Report No.-21

JSA-CTR

Scientific Action Plan for Sonipat

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Government of Haryana

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1. Introduction

1.1. History

Sonipat name is derived from the word Sonipat which means in Sanskrit language the suvarnaprastha (gold place). One popular tradition avers that it is one of the five patas or prasthas (Indraprastha, Panipat, Talpat, Bhaghpat and Sonipat) mentioned in the Mahabharata which Yudhishthira demanded from Duryodhana. Another tradition ascribes its foundation to Raja Soni, thirteenth descent from Arjuna, a brother of Yudhishthira.

There has never been any doubt regarding the antiquity of the district. The region has yielded pottery of pre-Harappan, late-Harappan, Painted Grey Ware, early historical, Northern Black Polished Ware and early medieval times showing thereby that parts of the district were inhabited by different people, some of these parts show continuity while in others there is a break. The evidence so far available archaeological as well as literary – is quite meagre even to provide any clear outline of the historical growth of the district during the early phases.

The pre-Harappa was the earliest people inhabiting the district. The next important phase in the pre-history of the region is marked by the advent of the people using Painted Grey Ware and generally associated with the Aryans. The earliest literary reference to Sonipat is, of course, in the Paniniya Ashtadhyayi where it has been mentioned along with other towns whose names end in prasthas (Sonaprastha).

1.2. Location

Sonipat is a city and a municipal corporation in Haryana state of India. It comes under the National Capital Region and is around 44 kilometres (27 mi) from Delhi. It is also around 214 km (128 miles) southwest of Chandigarh, the state capital. Sonipat district is oblong-shaped. It is bounded by Panipat district in the North, Delhi State and Jhajjar district in its South, Rohtak district in the Southwest and Jind district in the Northwest. Eastern boundary is made by the Yamuna River and on the other side lies Meerut district of Uttar Pradesh. Sonipat district lies between 28°47’48” North and 29°17’31” North latitude and 76°28’36” East and 77°13’40” East longitude. It is having a geographical area of 2122 square kilometers, containing 2039.99 square kilometers of rural area and 82.01 square kilometers of urban area. The Location Map of Sonipat district is shown in **Figure 1**.

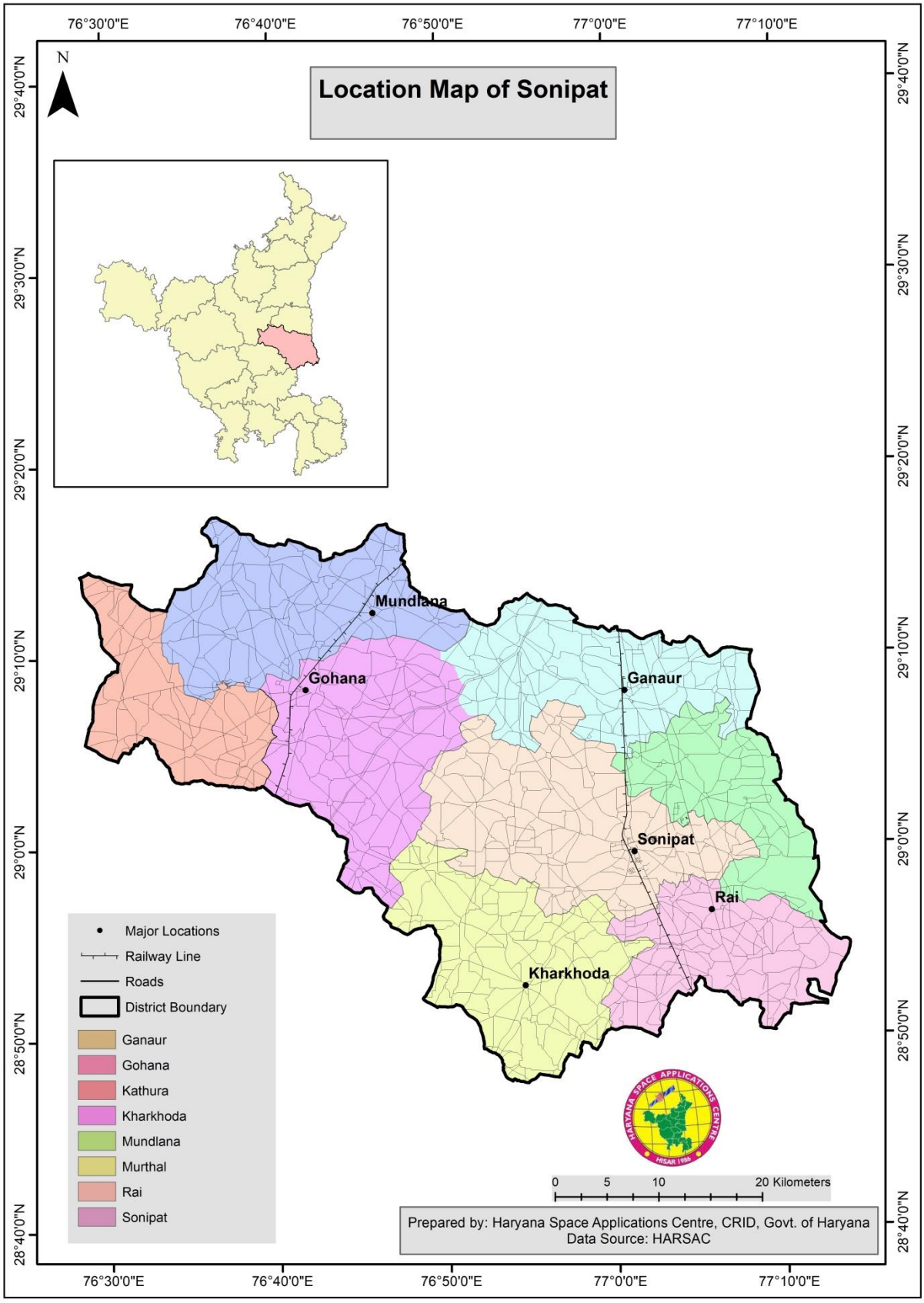


Figure 1- Location Map of Sonipat District

1.3. Administrative setup

The administrative setup of the District of Sonipat has been described in the following table, with specific sectoral development such as water, animal husbandry, agriculture, roadways is operated under specific departments. The detailed administrative setup is shown in **Table 1**.

Table 1- Major Administrative Jurisdictional Setup of Sonipat District

Country	India
State	Haryana
Division	Sonipat
Headquarters	Sonipat
Tehsil	1. Sonipat 2. Kharkhauda 3. Gohana 4. Ganaur
Total Area	2,260 km² (870 sq. mi)
Total Population (2011)	1,450,001
Density	640/ km² (1,700/sq. mi)
Demographics **Literacy** **Sex ratio**	 73.71 937/1000
Major highways	NH-1 NH-71 Eastern Peripheral Expressway, Western Peripheral Expressway National Highway 334B (India) National Highway 44 (India)
Vidhan Sabha constituencies **Lok Sabha constituencies**	Ganaur, Rai, Kharkhauda, Sonipat, Gohana, Baroda Sonipat
Website	http://sonipat.nic.in/
Coordinates	28°47’48” North and 29°17’31” North latitude and 76°28’36” East and 77°13’40” East longitude.
Elevation	224.15 m (735.40 ft) above the sea level

Sub Divisions (4)	Gohana, Kharkhoda, Sonipat, Ganaur

Tehsils (4)	Sonipat, Kharkhoda, Gohana, Ganaur
Sub-Tehsils (2)	Khanpur Kalan, Rai
Blocks (8)	Sonipat, Gohana, Ganaur, Kharkhoda, Kathura, Mundlana, Rai, Murthal
Municipal Corporation (4)	Gohana, Kharkhoda, Sonipat, Ganaur
Municipal Council (4)	Gohana, Kharkhoda, Sonipat, Ganaur
Municipal Committees (4)	Gohana, Kharkhoda, Sonipat, Ganaur
Population (Census 2011)	1,450,001

Total Villages	349
Total Panchayats	187
Village Level	Panchayat (187)
Block Level	Panchayat Samiti
District Level	Zila Parishad (23)

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

1.3.1. Demography

As per 2011 census, the total population of the district is 14,50,001 out of which population of female and male are 6,68,702 and 7,81,299 respectively. Sonipat district is the 6th largest in terms of population in the state. District is predominantly rural and around 68.7 percent of the population resides in rural area.

Sonipat ranks second last (20th) in terms of sex-ratio in the state with a sex ratio of 856 females per 1,000 males against 879 females per 1,000 males of state average. Compared to 2001 census, the decadal growth in population of Sonipat has been 13.35 percent, *i.e*., 1.335 percent growth per annum. The district has a literacy rate of 79.12 percent. The literacy rate of male and female are in Sonipat district is 87.18 percent and 69.80 percent respectively. Block wise demography of Sonipat district shown in **Table 2.**

Table 2 -Block wise demography of Sonipat

Block	Population			SC		General		Total	
	Male	Female	Children	NHH	NMM	NHH	NMM	NHH	NMM
Mundlana	60537	51443	14685	4671	23294	16386	88686	21057	111980
Kathura	39509	33200	9442	2874	14436	10694	58273	13568	72709
Gohana	98974	88371	15704	7055	35993	28042	151352	35097	187345
Ganaur	122635	102996	26202	7851	39807	34668	185824	42519	225631
Rai	108330	90377	27646	7648	39297	31020	159410	38668	198707
Sonipat	263227	227544	28551	15578	80698	80187	410073	95765	490771
Kharkhoda	88087	74771	17416	7024	36410	24028	126448	31052	162858
Total	**781299**	**668702**	**139646**	**52701**	**269935**	**225025**	**1180066**	**277726**	**1450001**

1.4. Climate

The climate of Sonipat is dry with hot conditions in summers and cold atmosphere in winters. The weather becomes pleasant during monsoon period between July and September. The post-monsoon time of October and November is regarded as a transition period prior to the beginning of winter.

1.4.1. Temperature

The average annual temperature is 24.9 Â°C in Sonipat. About 653 mm of precipitation falls annually. At an average temperature of 33.9 Â°C, June is the hottest month of the year. The lowest average temperatures in the year occur in January, when it is around 14.1 Â °C. Four seasons are observed in a year. Mid-March to end of June is summer season, followed by rainy season from July to mid-September, after which a transition period of two months follows. Then the cold season comes from mid-November to mid-March. With the start of cold season temperatures begin to decrease rapidly. January is the coldest month when mean daily maximum temperature is about 21.2°C and mean daily minimum temperature is about 6.4°C. Cold waves affect the region when minimum temperatures sometime drop down to freezing point. With the onset of summer season temperatures begin to rise rapidly. May and June are the hottest months with maximum temperatures sometimes reaching 39.8°C. Hot westerly winds locally known as ‘looh’ begin to blow from the month of April. With the onset of monsoon season, day temperatures drop appreciably whereas nights continue to be as hot as in summer.

1.4.2. Rainfall

Throughout the year, in Sonipat, 767.9mm (30.23") of rain is accumulated. During rainy season, weather is unpleasant due to increased moisture in the air. After monsoon season day temperature remain high but night temperature goes down rapidly. Yearly (2005-2009) average rainfall and temperature in mm of Sonipat district is shown in **Table 3**.

Table 3 -Temperature and rainfall of Sonipat

Month	Temperature(^{0}C)			Rainfall (mm)
	Mean Min	Mean Max	Average	
January	7.2	21	14.1	7.2
February	9.6	24.2	16.9	9.6
March	14.7	30.3	22.5	14.7
April	20.1	36.2	28.1	20.1
May	25.3	40.4	32.8	25.3
June	27.8	40	33.9	27.8
July	26.6	35.3	30.9	26.6
August	25.7	33.5	29.6	25.7
September	24.1	34	29	24.1
October	18	32.7	25.3	18
November	11.5	28.5	20	11.5
December	7.9	23.4	15.6	7.9

Rainfall records (2005-2009) reveal that average annual rainfall in the district is 662.4 mm. and about 73.45 per cent of the normal annual rainfall in the district is received during June to September, September being the rainiest month. Rainfall, generally, increases from southwest to north-east. On an average there are 28 rainy days in a year in the district.

In general, winds are low for most part of the year but these gain strength during the monsoon season in July and August. Cloudiness is also heavy during this season. Rest of the year, skies are clear or lightly cloudy. Often skies are overcast with passage of western disturbances. Easterly or south-easterly winds blow during summer monsoon season but for the rest of the year winds are westerly or north-westerly. Air is dry for most part of the year but humidity is very high during monsoon season. Dust storms mostly occur during April to June. Highest incidence of thunderstorms is in between April and September. Thunderstorms occur in winter months also in association with western disturbances. Dense fog occurs in the winter months of December and January. The rainfall map of Gurugram district is shown in **Figure 2**.

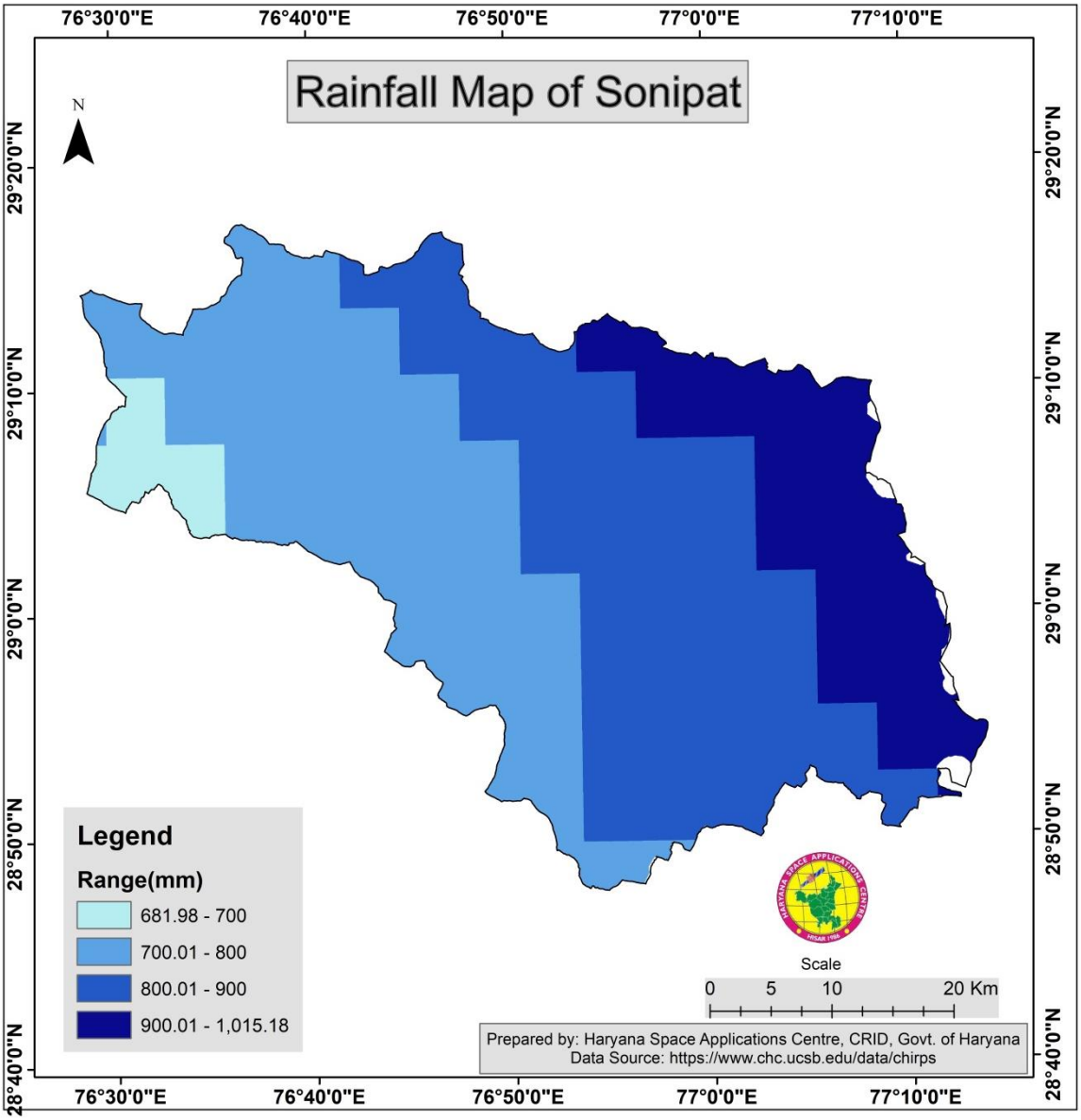


Figure 2- Rainfall Map of Sonipat District

1.5. Elevation and Topography

The height above mean sea level of the district is 224.15 m **(Figure 3).** Topographically, Sonipat district is divided into three regions, the Khadar, Upland Plain and Sandy Region. Sonipat city lies on the upland plains, which are covered with old alluvium, which, if properly irrigated, is highly productive. Broadly speaking, the district is a continuous part of the Haryana-Punjab Plain, but the area is not level in some parts. Sonipat District has fine loamy soil with a rich colour. However, some areas have sandy soil. Khanda, Sonipat village is Famous for Brick Factories there are 100+ Bhattas (Kiln) in this village.

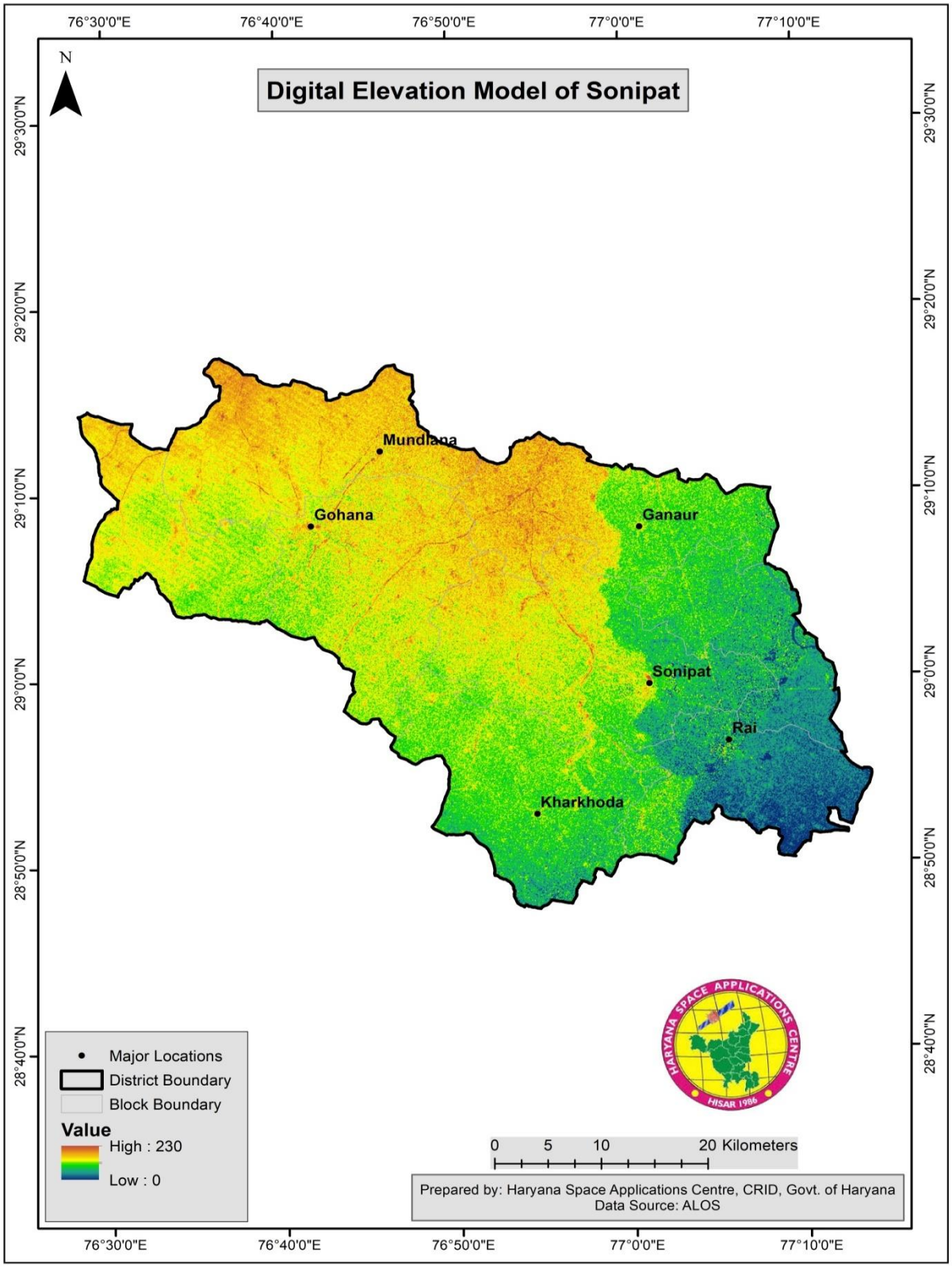


Figure 3 -Digital Elevation Model of Sonipat District

Slope ranges from flat to >35 degree (**Figure 4**). Most of the area of Gohana and Rai is flat to less sloppy. Contours of 5 meters interval showed similar topography as in digital elevation model, (**Figure 5).**

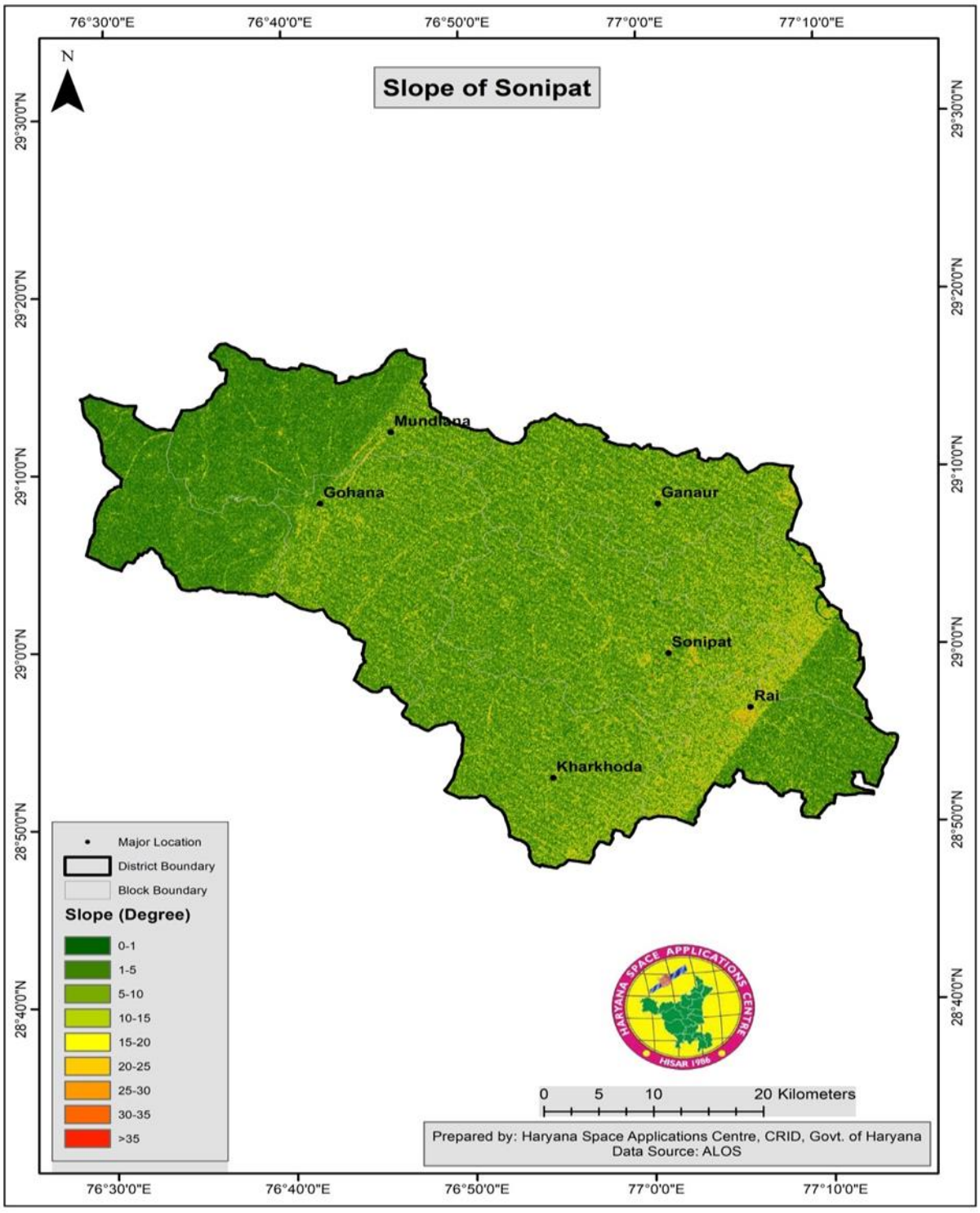


Figure 4- Slope Map of Sonipat District

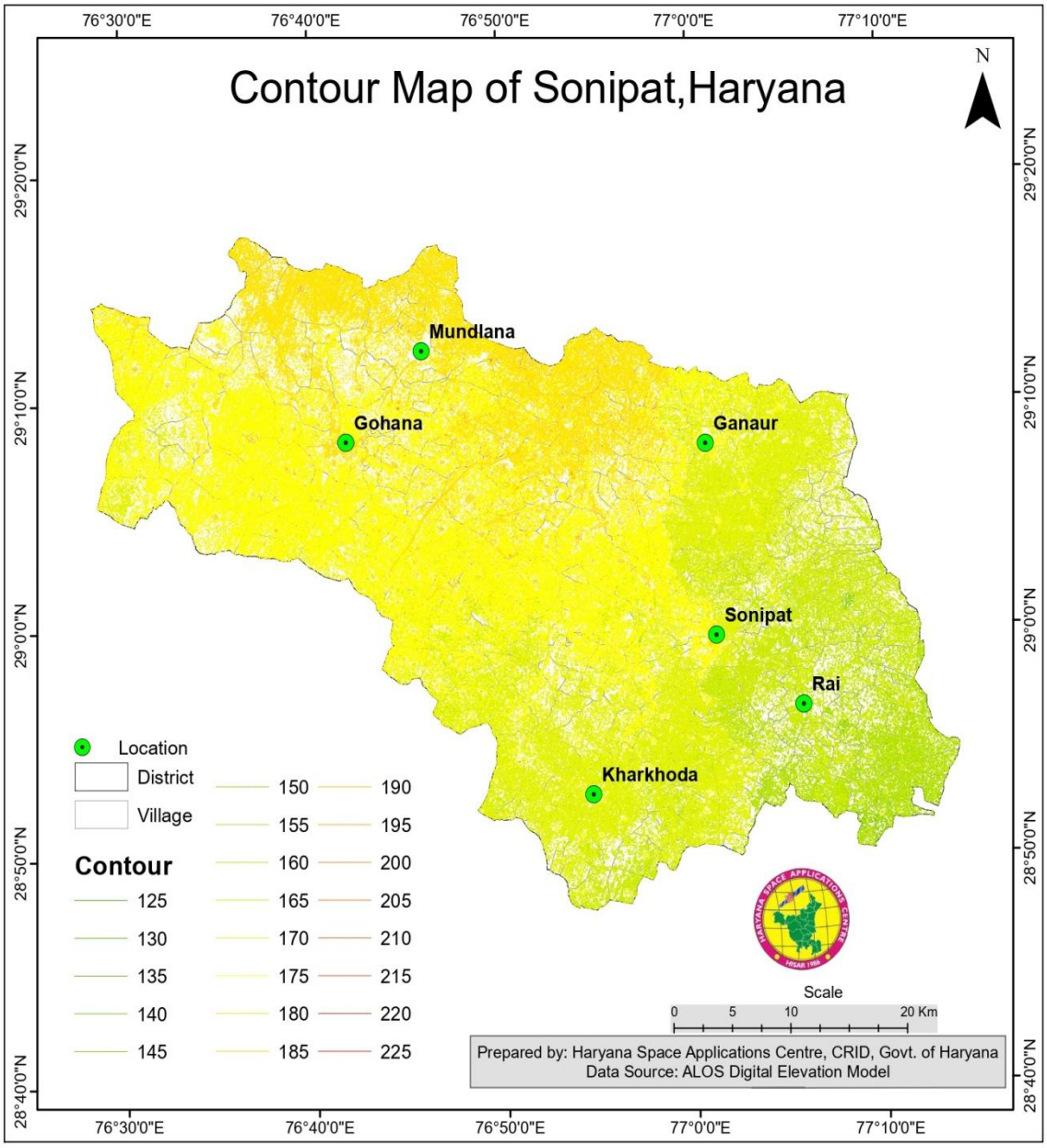


Figure 5 - Contour Map of Sonipat District

1.6. Geology and Lithology

The district is a continuous part of the Haryana-Punjab plain, but the area is not levelled in some parts. Over most of the district, the soil is fine loam of rich colour, **(Figure 6).**However, some areas have sandy soil and others are comprised of Kallar. The plain has a gradual slope to the south and east. The district may be roughly divided into three regions:

1. **The Khadar**

Along the River Yamuna is a narrow flood plain, 3 to 6 km wide, and is formed by the river along its course. The Khadar plain is 20 to 30 ft. lower adjoining upland plain. It is comprised of fine clay loam left by the receding floods of the Yamuna. Presently, rice and sugar cane cultivation is undertaken by the farmers in the Khadar area. Recently, the farmers have started planting Banana, Papaya and other fruits trees in this area.

2. **The Upland Plain**

It consists of Sonipat tehsil lying to the west of the Khadar, and is the most extensive of the three regions: The Upland Plain is covered with old alluvium, which if properly irrigated, is highly productive. Extensive Farming of crops, oil seeds, horticultural plants, vegetables and flowers, is undertaken in this region. The ridges in Gohana tehsil represent the northern most extension of the Aravalli.

3. **The Sandy Region**

A very smaller part of the district is covered with soil comprising of sand or sandy loam. Parts of this region have high PH value leading to kallor land.

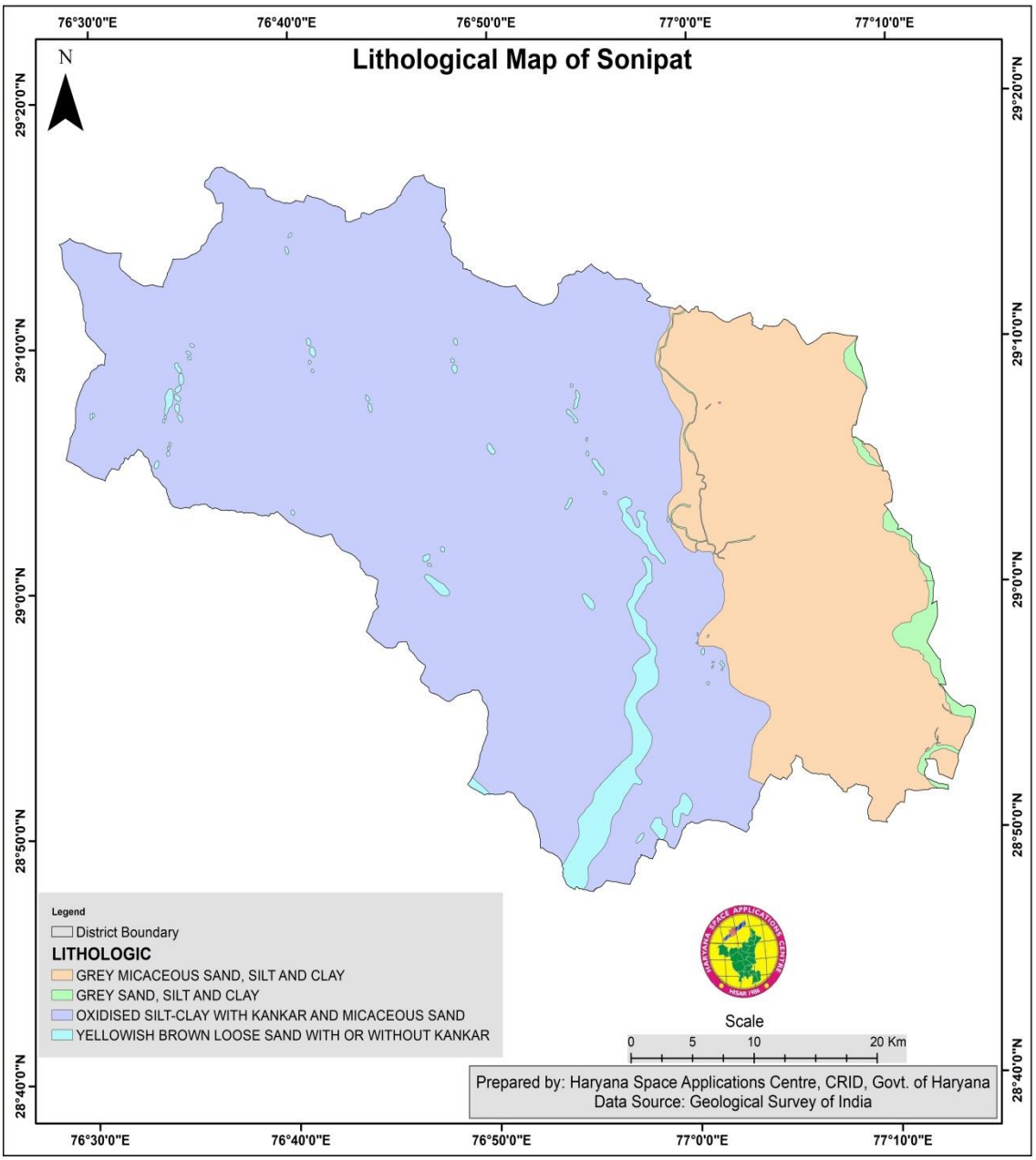


Figure 6 -Lithological Map of Sonipat District

1.7. Soil Profile

District Sonipat, comprising of Sonipat, Gohana and Ganaur sub divisions, has 343 villages and covers an area of 2, 13,080 hectares. The irrigated area (both with the help of canal irrigation as well as through tube wells) is 2, 86,504 acres and the un-irrigated rain fed area is 43,979 acres. Sonipat is an important saltpeter producing area. The saltpeter appears as efflorescence on the surface during the summer season, especially in the village of Sonipat sub-division.

Psammaquents and Haplaquept soils are found in Yamuna Plains (Marwaha, 2008).Haplaquept are non-saline; alkalinity hazards are classified as Typic Custochrepts, but water logged soils with loam to clay loam texture showing the effect of glazing are classified as Aeric /Typic Haplaquepts. Areas as aeridic soil moisture have soils classified as camborthics and torropsamments. Parts of Kathura, Gohana, Mundlana and Kharkhoda blocks have problems of shallow water levels or water logged areas and soil and water salinity at shallow levels. Soil in the area was sandy loam having hydraulic conductivity of 0.8m/day.

Water logging is a serious problem affecting the productivity of land. The water-logged area, in which the water table is between 0 to 5 ft., faces a serious problem. Where the water table is between 5 to 10 ft., the problem of water logging is imminent. There has been an alarming rise in the water table during the last two decades, especially in the areas adjoining the canals. This has led to appearance of Thur on the surface of soil, followed by sem in several parts of the district, especially the areas adjoining the Yamuna and minor canals running through the district.

The soil in Sonipat is rich and quite suitable for all types of agricultural crops as well as forest cover. The types of soil may be classified according to textures as:

- Sandy (Raitali)
- Sandy loam (Bhuri)
- Loam (Rausli)
- Clay loam (Karti)
- Clay(Dakar)

Soil types and area covered in Sonipat district is shown in **Table 4**. The general profile of soil health of Haryana sate is shown in **Figure 7**. The alluvium in the area comprises. Sandy (Raitali), Sandy loam (Bhuri), Loam (Rausli), Clay loam (Karti) and Clay (Dakar), shown in **Figure 8**.

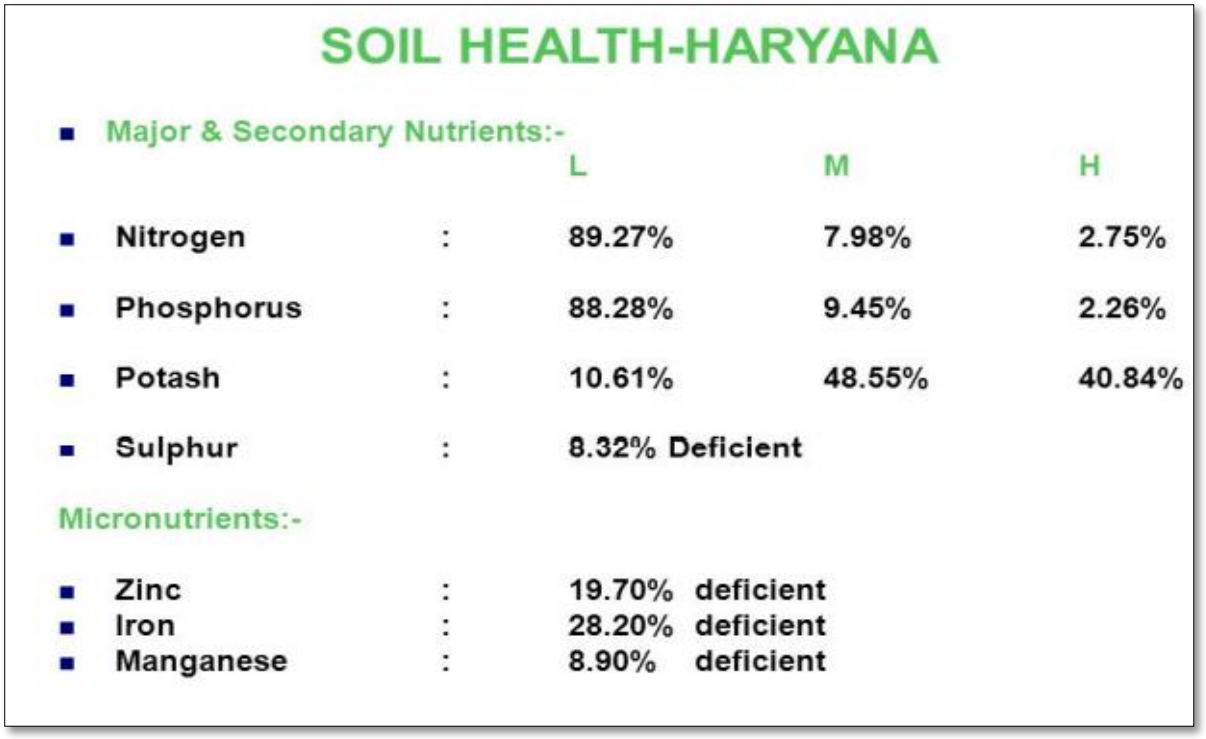


Figure 7 -General Soil health profile of Haryana

Table 4 -Soil types in Sonipat

Soil Type	Area(ha)	Land Slope			
		0-3%(ha)	3-8%(ha)	8-25%(ha)	>25%(ha)
Sandy Loam	148515	148515	Nil	Nil	Nil
Sandy Soil	13815	13815	Nil	Nil	Nil
Loans and	6909	6909	Nil	Nil	Nil
Clay Loam	3454	3454	Nil	Nil	Nil
Total	172693	172693			

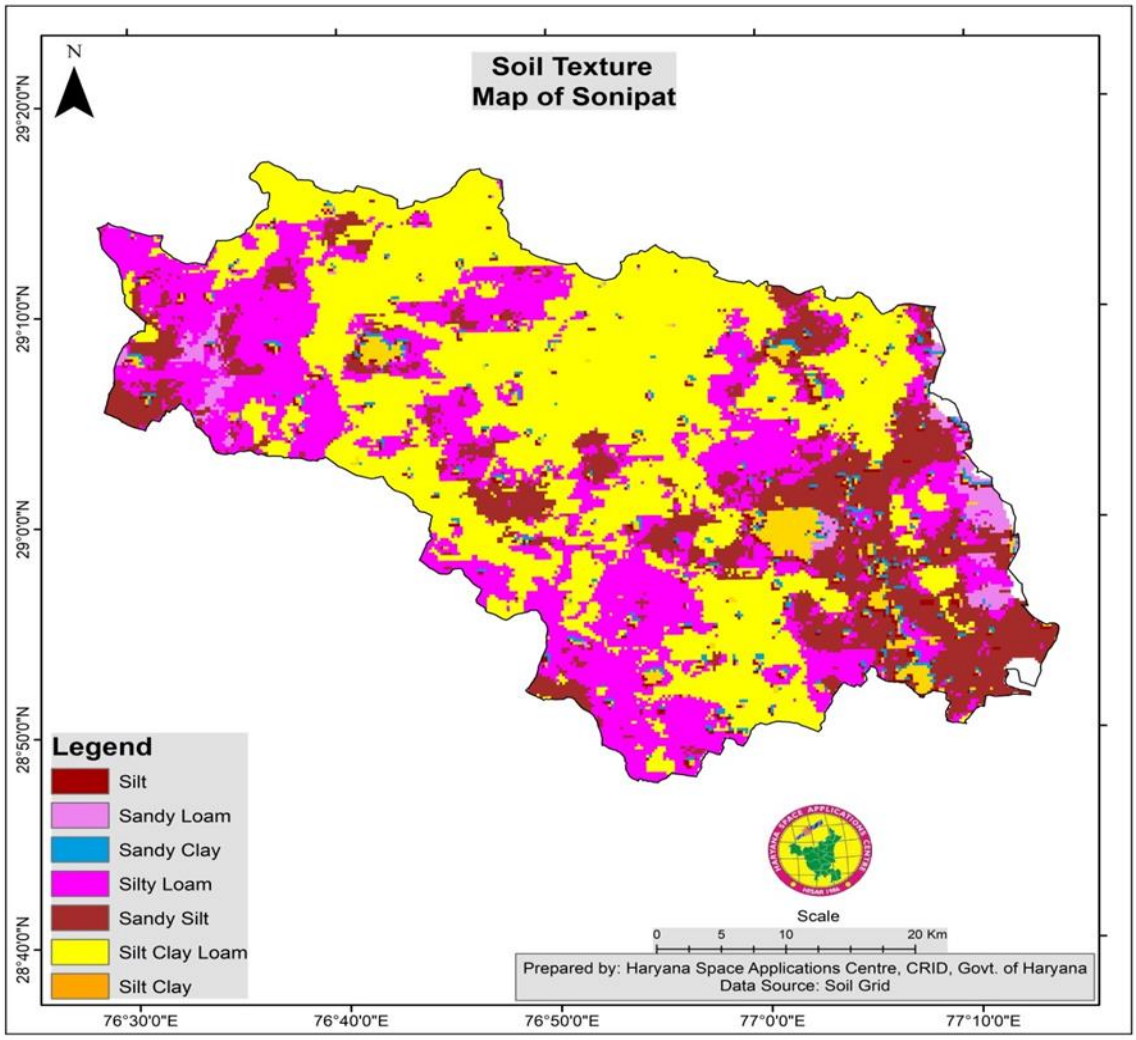


Figure 8 - Soil texture map of Sonipat District

1.7.1. Sand dunes

Sand dune, any accumulation of sand grains shaped into a mound or ridge by the wind under the influence of gravity. Sand dunes are comparable to other forms that appear when a fluid moves over a loose bed, such as subaqueous “dunes” on the beds of rivers and tidal estuaries and sand waves on the continental shelves beneath shallow seas. Dunes are found wherever loose sand is windblown in deserts, on beaches, and even on some eroded and abandoned farm fields in semiarid regions.

1.8. Land use

In the year 2010-11, against a geographical area of 2,122.00* sq. Kms (includes 82.01 sq. Kms. of urban area); the area of the district according to village papers supplied by the revenue authorities is 2076.24 sq. Kms (rural area only). This shows difference in two sets of areas arrived at by different methods of measurement adopted by two separate agencies. Of the total area of 207,624 hectares,

168,332 hectares is net sown area; 3,061 hectares is culturable waste (including gauchar and groves) and 3,843 hectares of area is not available for cultivation to which we may call barren and unculturable land. Net area sown in the district is 81.08 per cent of total area. Gohana tehsil has a rural area of 790.63 sq. Kms, Whereas, **Sonipat, Ganaur and Kharkhoda tehsils possess 690.41 sq. Kms,** 304.91 sq. Kms and 290.29 sq. Kms of rural area respectively.

The largest Block of the district is Sonipat which comprises of a Total Geographical Area (TGA) of 41,300 hectare *i.e.* about 19.4 percent of the TGA of the district. It has been observed from records of Revenue department in the district that the Gross Cropped Area of the district is 3.04 lakh hectares out of which 64,380 hectares *i.e.* around 21.1 percent area falls in Sonipat block. The cropping intensity is at maximum in case of Ganaur block (212%) while it is least in Kharkhoda block (182%) shown in **Table 5**. The land use land cover map of Sonipat District is shown in **Figure 9**.

Table 5 -Land use pattern in Sonipat

Block	Total Geographical Area	Area under Agriculture			
		Gross Cropped Area	Net Sown Area	Area sown More than once	Cropping Intensity
Ganaur	28905	43458	20460	22998	212%
Gohana	35400	47365	24019	23346	197%
Kathura	20320	33652	17003	16649	198%
Kharkhoda	29450	38809	21309	17500	182%
Mundlana	29852	39490	20574	18916	192%
Rai	27854	37340	19657	17450	190%
Sonipat	41300	64380	33227	31386	194%
Total	213081	304494	156249	148245	195%

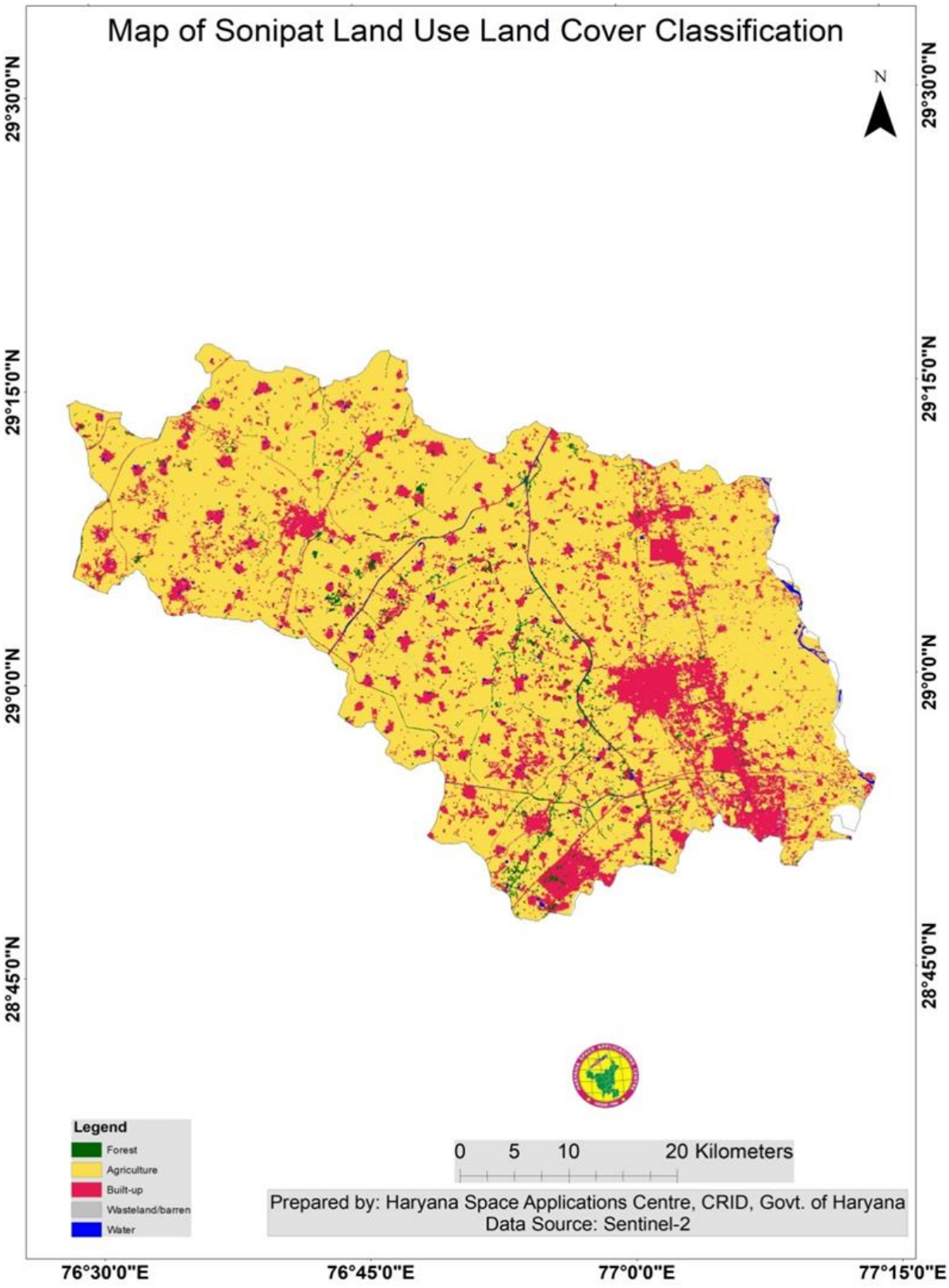


Figure 9- Land use and Land cover of Sonipat District

2. District Water Profile

In the past, the economy of the district was mainly agricultural though tertiary activities are now taking lead in the district, yet the proportion of marginal workers engaged in agricultural activities (cultivators and agricultural laborer) are very high (63.1 per cent). Main workers engaged in agricultural activities during 2001 were 45.8 per cent whereas they are now 41.4 per cent in 2011 Census showing a steep decline in these activities. However, the government is making all efforts to encourage agricultural production by distributing improved seeds, fertilizers, pesticides, providing latest developments in modern techniques, multiple cropping pattern techniques increasing irrigation facilities, providing easy loans for modern agricultural machinery etc. Farmers are being continuously advised to change crop pattern to increase soil nutrients.

2.1. Source of Water

2.1.1. Rivers

The river Yamuna, which borders the district in the East, is the main river in the district. The district is drained by drain no.8, which was constructed to take out excess monsoon runoff from uplands to River Yamuna. The areas east of upland plains are more prone to flooding because of its low-lying nature.

Irrigation in the district is mostly done by canals and tube wells. The general slope of the district is from north to south. The natural drainage is a problem in some parts of Gohana tahsil.

2.1.2. Canals

Canals form the chief means of irrigation. The Western Yamuna Canal is the oldest Canal in the district. All the distributaries depend upon the Yamuna Canal for water requirement. The canal takes off from the Yamuna River at Tajewala headquarters. At Indri Regulator, the Canal bifurcates into Sirsa Branch and Main Branch. Further 48 kilometers down at Munak, Main Branch bifurcates into Hansi and Delhi Branches and Gohana Distributary. A good network of canals has come up assuring prosperity of the area.

Water Channels and distributary system that irrigate the district include Israna, Gohana, Bajana, Rohtak, Bhalaut sub branch, Dobheta, Bhainswal, Juan, Pai, Ganaur, Rajpura, Sardhana, Sonepat, Kakroi, Harsana, Ladpur, Nahri Major, Nahri Minor, Butana, Sunder, Munshi Ram Minor, Bayanpur Minor, Bidnauli Minor and Turakpur minor and direct outlets of Delhi Branch.

2.1.3. Ponds

A **pond** is a body of standing water, either natural or man-made, that is usually smaller than a lake. 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 features. The map of total waterbodies that include ponds, canals are shown in **Figure 10(a)** and map of Monsoon waterlogged area in Sonipat district **Figure 10 (b).** Block wise No. of Ponds in Sonipat District is shown in **Table 6.**

Table 6 -Block wise No. of Ponds in Sonipat District

Sr. No.	Block Name	No. of Ponds
1	Kharkhoda	253
2	Rai	167
3	Murthal	103
4	Sonipat	287
5	Ganaur	199
6	Gohana	296
7	Kathura	220
8	Mundlana	258

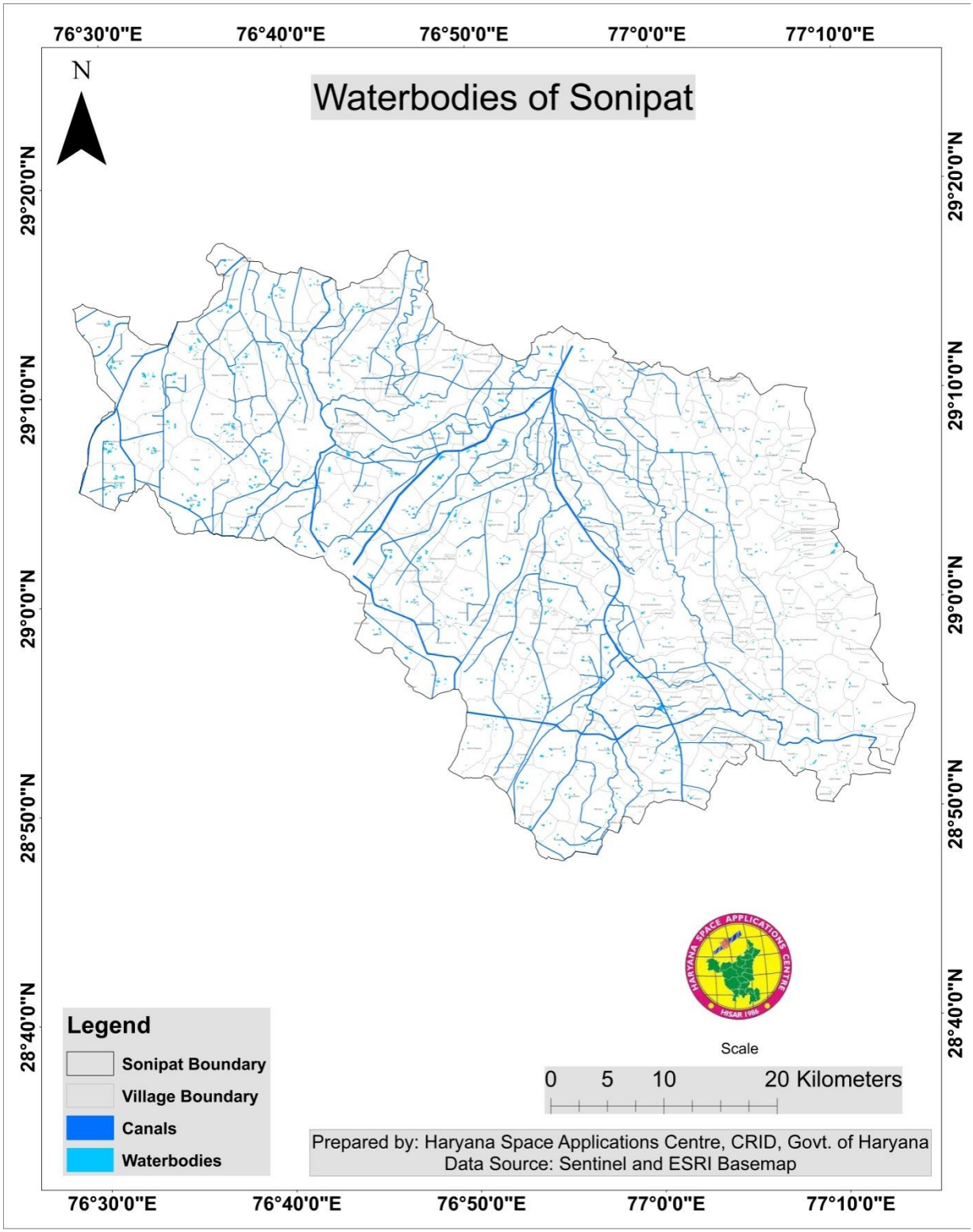


Figure 10- Water bodies of Sonipat District

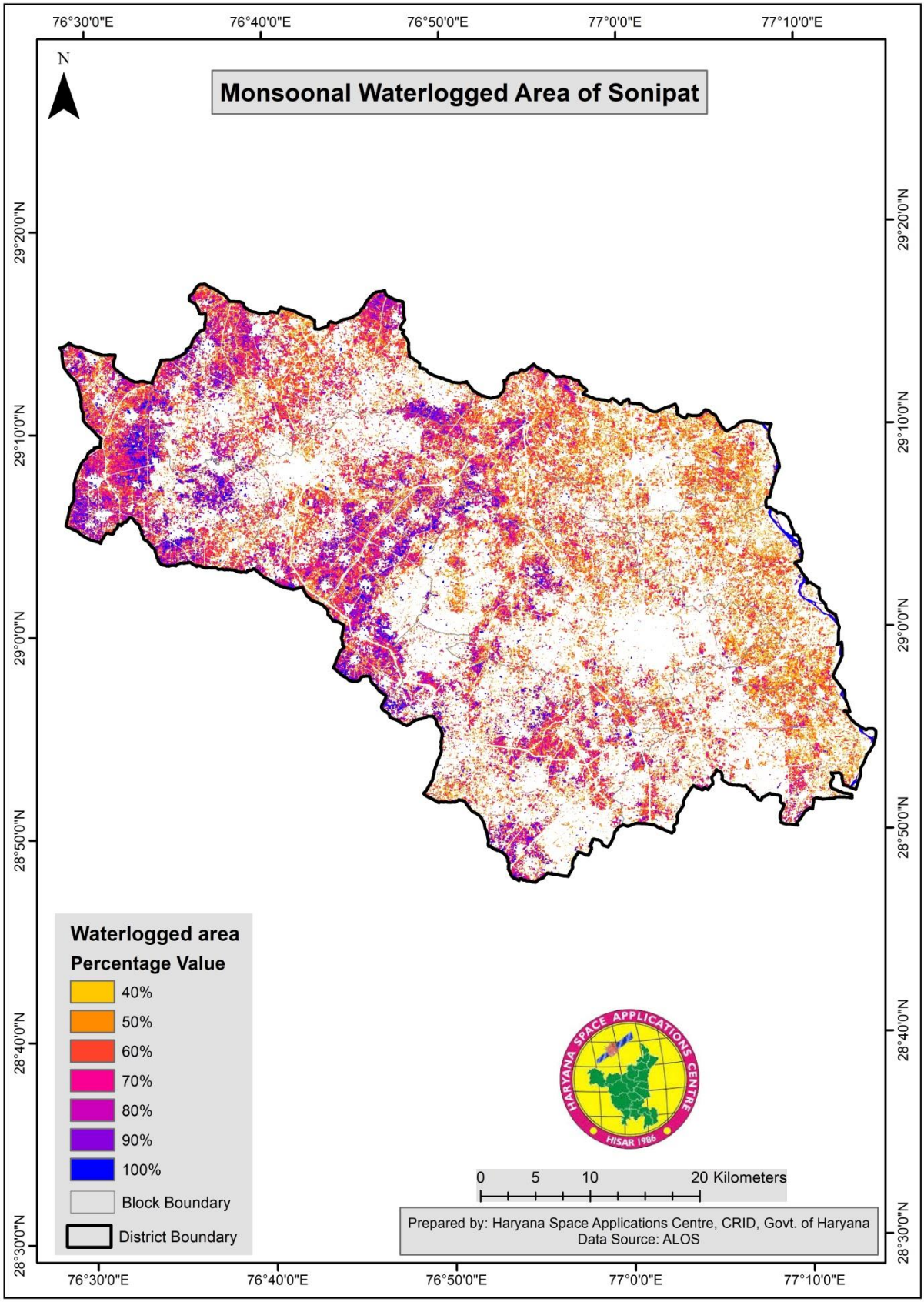


Figure 11 -Water Persistence's of Sonipat District

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. The drainage map of Sonipat District **Figure 11** and the statistics of length of drainage in Sonipat district are shown in **Table 7**.

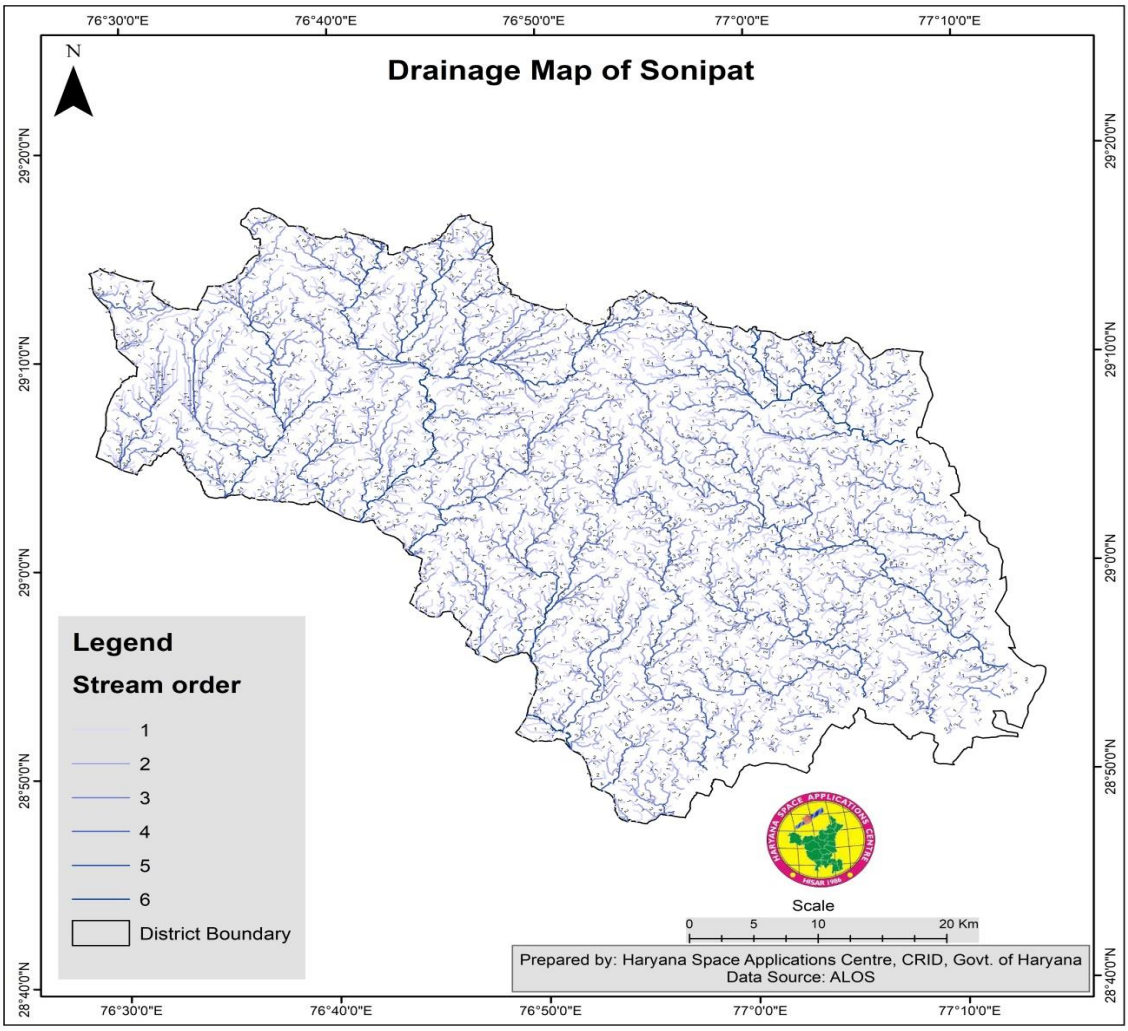


Figure 12 -Drainage Map of Sonipat District

Table 7 -Drainage order and total length of the drains in Sonipat district

Sr. No.	Order of Drainage	Total Length (in meter)
1	1st Order	1977362.87
2	2nd Order	1086927.31
3	3rd Order	551463.49
4	4th Order	303384.37
5	5th Order	154124.52
6	6th Order	58852.85

2.2. Water Harvesting System

2.2.1. Roof Top Harvesting

Agriculture department has introduced a State Plan scheme during the year 2005-06 namely "2402 soil & water conseration-102-soil conservation, sb-80 scheme for providing assistance on adoption of water saving technologies" under which a component "accelerated recharge to ground water" to recharge the ground water in water level depleting areas of the state. Under this scheme, 850* roof top rainwater harvesting structures has been constructed on Govt. buildings in the State up to 2018-19.

These structures are installed in Govt. buildings, preferably in Schools.

• It ensured that no contaminated water reaches the structure.

• The Roof-top area where recharge structure is to be constructed should be more than 100 square meters.

• The size of recharge pit/filtration tank taken for uniformity is of 2.5*2.5*2.5 m3 dimensions. The laying of filter-material lying in the tank is at least 0.50m, 0.40m and 0.40m thickness, comprising of respectively the rounded (not broken) boulders, gravel and sand from bottom to top.

In general, there are three main types of rainwater harvesting systems, which include direct pump, indirect pump and indirect gravity. Mentioned below (**Table 8**) is some of the most popular rain water harvesting techniques.

Table 8 -Water Harvesting System in Sonipat District

Sr.NO.	Activity Name	Works Completed	Works Ongoing	Expenditure (in Lakhs)
1	Check Dam		1	
2	Pond / Tank		2	
3	Trench	0	0	
4	Rooftop Water Harvesting Structure (Public)	126	0	
5	Rooftop Water Harvesting Structure (Private)	215		
6	Other Rainwater Recharge Structures (Open Well Recharge, Sand Filter for open well recharge)		3	
7	Other Water Conservation Structures (Bench Terracing, Canal)		9	
1	Traditional Water Bodies Restored	24	9	
1	Soak Pit	1218	0	
2	Stabilization Pond	0	0	
3	Other Reuse / Recharge Structure	4	0	
1	Gully Plug	0	0	
2	Percolation Tank		0	
3	Staggered Trenches	0	0	
4	Other Watershed Construction Activities	40	15	
1	Intensive Afforestation-Nurseries	424753	0	
2	Intensive Afforestation-Plantation		1	

1	Farmer's training programs by KVKs on Water Use Efficiency and Appropriate Crops	3		
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	571		
1	Use of Treated Waste Water	72		

2.2.2. Water Harvesting system other than roof top

The perusal of depth wise chemical data as tabulated indicates that many of the ground water samples of the 1st aquifer system have pH higher than BIS permissible limit for drinking water (6.5-8.5) and varies from 7.96 to 8.86. The water has low salinity with highest EC value of 636µmhos/cm. All the parameters determined are within the BIS permissible limits for drinking water. Well waters from 4th aquifer system have the parameters within the BIS permissible limits of drinking water with exception of pH and F which vary up to 8.8 and 1.62 mg/l respectively. A wide variation in the computed alkalinity hazard ratios have been observed in the 1st aquifer zone with SAR values ranging between 0.36 to 13.31. Similarly, RSC values range from 0.93 to3.31 m eq/l. Water only from Bakarpur is suitable for irrigation purposes with respect to SAR and RSC. The water from other locations can be used on well drained soils or after blending with better quality water before use for agriculture. Though the water of the 4th aquifer has low salinity and medium SAR values with respect to irrigation, it has limited suitability for irrigation purposes due to high RSC values that vary from 2.86 to 3.26 m eq/l. It is observed that the water quality of 1st and 4th aquifer is similar with exception of Fluoride which is higher and also beyond the BIS permissible limit in the 4th aquifer. In general, there is not much variation in salinity, SAR and RSC values with depth with exception in the sample of the 1st aquifer at Bakarpur where the values are low and water is suitable for irrigation. The map of water conservation activity in Sonipat at rural and urban level is shown in **Figure 12**. The total no of activities achieved in Sonipat District for rain water harvesting is shown in **Table 9** at rural and urban area.

Table 9 -Water Harvesting technique in Rural area and Urban Area.

In Rural Area		
Sr. No.	**Block Name**	**Total No of Activity**
1	Ganaur	170
2	Gohana	92
3	Kathura	225
4	Kharkhoda	358
5	Mundlana	60
6	Rai	241
7	Sonipat	254
8	Murthal	13
In Urban Area		
1	Sonipat	259

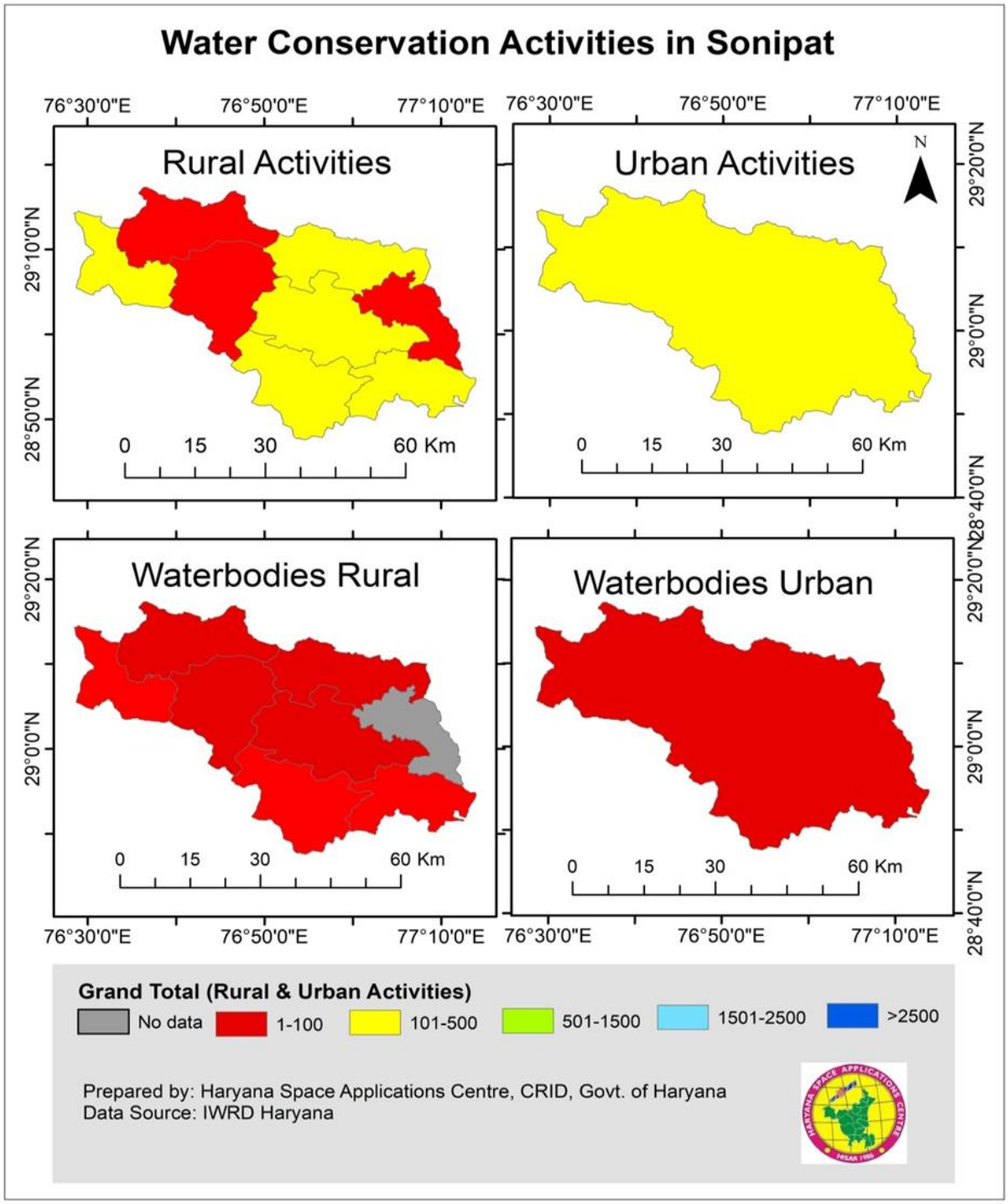


Figure 12- Water Conservation Activities in Sonipat District

2.2.3. Sewerage Treatment Plant

Sewage treatment (or domestic wastewater treatment, municipal wastewater treatment) is a type of wastewater treatment which aims to remove contaminants from sewage to produce an effluent that is suitable for discharge to the surrounding environment or an intended reuse application, thereby preventing water pollution from raw sewage discharges. Sewage contains wastewater from households and businesses and possibly pre-treated industrial wastewater. There are a high number of sewage treatment processes to choose from. These can range from decentralized systems (including on-site treatment systems) to large centralized systems involving a network of pipes and pump stations (called sewerage) which convey the sewage to a treatment plant. For cities that have a combined sewer, the sewers will also carry urban runoff (storm water) to the sewage treatment plant. Sewage treatment often involves two main stages, called primary and secondary treatment, while advanced treatment also incorporates a tertiary treatment stage with polishing processes and nutrient removal. Secondary treatment can reduce organic matter (measured as biological oxygen demand) from sewage,using aerobic or anaerobic biological processes.

A large number of sewage treatment technologies have been developed, mostly using biological treatment processes. Engineers and decision makers need to take into account technical and economic criteria, as well as quantitative and qualitative aspects of each alternative when choosing a suitable technology. Often, the main criteria for selection are: desired effluent quality, expected construction and operating costs, availability of land, energy requirements and sustainability aspects. In developing countries and in rural areas with low population densities, sewage is often treated by various on-site sanitation systems and not conveyed in sewers. These systems include septic tanks connected to drain fields, on-site sewage systems (OSS), vermifilter systems and many more. On the other hand, advanced and relatively expensive sewage treatment plants in cities that can afford them may include tertiary treatment with disinfection and possibly even a fourth treatment stage to remove micro pollutants. The purpose of a sewage treatment plant is to thoroughly treat wastewater. The sewerage treatment plant map is shown in **Figure 13**. In Sonipat District total 8 treatment plant are installed having total capacity of approx. 80-90 MLD.

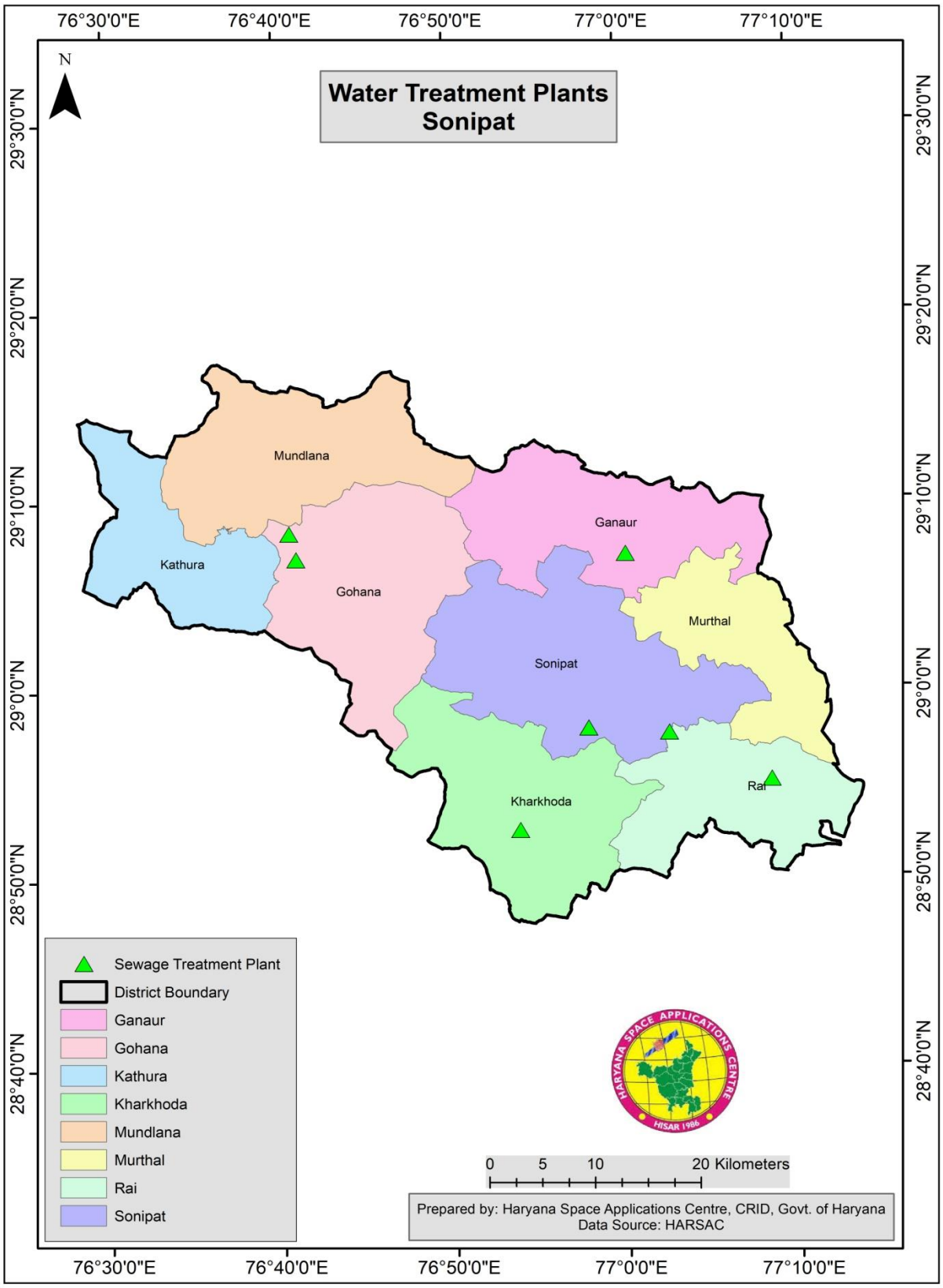


Figure 13- Water Treatment Plant in Sonipat district

3. Irrigation Profile

Irrigation in the district is done by surface and ground water as well. Around 42% of the area is irrigated by tube wells and rest of the area is irrigated by canals. About 96% area has been irrigated with respect to net sown area in the district. The district has a high irrigation intensity of 159%. About 91% area of the district is gross area irrigated with respect to total cropped area. The area, which is irrigated by surface water lies towards west where ground water is mostly saline while ground water irrigation is maximum in the eastern parts adjoining the Yamuna River. In this part of the district, ground water is fresh. The canal irrigation is mainly done by West Yamuna Canal system.

3.1. Water Availability

3.1.1. Surface Water Availability

Sonipat district has poor surface drainage due to which systems of abundant paleo-channels have developed. The Yamuna River makes a common boundary of about 49 kilometers between the district and Uttar Pradesh State. During this course, the river falls in elevation from 218 meters to 209 meters giving it a very gentle gradient and forms a flood plain on eastern side of its bed.

3.1.2. Ground Water Availability

The block wise ground water resource potential in the district has been assessed as per GEC-97 as on March 2009. The stage of ground water development ranges between 78% (block-Kathura) to 196% (block-Rai). The total replenish able ground water resource in the district is 774.26 mcm, of which the total existing ground water draft by all means is 945.35 mcm. The net utilizable ground water resources for future irrigation development are -173.64 MCM.

Discharge of the tube wells increases from west to east towards river Yamuna. Good aquifer exists in the flood plain of Yamuna River. The discharge of tube wells constructed in Mundlana, Gohana, Kathura, and Kharkhoda blocks is generally up to 10 lps (86.4 m3 /day). However, in the eastern parts of Ganaur, Sonipat and Rai blocks high discharge wells up to 20 lps have been reported. The following map (**Figure 14**) depicts the ground water depth in Sonipat district and the **Table 10** gives the description of ground water resource and development potential of Sonipat District.

Table 10- Block wise Ground water Resources of Panipat District

Block	Net annual Groundwater availability (ham)	Existing Gross groundwater draft for irrigation(ham)	Existing Gross groundwater draft for all uses(ham)	Provision For domestic & industrial requirement supply to 2025 (ham)	Net annual Ground Water Availability for future irrigation development (ham)	Stage of Ground Water development (%)	Category
Ganaur	19778	22384	23711	1327	-3933	120	OVER EXPLOITED
Gohana	7609	10183	10282	99	-2673	135	CRITICAL
Kathura	5344	4187	4193	261	896	78	SAFE
Kharkhoda	8067	11420	11541	121	-3474	143	CRITICAL
Mundlana	15751	12566	12575	9	3176	80	SAFE
Rai	7902	14472	15526	1054	-7624	196	OVER EXPLOITED
Sonipat	12975	15410	16707	1297	-3732	129	OVER EXPLOITED
Total	77426	90622	94535	4168	-17364	122	

Source: http://cgwb.gov.in/District_Profile/Haryana/Sonepat.pdf

The stage of ground water development ranges between 78% (block-Kathura) to 196% (block-Rai). The total replenish able ground water resource in the district is 892.42MCM, of which the total existing ground water draft by all means is 907.29 MCM. The net utilizable ground water resources for future irrigation development are -173.64 MCM. **Table 11** gives the description of ground water availability of Sonipat District.

Table 11 -Ground Water availability

Block Name	Critical	Semi-critical	Safe	Draft	Recharge	Gap
Ganaur	Overexploited			244.42	220.44	24.02
Gohana			Safe	74.27	82.99	8.72
Kathura			Safe	46.68	66.84	20.16
Kharkhoda			Safe	72.22	81.73	9.51
Mundlana			Safe	132.59	181.47	48.88
Rai	Overexploited			139.83	96.79	-43.04
Sonipat	Overexploited			197.28	162.16	-35.12
Total				**907.29**	**892.42**	**-14.91**

Source: Ground Water Cell, Sonipat

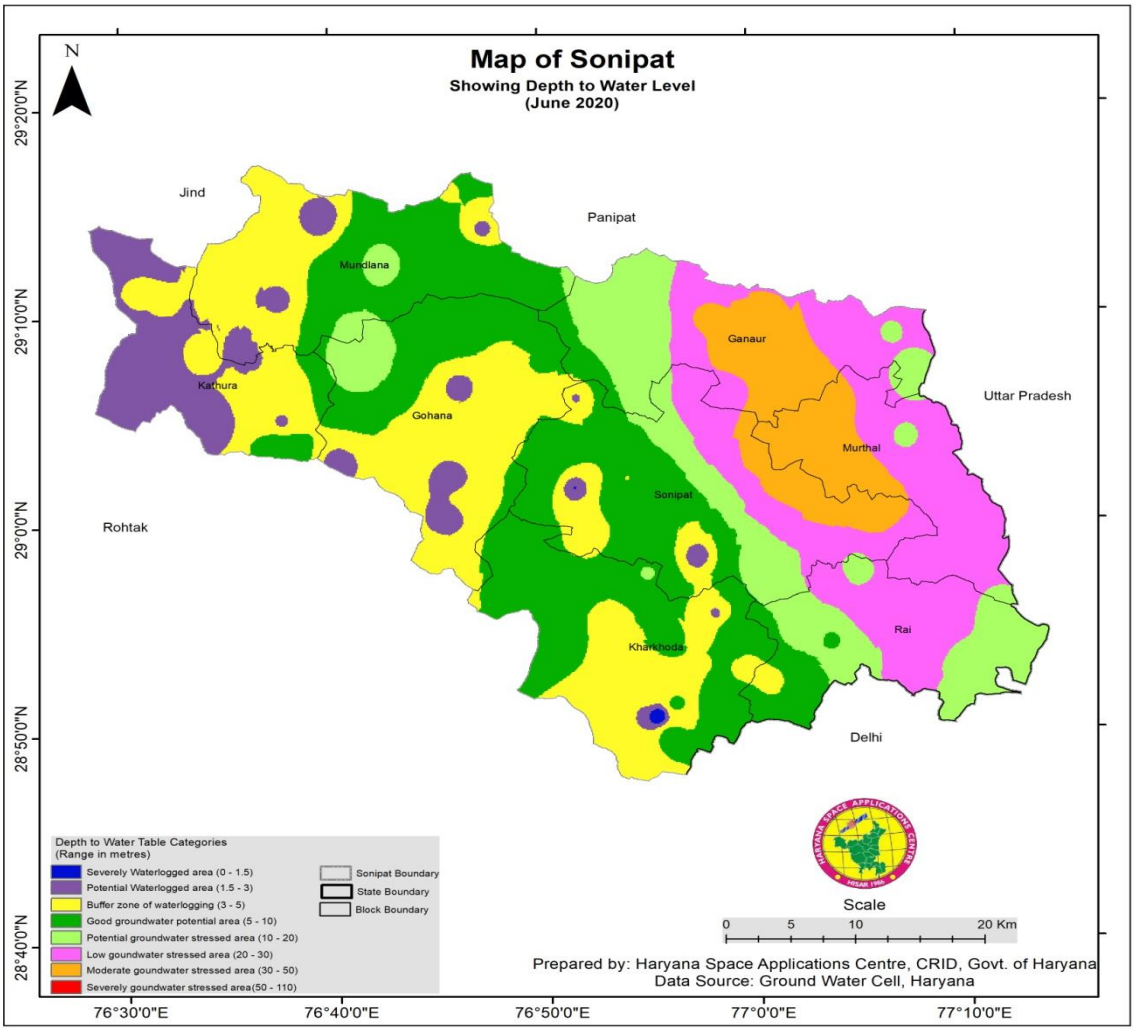


Figure 14- Ground water Availability Map of Sonipat District

3.2. Ground Water Quality

Groundwater of the Sonipat district is alkaline in nature and of medium to high salinity category. Spatial differences between the EC and TDS values reflect the wide variation in the activities and processes prevailing in the region. HCO3, Cl and SO4 are the dominant anions both in shallow and

deep aquifer. Water chemistry of the Sonipat district is dominated by alkalis over alkaline earths (Ca and Mg) and Na alone constitute 50% of the total cations The values of TDS exceed the desirable level in 87% and total hardness values in >74% of the samples, indicating higher dissolved ionic concentrations. Concentration of Exceeds the permissible limit of 1.5 mg/l in about 26% of the groundwater samples. Concentrations of Cland SO4 2- also exceed the desirable levels in many groundwater samples of the area. In general, drinking water quality is beyond the acceptable standard in respect of TDS, SO4, F, Ca, Mg, alkalinity and hardness in several cases. Heavy metals analysis shows that concentrations of some heavy metals (Fe, Mn, Al, Cu, Ni, As and Se) are present well above the prescribed desirable levels recommended for the drinking water in many groundwater samples. Concentrations of Co and Cd are found well within the threshold values. Quality assessment of water for irrigation uses show that the groundwater is good to permissible quality. However, high values of salinity, residual sodium carbonate (RSC) and Na% are seen at certain sites.

The shallow ground water of the district is generally alkaline in nature and is moderate to highly mineralize with EC ranging from 597 to 6710µS/cm. at 250C. Ground water occurring in the southern and N-W parts of the district is more saline as compared to ground water occurring in the rest of the district. Among anions, either bicarbonate predominates or none of the anion dominates. Similarly, among cations, sodium predominates in 50% of the samples and in the remaining calcium + magnesium combined dominates.

On comparing the ionic concentration of major ions with the recommended limits prescribed by Bureau of Indian standards for drinking waters, it is found that more than half (68%) the ground waters are not suitable for drinking purposes mainly due to salinity and fluoride contents that exceed the maximum permissible limits of these chemical parameters, which are 3000µS/cm. and 1.5mg/l respectively. Plot of USSL diagram used for the determination of irrigation rating of ground waters indicates that ground waters at several places fall under C2S1, C3S1, C3S2, C4S2 classes of irrigation rating. These waters are, therefore, suitable for customary irrigation for salt tolerant crops like wheat, rice, maize, gram etc. without any fear of salinity hazards to the crops. Waters falling under C4S3 and C4S4 classes are likely to cause salinity as well as sodium hazards. It would be better if such waters are used for irrigating salt tole.

Type of Water: The shallow ground water is of Ca +Mg-HCO3 and Na-mixed Anion type and mixed facies type of water also occur in the district. Based on that Sonipat district's water quality varies from good to poor (**Figure 15**) and block wise average water quality index value in Sonipat District is shown in **Table 12** below.

Table 12 Block wise average water quality index value in Sonipat District

Sr. No.	Block Name	Average Water Quality Index value
1	Ganaur	150.555463
2	Gohana	189.87398
3	Kathura	161.515159
4	Kharkhoda	189.976492
5	Mundlana	222.014641
6	Rai	261.573759
7	Sonipat	166.167859
8	Murthal	113.37977

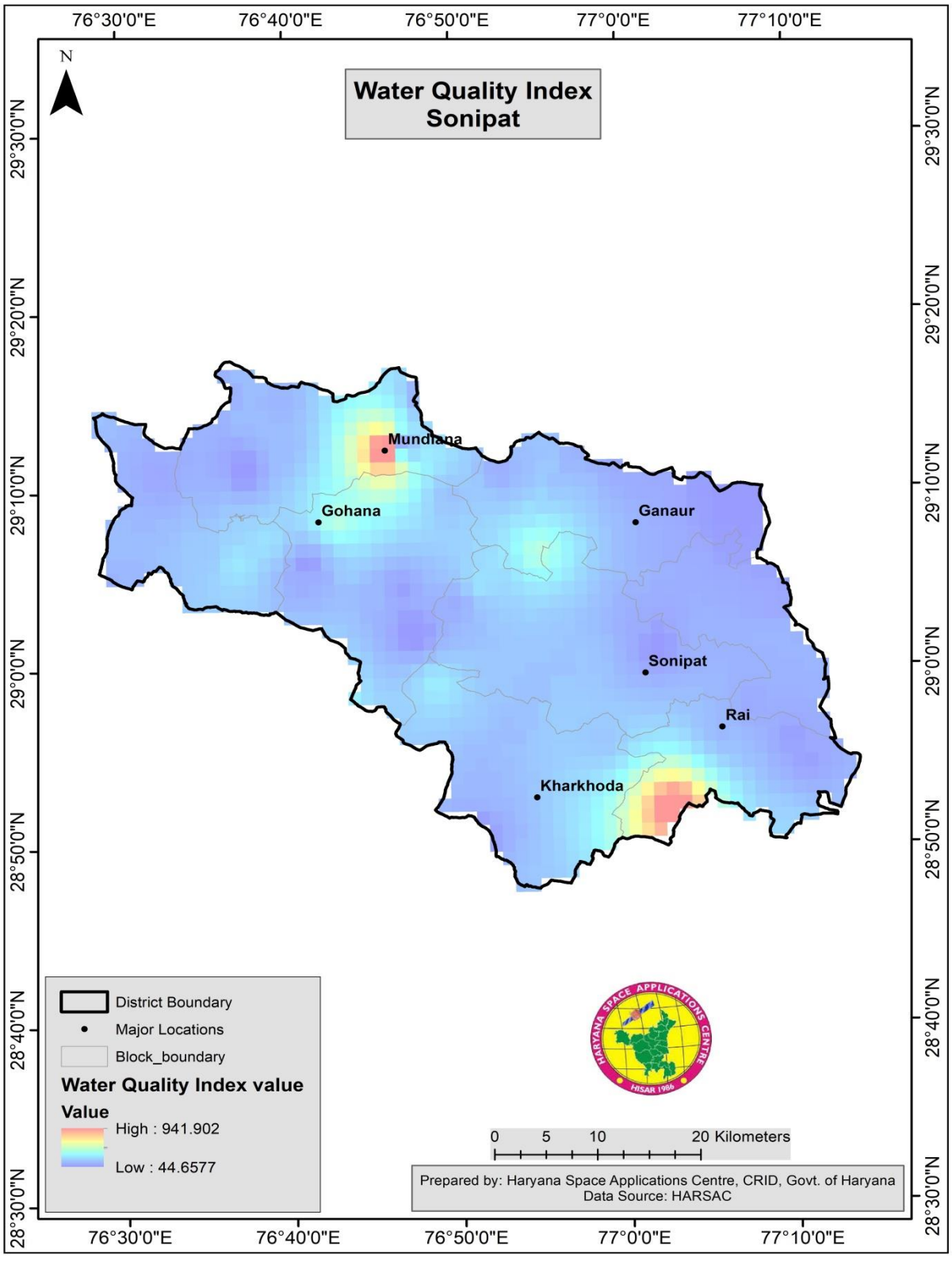


Figure 15 Water quality index of Sonipat District

4. Aquifer System

Ground water occurs in alluvial sand, silt, kankar and gravel, which form potential aquifer zones. Depth to water level during pre-monsoon varies from 1.41 – 23.22m while during post-monsoon it varies from 0.99 – 24.46m. The depth to water level lies within 10m below the land surface in most parts of the district. It rests between 2 to 25m deep in the eastern side and 2 to 10m in the north western parts of the district. Only in small patches in the Rai block, water table are deeper having range of 20m to 40m. Water table elevations range from 230 to 220m amsl and the general ground water flow is from northwest to southeast. In general, the water table has declined all over the district over the past decade. During past few decades the district has recorded a fall of less than 1m to 7m. The decline was 2 to 4m in most parts of the district. Long term water level fluctuations indicate rise of water level over a period of last one decade in Mundlana, Kathura, Kharkhoda and Rai blocks. The trend of rise of water level is in the range of 0.05 to 0.32m/year. The trend of decline of water level is 0.05 to 0.95m/year. Central Ground Water Board has drilled 15 wells underground water exploration programme; 8 are exploratory wells, 5 are piezometers and 2 are slim holes. Out of 8 boreholes drilled for ground water exploration, 7 were abandoned due to poor quality of ground water or due to inadequate thickness of permeable granular zones. Granular zones exist down to 460m depth *i.e*. to depth explored. However, the chemical quality of ground water is not fresh in deeper horizons in most parts of the district and in shallow horizons; in some parts. In general, the quality of ground water in shallow dug well zones is fresh in the eastern and north, northwest parts and gradually gets deteriorated in the western and southwestern parts. Also the deep zones below 150m depth contain brackish / saline ground water. A number of shallow tube wells exist in all the blocks – more in number in Sonipat, Rai and Ganaur block and these tap water bearing zones in the shallow unconfined aquifer group. These tube wells yielded 300 to 600 lpm for moderate drawdowns. Detailed test drilling has established occurrence of three distinct aquifer groups, down to 450m depth in Upper Yamuna Basin which includes Sonipat district. Aquifer group-I which was in unconfined state extends from water table down to 70m depth. A tube well located at Khera in the eastern part of the district and tapping this aquifer group-I, yielded 4540 lpm for about 7.5m of drawdown. Aquifer characteristics at Khera site were – transmissivity: 2340m2 /day, lateral hydraulic conductivity – 36m/day and specific yield – 2.15 x 10-1 (21.4%). This aquifer group-I contains fresh water in eastern parts of the district. Aquifer group-II which is under semi-confined/confined state occurs in the depth range of 90 to 200m and has not been tested for its yield and aquifer characteristics since the formation water is saline. Aquifer group-III which too is under confined state occurs in the depth range of 250 to 400m and contains brackish saline ground water.

5. Water Requirement/ Demand

There is exploitation of ground water due to availability of less water in existing canal system and sweet ground water. In three no blocks water table has gone below critical level. The gap in ground water recharge is highest in case of Rai block where it has been estimated at-

43.04 MCM followed by Sonipat (-35.12 MCM) and Ganaur (-24.02 MCM). There is surplus of ground water in remaining blocks due to proximity of Yamuna River.

Some of the suggestions offered by CGWB in its district report are:

- Construction of shallow tube wells in areas along active flood plains of river Yamuna, which have shallow water level can help in augmenting water supplies in the area
- Areas witnessing decline of water levels have to be demarcated and rainwater harvesting to artificial recharge measures be taken up in a big way to reduce the impact.
- Areas having shallow water levels and soil water salinity be improvised using subsurface drainage.

Possibility of Artificial Recharge

There are few isolated pockets located in the eastern part of the district where water levels are declining very fast. Fresh ground water at deeper level is being exploited by deep tube wells. Limited possibilities of artificial recharge exist in these areas during monsoon season, where excess runoff from upland areas can be utilized. Some of drains which were constructed to drain out excess water can be utilized for artificial recharge by constructing suitable recharge structures, such as injection wells, recharge shafts etc.

Water Conservation Structures

There is not much work carried out in the district. However, about 402 ponds exist in all the blocks, which act as fresh rainwater conservation structures. Out of these 75 ponds exist in Ganaur, 52 in Gohana, 30 in Kathura, 50 in Kharkhoda, 38 in mundlana, 65 in Rai and 92 in Sonepat block.

Ground Water Development

The hydrogeological data generated through exploratory drilling has proved a vital information regarding identification of aquifer systems, demarcation of their vertical and lateral extent, delineation of potential aquifer characteristics. These studies also provide information on well design and drilling techniques. A well assembly of 203mm dia, using about 20m to 30m long housing pipe and MS slot pipe with slots of 1.19 mm to 1.59 mm size would be ideal in the district area. “V” wires galvanized Screen having 0.50- 1.5mm slot can also be used as it can provide more open area then conventional

slotted pipes. Entrance velocity of water in the well has to be kept in mind while designing the well assembly.

5.1. Water Supply and Gap

Domestic Water Demand

Data of Census 2011 and 2001 has been considered to arrive at the growth rate of population of the district. As per Census 2011, the district has shown an annual growth rate of 1.335 percent. Current and projected population has been estimated assuming the same growth rate of 1.335 percent per annum. It has been assumed that per capita daily water requirement of people residing in urban areas of the district is 150 Liters and for population in rural areas, the daily per capita daily water requirement is 70 Liters. Using the same norms domestic water supply demand has been worked out and given in **Table 13** below.

Table 13 -Domestic Water Requirement (MCM)

Blocks	Population In 2011	Existing Population	Present Water Requirement	Projected Population In (2022)	Annual Water Requirement In (2022)
Ganaur	225631	240692	6.8	259972	8.16
Gohana	187345	199850	6.71	215858	7.72
Kathura	72709	77562	1.86	83775	2.14
Kharkhoda	162858	173729	4.89	187645	5.65
Mundlana	111980	119455	2.86	129023	3.30
Rai	198707	211971	5.91	228950	6.81
Sonepat	490771	523530	21.25	565465	24.49
Total	145001	1546789	50.29	1670688	58.27

It can be inferred from the table that considering the growth rate of population of the district, the quantity of water required in 2022 for domestic consumption shall be approximately 58.27 MCM which is 7.98 MCM more than the present water requirement.

Crop Water Requirement

The crops grown in the district are divided into two main categories viz. Kharif and Rabi, locally called as Sawani and sadhi. The former is the summer season harvest and the later, the winter season harvest. Any crop which does not strictly fall within these two harvests is known as a Zaid crop and its harvest is called the Zaid Kharif or Zaid Rabi, according to the harvest with which it is assessed. Toria (an oilseed) is cultivated as Zaid Kharif and vegetables, melon and green fodder as Zaid Rabi.

Major Kharif crops of the district include paddy, jowar, bajra pulses and sugarcane. Minor ones include maize and cotton. Major Rabi crops reported from the district include wheat and rapeseed &

mustard only. Vegetables, potatoes and onions are also part of Rabi and kharif crops. Apart, fresh fruits are also produced on 1,289 hectares. Taking into account, the water requirement for different crops, block-wise crop water requirement have been worked out and presented in **Table 14** below:

Table 14 - Crop Water Requirement (MCM)

Block	Area sown (Ha)	Irrigated area(ha)	Crop Water Demand	Water Potential Required	Existing Water Potential	Water Potential To be created
Ganaur	40800	40800	204	255	204	51
Gohana	37900	37500	189.5	236.88	189.5	47.375
Kathura	31000	30900	155	193.75	155	38.75
Kharkhoda	37100	37100	185.5	231.88	185.5	46.38
Mundlana	42000	41800	210	262.5	210	52.5
Rai	30200	30200	151	188.75	151	37.75
Sonipat	39900	39900	199.5	249.38	199.5	49.88
Total	25890	258200	1294.5	1618.13	1295	323.63

Livestock

The requirement of water for livestock of the district has been derived from last two livestock census (2007& 2012). The table below represents the animal wise water requirement as well as total water requirement of the district for livestock.

The block wise water estimation for livestock is as follows in **Table 15:**

Table 15- Livestock Water Requirement (MCM)

Block	Total number of livestock	Present water Demand	Water Demanding (2022)	Existing Water potential	Water potential to be created
Ganaur	323707	1.27	1.27	1.27	0
Gohana	200177	1.19	1.19	1.19	0
Kathura	75946	1.16	1.16	1.16	0
Kharkhoda	317802	1.25	1.25	1.25	0
Mundlana	111795	1.29	1.29	1.29	0
Rai	323586	1.36	1.36	1.36	0
Sonipat	148746	1.24	1.24	1.24	0
Total	1501759	8.76	8.76	8.76	0

Based on the projected water requirement for livestock in 2020, the gap has been assessed. The total potential which has to be created for livestock in 2020 is nil. This has been assessed on the terms of the following:

- Per capital daily water requirement for cows/buffaloes 65 liters, sheep/goats/pigs 5 liters and Poultry 0.25 liters.
- For projecting the water demand of livestock, growth rate as deduced from census has been considered during calculations. In case of livestock with decreasing growth rate of population, the present population has been considered. It is assumed that present water requirement of livestock is met from existing water usage and hence existing potential is equal to existing demand.

Industrial Water Requirement

Sonipat district was having no big industrial unit in the pre-partition period. Major base of the economy of the district was agriculture. Only Village and Cottage industries were dominating like carpentry, stone-dressing, pottery, leather tanning, handloom weaving and utensil making. Owing to one reason or the other, these have been decaying. At present, 158 large and medium industrial units are functioning in the district as per list of large and medium units, 2010 issued by the Industries Department, Haryana. Most of these have sprung up during the past two decades only.

Large and medium units are mainly concentrated in Sonipat urban and surrounding rural areas falling between Sonipat and Delhi which cover villages Kundli, Bahalgarh, Murthal, Rasoi, Rai etc.

The requirement of water for industries has been calculated from data availed from District Industries Centre, Sonipat. Table below indicates the present and future water demand of industrial units in the district. Industrial Water Requirement (MCM) shown in **Table 16**.

Table 16 Industrial Water Requirement (MCM)

Block	Name Of The Industry	Current Water Demand	Water Demand In 2022	Existing Water Potential	Water Potential to be created
Ganaur		0.006	0.006	0.006	0.000
Gohana		0.001	0.001	0.001	0.000
Kathura		0.000	0.000	0.000	0.000
Kharkhoda		0.002	0.002	0.002	0.000
Mundlana		0.001	0.001	0.001	0.000
Rai		0.015	0.017	0.017	0.000
Sonipat		0.032	0.035	0.035	0.000
Total		**0.057**	**0.063**	**0.063**	**0.000**

Water Demand for Power Generation

The district does not have any thermal/ nuclear power plant where water is consumed. It has been decided to switch to Solar power which require nominal water if installed.

Total Water Demand of the district for various sectors

This section presents the total water demand of the district and has been calculated by summing up all major sectors consuming water. The projected water demand has been depicted in **Table 17** below:

Table 17 -Sector wise present water requirement (2016)

Blocks	Demand from components (MCM)					Total
	Domestic	Crop	Livestock	Industrial	Power	
Ganaur	6.8	255	1.27	0.006	0	263.08
Gohana	6.71	236.88	1.19	0.001	0	244.78
Kathura	1.86	193.75	1.16	0.000	0	196.77
Kharkhoda	4.89	231.88	1.25	0.002	0	238.02
Mundlana	2.86	262.5	1.29	0.001	0	266.65
Rai	5.91	188.75	1.36	0.015	0	196.04
Sonepat	21.25	249.38	1.24	0.032	0	271.90
Total	50.29	1618.14	8.76	0.057	0	1677.25

The present water demand of the district has been assessed at 1677.25 MCM annually, with Sonipat being the block with maximum water requirement (271.9MCM). Mundlana and Ganaur blocks stand at 2nd and 3rd position. Demand from components (MCM) shown in **Table 18**.

Table 18- Demand from components (MCM)

Blocks	Demand from components (MCM)					Total
	Domestic	Crop	Livestock	Industrial	Power	
Ganaur	8.16	255	1.27	0.006	0	264.44
Gohana	7.72	236.88	1.19	0.001	0	245.79
Kathura	2.14	193.75	1.16	0.000	0	197.05
Kharkhoda	5.65	231.88	1.25	0.002	0	238.78
Mundlana	3.30	262.5	1.29	0.001	0	267.09
Rai	6.81	188.75	1.36	0.017	0	196.94
Sonepat	24.49	249.38	1.24	0.035	0	275.15
Total	**58.27**	**1618.14**	**8.76**	**0.063**	**0**	**1685.24**

5.2. Water Budget

The total water gap for the district has been estimated at 311 MCM during 2022. The gap is maximum in case of Kharkhoda Block with108.9MCM followed by Kathura block (98.13 MCM) and Gohana block (55.5 MCM). Water budgeting (MCM) shown in **Table 19**.

Table 19 -Water budgeting (MCM) Sonipat District

Name of Blocks	Existing water availability		Total	Water Demand		Water Gap	
	Surface	Ground		Present	Project	Present	Project
Ganaur	38.67	220.44	259.11	263.08	264.44	-3.97	-5.33
Gohana	107.25	82.99	190.24	244.78	245.79	-54.54	-55.55
Kathura	32.08	66.84	98.92	196.77	197.05	-97.85	-98.13
Kharkhoda	47.97	81.83	129.8	238.02	238.78	-108.22	-108.98
Mundlana	106.13	181.47	287.6	266.65	267.09	20.95	20.51
Rai	38.65	96.79	135.44	196.04	196.94	-60.60	-61.50
Sonipat	110.58	162.16	272.74	271.9	275.15	0.84	-2.40
Total	**481.33**	**892.42**	**1373.85**	**1677.25**	**1685.24**	**-303.39**	**-311.382**

6. Strategies for Water Conservation

1. Construction of shallow tube wells in areas along active flood plains of river Yamuna, which have shallow water level, can help in augmenting water supplies in the area
2. Areas witnessing decline of water levels have to be demarcated and rainwater harvesting to artificial recharge measures be taken up in a big way to reduce the impact.
3. Areas having shallow water levels and soil water salinity be improvised using subsurface drainage.
4. Improved agricultural practices like establishing good crop stand, sowing/planting practices, material management, Irrigation water management e.g. land leveling should be implemented in the shallow water levels areas.
5. Local farmers, NGOs be educated in water management, conjunctive use of saline and fresh water, rainwater harvesting and artificial recharge methods.

Year Wise Total Plan of the District

Estimated plan for whole district under the scheme for six years works out to be Rs55838.36 lakhs. Irrigation Department accounts for a maximum share of Rs 35213 Lakh (63.06%) and is followed by CAD Department which has a budget of Rs 13290.7 Lakh *i.e.* 23.80%. Soil Conservation

Department accounts for the third highest share of about Rs. 4305.9 lakhs (7.71%) and is followed by Horticulture department which has a budget of Rs. 3028.76 lakh *i.e.* 5.42 percent. Details of the plan

are given in table and **Figure 16** below. Department wise proposed outlay of Sonipat district is shown in **Table 20.**

Table 20- Department wise proposed outlay

Year	Department wise outlay in Rs Lakh				Total
	Horticulture*	Irrigation	CADA	Agriculture & Soil Conservation	
2016-17	49.76	0	1684.9	717.65	2452.312
2017-18	266	11496	3415.4	717.65	15895.05
2018-19	343	4324	2149	717.65	7533.65
2019-20	540	5679	2455	717.65	9391.65
2020-21	825	7197	1675.05	717.65	10414.7
2021-22	1005	6517	1911.35	717.65	10151
Total	3028.76	35213	13290.7	4305.9	55838.36
					***Includes ATMA**

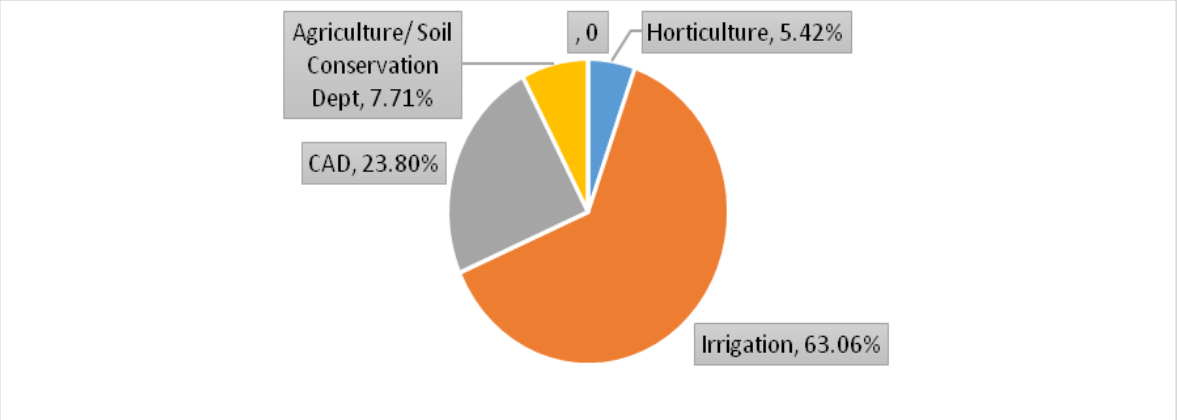


Figure 16- Department wise Share in PMKSY Plan

Component-wise Plan

The plan is prepared component wise also. Table 5.2 shows component wise plan for 6 years starting from 2016-17 to 2021-22. AIBP component is comprised of Rs. 22967 lakh which is 41.13 percent of the total proposed outlay. “Her Khet ko Pani” comprises of Rs. 25429.70 lakh *i.e*. 45.54 percent of the outlay. Per Drop More Crop component will be executed by Soil Conservation Department and Horticulture department. This component has a share of Rs. 5865.16 lakh *i.e*. 10.50 percent of the total outlay. Watershed component is to the tune of Rs. 289.5 lakh *i.e*. 0.52 percent of the outlay. Convergence with MGNREGA has a share of Rs 1287 Lakh which is 2.30 percent of the total outlay as shown in **Table 21** and in **Figure 17** below.

Table 21 -Component wise proposed outlay (amount in Rs. Lakh)

Component	AIBP	HKKP	PDMC	Watershed	Convergence With MGNREGA	Total
2016-17	0	1964.902	439.16	48.25	0	2452.312
2017-18	9540	4938.4	1155.4	48.25	213	15895.05
2018-19	1478	5039	732.4	48.25	236	7533.65
2019-20	3450	4706	929.4	48.25	258	9391.65
2020-21	5350	3525.05	1214.4	48.25	277	10414.7
2021-22	3149	5256.35	1394.4	48.25	303	10151
Total	22967	25429.702	5865.16	289.5	1287	55838.36

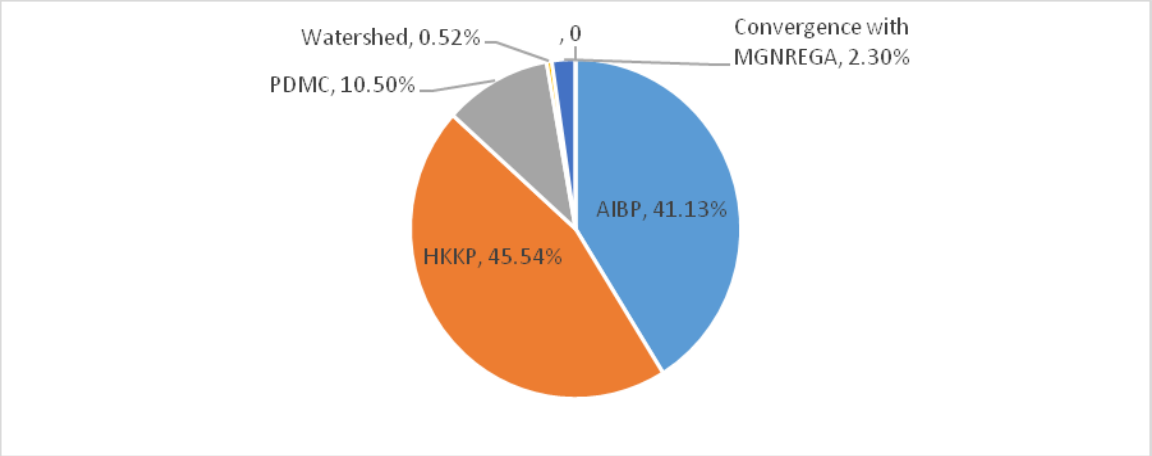


Figure 17 -Component wise proposed outlay (amount in Rs. Lakh)

Block wise Plan

Out of the total plan of 55838.36 lakh, 24.71% is pertaining to Sonipat block while Ganaur and Kharkhoda block each has a share of 19.67 % and 17.37% respectively. The share of Mudlana block is to the tune of 11.96% in total plan. Table below describes block and department wise share in plan. Block wise Plan (amount in Rs lakh) is shown in **Table 22** and in **Figure 18** below:

Table 22 -Block wise Plan (amount in Rs lakh)

Year	Ganaur	Gohana	Kathura	Kharkhoda	Mundlana	Rai	Sonipat	Total
2016-17	164.22	757.52	265.97	388.35	143.06	122.31	610.90	2452.31
2017-18	3472.95	998.90	142.80	1710.85	903.30	778.50	7887.75	15895.05
2018-19	1029.20	1136.45	289.80	838.15	1406.75	1051.70	1781.60	7533.65
2019-20	1556.34	1256.29	427.21	2278.69	1295.19	1670.19	907.74	9391.65
2020-21	3164.40	1039.85	346.60	2567.00	1009.40	1223.65	1063.80	10414.70
2021-22	1594.85	1349.25	539.40	1918.85	1922.65	1277.50	1548.50	10151.00
Total	10981.96	6538.26	2011.78	9701.89	6680.35	6123.85	13800.29	55838.36

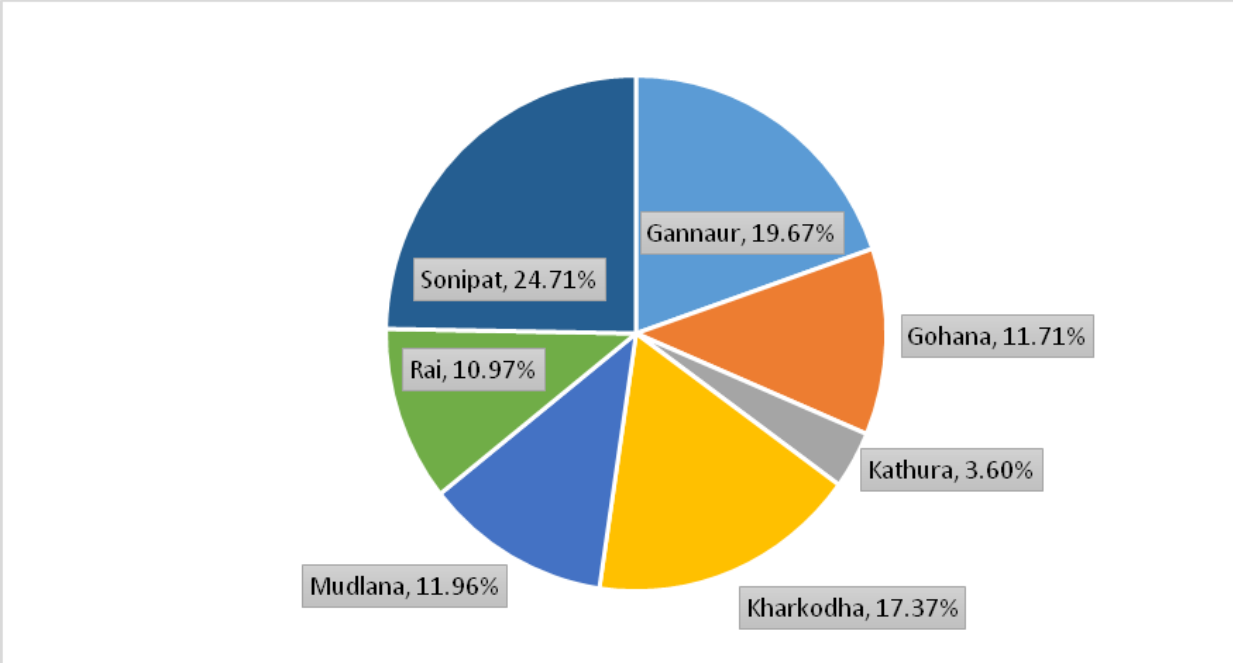


Figure 18- Share of Plan in PMKSY Outlay

Suggestions

For successful implementation of PMKSY plan it is suggested that:

- All the stakeholders should convene meeting of Panchayat Samities and then finalise the village plan and prepare DPR.
- There should not be any duplicity of project.
- The Department should supplement each other so that the maximum irrigation efficiency is achieved.
- Agriculture and Horticulture Department should take micro irrigation projects in the command of minor irrigation projects which are either completed or likely to be completed in near future.
- All the irrigation projects should have a component of water conveyance so that the each drop of water is judiciously utilized. Canal and watercourses should be maintained efficiently to provide water to each field to fulfill the dream of "Her khat Ko Pani".
- It is suggested that officer of rank of Sub Divisional officer, ADO of Agriculture & Horticulture, scientist of University should have one meeting with farmers in block per fortnight to know their requirements /difficulties regarding crop.
- Wherever feasible, Solar Pump sets should be installed.
- All the structures planned should be geo tagged and marked on map, so that social monitoring of the projects can be conducted. This will also avoid the duplicity.
- Priority should be given to projects to minimize the gap in potential created and potential utilized.
- Execution of the scheme should be expeditiously completed.
- There should be smooth fund flow for timely completion of the project and to avoid cost escalation.
- Water can be saved by its optimum utilization and adopting drip & sprinkler irrigation system.
- Farmers should be educated by Agriculture, Irrigation &Water Resources, Horticulture, and DRDA Department regarding optimum utilization of water.
- Availability of surface water through canal network should be increased to reduce the overdraft of limited underground water.

6.1. Artificial Recharge

There are few isolated pockets located in the eastern part of the district where water levels are declining very fast. Fresh ground water at deeper level is being exploited by deep tube wells. Limited possibilities of artificial recharge exist in these areas during monsoon season, where excess runoff

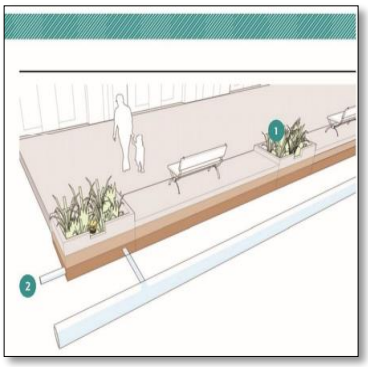
from upland areas can be utilized. Some of drains which were constructed to drain out excess water can be utilized for artificial recharge by constructing suitable recharge structures, such as injection wells, recharge shafts etc.

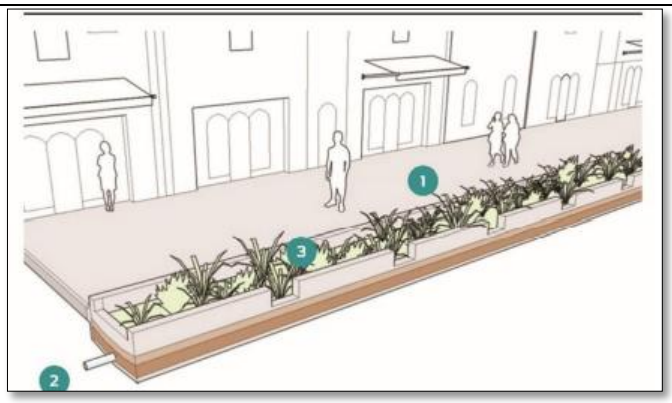
Possibility of Artificial Recharge There are few isolated pockets located in the eastern part of the district where water levels are declining very fast. Fresh ground water at deeper level is being exploited by deep tube wells. Limited possibilities of artificial recharge exist in these areas during monsoon season, where excess runoff from upland areas can be utilized. Some of drains which were constructed to drain out excess water can be utilized for artificial recharge by constructing suitable recharge structures, such as injection wells, recharge shafts etc.

6.2. 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 Sonipat. 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 more scarce in terms of frequency. The methods of water table recharge strategies in urban area are shown in **Table 23**.

Table 23 -Following table shows 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**	

6.3. 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 Sonipat 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. The wasteland that could be used for plantation for conservation of water in Sonipat district is shown in **Figure 19** and **Table 24** shows the plantation target in Gurugram District.

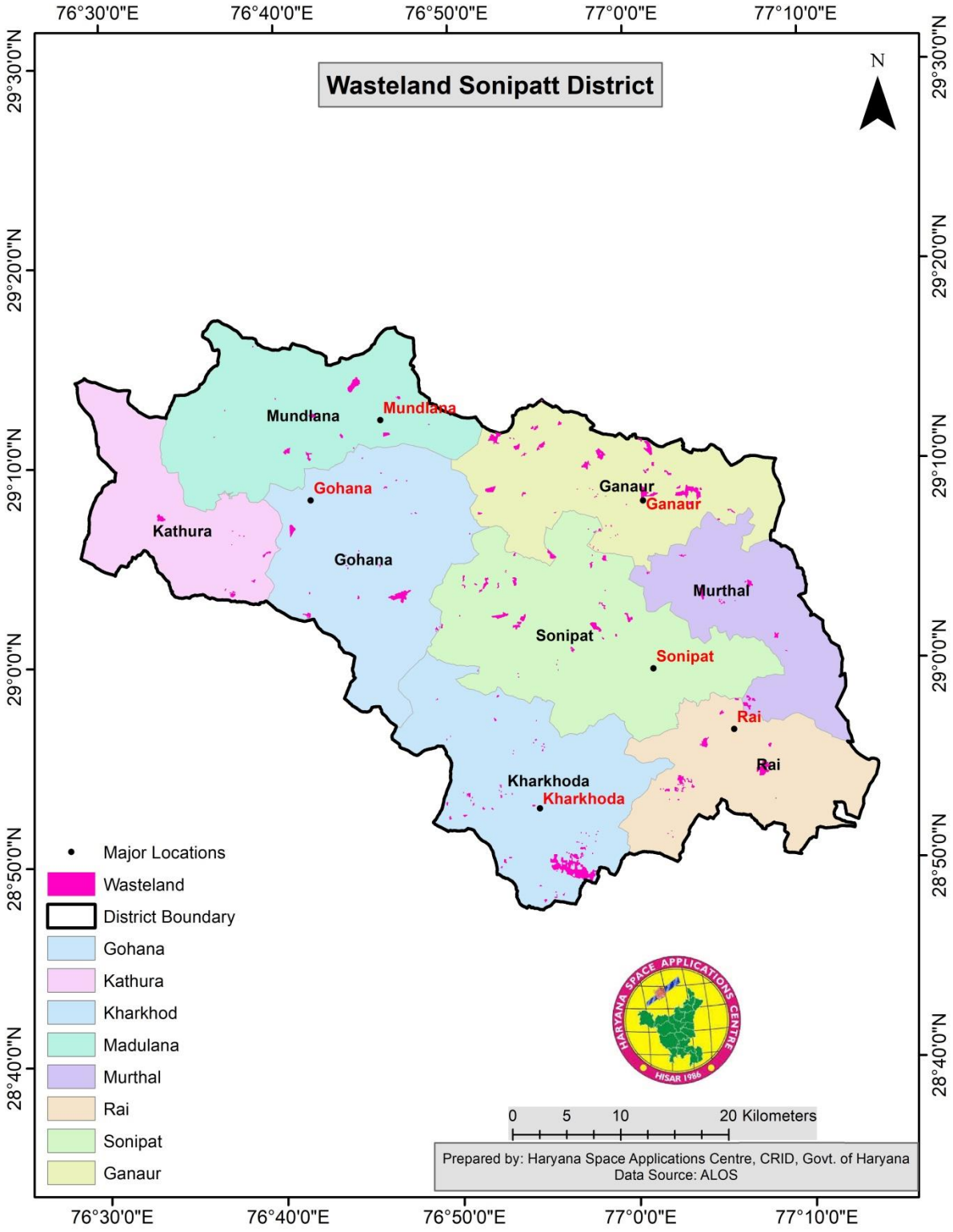


Figure 19- Wasteland Map of Sonipat district

Table 24 -The plantation targets have been provided in the table below

Block	Wasteland Area (Sq. ft.)	Plantation at 5 feet spacing
Sonipat	34476309.93	6895261
Gohana	21448826.14	4289765
Ganaur	68866322.52	13773264
Kharkhoda	61387558.53	12277511
Kathura	8033502.47	1606700
Mundlana	19751221.07	3950244
Rai	27000031.70	5400006
Murthal	14680543.07	14680543.1

6.4. Surface water management

There is not much work carried out in the district. However, about 402 ponds exist in all the blocks, which act as fresh rainwater conservation structures. Out of these 75 ponds exist in Ganaur, 52 in Gohana, 30 in Kathura, 50 in Kharkhoda, 38 in Mundlana, 65 in Rai and 92 in Sonipat block.

6.4.1. Pond restoration and rejuvenation

Priority ponds in Sonipat district 178.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 m3 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 a 11-step procedure 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.

6.4.2. 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 exists outside the city center and rural areas where open drainage systems still exits

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- 25** shows a list of generic conditions that are most often found in Sonipat according to the type of treatment considerations and other main constraints such as land availability and population, given that finances are a constant

Table 25- Indicators and factors to decide the type of decentralized 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 26**.

Table 26- 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

6.5. 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. . The following image shows the various stakeholders involved in IEC Activities (**Figure 20** and **Table 27** shows the numerous activities and interventions that can be carried out for IEC.

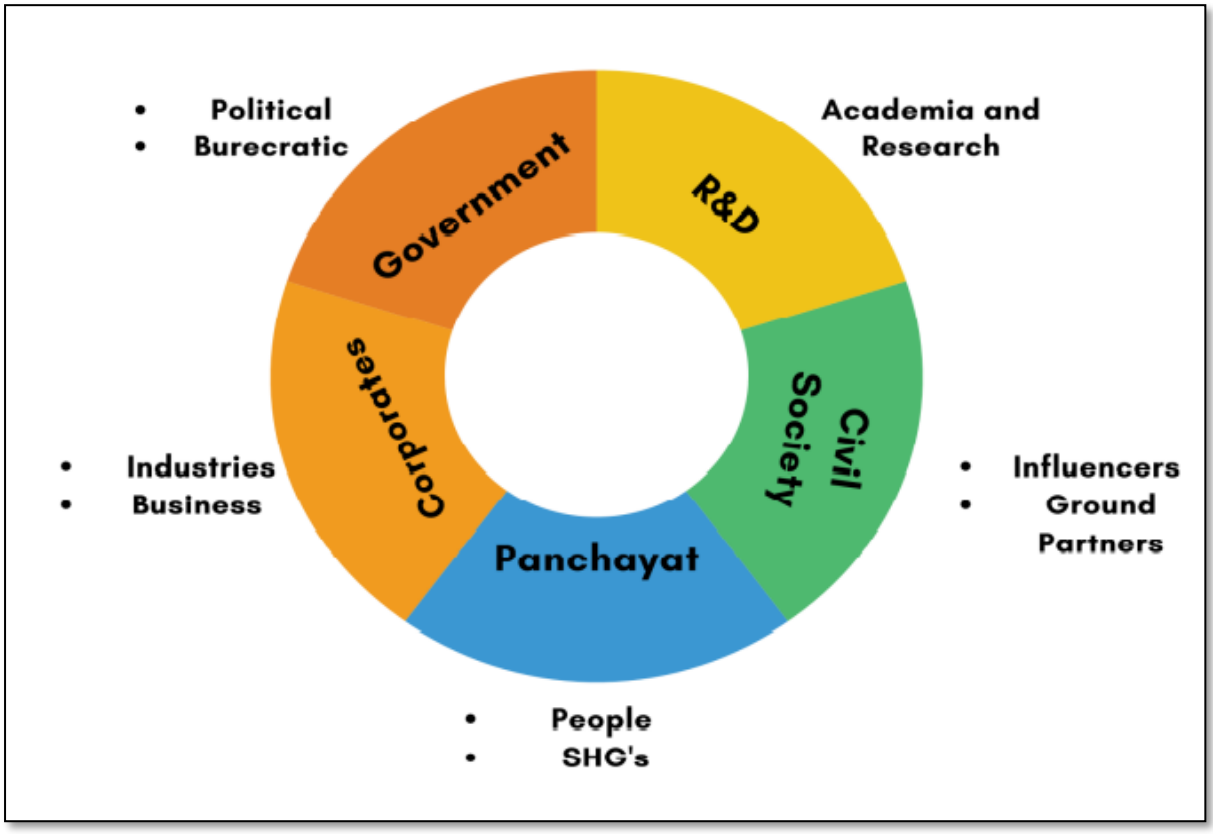


Figure 20- The above figure shows the various stakeholders of IEC Activities

Table 27- 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

7. Proposed Activity

7.1. 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 21).** For the process of calculating suitable site a fixed weightage is needed to be applies on the above-mentioned criteria **Table 28** and Block wise area under very good suitable site proposed for rain water harvesting **Table 29**.

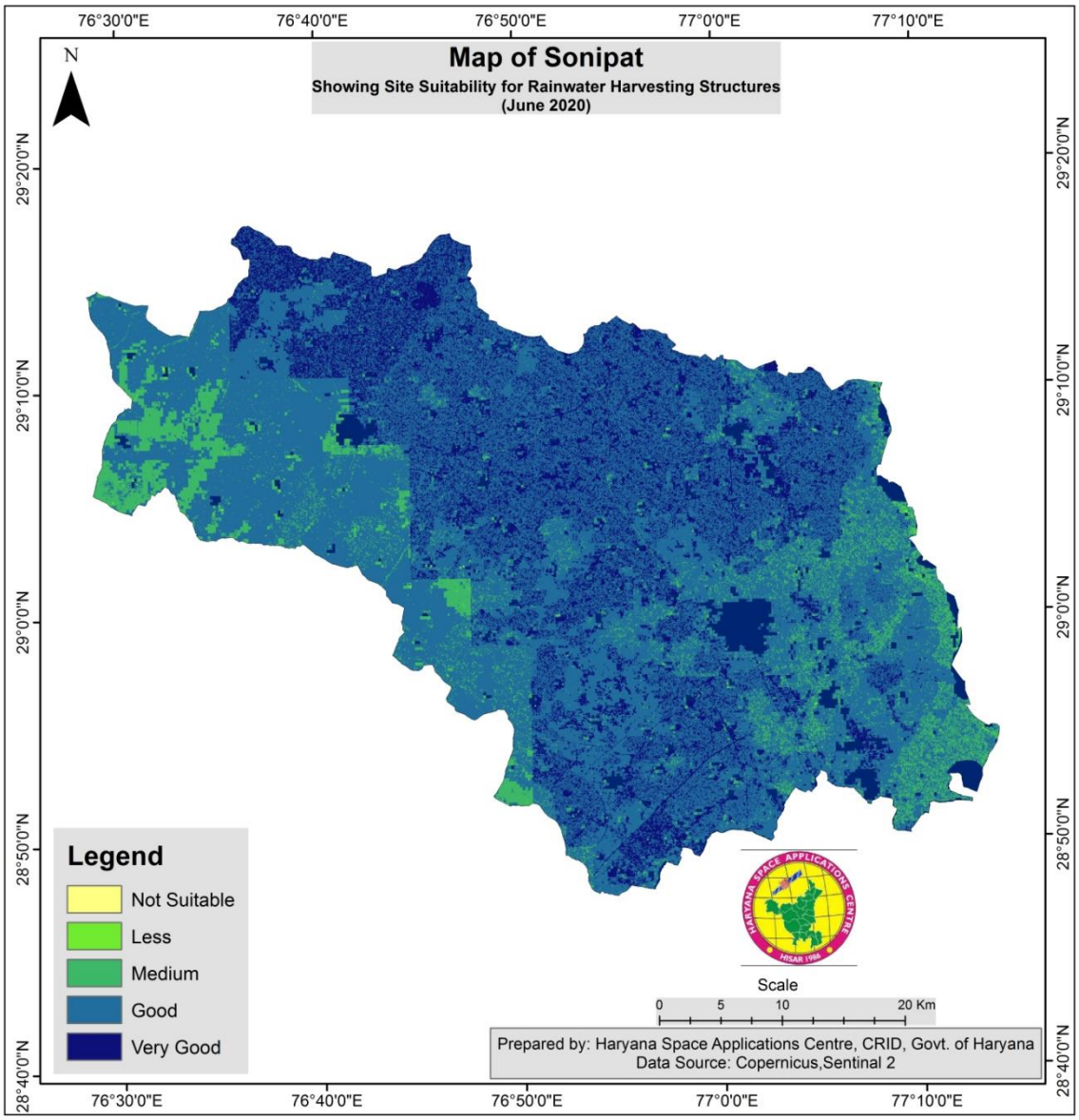


Figure 21- Rainwater Harvesting Structures of Sonipat District

Table 28- Block wise area under very good suitable site proposed for rain water harvesting

Sr. No.	Block Name	Area (Very Good suitability area in Sq. meter)
1	**Ganaur**	92864403.16
2	**Gohana**	62174397.15
3	**Kharkhoda**	77524959.43

4	**Mundlana**	98319809.53
5	**Rai**	37323603.53
6	**Sonipat**	98159024.31
7	**Murthal**	32337643.96

Table 29- Assigned Weight for layer

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

7.2. Based on Drainage

The drainages that are created from satellite imagery can be used as base for the water harvesting structure. 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, 2nd Order Stream, Pakka check Dams 3rd Order Stream, Micro Irrigation tanks 4th Order can be built. **Figure 22** shows the proposed suitable sites based on drainage structure in Sonipat district. Proposed harvesting structures in Sonipat based on drainage shown in **Table 30**.

Table 30 -Proposed harvesting structures in Sonipat based on drainage

Sr. No.	**Block Name**	**Mini percolation Tank**	**Percolation Tank**	**Pakka Check Dam**	**Annicut**	**Micro Irrigation Tank**
1	Ganaur	19	25	36	55	21
2	Gohana	73	77	95	54	61
3	Kathura	49	38	58	47	24

4	Kharkhoda	17	32	36	65	22
5	Mundlana	68	90	70	51	53
6	Rai	12	5	19	16	18
7	Sonipat	18	32	42	90	12
8	Murthal	10	7	28	19	10

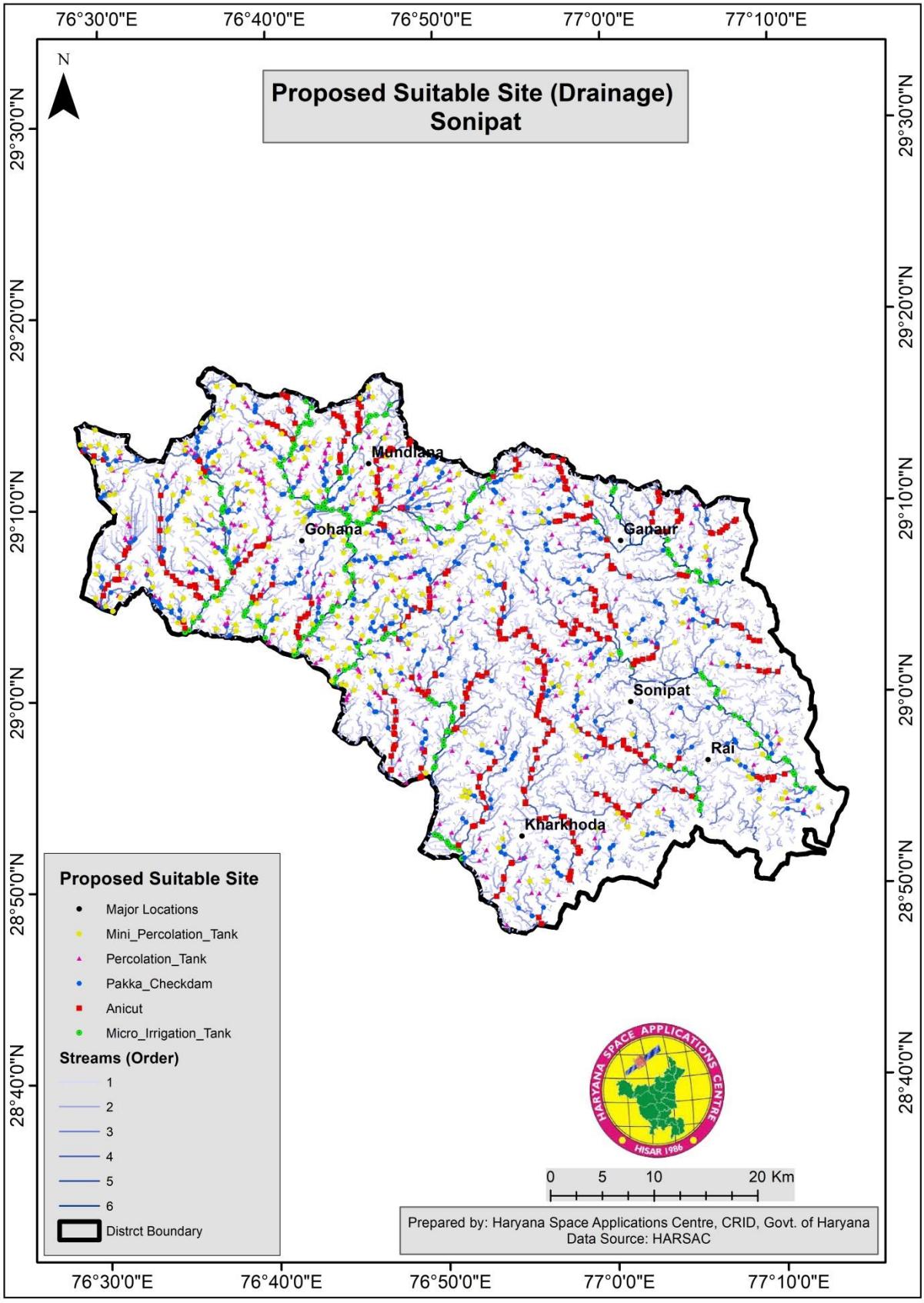


Figure 22- Proposed suitable sites based on drainage in Sonipat District

8. Conclusion

Due to rapid urbanization, Sonipat 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

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