Report No.-06

JSA-CTR

Scientific Action Plan for Gurugram

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1 Introduction

1.1 History

The District of Gurugram has been in existence since the times of Mahabharata. It was earlier known as Guru-gram, a name derived from the name of Guru Dronacharya. In the course of time the name got distorted to Gurugram. It was under the control of a succession of rulers appointed by the ruling power in Delhi including Yaduvanshi Rajput, Mughals, Marathas in consecutive order. For a few years Farrukh Nagar was taken from the Nawab and Ghasera from the Bad Gujar Rajput Rao Bahadur Singh of Ghasera by Jat Maharaja Suraj Mal of Bharatpur Kingdom in 1753 and held till 1763. With decay of Mughal Empire, the district remained in a turbulent state till 1803 and thereafter most of it came under the British rule through the treaty of Surji Arjungaon with Sindhiya. In Later on in 1861 the district was rearranged into five tehsils Gurugram, F.P. Jhirka, Nuh, Palwal and Rewari. Since the beginning of the twentieth century various changes have occurred in the territorial composition of the district.

In 1912, a part of Ballabgarh tehsil was transferred to Gurugram district. Under the province and state order 1950, 9 villages of the district including Shahjahanpur were transferred to Rajasthan, and with merger of Pataudi State it gained two villages from Rajasthan and 78 villages from PEPSU. In 1972, Rewari tehsil was removed from Gurugram and got included in Mahendragarh district. On 15 August, 1979, a new district Faridabad, consisting of tehsils of Ballabgarh and Palwal, was formed out of Gurugram district. On 4thApril, 2005, Mewat district has been carved out of Gurugram district. Gurugram is the millennium city and one of the most happening cities of the country. Gurugram is industrial hub of the state of Haryana.

1.2 Location

The District of Gurugram is the 4thlargest District of the state of Haryana that occupies a total area of 1253 Square Kilometers. Gurugram District falls in the southern most region of the state of Haryana. Its headquarters is at Gurugram. It lies in between the 27° 27’ 20” and 28° 32’25’’ latitude, and 76° 39’ 39’’ and 77° 20’ 50’’ longitude. As it shares its borders with Delhi, Gurugram falls under National Capital Region (NCR). On its north, it is bounded by the District of Jhajjar and National Capital Territory of Delhi; Faridabad District lies to its east; Palwal District lies to its south east. On south it shares boundaries with Mewat whereas Rewari lies to its west. To its South, lies the state of Rajasthan.The Location Map of Gurugram district is shown in **Figure 1**.

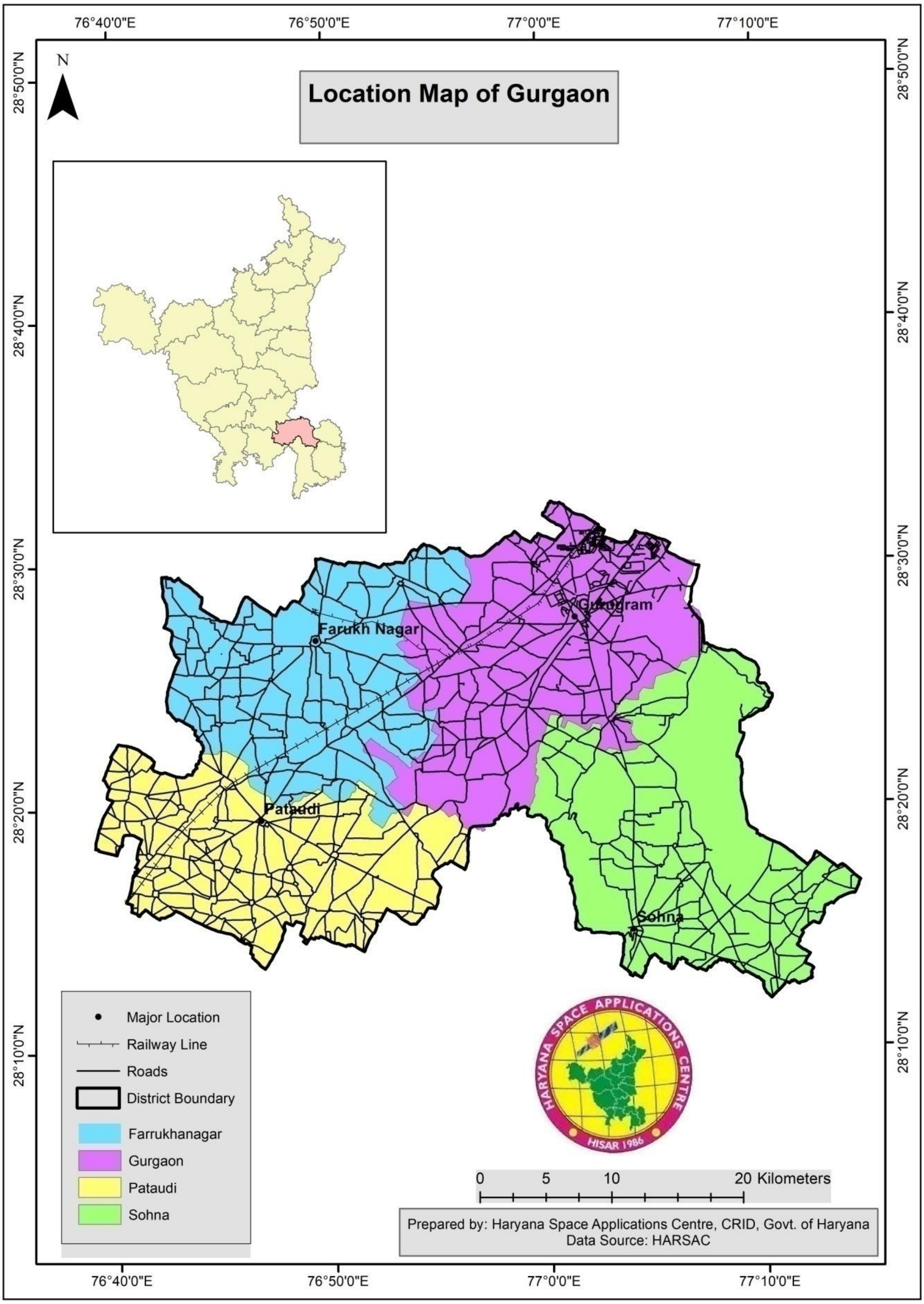


Figure 1 Location Map of Gurugram District

1.3 Administrative Setup

The administrative setup of the District of Gurugram has been described below, with specific sectoral development. The detailed administrative setup is shown in **Table 1**.

Table 1 Major Administrative Jurisdictional Setup of Gurugram District

Country	India
State	Haryana
Division	Gurugram
Headquarters	Gurugram
Tehsil	1. Gurugram, 2. Sohna, 3. Pataudi, 4. Farrukh Nagar 5. Manesar 6. Wazirabad7. Bad Shahpur 8. Kadipur 9. Garhi Harsaru
Total Area	1258 km2 (486 sq. mi)
Total Population (2011)	1,514,432
Density	1,200/km^2 (3,100/sq. mi)
Demographics **Literacy** **Sex Ration**	 84.4% 853
Website	http://gurugram.gov.in
Location of Gurugram	Southern most region of Haryana
Coordinates	27° 39’ and 28° 32’25’’ latitude, and 76° 39’ 30’’ and 77° 20’ 45’’ longitude
Total Area	176.5 sq. mi
Elevation	711.9 ft above the sea level

Source: https://en.wikipedia.org/wiki/Gurugram_district

Sub Divisions (4)	Gurugram, Sohna, Bad Shahpur &Pataudi
Tehsils (5)	Gurugram, Sohna, Pataudi, Farrukh Nagar, Manesar
Sub-Tehsils (4)	Wazirabad, Bad Shahpur, Kadipur, Harsaru
Blocks (4)	Gurugram, Sohna, Farrukh Nagar, Pataudi
Municipal Corporation (2)	Municipal Corporation, Gurugram Municipal Corporation, Manesar
Municipal Council (1)	Sohna
Municipal Committees (3)	Pataudi, Haily Mandi, Farrukh Nagar
Population (Census 2011)	15,14,085

Source: https://gurugram.gov.in/about-district/administrative-setup/

Local Institutions: -

Total Villages	193
Total Panchayats	162
Village Level	Panchayat (162)
Block Level	PanchyatSamiti (4)
District Level	ZilaParishad (1)

Source: https://gurugram.gov.in/about-district/administrative-setup/

1.4 Climate

1.4.1 Temperature

The mean daily maximum temperature is about 41° C in the months of May and June. It may go up to 45℃ or more in June. During winter the mean daily maximum temperate in January in 21 ℃ and the minimum is about 3-4℃. May and June are the hottest months and January is the coldest month.

1.4.2 Rainfall

An analysis of the rainfall over the past 50 years has been done, in order to understand the average rainfall that can be possibly received. Globally while the annual rainfall overall has been decreasing, the intensity of the rainfall has been increasing. It has therefore been increasingly important to understand the changes in the rainfall pattern. The change in rainfall pattern is crucial and essential to understand how to build resilience in order to build these structures.

The following graph (**Figure 2**) shows the historical data for annual rainfall seen for the District of Gurugram according to the District Hydrology Cell of Gurugram for the past 50 years from the year of 1970 to 2019. Through these rainfall data, the impact that external factors such as climate change may also possibly be tracked.

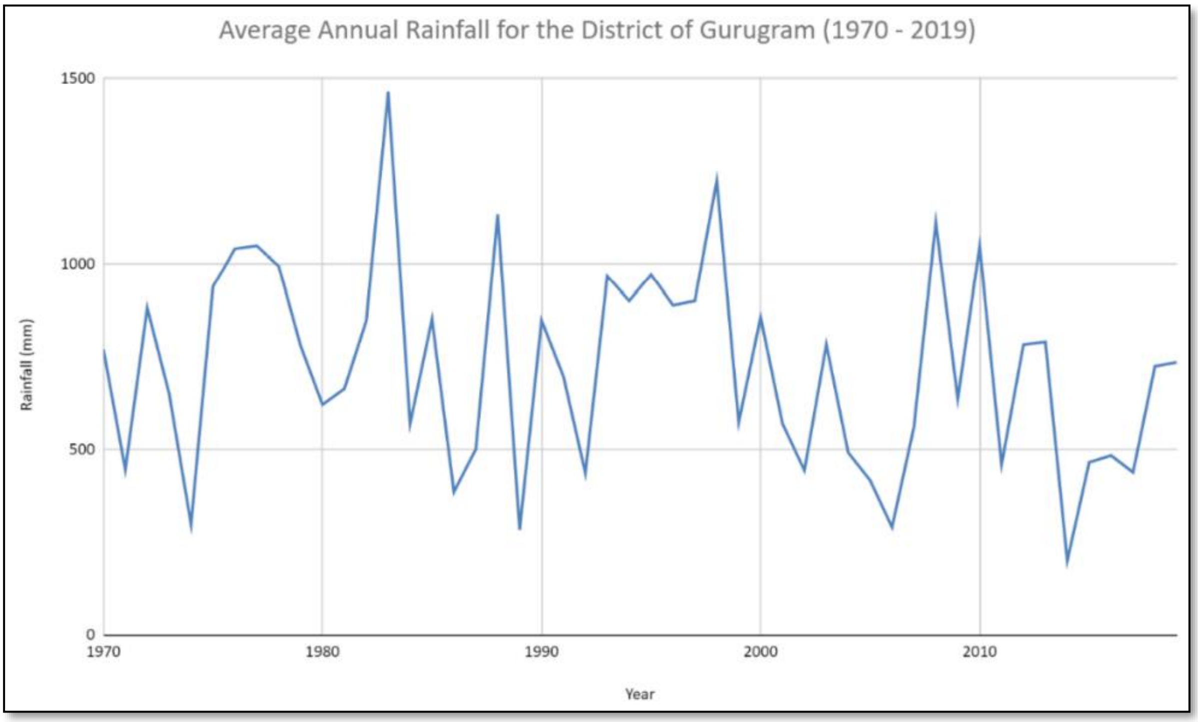


Figure 2 The variation in average annual rainfall over the past 50 years in the District of Gurugram (District Hydrology Cell)

For reference, the past five years of data of annual rainfall (in mm) that has been plotted in the above figure, has been presented in the table below (**Table 2**). The satellite derived average annual rainfall map (showing average annual rainfall from 2010 to 2020) of Gurugram district is shown in **Figure 3**. This shows little over estimation in the rainfall measurements. The annual average of rainfall ranges 438 to 859 mm (obtained both from ground and satellite observations). The amount of rainfall occurs in Gurugram shows a huge potential of rain water harvesting in the district. Since the impervious surfaces have been increasing continuously, it is again necessary to manage excess runoff water through suitable water harvesting mechanisms. The climate extremes and related risks as expected in near future again compel to make suitable mechanism for the rain water harvesting.

The Indian Meteorological Department (IMD) monitors rainfall patterns throughout the country, at a District level as well as at a State Level. For the State of Haryana, piezometers, and there are 16 piezometers in the District of Gurugram, according to the Central Groundwater Board (CGWB).

Table 2 Annual Rainfall Data obtained from District Hydrology Cell of Gurugram District

Year	2015	2016	2017	2018	2019
Annual Rainfall (mm)	465	483	438	723.5	734

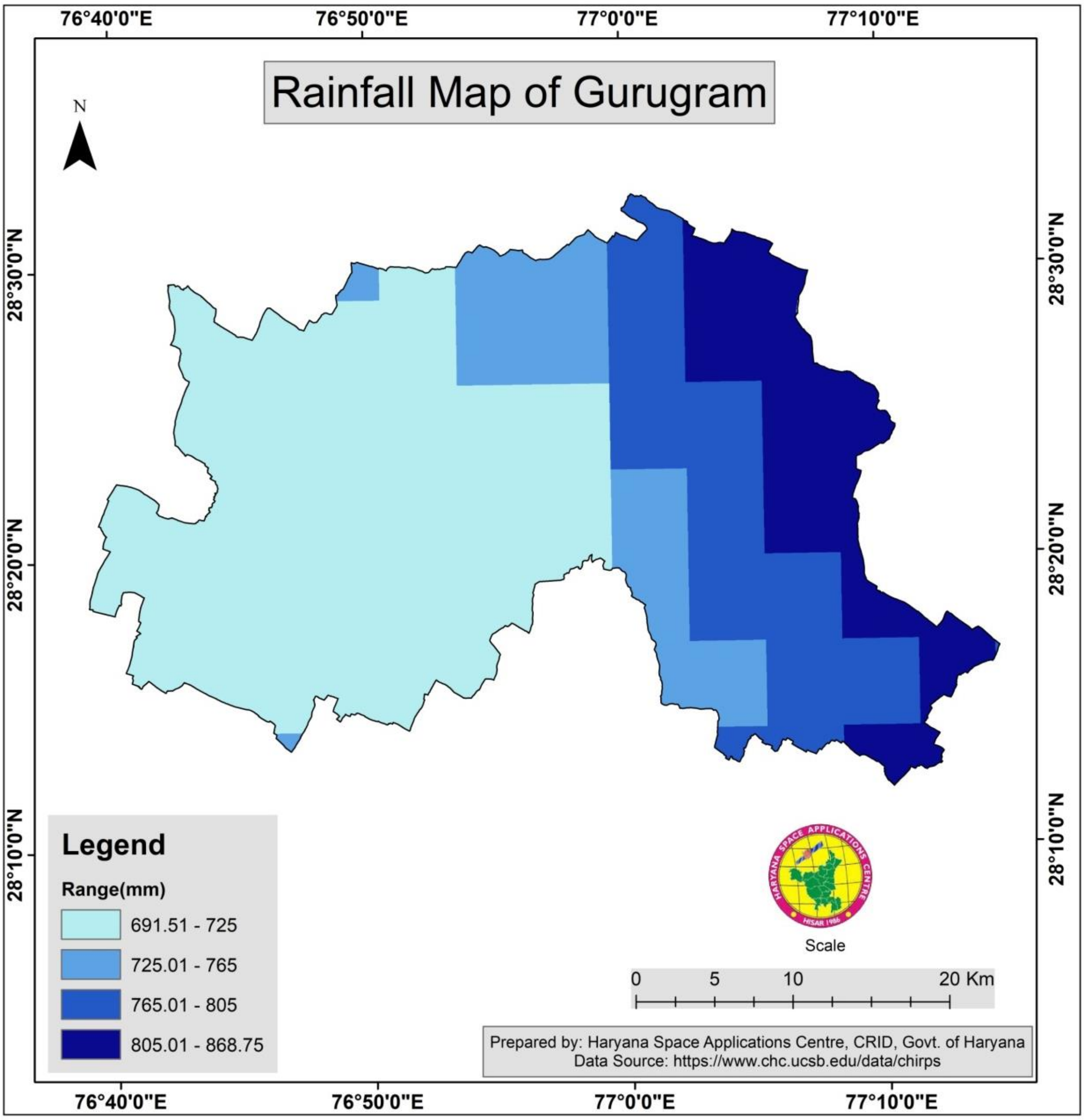


Figure 3 Rainfall Map of Gurugram District

Another database that provides the past annual rainfall data (in mm) is Customized Rainfall

Information System provided by IMD. The following **Table 3** shows the rainfall values recorded over the five years from 2016 to 2020.The green cells refer to the highest amount of rainfall experienced in the respective years. The following graph shows the variation of rainfall for the past five years for the District of Gurugram

Table 3 The rainfall (in mm) recorded over the five years (CRIS, 2020)

Months	**Year**				
	2016	**2017**	**2018**	**2019**	**2020**
January	0	28.8	1.6	17	14.9
February	0	0	0	11.9	1.3
March	16.2	2.4	0	7.1	41.8
April	0.5	2.8	4.8	7.7	3.3
May	17.6	15.8	3.4	20.4	19
June	38.8	97.3	64.9	4.6	34
July	186.8	61.2	118.3	148.2	150
August	138	33.4	116	97.3	292.3
September	35.7	65	112.2	34.6	31.3
October	15.4	0	0	8.8	0
November	0	0	4.3	1	0.8
December	0	1.3	0.3	19.8	0
Total	**449**	**308**	**425.8**	**378.4**	**588.7**

1.5 Elevation and Topography

The height above mean sea level of the district as shown by Digital Elevation Model ranges from 190 to 294 m (**Figure 4**). The district comprises of hills on the one hand and depressions on the other, forming irregular and diverse nature of topography. Two ridges i.e., Firozpur Jhirka-Delhi ridge forms the western boundary and Delhi ridge forms the eastern boundary of the district. These hills are northern continuation of Aravalli hills. The north-western part of the district is covered with sand dunes lying in the westerly direction due to south-western winds. Slope ranges from flat to >35 degree (**Figure 5**). Most of the area of Faruk Nagar and Pataudi is flat to less sloppy. Contours of 5 meters interval showed similar topography as in digital elevation model (**Figure 6**). Southern part of Sohna bock is also flat and slop is meeting in Yamuna River.

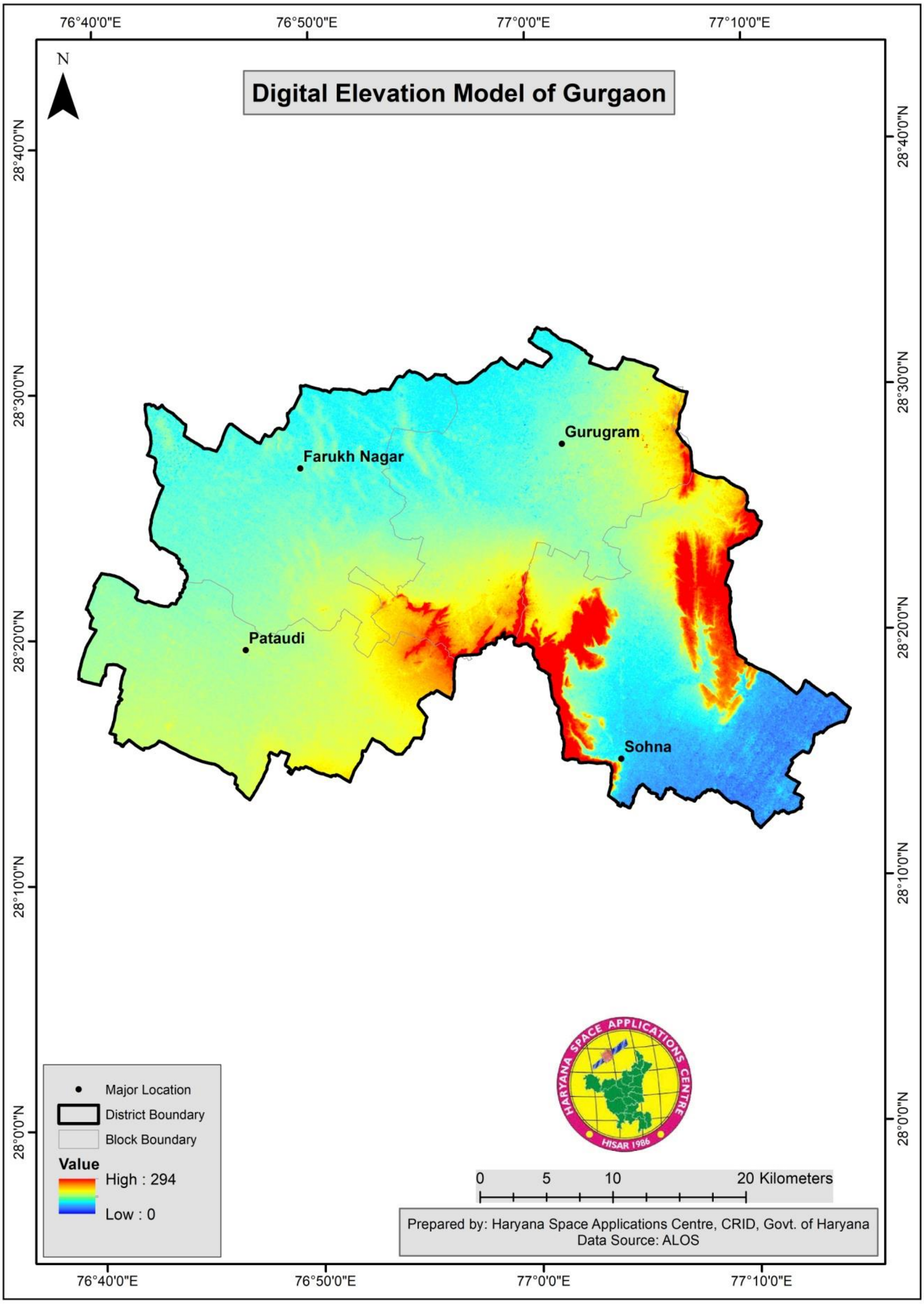


Figure 4 Digital Elevation Model of Gurugram District

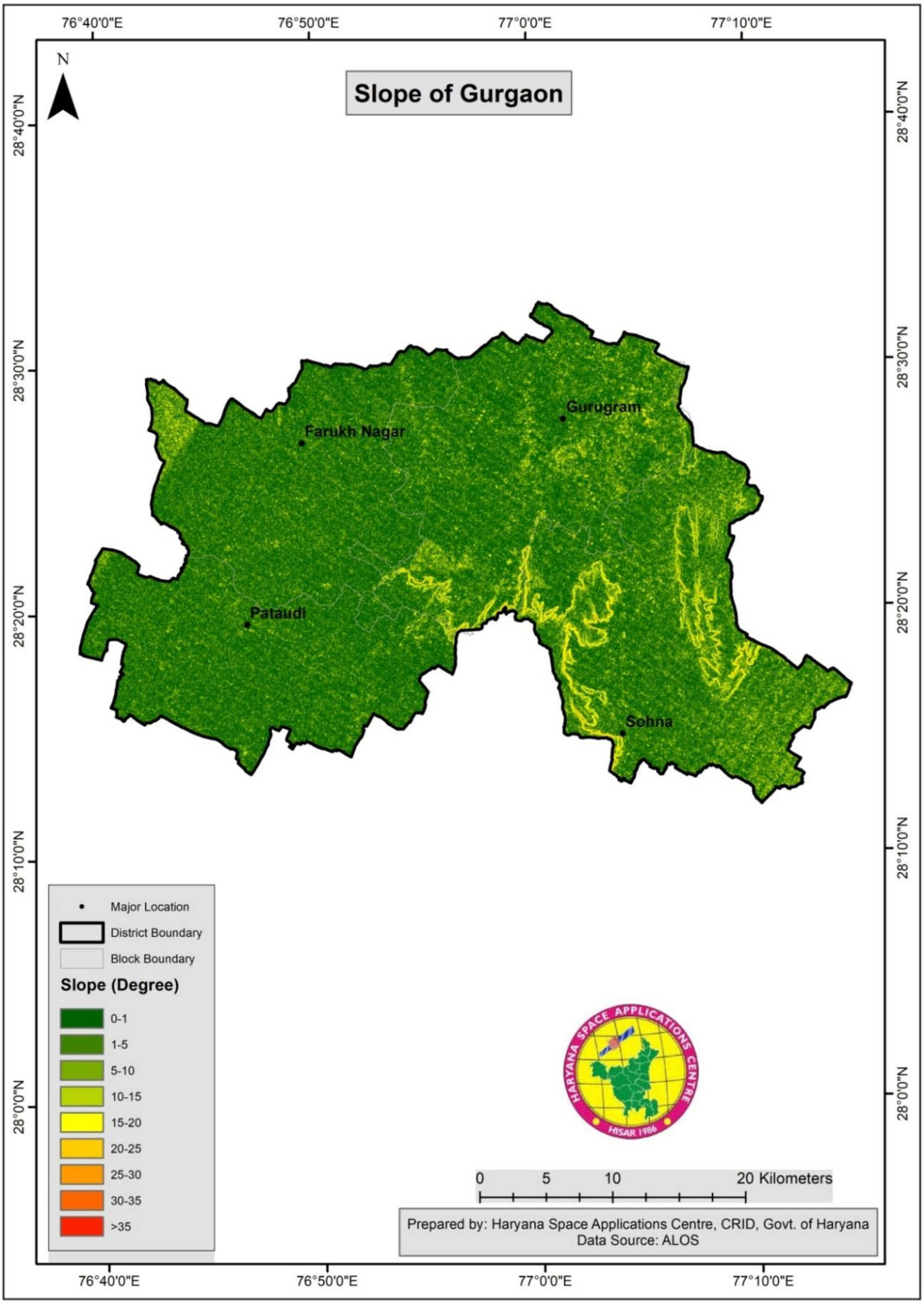


Figure 5 Slope Map of Gurugram District

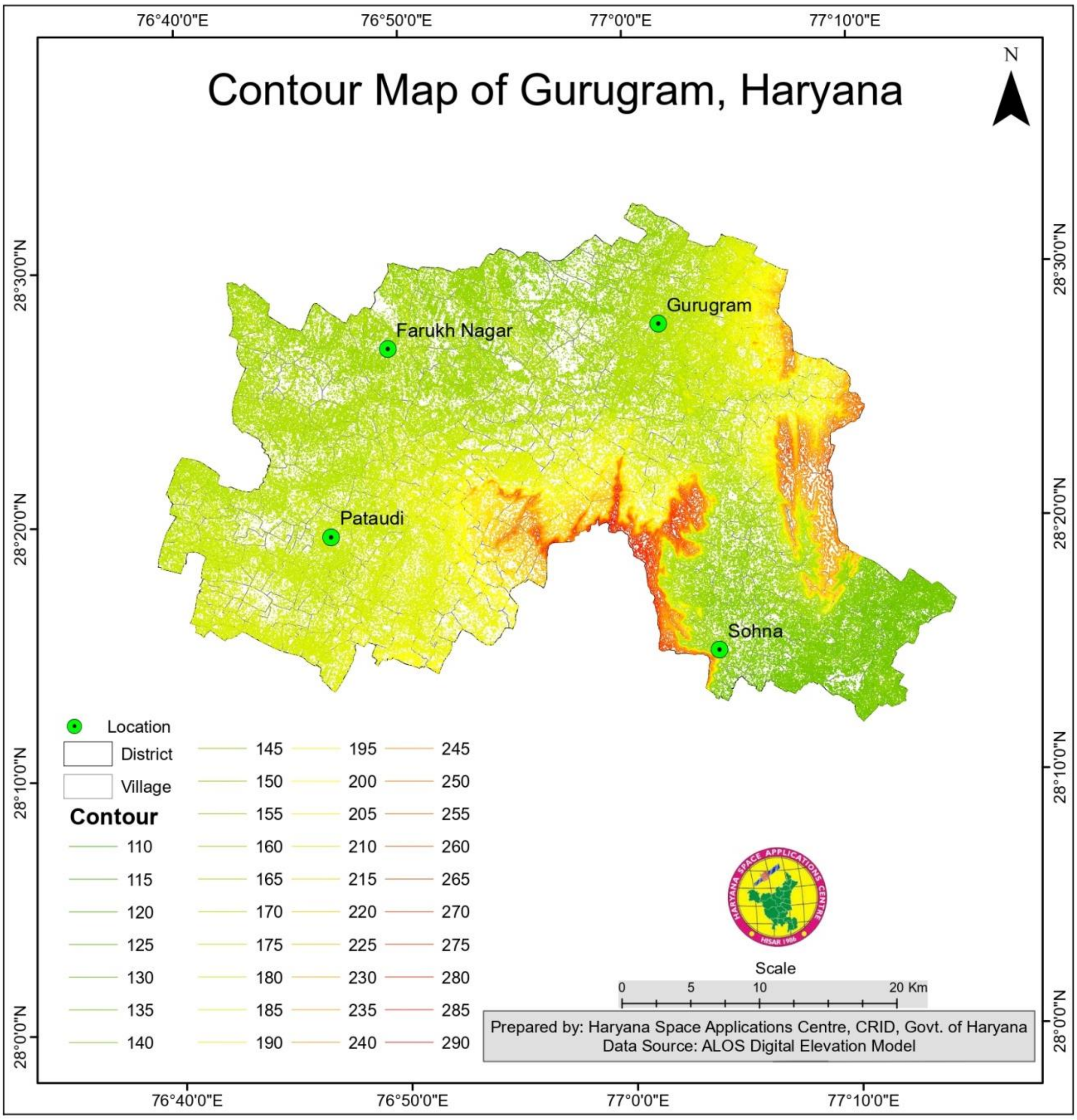


Figure 6 Contour Map of Gurugram District

1.5.1 Geology and Lithology

The area is conspicuously flat topography; however, in the north-eastern part small isolated hillocks of Precambrian rocks are exposed (**Figure 7**). The alluvial plain is formed by the Sahibi River which is tributary of River Yamuna. Soils of the Gurugram district are classified as tropical and brown soils, existing in the north western extreme, northern and north eastern parts of the district and water logged and salt affected soils in the southern parts of the district.

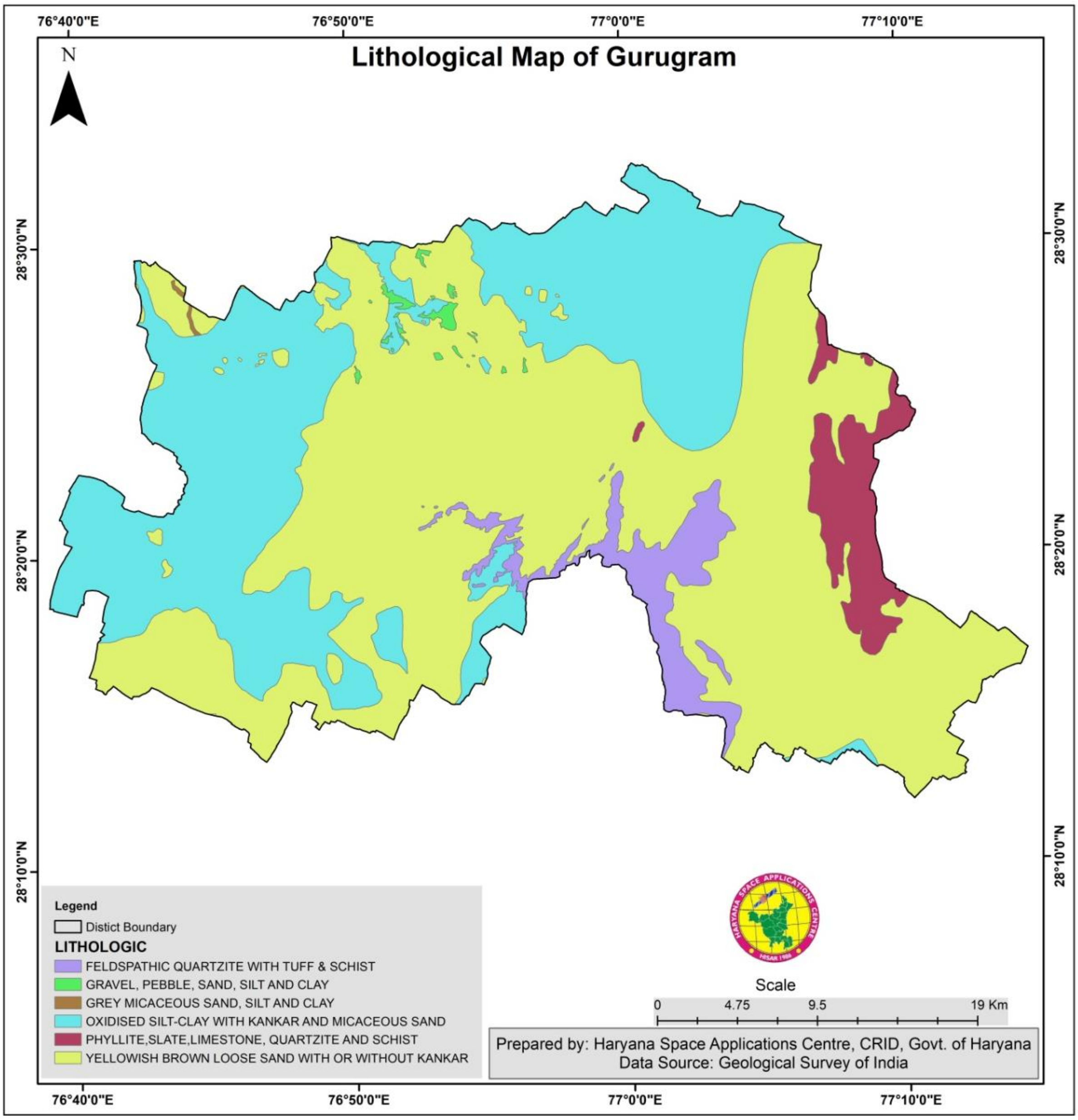


Figure 7 Lithological Map of Gurugram District

1.5.2 Soil Profile

The soils are medium textured loamy sand is the average texture in Gurugram and Sohna blocks. In Pataudi and Sohna blocks the organic content of soils is lowest, just up to 0.20 per cent (very low category). In the rest of the district, organic contents are 0.2 to 0.40 percent and falls in low category. Gurugram is loamy sand soil which covers 101 thousand Ha constituting around 84.2 % of total geographical area. The alluvium in the area comprises silt, sand, gravel, clay and kankar (**Figure 8**). The general profile of soil health of Haryana state is shown in **Figure 9**.

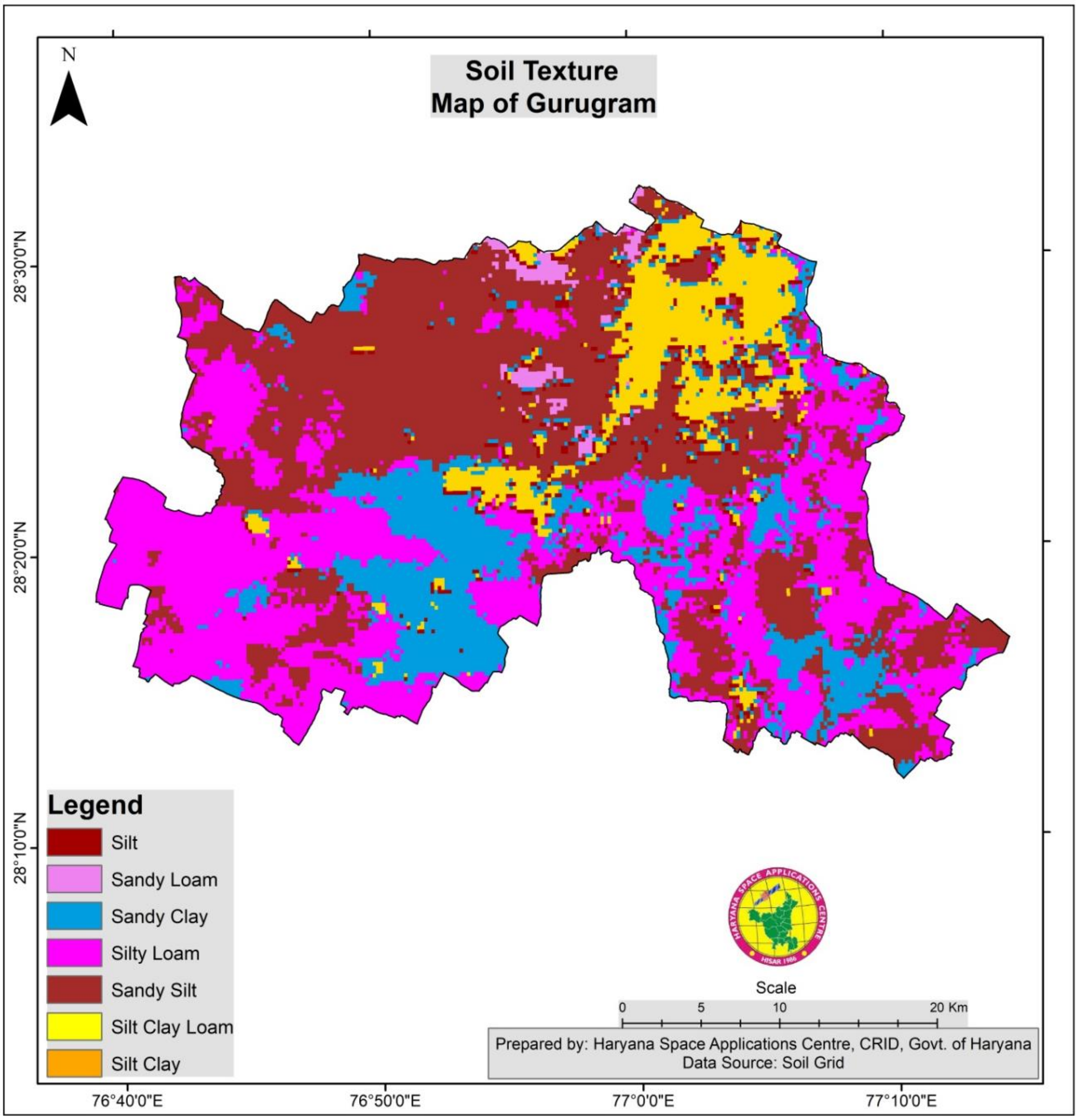
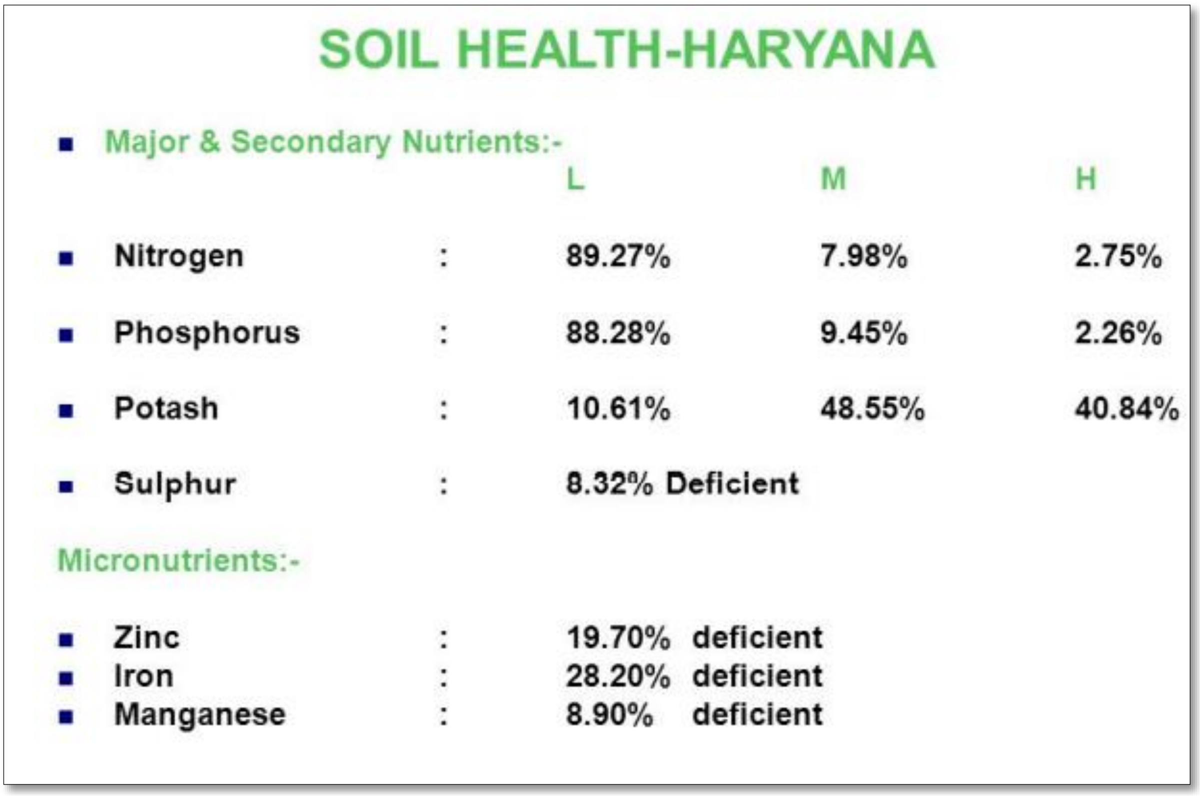


Figure 8 Soil texture map of Gurugram District

Sand Dunes:

Strong winds carry sand and silt, forming dunes, from adjacent Rajasthan to this area with the prevailing wind conditions. These sand dunes are seen in the whole of the area but are more conspicuous in the area between Pataudi, Faruk Nagar, and Garhi Harsru and attain heights of 3-6m in general. The dune sand is generally well sorted, found fine to medium grained and comprises quartz, ferromagnesian minerals, tiny flakes of mica with small particles of kankar. The sand is loose and dunes keep shifting their positions depending upon the prevailing wind condition.



SOIL HEALTH-HARYANA

Major & Secondary Nutrients:-

		L	M	H
Nitrogen	:	89.27%	7.98%	2.75%
Phosphorus	:	88.28%	9.45%	2.26%
Potash	:	10.61%	48.55%	40.84%
Sulphur	:	8.32% Deficient		

Micronutrients:-

Zinc	:	19.70% deficient
Iron	:	28.20% deficient
Manganese	:	8.90% deficient

Figure 9 General Soil health profile of Haryana

1.6 Landuse

The Gurugram city had a total built-up area of 380.29 sq km and 546.23 sq km area under agriculture, vegetation 104.79 sq km, Barren 213.48 sq km and water body 13.21 sq km. Research suggests a projected change in the land use pattern, with an increase in the built-up area by 30 % in 2031 and 60.43 % by 2051. On the other hand, the agriculture area will witness a decline of 10.18% in 2031 and a whopping 48.78 % in 2051 (Misra et al., 2018). The city should be made resilient to tackle the challenges posed to water supply by this drastic scale of fast-paced urbanization and population growth. The land use land cover map of Gurugram District is shown in **Figure 10**. The graph shown in **Figure 11** depicts the land use/ land cover area of Gurugram district in the year 2017.

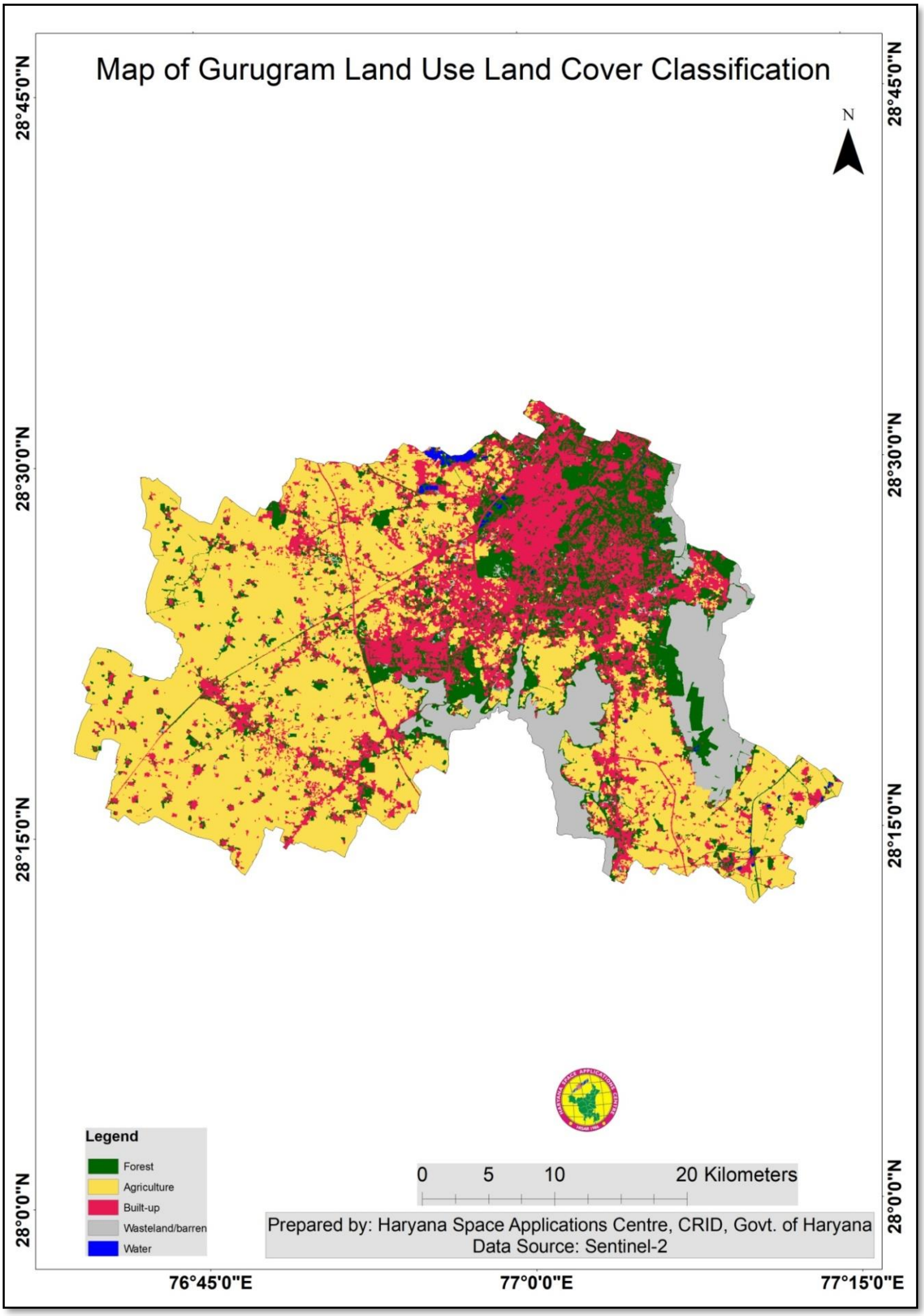


Figure 10 Landuse and Landcover of Gurugram District

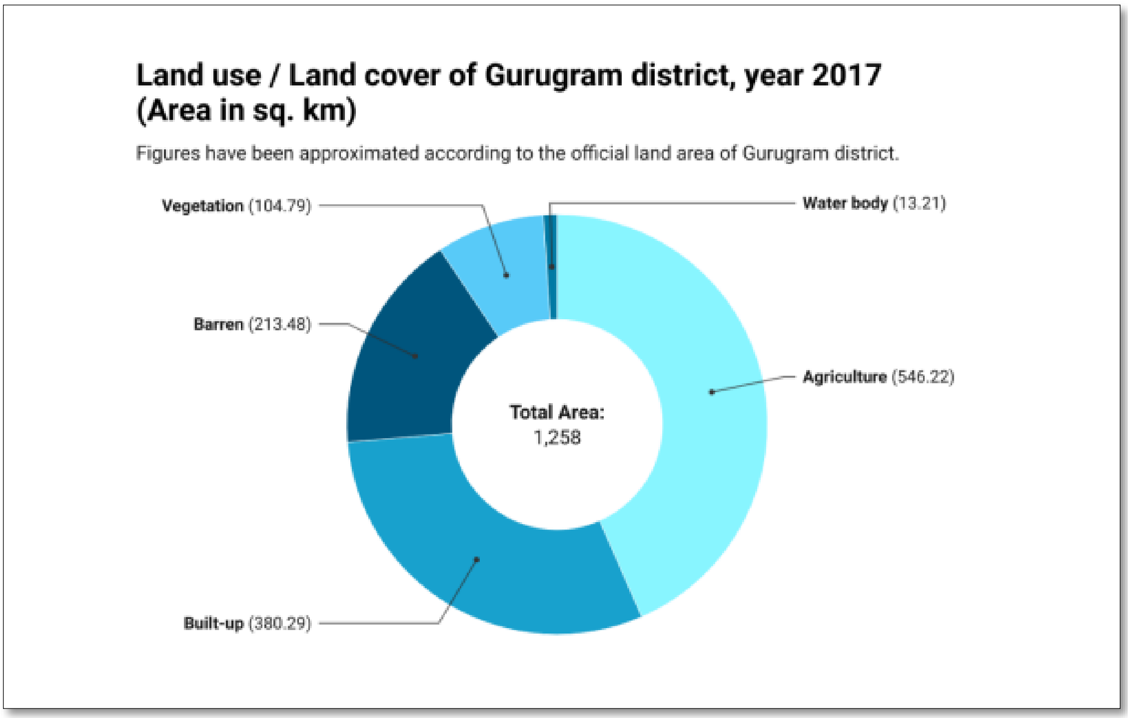


Figure 11 Landuse pattern of Gurugram District
(International Journal of recent technology and Engineering)

2 District Water Profile

2.1 Sources of Water

Gurugram fulfill its water requirement by natural and manmade modes like canal, Ponds, treatment plants, extraction of groundwater by tube-wells, water harvesting structures, rainfall water harvested from rooftop and many more. The current sources of water in Haryana are described in forthcoming sections.

2.1.1 Canals

Gurugram gets its water from the Yamuna River's Tajewala head works near Yamunanagar. The water comes through the WYC near Sonepat and then through the 70-km Gurugram Water Supply (GWS) Canal from Kakroi village to Basai in Gurugram. It is designed to carry almost 245 MLD (0.010208333 MCM) of water at the head at Kakroi village. About 50 per cent is lost while in transit through evaporation and diversion to villages and a township enroute. However, the canal meets just 30 per cent of the city's water needs, says R S Rathee, president of the Qutub Enclave Residents' Welfare Association of DLF, which has been part of protests against rampant extraction of groundwater by about 265 construction projects across the city.

2.1.2 Ponds

A **pond** is a body of standing water, either natural or man-made, that is usually smaller than a lake (**Figure 12**).

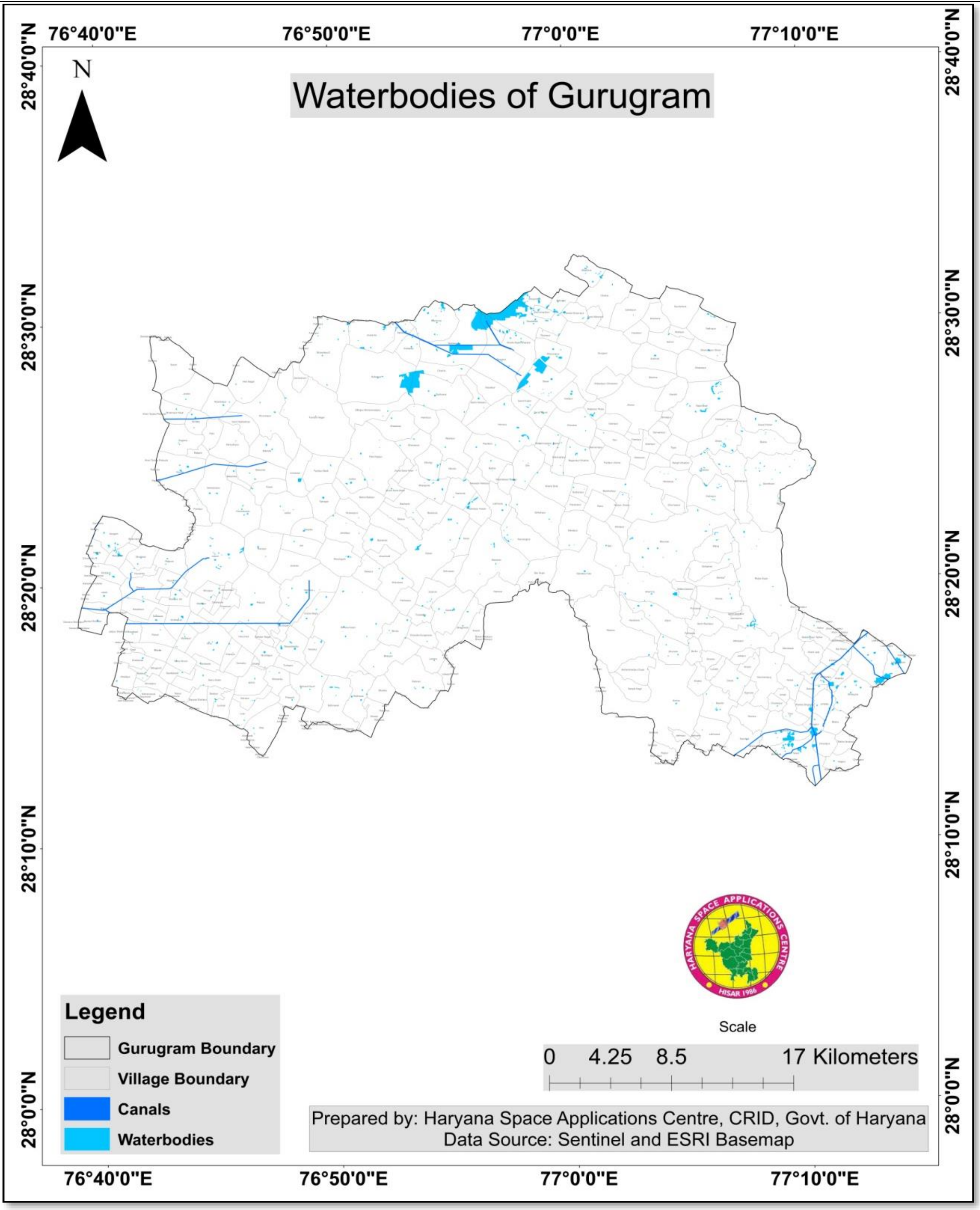


Figure 12 Water bodies of Gurugram District

They may arise naturally in floodplains as part of a river system, or they may be somewhat isolated depressions (examples include vernal pools and prairie potholes). Usually, they contain shallow water with marsh and aquatic plants and animals. A wide variety of man-made bodies of water are classified as ponds. Some ponds are created specifically for habitat restoration, including water treatment. Others, like water gardens, water features and koi ponds are designed for aesthetic ornamentation as landscape or architectural. In Gurugram district total 776 ponds/waterbodies found on satellite data. The map of total ponds/waterbodies that include ponds, canals are shown in **Figure 12.**

2.1.3 Drain

Natural drainage means a drainage consisting of native soils such as a natural swale or topographic depression, which gathers or conveys run-off to a permanent or intermittent watercourse or waterbody. During rain or irrigation, the fields become wet. The water infiltrates into the soil and is stored in its pores. When all the pores are filled with water, the soil is said to be saturated and no more water can be absorbed; when rain or irrigation continues, pools may form on the soil surface. Surface drainage is the removal of excess water from the surface of the land. Shallow ditches, also called open drains, normally accomplish this. The shallow ditches discharge into larger and deeper collector drains. In order to facilitate the flow of excess water toward the drains DEM is very important. The drainage map of Gurugram District is shown in **Figure 13.** The statistics of length of drainages under each order are shown in **Table 4**.

Table 4 Drainage order and total length of the drains in Gurugram district

Sr. No.	**Order of Drainage**	**Total Length (in meter)**
1	1st Order	1174503.88
2	2nd Order	644853.84
3	3rd Order	302985.68
4	4th Order	234460.30
5	5th Order	63700.69
6	6th Order	42087.89
7	7th Order	4937.92

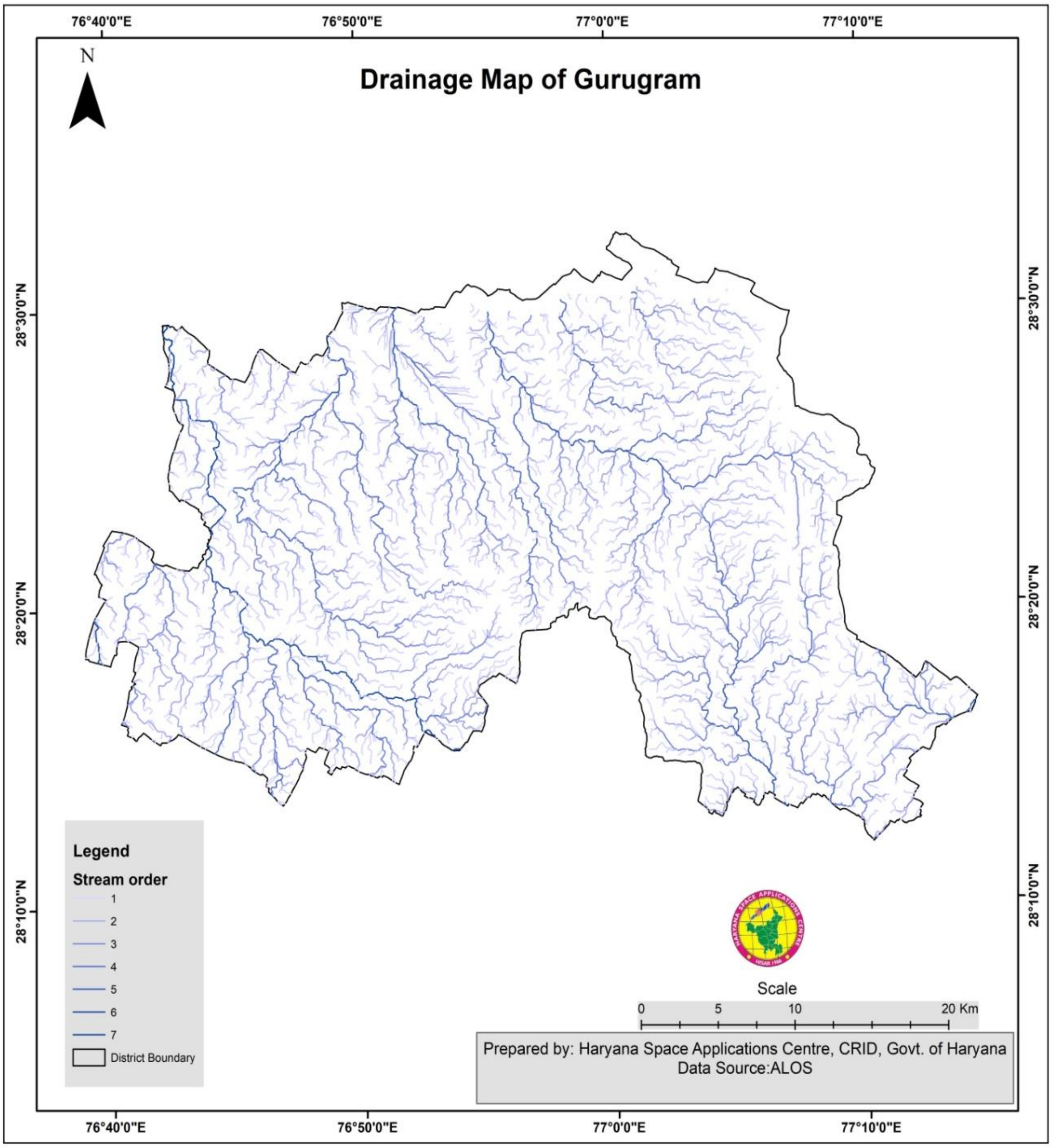


Figure 13 Drainage Map of Gurugram District

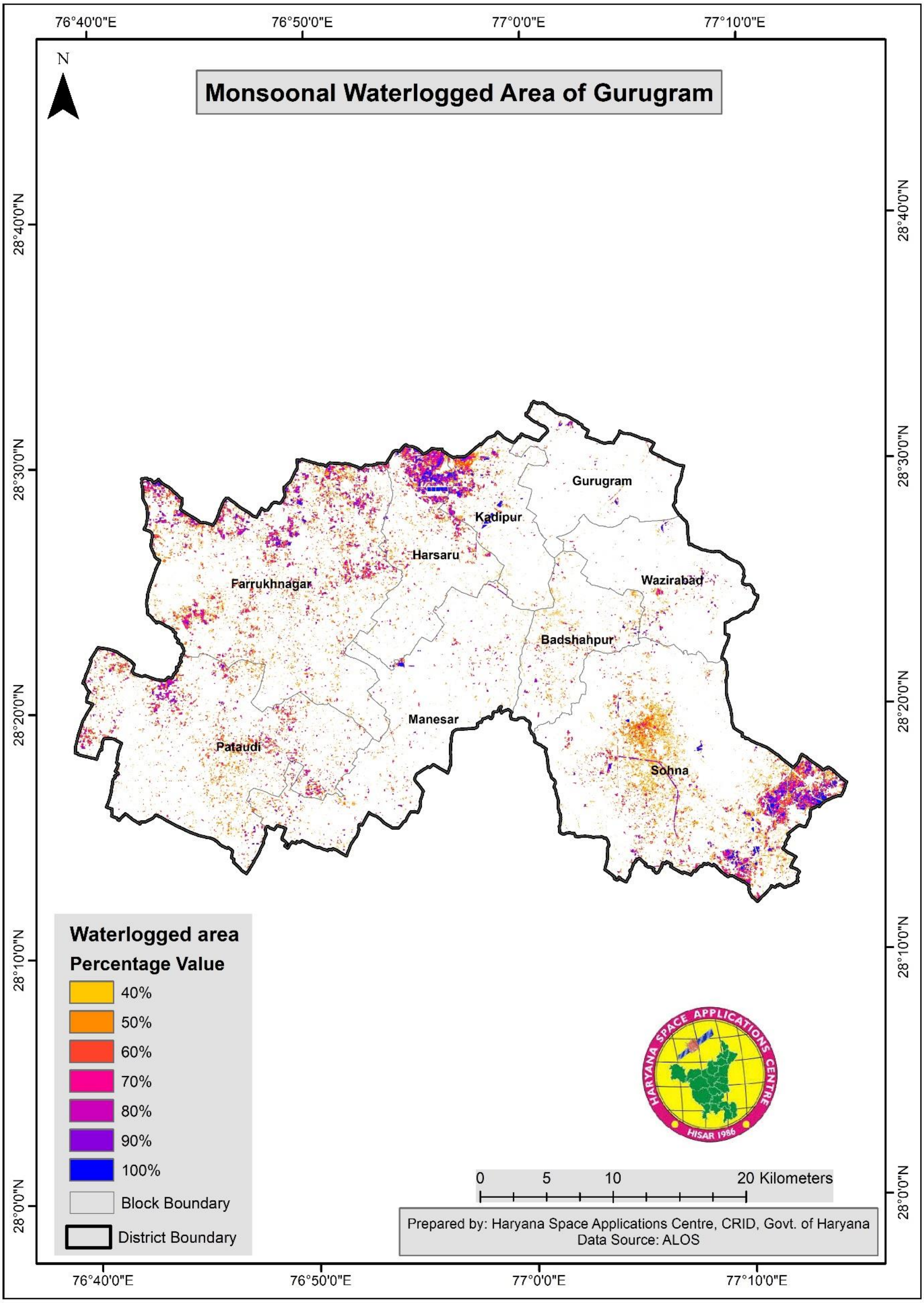


Figure 14 Monsoon waterlogged area of the district

2.2Water Harvesting System

A rainwater harvesting system comprises components of various stages - transporting rainwater through pipes or drains, filtration, and storage in tanks for reuse or recharge. Water harvesting profile of Gurugram district is shown as followed.

2.2.1 Roof Top Harvesting

There are a number of different ways to harvest rain water. But the one most essential thing that is common in all of the available water conservation techniques is to utilize natural rainwater to supplement the daily life's water consumption. People in the city are becoming all the more conscious day by day in implementing the best possible water conservation techniques. The major benefits of harvesting natural rainfall that the water can be harvested on a small-scale basis, such as on a bungalow or in housing societies, and it can also be done on a large-scale basis, such as at industrial level.

Many commercial premises have incorporated rainwater harvesting system in their building. And slowly, a lot of housing societies are also incorporating this technique. Harvesting rainwater involves the installation of a very simple technology that can be used by both commercial as well as residential places to make a tiny difference for a good cause.

In general, there are three main types of rainwater harvesting systems, which include direct pump, indirect pump and indirect gravity. Mentioned below (**Table 5**) is some of the most popular rain water harvesting techniques:

Rooftop Rain Water Harvesting is the technique through which rain water is captured from the roof catchments and stored in reservoirs. Harvested rain water can be stored in sub-surface ground water reservoir by adopting artificial recharge techniques to meet the household needs through storage in tanks. The Main Objective of rooftop rain water harvesting is to make water available for future use. Capturing and storing rain water for use is particularly important in dryland, hilly, urban and coastal areas.

Table 5 Water Harvesting System in Gurugram District

Sr.NO.	**Activity Name**	**Works Completed**	**Works Ongoing**	**Expenditure (in Lakhs)**
Water Conservation and Rain Water Harvesting				
1	Check Dam		0	
2	Pond / Tank		0	
3	Trench	0	0	

4	Rooftop Water Harvesting Structure (Public)	218	0	
5	Rooftop Water Harvesting Structure (Private)	0		
6	Other Rainwater Recharge Structures (Open Well Recharge, Sand Filter for open well recharge)		36	
7	Other Water Conservation Structures (Bench Terracing, Canal)		0	
Total			**36**	**1**
Renovation of Traditional and other Water Bodies / Tanks				
1	Traditional Water Bodies Restored	22	5	
Total		**22**	**5**	**12**
Reuse and Recharge Structures				
1	Soak Pit	716	0	
2	Stabilization Pond	1	0	
3	Other Reuse / Recharge Structure	8	0	
Total		**725**	**0**	**5**
Watershed Development				
1	Gully Plug	1	0	
2	Percolation Tank		0	
3	Staggered Trenches	0	0	
4	Other Watershed Construction Activities	33	16	
Total			**16**	**107**
Intensive Afforestation				
1	Intensive Afforestation-Nurseries	214500	0	
2	Intensive Afforestation- Plantation		10	
Total			**10**	**34**
Awareness Programs by KVK				
1	Farmer's training programs by KVKs on Water Use Efficiency and Appropriate Crops	183		

2	Distribution of one packet of vegetable seeds and saplings of five nutritious plants to farmers			
3	Awareness Programs/ KisanMela on the theme Valuing Water	141		
Total		**324**		
Waste Water Treatment				
1	Use of Treated Waste Water	53505		
Total		**53505**		

2.2.2 Water Harvesting System other than Roof Top

The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be a terrace, courtyard, or paved or unpaved open ground. The terrace may be a flat RCC/stone roof or sloping roof. Therefore, the catchment is the area, which actually contributes rainwater to the harvesting system. Rainwater from the rooftop should be carried through down to take water pipes or drains to the storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) of the required capacity. The total no of activities achieved in Gurugram District for rain water harvesting is shown in **Table 6** at rural and urban area. The map of water conservation activity in Gurugram at rural and urban level is shown in **Figure 14**.

Table 6 Water Harvesting activities in Rural area and Urban Area

In Rural Area		
Sr. No	**Block Name**	**Total No of Activity (no.)**
1	Gurugram	43
2	Pataudi	309
3	Sohna	159
4	Farrukh Nagar	0
In Urban Area		
1	Gurugram	8

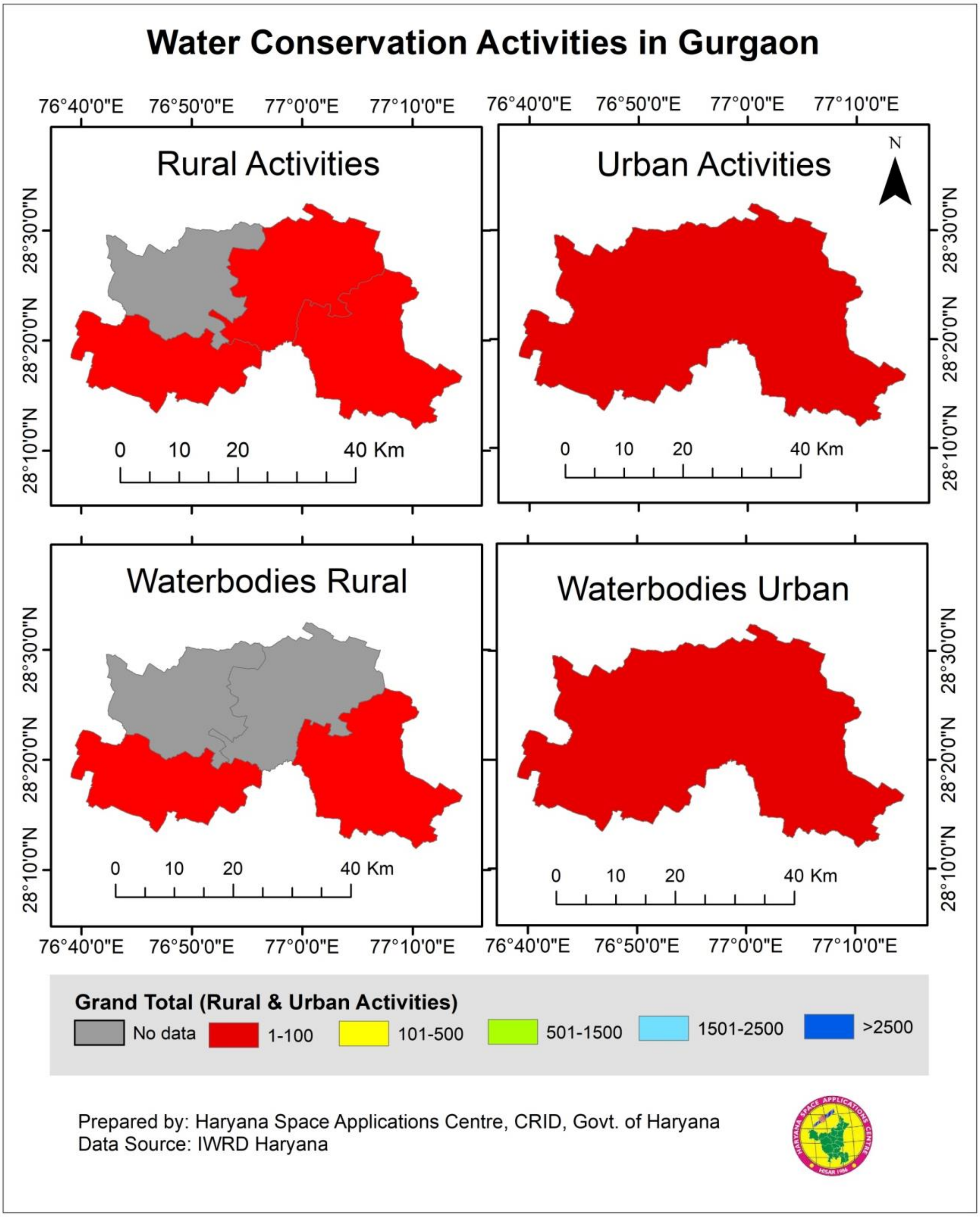


Figure 15 Water Conservation Activity in Gurugram District

2.2.3 Sewerage Treatment Plants

Sewage from every residential colony, hotel, or corporate office collected in the sewage collection system. The purpose of a sewage treatment plants (STPs) is to thoroughly treat wastewater. The sewerage treatment plant map is shown in **Figure No 15**. In Gurugram District a total of 7 treatment plant are installed having total capacity of approx. 300-400 MLD. In Gurugram District there is one major biomedical waste management site in Sohna Block.

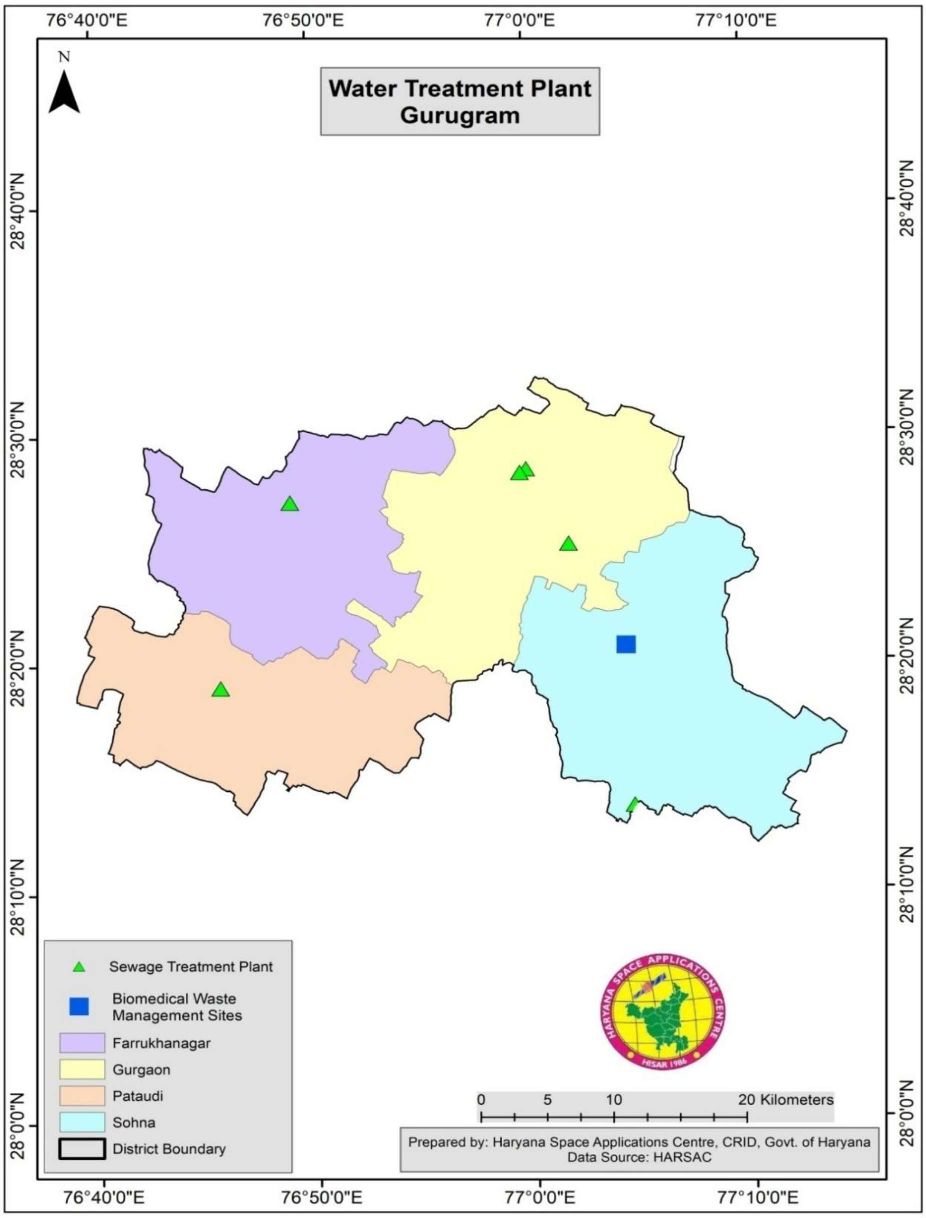


Figure 16 Water Treatment Plant Map of Gurugram District

3 Irrigation Profile

Irrigation is the agricultural process of applying controlled amounts of water to land to assist in the production of crops as well as to grow landscape plants and lawns, where it may be known as watering. Agriculture that does not use irrigation but instead relies only on direct rainfall is referred to as rain-fed. Irrigation helps to grow agricultural crops, maintain landscapes, and create greening over disturbed soils in dry areas and during periods of less than average rainfall. Irrigation also has other uses in crop production, including frost protection, suppressing weed growth in grain fields and preventing soil consolidation. Unmanaged and unplanned irrigation requirements due to various reasons costs water availability and affect the water resources drastically. This a managed plan for improving irrigation profile of the district is required. Irrigation based classification for Gurugram may be based on water availability and described below.

If the condition is "Delayed/ limited release of water in canals due to low rainfall" measures like Change in crop/cropping system, Agronomic measures etc. is required. For Sandy soils/sandy loam soils irrigated with canal Pearl millet + Moong- Raya is suggested in place of Pearl millet/Wheat. For Well drained, medium alluvial soils, canal irrigated conditions, Cotton-Wheat is suggested. For Clay soils, canal irrigated condition, Summer Moong-Rice is suggested in place of Rice-Wheat cropping pattern and Vegetables/ flowers in place of Sorghum fodder- Wheat. Similarly, for a major condition "Non release of water in canals under delayed onset of monsoon in catchment" where the dominance of Sandy soils, and canal tubewell irrigated system is present the Pulses-Raya is suggested in place of Pearl millet-Raya. For the similar major condition where well drained, medium alluvial soils, canal irrigated system is present the Cotton-Wheat is suggested in place of Cluster bean-Barley.

Similar measures in of crop pattern changes, agronomic measures etc. are required for condition like "Lack of inflows into tanks due to insufficient /delayed onset of monsoon", and "Insufficient groundwater recharge due to low rainfall". For unusual rainfall the suggested contingency measures would be different for Vegetative stage, Flowering stage, Crop maturity stage, and post-harvesting stage. Continuous high rainfall in a short span leading to water logging, where the crops like Rice and Cotton are grown after suitable conditions arrived. Drainage of excess water from these areas is suggested specially if the depth of standing water is > 5-6 cm in vegetation stages, flowering stage and fruiting stage. The Shifting the produce to dry place is suggested during the post-harvest stage.

4 Water Availability

4.1 Surface Water Availability

From the description of surface and ground water sources discussed in previous sections above, we summarize below, the direct source water availability at present in the Gurugram districts of Haryana sub-region. **Table 7** shows the type of water resources available in Gurugram District.

Table 7 Type of water resources available in Gurugram District

Sr. No.	Source of water	Quantity in MLD						
		2019	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**
1	Canal Based	400	420	462	508	558	615	676
2	TW installed by MCG @200 LPM	58	53	50	45	40	38	36
3	TW installed by private agencies/ persons	60	55	50	45	40	38	36
	Total water supply (1+2+3)	518	528	562	598	638	691	748
4	Sewerage generated (80% of w/s)	414	422.5	449	478	510	553	598
5	Waste water treated by colonizers and put to reuse (Haryana Govt. Notification dt 5.11.2019)	35	40	55	70	80	90	100
6	Net sewage to be treated at STPs	379	382.5	394	408	430	463	498
7	Present treatment capacity of STPs	388	388	394				
	68 MLD Dhanwapur	68	68	68				
	100 MLD Dhanwapur	100	100	100				
	50 MLD Dhanwapur	50	50	50				
	120 MLD Behrampur	120	120	120				
	50 MLD Behrampur	50	50	50				
	Decentralized STPs			6				
8	Sewage being received & treated at STPs	282	310	325				
	68 MLD Dhanwapur	54	65	65				

	100 MLD Dhanwapur	75	85	90				
	50 MLD Dhanwapur	43	45	45				
	120 MLD Behrampur	90	90	90				
	50 MLD Behrampur	20	25	30				
	Decentralized STPs			5				
9	Balance capacity available at STPs	106	78	69				
10	Untreated sewage flowing in drains	108.6	47.70	33.00	0	0	0	0
	Leg-I	8.6	10	10				
	Leg-II	25	8.5	2.5				
	Leg-III	75	29.2	20.50				
11	Proposal for construction of STPs							
A	Standalone STP under construction	0	6	5	0	0	0	0
B	STP at jahajgarh	0	0	20	0	0	0	0
C	Dhanwapur	0	0	0	100	0	0	0
D	CETP at Sector 34	0	0	0	20	0	0	0
E	CETP at Sector 37	0	0	0	9	0	0	0
F	CETP at Sector 18	0	0	0	1.5	0	0	0
G	CETP at IDC Sector 14	0	0	0	0.75	0	0	0
H	50 MLD STP at Behrampur	0	0	0	0	0	0	0
	Total Capacity	388*	394	419	550.25	550.25	550.25	550.25

Source: GMDA Gurugram

4.2 Ground Water Availability

In general, the water table contours follow the surface topography. The altitude of water table ranges between 176.78 to 274.85 m amsl. In north and western parts of the district, the water table slopes north and north-west of the area whereas in southern part water table slopes toward southeastern direction with an average hydraulic gradient of 1.5 m/km. Ground Water Resources estimation of the district was done in 2009 for Gurugram district. Perusal of the Estimates reveals overall stage of ground water development in the block is of the order of 232 % which has exceeded the replenishable recharge and thus the district has been categorized as over exploited. Net annual ground water availability of the district is 23261 ham and existing gross ground water draft for all users is 53927 ha

m. The following map (**Figure 16**) depicts the ground water depth in Gurugram district and the **Table No 8** gives the description of ground water resource and development potential of Gurugram District.

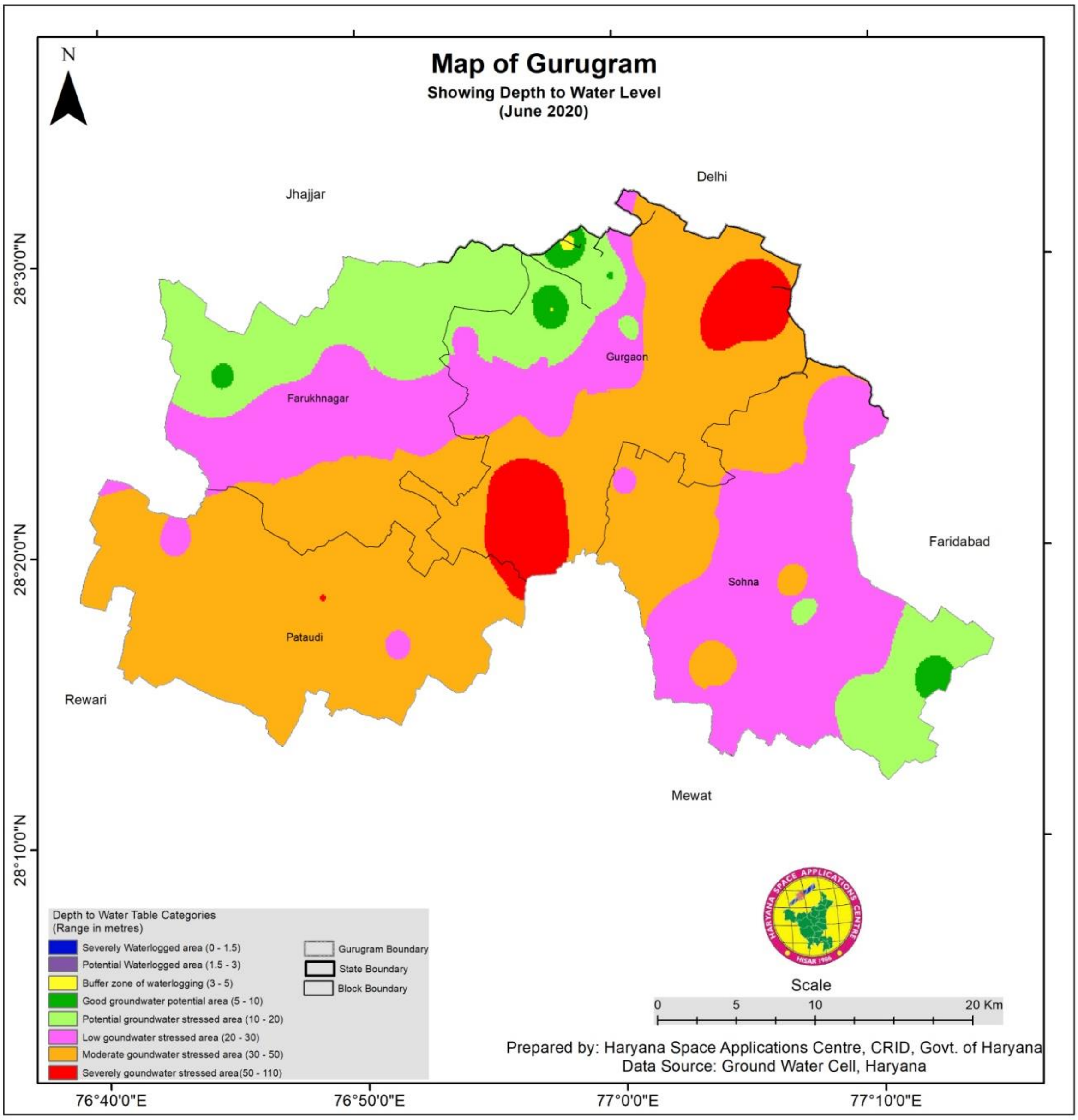


Figure 17 Ground water Availability Map of Gurugram District

Table 8 The Ground water resource and development potential of Gurugram district as on 31st march, 2009 in ham

District Name	Assessment Unit/Block	Net Ground Water Availability (Ha m)	Existing Gross Ground Water Draft for irrigation (ham)	Existing Gross Ground Water Draft for domestic and industrial water supply (ham)	Existing Gross Ground Water Draft for all uses	Allocation for domestic and industrial requirement supply up to next 25 years (ham)	Net ground water availability for future irrigation development(ham)	Stage of ground water development %
Gurugram	F Nagar	3649	8053	177	8230	177	-4581	276
	Gurugram	7585	6254	17128	23382	17128	-15797	308
	Pataudi	7495	11455	438	11893	438	-4398	159
	Sohna	4532	10015	407	10422	407	-5890	230
	Total	23261	35777	18150	53927	18150	-30666	232

4.2.1 Ground Water Quality

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock. It is stored in and moves slowly through geologic formations of soil, sand and rocks called aquifers. Ground water quality index determines the purity of water. Higher the values on index represent the more turbid water which cannot be used for drinking purpose. In contrast to those lower values on quality index represent the purity of water and are suitable for drinking purpose. According to (http://www.sarasota.wateratlas.usf.edu/library/learn-more/learnmore.aspx?toolsection=lm_wqi) water quality range from 0-45 is good, 45-60 is fair and >60 is very poor quality of water. So, based on that Gurugram district's water quality varies from good to poor (**Figure 17**) for the whole district. Whereas block wise water quality index value is shown in **Table 9**.

Table 9 Block wise average water quality index value in Gurugram District

Block Name	Average Water Quality Index Value
Farrukh Nagar	173.44
Gurgaon	97.61
Pataudi	144.12
Sohna	115.62

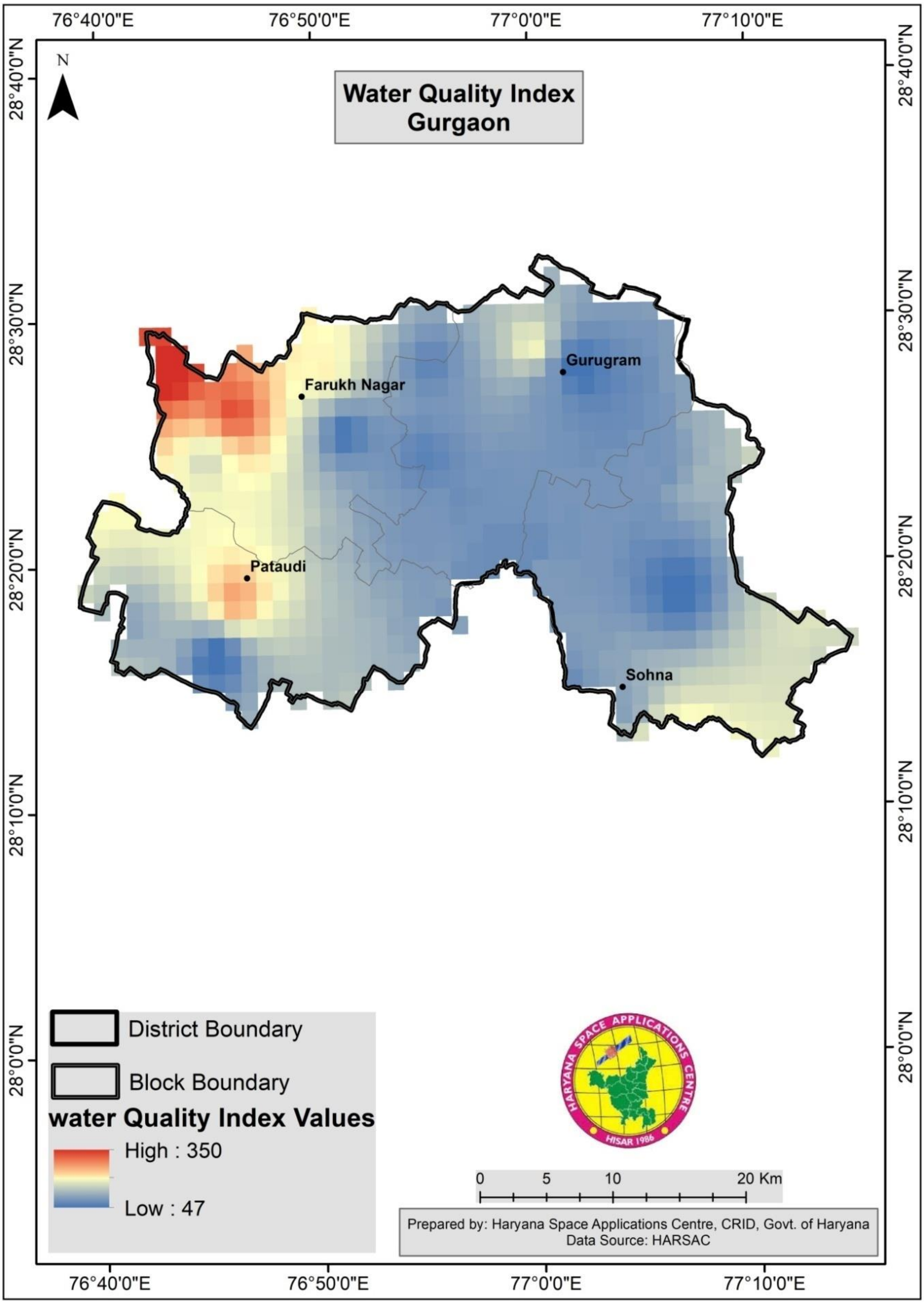


Figure 18 Water quality index of Gurugram District

5 Aquifer System

The major part of Gurugram district is underlain by Quaternary alluvium consisting of sand, clay and silt. The quartzite ridge trending NNE-SSW is located about 7 km east of town in which ground water occurs in fractures, joints and cervices. Sandy layers at various depth form major water bearing horizons above the crystalline basement.

Ground water in the Gurugram block occurs in unconfined and semi-confined condition. The upper zone of saturation consists of fine sand with silt varying from place to place. In Udyog vihar and city area the depth of first aquifer varies from 34 to 43 mbgl. However, in industrial area of Manesar top most aquifer can be encountered at 20m. The thickness of sandy layer is very limited. The drawdown is generally high indicating absence of highly potential ground water bearing aquifers. Tubewells in the depth range of 45 to 90 m bgl have been installed by different agencies in the block. The yield of these tubewells varies in different areas ranging within 129 to 606 lpm.

The hydrogeological details of some of the tubewells drilled by Central Ground Water Board and state Govt. agencies are given in Table 9.

Table 10 Hydrogeological Parameters of Tubewells Drilled in Gurugram City

Sr. No.	Location	Year	Depth of T/W (m)	Aquifer Deciphered (m)	SWL at time of construction (m)	Drawdown (m)	Discharge (lpm)
1	Sector-40	1995	73.5	34.80-37.8,43.9-47.0,53-70.1.	21.60	11.17	473
2.	Sector-29	1996	79.6	34.8-37.8,56.1-59.1,65.2-67.4,71.3-77.4	22.2	13.90	473
3	Sector-23	1996	89.00	28.7-31.7,53.4-60.4,68.3-71.3,74.4-80.5,83.5-86.6.	22.00	6.80	265
4	Sector-15 Part-1	1995	84.1	50.3-86.9	27.7	7.2	606
5	Sector-39	1995	79.9	36.6-67.1,73.2-91.5	21.80	10.6	606
6	Sector-40	1995	57.6	34.80-57.90	20.90	12.1	455
7	Sector-55,56	1995	67.1	27.4-37.8,48.8-56.1,59.8-64.0	19.1	7.0	436
8	Jharsa	1994	68.9	31.1-68.3	23.9	10.3	227
9	Govt. school near Hospital	1994	66.5	25.6-64.0	27.9	6.8	360
10	Civil Lines	1994	68.9	22.6-45.1,54.6-65.9	27.7	8.8	340
11	Sector-34	1994	72.6	42.1-79.3	15.6	5.4	379
12	Sector-5	1994	43.0	24.4-30.5,36.6-48.80	21.0	7.2	152
13	Sector-32	1993	65.9	28.7-65.2	25.0	10.3	227
14	GWC office	1998	60.0	44-47,49-56	31.06	-	129

15	Samaspur	1957	224.0	20.7-31.1,178.78-181.05,190.19-194.46	N.A.	N.A.	732

6 Water Requirement/ Demand

6.1 Water Supply and Gap

In the previous sections, it is made evident that Gurugram is one of the fastest evolving Districts of the State inevitably accompanied by an increasing water demand. The district is home to many multi-national companies and major automobiles like Hero Moto Corp. and Maruti Suzuki, along being home to several industrial clusters. In the past few decades' population of Gurugram has steadily increased manifold which has directly impacted the infrastructure of the Gurugram. The following map shows the main source of surface water to Gurugram, the Yamuna Canal that carries water to the district from over 270 km. **Figure 18** shows the map of water that is supplied by surface water resources in Gurugram.

Apart from the supply of water from this canal, the main water source is groundwater. However, the increase in freshwater demand has led to the over exploitation of groundwater resources by 308% according to CGWB; one of the highest in the State of Haryana. The over exploitation of available freshwater resources, and the lack of implementation of a contingency plan to meet the projected growing water demands, is concerning. The following table shows the net water draft (consumption) according to each of the block of the Gurugram is given in the following **Table 11** as per estimations made by Malik et al. (2015) for the year of 2006 to 2010 in Ha-m.

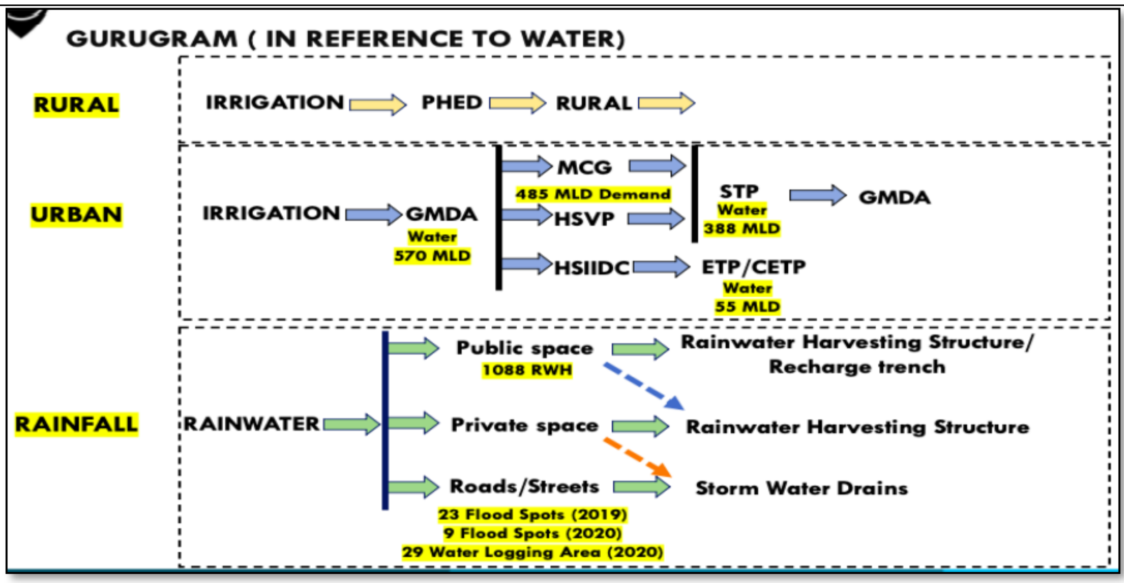


Figure 19 The map of water that is supplied by surface water resources in Gurugram District

Table 11 Groundwater Demand Block wise for domestic and agricultural use in the District of Gurugram (Malik et.al 2015)

Block	**Annual Draft of Ground Water Resources**		
	Domestic	**Irrigation**	**Total**
Gurugram	2529	6237	8766
Sohna	876	9053	9929
F Nagar	593	9695	10288
Pataudi	825	11136	11961
District	4823 (11.77%)	36121 (88.23%)	40944 (100%)

Moreover, research also suggests, that as population further increases, the demand will increase as shown in the graph below in **Figure 19**.

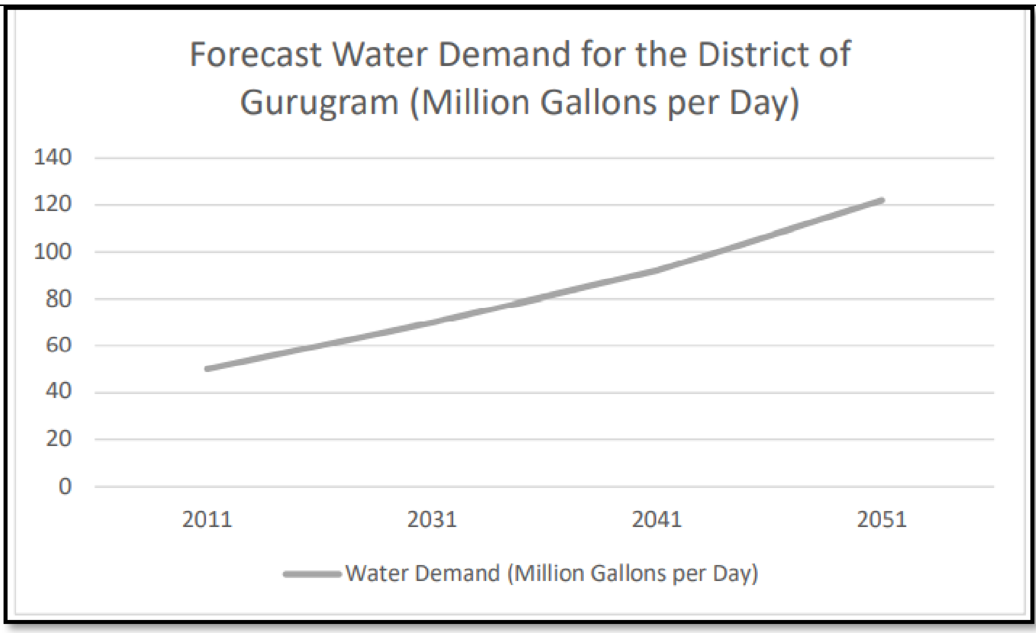


Figure 20 The future water demand for the District of Gurugram (Misra et. al. 2018)

Currently due to the rapid infrastructure development, and introduction of schemes such as Jal Jeevan Mission, availability of freshwater has been made available. The total number of households with tap water connection stood at 16.87% in August 2019, which has increased to 38.09% till date as reported by the Ministry of Jal Shakti. With the advent of freshwater availability, the wastewater generated would also be increased. However, in rural and peri urban areas, the problem of discharging wastewater without prior treatment is prevalent.

As access to the piped water supply became more prevalent, these life-giving waterbodies started to become neglected. According the District Revenue Records of Gurugram, the water bodies have reduced from a total of 641 in 1956 to 487 in 1976 to only 123 remaining in the year of 2018. The water bodies that do remain have severely been polluted.

The wastewater generated out of the local community usually is leads to water pollution of surface waters, with unregulated release of polluted effluents with high concentrations of toxic constituents. The eventual percolation of these toxic surface waters to ground water, have shown a very high potential of contributing to the pollution of already depleting ground water table.

It has been shown that the overflow from these johads will go into localized drains that will carry the drainage water in succession of, to the Bad Shahpur Drain, followed by the Najafgarh drain and the finally draining into the Yamuna River. One of the most notable examples of this phenomenon is seen in the stretch of Yamuna in the Wazirabad Bridge in Delhi. Before the bridge, the waters of Yamuna River remain pristine, however right after crossing the bridge, the Yamuna River receives direct outfall from several drains carrying concentrated wastewater. The chain of order is shown in the figure given below. The situation is no better in urban areas. The total wastewater that is generated and treated within the Gurugram Metropolitan Planning Area is approximately 443 MLD that is treated in Behrampur and Dhanwapur wastewater treatment plants. The wastewater treatment capacity that lags is approximately 33 MLD that is discharged into the Najafgarh drain through the Behrampur Drains/Legs of I, II and III (**Figure 20**).

While several laws and acts have been passed post-independence regarding the abatement of unregulated pollution activities, much remains to be done in order for better enforcement of these regulations on ground in order to gain control of India’s water ways.

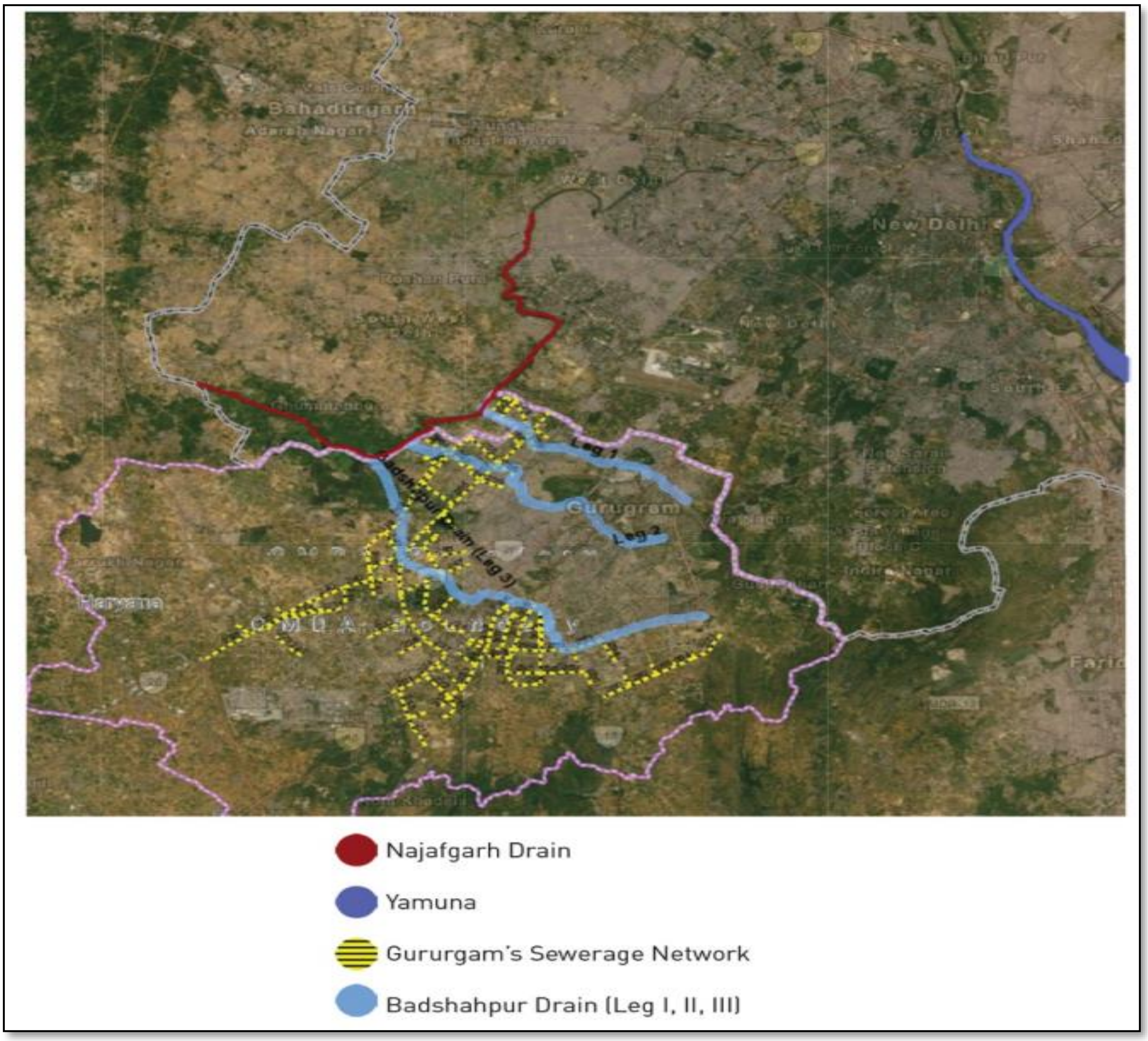


Figure 21 The Behrampur Legs 1,2 and 3 that carry the wastewater generated with GMDA planning area into Najafgarh Drain

6.2 Water Budget

1. Domestic Water Demand

Table 12 Expected estimation of domestic water demand till year 2022

Block	**Present water demand (MLD) 2021**	**Expected water demand in 2022 (MLD)**
Gurugram	8.87	9.04
Sohna	1.62	1.64
Farrukh Nagar	10.34	11.43

2. Water Budget (MCM)

Table 13 Block wise water budget

Block	**Existing water availability**			**Water Demand**	
	Surface	**Ground**	**Total**	**Present**	**Project**
Gurugram	0.0031	0.0057	0.0088	0.0088	-
Sohna	0.0000	0.0016	0.0016	0.0016	-
Farrukh Nagar	0.0063	0.0048	0.0111	0.0111	-

Table no 12 and **Table 13** depict the block wise domestic water demand and block wise water budget in Gurugram district.

7 Strategies for Water Conservation

The ground water availability in Gurugram is limited and presently being over exploited results in decline of ground water levels. The Gurugram town is situated in semi-arid area and rain is the main source of recharge to ground water. Due to heavy urbanization and industrialization, most of the storm runoff goes to the sewer or storm drains and reduces the recharge contribution from rainfall. The over exploitation of this vital resource along with the ground water pollution may lead to adverse environmental impact. Thus, there is an urgent need for protection of this vital resource by adopting the following measures.

1. In order to arrest the declining trend of water levels in the district, the rooftop rainwater harvesting technology should be adopted and recharge structures may also be constructed in depression areas

where water gets accumulated during rainy season. This will help in enhancing the recharge to ground water reservoir.

2. The crops consuming less quantity of water may be grown in place of crops requiring more water in the over exploited block

3. The abandoned dug wells may be cleaned and should be used for recharging the ground water by utilizing the surface monsoon runoff.

4. The water level monitoring network needs to be increased in the block.

5. The contribution of surface water to irrigation in the district is very less. Measures should be made to increase the canal water supply for irrigation and also for drinking purposes.

6. Local populaces to be educate regarding consequences of mining of ground water and need for its effective and economic use.

7. Roof top rain water harvesting for factories institutional buildings, housing complexes and other big buildings has been made mandatory to augment the ground water recharge and may be included in building laws. The law should be strictly implemented.

8. Water harvesting and artificial recharge structures should be constructed in Delhi ridge area, which is one of the major recharge zones for Gurugram. The run off should be diverted to abandoned mining pits. Small check dams can be constructed in hilly areas to recharge/ utilize surplus run off.

9. The industrial effluents causing ground water pollution should be treated before discharge so as to curb ground water pollution.

10. Strict regulatory measures are required for ground water pump age, particularly for industrial use. Water meter should be fitted on every tubewell and be allowed to withdraw fixed quantity of ground water.

11. Industries should be persuaded to recycle the effluents to minimize consumption of water.

12. Construction of new tubewells by individuals for domestic purpose should be regulated.

13. The municipal sewage should be treated properly to avoid ground water contamination. The same may be utilized for horticulture and other industrial uses, thus reducing the pressure on ground water.

14. Periodic monitoring of chemical quality should be carried out, particularly with reference to heavy metals, fertilizers, nitrates etc.,

15.Some areas of north- western portions of Gurugram block is underlain by shallow ground water level where quality is also poor i.e., saline. Such areas should be de- notified.

16. Strict regulatory measures are required for ground water pump age, particularly for construction and infrastructural development purposes.

17. As per state govt. record, In and around Gurugram city, there are 47 no. of ponds whose area ranges from 2 acre to 8 acre. These ponds which are either dried up or filled with municipal waste and garbage needs repair, renovation and restoration which will help to augment ground water resources by natural recharge.

18. There are 7 no. of natural drain along the foothill of Aravalli range in Gurugram town which can be utilized for rain water harvesting and artificial recharge to ground water.

19. More artificial recharge structures should be constructed in Udyog Vihar area and peripheral areas by factories, NGO and state government department where water level is declining at fast rate.

Understanding the climatic water crises that India could potentially face, the Jal Shakti Abhiyan was launched as a dedicated mission by the Hon'ble Prime Minister of India, in order to ensure that the maximum amount of water was being conserved, treated and reused. While all of the schemes introduced under the campaign are not applicable to the water conservation efforts for the district, the notable suggestions of authorities and research institutions have been mentioned in this chapter. This will thus serve as a strategic framework for which water conservation structures are to be made.

7.1 Artificial Recharge

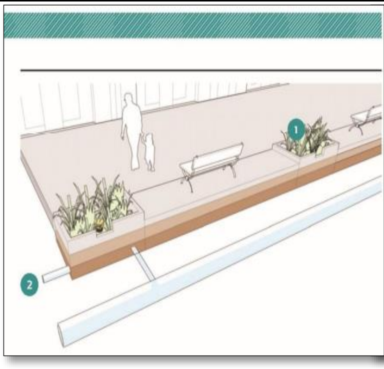
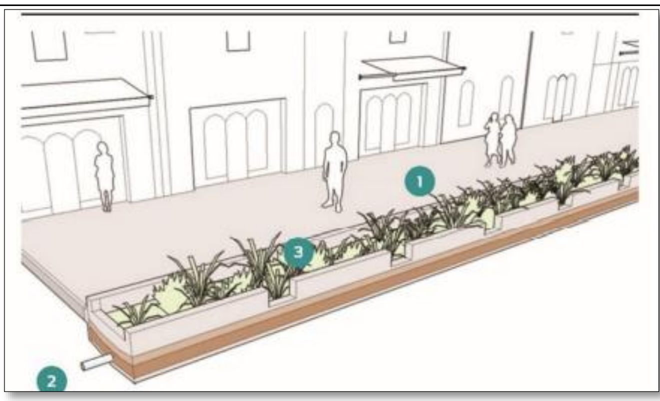
According to the research that was conducted National Aquifer Mapping Committee of the Central Ground Water Board, out of the total area of 1258 km2 of the District of Gurugram, the total area available for artificial recharge and augmentation is 1190 km2 which accounts for more than 95% of the total area of the district that is currently available for active interventions that can be utilized for such measures. Therefore, the scope for increasing the depleting groundwater tables all across the district remains to be tremendous. In fact, as elaborated in Chapter 1, the sand type in the district is loamy in majority and therefore allows a higher percolation rate of water. However, in the south-eastern part of the region, or Sohna Block, the area falls within the region of Aravalli and thereby the rocky terrain does not allow for the artificial recharge interventions to be put in with ease. In such cases, water retention structures will be crucial in these areas, such as the development of check dams and trenches. Given the decreasing trend of rainfall received in Gurugram, as discussed in Chapter 1, it is further imperative to put in measures that can The District has the target of implementing the following measures and construction of both infrastructural and non-infrastructural methods to increase the artificial recharge rates.

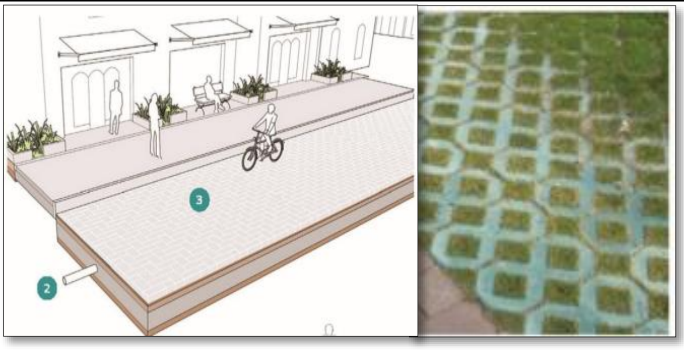
In fact, in order to encourage WSUD element design, major building certification and by laws, including the Haryana Building Code of 2016, has made it mandatory for the construction and presence of rainwater harvesting structures in any property of above 500 m^2 and has recommended it for any property above 100 m2 to have a recharge structure on the premises.

7.2 Water Sensitive Urban Design

As more and more portions of the district become urbanized, it is crucial to integrate water sensitive urban design into planning of the major upcoming clusters of towns and cities that are in the satellite of the main city of Gurugram. Water Sensitive Urban Design (WSUD) is a familiar concept for engineers and architects practicing and designing in the face of overwhelming environmental changes brought in by climate change. A major part of WSUD also allows us as a society to grow more resilient towards more intensive changes in rainfall patterns, as they grow more intensive, however scarcer in terms of frequency. The methods of water table recharge strategies in urban area are shown in **Table no 14**.

Table 14 The methods of water table recharge strategies in urban area

Sr. No.	Method	Image
1	**Flow Through Planters**	 
2	**Pervious Strips**	

3	**Pervious Pavement**	
4	**Stormwater Tree**	

7.3 Plantation

A major portion of WSUD that is popular within the Government Departments is plantation of various species of plants, both in public and private spaces, to encourage community participation and increase green cover. While increasing the aesthetic value of a location, plants are heavily influential to change microclimates and in fact playing a factor to rainfall patterns. Along with benefits of carbon sequestration, they contribute to increasing the local biodiversity of the region by attracting several types of fauna as well. Currently a multi-departmental approach within Gurugram is being undertaken both within and outside of government with the engagement of several active citizen stakeholders and non-governmental organizations. Geo-tagging of these plantations and survival monitoring would be undertaken actively by engagement of the mentioned stakeholders. According to present scenario intensive Afforestation is being done in Gurugram. Approx. 419500 number of plants is in target for plantation in the district. Although there is large amount of land is in wasteland form that could be used for plantation. The wasteland that could be used for plantation for conservation of water in Gurugram district is shown in **Figure 21** and **Table 15** shows the proposed no of plantation targets in Gurugram District.

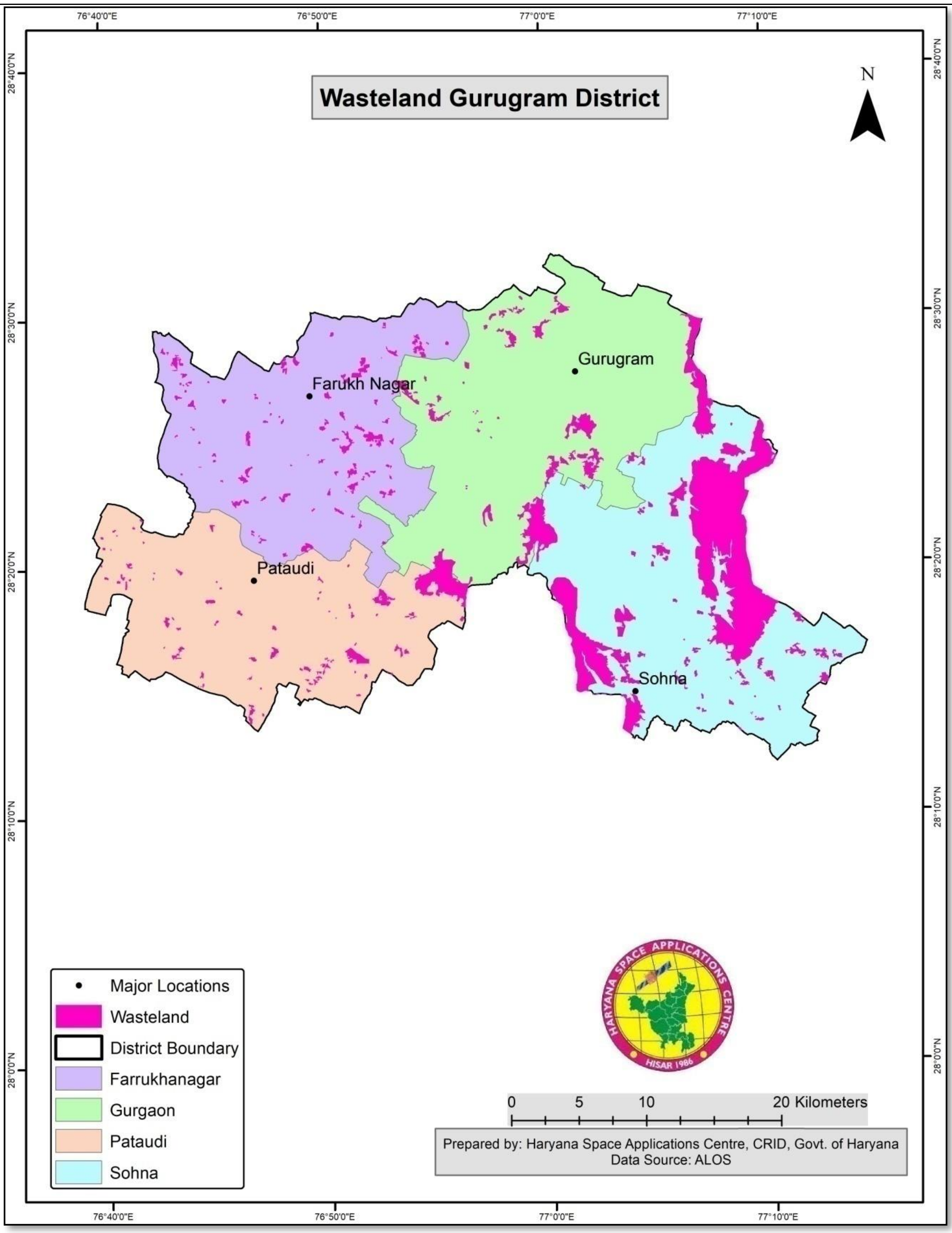


Figure 22 Wasteland Map of Gurugram District

Table 15 The proposed targets for plantation in Gurugram District

Block Name	Wasteland Area (acre)	Plantation at 5 feet spacing
Sohna	22279.10	194095530
Pataudi	2820.73	24574202
Gurugram	4834.49	42118059
Farrukh Nagar	2535.09	22085668
Total	32469.41	282873459

7.4 Surface water management

7.4.1 Pond restoration and rejuvenation

As earlier mentioned, in Chapter II, the number of surface water bodies such as ponds and lakes are continuously disappearing from the landscape. However, their preservation, restoration and rejuvenation would be essential to not only survival of biodiversity, but also to maintain microclimates, and ultimately essential to preserve human civilization.

Research also shows that that storage of water within a single pond structure contributed to a range of 26,000 to 62,000 m^3 to groundwater recharge over a year, that was equivalent to 1.3 to 3.6% of the total water recharge volumes in the study carried out in Ramganga Basin, India, which would serve to irrigate lands of 8 to 18 hectares of land cropped in the rabi season. As such ponds demonstratively serve as an essential structure for water security. Although it serves to only hold a relatively small volume of water, the stored water becomes vital for food security and economic stability within a small community.

Ponds are also essential structures that provide water security in areas where groundwater has grown extremely saline and cannot be used for irrigation purposes. Irrigation channels have been built in such areas during the Green Revolution in these areas in order to meet irrigation demands in this region. However, in order to supply to the increasing demands of high yield production, a lot of pressure has been put on the agriculture industry, as a result of which freshwater demand has increased. The original channels are therefore not sufficient to meet the current water demands. Without accesses to enough water, structures such as ponds become of essential service to allow for agriculture to be sustained in areas of water scarcity.

These traditional water bodies are what saved drought hit villages from the brink of extinction and starvation in the great spell of droughts that the nation faced in the 1970's. Examples led by pioneers such as Anna Hazare and P R Mishra who revolutionized and reinstated the importance of having water storage and wise utilization for increasing crop yield have served as models for reviving these traditional lifelines within the rural eco-system, while setting important benchmarks for its urban counterparts. Culturally, due to its life-sustaining properties, ponds have also been the centers or natural hubs for monthly or annual fairs to be held, and have been biodiversity hotspots that encourage the link between human and wildlife.

Therefore, ponds form a fundamental part of the hydrological cycle in the environment and has allowed a rich cultural, agricultural and societal practices to flourish in India Since ponds can be formed in a much broader range of environments and landscapes, they demonstrate a wide range of physiochemical activities that allows a wide range of flora and fauna to flourish. Currently Gurugram has a gap of 32 MLD of untreated wastewater, according the National Green Tribunal Status Report of February 2020 on Yamuna Action Plan that is being discharged directly into the Najafgarh Drain that directly drains into the Yamuna River. However, the ground reality suggests that there are a lot of unmapped points of discharge of wastewater that pollute the local waterbodies. These localized incidents of pollution of water bodies contribute to the loss of biodiversity and pose a threat to water security. In the recent years, it has been realized that wastewater may be an essential commodity and tool that may be used to close the demand supply gap and augment freshwater supply.

In order for pond restoration and rejuvenation to be done in a scientific and methodical manner, following 11 step procedures that is accommodative of each individual pond site requirements are given below

1. Pond Identification and Pond profiling

2. Project Feasibility Assessment

3. Administrative Approvals (Demarcation, GIS mapping, and Panchayat Resolution)

4. Detailed Project Report

5. Financial Approval

6. Community Mobilization

7. Cleaning and Levelling

8. Civil Work, Micro-STP Installation and Waste Management

9. Landscaping and Beautification

10. Sustainability Plan (O & M)

11. Monitoring and Evaluation

While the above methodology has been described in a step wise fashion, the cycle of pond rejuvenation and restoration functions on a feedback system and therefore inputs from each step can integrated into steps proceeding and after as well.

7.4.2 Decentralize Treatment Plant

It is recognized that in the absence of 100% sewerage network connectivity just managing the gray water component would be an incomplete solution. In the rapidly urbanizing cities of developing countries, decentralized wastewater treatment systems are an attractive solution for addressing the problems of water pollution and scarcity.

Decentralized wastewater treatment consists of a variety of approaches for collection, treatment, and dispersal/reuse of wastewater for individual dwellings, industrial or institutional facilities, clusters of homes or businesses, and entire communities. An evaluation of site-specific conditions is performed to determine the appropriate type of treatment system for each location. These systems are a part of permanent infrastructure and can be managed as stand-alone facilities or be integrated with centralized sewage treatment systems. They provide a range of treatment options from simple, passive treatment with soil dispersal, commonly referred to as septic or onsite systems, to more complex and mechanized approaches such as advanced treatment units that collect and treat waste from multiple buildings and discharge to either surface waters or the soil.

Decentralized wastewater treatment systems could be a feasible alternative for areas which are not connected to sewer networks as well as ones which are newly developed, so that the construction of their infrastructure is inadequate, not ready or would be executed in the future. Therefore, for local communities in the peripheries of urban development that exist outside the city center and rural areas where open drainage systems still exit. Over the past three decades, the city limits of Gurugram city have been continuously growing as evidenced by the satellite images of increasing urban infrastructure.

However, planning for sewage infrastructure and pipelines are a long-term investment, with the advent of exponential population increase also has been a challenge. Instead, decentralized wastewater management approach can be considered as a sustainable and cost-effective alternative as it treats discharges or reuses the effluent in the relative vicinity of its source of generation. Therefore, decentralization of wastewater treatment facilities is a feasible solution that may allow for localized treatment which may eventually be reused for secondary purposes. Like other systems, decentralised systems must be properly designed, maintained, and operated to provide optimum benefits.

The following table (**Table 16**) shows a list of generic conditions that are most often found in Gurugram according to the type of treatment considerations and other main constraints such as land availability and population, given that finances are a constant.

Table 16 Indicators and factors to decide the type of decentralised treatment required

Type of Effluent Received	Land Availability	Number of people	Type of Treatment Required
Grey and Black Water Effluent	Yes	<5000 people	Natural Based Technology
Grey + Black Water Effluent	Yes	>5000 people	Hybrid Technology
Grey and Black Water Effluent	No	>5000 people	Mechanized
Black Water	Yes	<5000 people	Hybrid
Black Water	No	>5000 people	Mechanized FSTP for a cluster

Currently, the District has the following target for activities related to Pond Restoration and Rejuvenation (**Table 17**).

Table 17 The activities being undertaken by the District for Surface water management

Pond Restoration Activity	Structure	Target
Restoration and Rejuvenation of Water Bodies	Water Bodies/TANKS	21
3D Village Contour Mapping	Village Covered	320
Urban Wastewater Reuse	In Million Litres per Day	370

7.3 Information Education and Communication

Through open exchange of information, education and communication established between the community and the implementing agency, ownership of the projects and interventions is reinstated; from inception to implementation and beyond. Selected committee members that form groups such as self-help groups, youth groups are in fact chosen to carry out regular capacity building of the community at large, with special attention paid to children, women and those belonging most vulnerable groups are carried out. Knowledge exchange and capacity building are at the core of IEC activities. The following image shows the various stakeholders involved in IEC Activities (**Figure 22**) and **Table 18** shows the numerous activities and interventions that can be carried out for IEC.

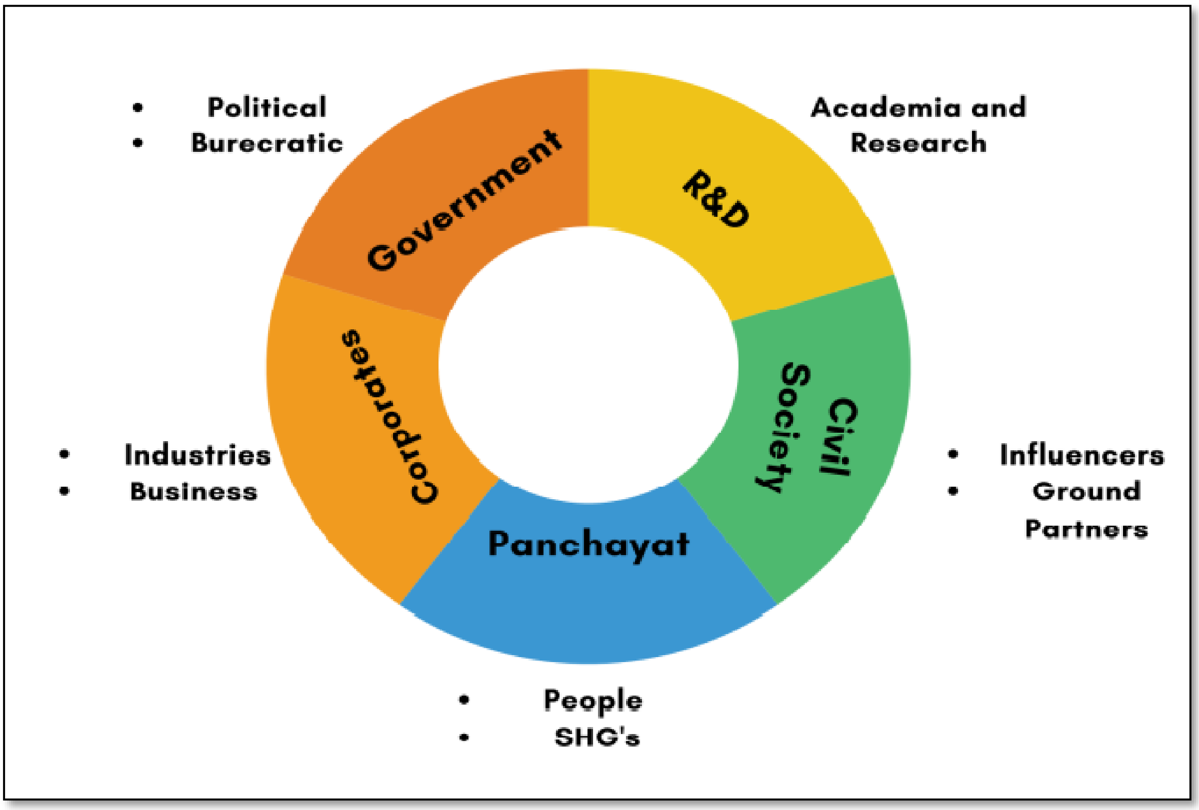


Figure 23 The various stakeholders of IEC Activities

Table 18 The numerous activities and interventions that can be carried out for IEC

. S. No.	IEC	Intervention / Topic	Target Group	Objective	Collaterals	Outcome/ Result
1	Webinars	- Role of RWA, Schools and Citizen in Rain water harvesting - How to Harness and Harvest Rain	- RWA(through MCG) - Schools (3rd party) - Corporates(3rd Party)	- To Engage Local People in Rain water Harvesting - To make them aware of the facts and rules of RWH	Letter from which dept. Letter to Mayor and Commissioner for inviting for webinar	- Knowledge about Rain water harvesting - Respective roles and duties towards RWH
2	Capacity Building Sessions	- Technical Training sessions - Awareness Training Sessions - Workshops	- MCG Workers - MCM Workers	- Training of ground worker of MCG - Implementation Work	Presentation Retrofitting Checking list Repair and Cleaning List	1. The workers will clean and repair the RWH post training - Training on Real time Problems - Generate Employment Opportunities
3	Competitions in RWA's (Same type of Settlements)	- Water Man agent and Conservation	- RWA	-To save water - To bring the best practices through RWA	- Competition brief with parameters	- To recognise and reward the best RWA - Lead by by Example
4	Formation of Clubs	-how do we know about good vendor? - how do we identify places for RWH - How do we build RWH?	RWA	To make water representative from every RWA	Check list of water auditing for the water representative	1. do the meetings with respective water representative from every RWA. -Team building for the Society
5	Guidelines	- Guidelines for All the drops of the Society	- RWA - govt institutions - Schools - Corporates	Information Flow	- guidelines and poster	- Information and Awareness on Water

		regarding Rain water harvesting and its maintenance	- Rural Public buildings			conservation and Rules
6	Information Boards	- Water awareness (Ponds, RWH, Plantation)	- Schools - Public Institutes Open Spaces Roads -	- To change the perspective of people	Location, Capacity, Design OF RWH, information board	Awareness , mobilise citizens - Information about the RWH in Their vicinity
7	Rain Centre	- Any Problems related to water	- All the Citizens	To Resolve the issue related to RWH	FAQ (Technical)	Acts as Point of Contact for all the queries in Water Management
8	Social Media	- All the updates of the Events and posts	- All the Citizens	- Digital marketing - Awareness	FAQ TYPES Best Practices Video clips of Officers and celebrities	Awareness , mobilise citizens
9	Recognitions/Awards	- Rain water Harvesting - Best Practises - Best RWA in Water management	- RWA - In Panchayats - NGO - Schools - Corporates - Active Citizens	to recognice best practices	-Parameters list for best practices	To encourage more practices and people - Increase interest and motivation for the end users
10	Video Clips and Interviews	- Individual water Conservation steps - Best Water Management Practices	- RWA - In Panchayats - NGO - Schools - Corporates - Celebs	Digital marketing - Awareness - virtual presence	- letters for the celebs, script.	To recognise people, encourage more
11	Working Models	- Rain water Harvesting Models - GuruJal Pond Sites	- Schools	To aquire more prototypes for District Administration	- Proper Guidelines	Showcasing Children work in Administration

12	Plantation Drives	- Awareness on Plantation drives	- Urban (RWA, MCG, MC) - Rural (Pond Sites) - Schools -NGO's	-To increase the green Cover To increase the water holding Capacity	- Plant List Nursery Database - Distribution Chain Management Posters	Better environment for Future Generations
13	Collaborations	- For IEC	- NYK - District Youth Affairs and Sports -Kalagram -NGO's -Durga Shakthi -Civil Defence -Lion Club	To involve stakeholders to facilitate sessions	- Letter of Collaboration -Google form	- No Overlapping of the work or activities - More effectiveness in Catch the rain Campaign

8 Proposed Activity

8.1 Rainwater harvesting

Rain water harvesting primarily consists of the collection and storage of rainwater for subsequent use as source of water. The harvested water can be used for both potable and non-potable applications. There are many examples of rainwater harvesting systems which provide water for domestic, commercial, institutional and industrial purposes as well as agriculture, livestock, groundwater recharge, flood control, process water and as an emergency supply for firefighting. There are different criteria and techniques to select suitable sites for harvesting rainwater. In recent years, the analytical hierarchy process (AHP) and multi-influencing factors (MIF) are most widely used model for identification of rainwater harvesting sites. The AHP technique determines the weights of thematic layers and their rank to process identify the zones of rainwater harvesting sites. MIF analysis is an effective tool for water management because it is comparatively simple and reliable.

There are some factors that affect the rainfall water harvesting which needs to be focused for the development of suitable sites of water harvesting. These factors include rainfall, slope, soil texture, drainage, topography and land use / land cover and integration of these factors using weighted overlay analysis that results in suitable sites for rainwater harvesting. These sites are then classified into various suitability levels, namely, not suitable, less, medium, good and very good. The most suitable sites for rainfall water harvesting are shown in map (**Figure 23**). The block wise area proposed for rainwater harvesting under most suitable sites is shown in **Table 19.** For the process of calculating suitable site a fixed weightage is needed to be applies on the above-mentioned criteria (**Table 20).**

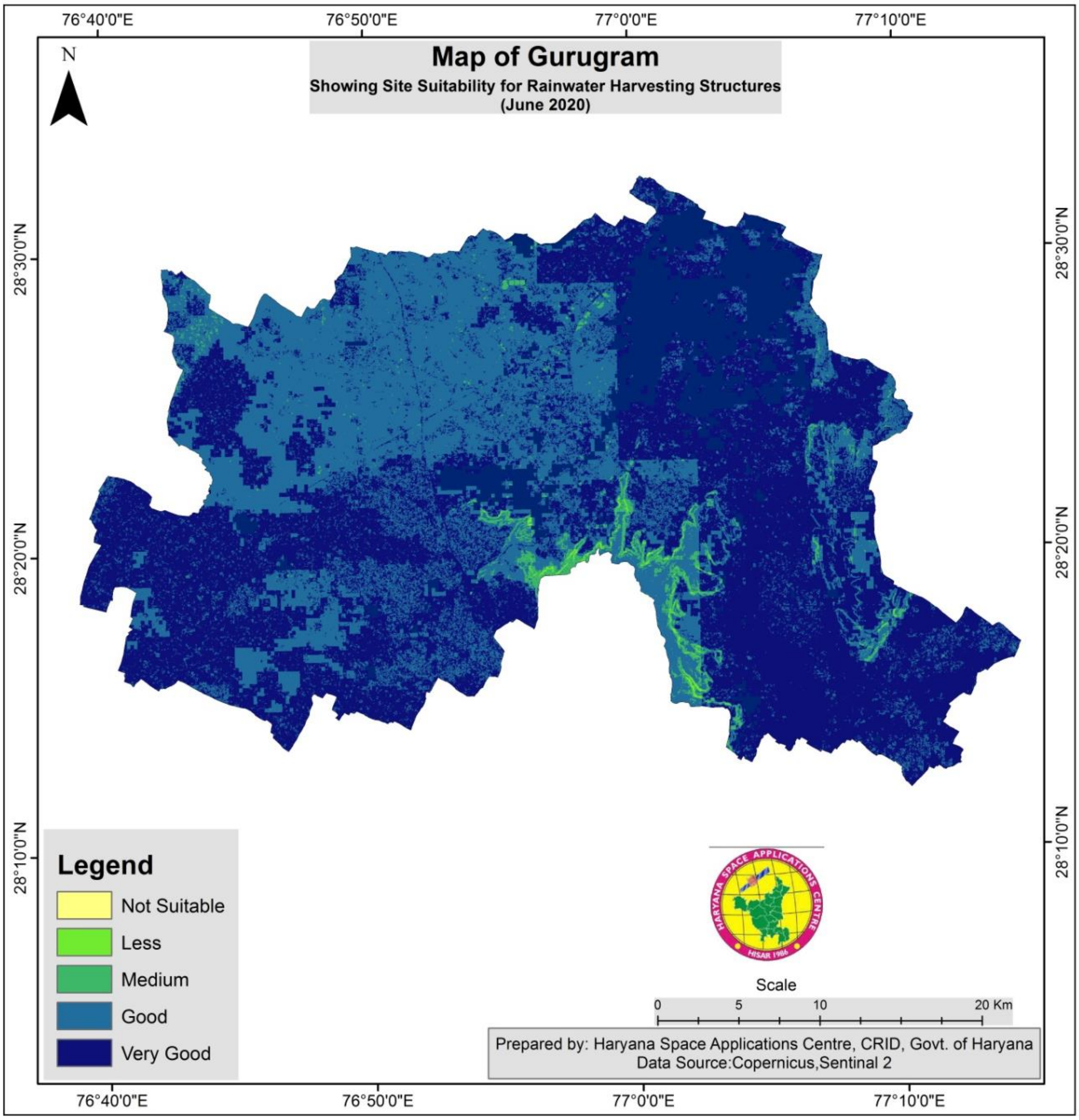


Figure 24 Proposed Site Suitable Map for rain water harvesting

Table 19 Block wise area under very good suitable site proposed for rain water harvesting

Block Name	**Area (Very Good suitability area in Sq meter)**
Farrukh Nagar	6399636.07
Gurgaon	106685999.8
Pataudi	3792852.6
Sohna	38210855.45

Table 20 Assigned Weight for Criteria Parameters

Parameters	Weightage
Rainfall	35
Slope	25
Drainage Density	5
Soil Texture	20
LULC	15

8.2 Proposed Suitable Site based on multi-criteria

In this section some water harvesting structures are proposed with the suitable sites. These structures are calculated based on different criteria. These criteria are Natural drainage and water occurrence datasets that should exclude the settlement and water bodies on the same place. Stream order system is a simple method of classifying stream segments based on the number of tributaries upstream. Following are the outcomes that show the type of structure on the streams. **Figure 24** shows the proposed suitable site based on multi criteria. Block wise proposed suitable sites based on multi-criteria is shown in **Table 21**.

Following are the harvesting structures proposed based on criteria mentioned as above.

1. 7 Mini percolation Tanks
2. 7 Percolation Tanks
3. 4 Pakka check Dams
4. 2 Annicut
5. 4 Micro Irrigation tanks

Table 21 Block wise proposed suitable sites based on multi-criteria

Sr. No.	Block Name	Mini percolation Tank	Percolation Tank	Pakka Check Dam	Annicut	Micro Irrigation Tank
1	Faruk Nagar	1	1	0	1	0
2	Sohna	5	6	3	1	3
3	Pataudi	0	0	0	0	1
4	Gurugram	1	0	1	0	0

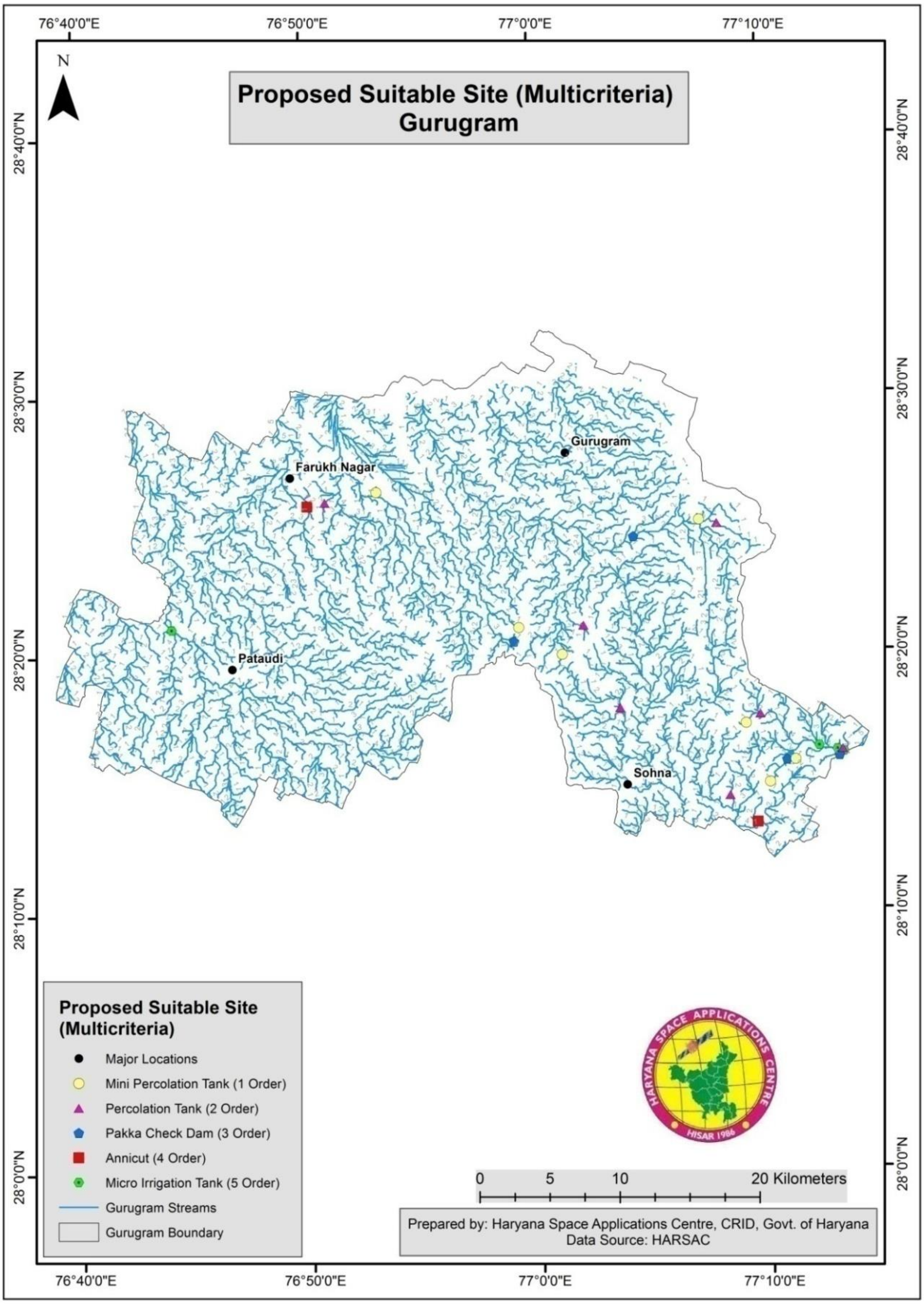


Figure 25 Proposed suitable sites based on multicriteria in Gurugram District

8.3 Proposed Suitable Site based on Drainage

The drainages that are created from satellite imagery can be used as base for the water harvesting structure **(Figure 25).**

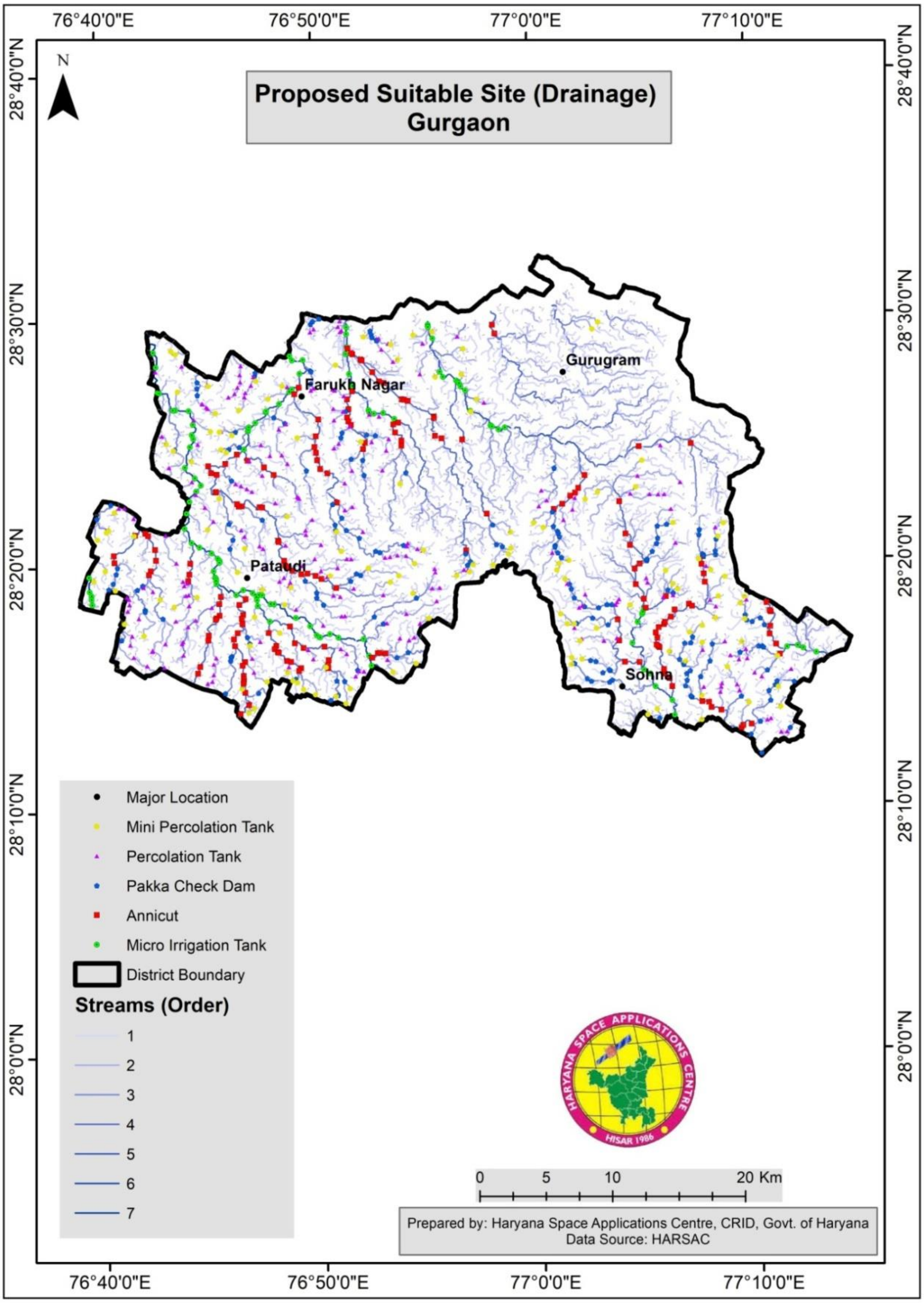


Figure 26 Proposed suitable sites based on drainage in Gurugram District

Stream order system is a simple method of classifying stream segments based on the number of tributaries upstream. So, based on the order of streams we can propose the suitable sites for water harvesting structures. A general idea says that Mini percolation Tanks on Ist order Stream, percolation Tanks on 2nd Order Stream, pakka check Dams 3rd Order Stream, Annicut on 4th order, Micro Irrigation tanks 5th Order can be built. **Figure 25** shows the proposed suitable sites based on drainage structure in Gurugram district. Proposed harvesting structures in Gurugram based on drainage **Table 22.**

Table 22 Proposed harvesting structures in Gurugram based on drainage

Sr. No.	**Block Name**	**Mini percolation Tank**	**Percolation Tank**	**Pakka Check Dam**	**Annicut**	**Micro Irrigation Tank**
1	Faruk Nagar	30	84	43	46	45
2	Sohna	47	56	80	53	14
3	Pataudi	43	82	38	67	38
4	Gurugram	17	16	9	17	12
	Total	137	238	170	183	109

9 Conclusion

Due to rapid urbanization, the Gurugram has seen problems related to water resources. There is water scarcity in lean season and waterlogging in monsoon season. Water logging over roads due to insufficient/unmanaged drains is the major problem. Current scientific report includes required information for the water harvesting where it is excess especially during monsoon/rainy season. The current water infrastructure information related to ponds/waterbodies, canals, natural drains, and drains based on slope is helpful in taking decisions on the construction of new structures for water harvesting. Block-wise estimates are given in the report while village level information is available at https://onemapggm.gmda.gov.in/portal/apps/webappviewer/index.html?id=dba1be50c558408cb6b06c27d337bdb4.

Water being an ongoing reliable source around the world, it will not be available forever. When top energy consumers include the United States and China, along with environmental factors affecting these two regions, there is no doubt that this valuable resource will be limited on Earth. Water scarcity is no joke and shouldn’t be taken lightly for it has great effects on food production, our farm lands, our health, and our economies. Droughts are common factors of this scarcity of water by drying up land and all the life contained in it. The land for crops is shrinking and are in need of more and more water everyday causing limited amounts of fruits and vegetables to be produced according to the research found by Daryanto and Gilis. When there is low food production, there come high demands which affect the economy.

Environmental concerns are not situated in one side of the world. Water is a broad source extending to different countries along with different advanced technologies. Irrigation has become widespread to improve farming and food production as well. Risks are taken into account because there may be cases in which misuse of conservation technology can affect our health and other resources other than water. Menses illustrates this situation well in his research regarding wastewater in the dairy industry. Through extended research, it is found that these happenings don't just occur once and in one place. The solution to prevent these occurrences exists in such initiatives of the government such as the JAL SHAKTI ABHIYAN. This is where collaboration is important among states and regions. To better and preserve our natural resources, actions and attitudes towards sustainability must stay at a high level throughout nation who is willing to work together towards the same goal.

…………………………………………….END…………………………………………………

“Jal Shakti Abhiyan: Catch The Rain”

WATER CONSERVATION AND RAIN WATER HARVESTING

RENOVATION OF TRADITIONAL WATER BODIES

REUSE AND RECHARGE STRUCTURES

WATERSHED DEVELOPMENT

INTENSIVE AFFORESTATION

ENUMERATION OF WATER BODIES

TRAINING / AWARENESS PROGRAMS BY KVK

Catch The Rain

Where it falls, When it falls

PIKU