	98.56
North West	2373.33	1870.97	0.56	501.8	2373.33	67.49
Shahdara	2038.17	1633.32	0.50	404.35	2038.17	108.58
South	4388.72	4344.98	0	756.84	5101.82	116.25
South East	2649.11	2373.64	12.74	229.51	2615.89	98.75
South West	6921.47	1614.32	0	4373.41	6987.73	100.96
West	3779.50	2848.45	0.6	731.98	3581.03	94.75
Nazul Land	608.53	114.60	0	301.6	416.2	68.39
Total	36,946.46	27163.96	66.91	9036.27	36267.14	98.16

There is change in category in 9 assessment units. 7 assessment units have shown improvement and 2 assessment units have shown deterioration.

After detailed deliberations on GWRE, 2022, the same has been approved by State Level Committee.

Agenda 2: Constitution of State Groundwater Coordination Committee of NCT, Delhi

Shri S.K. Mohiddin, OIC, SUO, Delhi said that there is a need for formation of State Groundwater Coordination Committee in Delhi to give direction for different groundwater issues as there is no separate Groundwater Department in Delhi. Ground water in NCT, Delhi is facing number of crisis in NCT Delhi. The main issues are: Water logging problem in part of NCT, Delhi like GK_2, Sukhdev Vihar, Nizamuddin area etc, Ground water pollution aspects -both geo-genic and anthropogenic, contaminations, Over-exploitation of ground water resources and related land subsidence issues, Complaints related to illegal construction of tubewells and illegal extraction of ground water.

The matter was discussed and deliberated upon and it was agreed that a State Groundwater Coordination Committee will be constituted very soon. The same committee will also be responsible for yearly assessment of ground water resources in NCT Delhi and approving the same in future.

(Action: CGWB & UD Department)

Agenda 3:Implementation of CGWA "Guidelines to regulate and control groundwater extraction in respect of NCT, Delhi"

Shri S.K. Mohiddin, OIC, SUO, Delhi informed that Ministry of Jal shakti has revised guidelines for issuing NOC's vide notification dated 24-9-2020 which needs to be implemented in NCT, Delhi. Guidelines have pan-India applicability. CGWA guidelines shall prevail in case of inconsistency with State guidelines. If the State has more stringent provisions, the State provisions shall prevail. NOCs are being issued based on the availability of ground water resources estimated by GWRE methodology. Thus the present notification is in contravene to the Central Guidelines and need to be modified and revised notification need to be brought out.

The matter was discussed and deliberated upon and it was agreed that draft guidelines will be forwarded to Urban Development, GNCTD by CGWB and then UD will implement the guidelines in Delhi and the groundwater regulation is being done as per the notification dated July, 2010. This needs to be revised as per the CGWB guidelines of September, 2020.

(Action: CGWB & UD Department)

The meeting ended with vote of thanks to the chair.

(Rajesh Kumar)
Deputy Secretary (Water)

F.No. 16 (554)/UD/W/2015/834-854 Dated: 3/08/2022

Copy to:-

1. The Commissioner, Department of Industries, 419, Udyog Sadan, Flatted Factory Area, Patparganj, Delhi – 110092.
2. The Managing Director (IAS), Geospatial Delhi Ltd., Govt. of NCT of Delhi, 3rd Level, " C"-Wing, Vikas Bhawan-II, Civil Lines, Delhi-110054.
3. The Managing Director (IAS), Delhi Metro Rail Corporation Ltd., Metro Bhawan, Fire Brigade Lane, Barakhamba Lane, New Delhi-110001.
4. The Chief Executive Officer, Delhi Cantonment Board, Sadar Bazar, Delhi Cantt., Delhi – 110010.
5. The Member (Water Supply), Delhi Jal Board, Varunalaya, Phase-II, Jhandewalan, New Delhi-110005.
6. The Member (Engineering), Delhi Development Authority, Vikas Sadan, INA, New Delhi.
7. The Chief Engineer (Civil-I), New Delhi Municipal Council, Palika Kendra, Sansad Marg, New Delhi.
8. The Chief Engineer, Zone-I, Irrigation and Flood Control Department, LM Bund Office Complex, Shastri Nagar, Geeta Colony, Delhi – 110031.
9. The Chief Engineer, Zone-II, Irrigation and Flood Control Department, LM Bund Office Complex, Shastri Nagar, Geeta Colony, Delhi – 110031.
10. The Chief Engineer, South Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi-110001.
11. The Chief Engineer, North Delhi Municipal Corporation, Dr. S.P. Mukherjee Civic Centre, JLN Marg, Minto Road, New Delhi-110001.
12. The Chief Engineer, East Delhi Municipal Corporation, Patparganj Industrial Area, Delhi.
13. The Director, Department of Environment, Govt. of NCT of Delhi, 6th Level, "C" Wing, Delhi Secretariat, I.P. Estate, New Delhi – 110002.
14. The Joint Director (Agriculture), Development Department, 11th Level, MSO Building, ITO, New Delhi-110002.
15. The General Manager, NABARD, NABARD Tower, 24, Rajender Place, New Delhi-110005.

16. The Superintending Engineer (RWH), Delhi Jal Board, Varunalaya, Phase-II, Jhandewalan, New Delhi-110005.
17. The Garrison Engineer (Utility),Water Supply, MES, Delhi Cantonment Board, Delhi-110010.
18. The Office-in-charge, State Unit Office, Central Ground Water Board, Ministry of Jal Shakti, Department of WR, RD & GR, GoI, West Block-2, Wing-3, Sector-1, R.K.Puram, New Delhi-110066.

Deputy Secretary (Water)

Copy for information to:-

1. PS to Secretary (UD), Urban Development Deptt., 9th Level, "C" Wing, Delhi Secretariat, New Delhi-110002.
2. PS to Special Secretary-I, Urban Development Deptt., 10th Level, "C" Wing, Delhi Secretariat, New Delhi.
3. PS to Joint Secretary, Urban Development Deptt., 10th Level, "C" Wing, Delhi Secretariat, New Delhi

Annexure IV: Assessment Unit Wise Annual Rainfall

Name of District	Name of Assessment Unit (as per GWRA-2022)	Annual Rainfall(in mm)					
		Rainfall-2021 (Monsoon)	Rainfall-2021 (Non-Monsoon)	Rainfall-2019 (Monsoon)	Rainfall-2019 (Non-Monsoon)	Rainfall-2016 (Monsoon)	Rainfall-2016 (Non-Monsoon)
CENTRAL	KOTWALI	657.2	161.1	243.76	123.96	268.97	35.19
CENTRAL	CIVIL LINES	657.2	161.1	243.76	123.96	268.97	35.19
CENTRAL	KAROL BAGH	657.2	161.1	243.76	123.96	268.97	35.19
EAST	MAYUR VIHAR	585.29	157.02	256.38	130.25	344.46	54.79
EAST	GANDHI NAGAR	585.29	157.02	256.38	130.25	344.46	54.79
EAST	PREET VIHAR	585.29	157.02	256.38	130.25	344.46	54.79
NAZUL LAND	NAZUR LAND	585.29	157.02	256.38	130.25	344.46	54.79
NEW DELHI	VASANT VIHAR	536.93	154.3	266.86	135.43	407.12	71.06
NEW DELHI	CHANAKYAPURI	536.93	154.3	266.86	135.43	407.12	71.06
NEW DELHI	DELHI CANTONMENT	536.93	154.3	266.86	135.43	407.12	71.06
NORTH	MODEL TOWN	763.47	257.59	384.82	141.55	440.61	42.81
NORTH	ALIPUR	763.47	257.59	384.82	141.55	440.61	42.81
NORTH	NARELA	763.47	257.59	384.82	141.55	440.61	42.81
NORTH EAST	SEELAMPUR	657.2	161.1	240.8	122.5	251.3	30.6
NORTH EAST	YAMUNA VIHAR	657.2	161.1	240.8	122.5	251.3	30.6
NORTH EAST	KARAWAL NAGAR	657.2	161.1	240.8	122.5	251.3	30.6
NORTH WEST	KANJHAWALA	763.47	257.59	384.82	141.55	440.61	42.81
NORTH WEST	SARASWATI VIHAR	763.47	257.59	384.82	141.55	440.61	42.81

Name of District	Name of Assessment Unit (as per GWRA-2022)	Annual Rainfall(in mm)					
		Rainfall-2021 (Monsoon)	Rainfall-2021 (Non-Monsoon)	Rainfall-2019 (Monsoon)	Rainfall-2019 (Non-Monsoon)	Rainfall-2016 (Monsoon)	Rainfall-2016 (Non-Monsoon)
NORTH WEST	ROHINI	763.47	257.59	384.82	141.55	440.61	42.81
SHAHDARA	VIVEK VIHAR	657.2	161.1	240.8	122.5	251.3	30.6
SHAHDARA	SEEMAPURI	657.2	161.1	240.8	122.5	251.3	30.6
SHAHDARA	SHAHDARA	657.2	161.1	240.8	122.5	251.3	30.6
SOUTH	SAKET	526.72	155.73	273.52	138.83	434.57	77.26
SOUTH	HAUZ KHAS	526.72	155.73	273.52	138.83	434.57	77.26
SOUTH	MEHRAULI	526.72	155.73	273.52	138.83	434.57	77.26
SOUTH EAST	KALKAJI	526.72	155.73	273.52	138.83	434.57	77.26
SOUTH EAST	DEFENCE COLONY	526.72	155.73	273.52	138.83	434.57	77.26
SOUTH EAST	SARITA VIHAR	526.72	155.73	273.52	138.83	434.57	77.26
SOUTH WEST	NAJAFGARH	900.82	265.72	381.81	189.36	540.37	63.05
SOUTH WEST	KAPASHERA	900.82	265.72	381.81	189.36	540.37	63.05
SOUTH WEST	DWARKA	900.82	265.72	381.81	189.36	540.37	63.05
WEST	RAJOURI GARDEN	816.89	288.35	427.9	153.36	506.42	48.02
WEST	PATEL NAGAR	816.89	288.35	427.9	153.36	506.42	48.02
WEST	PUNJABI BAGH	816.89	288.35	427.9	153.36	506.42	48.02

Annexure V: District wise Ground Water Recharge – All Sources (GWRE 2022)

District Name	Monsoon (ham)		Non-Monsoon (ham)	
	Rainfall	Other Sources	Rainfall	Other Sources
Central	525.12	716.85	35.36	1418.3
East	167.2	510.45	11.26	1007.06
New Delhi	1246.96	713.78	83.98	1353.35
North	2620.6	746.28	176.5	1441.87
North East	216.9	557.06	16.38	1107.68
North West	1477.2	782.45	99.49	1547.87
Shahdara	189	635.58	1273	1248.47
South	1348.96	1161.01	90.86	2275.53
South East	738.84	726.06	49.76	1428.81
South West	3327.09	1477.39	224.09	2661.94
West	1581.26	851.36	106.51	1660.33
Nazuland	444.95	75.24	29.97	125.99
Total	13884.08	8953.51	2197.16	17277.2

References:

2 Census of India Report -2011; District Census Handbook, Directorate of Census Operations, Delhi

3 IMD Published Rainfall Normal and Annual Rainfall Data. (http://www.imd.gov.in/)

4 GSI – Published work on Delhi Area - 1997

5 GSI Study Report: Kachroo and Baghchi, 1999.

6 CGWB, SUO, Delhi: Compilation of Exploratory Drilling Data of Delhi, 2000

7 CGWB, SUO, Delhi…NAQUIM Report / Aquifer Mapping and Ground Water Management Plan of NCT, Delhi -2016 (http://cgwb.gov.in/AQM/NAQUIM_REPORT/Delhi/old/Naquim%20Report%20Delhi%20.pdf)

8 CGWB, Report on GEC 2015 Methodology

9 GNCT Report Economy Survey of NCT Delhi

10 Ground Water Resource Estimation Report 2020 by Central Ground Water Board, SUO, Delhi (http://cgwb.gov.in/gwresource.html)

11 India WRIS Web application (https://indiawris.gov.in/wris/#/DataDownload)