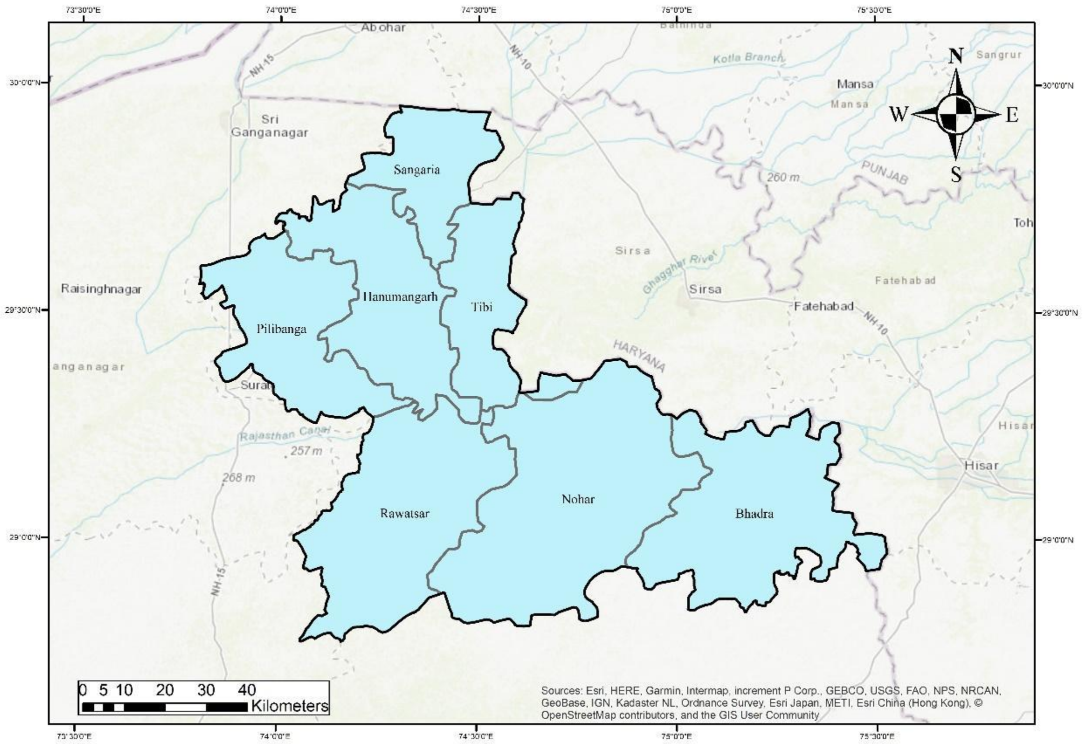
DISTRICT ENVIRONMENT PLAN

For

Hanumangarh District



Submitted By:

Sh. Nathmal Didel
District Collector and District Magistrate
Hanumangarh, Rajasthan

Prepared By:

MNIT Jaipur, Rajasthan

Preface

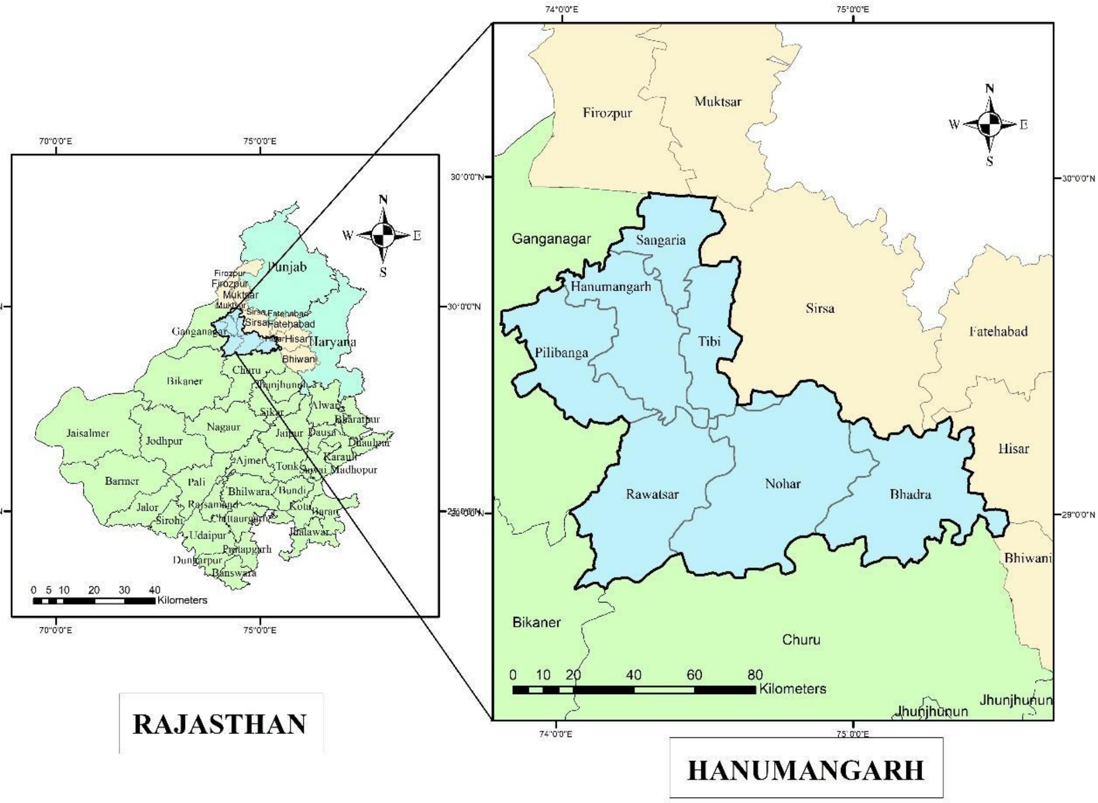
Our biosphere is rigidly limited with finite resources. Humankind, regardless of its technological advancements till date and far in future, remains in a state of obligate dependence on the productivity and life support services of the ecosphere. It is necessary to examine environmental burdens arising from development choices and prepare an environmental management plan to enhance preparedness in mitigating the adverse environmental impacts of development.

The District Environment Plan for Hanumangarh district has been prepared in pursuance of the directions issued by the Honorable National Green Tribunal (NGT) and is based on Model template for District Environment Plan proposed by Central Pollution Control Board (CPCB), New Delhi. The plan presents the current status of various environmental attributes, identifies probable environmental issues and proposes an action plan. I am confident it will be a useful reference in planning and executing various development schemes of the district for maintaining the environmental quality and will prove to be an invaluable asset for concerned departments.

The active participation, invaluable contributions and team effort of all the concerned district officials is highly appreciated with a request to forge similar synergies in their respective domains to make this plan a success.

Special thanks are extended to Dr. Nand Kumar, Associate Professor and Head, Department of Architecture and Planning; Dr. Mahesh Kumar Jat, Professor, Department of Civil Engineering; Dr. Satish Pipralia, Associate Professor, Department of Architecture and Planning; Dr. Amit Kumar, Assistant Professor, Department of Civil Engineering; Dr. Meena Nemiwal, Assistant Professor, Department of Chemistry, MNIT Jaipur and their team for accepting the task of preparing the district environment plan for Hanumangarh district. His relentless efforts throughout the preparation of this report are highly appreciated. The plan shall surely prove fruitful to the region and the people of Hanumangarh.

Hanumangarh	Shri Nathmal Didel
June 2021	District Collector and District Magistrate



Location of Hanumangarh District

Prologue

Nature is indispensable to our lives; we are solely dependent on natural processes for the bulk of our waste disposal; for most of the cycling of chemical nutrients that sustain our food production; and for maintaining a library of genetic information. In the backdrop of the fact that biosphere is rigidly limited with finite resources and humankind regardless of its technological advancements till date and far in future remains in a state of 'obligate dependence' on the productivity and life support services of the ecosphere, it is necessary that development choices are made in cognizance of the environmental carrying capacity.

There is a complex set of relationships, arising firstly from our place in nature, secondly coloured by our system of values, thirdly leading us to specific kinds of conduct, and fourthly leading us to attempt modifications of nature. This modification of nature may take many physical forms; varying with our varied needs. Not with standing the varied physical forms arising from our differentiated activities, in fact we are simply a part of a large and exceedingly complex system and are continuously adjusting our relationship with nature. The overall aim of environmentally sound development, therefore, is to minimize the negative impact of development on the environment.

Vision

The Government of Rajasthan intends to adopt 7R approach (Reduce, Reuse, Recycle, Refurbished, Recover, Refill, and Remove) by imparting thrust on collection, segregation, improving data and analytics, minimizing environmental impacts, creating market for recyclable products and aiming towards sustainable development. The principle of 7R is essential strategy for achieving the sustainability. It reduces the load and over exploitation on the natural resources and is a key for resource efficiency. It envisions sustainable use of natural resources like cultivable land, forests and water bodies and also aims at reversing environmental degradation by restoring the degraded ecosystems thus ensuring their availability for future generations.

Mission

Environmental concerns in India have been attended significantly in the past few decades marked by notable increase in citizen awareness, proactive approach by governments and landmark judgments by the judiciary and evolution in jurisprudence. At this juncture, it is pertinent to evolve context specific strategies to attend the environmental concerns. The district environment plan is one such attempt to examine environmental burdens arising from development choices and prepare an environmental management plan to enhance preparedness in mitigating the adverse environmental impacts of development at the district level. Subsequently, information from all district environment plans shall serve as basis for preparing the State Environment Plans and finally, the National Environment Plan.

Central Pollution Control Board (CPCB), New Delhi, in pursuance of the directions issued by Honorable National Green Tribunal (NGT) has placed the model template of the District Environment Plan on its website, which specifies the scope, data requirements and structure of the report. Typically, District environment plan should outline the present status and gaps in implementation and also identify agencies responsible, requirement of infrastructure facilities for sewage treatment, waste management, monitoring environmental quality etc. District environment plan should also provide timelines for implementation; identify local issues, constraints in implementation, priority action areas and issues requiring more attention. Accordingly, the report on 'District Environment Plan for Hanumangarh District' is being organized in sixteen chapters and the chapter outline is presented below, in sequel.

Chapter 1 Introduction: The Chapter deals with background information for preparation of the District Environment Plan along with its objectives, scope, and the details of the District Environment Committee for Hanumangarh district of Rajasthan state.

Chapter 2 Profile of the Hanumangarh District: A brief profile of the aspects that define the development context of Hanumangarh district such as: Administrative System, Geographic Location and regional connectivity, Topography and Climatic Conditions,

Chapter 3 Demography of Hanumangarh District: A brief profile of the aspects that define the development context of Hanumangarh district such as: Demographic profile, Economy and Workforce Profile, Industrial Profile, Social and Physical Infrastructure; etc. is presented in this chapter.

Chapter 4 Waste Management: duly filled and verified dataset of the CPCB prescribed waste management parameters i.e., Solid Waste Management, Plastic Waste Management, Construction and Demolition Waste, Bio Medical Waste Management, Hazardous Waste Management, and E- Waste Management, ULB wise analysis of existing scenario and future projections, present status of implementation, identification of gaps, the details of action plan, actionable points along with proposed timeline and estimate of financial cost is presented in the chapter.

Chapter 5 Water Quality Management Plan: duly filled and verified dataset of the CPCB prescribed water quality and Domestic Sewage parameters, an analysis of existing scenario, present status of implementation, identification of gaps, the details of action plan, actionable points along with proposed timeline is presented in the chapter. The chapter also has description for Rainwater Harvesting provisions in the district.

Chapter 6 Air and Noise Pollution Management Plan: deals with the Status and Inventory of Air Quality Management in the Hanumangarh District along with a brief insight on each of the air pollutants. 'Noise Management Plan' deals with the Status and Inventory of noise pollution in Hanumangarh District

Chapter 7 Industrial Waste Management Plan: duly filled and verified dataset of the CPCB prescribed Industrial Waste Management parameters, an analysis of existing scenario, present status of implementation, identification of gaps, the details of action plan, actionable points along with proposed timeline is presented in the chapter.

Chapter 8 discusses the ‘Mining Activity Management Plan'. Hanumangarh district is rich in mineral resources. Hanumangarh is fairly endowed with various minerals whose industrial use has immensely contributed to the economy of the district.

Chapter 9 on Rural Environment Management Plan is a comprehensive account of different aspects of the environment in the rural areas of the district.

Chapter 10 on ‘Forest Conservation Practices’ covers the general information regarding types of forest found in Hanumangarh district, forest land, the current management practices being adopted. The threats to forest/forest land in context to this district have also been identified and discussed. Finally, different afforestation activities proposed in forest land, as well as city/town area, are listed along with brief action plans.

Acknowledgement

It gives us immense pleasure to present the District Environmental Plan for Hanumangarh district. We acknowledge the support and constructive push of Smt. Sreya Guha, IAS, Principal Secretary, Shri Pavan Kumar Upadhyay, Secretary, Department of Forest & Environment, Govt. of Rajasthan to complete the District Environment Management Plan. We express our sincere gratitude and indebtedness towards the District Collector, Mr. Nathmal Didel, IAS, for his invaluable guidance and encouragement throughout the process of preparation of the environment plan. The team thank the contribution and support of Shri Vikram Kesharee Pradhan, Director cum Joint Secretary, Department of Forest & Environment, Govt. of Rajasthan. We are also thankful to Sh. Ashok Aseeja, ADM/CEO, Zila Parishad for his constant cooperation in the task. The Forest Department (especially Shri Karan Singh, the Deputy Conservator of Forest, Shri Dileep Singh Rathore, Assistant Conservator of Forest, Nohar, Hanumangarh) has been the guiding light for us in this humongous task of collecting data, analyzing it and drawing inferences from it. This work would not have been possible without their support.

We also express our gratitude to all the Executive officers of ULBs in the district. Some officers that we interacted directly with are Mr. Subhash Bansal, Executive Engineer, Hanumangarh and Mr. Meghraj Verma, A. En., ULB, Hanumangarh.

We express our sincere thanks to various departments: Regional Office Rajasthan State Pollution Control Board, District Transport Office, Police Department, Zila Parishad, Nagar Palika /Nagar Parishad, Department of Water Resources, Public Health Engineering Department, District Industrial Centre, Factories and Boilers office, RIICO, Education Department, Health Department, SPCB, Public works Deptt, Agriculture Department, Mining Department; in the district for their whole-hearted support in this work.

We also thank Prof. Uday Kumar Yaragatti, Director, MNIT Jaipur, Prof. Gunwant Sharma, Dean R&C, MNIT Jaipur for their constant support and help in timely executing the work. We also thank Shri Surjeet Singh, Secretary-General, ISPER, Panchkula for providing his valuable suggestion for the improvement of the work. The team also thank M. Plan and M. Tech. students, who have contributed a lot to the exercise.

Executive Summary

After the industrial revolution, the global economy has developed vigorously in both the industrial, agricultural and household sectors resulting in exponential production and usage of chemicals which enter the environment often as potentially toxic contaminants. A large number of contaminants (ECs) have been detected in all the environmental media including soil and water bodies across India.

Studies have found the presence of these pollutants in surface water, groundwater, stormwater, treated wastewater, treated industrial effluent, bottled water, snow from glaciers on the Indo-Chinese border, air and soil. As all the compartments are inter-connected, it takes the contamination of one medium only to start the process of contamination of other compartments. The contaminants in surface water can get into deep aquifers as it recharges the groundwater. In the process, the soil may also get contaminated and plants (edible or otherwise) can uptake these contaminants. These pollutants can cause adverse ecological and human health effects. To minimize the effects of these pollutants, it becomes necessary to formulate plans for managing these pollutants on a regional basis. In this direction, district environmental plans are a good initiative taken by the Department of Environment in Rajasthan. It is worthwhile to mention here the honourable National Green Tribunal, which is the main apex body behind these initiatives for environmental protection.

For the preparation of the district environmental plan, detailed discussions were held with Municipal Councils, Regional Offices, Rajasthan State Pollution Control Board and Department of Environment. In addition, all the other departments involved at the district level i.e. District Transport Office, Police Department, Zila Parishad, Nagar Palika /Nagar Parishad, Department of Water Resources, Public Health Engineering Department, District Industrial Centre, Factories and Boilers office, RIICO, Education Department, Health Department, SPCB, Public works Deptt, Agriculture Department, Mining Department and Forest Department were consulted with and the essential inventory data related to each element of environment was obtained from authentic sources. The meetings of the District Environment Committee were held several times to formulate the District Environment Plan for Hanumangarh District.

Inventory on various elements of the environment has been collated from the responses of the questionnaire sent to the various ULB's. A brief profile of the district is presented in the initial chapters based on studies conducted by the government. Various aspects such as history, physiography, topography, administrative setup, rainfall, climatic conditions, forest, flora and fauna, availability of minerals, hydrogeology and agriculture, geology, geomorphology, irrigation projects, ground water quality and quantity in Hanumangarh is discussed in great detail in the brief profile and along with the various chapters.

The data provided by all the representatives of ULB's is on the outline given by CPCB, as well as data accessed from relevant state web portals i.e. Department of Mines and Geology, Central ground water board of Rajasthan, Ministry of micro small and medium enterprises, Environment department of Rajasthan, Rajasthan State pollution control board (RSPCB), Rajasthan State Industrial Development & Investment Corporation, Hanumangarh District Collectorate, Ministry of Water Resources.

In the area of solid waste management, all the six ULBs are having 100% door-to-door collection. A slight improvement of including the houses/commercial establishments present on the fringes of a ULB may be made by all the ULBs. All ULBs should have ICT (Information and Communication Technology) and IoT (Internet of Things) based monitoring of Door-to-Door waste collection. At the user-end source, segregation is lacking and there is an urgent need for creating awareness and willingness in the society for source segregation. The frequency of waste collection may also be different for various fractions (dry, wet, domestic hazardous and sanitary).

Because the waste is not source segregated, it is also not processed by recycling, composting or any other method. The waste processing is at a very minimal stage presently. However, waste processing facilities are being set up which are in various stages of construction in the district. Composting of wet waste has already been initiated in Hanumangarh. For the provision of a sanitary landfill, a cluster of ULBs may be formed and a suitable piece of land may be allotted for the waste disposal from the cluster of ULBs. Engineered landfill may be in the clusters: the cluster of Hanumangarh and Sangaria; the cluster of Pilibanga and Rawatsar; the cluster of Nohar and Bhadra;

Plastic waste management includes activities like door-to-door collection of plastic waste and plastic waste segregation at source, immediate actions like a ban on carrying bags and other single-use plastics as notified by the State Government and ensuring no open burning and littering. It also includes the management by the waste generator through PROs to be implemented in all the ULBs of Hanumangarh District. Other initiatives may be taken for utilization of non-recyclable plastic waste (e.g. road construction, waste to fuel, waste to energy, alternative uses identification etc.). The recycles can also be given incentives (e.g. land for setting up plants) for better management of plastic waste in each ULBs.

For the construction and demolition waste, there is no formal procedure in the district. First and foremost is the assessment of quantities being generated in the district. The second measure may be the establishment of C&D waste processing facilities with each ULB or in clusters. Provision for utilization of items made from C&D waste should be made by the ULBs.

Biomedical waste is managed by sending the waste to a common treatment facility located in Hanumangarh city. The management of biomedical waste may be improved by (i) preparing an inventory of all the entities producing biomedical waste in the district, (ii) tracking all the biomedical waste using barcode; (iii) the compliance of environmental regulations by the common biomedical waste treatment facility in Hanumangarh.

As of now, there are not any dedicated facilities for the management of E-waste in the district. ULBs should start the process of establishing linkages with authorized PROs for the proper management of discarded e-waste. ULBs should establish Toll-free number helpline where a citizen can contact for deposition of their e-waste. An awareness programme should be initiated by the ULBs and NGOs. A common recycling/dismantle facility may be established at the district level as ULB except Hanumangagh has a small population.

For monitoring ambient air quality, there is no monitoring station present in Hanumangarh, and therefore no data is available on ambient air quality. The foremost priority should be installing air quality monitoring stations and then analyzing the data obtained from them. The action plan has been provided focusing on the various sources of air pollution. Similarly for noise pollution, there is no detailed or proper information regarding the noise levels in Hanumangarh and all particular ULBs. Therefore, the action plan suggested in the study is more focused on noise monitoring but not on the controlling measures.

For ground water quality in Hanumangarh district, over exploitation of ground water is leading to serious salinity hazards in some parts of the district. There is an alarming amount of decrease in ground water in the district which need attention. The chemical constituents such as chloride, fluoride, iron are exceeding the permissible limits in some parts of the districts. Rawatsar and Nohar block has the deepest level of groundwater availability. Artificial recharge of ground is needed in these blocks. Rainwater harvesting should be encouraged in this area by constructing anicuts, bunds and check dams. Roof top rain water harvesting techniques should be promoted in this area. Ground water development programme should be launched in the Ghaggar flood plain. Although, the data obtained from the agriculture department says otherwise, the water logging problem from canals is observed in some areas of the district.

Domestic sewage needs improvement in the collection as well as treatment of sewage in all the ULBs. Most of the ULBs do not have sewer networks and treatment plants for sewage. There are no facilities available for faecal sludge treatment. In absence of the sewer network, it becomes essential to have facilities available for faecal sludge treatment. The possibilities of water reuse may also be explored after sufficient treatment facilities are installed in the ULBs.

For industrial waste, all the industries in the district are meeting the discharge standards as per data received from SPCB. However, during one of the site visits, it was observed that the industrial waste was being disposed-off in open in Hanumangarh city. The clean-up of this area and proper disposal of this industrial waste may be considered as an urgent issue by the district authorities. Also, there are no common effluent treatment facilities in the industrial clusters.

Proper policies and regulations that govern the Environment during mining and after mine closure should be taken into account while starting any new activity in the district Hanumangarh. As of now, there is mining done for brick earth and gypsum in the district. As per data received from the mining office, the mining activities and the associated waste are being properly managed.

The discussion regarding soil, agriculture and rural environment have been combined in a chapter dedicated for the purpose. The challenges for environment management differ in urban and rural areas. The infrastructure to supply water and energy and manage wastewater in many cases in rural areas simply does not exist, and economic and social barriers put basic services even out of reach for a large number of people. The main issues prevailing in rural areas are improper management of liquid and solid waste and emphasis on chemical farming.

Forest preservation is the act of planting and keeping up forested regions for the advantage and sustainability of people in the future. The report highlights the measures taken by the forest department for improving the green cover in the district. The forest department has been actively involved in the preservation and enhancing the forests in the region.

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1. Introduction

1.1 District Environment Plan; Background

Hon'ble National Green Tribunal, New Delhi has passed an order on 15-07-2019 in O.A. No. 710/2017 titled as Shailesh Singh Versus Sheela Hospital and Trauma Centre Shahjahanpur that it is necessary to have a District Environment Plan to be operated by the District Committee and further vide order dated 26-09-2019 in O.A. No. 360 of 2018 filed by Shree Nath Sharma Vs Union of India and others directed that CPCB shall facilitate the District Magistrates in preparation of District Environmental Plan by placing model plan on its website. This model plan may be adopted as per local requirements by all districts under the supervision of the District Magistrate.

In the above-said order, it is stated that among others

"Chief Secretaries may personally monitor compliance of environmental norms (including BMW Rules) with the District Magistrate once every month. The District Magistrates may conduct such monitoring twice every month."

"We find it necessary to add that in view of Constitutional provisions under Articles 243 G, 243 W, 243 ZD read with Schedules 11 and 12 and Rule 15 of the Solid Waste Management Rules, 2016, it is necessary to have a District Environment Plan to be operated by a District Committee (as a part of District Planning Committee under Article 243 ZD) with representatives from Panchayats, Local Bodies, Regional Officers, State PCB and a suitable officer representing the administration, which may, in turn, be chaired and monitored by the District Magistrate. Such District Environment Plans and Constitution of District Committee may be placed on the website of Districts concerned. The monthly report of monitoring by the District Magistrate may be furnished to the Chief Secretary and may be placed on the website of the district and kept on such websites for a period of one year. This may be made operative from 1.08.2019. Compliance of this direction may also be seen by the Chief Secretaries of the States/UTs. This may not only comply with the mandate of law but provide an institutional mechanism for effective monitoring of environment norms."

Keeping in view of the above facts, it has been planned to prepare the Environment Development Plan of Hanumangarh District in such a way so that the District environment plan not only outlines the present status and gaps in implementation but also identify agencies responsible, requirement of infrastructure facilities for sewage treatment, waste management, monitoring environmental quality etc. It should also provide timelines for implementation, identify local issues, constraints in implementation, priority action areas and issues requiring more attention.

Based on the District Environment Plans, State Environment Plans and National Environment Plan shall be prepared. It is required to ensure that information pertaining to all District Environment Plans is captured into State Environment Plans and National Environment Plans.

1.2 Constitution of District Environment Committee

Given the directions, the District collector of Hanumangarh vide letter no. F-Misc./2020-21 Letter no. 970 dated 16.02.2021 constituted a District Committee with representatives from Village Panchayats, Municipal Councils, Regional Offices, Rajasthan State Pollution Control Board, Department of Environment and an officer representing the administration for preparing the District Environment plan. MNIT Jaipur has been given the work of preparation of the District Environment Plan in association with Shri Nathmal Didel, Head of District Environment Committee and District Collector, Hanumangarh.

This plan has been prepared in line with the model District Environment Plan (DEP) of CPCB and covers the following thematic areas:

- Waste Management Plan
- Solid Waste Management Plan
- Plastic Waste Management
- C&D Waste Management
- Biomedical Waste Management
- Hazardous Waste Management
- E-Waste Waste Management
- Water Quality Management Plan
- Domestic Sewage Management Plan
- Industrial Wastewater Management Plan
- Air Quality Management Plan
- Mining Activity Management plan
- Noise Pollution Management Plan

The awareness about the preparation of District Environment Plans among the stakeholders of each department were created in a time-bound manner and action plans were formulated to implement it.

1.3 National Green Tribunal Directions

a. As per the order of NGT dated 15.07.2019 in O. A. No 710-713/2017, O.A. No. 606/2018, it is the duties and responsibilities of various stakeholders to make the solid waste management plan a successful and implementable action.

b. National Green Tribunal has issued several directions in various matters which have been based on status brought out by the CPCB on their website and status reports filed before the Tribunal.

c. In vide order dated 26.09.2019 in the present matter, it was observed: - (i) “This Tribunal in O.A. No. 606/2018, while dealing with the compliance of Municipal Solid Waste Management Rules, 2016 also flagged other issues and required monitoring at the level of the Chief Secretaries and the District Magistrates. The Chief Secretaries of all the States/UTs have appeared before this Tribunal, including the Chief Secretary of State of Rajasthan and directions have been issued for continuous monitoring and filing of further reports. (ii) Vide order dated 12.09.2019, while fixing a schedule for the further appearance of the Chief Secretaries of all the States/UTs, the direction has been issued to compile information with reference to the following specific thematic areas viz.:

- Compliance with Solid Waste Rules including Legacy Waste.
- Compliance to Bio-medical Waste Rules.
- Compliance with Construction & Demolition Waste.
- Compliance with Hazardous Waste Rules.
- Compliance with E-waste Rules.
- 351 Polluter Stretches in the country.
- 122 non-attainment cities.
- 100 industrial clusters.
- Status of STPs and re-use of treated water.
- Status of CETPs/ETPs including performance.
- Ground water extraction/contamination and re-charge.
- Air pollution including noise pollution.
- Illegal sand mining.
- Forest Conservation Practices and Management Plan
- Rejuvenation of water bodies.

d. Hon'ble National Green Tribunal (NGT) has ordered Pan-India Directions on various issues relating to environment management and these are to be executed by the Central and State Governments and concerned institutions. Further, the Directions are required to be executed at District Level covering all cities, towns and villages.

e. The role and responsibilities of enforcement are with District Collectors/Magistrates, Pollution Control Boards, Municipal Bodies, Public Health Engineering Departments and others.

f. The present state-level execution and monitoring mechanism on various State and Central Government's Schemes are monitored by Chief Ministers/ Chief Secretaries with DMs/DCs.

g. Various Directions of NGT to be covered in the District Environment Management Plan (DEMP).

h. Information about any District Specific case (if any) and Committee/Task Force Constituted has also been discussed.

1.4 Objectives of the District Environment Plan

The objectives of this District Environment Plan (DEP) are set as given below:

- To ensure the conservation of the environment and natural resources at the district level.
- Restore ecological balance.
- To achieve the Sustainable Development Goals (SDGs) and district level targets within the prescribed timeline.
- To ensure sustainability at the district level following the principles of resource efficiency.
- To ensure decentralized micro-level planning, execution and monitoring regarding environment conservation.
- To incorporate all facets of environmental conservation in micro-level planning.
- To harness the active participation of all stakeholders in planned environment conservation actions.
- Assess, mitigate and monitor adverse impacts of various pollution sources at the district level.
- Capacity building of stakeholders, departments, agencies, organizations and individuals at the district level to understand and implement micro-level environmental conservation actions.
- To harness inter-departmental coordination for the implementation of action plans.

- To develop local knowledge centres and expertise for developing environmental conservation strategies at the district level.

2. Profile of Hanumangarh District

2.1 Introduction

Carved out from Sriganganagar district and formally Created on 12th day of July 1994 as 31st district of Rajasthan state. Hanumangarh district, situated at 29° 5' to 30° 6' North and 74° 3' to 75º 3' east, shares its boundaries with Haryana state in the east, Sriganganagar district in the west, Punjab state in the North and Churu district in the South. The geographical area of the district is 9656.09 Sq. Km. The climate of the district is semi-dry, extremely hot during the summer and extremely cold during winter. The maximum average temperature remains 18° to 48° and the minimum average is 2° to 28° Celsius. The average rainfall during the year is 225 to 300 mm.

The district is located in the extreme north of Rajasthan. It has an area of 12,645 km², a population of 1,774,692 (2011 census) and a population density of 184 persons/km². It is bounded in the north by Punjab state, in the east by Haryana state, in the east and south by Churu District and in Bikaner District and on the west by Ganganagar District. The major livelihood of the district is farming; major crops include rice, millet, cotton, sonamukhi (senna), wheat, and vegetables. It is called the food basket of Rajasthan along with Sri Ganganagar. It is the 31st district of Rajasthan. It was made as a district on 12 July 1994 from Ganganagar district. Earlier it was one of the Tehsils of Sri Ganganagar district.

Some people informally call it Punjab of Rajasthan because of a large number of Punjabi speaking people in the district comparing to the rest of Rajasthan, though Punjabi speakers are still in minority. Most people can understand Rajasthani (Bagri and other close dialects), Punjabi and Hindi.

History of Hanumangarh

The Hanumangarh area was shaped on 12.7.1994 from the than Ganganagar as the 31st region of Rajasthan state. Seven tehsils of Ganganagar regions of Bikaner division viz. Sangaria, Tibi, Hanumangarh, Pilibanga, Rawatsar, Nohar and Bhadra were incorporated into the recently made area of Hanumangarh. The region Hanumangarh is arranged on the bank of Ghaggar River which is the current type of the last legendary waterway Saraswati. Ghaggar River, which is called 'Nali' in neighborhood vernacular partitions the locale settles into two sections.

Hanumangarh Town is the primary focus of business exercises and the wide range of various fundamental workplaces including the office of the area authority are arranged in Hanumangarh Town. Prior, Hanumangarh was the realm of 'Bhati' Rajputs. It was worked by Bhupat child of Bhati King of Jaisalmer in 1295 AD. Bhupat named it 'Bhatner' in memory of his dad. Bhatner's most extreme significance was because of its area on the Delhi-Multan roadway. Brokers from Central Asia, Sindh and Kabul used to head out to Delhi and Agra through Bhatner.

The Hanumangarh district also has a significant place in ancient history. The remains found at Kalibanga [Pilibanga] in 1951 reveal that this area was a part of nearly 5000 years old "INDUS VALLEY" civilization. The remains of a human skeleton, unknown scripts, stamps, coins, utensils, jewellery, toys, statues, wells, bathrooms, fort, streets, markets etc., found in excavation tell the story of the well-developed lifestyle of our ancestors. Besides Kalibanga, more than 100 other places are also there in the district where evidence of this old civilization has been found. The remains found at these places have been kept at Museum at Kalibanga and National Museum in Delhi.

Earlier, Hanumangarh was known as "BHATNER". In the year 1805, emperor Soorat Singh of Bikaner captured BHATNER after defeating Bhatis and the day of his victory was Tuesday (known as the day of god "Hanuman"), he named BHATNER as "HANUMANGARH".

2.2 Geographic Profile

2.2.1 Location and Extent

The State of Rajasthan is situated in the western part of India, which faces severe water scarcity, poor rainfall, and is classified as an arid/semi-arid region. The entire western flank of the State borders Pakistan, while Punjab, Haryana, Uttar Pradesh and Madhya Pradesh bound Rajasthan in the northeast, southeast and Gujarat in the south-west. Geographically, deserts in the State constitute a large share of the landmass. The forest cover of the State contributes 4.19% to the national forest cover. Three major rivers are flowing through Rajasthan, the Chambal, Tapi and Luni. The state is severely deficient in the most important resource, that is, water. With 10.4 per cent of the country's area and 5.5 per cent of its population, Rajasthan has only about 1 % of the country's water resources. Based on climatic conditions and agricultural practices, Rajasthan has been divided into 10 agro-climatic zones ranging from arid western to flood-prone eastern. Rajasthan is the largest state of India, comprising 10.4 % of the country's total area. Nearly 76 % of the state's population resides in rural regions. Rajasthan produces 5.49% of the nation's total food grains production and 21.31 % of its oil seeds.

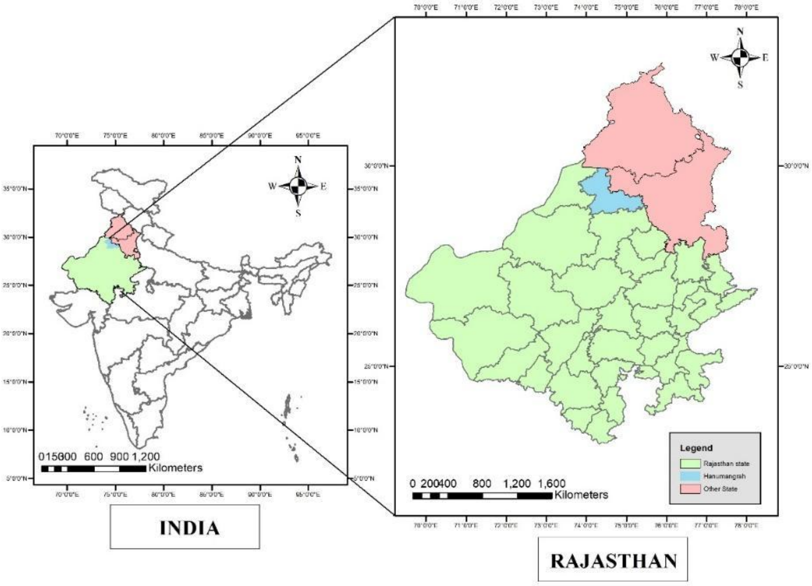

Figure 2.1 Location of Hanumangarh in Rajasthan State

Hanumangarh district is located in the northern part of Rajasthan. It is bounded in the north and east by states of Punjab and Haryana, in the south by Churu district and by Bikaner and Ganganagar districts in the west. It stretches between 28º 46' 25.07" to 29º 57' 26.90" north latitude and 73º 47' 41.74'' to 75º 31' 58.70'' east longitude covering an area of 9,929.3 sq km. This district does not have a systematically evolved drainage system and forms part of an 'Outside' Basin. The only known river in the district is the Ghaghar River that flows near the city of Hanumangarh. Carved out from Sri Ganganagar district and formally Created on 12th day of July 1994 as 31st district of Rajasthan state.

The geographical area of the district is 9656.09 Sq. Km. The district is situated in the northernmost region of the state and forms a part of the Indo-Gangetic plain. Figure 2.1 shows the geographic location of the state of Rajasthan in India, and Figure 2.2 shows the location of the Hanumangarh district in the State of Rajasthan. It has a geographical area of 12,645 km^2.

Table 2.1 Location and Geographical area

Location		**Area [Sq. Km]**	
North	29°5' to 30°6'	Total Geographical area	9656.09
South	74°3' to 75°3'	Total Forest area	302.75

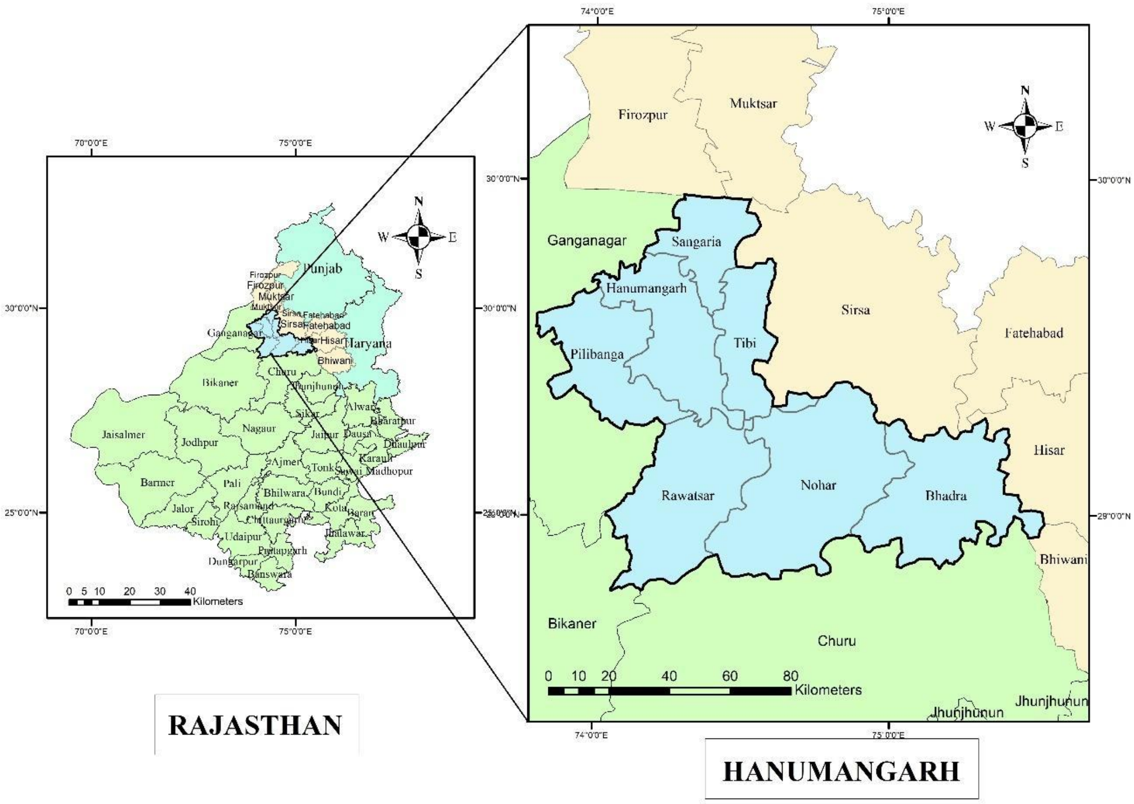

Figure 2.2 Location of Hanumangarh District

The population of the Hanumangarh district is approximately 18 lakhs. It is bounded on the north by Punjab state, on the east by Haryana state, on the south by Churu district of Rajasthan, on the west by Sri Ganganagar district of Rajasthan. The climate of the district is marked by the large variation of temperature, extreme dryness and scanty rainfall. The minimum and maximum temperature is 1°C and 45°C respectively, whereas the mean temperature remained 23°C. The normal annual rainfall of the district is 253 mm. Residents of these areas are poor, mostly illiterate farmers, who use the groundwater for irrigation and domestic consumption without prior treatment. The area is covered by windblown sands and alluvium excepts for a few patches of recent calcareous and sandy sediments associated with Gypsite. The oldest rocks of the area belong to Aravalli Super Groups which includes phyllite, shale and quartz veins, which are overlain by the rocks of the upper Vindhyan which are entirely made up bright to pale red fine and medium-grained compact sandstone and siltstone. The only major mineral occurrence of the district is Gypsite. The whole district is plain. Its shows a general slope toward the north, generally the sand dunes are 4-5 m high except in the south western part, where they are more intensely developed, being sometimes 10-15 m high. No important hill exists in the district. The height of the district varies between 168 and 227 m above the mean sea level. The Ghaggar River is an ephemeral one and has a north-east to a south-west course near Hanumangarh.

The soil of the Hanumangarh district is yellowish-brown in colour, loam to silty loam with massive or blocky structure and are calcareous in nature stratification is common in these soils. Soils vary in their characteristics at a very short distance. At many places, they are intermixed with sandy material.

2.2.2 Land Use Pattern

The socio-economic factors have a significant influence on land use both in rural and urban areas. Landform, slope, soils and natural resources are some of the important factors which control the land use pattern of the district. Hanumangarh is one of the highest per capita income-earning districts in India. To assess its economic potential, it would be worthwhile to explore the land-use pattern. The economy of the district and surrounding area is mainly based on agriculture and animal husbandry. Hanumangarh is the main mandi (market) for the agricultural produce of the area. The district is the main supply point for surrounding villages.

Table 2.2 Classification of Land Use for Hanumangarh District (Source: Rajasthan Agricultural statistics at a glance 2018-19)

Sr. No.	Classification	Area in Hectare
01.	Total Geographical area (ha.) (Area under forest + non-Agriculture land + Uncultivated land (excluding fellow land) + Fellow land + Cultivated land)	9,70,315
02.	Area under forest (ha.)	18,261
03.	Non-Agriculture land (ha.)	56,526
04.	Uncultivated land (excluding fellow land) (ha.)	8,127
05.	Fellow land (ha.)	94,555
06	Cultivated land (ha.)	7,92,846
07.	Cultivable land (ha.) (Uncultivated land (excluding fellow land) + Fellow land + Cultivated land)	8,95,528
08.	Irrigated area (ha.)	4,73,451
09.	Un-irrigated area (ha.)	4,22,077

Land Utilization Pattern

Landform, slope, soil typology and availability of natural resources are the important factors that direct the land utilization pattern of a settlement. The most dominant land use in the district is agriculture which encompasses 94 per cent (9046.6 sq.km.) of TGA. Sub-class Cropland is most dominant in the agriculture class and it covers approximately 4617.62 Sq. Km. of TGA.

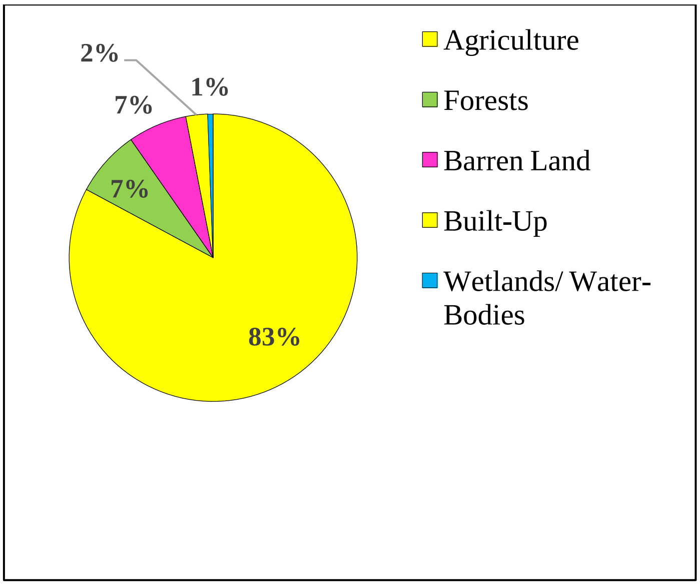

Figure 2.3 Percentage of Land Use with respect to Total Geographic Area of Sikar, 2016

With significant differences in percentage, built-up class stands second after agriculture and it encompasses approximately 237.9 Sq. Km. In built-up class, the rural sub-class is most prominent in the district with approximately 79.57 per cent (189.30 Sq. Km) of the total built-up area. Barren land and Forest classes of land use cover 208.85 and 53.57 Sq. Km. Only 1% of TGA is comprised of water bodies and wetlands.

Table 2.3 Trend of Land Utilization Pattern in Hanumangarh District

Land Use Classes / Year	**2005-06**	**2011-12**	**2015-16**
Agriculture	8889.91	9043.79	9046.6
Barren	379.15	209.07	208.85
Built-Up	224.01	237.68	237.9
Forests	67.33	53.56	53.57
Water-Bodies	95.6	111.88	109

2.3 Administrative Setup

Hanumangarh district is one of the four districts, that comes under the Bikaner division. District Collector is head of the district for revenue, law and order matters. District Collector & District Magistrate is the head of District Administration.

For administration and development, the district is divided into Subdivisions and tehsils (sub-districts). The District Hanumangarh has 7 subdivisions. Each of the sub-divisions is headed by a

Sub-divisional Officer (SDOs) / Magistrates, the officers are responsible for the implementation of law-and-order matters in their respective sub-divisions. There are 7 Tehsil headquarters in Hanumangarh district and each one has a Tehsildar as an administrative officer who works in accordance with the Land Record System to serve the rural farmers and land holders and is responsible for maintaining the revenue matters in their respective tehsils.

The district has 7 sub-divisions or tehsils, which are Pilibanga, Tibi, Hanumangarh, Rawatsar, Bhadra, Sangaria and Nohar. The tehsils are divided into 3 Panchayat Samitis which are Hanumangarh, Bhadra and Nohar. The population of the district as per the 2001 census is 1,517,390.

Table 2.4 Administrative setup of Hanumangarh District

S. No	Name of Sub-Division	Name of Tehsils	Name of Sub-Tehsils
1	Hanumangarh	Hanumangarh	Dabali Rathan
2	Pilibanga	Pilibanga	
3	Sangaria	Sangaria	
4	Tibi	Tibi	
5	Rawatsar	Rawatsar	Pallu
6	Nohar	Nohar	
7	Bhadra	Bhadra	Chhani Badi

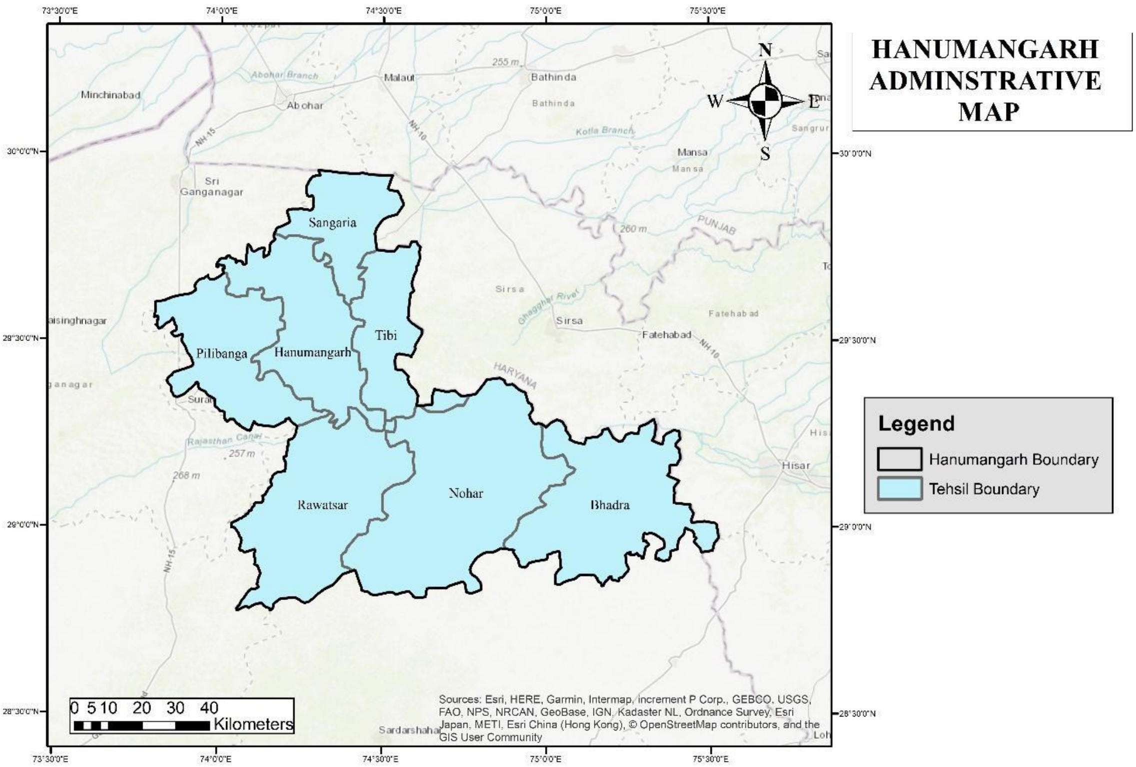

Figure 2.4 Administrative Map of Hanumangarh District

For the implementation of rural development projects/ Schemes under the Panchayat Raj System, the district is divided into the 7 Panchayat Samitis (Blocks). Block Development Officer or Vikas Adhikari is the Controlling Officer of each of the Panchayat Samiti to serve as an extension and developmental executive at the block level. The compositions of Panchayat Samities are as follows:

Table 2.5 Hanumangarh panchayat and tehsil data

S. No	Panchyat	Tehsils	Gram Panchyat	No. of Villages	Development Villages
1	Sangaria	Sangaria	26	188	172
2	Tibi	Tibi	30	254	235
3	Hanumangarh	Hanumangarh	33	405	364
4	Pilibanga	Pilibanga	32	307	264
5	Rawatsar	Rawatsar	34	321	284
6	Nohar	Nohar	47	224	191
7	Bhadra	Bhadra	49	215	190

Table 2.6 Municipalities of Hanumangarh District

S.No.	Name of ULB
1	Hanumangarh(Municipal Council)
2	Pilibanga
3	Sangaria
4	Rawatsar
5	Nohar
6	Bhadra

Table 2.7 provides the police administration details for the Hanumangarh district. There are four 'Arakshi Circle' in the whole district having 16 police thanas in total. In Hanumangarh circle, there are 7 thanas. In Nohar and Sangaria circles, there are 3 thanas in each. In Rawatsar circle, there are three police thanas.

Table 2.7 Police Administration of Hanumangarh District

Arakshi Circle	Thana
Hanumangarh	7
Nohar	3
Sangaria	3
Rawatsar	3
Total	**16**

2.4 Physical Linkages

2.4.1 Regional Connectivity

Hanumangarh Junction railway station is the main railway station in Hanumangarh district, Rajasthan. Its code is HMH. It serves Hanumangarh city. Hanumangarh is a major railway station on Jodhpur–Bathinda line, Sadulpur, Rewari, Jaipur, Sriganganagar, Anupgarh.

The meter-gauge train has become history for Hanumangarh because in October 2012 Hanumangarh–Sadulpur meter-gauge track closed and is being converted into broad gauge. Hanumangarh to Sri Ganganagar railway track has been converted into broad gauge and presently three trains are running on this track from Hanumangarh to Sri Ganganagar.

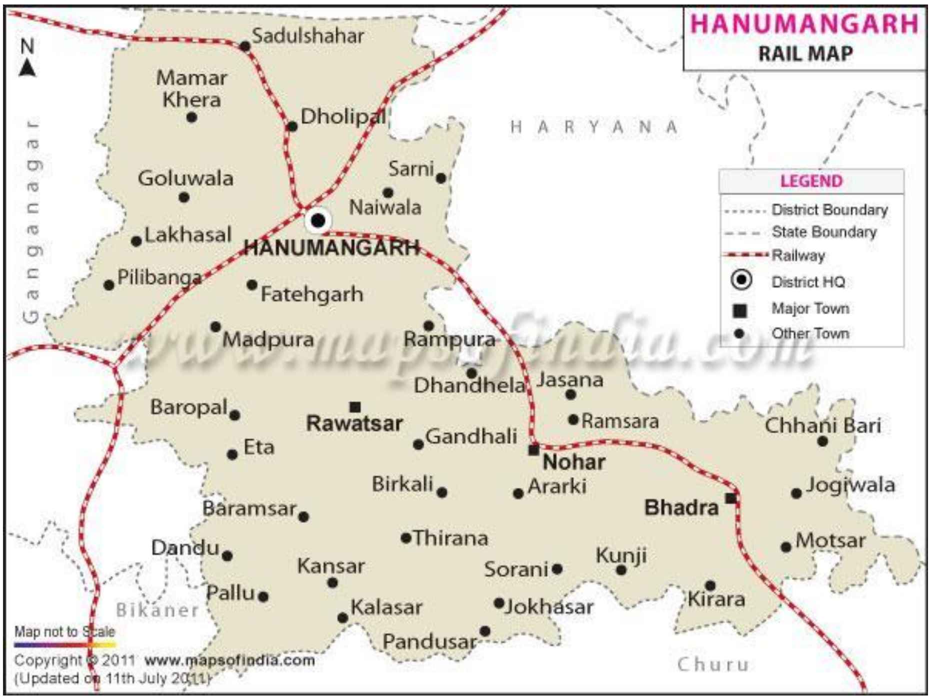

Figure 2.5 Railway Map of Hanumangarh District

There is no service via air in Hanumangarh as of now. As for the road network, National Highway (NH) number 54 and NH15 pass through the district. Apart from the National Highways, 10 State Highways No.7, 7A, 36, 76, 94, 99, and 106 passes through the state. Various types of road and its length in Hanumangarh District is been specified in Table 2.8.

Table 2.8 Type and Length of Road in Hanumangarh District

Sr. No.	Type of Road	Year	Length of Road (Km.)
1.	National Highway	2010-2011	NIL
2.	State Highway	2010-2011	260.30
3.	Main District Highway	2010-2011	398.85
4.	Other District and Rural Roads	2010-2011	279.85
5.	Rural Road/Agriculture Marketing Board Road	2010-2011	11004.20
6.	Kachha Road	2010-2011	30.15

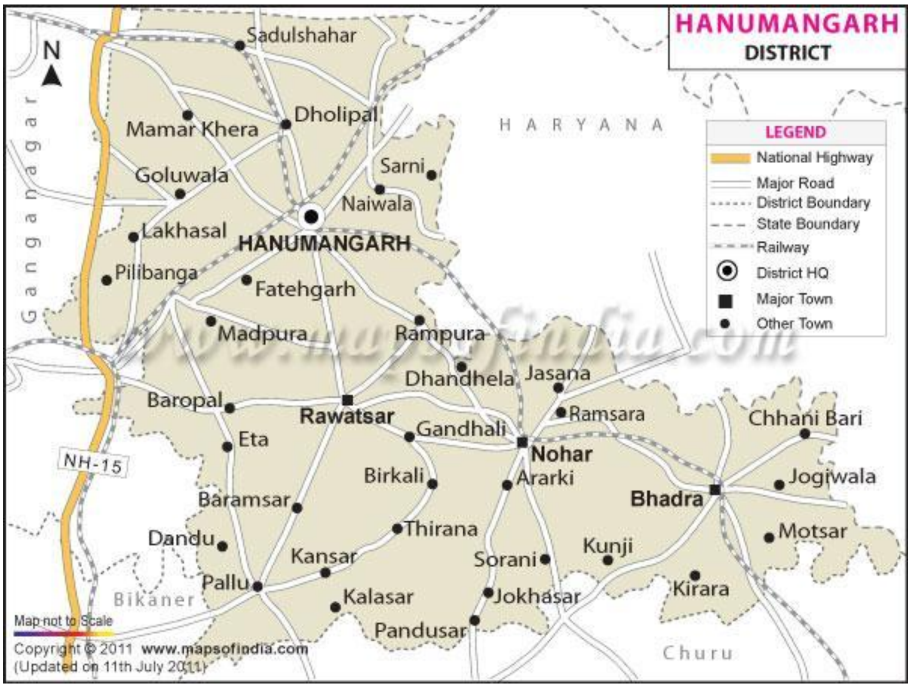

Figure 2.6 Hanumangarh district major towns and Highway network

Hanumangarh is situated in the northern part of Rajasthan, situated on the banks of the river Ghaggar also identified as an ancient Sarasvati River, located about 400 km from Delhi. The area around Hanumangarh appears to be quite old. The Hanuman district also has a significant place in ancient history. The climate of the district is semi-dry, extremely hot during the summer and extremely cold during winter. Hanumangarh is well connected with rail transport as ‘Hanumangarh Junction' is a major railway station in Jodhpur- Bathinda line; Sadulpur, Rewari, Jaipur, Sriganganagar, Anupgarh. Bagri is the major language in Hanumangarh popularity known as the Khichdi language because of having Punjabi words and Haryanvi accent. Many festivals and fairs are also held in this place, thereby giving one a good idea about the culture of Rajasthan. Due to its rich history, the district has some of the major tourist attractions. The places, tourists can visit include Bhatner Fort, Kalibangan, Bhandrakali Mata Temple, Pallu, Brahmani Temple etc. Industrial development has been started since long as industrial zone established 'Industrial area Hanumangarh-I and II' which had set us by RICCO and well-developed quality infrastructural facilities like well-developed national highways, state highway, district network and electric supply. Civil infrastructural facilities like a post office, government dispensary, banks, schools and colleges are also well developed in Hanumangarh.

Table 2.9 Distances of Important Places from District Headquarter Hanumangarh

Name of Places	Distance (In K.M.)	Available Vehicles
Sangaria	27	Rail / Bus
Tibbi	24	Rail / Bus
Rawatsar	36	Bus
Nohar	80	Rail / Bus
Bhadra	115	Rail / Bus
Pilibanga	26	Rail / Bus
Sri Ganganagar	60	Rail / Bus
Bikaner	225	Rail / Bus
Jaipur	435	Rail / Bus
Delhi	345	Rail / Bus
Ajmer	470	Rail / Bus

2.5 Physical Setting

2.5.1 Topography

The district is situated in the northernmost region of the state and forms an Indo Gangetic plain. The district is located between 28.7^0 to 29.7^0 latitude and 73.8^0 to 75.30^0 North. Longitudes. It is bounded on the south by Churu district, on the North- East by Punjab and Haryana and on the North and West by Sri Ganganagar district.

Elevation ranges from a minimum of 164.1 m above mean sea level in Pilibanga block in the western part of the district and the highest elevation of 239 m found in Rawatsar block in the northwestern part of the district The sand dunes are generally 4 to 5 meters high except in the south western part where they are more intensely developed, being sometimes 10 to 15 meters in height. The total geographical area of the district is 9656.09 Sq.mtr. which is 2.83 % of the total area of the State. Hanumangarh is the district head-quarter.

It has 7 Sub Divisions, 7 Tehsils, 3 Sub Tehsils, 7 Panchayat Samitis, 251 Gram panchayats,1906 Revenue Village and 5 Nagar Palikas and 1 Nagar Parisad.

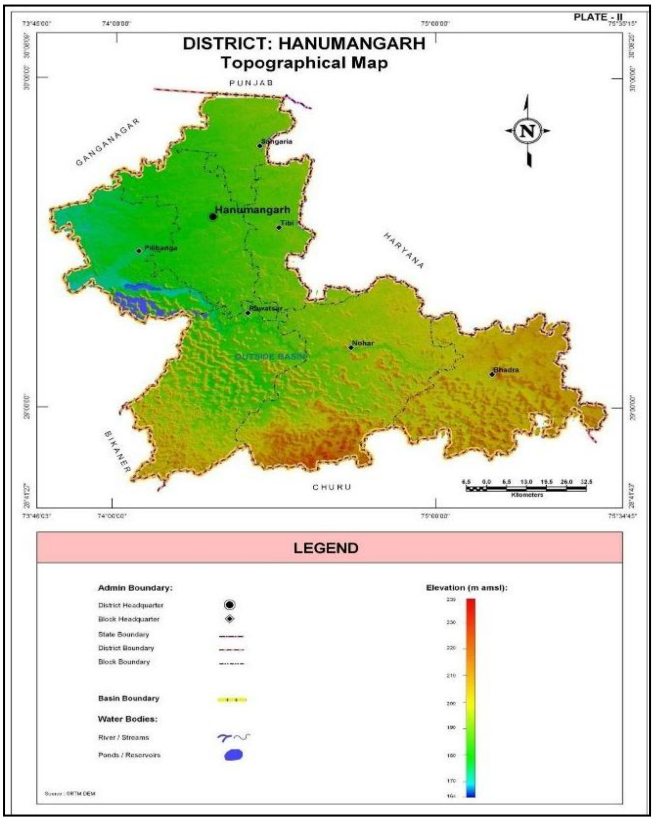

Figure 2.7 Topographical map of Hanumangarh district

2.5.2 Climate

The climate of the district is largely arid, which turns extremely hot during the summer and extremely cold during winter. The maximum average temperature ranges between 18º C to 48º C and minimum average between 2º C to 28º C. The annual rainfall gradually decreases from the southern part to the northern part. The summer months extend from March/April to June/July till the monsoon sets in although with very limited rains which last till the end of September. The average annual rainfall of the district is 303.0 mm. Months between November and February are cold as the winter season sets in with very cold nights and low day temperatures.

Most of the district received rainfall in the range of 500-600 mm in the year 2010 except Pilibanga. The average annual rainfall was 528.6 mm based on the data of available blocks while the highest average annual rainfall is 648.1 mm in the Bhadra block. The lowest annual rainfall was seen in the Sangaria block (368.5 mm). Bhadra block has received the highest maximum annual rainfall of about 736.7 mm. The district had received more than the average rainfall in most parts of the district in the year 2010.

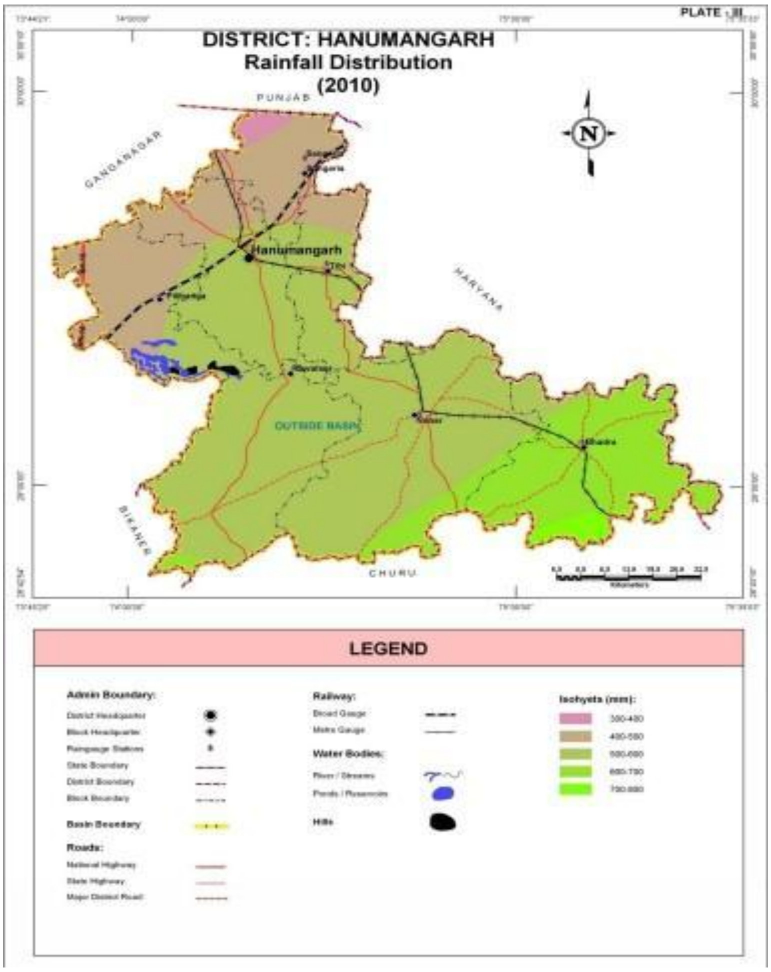

Figure 2.8 Rainfall Distribution of Hanumangarh District 2010

The normal annual rainfall in the district is 309.05 mm. The long-term rainfall data (1970-2019) of the rain gauge stations located at all the block headquarters was subjected to various types of analysis to understand the characteristic of the rainfall. It was observed that the distribution of rainfall is quite uniform in the area except for Sangariya and Nohar Block. The rains usually start in July and last till the end of September. The intensity of rainfall is the highest in August. Based on rain fall analysis it is observed that:

- On average, the monsoon rainfall is 309.1 mm and. Of these, 25 days are during the monsoon months. Four to five days in June are rainy.
- Most of the rainfall is received (93.5 %) during the monsoon months viz July to September. • Precipitation during the winter season is almost negligible.
- Highly deficient rainfall was recorded @ 67 % during the year 2002 and deficit during the year 2007. • The coefficient of variation in rainfall has been observed between 36.7 and 44.6.

- The district is prone to a mild and normal types of droughts. The probability of normal annual rainfall exceeding is only 53 %.
- The long-term trend of rainfall was also calculated and a declining trend was observed @ 0.09 mm/year

Table 2.10 Block wise annual rainfall statistics (derived from the year 2010 meteorological station data)

Block Name	Minimum Annual Rainfall (mm)	Maximum Annual Rainfall (mm)	Average Annual Rainfall (mm)
Bhadra	554.4	736.7	648.1
Hanumangarh	410.5	546.4	507.1
Nohar	502.5	648.4	557.2
Pilibanga	442.4	530.7	485.3
Rawatsar	519.2	620.3	554.1
Sangaria	368.5	529.5	435.1
Tibi	468.4	536.4	513.4

Drought Analysis

Drought frequencies and years of the occurrence of droughts have been computed using Agricultural Classification. It takes into account negative departure percentages of annual rainfall from mean annual rainfall. It is observed that almost the whole of the area had experienced mild and normal droughts for 10 to 60 % of years except for Tibbi Block which has experienced more years of mild droughts. Hanumangarh block and Nohar lock have suffered from severe draft of 6 to 9 % of years respectively.

2.5.3 Physiographic Set Up

Physiography

The district is a part of the Thar Desert and is covered by a thick layer of alluvium and wind blown sand. Generally, sand dunes are 4 to 5 m in height. Regional elevation of ground ranges from 100 to 300 metres above mean sea level (masl). The district has a regional slope of less than 5 m/km. Geomorphologically, the land forms in the district can be divided into various units as shown in Table 2.11.

The district is a part of the Thar desert and is covered by thick layer of alluvium and wind blew sand. Generally, sand dunes are 4 to 5 m in height. Regional elevation of ground ranges from 100 to 300 metres above mean sea level (masl). The district has a regional slope of less than 5 m/km.

Geomorphologically, the land forms in the district can be divided into various units. Ghaggar river, locally known as Nali, is the only marked surface water drainage, which flows from NE to SW. It is an ephemeral river that sometimes gets flooded during the monsoon. The district is drained by canals of (1) Bhakra canal system, (2) Indira Gandhi Nahar Pariyojana and (3) Sidmukh canal system. Canal water is mainly used for irrigation and drinking purposes.

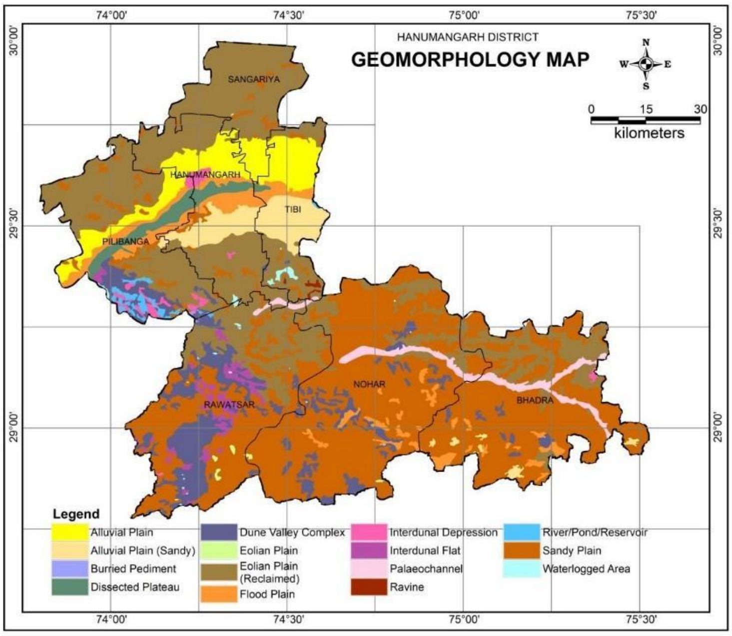

Figure 2.9 Geomorphological Map of Hanumangarh District

Bhakra canal system: Bhakra canal system utilizes water from the Sutlej and Beas rivers. Rajasthan's share in Sutlej water is 2096 million cubic metres (mcm)/year. It provides irrigation to 372,000 hectares (ha) area through a total of 1,949 km of the canal network. Branches of the Bhakra canal irrigate northern parts of the Hanumangarh district.

Indira Gandhi Nahar Pariyopjana: Indira Gandhi Nahar Pariyojana is a multidisciplinary irrigation project conceived to use 10.69 billion cubic meters (bcm) of water available from the Ravi and Beas rivers annually to cultivate 1087 million hectares (mha) of land in the Thar desert of western Rajasthan.

Sidmukh Nohar Canal System: It is an irrigation project planned to provide irrigation in Nohar and Bhadra tehsils by utilizing Rajasthan's share in Ravi and Beas waters.

Table 2.11 Geomorphologic units, their description and distribution of Hanumangarh District

Origin	Landform Unit	Description
Aeolian	Dune Valley Complex	A cluster of dunes and interdunal spaces with undulating topography formed due to wind-blown activity, comprising of unconsolidated sand and silt.
	Eolian Plain	Formed by aeolian activity, with sand dunes of varying height, size and slope. Long stretches of sand sheet. Gently sloping flat to undulating plain, comprised of fine to medium-grained sand and silt. Also scattered xerophytic vegetation
	Eolian Plain (Reclaimed)	Gently sloping with a sheet of sand or sand dunes, scattered xerophytic vegetation.
	Interdunal Depression	Slightly depressed area in between the dunal complex showing moisture and fine sediments.
	Interdunal Flat	Flat, narrow land between dunes
	Sandy Plain	Formed of aeolian activity, wind-blown sand with gentle sloping to undulating plain, comprising of coarse sand, fine sand, silt and clay
Denudational	Buried Pediment	Pediment covers essentially with relatively thicker alluvial, colluvial or weathered materials
Fluvial	Alluvial Plain	Mainly undulating landscape formed due to fluvial activity, comprising of gravels, sand, silt and clay. Terrain mainly undulating, produced by extensive deposition of alluvium.
	Alluvial Plain (Sandy)	Flat to gentle undulating plain formed due to fluvial activity, mainly consists of gravels, sand, silt and clay with unconsolidated material of varying lithology, predominantly sand along river.
	Flood Plain	The surface or strip of relatively smooth land adjacent to a river channel is formed by a river and covered with water when river overflows its bank. Normally subject to periodic flooding.
	Paleochannel	Mainly buried on abandoned stream/river courses, comprising of coarse-textured material of variable sizes.
	Ravine	Small, narrow, deep, depression, smaller than gorges, larger than gulley, usually carved by running water
	Water logged/ Wetland	Area submerged in water or area having very shallow water table. So that it submerges in water during rainy season
Structural	Dissected Plateau	Plateau, crisscrossed by fractures forming deep valleys.
Hills	Denudational, Structural Hill, Linear Ridge	Steep sided, relict hills undergone denudation, comprising of varying lithology with joints, fractures and lineaments. Linear to arcuate hills showing definite trend-lines with varying lithology associated with folding, faulting etc. Long narrow low-lying ridge usually barren, having high run off may form over varying lithology with controlled strike.

2.5.4 Hydrogeological Framework

Geology

The entire Hanumangarh district is covered by Quaternary Alluvium overlain by a thin veneer of wind blown sand in the central part and by high dunes in the southern Part. In the northern part and in the Ghaggar flood plain, alluvium is without any blown sand cover. Quaternary alluvium is mostly fluvial in origin and consists of an alternating sequence of sand, silt and clay. The thickness of alluvium varies from 100m in the southern part to over 400m in the northern part. The basement below alluvium consists of rocks belonging to the Palana series and the Nagaur group of the Marwar Super group. Basement rocks consist of claystone, sandstone and basal evaporites sequence.

The surface geology is marked by a thick cover of blown sand and alluvium except for a few isolated patches of Recent calcareous and sandy sediments. However, the sub surface geology built up with the help of data obtained from dug wells reveals that the oldest rocks in the area belong to the Aravalli Super Group which includes phyllite, shale and quartz veins. These are overlain by the rocks of upper Vindhyans which are entirely made up of bright to pale red, fine and medium-grained, compact sandstone and siltstone which are seen in dug wells near Dalenan, Jaitsar, Pichgarain and many other places. The wind-blown sand of Recent to sub-Recent periods mainly consists of quartz with minor biotite and magnetite. Gypsite rich beds are found in a shallow depression surrounded by sand dunes.

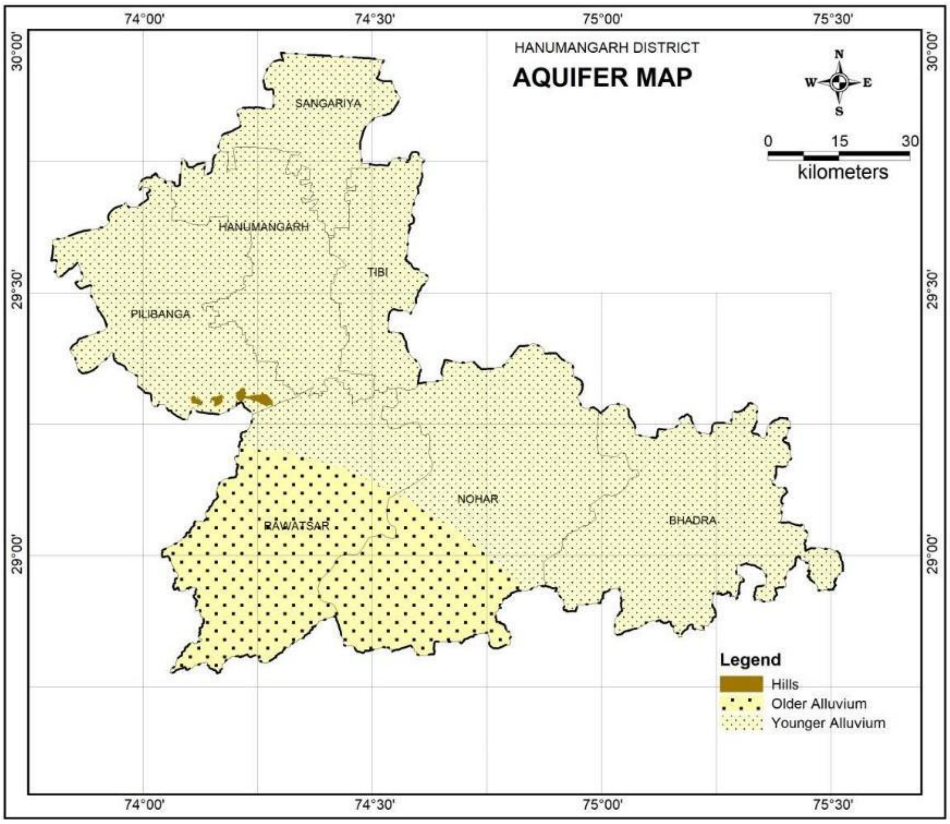

Figure 2.10 Geological Map of Hanumangarh District

Table 2.12 Surface Geology of Hanumangarh District

Age	Group	Formation
Recent to Sub-recent	Recent to Sub-recent	Blown sand, alluvium, isolated calcareous and sandy sediments associated with Gypsite
Upper Vindhyan Supergroup	Upper Vindhyan Supergroup	Bright to pale red, fine and medium-grained, compact medium-grained, compact sandstone and siltstone
Aravalli Supergroup	Aravalli Supergroup	Phyllite, shale and quartz veins

Soil and Irrigation Practices

The northern part of the district is covered by arid soils which are characterized by alluvial soils. These soils are loamy. The central part of the district is characterized by entisols, i.e., desert soils which are loamy along the Ghaggar river course. The southern part of the district is characterized by arid soils i.e. non-calcic brown desert.

The principal means of irrigation in the district is through canals, though some areas are irrigated by wells/ tubewells. Surface water, the main source of irrigation, is utilised through canal networks. As per the data available on the website of Dpt. of Economics and Statistics, Ministry of Agriculture, Govt. of India, as on 2009-10, net area irrigated from canals is 361603 hectares. Net area irrigated through tubewells is 6170 hectares and that from other wells is 2894 hectares. Only a small area of 179 hectares is irrigated through other sources. Total net area irrigated in the district is 370846 hectares and gross area irrigated is 636384 hectares including 622370 hectares area irrigated by canals, 8959 and 4871 hectares by tubewlls and other wells respectively and 184 hectares irrigated by other sources.

Drainage and Hydrology of Hanumangarh District

Ghaggar river, locally known as Nali, is the only marked surface water drainage, which flows from NE to SW. It is an ephemeral river which sometimes gets flooded during monsoon.

Hanumangarh district is divided into two units i.e., Younger Alluvium and older alluvium. Younger Alluvium covers maximum area of the district whereas older alluvium occurs only in the southern part of the district. The ground water in the district occurs under water table condition but at a few places, it also occurs under semi-confined conditions due to presence of over lying impermeable clay horizons. Younger Alluvium: It comprises unconsolidated to loosely consolidated sediments of sand silt, clay and kankar. It forms the principal aquifer and all potential zones fall in this hydrogeological unit. Almost all tehsils have younger alluvial formation except Rawatsar.

Older Alluvium: It comprises of sandy and gypseous clay with kankar. It occurs in the southern parts of the district. The older alluvium does not contain any potential zone. Aquifer Parameters: Based on groundwater exploration, the transmissivity of the aquifer has been estimated to vary from 80 m^2/day to 1600 m^2 /day. Transmissivity and permeability values are higher around Ghaggar Flood plain area and decrease away from it. The average yield of dug wells and dug-cum bore wells/ tube wells in younger alluvium is 20,000 and 3,00,000 litres per day.

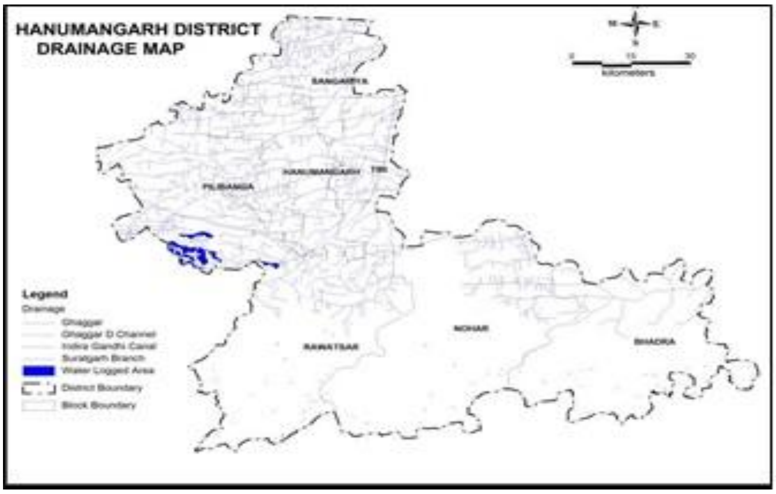

Figure 2.11 Drainage Map of Hanumangarh District

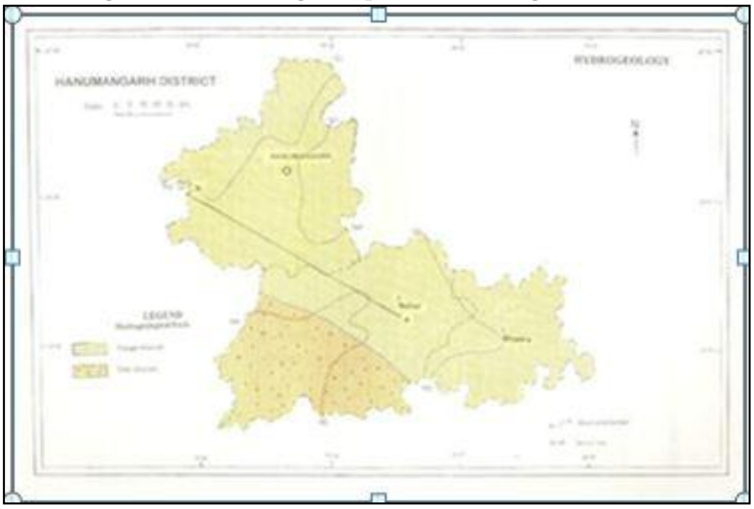

Figure 2.12 Hydrology map of Hanumangarh District

Depth to Water Level (Pre-Monsoon 2011)

The depth to water level varies widely depending upon the topography, drainage, bedrock geology etc. Depth to water varies from less than 1.7 m at Gandehali to 47.25 m at Dudhal in Nohar block. Groundwater level is deeper in the southern part of Nohar block and is generally shallower in the remaining parts of the district. In general, depth to water level varies from 10 m to 30 mbgl. Block wise details of regional depth to water level as observed during May 2011 are given in Table 2.13 and depth to water level map as on May, 2011 is presented in Figure 2.13.

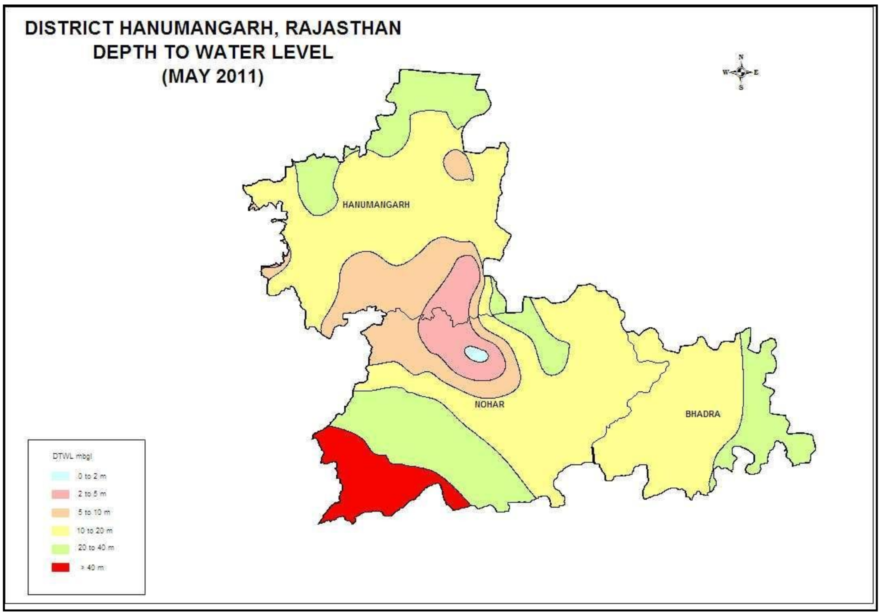

Figure 2.13 Depth to Water Level (May, 2011)

Table 2.13 Block wise details of depth to water level during May, 2011

Block	**No. of wells monitored**	**Depth to water (mbgl)**		**No. of wells showing depth to water in the range**					
		Min	Max	0-2	2-5	5-10	10-20	20-40	>40
Bhadra	3	13.06	17.1	-	-	-	3	-	-
Hanumangarh	18	2.18	27.6	-	1	4	9	4	-
Nohar	13	1.7	47.25	1	1	1	4	3	3

Depth to Water Level (Post Monsoon 2011)

During November, 2011, the water level varied widely from 2.14 m at Rawatsar to 47.14 m at Dudhal in Nohar block. Water level is shallower in central part of the district. In general, depth to water level varies from 10 m to 20 m in Bhadra block, 2 m to 50 m in Nohar block and 2 m to 30 m in Hanumangarh block. Block wise details of regional depth to water level as observed during November, 2011 are given in Table 2.14 and depth to water level map as on November, 2011 is presented in Figure 2.14.

Table 2.14 Block wise details of depth to water level during November, 2011

Block	**No. of wells monitored**	**Depth to water (mbgl)**		**No. of wells showing depth to water in the range**					
		Min	Max	0-2	2-5	5-10	10-20	20-40	>40
Bhadra	3	12.24	16.04	-	-	-	3	-	-

Hanumangarh	18	1.56	27.21	1	1	4	9	3	-
Nohar	13	2.14	47.14	-	2	1	4	3	3

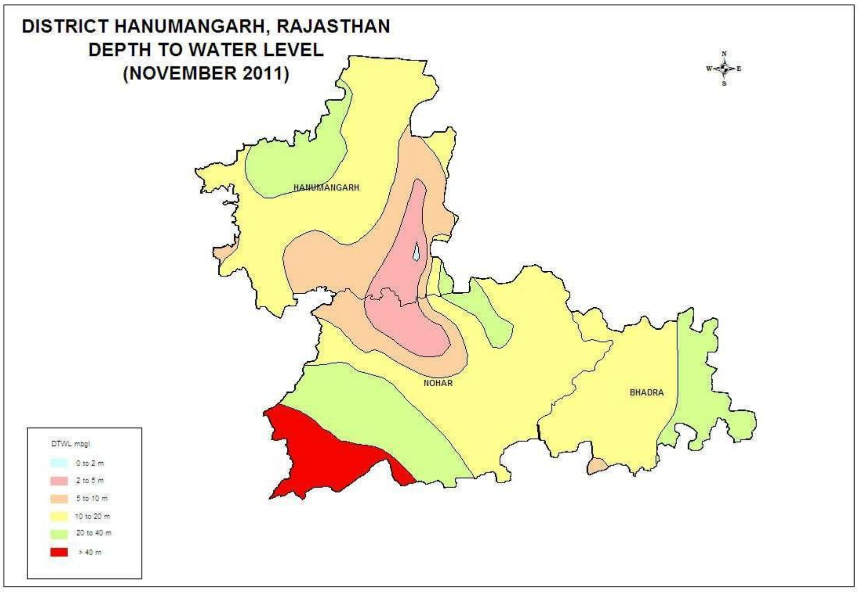

Figure 2.14 Depth to Water Level (November, 2011)

Water Level Fluctuation

Seasonal fluctuation in water level based on Pre and Post-monsoon 2011 indicate that majority of wells in all the blocks have registered a rise in water levels. The decline in water level has been observed in central and northwestern parts of the district comprising parts of Hanumangarh and Nohar blocks. Block wise details of water level fluctuation during Pre- and Post- monsoon periods, 2011 are given in Table 2.15. Seasonal water level fluctuation map is given in Figure 2.15.

Table 2.15 Block wise details of water level fluctuation in Hanumangarh district (May – November 2011)

Block	Rise			Fall		
	No. of wells	Minimum	Maximum	No. of wells	Minimum	Maximum
Bhadra	3	0.07	1.06	-	-	-
Hanumangarh	12	0.03	13.26	6	0.07	9.77
Nohar	11	0.07	1.58	2	0.37	0.86

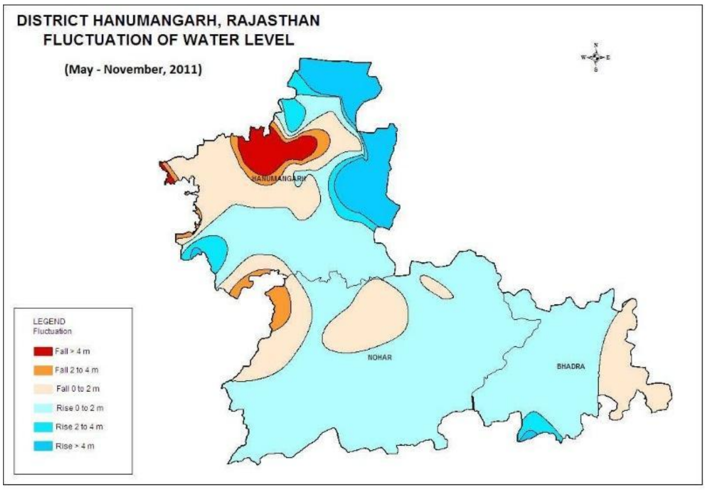

Figure 2.15 Seasonal water level fluctuation map (May – November, 2011)

Groundwater Resources

Groundwater resources have been re-estimated, as on March 2009, jointly by Central Ground Water Board and State Ground Water Department as per the norms recommended by GEC '97. While assessing the fresh ground water resources, saline areas have not been considered. As per the estimation, the total annual ground water recharge of the district based on water level fluctuation method is 225.58 mcm with the natural discharge of 22.558 mcm. Thus, the net annual ground water availability is estimated to be 203.022 mcm. Annual withdrawal of ground water for all uses has been estimated as 163.24 mcm and over all stage of development is 80.4 1%. Summarized block wise estimates of fresh groundwater resources are given in Table 2.16.

Table 2.16 Estimates of fresh ground water resources in Hanumangarh district (As on 2009)

Assessment Unit	Type of area	Total Annual Replenishable Ground Water Resource	Net Annual Ground Water Availability (mcm)	Gross ground water withdrawal for irrigation (mcm)	Gross ground water withdrawal for domestic and industrial uses (mcm)	Gross ground water withdrawal for all uses (mcm)	Stage of ground water development (%)
Bhadra	C	18.1856	16.3670	10.1280	2.1000	12.2280	74.71
Hanumangarh	C	197.8903	178.1013	138.7155	4.7565	143.4720	80.56
Nohar	C	9.5041	8.5537	7.4256	0.1190	7.5446	88.20
Total		225.58	203.0220	156.2691	6.9755	163.2446	80.41

No significant decline in ground water levels has been observed both during the pre and post-monsoon period except in the Hanumangarh block where the significant decline has been observed in some parts. All the blocks fall under 'Safe' category

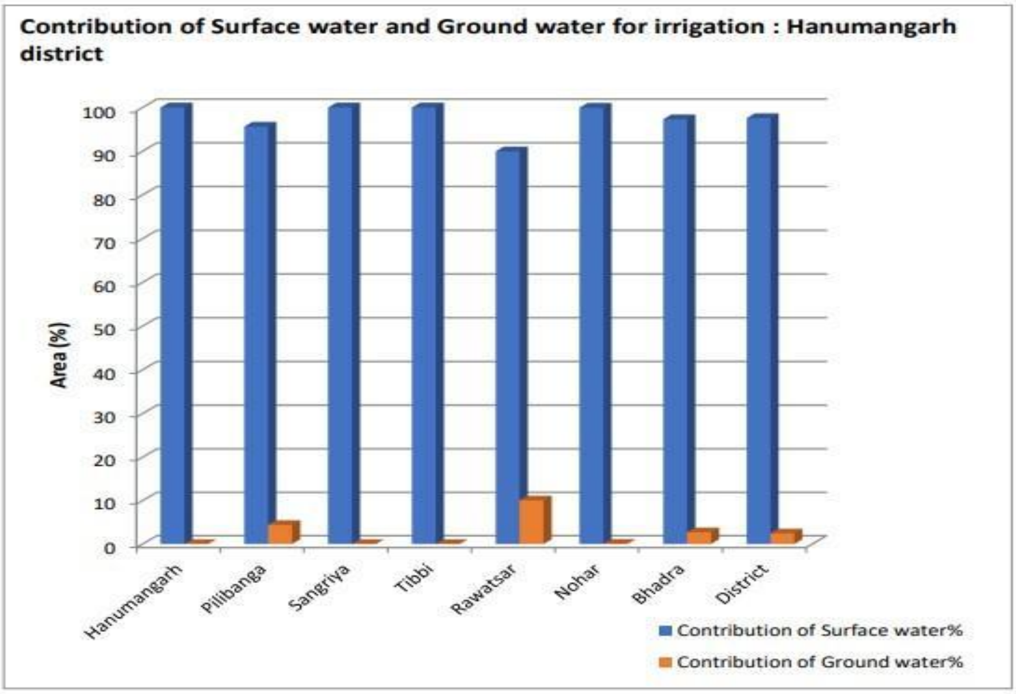

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Figure 2.16 Use of surface & GW in irrigation, Hanumangarh District

Saline ground water resources in the district have been assessed separately. The net annual availability of saline ground water resources has been estimated as 683.8027 mcm, against which annual ground water withdrawal for all uses has been assessed to be 194.6965 mcm.

Status of Groundwater Development

The principal aquifer in the district is alluvium comprising sand, silt, clay, and gravel. Its thickness varies from 100m to 400m. The bed rock below alluvium consists of Palana or Nagaur series of rocks, which do not outcrop anywhere in the district. Groundwater occurs both under water table and confined conditions.

Shallow Water Table Aquifer: The thickness of water table aquifer varies from a few meters to about 80 m. Depth to water level varies from near surface to about 50 m, being 20 m in Ghaggar flood plain. Dug wells tapping the water-table aquifer in Hanumangarh district range in depth from 10 m to 25 m with drilling to an additional 40 m tapping deeper semi-confined aquifer.

Deeper Confined Aquifer: CGWB has carried out ground water in Hanumangarh district. A confined aquifer is found both in alluvium and under lying Palana and Nagaur sandstone. The first confined aquifer is encountered at depths ranging from 90 to 100 m.

The yield of Wells: The yield of dug-cum-bore wells is reported to be between 42 to 110 m^3/hr. The yield from tube wells is about 7 to 70 m^3/hr. Transmissivity of aquifer varies from 100 to 1600 m^2/day, reaching maximum in Ghaggar flood plain.

Urban and Rural Water supply

Since the native groundwater of the entire district is brackish to saline except in small pockets, the urban and rural water supply schemes primarily depend upon surface water source. The maximum requirement is fulfilled from surface water supply through Bhakra canal and Indira Gandhi canal system. Urban areas of Hanumangarh and Pilibanga have water supply schemes from groundwater. Rest of urban areas i.e., Sangaria, Nohar, Bhadra, and Rawatsar entirely depend upon surface water source.

Ground Water-Related Issues & Problems

Water Logging

Natural inter-dunal depressions located in the west of Hanumangarh district are used to store excess floodwaters of Ghaggar river. As the depressions are filled with water, the area around depression experiences a sudden rise in ground water level causing wide spread water logging condition. The specific areas affected by water logging are west and southwest of Baropal, southeast and southwest of Manaktheri, southeast of Rangmahal, southwest of Kalanwali Dhani.

Impounding of Ghaggar flood water in natural depression is the main cause of water logging. The physiographic situation of these villages is such that villages in this belt are located at lower altitude than the depression, which creates a steep gradient and sand dunes being pervious, cause heavy seepage which results in water logging conditions in surrounding areas. The unlined canals from the saddles have further added to the problem.

Study on conjunctive use of surface and ground water was undertaken by CGWB in IGNP Stage I during 1992-1995. The following recommendations were made:

- To mitigate the problem of water logging, ground water development should be 18 % of canal water release at the head.
- A total of 10.023 shallow tube wells be constructed in the command area.
- In areas where water level is shallow (< 10 m, bgl) skimming wells have been recommended.

Water Quality Hazard

There is a wide variation in the quality of ground water. The salinity varies from low (<1500 mmhos/cm) to very high (> 8000 mmhos/cm). Patches of very high EC are observed in southern and western parts of Nohar block and northern and western parts of Hanumangarh block. In the region comprising Ghaggar flood plain, EC ranges from 300 to 3000 mmhos/cm indicating medium to low salinity of ground water. EC of confined aquifer varies from 3000 to 3500 mmhos/cm. In the entire district, the confined aquifer is saline except locally.

2.6 Mineral resources

In the Hanumangarh district, most of land is covered with dune significant quantity and varieties of minerals available here, only some gypsum exists here.

Potash: (Major Mineral) the potential areas of exploration for potash have been identified in Hanumangarh district by the GSI. Potash mineralization is in the form of polyhalite and sylvite which showing occurrences in the Bharusari and Satipura near Hanumanarh city. At present no mining lease is granted in Hanumangarh district.

Gypsum: Gypsum (gypsite) occur at a number of places, of which deposit near Rawatsar, Nohar, Bhadra, Pilibanga Tehsil are quite promising. These occurrences lie below the surface at depth ranging from 0.3 to 1.5 meter. All these deposits are very small, and grade is also variable.

Saltpeter: Saltpeter in the form of efflorescence (Powdery substance after exposure to air) is found on the soil at certain localities in Hanumangarh, Tibbi. Pilibanga tehsil. At present no mining lease is granted in Hanumangarh district.

Brick Earth: Brick earth is available in whole of the district. At present around 320 Brick Earth units are running in all around Districts. Top layer of soil which is an admixture of clay, is used for making bricks. 5 to 7-metre-thick column of a clayey soil is found at different places in the district is used for this purpose. There is no stone quarry in the district so only bricks are used in construction.

The district is not rich in respect of mineral resources. Gypsum is the main mineral which is found in Rawatsar and Pilibanga Tehsils. Gypsum used in manufacturing of fertilizer, Portland cement & Plaster of Paris. About 90% of the total production of Gypsum are send outside the district. Sweet lime and Kalmi Shora is also found in the district.

2.7 Forest Cover

Flora and Fauna

Out of the total area of 9656.09 sq. km. 239.46 Sq. km. was covered by forest. There are 113.25 sq. km. protected forest and 126.21 sq. km. are unblissful forests. Formerly there is no forest. Gradually with the availability of water through canals, irrigated forest plantation has been taken up. Trees like Shisham, Mulberry, Eucalyptus is being grown on the banks of the canals, distributes and minors, Roadside plantation has also been taken up. Main forest produce is Ber, Kinno, Timber and Firewood as per Rajasthan Statistics forest - 2009.

Most of the area of the district is sandy. The paucity of water has been reused in very little vegetation. After the availability of water through the Indira Gandhi canal a portion of the district has been vegetation. The flora in the district is positively transforming with the completion of the canal and increased irrigation facilities However, vegetation available on sand dunes where shrubs is like "Aak", "Bawali", "Gekhru", grow sparsely over some of the undulating sand dunes. The Alluvium soil in the famous Ghaggar beed is also sparsely Strawn with vegetation which generally grows species like Methi, Bathua, Loni and Farash. Trees like Kikar, Babool, Moouj, Weed are also grown in the irrigated area.

Forest

The district has a very adverse xerophytic climatic conditions with temperature extremes. The mean annual rainfall in the area is around 286.1 mm and the average number of rainy days during monsoon and during the entire year lies in the range of 15-19 days and 19-27 days, respectively in the district. The area is scanty in natural vegetation cover. The arrival of canal water however gradually, but significantly, changed the landscape. Forest plantations are taken up along and on the banks of canals (main, distributaries and minor canals) and species such as Seesham (*Dalbergia sissoo*), Mulberry (*Morinda citrifolia*), *Eucalyptus*, etc., have been grown. Roadside plantation has also been taken on large scale to improve the green cover in the area. Phoge (*Calligonum polygiionoides*), khimp (*Leptadenia pyrotechnica*) and Kair bushes and Khejri, Royara and Babul trees are mainly found on the sand dunes. Shrubs like "Aak", "Bawali", "Gekhru", grow sparsely. As the lands are extensively cultivated, there is no natural habitat left in and around Hanumangarh. There are no ecologically sensitive areas or wildlife habitats in the area.

3. Demography of Hanumangarh District

Hanumangarh is one of the district of Rajasthan in India. There are 7 Tehsils, 1907 villages and 6 towns in the Hanumangarh district. In 2011, Hanumangarh had a population of 1,774,692 of which male and female were 931,184 and 843,508 respectively. In the 2001 census, Hanumangarh had a population of 1,518,005 of which males were 801,486 and the remaining 716,519 were females.

Hanumangarh District Density 2011

The initial provisional data released by census India 2011, shows that the density of Hanumangarh district for 2011 is 184 people per sq. km. In 2001, Hanumangarh district density was at 157 people per sq. km. Hanumangarh district administers 9,656 square kilometres of areas.

Hanumangarh Sex Ratio 2011

With regards to Sex Ratio in Hanumangarh, it stood at 906 per 1000 male compared to the 2001 census figure of 894. The average national sex ratio in India is 940 as per the latest reports of the Census 2011 Directorate. In the 2011 census, the child sex ratio is 878 girls per 1000 boys compared to the figure of 872 girls per 1000 boys of 2001 census data.

Hanumangarh District Population Growth Rate

There was a change of 16.91 per cent in the population compared to the population as per 2001. In the previous census of India 2001, Hanumangarh District recorded an increase of 30.31 per cent to its population compared to 1991.

Hanumangarh District Urban Population 2011

Out of the total Hanumangarh population for 2011 census, 19.75 percent lives in urban regions of district. In total 350,464 people lives in urban areas of which males are 184,297 and females are 166,167. Sex Ratio in urban region of Hanumangarh district is 902 as per 2011 census data. Similarly, child sex ratio in Hanumangarh district was 852 in 2011 census. Child population (0-6) in urban region was 43,663 of which males and females were 23,570 and 20,093. This child population figure of Hanumangarh district is 12.79 % of total urban population. Average literacy rate in Hanumangarh district as per census 2011 is 75.45 % of which males and females are 83.32 % and 66.79 % literates respectively. In actual number 231,477 people are literate in urban regions of which males and females are 133,919 and 97,558 respectively.

Hanumangarh District Rural Population 2011

As per the 2011 census, 80.25 % population of Hanumangarh districts lives in rural areas of villages. The total Hanumangarh district population living in rural areas is 1,424,228 of which males and females are 746,887 and 677,341 respectively. In rural areas of the Hanumangarh district, the sex ratio is 907 females per 1000 males. If child sex ratio data of Hanumangarh district is considered, the figure is 884 girls per 1000 boys. The child population in the age 0-6 is 190,563 in rural areas of which males were 101,170 and females were 89,393. The child population comprises 13.55 % of the total rural population of Hanumangarh district. The literacy rate in rural areas of Hanumangarh district is 65.06 % as per census data 2011. Gender wise, male and female literacy stood at 75.94 and 53.12 per cent respectively. In total, 802,659 people were literate of which males and females were 490,362 and 312,297 respectively.

Table 3.1 Comparative Analysis of Demography of Rural and Urban

Description	**Rural**	**Urban**
Population (%)	80.25 %	19.75 %
Total Population	1,424,228	350,464
Male Population	746,887	184,297
Female Population	677,341	166,167
Sex Ratio	907	902
Child Sex Ratio (0-6)	884	852
Child Population (0-6)	190,563	43,663
Male Child (0-6)	101,170	23,570
Female Child (0-6)	89,393	20,093
Child Percentage (0-6)	13.38 %	12.46 %
Male Child Percentage	13.55 %	12.79 %
Female Child Percentage	13.20 %	12.09 %
Literates	802,659	231,477
Male Literates	490,362	133,919
Female Literates	312,297	97,558
Average Literacy	65.06 %	75.45 %
Male Literacy	75.94 %	83.32 %
Female Literacy	53.12 %	66.79 %

For administrative convenience, the district is divided into 7 tehsils and development blocks viz. Bhadra, Hanumangarh, Nohar, Pilibanga, Rawatsar, Sangaria and Tibi Tehsils. It has a total population of 1774692 as per 2011 Census. The district has 1907 villages and 6 urban towns. Rural and urban population of the district is 14.29 lakh and 3.51 lakh respectively. Population wise data are presented in diagram below :

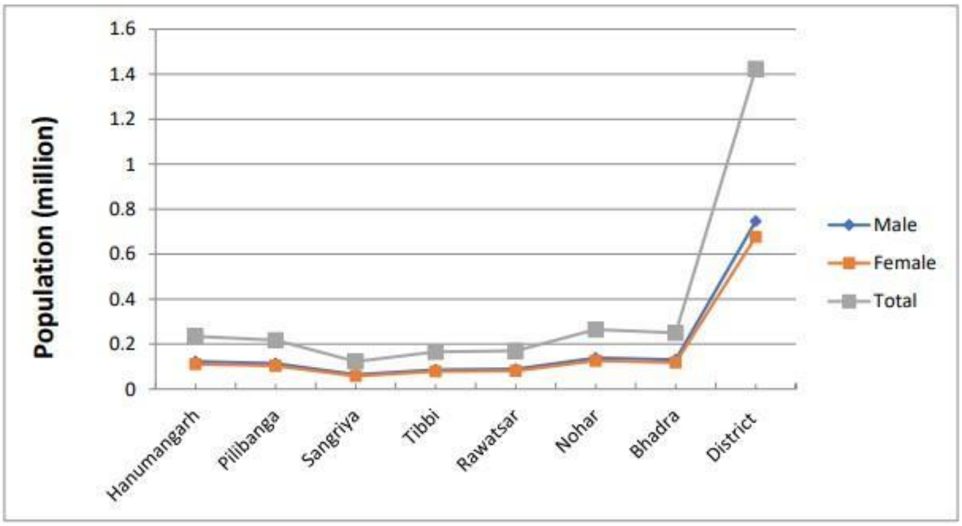

Figure 3.1 Population Graph of Hanumangarh District

Economy

Main source of income in the district is from the agriculture sector and per capita income is Rs. 1,07,244. The crime rate in the district is 216.94 for the year 2018. Total cropped area is 12,91,650 in hectares and the forest area is 89.96 in sq km (2019).

Working force and Occupational pattern-

As per census of 2001 total workers in the district is about 638311 persons which constitute 41.39 % of the total population of the district among the total workers 429127 are male and 214184 are female the occupational distribution of the working population of the district is shown in the following table-

Table 3.2 Working force occupational pattern

Sr. No.	Occupation	Total	Males	Females	Percentage
1	Cultivators	376501	225490	151011	68.18
2.	Agriculture Laboure's	100570	61008	39562	18.21
3.	Workers in Household Ind.	59073	47728	11345	10.70
4.	Other workers	16093	129271	19216	2.91
	Total	552237	463497	221134	100

Material Resource

Agriculture-

Agriculture is the principal occupation of the people in Hanumangarh district about 76.14 % of total working force is engaged in agriculture. It would therefore be essential to assess the possibility of further agro industrialization in the Hanumangarh district by exploring existing land use patterns, irrigation facilities and cropping patterns of the area. The land utilization pattern reveals that the cultivated area in 2011-12 was 882381 hectares as against the total land 970359 hectares in the Hanumangarh district. Area under fallow land 70157 hectares and forest was 18439 hectares. The following table gives the land use pattern of the Hanumangarh district.

Table 3.3 Land use Pattern as of 31.3.2016 (Source: Agriculture Dy. Dir. Office, Hanumangarh)

Sr.No.	Classification of Land	Area in Hectares as on 31.3.2015
1.	Total Geographical area	970359
2.	Area under Forest	18439
3.	Permanent Pasture	56423
4.	Fallow land	70157
5.	Other unclutivable waste land	7079
6.	Net area sown (Cropped area)	871000
	(i) Irrigated Area	371000
	(ii) Un- irrigated area	500000

Major Crops

Total area sown in the district is continuously increasing. The irrigated area is increasing resulting in increase of double cropped area. The major crops grown in Kharif Season in the Rice, Bajra other Kharif Pulses, Cotton, Sugarcane and guar seeds and in Rabi season the major crops grown are wheat, Barley, Mustard and Taramira. The area and production of Principal crops in the district are given in the following table.

Table 3.4 Area and Production of principal Crops in the district Area in Hectares and Production in M.T. (Source- Office of Dy. Director, Agriculture, Hanumangarh)

S No	Crop	2012-13		2013-14		2014-15	
		Area	Production	Area	Production	Area	Production
1	Cotton	174720	404440	151171	267028	172385	660770
2	Paddy	24635	128102	22311	147252	21401	149807
3	Bajara	47976	31184	82300	92664	31603	34763
4	Til	6514	3908	4683	4868	1264	1079
5	Moong	10026	7319	30350	20027	11210	8968
6	Moth	34936	8734	91726	28438	12597	3779
7	Guar	195932	156745	291028	229460	491003	343706
8	Wheat	162900	521280	221200	884800	234282	960556
9	Mustard	111455	190951	98000	117600	105523	126628
10	Gram	228077	21226	220000	220000	70150	63135
11	Barley	20032	60036	25400	106680	16554	66216
12	Tara Mira	1741	870	609	243	923	406

Horticulture

The climate condition or the district Hanumangarh are favorable for the development of arid horticulture. The major fruits grown in the district includes Kinnow, Ber, Grapes, Pomegranate and Guava. The Malta, Mausmi, Orange, Lemon and Potato. The fallow land of 39664 hectares can be developed for horticulture and other tree crops.

A number of private nurseries particularly for "Citrus" plants have also been established by Horticulture Department. The climate of the district is suitable for "Jojoba" plantation. The seedling of Jojoba plant are locally available in the nurseries at Nohar block. Bhadra and Nohar blocks of the district are suitable for the cultivation of "Sonamukhi". Besides the main fruit crops vegetables are also grown on fairly good area. About 5960 Tonnes of Malta, Kinnu and Mausmi are surplus based on surplus two food processing units can be setup in the district at Hanumangarh. Tomato is also grown in large area. During the field survey it was revealed that in the season the rates of tomato go down.

Keeping in view all the foods a good processing unit for preparation of Jem and Jelly can be setup. because tomato and other fruit are available in abundance and area under horticultures is creasing. The details of the horticulture's crops are as given below-

Table 3.5 Details of Horticulture Crops

Sr.No.	Name of Crops	Year 2014-15	
		Area in Hectares	Production in M. Tonnes
	FRUITS		
1	Guava	25	950
2	Lemon	36	60
3	Kinnow	1893	45000
4	Mosambi	55	1925
5	Malta	25	875
6	Pomegranate	21	400
7	Ber	62	744
8	Anola	27	405
9	Datepalm	112	532
10	Beel	14	0
11	Other	8	1.6
Total		**2278**	**50892.6**

Sericulture

Mulberry trees are grown on the banks of the canals and tributaries. If the farmers and inspired to grow up to the mulberry trees on commercial basis, then sericulture can be developed in the area.

Forest

The total forest area in the district was placed at 18439 hectares during 2014-15. The district does not have any defined forest area. However, trees have been grown along the roads and canals. These are Eucalyptus or Safeda. It is reported that these will form a good raw material for paper.

Due to adverse climate conditions such as scarcity of water (Surface), unsuitability of soils, no forest could be developed, Efforts, however, are made to preserve the meagre tree growth and for the planting of new trees. Species like Shisham (Dalberiat) Mulberry, Eucalyptus and Kikar are planted on the banks of Indira Gandhi Canal. Forest produce for commercial or industrial purpose is not available in the district.

Fisheries

Hanumangarh District is in the arid zone of Rajasthan State. The rainfall is scanty. The normal rainfall is 253 mm. There are no reservoirs and tanks in the district. The flood water of Ghaggar has been diverted to depressions. Also, with the completion of the Indira Gandhi canal.

Gandhi Canal Stage I and II and Bhakra canals a large number of burrow pits have been developed adjacent to the canals. These lands can be developed in the fish culture ponds. Fish ponds ranging between 1 hectare to 5-hectare water area can be constructed to undertake culture in water logged land available around diversion channels. Area available for development of Fisheries in Hanumangarh district is as under-

Table 3.6 Area available for the development of Fisheries in Hanumangarh district

S.No.	Source	Area in Hectares
1	Ghaggar Land Depressions	18000
2.	Low lying water- logged land and burrow pits. & Brackish water- logger	11000

In view of the availability of ample surface water from the Ghaggar river and various canals, there is good scope for the development of pond fish culture. At present State Fisheries Department is allotting ponds on 3 years' contracts is borrow pits and depressions to contractors from which annual revenue ranging between Rs. 42 lakhs to Rs. 50 Lakhs is received. State Fisheries Department is providing training to farmers for the development of fish culture in the district. There are two fish seed farms in the district, one at Lakhowali and other at Talwara with capacity of 20 lakh fingerlings each year. One hatchery unit at Hanumangarh is in the private sector with production capacity of one crore friy per year. About 50 lakh fish seeds are also available from natural sources. The target and achievement of district fisheries department for the year 2016-17 are given below.

Table 3.7 Target and achievement of district fisheries department for the year 2016-17
(Source fisheries Dept. Hanumangarh Town)

S.No.	Particulars	2014-15	
		Target	Achievement
1.	Seed Production (Fries in Lakh)	300 Lac.	531.00 Lac.
2.	Fish Production	2900 MT.	3063.00 MT.

The district fisheries Department helps the farmers in the supply of fish seeds and marketing of products. It is providing subsidy @ of 20% of excavation of ponds and inputs cost subject to Rs. 12500/- for sc and Rs. 10000/- for general category per hectare respectively.

During 2013-14 about 8,92,649 hectares was the net sown area in the district out of which 542853 hectares was irrigated which constitutes 61.60% of the total area sown. The availability of irrigation facilities in the district is far compared to other districts of the State. Irrigated area of the district is shown in the following table.

Table 3.8 Tehsil wise irrigated area of Hanumangarh district during 2016-17 (Source: Land Record Collectorate, Hanumangarh)

Sr.No.	Tehsil	Irrigated Area
1.	Hanumangarh	91699
2.	Pilibanga	68375
3.	Sangaria	54959
4.	Tibbi	60011
5.	Rawatsar	47876
6.	Nohar	47532
7.	Bhadra	41791
	Total	**412243**

Canals

Canals are the main source of irrigation as about 32.38% of the gross area were irrigated through canal only during 2013-14. Among the canal's irrigation is done mainly through Bhakra multiple projects and Indira Gandhi Canal. In some of the area of the district the irrigation from Ghaggar canals is also available. The renovation Bhakra canals project has become helpful for increasing the irrigational facilities to a greater extent. The main canal project of irrigation in the district are given below-

- Bhakra Canal Project.
- Ghaggar Flood Control Project
- Indira Gandhi Canal Project
- Sidhmukh Canal Project
- Nohar Feeder Project

Above mentioned irrigation system has put the district in the agriculture map of the country and has become the centre of food grain in the State.

Wells- Pump Sets

Wells and pump sets are the major source of irrigation in Bhadra and Nohar Tehsil. Only 15991 hectares out of 676112 hectares that is only 2.37 % of the total irrigated area in the district.

Livestock Resources

Livestock plays an important role in the economy of the district According to livestock Census 2007, there was 1506302 livestock population in the district. Cattle found in Hanumangarh district belong to Haryana and Rathi breeds, sheep's of Nail breeds. Buffaloes of Murrah breed, Camels of Bikaner breeds and the horses, donkeys, goats and pigs found are mostly of mix deshi breeds. Buffaloes, cows, camels, goats are main domestic animals and are kept for milk, dairy etc. The details of livestock and poultry as per 2007 Census is given below-

Table 3.9 Livestock Census 2007 of Hanumangarh District (Source-Offices of the Dy. Director, Animal Husbandry Dep. Hanumangarh)

Sr.No.	Category	Numbers
1	Cattle	502071
2	Buffaloes	389303
3	Sheep	189210
4	Goat	212993
5	Horse/Ponnies	1223
6	Donkeys	3370
7	Camel	31226
8	Pigs	1462
9	Dogs	49647
10	Poultry	136222
	Total livestock	**1516727**

Dairy Development

As per livestock census 2007 there were 312059 cattle and about 333047 buffaloes, 243046 goats and 292792 sheep. On the basis of this population the district has good potentiality of milk production. Good quality animals are available in the district and can be purchased from adjoining States of Haryana and Punjab. The details of present infrastructure facilities at present are as under-

Table 3.10 Details of present infrastructure facilities

1	Veterinary Hospitals Ist Grade	07
2	Veterinary Hospitals	45
3	Veterinary Sub Hospital	52
4	Milk Chilling Plant 10000s Liter/day	05
5	Dairy Co- operation Societies	949
6	Milk Plant one lakh liter capacity per day	01

There is well-established network of milk handling capacity of the dairy plant at Hanumangarh is one lakh liter per day.

Poultry Development-

Eggs and poultry meat are important sources of high-quality proteins to balance the diet of common people. Poultry Farming to provide a source of subsidiary income and gainful employment to farmers throughout the year poultry manure has high fertilizer value and can be used for increasing yield of value and can be used for increasing yield of agriculture crops. Thus, poultry production has an important place in rural based economy.

Due to the military cantonment areas of Suratgarh and Sriganganagar the demand for poultry is high. The daily demand for eggs is about 1.50 lakh whereas the supply is only 40000 eggs per day. In the absence of local production, the gap of supply is met by important from adjoining districts/States. There is no hatchery unit in Hanumangarh district. Day-old chicks are being purchased from Jaipur, Ajmer or Punjab.

4. Waste Management

4.1 Literature Review

4.1.1 Municipal Solid Waste

Waste includes any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and community activities. Almost everything we do generates some kind of waste.

Municipal Solid Waste (MSW) - more commonly known as trash or garbage - consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. This comes from our homes, schools, hospitals, and businesses.

An inefficient municipal solid waste management system may create serious negative environmental impacts like infectious diseases, land and water pollution, obstruction of drains and loss of biodiversity. If cities continue to dump the waste at the present rate without treatment, it will need 1240 hectares of land per year and with the projected generation of 165 million tons of waste by 2031, the requirement of setting up of land fill for 20 years of 10-meter height will require 66,000 hectares of land.

The task of meeting the incremental infrastructural needs of a growing urban population is becoming increasingly difficult in urban India (CPHEEO, 2016b). Municipal solid waste management in the country has become difficult as the country's population grows, not only because of environmental and aesthetic concerns but also due to the massive amounts of municipal solid waste (MSW) generated every day. As per Central Pollution Control Board (CPCB), India created 1,43,449 tons per day (TPD) of MSW in 2014–2015, with an average waste of 0.11 kg/capita/day. Only 32,871 TPD (22%) of the whole MSW was processed or treated, although about 1,17,644 TPD (80%) was collected. Per capita waste generation from 0.2 kg to 0.6 kg varies depends on the household and economic size of the Indian population. Segregation at source, collection, transportation, treatment, and scientific disposal of waste was all unsatisfactory, resulting in environmental degradation and a lower standard of living (CPHEEO, 2016b). MSW generation is undeniably rising over the world as a result of fast population and economic growth, as well as changes in living practices and consumer trends (Al-Ghouti et al., 2021). The rising volumes of garbage generated would not be a problem if garbage was treated as a resource and properly handled (S. Kumar, 2016). Waste must be viewed as a mostly untapped resource for recovering resources, realizing environmental, economic, and social advantages, and taking a step toward a more sustainable future (Ferronato & Torretta, 2019).

Municipal solid waste (MSW) dumps in Indian cities are in dire state (Datta & Kumar, 2016). Heights and base areas of 62 dumps in 26 cities range from 2 to 29 m (i.e., 6 to 95 ft) and 2 to 53 ha (i.e., 5 to 130 acres) respectively (interquartile ranges). These dumps have potential for environmental impact since 62% of the sites are less than 500 m from the communities, 85% of the sites have groundwater (GW) at less than 25 m depth and 40 % of the sites have surface water bodies within 2 km distance.

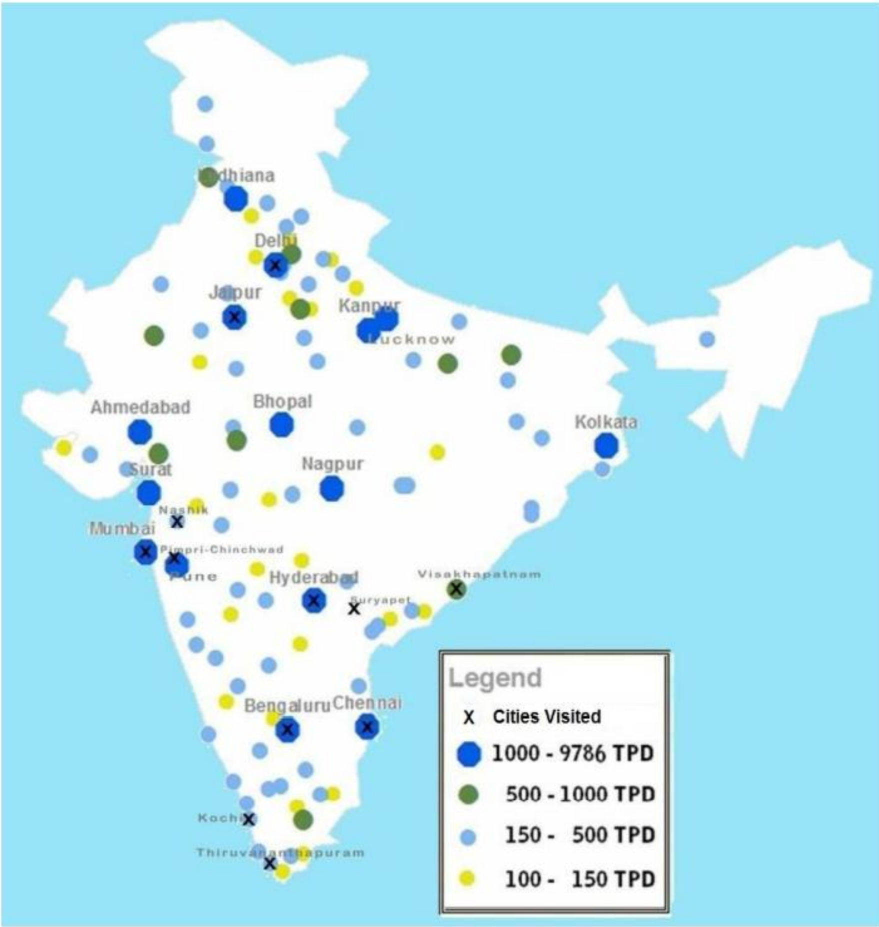

Figure 4.1 Map of Cities Generating Different Quantities of MSW; Cities Visited by the Author during Research Visits

As shown in figure 4.2 the composition of urban MSW in India is 51 % organics, 17.5 % recyclables (paper, plastic, metal, and glass) and 31 % of inert. The moisture content of urban MSW is 47 % and the average calorific value is 7.3 MJ/kg (1745 kcal/kg). The composition of MSW in the North, East, South and Western regions of the country varied between 50-57 % of organics, 16-19 % of recyclables, 28-31 % of inert and 45-51 % of moisture. The calorific value of the waste varied between 6.8-9.8 MJ/kg (1,620-2,340 kcal/kg).

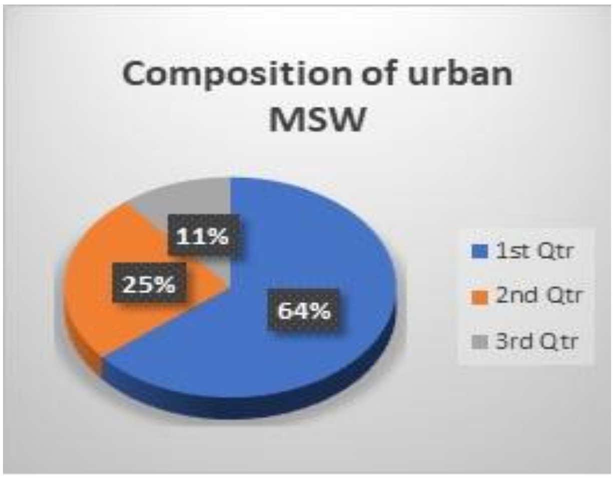

Figure 4.2 Composition of Urban MSW

The Ministry of Urban Development initiated the Swachh Bharat Mission (SBM) in 2014 to promote municipal solid waste management in cities (CPHEEO-Part I, 2016). SBM aims to promote cities as engines of economic growth by improving urban infrastructure quality, ensuring service standards, and ensuring efficient governance. SBM also intends to resolve municipal solid waste management concerns and assist cities in creating modern and appropriate solutions according to (CPHEEO, 2016b). Solid waste management can be conceived as a series of interconnected steps that begin with waste generation by individual families, institutions, and businesses and progress via Collection, Segregation, Processing, and Disposal. The modern integrated municipal solid waste management is based on the waste management hierarchy shown in Figure 4.3 the aim of which is to reduce the amount of waste being disposed while maximizing resource recovery and efficiency (CPHEEO-Part I, 2016)

Total 193 ULBs are responsible for MSW management in the state of Rajasthan. The total solid waste generation in the State is 6625.56 TPD out of which 6475.39 TPD is being collected through Door-to-door collection system from 5350 wards out of 5399 wards of Urban Local Bodies. Currently, 780.18 TPD waste is being processed by ULBs out of 6625.56 TPD in 4 solid waste processing facilities operating in the State (GOR, 2019)

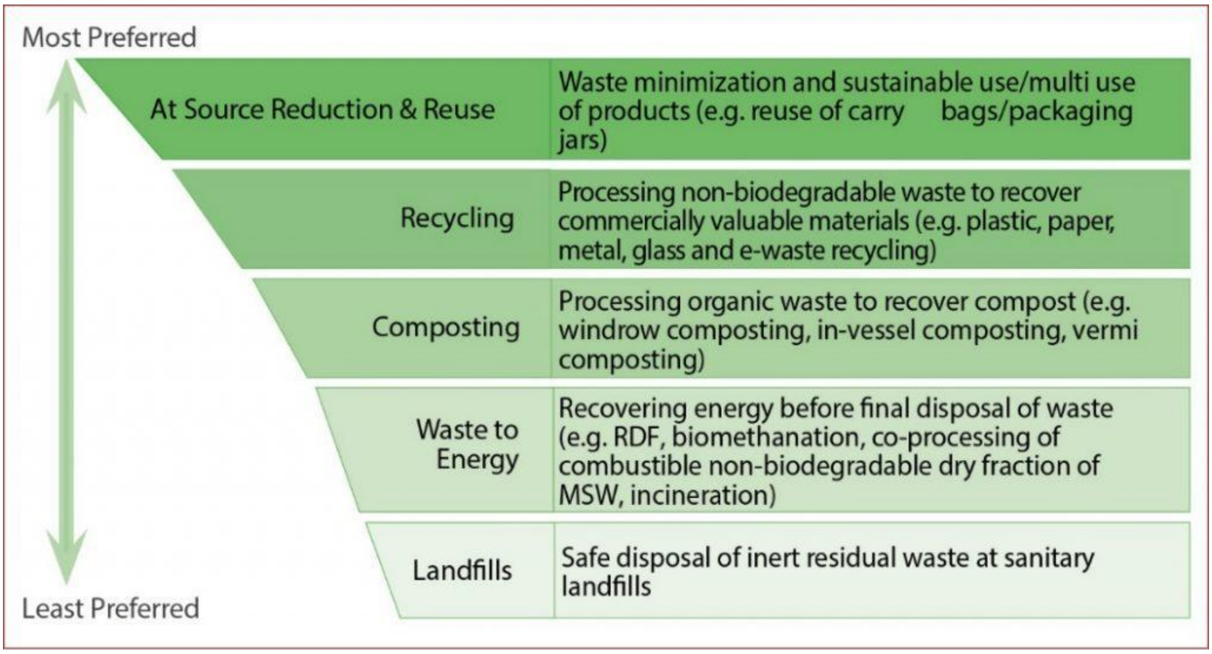

Figure 4.3 Waste Generation Techniques

Decentralized waste management v/s Centralized waste management

In some cases, decentralized waste management methods at the community level are preferable to centralized waste management methods (CPHEEO, 2016c) e.g., as the size of city increases or population increases the waste generated also increases so to decrease the burden on a centralized waste management facility decentralized waste management systems are preferred.

Decentralized waste management systems, also known as community waste management systems, alleviate the strain of managing huge volumes of MSW at a central location, lowering transportation and intermediate storage expenses (Central Public Health and Environmental Engineering Organisation (CPHEEO, 2016c) Potential drawbacks of decentralized waste management as per (CPHEEO, 2016c) are: i) In many urban locations, the land is difficult to come by. ii) Inadequate space, training, and capacity of workers make it impossible to maintain scientific and hygienic conditions. iii) Unreliable end-product quality.

Integrated solid waste management and role of the informal sector

Integrated solid waste management is a comprehensive approach to solid waste prevention, recycling, and management. According to (Datta & Kumar, 2016) in the end, this comprehensive approach will aid in the protection of human health and the environment. ISWM examines local demands and conditions before mapping out the best waste management strategy for each situation. Complete waste management, including composting, burning, and disposal at a well-constructed and managed landfill site, are the main operations. Even a small increase in income in cities can lead people's consumption patterns to shift, resulting in trash types and volumes that are more difficult for municipalities to manage. e.g., the imposition of lockdowns and the closure of eating establishments (cafés and restaurants) has resulted in a surge in the transportation of food rations and groceries, resulting in the growth of various plastic wastes such as High-Density Polyethylene (HDPE), Low-Density Polyethylene (LDPE), Polypropylene (PP), Polyethylene Terephthalate (PET), etc (S. Kumar, 2016).

ULBs should address a variety of concerns while planning a Municipal Solid Waste management system, such as trash flow allocation and waste inventory (Al-Ghouti et al., 2021). Effective approaches that can holistically address these issues are greatly needed to aid MSW management planning. According to (Batista et al., 2021)11 critical success factors which if implemented correctly can represent a viable way to overcome the present dilemma that surrounds the management of Integrated Municipal Solid Waste Management are that they should be aligned with public policies (Digital public consultation, articulated actions, enhanced logistics), disposal techniques (leaching, incineration), legal aspects (flexible contracts, integrated legislation), Public-Private Partnerships (current and relevant practices, enhanced models for infrastructure) and Energy recovery (incinerated solid waste, incentives and investments).

Three governance characteristics are crucial for sustainable solid waste management, according to the UN-Habitat framework: inclusivity (which includes both users and providers of services), financial sustainability, and effective institutions and proactive policies (United Nations, 2009). A well-designed and carefully implemented waste management policy will help to achieve all three "pillars" of sustainable development (environmental, economic, and social): improving economic efficiency, particularly in resource extraction and use; reducing or eliminating negative impacts on health and the local and general environment; and providing more attractive and pleasant human settlements (Le Blanc & UN Environment Programme, 2017)

The informal sector (which includes rag pickers and illegal or unauthorized recyclers) must also be integrated into the mainstream waste management process because they handle a significant amount of rubbish without the necessary environmental safeguards (S. Kumar, 2016). Recyclables should be collected at the community level, preferably with the assistance of the informal sector, and organic waste should be managed through household composting systems and community composting systems (CPHEEO, 2016c)The informal sector, which includes the kabaddi system and waste pickers, is critical to the SWM value chain because it recovers valuable materials from the garbage. As per (CPHEEO, 2016c) in India the informal sector, which includes the kabaddi system and waste pickers, plays a vital role in recycling material collection and processing. Waste dumped in unauthorized places, vacant lots, etc., garbage recovered by kabaddi system, garbage collected by informal waste collectors or waste pickers are all excluded from waste measurement at transfer stations, processing or disposal sites, which does not adequately reflect waste generation rates, since these measurements do not include: waste disposed at unauthorized places, vacant lots, etc., waste recovered by kabaddi system, waste recovered by informal waste collectors or waste pickers from the street, bins, and intermediate transfer points, etc. (CPHEEO, 2016c). Rag-pickers save over 14 % of the municipal budget each year, yet their effort goes virtually unnoticed, and they are commonly denied the right to work (Joshi & Ahmed, 2016). According to estimates stated by (Joshi & Ahmed, 2016) rag-pickers lower the load on transportation and landfills by up to 20 %. This further makes an argument in the favor of inclusion of the informal sector in the municipal solid waste management system so that the waste collected by them can also be accounted for in the waste generation rates. The benefits of integrating the informal sector according to (CPHEEO, 2016c) include the creation of livelihoods, social acceptance, and security for informal sector workers, as well as the regularization of the recycling market. This can be accomplished by forming self-help groups (SHGs) or cooperatives to enable people to work as entrepreneurs in a business organisation (Central Public Health and Environmental Engineering Organisation (CPHEEO, 2016c). So that they might own modest recycling facilities that are scientifically and hygienically managed in the future. The informal sector has made a significant contribution to the recycling of secondary materials, with the ratio of totally recyclable materials purchased by scrap buyers exceeding the average amount of domestic solid waste generated and collected in the Mekong Delta, Vietnam, by 7.9 % and 17.8 %, respectively, allowing the economy to function and grow efficiently. As a result, the economy can transition to a circular economy model (He & Mai, 2021).

Roles and Responsibilities of concerned Institutions

Role of Urban Local body

Due to the large number of institutions and stakeholders engaged in MSWM, it is critical that the MSWM plan, which attempts to close gaps or improve service quality, is produced collaboratively. The ULB, specifically the SWM division, is primarily responsible for developing an MSWM plan. As per (CPHEEO, 2016a) to design the MSWM plan, a core team or advisory team, often known as internal stakeholders, may be formed. This team should be cross-functional, with representatives from all departments connected with, influenced by, or influencing SWM services in a city. The internal stakeholder team should be led by the ULB's commissioner or chief executive (CPHEEO, 2016a)

According to (CPHEEO, 2016a) municipal officials may also seek advisory assistance from subject-matter experts, academicians, and environmental planners and engineers if capacity within the ULB is insufficient. Informing and involving the community (external stakeholders), as well as establishing channels for all stakeholders to engage in decision-making, are all critical stages for successful MSWM strategy implementation (CPHEEO, 2016a).

A MSWM system's typical stakeholders include homes, businesses, industries, the informal sector, local government, non-governmental organizations (NGOs), community-based organizations (CBOs), self-help groups (SHGs), women groups, secondary school and college students, and members of other institutions that may play a role in assuring community participation (CPHEEO, 2016a). According to (CPHEEO, 2016a) these groups would have to represent the interests of men, women, youth, and other marginalized or vulnerable groups of persons involved in the MSWM process. Women's groups, in particular, must be involved in the planning phase (CPHEEO, 2016a)*).*

Action points and stakeholder responsible as per SWM rules, 2016 (District Collector and District Magistrate)

- Collection, segregation and treatment of solid waste, strengthening the capacities of the ULB's – ULB's
- Notification and implementation of by-laws – ULBs and District Information and Public Relations Office (DIPRO)
- Awareness – ULB's, NGO's, SHG's, Insp. Of schools, DIPRO
- Monitoring and Review – EO of ULB's and District level committee

Role of State and regional level authorities

In addition to the ULBs, states also have particular MSW management duties. These are:

- The Secretary-in-Charge of the Department of Urban Development Department (UDD) of the concerned state or union territory has the overall responsibility for MSWM system installation in cities and municipalities in accordance with the SWM Rules
- UDD is responsible for developing an MSWM state policy and strategy inside the state
- UDD is required to report on SLBs in order to provide SWM services in ULBs to Ministry of Housing and Urban Development (MoUD).
- UDD is also in charge of approving land transfers from the state to ULBs (for all projects).
- The establishment of staff posts is regulated by the states in the ULBs (both technical and nontechnical).
- The State Pollution Control Board (SPCB) is in charge of regulating pollution in the state. Ensuring that the MSWM and SWM rules are being followed. It also has the authority to provide environmental permits.
- The authority to provide local authorities or operators permission to establish treatment and disposal facilities is also in the hand of SPCB

State governments are also required to keep a check on the following:

- The source segregation of waste has been mandated to channelize the waste to wealth by recovery, reuse and recycle.
- No person should throw, burn, or bury the solid waste generated by him, on streets, open public spaces outside his premises, or in the drain, or water bodies.
- Hotels and restaurants should segregate biodegradable waste and set up a system of collection to ensure that such food waste is utilized for composting / bio methanation.
- Resident welfare associations and gated communities with an area >5,000 sq. m should segregate waste and hand over recyclable material to either the authorized waste pickers or the authorized recyclers, or the urban local body.
- Every street vendor should keep suitable containers for storage of waste generated during his activity such as food waste, disposable plates, cups, cans, wrappers, coconut shells, leftover food, vegetables, fruits etc. and deposit such waste at waste storage depot or container or vehicle as notified by the local authority

Best practices for solid waste management

The Panaji module explains how the vision of a city for attaining zero landfilling has been successfully translated into reality by the Corporation of the City of Panaji. The entire city segregates waste into a minimum of 6 fractions. The dry waste is further segregated into 18-20 fractions for recycling, organic waste is composted, and dry waste rejects are sent for co-processing among other good practices. One vision, stable leadership, repeated and targeted campaigns for different user groups and continuous innovation to overcome the challenges of new waste streams have helped Panaji achieve this success.

The Gorai module details the need for the scientific closure of a dumpsite by the Municipal Corporation of Greater Mumbai. It captures briefly the technical process involved with a special focus on the community's perspective. The module showcases the overall improvement in the standards of living, local economy, environment, and biodiversity of the region before and after the scientific closure.

The Vijayawada Municipal Corporation has showcased the simple and effective management of organic waste through decentralized vermicomposting facilities. The module details out the step-by-step guide to vermicomposting technique - its operation, maintenance, pre and post-care. It also highlights the positive outcomes of vermicomposting for replication by other urban local bodies.

Best practices at the collection and transportation stage

A well-synchronized primary and secondary collection and transportation system is essential to avoid containers' overflow and waste littering on streets (CPHEEO, 2016a).

Primary collection**:** Primary collection refers to the process of collecting waste from households, markets, institutions, and other commercial establishments (CPHEEO, 2016a).

Secondary collection**:** Secondary collection includes picking up waste from community bins, waste storage depots, or transfer stations and transporting it to waste processing sites or to the final disposal sites (CPHEEO, 2016a).

ULBs are responsible for planning the collection of segregated waste (wet waste, dry recyclables, and domestic hazardous waste), sanitary, horticulture, and construction and demolition trash from residential, commercial, and institutional locations (CPHEEO, 2016a). The frequency of waste collection is determined by the amount of waste created by each of these groups and the extent to which waste is segregated. While residential waste should be collected daily, market areas, commercial establishments, and institutions may have their rubbish collected twice daily. The volume of waste created and collected also dictates the form of rubbish collection at the curb. Separate containers for different fractions are necessary; at a bare minimum, ULBs must collect wet and dry waste separately. Waste collected from doorsteps may be held in a secondary collection station or transferred directly to secondary collection vehicles, depending on the practicality of secondary storage or direct transfer to secondary collection vehicles. The viability of secondary storage or direct transfer to secondary collection vehicles is determined by the availability of secondary collection vehicles, the size of the area, and the timing of collection. It is advisable to coordinate main and secondary collection whenever possible to prevent the requirement for secondary storage bins or depots (CPHEEO, 2016b)

Some of the additional points that may be followed for the collection of municipal solid waste are:

- Daily wet waste collection is recommended. A weekly collection of dry waste and home hazardous garbage is possible. Separate sanitary garbage should be collected and disposed of daily in an incinerator by the local ULB.
- All ULBs shall monitor Door to Door rubbish collection using ICT (Information and Communication Technology) and IoT (Internet of Things) technologies. This should be applied in all ULBs to ensure the waste collection is 100 per cent. Usage charges may be assessed against the end-user using smart home cards. Additionally, the smart card can be utilised to update the status of garbage pickup for all users.

- Additionally, compactor bins can be geo-tagged and equipped with a smart card to enable monitoring of the bin lifting operation.

The quantity of revenue earned is exactly proportional to the volume of waste treated at treatment facilities. As a result, a greater proportion of garbage must be transported to treatment facilities rather than disposal centers. The disposal facility also collects garbage from treatment facilities, reducing the former's maximum trash holding capacity. As a result, the volumes transported from distribution centers to treatment facilities must be greater than those transferred to disposal sites to maximize waste allocations (Jalil et al., 2018)

Even though the cost of keeping garbage per ton at Distribution Centers is cheaper than the cost of transportation from Distribution Centers to treatment facilities and disposal centers, more garbage is dispatched than is maintained as inventory this is due to the inflow capacities of Distribution Centers, which limits the quantity of garbage that could be retained as inventory to less than or equal to the distribution centers' maximum inventory holding capacity. The inventory holding capacities of Distribution Centers are reduced to minimize inventory levels and increase trash shipment from Distribution Centers to treatment and disposal facilities. However, that the decision-maker, on the other hand, may expand these capacities in accordance with the specifications to meet the needs of Distribution Centers and the problem (Jalil et al., 2018).

Best practices at segregation stage

Individuals should be aware of the importance of waste separation at the source. Source reduction and reuse are two terms that refer to operations that help reduce trash output. NGOs, SHGs, and RWAs should raise awareness regarding trash separation at the source. School students may be the ideal target group for instilling the source segregation culture in private houses.

For all ULBs, 100 per cent source segregation should be implemented. At the moment, no ULB has a facility for source segregation. Segregation can be achieved manually or mechanically.

- Efforts should be made to implement decentralized waste management strategies.
- Given the low cost of labor in India, manual classification of recyclable fractions into distinct components such as paper, plastic, and so on may be more appropriate (Malaviya National Institute of Technology Jaipur, n.d.)
- All ULBs should provide a waste transfer point.
- The location of intermediate transfer stations should be dictated by the distance between secondary trash-collecting points and the final treatment and disposal location. Transfer stations

may be created if the distance between the city jurisdiction and the ultimate treatment and disposal points exceeds 15 kilometres, or if land becomes available and required.

A study concluded that applying source-separated material collection for paper products, plastics, glass, and metals will not result in a higher material recovery rate of greater than or equal to 35 per cent unless incentives are offered to the city's inhabitants so that they will participate in source-separated collection schemes to a much higher degree than is normally encountered in the industry. As a result of which the potential recycling rate might be increased (Fabbricino, 2001).

Best practices at processing and treatment stage

Inefficient municipal solid waste management can have major negative environmental consequences such as infectious diseases, land and water pollution, drain obstruction, and biodiversity loss, but on the other hand if done efficiently results have showed that plastic recycling contributed significantly to the economy among plastic, metal, glass, paper, and non-recyclable garbage, and recycling being the most economical waste management method.

As per findings from model prepared for city of Tehran-Iran it was found out that gasification and incineration are the most efficient ways to generate energy while also reducing waste volume. Also stated that recycling and composting are the best solutions and should take precedence. Overall, recycling is a non-negotiable option that can be a big income source and aid in the coverage of expenses (Ahmadi et al., 2020). Another study conducted in a Greek region found that recycling and incineration are the most common treatment options, with landfilling being the least acceptable management option (Minoglou & Komilis, 2013).

The adoption of processing technology is highly dependent on the volume and composition of waste generated. Before implementing any processing or treatment system, it is critical to quantify and characterize the waste created by the local body. The major components of waste and processes required for treating them are given in Table 4 (TERI, 2014).

Table 4.1 Components and treatment for municipal solid waste (The Energy and Research Institute (TERI), 2014)

Type	Components of Waste	Process	
Biodegradable	Kitchen, garden and food waste	Biological Treatment	Aerobic processes, anaerobic processes
		Thermal treatment	Incineration, pyrolysis systems, gasification systems
		Transformation	Mechanical transformation, thermal transformation
Recyclable	Plastic	Plasma Pyrolysis Technology (PPT), Alternate fuel as Refuse Derived Fuel (RDF)	
	Paper	Dissolution, Screening, De-inking, Sterilization and bleaching process	
	Glass	Vitrification technology	
Inert	Sand, pebbles & gravels	Landfilling: Jaw and Pulse Crusher	

A landfill without engineered measures may result into a number of hazards e.g. groundwater contamination (A. Kumar et al., 2019) surface water contamination (A. Kumar et al., 2016) air contamination and landfill gas explosion (A. Kumar et al., 2018) So it is highly recommended to develop a sanitary/engineered landfill. To provide a sanitary landfill, a cluster of ULBs may be constructed and a suitable piece of land designated for the cluster's waste disposal (A. Kumar et al., 2016) (A. Kumar et al., 2018) (A. Kumar et al., 2019). The landfill site shall be sufficiently large to endure at least 20-25 years and shall be developed in phases to avoid water logging and misuse. As per (CPHEEO, 2016b) the dump site must be at least 100 meters from a river, 200 meters from a pond, 200 meters from highways, habitats, public parks, and water supply wells, and 20 kilometres from airports or air bases. However, in exceptional circumstances, landfill sites may be established within a 10 to 20 kilometer radius of an airport/airbase after getting a certificate of no objection from the civil aviation authority/air force, as the case may be. The landfill site shall not be permitted inside flood basins as defined by historical records, coastal regulation zones, wetland areas, critical habitat areas, or sensitive eco-fragile areas (CPHEEO, 2016b).

A no-development zone shall be maintained around solid waste processing and disposal facilities with installed capacity greater than five tons per day and this will be accomplished within the confines of the solid waste processing and disposal facility's complete footprint. The local body, in collaboration with the appropriate State Pollution Control Board, shall prescribe the buffer zone on an individual basis (CPHEEO, 2016b). After fifteen years of post-closure monitoring, the use of closed landfill sites for human habitation or other purposes can be considered only after confirming that gaseous emission and leachate quality assessments meet stipulated standards and soil stability is maintained. The typical section of a sanitary landfill is shown in Figure 4.4.

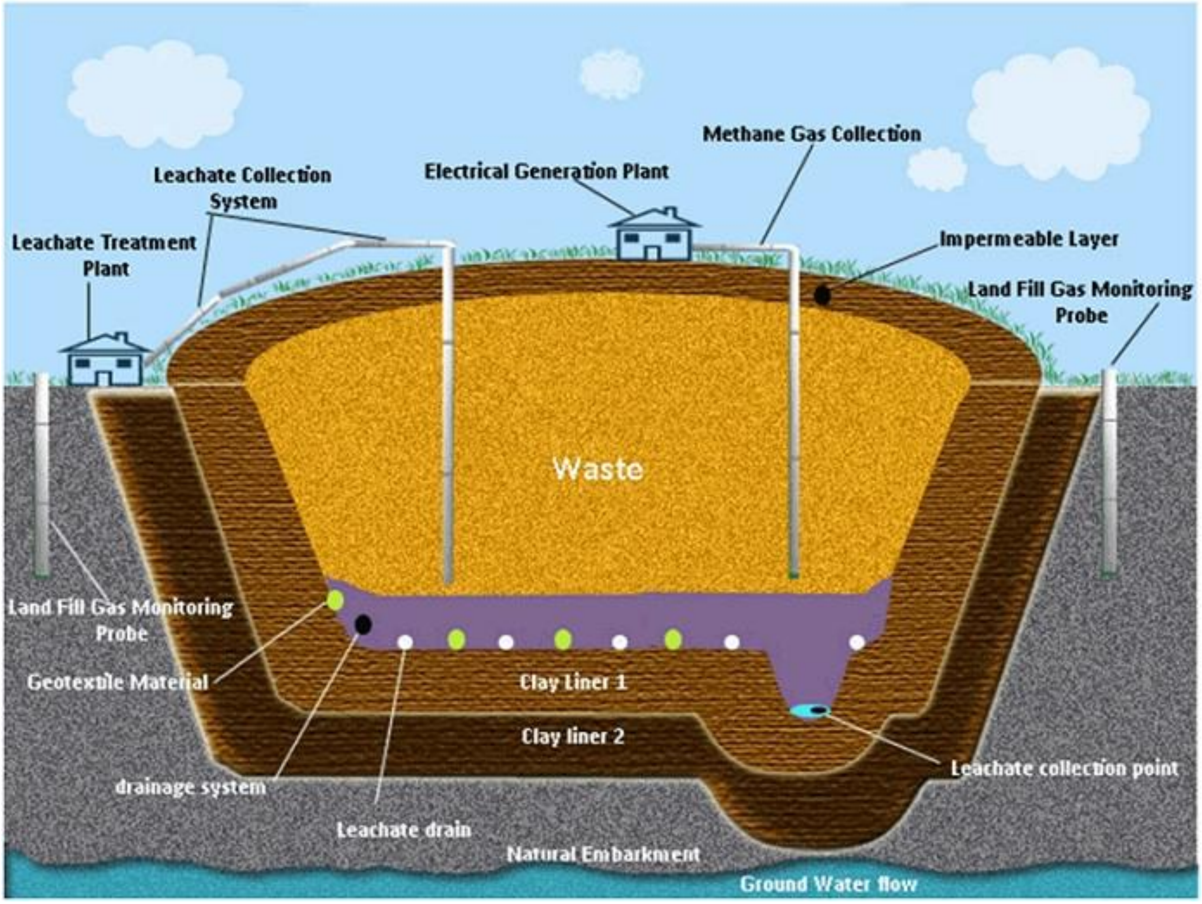

Figure 4.4 Typical section of sanitary landfill (CPHEEO, 2016b).

4.1.2 Plastic Waste Management

Plastic products have become an integral part of human lives in present times. Its use can be easily witnessed in day-to-day activities across the globe, from small towns to developed metropolitan cities. But, at the same time, their high scale production and usage are leading to mass generation and production of plastic waste.

Plastic waste can be termed discarded plastic when its utility is over. This waste is non-biodegradable and therefore, it keeps on accumulating in the near environment for a long period creating a negative impact on animals, marine life, and humans. Virgin plastic can be recycled for reuse up to 2-3 times only because the material deteriorates under thermal pressure, reducing its life span. But these secondary/tertiary forms contain additives and colours which are also harmful to nature. Therefore, recycling is neither safe nor a permanent solution for plastic waste disposal.

The negative effects of improper plastic waste management not only end in a disgusting view but also affects the overall economy of a country. Furthermore, animals that rely on the environment face a significant threat as a result of consuming plastic trash and water contamination. The combustion of any dumped garbage and plastic items pollutes the air and the environment. Inadequate plastic waste management results in the production of microplastics, which are toxic to both humans and animals.

The plastics are divided into two categories (Figure 4.5): Thermoplastics or Recyclable Plastics (do not undergo changes in their chemical composition when they are exposed to heat, and hence, can be moulded repeatedly) and; Thermosetting Plastics or as Non-Recyclable Plastics (can melt and only be shaped once and very hard to be moulded again using the existing technologies).

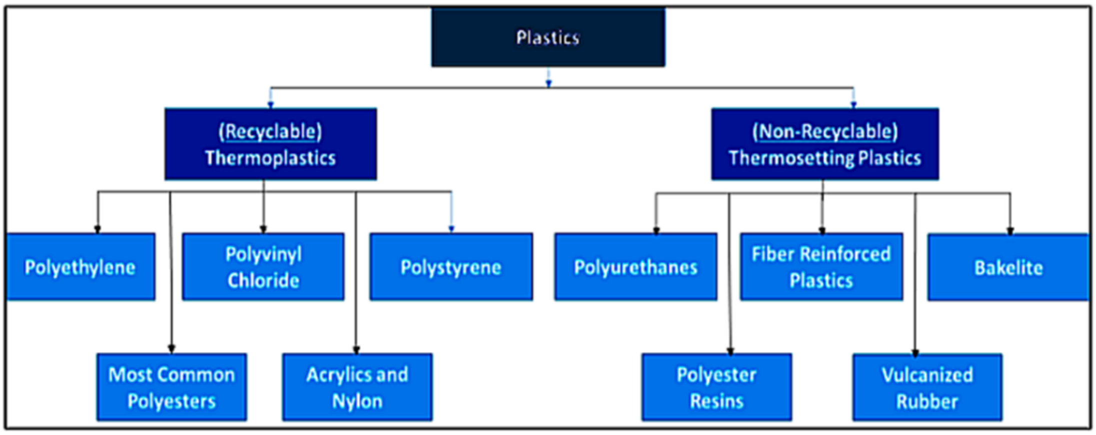

Figure 4.5 Types of Plastics (Bhawan & Nagar, 2013a)

Plastic waste, if left unattended, can be toxic and hazardous for humans, animals and the environment, posing serious consequences. They get mixed up easily with land and water to form micro plastics and their macro forms act as physical barriers which further degrade the quality of the soil and get ingested by livestock and other animals. Plastic waste also causes choking of drains and streams which sometimes also leads to severe flooding and obstructions to runoffs (CPCB, 2013) (S. Sharma & Mallubhotla, 2019)

Moreover, plastic waste is more hazardous to marine ecosystems. As per the research done by "The Energy and Resource Institute", it was found that there are 8 million tons of Plastic waste entering the oceans every year throughout the globe. And till date, the total plastic waste in the oceans amounts to 150 million tons. Even in the efforts done for coastal clean-up, the plastic packaging material accounts for around 62 % of the total share (Bhattacharya et al., 2018)

In present times, the disposal of plastic waste is a serious concern due to improper collection and segregation in various cities. Plastic waste disposal methods are very basic but uninformed which increases the severity of the problem as open burning of plastic waste leads to the emission of toxic gases like carbon monoxide, dioxins, and nitrides.

As per the report of "The Energy and Resource Institute", about 60 % of the plastic produced is recycled, and about 9400 tons of plastic is left unattended in the environment causing land, air and water pollution. 70 % of plastics packaging products are converted into plastic waste in a short span (Bhattacharya et al., 2018). The key challenges in the process of Plastic Waste Management are lack of segregation of plastic waste, the absence of organized systems of collection and efficient aggregation, poor economic value in low-grade (thin) plastics and the livelihoods associated with plastic production.

To prevent the above-mentioned harmful effects on the environment and overcome the challenges, there rises an immediate need for a framework to deal with plastic waste. This can be done by applying various methods and processes at every stage, from generation, collection, to final disposal. The entire process is known as Plastic Waste Management. Moreover, there is an urgent need of spreading public awareness about their role in the process of Plastic Waste Management and to promote the usage of alternative materials to reduce the use of plastics in all forms.

Scenario in Country

Globally, the quantity of plastic production crosses 150 million tons every year (S. Sharma & Mallubhotla, 2019). This broad range of products includes packaging films, wrapping materials, shopping and garbage bags, fluid containers, clothing, toys, household and industrial products, and building materials. From the total quantity of plastic produced, approximately 70 % of packaging products are converted into plastic waste within a short period (S. Sharma & Mallubhotla, 2019)(Ministry of Housing and Urban Affairs, 2019).

In India, around 9.4 million TPA of plastic waste is generated, which turns out to be about 26,000 TPD. Out of this, about 60 % is recycled, most of it by the informal sector (S. Sharma & Mallubhotla, 2019). Whereas the recycling rate in India is considerably higher i.e., around 20 % more than the average global rate. Even after this, still, around 9,400 tons of plastic waste are either disposed of to landfills or ends up polluting streams or groundwater resources. There are a few plastics that do not decompose and even if it does, then, it takes up to 450 years to break down completely (S. Sharma & Mallubhotla, 2019)(GOI, 2019).

Traditionally, the policies formulated in India mainly aimed for the improvement and management of plastic waste in the urban parts of the country, focusing on segregation, collection, and even, banning the use of some specific categories of plastics. In 2016, rules were extended for rural areas for the first time, with specific duties demarcated for Gram Panchayats.

Scenario in State

In Rajasthan State, there are in all 33 districts, 193 Urban Local Bodies (ULBs), 295 Panchayat Samitis and 9,892 Gram Panchayats (GPs). As per the Census 2011, the state has a population of 6.86 crores, from which 24.78% resides in urban regions and 75.13 % in rural areas. The plastic waste generated in the state is about 4% of the total solid waste generated and the major sources of generation include ULBs, Industrial Units, RIICO, etc. (GOR, 2019).

Roles and Responsibilities

Central Pollution Control Board

Responsible for regulating and controlling noise-producing sources aiming to maintain the ambient air quality standards (CPCB, 2013)

State Level Monitoring Committee

Responsible for planning, facilitating, problem-solving and monitoring overall implementation of the programme in the state. The Rajasthan Pollution Control Board (SPCB) has issued their guidelines for the management of plastic waste to control the pollution levels in the entire state(GOR, 2019).

Department Of Environment, Science and Technology

Responsible for planning, coordinating, promoting/overseeing environment, science & technology, pollution prevention, abatement, controlling activities &programmes for environment protection, conservation & enhancement by regulation, policy formulation and, supervision &monitoring using innovative technologies(S. Sharma & Mallubhotla, 2019)

Ministry of Environment, Forest and Climate Change (MoEF&CC)

Responsible for effective implementation of rules, emphasizing plastic waste minimization, source segregation, recycling, the role of waste pickers, recyclers and waste processors in the collection system of plastic waste fraction from households or other sources of its generation (MoEFCC, 2020).

The Energy and Resource Institute (TERI)

It focussed on creating technologies and solutions that minimize waste generation and convert all waste into useful products. Their initiatives include the promotion of circular economy through resource-efficient and clean production in industries, and maximizing resource recovery and recycling for landfill-free cities (Bhattacharya et al., 2018)

Ministry of Housing and Urban Affairs (MoHUA)

Responsible for capacity building of Urban Local Bodies (ULBs) focus on various components of solid waste management and holistic sanitation including wastewater treatment through infrastructural development, capacitive building and communication (MoEF&CC, 2016).

Duties of Various Stakeholders as per Plastic Waste Management Rules 2011 (Amendment 2016 & 2018), MoEF&CC:

Responsibility of Local Body

i. Every local body shall be responsible for the development and setting up of infrastructure for segregation, collection, storage, transportation, processing and disposal of the plastic waste either on its own or by engaging agencies or producers.

ii. The local body shall be responsible for setting up, operationalisation and co-ordination of the waste management system and for performing the associated functions, namely: a)ensuring segregation, collection, storage, transportation, processing and disposal of plastic waste; b) ensuring that no damage is caused to the environment during this process; c) ensuring channelization of the recyclable plastic waste fraction to recyclers; d) ensuring processing and disposal on the non-recyclable fraction of plastic waste in accordance with the guidelines issued by the Central Pollution Control Board; e) creating awareness among all stakeholders about their responsibilities; f) engaging civil societies or groups working with waste pickers g) ensuring that open burning of plastic waste does not take place.

iii. The local body for setting up of a system for plastic waste management shall seek the assistance of producers and such system shall be set up within one year from the date of final publication of these rules in the Official Gazette of India. iv. The local body to frame bye-laws incorporating the provisions of these rules (MoEF&CC, 2016).

Responsibility of Gram Panchayat

Every gram panchayat either on its own or by engaging an agency shall set up, operationalise and coordinate for waste management in the rural area under their control and for performing the associated functions, namely: i) ensuring segregation, collection, storage, transportation, plastic waste and channelization of the recyclable plastic waste fraction to recyclers having valid registration;

ensuring that no damage is caused to the environment during this process; ii) creating awareness among all stakeholders about their responsibilities and; iii) ensuring that open burning of plastic waste does not take place (MoEF&CC, 2016).

Responsibility of Waste Generators

i. The waste generator shall: a) Take steps to minimize generation of plastic waste and segregate plastic waste at source in accordance with the Solid Waste Management Rules, 2016 or as amended from time to time; b) Not litter the plastic waste and ensure segregated storage of waste at source and handover segregated waste to the urban local body or gram panchayat or agencies appointed by them or registered waste pickers', registered recyclers or waste collection agencies. ii. All institutional generators of plastic waste shall segregate and store the waste generated by them in accordance with the Municipal Solid Waste (Management and Handling) Rules, 2016 or amendment from time to time and handover segregated wastes to authorized waste processing or disposal facilities or deposition centres either on its own or through the authorized waste collection agency. iii. All waste generators shall pay such user fee or charge as may be specified in the bye-laws of the local bodies for plastic waste management such as waste collection or operation of the facility thereof, etc. iv. Every person responsible for organising an event in open space, which involves service of foodstuff in plastic or multi-layered packaging shall segregate and manage the waste generated during such events in accordance with the Municipal Solid Waste (Management and Handling) Rules, 2016 or amendment from time to time (MoEF&CC, 2016).

Responsibility of Producers, Importers and Brand Owners:

i. The producers, within six months from the date of publication of these rules, shall work out modalities for waste collection system based on Extended Producers Responsibility and involving State Urban Development Departments, either individually or collectively, through their distribution channel or the local body concerned.
ii. ii. Primary responsibility for collection of used multi-layered plastic sachet or pouches or packaging is of Producers, Importers and Brand Owners who introduce the products in the market. They need to establish a system for collecting back the plastic waste generated due to their products. This plan of the collection is to be submitted to the State Pollution Control Boards while applying for Consent to Establish or Operate or Renewal. The Brand Owners whose consent has been renewed before the notification of these rules shall submit such a plan within one year from the date of notification of these rules and implement with two years thereafter.
iii. Manufacture and use of multi-layered plastic which is non-recyclable or non-energy recoverable or with no alternate use of plastic if any should be phased out in two years.

iv. The producer, within three months from the date of final publication of these rules in the Official Gazette shall apply to the Pollution Control Board or the Pollution Control Committee, as the case may be, of the States or the Union Territories administration concerned, for grant of registration.

v. No producer shall on and after the expiry of a period of Six Months from the date of final publication of these rules in the Official Gazette manufacture or use any plastic or multi-layered packaging for packaging of commodities without registration from the concerned State Pollution Control Board. vi. Every producer shall maintain a record of details of the person engaged in supply of plastic used as raw material to manufacture carry bags or plastic sheet or like or cover made of plastic sheet or multi-layered packaging (MoEF&CC, 2016).

Responsibility of State Pollution Control Board (As Per Rule 12):

i. The State Pollution Control Board in respect of a Union territory shall be the authority for enforcement of the provisions of these rules relating to registration, manufacture of plastic products and multi-layered packaging, processing and disposal of plastic wastes.

ii. The concerned Secretary-in-charge of LSG shall be the authority for enforcement of the provisions of these rules relating to waste management by the waste generator, use of plastic carry bags, plastic sheets or like, covers made of plastic sheets and multi-layered packaging.

iii. The concerned Gram Panchayat shall be the authority for enforcement of the provisions of these rules relating to waste management by the waste generator, use of plastic carry bags, plastic sheets or like, covers made of plastic sheets and multi-layered packaging in the rural area of the State or a Union Territory; and 3 As provided in Plastic Waste Management (Amendment) Rules, 2018.

iv. The authorities referred to in sub-rules (1) to (3) shall take the assistance of the District Magistrate or the Deputy Commissioner within the territorial limits of the jurisdiction of the concerned district in the enforcement of the provisions of these rules (MoEFCC, 2016).

Responsibility of Retailers and Street Vendors

i. Retailers or street vendors shall not sell or provide commodities to the consumer in carry bags or plastic sheets or multi-layered packaging, which are not manufactured and labelled or marked, as per prescribed under these rules.

ii. Every retailer or street vendors selling or providing commodities in, plastic carry bags or multi-layered packaging or plastic sheets or like or covers made of plastic sheets which are not manufactured or labelled or marked in accordance with these rules shall be liable to pay such fines as specified under the bye-laws of the local bodies (MoEFCC, 2016).

Rules and Regulations

Rules and Regulation to be followed for Plastic Production as per Plastic Waste Management Rules 2011 (Amendment 2016 & 2018), MoE&CC

i. The plastic carry bags used to carry or dispense commodities but don't include these bags which are an integral part of packaged products. The thickness of the bag shall not be <40µ.

ii. Carry bags can also be made from compostable plastics conforming IS/ISO:17088:2008.

iii. The Prescribed Authority for registration, manufacture & recycling shall be State Pollution Control Board (SPCB) or Pollution Control Committee (PCC). And for enforcement of Rules relating to use, collection, segregation, transportation & disposal of plastic waste, shall be concerned Municipal Authority.

iv. Multi-layered pouches or sachets used for packaging of gutkha etc. shall not use plastic material in any form.

v. Every carry bag made from plastic shall bear a label or mark "recycled" as per IS: 14534:1998. Each carry bag made from "Compostable Material" shall bear the label "Compostable" & shall conform to IS/ISO: 17088:2008.

vi. No carry bag shall be made available free of cost by retailers to consumers. The concerned Municipal Authority may be notification determine the minimum price for carry bags to encourage re-use to minimize plastic waste generation.

vii. vii. Each State Government shall constitute a State Level Advisory (SLA) Body to monitor the implementation of Rules. This body shall meet once a year and may invite experts if it considers necessary.

viii. The Plastic Waste Management (PWM) shall be as under;

a) recycling, recovery or disposal of plastic waste shall be carried out as per the rules, regulations and standards stipulated by the central government from time to time;

b) recycling of plastics shall be carried out in accordance with the Indian Standard IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time;

c) the Municipal Authority shall be responsible for setting up, operationalisation and coordination of the waste management system and for performing the associated functions, namely: to ensure safe collection, storage, segregation, transportation, processing and disposal of plastic waste; to ensure that no damage is caused to the environment during this process; to ensure setting up of collection centres for plastic waste involving manufacturers; to ensure its channelization to recyclers; to create awareness among all stakeholders about their responsibilities; to engage agencies or groups working in waste management including waste pickers, and; to ensure that open burning of plastic waste is not permitted;

d) for setting up plastic waste collection centres, the Municipal Authority may ask the manufacturers, either collectively or individually in line with the principle of Extended Producer's Responsibility (EPR) to provide the required finance to establish such collection centre;

e) recyclers shall ensure that recycling facilities are in accordance with the Indian Standard: IS 14534:194 titled as Guidelines for Recycling of Plastics and in compliance with the rules under the Environment (Protection) Ad, 1986, as amended from time to time; the concerned Municipal Authority shall ensure that the residues generated from recycling processes are disposed of in compliance with Schedule II (Management of Municipal Solid Wastes) and Schedule III (Specifications for Landfill Sites) of the Municipal Solid Wastes (Management and Handling) Rules, 2000 made under the Environment (Protection) Act, 1986, as amended from time to time;

f) the Municipal Authority shall incorporate the said rules in the Municipal Bye- laws of all the Urban Local Bodies;

g) the Municipal Authority shall encourage the use of plastic waste by adopting suitable technology such as in Road Construction, Co-incineration etc. The Municipal Authority or the operator intending to use such technology shall ensure the compliance with the prescribed standards including pollution norms prescribed by the Competent Authority in this regard.

ix. Each SPCB or PCC shall prepare and submit Annual Report to CPCB by 30th day of September each year. The Central Pollution Control Board (CPCB) shall consolidate the report on use of plastic carry bags, sachets/pouches etc. and management of plastic waste. The consolidated report along with recommendations on the implementation of the Plastic Waste (Management & Handling) (Amendment) Rules, 2011 will be submitted to MoEF by the 30th Day of December (CPCB, 2013), (MoEFCC, 2016)

Conditions for Production of Plastic

The manufacture, importer stocking, distribution, sale and use of carry bags, plastic sheets or like, or cover made of plastic sheet and multi-layered packaging, shall be subject to the following conditions, namely: i) carry bags and plastic packaging shall either be in natural shade which is without any added pigments or made using only those pigments and colorants which are in conformity with Indian Standard: IS 9833:1981 titled as “List of pigments and colorants for use in plastics in contact with foodstuffs, pharmaceuticals and drinking water”, as amended from time to time; ii) Carry bags made of recycled plastic or products made of recycled plastic shall not be used for storing, carrying, dispensing or packaging ready to eat or drink food stuff; iii) carry bag made of virgin or recycled plastic, shall not be less than fifty microns in thickness; iv) plastic sheet or like, which is not an integral part of multi-layered packaging and cover made of plastic sheet used for packaging, wrapping the commodity shall not be less than fifty microns in thickness except where the thickness of such plastic sheets impair the functionality of the product; v) the manufacturer shall not sell or provide or arrange plastic to be used as raw material to a producer, not having valid registration from the concerned State Pollution Control Boards or Pollution Control Committee; vi) sachets using plastic material shall not be used for storing, packing or selling gutkha, tobacco and pan masala; vii) recycling of plastic waste shall conform to the Indian Standard: IS 14534:1998 titled as Guidelines for Recycling of Plastics, as amended from time to time; viii) The provision of thickness shall not be applicable to carry bags made up of compostable plastic. Carry bags made from compostable plastics shall conform to the Indian Standard: IS 17088:2008 titled as Specifications for Compostable Plastics, as amended from time to time. The manufacturers or seller of compostable plastic carry bags shall obtain a certificate from the Central Pollution Control Board before marketing or selling and ix. plastic material, in any form including Vinyl Acetate - Maleic Acid - Vinyl Chloride Copolymer, shall not be used in any package for packaging gutkha, pan masala and tobacco in all forms (CPCB, 2013).

Registration of Producer, Recyclers and Manufacturer

i. No person shall manufacture carry bags or recycle plastic bags or multi-layered packaging unless the person has obtained a registration from the State Pollution Control Board, as the case may be, prior to the commencement of production. ii. Every producer or brand-owner shall, for the purpose of registration or renewal of registration, make an application in Form-I to, a) "The concerned State Pollution Control Board, if operating one or two States or Union Territories"; or b) "The Central Pollution Control Board, if operating in more than two States or Union Territories". iii. Every person recycling or processing waste or proposing to recycle or process plastic waste shall make an application to the State Pollution Control Board, for grant of registration or renewal of registration for the recycling unit, in Form II3. iv. Every manufacturer engaged in manufacturer of plastic to be used as raw material by the producer shall make an application to the State Pollution Control Board or the Pollution Control Committee of the Union territory concerned, for the grant of registration or the renewal of registration, in Form III4. v. The State Pollution Control Board shall not issue or renew registration to plastic waste recycling or processing units unless the unit possesses a valid consent under the Water (Prevention and Control of Pollution) Act, 1974 (6 of 1974) and the Air (Prevention and Control of Pollution) Act, 1981 (14 of 1981) along with a certificate of registration issued by the District Industries Centre or any other Government agency authorised in this regard. vi. The State Pollution Control Board shall not renew registration of producer unless the producer possesses and action plan endorsed by the Secretary in charge of Urban Development of the concerned State or Union Territory for setting of plastic waste management system. vii. On receipt of the application complete in all respects for the registration for recycling or processing of plastic waste under sub-rule (3), the State Pollution Control Board may, after such inquiry as it considers necessary and on being satisfied that the applicant possesses appropriate facilities, technical capabilities and equipment to handle plastic waste safely, may grant registration to the applicant on fulfilment of the conditions as may be laid down in terms of registration. viii. Every State Pollution Control Board or Pollution Control Committee shall decide on the grant of registration within ninety days of receipt of an application which is complete in all respects. ix. The registration granted under this rule shall initially be valid for one year, unless revoked, suspended or cancelled and shall subsequently be granted for three years. x. State Pollution Control Board or the Pollution Control Committees shall not revoke, suspend or cancel registration without providing the opportunity of a hearing to the producer or person engaged in recycling or processing of plastic wastes. xi. Every application for renewal of registration shall be made at least one hundred twenty days before the expiry of the validity of the registration certificate (CPCB, 2013), (MoEFCC, 2016).

Recommendations from CPCB

In India disposal of plastic waste is a serious concern, due to lack of technology and poor implementation however, several experiments have been conducted to reuse plastic waste in road construction or co-processing of plastic waste in cement kilns etc. In the present time, the mostlyused plastic waste disposal method is incineration but, due to under graded kilns and their poor maintenance, they release harmful gases including dioxins and furans burning chlorinated and brominated plastic waste, therefore, raising several environmental issues (CPCB, 2013)

The key issues relating to non-implementation of PWM Rules, 2011 are mainly emerged as indiscriminate use of sub-standard plastic carry bags and littering in cities and towns and use of plastic sachets or pouches in packaging of gutkha, tobacco and pan masala. Listing of key points based on interaction with representative of SPCBs/PCCs and other agencies may be considered for making suitable amendments in the Rule or issue an Office Memorandum for better PWM Rules, 2011: i. Definition of Plastic (Petro-based) and Compostable Plastic or Material (Renewable) may be looked at in the existing PWM Rules. ii. The monitoring mechanism shall be strengthened so that sub-standard carry bags (< 40μ) are not available in the market. iii. Prescribed Authority for enforcement on use of plastic carry bags and sachets & pouches may be mentioned in the existing PWM Rules, 2011. iv. The recommendations of Biodegradable Committee (under Director-General CIPET) may be examined by MoEF in the light of thickness and use of compostable plastic or material for food packaging’s. Municipal Authority may be directed to submit Annual Report to SPCBs/PCCs on implementation of PWM Rules, 2011, as the same is not given in the Rules. Accordingly, suitable amendments be made to the Rules. vi. SPCBs/PCCs may be asked to utilize plastic waste in road construction, co-processing of plastic waste in cement kilns, conversion of plastic waste into liquid fuel etc. vii. SPCBs/PCCs should develop laboratory facility for testing of thickness of plastic carry bags and plastic material in the sachets/pouches.viii. The thickness of plastic carry bags shall be uniform, as some States are still allowing to manufacture carry bags <40 µ such as Madhya Pradesh, Kerala etc (CPCB, 2013), (S. Sharma & Mallubhotla, 2019)*)*.

Sustainable Development Goal (SDG 12_UNDP): Ensure Sustainable Consumption and Production Patterns

SDG 12 of UNDP states that constant monitoring of the life cycle of plastic products should be carried out in such a way that the minimum resources may be utilized to produce maximum output (Figure 4.6). Recycling and Disposal techniques should be improved to minimize energy consumption and reduce waste generation (Le Blanc & UN Environment Programme, 2017).

Figure 4.6 Sustainable Development Goal 12

Governance and Management Structure

The various concerned institutions involved in the process of Plastic Waste Management are: Central Pollution Control Board; State-level monitoring committee; Department of Environment Science and Technology; Ministry of Environment, Forest and Climate Change; Central Public Health and Environmental Engineering Organisation; The Energy and Resource Institute and; Ministry of Housing and Urban Affairs.

Best Practices

Utilization of Plastic Waste in Road Construction in Bengaluru (Bruhat Bengaluru MahanagaraPalika)

Bruhat Bengaluru Mahanagara Palika (BBMP) along with KK Plastic Waste Management Ltd (Bangalore based firm), has worked on delivering innovative solutions for reusing non-recyclable plastics in the construction of roads. The technology has been patented and certified by the Centre of Transportation Engineering (CTE) and Central Road Research Institute (CRRI). Since 2002, they have successfully laid around 3000kms of road length using around 12,000 tonnes of plastic waste collected from local city garbage. In 2004-2005, the firm signed a Memorandum of Understanding for collecting city garbage and process it by mixing KK Poly Blend in Bitumen used for road construction. Their two large scale production units, capable of producing 20 tonnes of material per day are located at Yelchenahalli, Kanakpura Road and Anjanapur, Kanakpura Road.

The first stretch of road was laid 500m long as a trial run for Karnataka State Highway Improvement Project under World Bank Funding.

Figure 4.7 Process of making Recycled Road (S. Sharma & Mallubhotla, 2019)

This innovation has led to better processes for reusing and recycling plastic waste for the construction of roads and transport corridors (Figure 4.7). Plastic composites are mixed with other binding materials. Different types of plastics preferred for this method are Polystyrene (PS) (Hard packaging, cartons, plates, vending cups etc.); Polypropylene (PP) (ketchup bottles, yogurt cups etc.); Polyethylene (PE) (both high and low density) (plastic bags, water bottle, shampoo bottle etc.). Polyvinyl Chloride (PVC) sheets or Flux sheets should not be used (S. Sharma & Mallubhotla, 2019), (GOI, 2019).

Hyderabad - Use of Plastic Pavement Block

The first dog park located in Hyderabad; India is a marvellous example of reusing plastic waste. About 400 sq. ft pavement area outside the park is made up of 1,500 recycled plastic tiles. It was initiated and completed by GHMC and Bamboo House India (Hyderabad based start-up). The tiles are an eco-friendly alternative and a smart cost saving investment option for the governments as they are strong, long-lasting and have comparatively cheaper manufacturing cost. Each tile weighs upto 300 grams and is made up of 600 polybags. They are specially designed for the percolation of water to ensure better ground water recharge and are fire-proof and damage-free. Nowadays, these tiles are picking up in market and are being used for making several more pedestrian pathways across the city.

Apart from this, the parking shelter of Miyapur Metro Station was reconstructed by a unique house-made completely out of recycled plastic waste. A single house costs just Rs.1.5 lakhs which is almost half the cost of regular steel shelters. Since, the raw materials used were ‘trash’ like tetra packs, bottle caps and poly bags, the resultant structure is heat-proof, water- proof, fire-proof and damage-free. Not only this, other plastic wastes like Plastic pet bottles, plastic bags, shampoo bottles & toothpaste packets were also used for making public recycle bins. Each dustbin consisted of 30kgs of plastic (S. Sharma & Mallubhotla, 2019)

Go Green Initiative of Tetra Park

Tetra Pak India has launched the ‘Go Green' project, which encourages carton recycling. It has collaborated with McCann Health India on the campaign ‘Cartons le aao, classroom banao,' which encourages consumers to embrace green practices by depositing used paper-based Tetra Pak cartons for recycling at collection centers. These cartons can be turned into desks, notepads, exam pads, and even roofing sheets for the least fortunate. The project is part of Tetra Pak's ongoing flagship programme "Go green with Tetra Pak," which aims to create awareness and encourage the recycling of used cartons.

Since 2010, when the “Go Green” was initiated, 1.8 million cartons have been collected and recycled, and 250 school desks have been donated to schools for the less fortunate. The initiative is multi-city, with the first phase taking place in Mumbai in conjunction with retail chains – “Reliance Fresh, Reliance Smart, and SahakariBhandar, as well as NGO RUR Greenlife (Mumbai-based environment organization) at the forefront of encouraging recycling (S. Sharma & Mallubhotla, 2019), (GOI, 2019)

Conversion of Pet Bottle Waste into Textile Products

A Petrochemical business has launched an initiative to collect PET bottle waste from throughout India and turn it into textile items. The company is placing RVM (Reverse Vending Machines) at various areas such as malls, exhibition centres, schools/colleges, and temples/pilgrimage sites to collect PET bottle waste and raise awareness among citizens about how to safely utilise PET bottles. These gathered bottles are recycled and utilised to manufacture fabrics for bags, T-shirts, and clothes made from natural fibres such as cotton and wool (Figure 4.8).

The company has used 4R model instead of 3R model which added “Replace” along with “Reduce, Reuse and Recycle”.

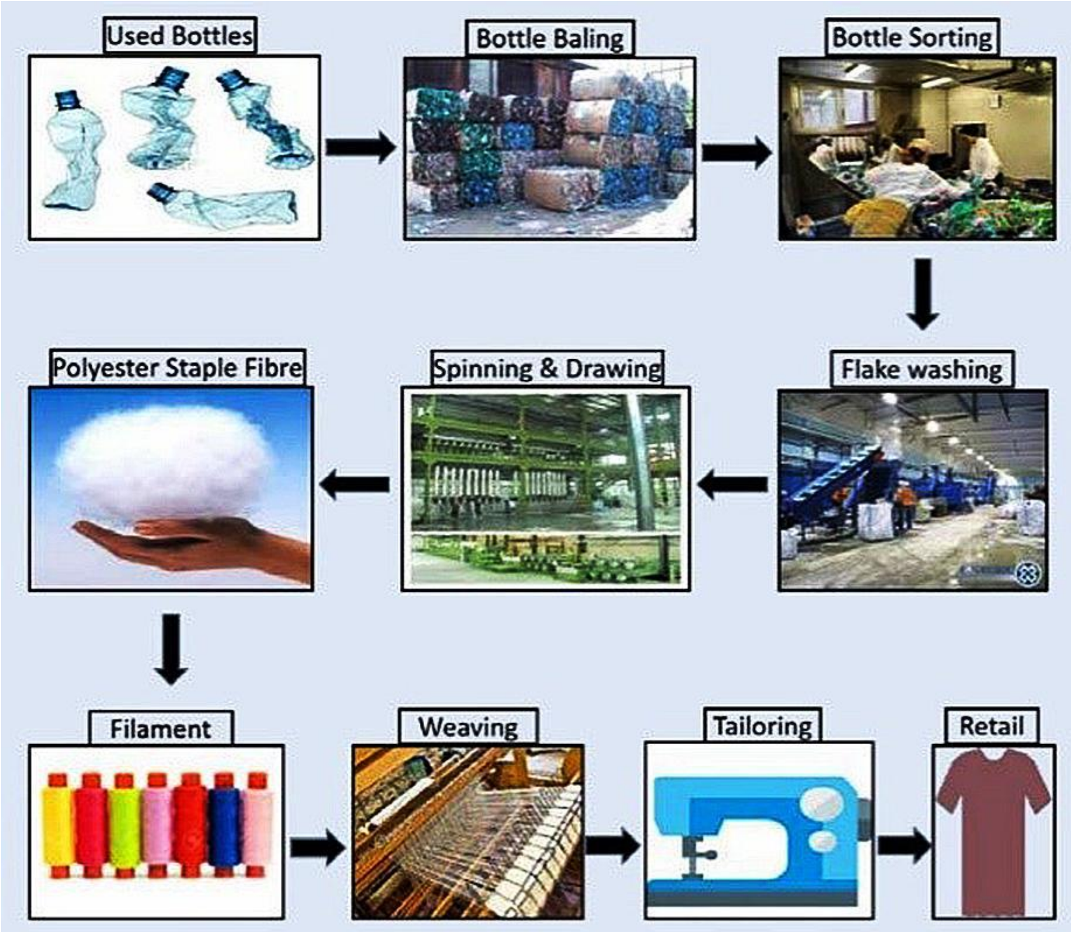

Figure 4.8 Process of making Bags and T-shirts

Doing so, they substituted old PET bottles with natural raw materials, and for every 8000 PET bottles recycled, one barrel of oil was saved. Further, the wet colouring procedure converts polyester staple fibre into a dry one without causing pollution and the removal of wet dyeing from this process eliminated associated pollutants. Thus, use of dry dyeing proved beneficial to the environment. Every bag or T-shirt made from PET bottles reduced water usage by 1400 Litres, redeemed 8 waste PET bottle from landfilling, reduced pesticide usage by over 50% and carbon footprint by 32%.

Therefore, this eco-friendly process of conversion of PET bottles to bags/textile products is based on zero waste concept, using renewable energy, preventing sewage pollution, reducing consumption of bags and creating green environment (GOI, 2019).

Plastic Bottle Recycling by "Green Recycling Industry", Guwahati (Assam)

"Green Recycling Industry" at Bongshar, Kamrup is the only Plastic Bottle recycling unit of Assam where 3MT waste Polyethylene terephthalate (PET) bottles are recycled for producing 'Hot Washed PET Flakes'. Mr. Ranendra Baishya is the proprietor of the unit. The Flakes and PET powders acts as the ingredient of different polyester garments and second grade PET bottles The waste plastic bottles are collected by the waste collectors and compressed into bales. The bales are then dispatched to the plant. After reaching the plant, the sorting process is done, and pet bottles are separated from other materials. The new recycled form is known as PET flakes. Later these flakes are transported to different facilities where it is transformed into different finished products.

Plastic Waste Collection and Processing Unit, Indore

Indore Municipal Corporation (IMC) has set up a Plastic Collection Centre (PCC) to reuse and recycle the city's plastic waste. Along with setting up a PCC, IMC has also installed a plastic cleansing machine known as a 'Phatka Machine.' Waste pickers segregate and sell the plastic waste that can be recycled. The remaining plastic waste is then taken to the PCC where it goes through the process of cleaning and shredding. Around 10 Tonnes of the shredded and purified plastic is sent to the plastic waste fuel converter unit while the rest of the plastic is sent to Madhya Pradesh Rural Road Development Authority for construction of roads. Plastic waste fuel convertor unit: IMC was facing difficulty in disposal of scrap plastic such as chocolate wrappers, tobacco and pan-masala pouches. So, IMC came up with a plastic waste fuel converter unit. This facility works on the reverse polymerization process and is capable of producing at least 3000 litre of fuel per day with 10 tonnes of scrap plastic waste. The entire process takes at least 16 hours. Presently, the unit is producing around 2400 litre fuel including diesel, petrol as well as crude oil. The fuel produced is of good quality. This plastic waste fuel conversion unit has solved the problem of disposal of scrap plastic waste collected on daily basis from the city. Approximately three crores have been spent as the cost of the plant.

Reduce

Plastic, of course, is particularly problematic since it is non-biodegradable and hence, persists for far longer than other types of waste. A few minor changes in daily life could help keep plastics out of the waste stream. Some initiatives that can be adopted: i) Discourage the use of disposal plastics. Take note of how often we rely on products and replace them with reusable versions. ii) Minimize Buying Water and make a habit of using reusable bottle in the bag. iii) Minimize use of Plastics Cutlery and use metal utensils. b) Purchase secondhand item as newer items come with lot of packaging materials instead try to use secondhand materials until it is very necessary. iv) Support a bag Tax or Ban Support legislation and by-laws that put taxes on ban of single-use plastics (CPHEEO, 2016b).

Reuse

Reuse is a step above recycling. It diverts plastic and relieves strain on recycling systems. Reuse serves as a bridge between reduce and recycle. Reusing plastics can help to lessen the need for new plastics, reduced demand for disposable plastic and reduction in the consumption of resources and energy, resulting in lower environmental impacts (CPHEEO, 2016b).

Recycle

There are various advantages of recycling and reusing waste plastics. It results in a reduction in use of virgin materials and energy, as well as a reduction in carbon dioxide emissions. The different types of recycling processes are (CPHEEO, 2016b)*;* (Ruj et al., 2015)

Mechanical Recycling:

Air Classifier (also known as a Zig Zag Separator): A technique used for Separating of light films or contaminating paper/foil, or for separating fine dust from reclaimed material such as plastic flake or other granular materials. It is usually used after Granulation or Dry-Cleaning Operations and is very effective.

Air Tabling: A density concentration technique in which particles of mixed sizes, shapes, and densities are separated from each other due to the differential settling in an upward airflow with controllable velocity and under the influence of a vibrating action.

Ballistic Separator: It is designed to separate solid waste at the inlet, depending on size, density & shape.

Dry and Wet Gravity Separation (or Sink Float Tank): In this technique, different types of plastics are separated based on their density. The heavier plastic fractions sink to the bottom of the tank whilst the lighter fractions float to the surface. It is used in the recycling of plastic bottles and their caps. Mostly the lids and caps of these bottles are made from coloured HDPE plastic and the bottles from PET plastic. Within the Sink-Float Tank the HDPE floats, whilst PET sinks.

Froth Flotation: It is an intensive rinsing process with the addition of either fluid or steam and it can extract large volumes of fluid making it an effective choice for recycling. Friction Separation dissolves and separates impurities sticking to the product, utilizing a high level of rotation and friction. Many a time, this is used for cleaning mixed plastics and highly contaminated films. This technique is an ideal choice for soiled plastics to be treated in the recycling process.

Electrostatic Separation (or Triboelectric Separation): In this technique, electrostatically charged particles are passed through a Tribocyclone, and negatively charged particles gravitate towards the positively charged plate and vice versa, thereby classifying 3 or more resins at once.

Plastic Color Sorting: In this technique, ultra-violet light is used in combination with excellent digital camera technology to identify materials as small as 0.04 mm. This range of plastics color sorting machines cover material throughputs of 300-1800 kgs/hr. The machine throughputs are dependent upon material type and quantity of contamination. The sorting accuracy is typically up to 99.99%.

Near Infrared (NIR): When materials are illuminated, they mostly reflect light in the near infrared wavelength spectrum. Based on how the light is being reflected, NIR sensor can differentiate between different materials. This uses optical sorting to positively identify different resins. It is usually used for whole bottles & jugs and requires a minimum particle size of 50mm.

Feedstock Recycling

Plastic to Road Construction

The use of plastics on roads creates a new opportunity for recycling post-consumer plastics. Plastic roads are made entirely of plastic or composites of plastic with other materials. Polystyrene (PS) (hard packaging, cartons, plates, vending cups, etc.); Polypropylene (PP) (ketchup bottles, yoghurt cups, etc.); and Polyethylene (PE) (both high and low density) are examples of plastics that can be used for road building (plastic bags, water bottle, shampoo bottle etc.). Please note that Poly Vinyl Chloride (PVC) sheets or Flux sheets should not be used.

Plastic to Pavement Blocks

In addition to the Toilet blocks, the Plastone Block technology can be used for the construction of Pavement blocks. The Plastone blocks are made from mixture of waste plastics and stones and be five times stronger than the cement concrete block and can withstand more pressure and resist the percolation of water. It has numerous advantages over traditional cement blocks. Each Plastone block necessitates the use of 300 plastic carry bags as well as four to six PET bottles. It weighs light and has high transverse strength. These blocks can be used for flooring especially outdoor, in raising compound walls and lining of canals.

Recycling of Multi-Layered Plastic

As per the CPCB and Plastic Waste Management Rules 2016, 'multi-layered packaging means any material used or to be used for packaging and having at least one layer of plastic as the main ingredients in combination with one or more layers of materials such as paper, paper board, polymeric materials, metalized layers or aluminum foil, either in the form of a laminate or co-extruded structure (CPCB, 2013).

Fruit juices and wines can be stored at room temperature for lengthy periods in containers made of paper, aluminum foil, and polyethylene film. Tea and sweets are packaged in laminated foil with paper on the inside. Even in hot conditions, this foil is three times as watertight as normal foil: the paper absorbs moisture while the foil protects the contents from other negative elements. Most companies prefer multi layered packaging because it is light, reduces shipping volume, doesn't take up much space on a shelf, and is graphics friendly.

Tertiary Recycling is most preferred option till the industry finds an alternative to Multi layered packaging since separating the individual layers is difficult and costly. Pyrolysis and gasification are two main processes for tertiary recycling of multi-layered packaging waste currently in use. If Tertiary recycling is not possible, Quaternary Recycling, i.e., the process for recovering energy from waste plastics by incineration may also be considered to recycle multi-layered plastics (S. Sharma & Mallubhotla, 2019).

Concept of Circular Economy

A circular economy is an industrial system that is restorative or regenerative. It replaces the concept of end-of-life with restoration, shifts toward the use of renewable energy, removes the use of hazardous chemicals that hamper reuse and return to the biosphere, and strives for waste elimination through the superior design of materials, products, systems, and business models. This is important as it encourages the process of Sustainable Production, Sustainable Consumption and Upcycling.

Sustainable consumption and production entails doing more with less. It is also about divorcing economic growth from environmental damage, enhancing resource efficiency, and promoting environmentally friendly lifestyles. It can also make a significant contribution to poverty alleviation and the transition to low-carbon and green economies.

Upcycling is the activity of making a usable product out of trash or undesirable material, or of modifying an existing product to add value. The goal of upcycling is to reduce waste and improve resource efficiency. There are 2-fold benefits of a circular economy approach, that is, economic and environmental benefits. The economic benefits include Substantial resource savings; Economic growth; Growth of employment; Innovation stimulus and Changing demand. The environmental benefits include: Less greenhouse gas emissions; Conserving vital soil; Water bodies; Bio reserves etc.

Circular economy relates to 4 loops, namely: Repair, Maintenance & Upgrade; Reuse; Remanufacturing; Re-Upcycling. The transition process from the linear economy to circular economy involves 4 different approaches, namely: Circular Economy Design; Reverse Cycle; New Innovative Business Model; Enabler System Conditions.

The new plastic economy has a few transition strategies like: Re-Design, Recycle and Reuse Plastics (Design packaging to make it a little less hard on the environment); Having economical attractive alternatives to reduce the generation of waste; Recycling Pay (Improving packaging at the design stage would make recycling easier and more profitable than sending plastic to the landfill sites).

Emerging Concept of 8R

The term 8R's refers to an expanded version of the 3R's waste hierarchy, which stands for reducing – reuse – recycle. The 8Rs require a rethinking of the consumer products purchasing process. The 8 R's include: "Rethink, Regift, Recover, Recycle, Refuse, Reduce, Reuse and Repair" (Figure 4.9).

Figure 4.9 Eight R's waste hierarchy extended diagram

4.1.3 Construction and Demolition Waste Management

Safe and cost-effective management of solid wastes (SW) is a significant environmental challenge for modern society. Rapid urbanization is changing the nature of solid waste management from a low priority, localized issue to a pervasive social and environmental problem with risks to public health and the environment.

"Construction and demolition waste" means waste comprising of building materials, debris and rubble resulting from construction, re-modeling, repair and demolition of any civil structure. Construction and demolition wste is generated whenever any construction/demolition activity takes place, such as, building roads, bridges, fly over, subway, remodelling etc (Figure 4.10). It consists mostly of inert and non-biodegradable material such as concrete, plaster, metal, wood, plastics etc (CPCB), 2017).

Due to rapid urbanization, India's construction sector is projected to grow at a rate of 7-8% over the next 10 years and is likely to become the world's third-largest by the middle of the next decade. It is estimated that almost 70% of buildings supposed to exist by 2030 are yet to be built (Mckinsey, 2010). Such massive construction will rely heavily on raw materials such as sand, soil, stone and limestone; the extraction and production of which have significant ecological impacts. Some of these materials, especially sand, are already facing supply constraints, thus affecting the sector (Sakshi Gupta & Malik, 2018).

Figure 4.10 Construction and Demolition Waste

There should be a common recycling facility for the whole district. The bulk of C&D waste is non-hazardous. However, there are environmental problems during the demolition and disposal phases. Some risk issues related to older buildings' waste include asbestos removal, polychlorinated biphenyl (PCBs), wires and cables (brominated flame retardants and copper metal), mercury in lighting products and fixtures, and lead paint (Duan et al., 2015). So, C&D waste facility can be managed in a time duration of 10 years.

Activities which generate C & D waste in cities / towns are mainly from: (i) Demolition of existing, old dilapidated structures; (ii) Renovation of existing buildings (residential or commercial); (iii) Construction of new buildings (residential or commercial or hotel etc.); (iv) Excavation/ reconstruction of asphalt/ concrete roads; (v) Construction of new fly over bridges/ under bridges/ sub-ways etc.; and (vi) Present collection and disposal system (CPCB), 2017).

A cradle-to-grave approach must be adopted for proper management of C&D waste according to the new C&D Waste Management Rules, 2016. The system should contain proper collection of segregated C&D waste from the generator, proper transportation of waste, storage of waste at designated transfer stations or collection points, followed by proper processing of waste into recycled or reusable products that have market value and where minimal rejects are produced which get disposed in designated landfills. A properly implemented management system also needs to contain proper quantification and classification system for C&D waste at different stages of handling and a properly implemented monitoring system with a neat documentation process.

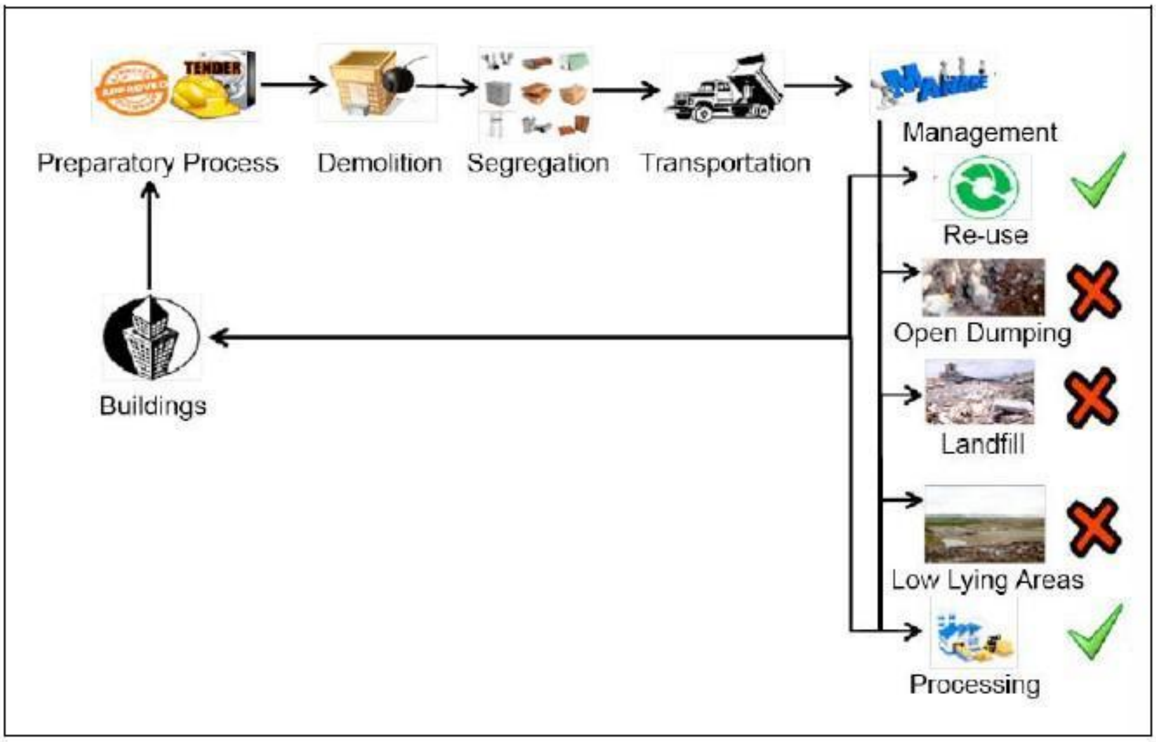

Figure 4.11 Schematic of Current vs. Ideal C&D Waste Management Processes in India

C&D waste generation and utilisation scenario

In India, it is very common to see huge piles of C&D waste, stacked alongside of major roads resulting in traffic jams, congestion and disruption & chocking of drains. Around 30% of the total municipal solid waste generated in the country comprises C&D waste. TIFAC has conducted a techno-market survey on 'Utilization of Waste from Construction Industry' targeting housing/building and road segments. The total quantum of waste from construction industry is estimated to be 12 to 15 million tons per annum out of which 7-8 million tons are concrete and brick waste (Shrivastava & Chini, 2005).

As per the Central Public Health & Environmental Engineering Organization (CPHEEO), the Indian Real Estate Industry alone is facing a shortage of aggregates to the extent of 55,000 million cum. In addition, 750 million cum of aggregates would be required to achieve the targets of the road construction sector, which will lead to tremendous pressure on natural resources (Jay, 2019).

The C&D waste generated in each city would reflect different characteristics based on each city’s growth pattern and lifestyle. While retrievable items such as bricks, wood, metal and tiles are recycled, the concrete and masonry waste, accounting for more than 50% of the waste from construction and demolition activities, are not being currently recycled in India.

The constituents of C&D waste generated and their respective quantum varies on a regional basis and also within the region. The representative C&D waste in urban areas of Northern plains would generally consist of soil, sand and gravel (26%), bricks & masonry (32%), Concrete (28%), metal (6%), wood (3%) others (5%) (Figure 4.12). Bricks, tiles, woods and iron metal are sold for reuse / recycling. The balance materials generally go for landfill (Vani & Shah, 2020).

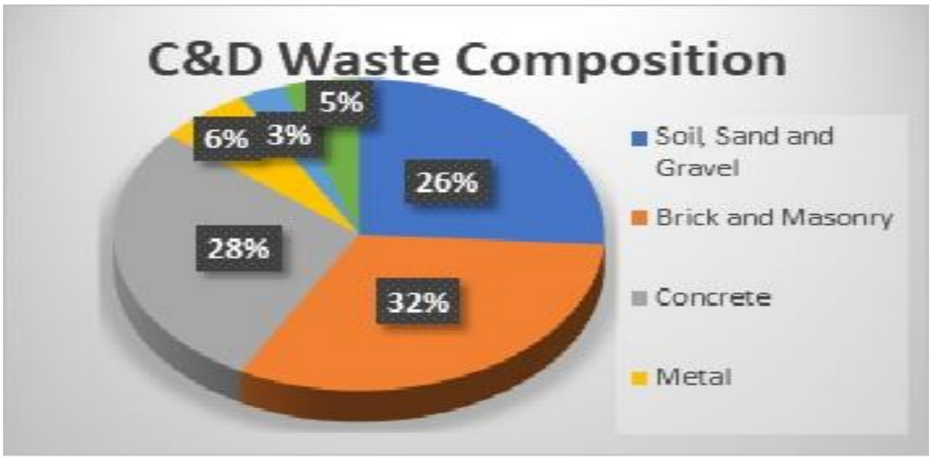

Figure 4.12 C&D Waste Composition: Indian Urban Areas

The Government, civic bodies and the industry are now very alert and active on the front of C&D waste management. More than ten Municipal Corporations have initiated the process to set up C&D waste processing facilities (Building Materials and Technology Promotion Council, 2018). In addition, Delhi is planning to set up four more plants for the processing of C&D waste, including one by Delhi Metro Corporation (BMTPC, 2018).

Rationale/Justification for C&D Waste Strategy

It is necessary to understand the importance/benefits of proper C&D waste management as well as identify the challenges and roadblocks so that an effective implementation strategy can be adopted.

Economic and Social Benefits

i. Hauling bulky C&D waste for disposal is a substantial expense for municipal bodies which can be significantly reduced (or avoided) with an appropriately designed C&D waste management system in which generators pay for disposal, as envisioned under the 2016 Rules.
ii. Mixing of C&D waste with solid waste worsens the municipal solid waste management system and also causes imbalances in the tipping fee rates of the MSW management.
iii. C&D waste processing into recycled products can generate employment through new enterprises, as already seen in Delhi and Ahmedabad.

iv. Unauthorised dumping of C&D waste creates widespread nuisance, safety and aesthetic problems which can be ameliorated with proper C&D waste management.

Environmental Benefits

i. Unauthorised dumping of C&D waste in drains and hydrological channels obstructs drainage and worsens flooding.

ii. Piles of C&D waste contribute to particulate air pollution when carried by wind.

iii. Unauthorised dumping of C&D waste in wetlands or stream/river channels disrupts local hydrology and associated ecosystems.

iv. Hazardous materials associated with C&D waste may leach out and contaminate soil and groundwater from unauthorised dumps.

v. Utilisation of recycled products from processed C&D waste helps relieve pressure on natural resources by reducing extraction of virgin materials like sand.

Congruence with Existing Government Policies and Priorities

i. Swachh Bharat Mission: Flagship programme of Government of India for improving waste management and resource recovery; C&D waste management falls squarely within its objectives. Cities must demonstrate improvements in cleanliness and waste management in comprehensive annual surveys, which should serve as an incentive to municipal bodies.

ii. AMRUT: Mission for urban infrastructure improvement with emphasis on pedestrian zones in 500 ULBs. Recycled products made from C&D waste (e.g., paver blocks) can be used beneficially for pedestrian zones (MoHUA & NITI Aayog, 2018).

iii. Smart Cities Mission: Mission envisions transformative projects in cities with an emphasis on innovation. C&D waste processing, as well as utilisation of recycled products, can be included in such projects.

iv. Housing for All (Pradhan Mantri Awas Yojana): Ambitious mission to address severe housing shortages by constructing 1.2 crores affordable housing units by 2022. Incorporation of "sustainable green materials" is encouraged by the mission, and recycled products from C&D waste can find utilisation.

Governance and Management

Duties and Responsibilities of Stakeholders

Recognizing the problems arising from C&D waste, the Government of India has notified the "Construction and Demolition Waste Management Rules" in 2016. These rules are quite comprehensive and address responsibilities of different stakeholders including generators, municipal bodies, state Pollution Control Boards, Urban Development Departments, etc.

Table 4.2 Duties and Responsibilities of Stakeholders (Central Pollution Control Board, 2017)

Stakeholder	Duties and Responsibilities
Waste generator	• Properly collect and store waste within their premises ensuring no spill over or mixing with MSW. • Deposit waste in designated locations as notified by local authority. • Submit waste management plan and get approval before starting construction/demolition work. • Pay relevant charges for collection and disposal as notified by local authority.
Utility service providers and their contractors	• Prepare a comprehensive waste management plan. • Collectandstorewastesecurelybyavoidinglocaldisruptionorpollution. • Arrange with urban local authority for disposal paying the relevant charges.
Local authority	• Pass by-laws mandating C&D waste management and fix relevant charges and penalties. • Designate intermediate collection points and site for processing facility, if needed in collaboration with state agencies. • Examine and approve waste management plan of generators and collect relevant fees. • Make arrangements for collection, transportation and processing, in contract with private party. • Establish C&D waste generation database through linking waste management permits and monitor compliance. • Carry out sustained IEC activities for all stakeholders.
State Pollution Control Board/ Committee	• Monitor implementation of the Rules by local authority. • Authorise C&D waste processing facility as per criteria and monitor environmental compliance. • Prepare annual reports for CPCB.

State government	• Prepare policy document for C&D waste management. • Help cities identify land for waste management where necessary. • Facilitate preferential procurement to recycled materials by all state agencies.
CPCB	• Prepare guidelines for C&D waste management. • Analyse data collected by SPCBs and prepare annual compliance report for central government.
BIS/Indian Roads Congress	• Prepare standards for suitable utilisation of recycled products from C&D waste in construction and inroads.
Central government	• Compliance facilitation by MoHUA, MoRD. • Review of implementation by MoEFCC.

The local authority is responsible to establish/ get established the C&D waste processing plant functional within 18 months from the date of notification of C&D Waste Management Rules, 2016 for 1 million and above population cities, within 24 months for cities with population of 0.5 -1 million and 36 months for the cities with population less than 0.5 million (MoEFCC, 2017).

Guidelines and Advisories

In 2012, the Ministry of Urban Development (MoUD), desired all states to set up environment friendly CDW recycling facilities in all cities/towns with population of over 1 million. Swachh Bharat Mission also also recognized and emphasized the need for CDW Management (MoHUA & NITI Aayog, 2018)

Central Public Works Department's (CPWD) 2014 'Guidelines for Sustainable Habitats' included a set of guidelines on the reuse of recycled C&D waste (Department, 2014). The guidelines include ways and precautions for recycling CDW as well as emphasis the need for a deconstruction plan to recover useful products that can be reused without much processing.

Building Materials and Technology Promotion Council (BMTPC) in 2016 released the 'Guidelines for Utilization of Construction & Demolition Waste in Construction of Dwelling Units and Related Infrastructure in Housing Schemes of the Government' to address the considerable shortage of conventional building materials in India based on high demand of building materials by 2021-2022.

The Ministry of Housing and Urban Affairs (MoHUA) has circulated a notification by CPWD on mandatory use of recycled portions of C&D waste in construction activities, if the same is available within 100 km of the construction site. It also specified that coarse and fine variety of Recycled

Concrete Aggregate (RCA) derived from C&D Waste are to be used in Lean Concrete, Plain Concrete Cement (PCC), and Reinforced Concrete Cement (RCC) for construction (MoHUA & NITI Aayog, 2018).

Delhi PWD issued an advisory to all Delhi Government Departments in 2015, mandating 2-10% use of recycled C&D waste products in building construction and road. The advisory was reissued by the Delhi PWD in 2018. This updated advisory also mandates the use of C&D waste products and recommends setting up of C&D waste recycling plants at different locations in the city, including at least one for each major stakeholder of the government. The advisory also notes that North Delhi Municipal Corporation has made available seven dumping locations for C&D waste generated from individual houses (CPCB, 2017).

Processing and Utilisation of C&D Waste

In India, currently material streams in C&D waste of immediate market value like metals, wood frames, etc. are recovered for the secondary market (usually by the informal sector), while the rest of debris is left behind. While a small fraction of this debris is used for backfilling and as daily landfill cover, most of it is not utilized (DGFIZ, 2017). Delhi and Ahmedabad have successfully set up C&D waste processing facilities that are manufacturing a wide range of products. As required under the new Rules, such processing units need to be established all over India (Vani & Shah, 2020).

Technologies for C&D Waste Processing

Since Indian C&D waste debris consists of debris of concrete, mortar, bricks and tiles, the processing usually just involves crushing, downsizing the material, washing and sieving it into uniform size aggregate particles, that can substitute primary aggregates in the construction market. The processing method is very similar to a stone crushing process and uses the same machinery and equipment's used in the stone crushing industry. The basic steps and simplified flow chart for processing C&D waste are depicted in figure 4.13 and figure 4.14.

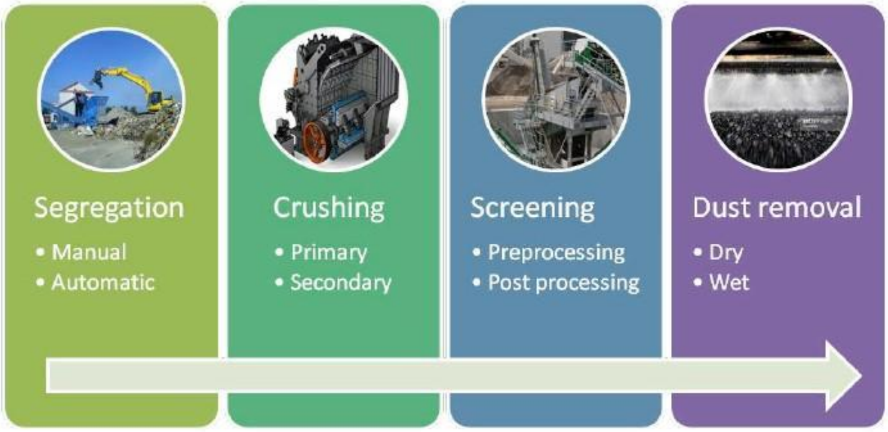

Figure 4.13 Major Steps in Processing of C&D Waste

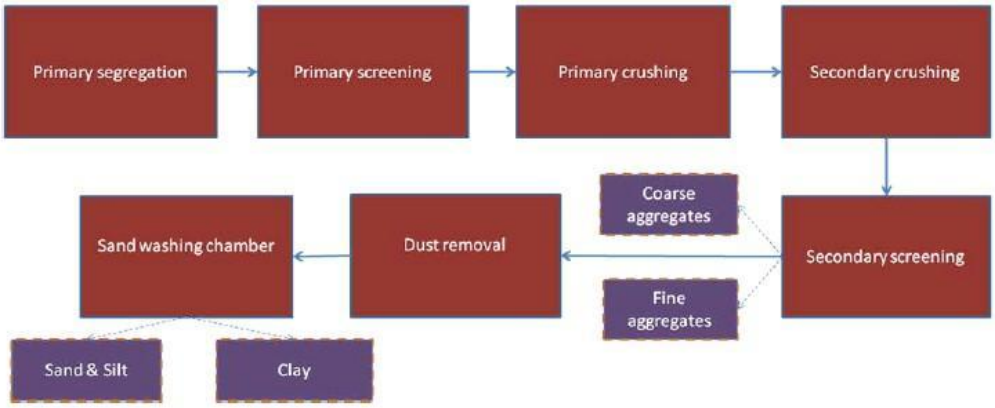

Figure 4.14 Process Outlay for Processing of C&D Waste into Secondary Raw Materials

Technology options for small towns and cities

For small cities and towns, which generate a much lesser quantity of waste, different approaches may be needed. C&D waste recycling is new in India; experience from the first few recycling units has shown that a centralised stationary processing facility is financially viable only for waste generation above 100 TPD*).* However, as the market and business models mature, stationary processing facilities might be viable for smaller capacities also (DGFIZ, 2017).

Although mobile crushing units are a viable decentralised model that could be adopted by small cities, such kind of a facility is not recommended for towns generating C&D waste quantities less than 20-30 TPD. For such towns, employing mini mobile crusher may be an option. The utilisation of mini mobile crushers is a practical solution for ULBs generating less than 1 or 2 truckloads of C&D waste per day. The mini crushers with processing capacities of around 5 TPD can be maintained by the ULB for processing waste into finer secondary raw material. Alternatively, the mini crushers can be maintained by designated pre-cast concrete building material manufacturers, to whom the C&D waste can be delivered as a business model. Such a model is under trial by the Foundation for MSME Clusters (DGFIZ, 2017).

A cluster approach for processing C&D waste is also feasible if ULBs sharing close boundary can operate a common C&D waste treatment facility. The stationary facility can be located at a common region accessible or equidistant from multiple ULBs. The facility can be maintained by a single ULB and other ULBs can supply C&D waste on a prorated basis based on a written agreement. Urban Development Authorities responsible for management of multiple ULBs (e.g., Chennai Metropolitan Development Authority, Mumbai Metropolitan Region Development Authority) can also coordinate the adoption of this kind of approach.

Optionally, the cluster can also operate a mobile crushing unit that can be shifted between ULBs over a fixed duration of days based on a written agreement. The material can be stockpiled in each ULB until a sufficient quantity has accumulated to bring in the machine and process the C&D waste over a specific period. Both the above-mentioned approaches are suggested for ULBs sharing close boundaries within 20-30 km, beyond which this may not be financially viable due to high transportation costs.

Best Practices of C&D Waste Management in India

Scientific processing and utilisation of C&D waste have achieved isolated successes in India. Delhi was the first city to implement a C&D waste management plan through a pilot processing facility developed under a public-private partnership (PPP) in 2010. After the initial success of the pilot plant processing waste at 500 tonnes per day (TPD), the capacity of the plant has been increased to 2,000 TPD (MoHUA & NITI Aayog, 2018). To minimize transportation distances and associated costs, Delhi planned to have a distributed network of processing facilities in different zones of the city. Accordingly, two smaller (500 TPD and 150 TPD respectively) plants have recently come online (2017-18), with planning for more underway (MoHUA & NITI Aayog, 2018)

Ahmedabad was the second city in India to implement C&D waste processing, by adopting a similar PPP model as that in Delhi. A 300 TPD processing facility was launched in 2014, the capacity of which was increased to 600 TPD 2016 after successful operation and now to 1,000 TPD in 2018 (BMTPC, 2018).

In both Delhi and Ahmedabad, Design-Build Operate Finance and Transfer (DBOFT) model is being followed. The Municipal Corporation contracts a private party, and this authorised agency is responsible for both transportation and processing of the C&D waste and develops the necessary infrastructure with its financing. The Municipal Corporation offers land to the contracted party for establishing the processing facility and also designates a series of intermediate collection points at favourable locations throughout the city. The authorised agency collects C&D waste from these designated collection points as well as from unauthorised dumps, as directed by the urban authority, and transports it to the processing facility. The municipal corporation pays the authorised agency an agreed fee per tonne of waste that is collected and transported. The authorised agency may also collect fees directly from large generators (such as Metro Rail) for waste collection; however, if generators bring waste to the processing facility at their own expense, the agency accepts it without charge. Therefore, the private partner has two sources of revenue – the "tipping fee" from the ULB and the sale of recycled products made from C&D waste. This ensures the viability of the enterprise. However, in both Delhi and Ahmedabad, the market uptake of recycled products made from C&D waste remains an ongoing challenge (BMTPC, 2018).

Proposed C&D Waste Management Model

Collection

Existing Practices– C&D waste in most ULBs is not collected or transported in an orderly manner. The waste is typically collected by a local transportation contractor and used for backfilling elsewhere or dumped in an unauthorised manner. Some municipalities have designated landfills/dumpsites for disposal, where the waste generator has to dump waste on his arrangements. However, in most cases, this does not happen since the dumpsite is either far away on the outskirts of the city or the designated area is not known to the waste generator due to improper communication by the ULB. Among the ULBs which have designated collection sites, only a few have a proper tracking system by means of weigh bridges.

***Changes to be adopted* -** As per the new Rules, C&D waste should be kept in the generator's compound in a properly segregated way and then transported to designated disposal sites prescribed by the local authority. Local authorities will formalise a collection system with adequate tracking and monitoring and communicate this to all generators.

Transportation

The C&D waste should be transported to the designated location/s on self-arrangements by generators or through other systems provided by ULB, whichever is mentioned in the by-laws of the ULB. Either way, both the generator and the transporting entity should maintain records of the quantum of waste transported to the designated dumping area. To minimise transportation distances, intermediate collection points/transfer stations are useful before removal to final disposal/processing facility. Vehicles carrying C&D waste should be covered to avoid dust, air pollution and spilling of debris on roads. These trucks can also be enabled with GPS devices for tracking waste flow from the collection points or generation site to the waste processing facility. The waste needs to be quantified at the disposal or processing site by weighing of trucks.

Disposal

Existing practices – C&D waste is mostly being disposed of in MSW dump yards or landfills, in which case it occupies huge volume and reduces the capacity of the landfill. It is also used as daily cover in MSW landfills. However, in most cities, only a small fraction of C&D waste generated reaches the ULB landfills. A huge portion of the waste is disposed of in low lying areas, open spaces, roadsides, etc. in an unauthorised manner.

Changes to be adopted – C&D waste should not be allowed to be dumped in landfills before recovering useful materials from the waste stream. The small fraction of C&D waste that comes out as unusable waste product after processing needs to disposed properly in a sanitary landfill and should not be mixed with other MSW. The hazardous fraction of C&D waste needs to be dumped in a hazardous waste landfill. More than 90% of the C&D waste composition in Indian cities can be processed/recycled and reused as secondary raw materials. Even for cities that do not have dedicated recycling facilities, the C&D waste debris can be used to some extent for approved public works construction projects where possible, and the rest should be disposed of at designated dumping sites which provides an opportunity for recycling them in the future.

In smaller towns where the waste generated is below 100 TPD, a processing unit may not be viable. In some rare instances, it may be possible for neighbouring towns to have a joint plant provided they are close enough to each other. In most cases, a mobile crusher may be a suitable option and the recycled aggregates produced may be used by the town's civil works, other public agencies such as PWD, or local building material manufacturers may be incentivized to use them. City adopts a preferential procurement policy to use recycled products made from C&D waste in municipal civil works and encourages other private and public entities to do the same. This standardized management model with a processing unit is depicted in a simplified way (MoHUA, 2018).

For smaller towns with low CDW generation rate, a processing facility may not be required. Smaller towns may follow a cluster approach whereby a common C&D waste treatment facility is operated jointly if several towns are located close by. This facility may be located in a common region accessible or equidistant from multiple ULBs. Alternatively, smaller towns may operate a mobile crushing unit that can be moved to sites where C&D waste is generated. Crushed and sorted C&D waste (recycled aggregates) may then be taken away by end-users, based on type of application (e.g., backfilling/landfill use/road repair or construction/etc. A standardized model C&D waste management model without a processing unit is depicted below (DGFIZ, 2017).

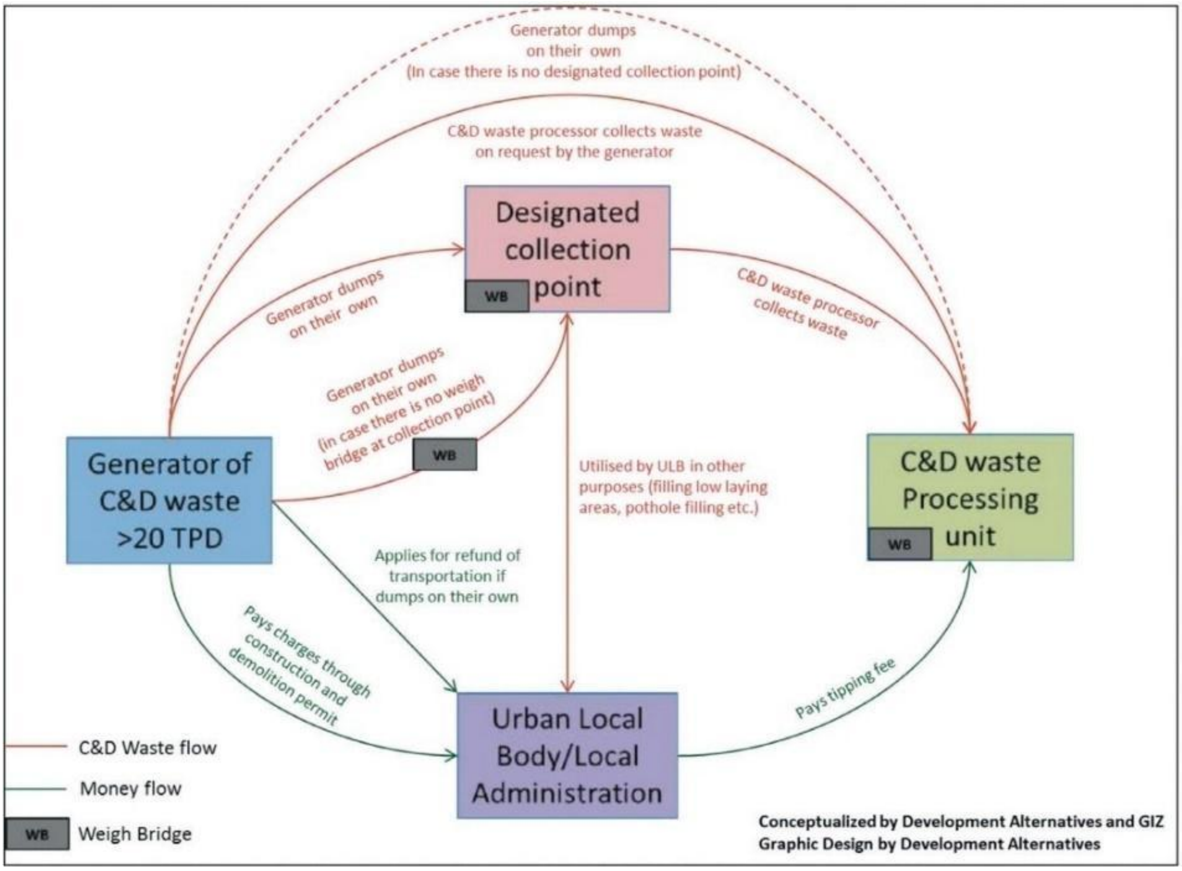

Figure 4.15 Material and Cash Flow in Standardised C&D Waste Management in a City with Processing Unit

4.1.4 Bio-Medical Waste Management

Human activities create a large amount of trash. Such trash may be hazardous, necessitating proper disposal. Depending on their source, solid waste may be divided into several categories. It consists of (a) domestic trash (b) industrial waste (c) biomedical waste, hospital waste, or infectious waste (Sachan & Chaurasia, 2006). Hospital waste is regarded as hazardous due to the presence of toxic substances. Bio-Medical Waste (BMW) comprises animal waste, laboratory trash, human anatomical waste, blood fluids and sharps created at hospitals, nursing homes, clinics, dispensaries, veterinary institutions, animal houses, pathology labs, and blood banks during diagnosis or medical treatment. BMW adopts a holistic approach to waste management, including categorization, quantification, segregation, storage, transportation, and treatment (Babu et al., 2009). After 1980, the Bio Medical Waste was considered as the critical issue, as the diseases like HIV and Hepatitis B infected materials can lead to an expansion of pathogen lead diseases in other patients (Patil & Pokhrel, 2005). The Bio-Medical Waste Management Concept is new in India and gain limelight after the notifications of Bio Medical Waste (Management and Handling) Rules, 1998. The issue can be correspondingly decreased with a strict source segregation approach. Similarly, with improved planning and administration, not only can waste creation be decreased, but also waste management costs may be kept under control.

These days, institutional/organizational structure, training, and motivation are all given a lot of weight. Proper training of healthcare workers at all levels, along with ongoing motivation, may significantly improve the situation.

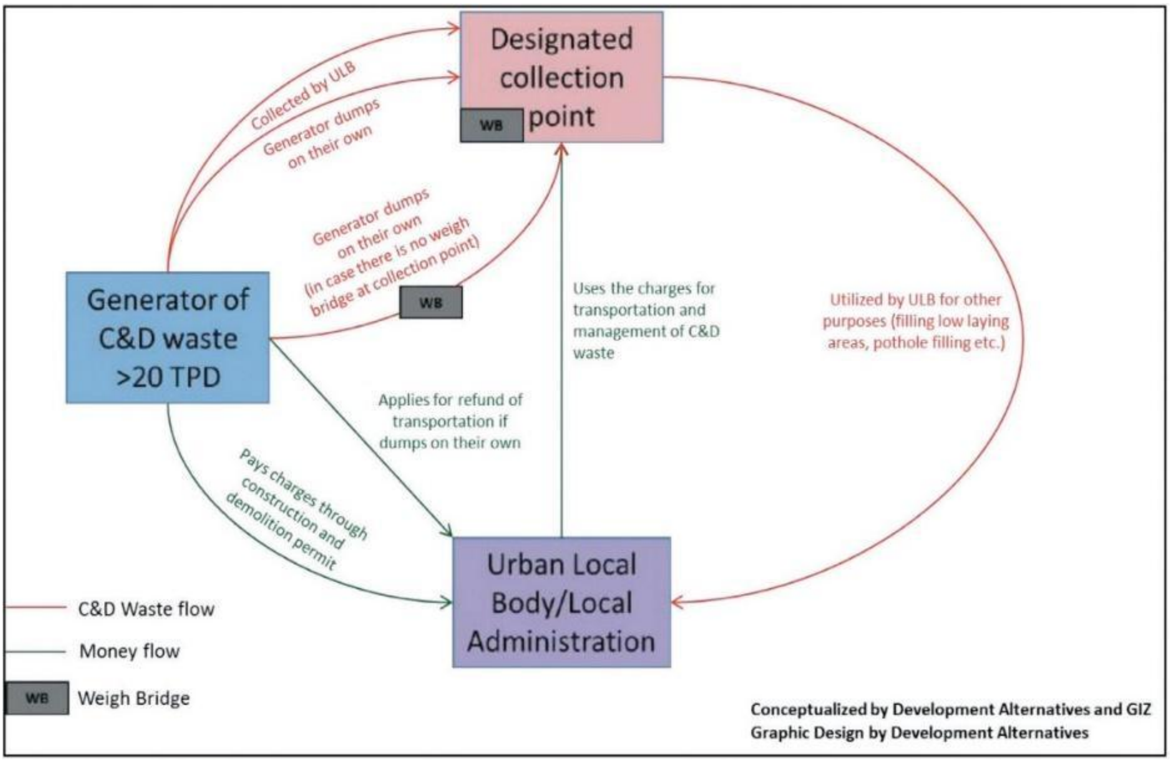

Figure 4.16 Material and Cash Flow for a Standardised C&D Waste Management Model without a Central Processing Unit

Unlike other garbage, the Bio-Medical waste is biohazardous, infectious, and pathological, which stimulates the growth of numerous diseases and vectors while also contaminating non-hazardous and non-toxic waste. This waste has high potential of transmission of diseases not only for rag pickers and waste collectors but for the general public and patients also. As a result, its treatment and disposal become a major concern.

The Bio-Medical Waste is thus segregated at source and disposed as per the best practices in the Cities and the Guidelines for it. Rather of disposing of trash, the finest BMW management (BMWM) strategies strive to prevent it from being generated or to recover as much as feasible. Prevent, reduce, reuse, recycle, recover, treat, and finally dispose of BMWs are the many options of BMW disposal, in order of their desirability.

Figure 4.17 3R's Concept

As a result, rather than taking an "end-of-pipe" approach, the waste should be addressed at the source. All parties involved in funding and supporting healthcare operations have a moral and legal obligation to safeguard the safety of others, and hence should contribute to the expense of BMW's appropriate management. It is the manufacturer's responsibility to provide environmentally friendly medical products to assure they are proper disposal.

Bio-medical waste is defined as any waste created during the diagnosis, treatment, or vaccination of humans or animals, as well as during related research activities and the manufacturing or testing of biologicals.

Hospital waste refers to all biological and non-biological waste that is dumped and not intended for further use.

Medical waste is defined as waste created as a result of a patient's diagnosis, treatment, or vaccination.

Infectious waste: Wastes that contain germs in high enough concentrations or quantities to cause illness. It is dangerous, for example, infectious agent culture and stocks from laboratories, surgical waste, and trash from infected patients.

Pathological waste: Human tissues, organs, body parts, bodily fluids, and specimens are among the wastes removed after surgery, autopsy, or other medical treatments, as well as their containers.

Sources of Bio-Medical Waste

The sources for Biomedical Waste Generation are Hospitals, Nursing homes, Clinics, Medical laboratories, Blood banks, Mortuaries, Medical research & training centres, Biotechnology institution/production units, Animal houses etc. Such waste can also be generated at home if healthcare is being provided there to a patient (e.g., injection, dressing material etc.)

Bio Medical Waste Components

Discarded Medicines, Tubing, Gloves, Intravenous sets, Urine Bags, Plastic Bottles, Syringe, Plaster, Human Tissues, Cotton, Untidy Bandages, Blood Bags, Placenta, Body Part carcass, Blades, Vials and ampoule of medicines and glass bottles etc. are the prime components of Bio Medical Waste. Only around 10% – 25% of BMW is dangerous, with the rest 75% - 90% being non-hazardous.

Hazardous waste poses a physical, chemical, and/or microbiological risk to the general public and healthcare personnel as a result of waste processing, treatment, and disposal (CPHEEO, 2000).

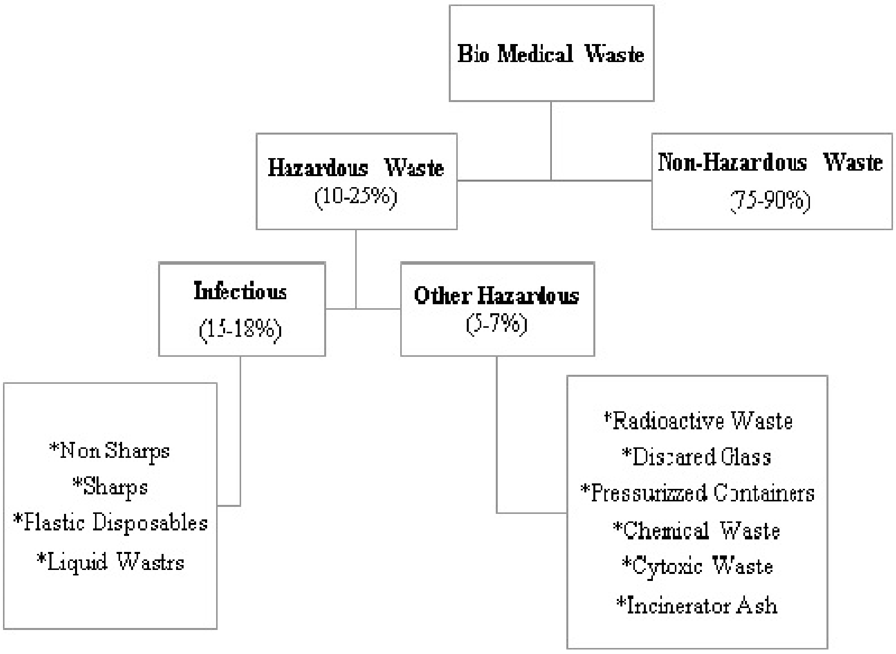

Figure 4.18 Categories of Bio-Medical Waste (Babu et al., 2009)

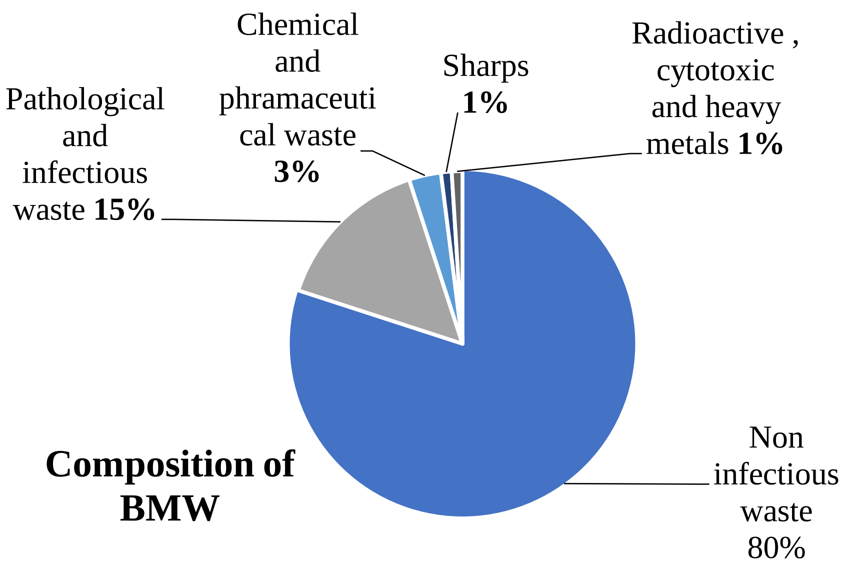

Figure 4.19 Composition of Bio-Medical Waste (Babu et al., 2009)

Categories of Bio Medical Waste

The most current advancements in healthcare facilities are specifically designed to prevent and safeguard community health. In numerous surgeries for illness treatment, sophisticated devices have become available. As a result of these advancements in scientific understanding, waste creation in health care units has increased per capita per patient.

Hypodermic needles, scalpels, blades, surgical cottons, gloves, bandages, garments, abandoned drugs and bodily fluids, human tissues and organs, chemicals, and other wastes are created in the health-care process. Radioactive wastes, mercury-containing devices, PVC plastics, and other wastes created in healthcare facilities are examples. These are the most ecologically sensitive healthcare goods, and they require a higher level of attention and monitoring (Babu et al., 2009).

Handling, segregation, mutilation, disinfection, storage, transportation, and final disposal are all important processes in ensuring the safe and scientific management of biological waste in any setting (Chatterjee, 2018).

Segregation (separate) and identification of biological waste are essential for its reduction and appropriate management. Sorting biomedical waste by colour is the most effective means of recognising the different types of trash. Handling, sorting, mutilation, disinfection, storage, transportation, and final disposal are all important procedures in the safe and scientific management of biological waste in any setting. Segregation (separate) and identification of biological waste are essential for its reduction and appropriate management.

Sorting biomedical waste into color-coded plastic bags or containers is the best approach to distinguish the different types of trash. According to Schedule II of the Biomedical Waste (Management and Handling) Rules 1998, biomedical wastes shall be divided into containers/bags at the site of production (Ibrahim Dincer Pouria Ahmadi, 2019).

Effects of Bio Medical Waste

Improper biomedical waste management has major environmental effects, including air, water, and land pollution. The three categories of pollutants that cause harm are biological, chemical, and radioactive pollutants. There are a variety of laws and policies in India that may be utilised to address environmental challenges. The classification of radioactive waste generated as part of biomedical waste is explored. The effects of pollution on air, radioactivity, land, health, and dangers are investigated (Patil & Pokhrel, 2005).

Table 4.3 Categories of Bio-Medical Waste (BMWM Rules, 1998) (CPCB, 2016)

CATEGORIES OF BIO-MEDICAL WASTE		
Option	**Waste Category**	**Treatment and Disposal**
Category No. I	**Human Anatomical Waste** (human tissues, organs, body parts)	incineration/ deep burial
Category No. 2	**Animal Waste** (animal tissues, organs, body parts carcasses, bleeding parts, fluid, blood and experimental animals used in research, waste generated by veterinary hospitals colleges, discharge from hospitals, animal houses)	incineration/ deep burial
Category No 3	**Microbiology & Biotechnology Waste** (wastes from laboratory cultures, stocks or specimens of micro-organisms live or attenuated vaccines, human and animal cell culture used in research and infectious agents from research and industrial laboratories, wastes from production of biologicals, toxins, dishes and devices used for transfer of cultures)	Local auto claving/ microwaving/ incineration
Category No 4	**Waste sharps** (needles, syringes, scalpels, blades, glass, etc. that may cause puncture and cuts. This includes both used and unused sharps)	disinfection (chemical treatment/ autoclaving / microwaving and mutilation/ shredding
Category No 5	**Discarded Medicines and Cytotoxic drugs** (wastes comprising of outdated, contaminated and discarded medicines)	incineration/ destruction and drugs disposal in secured landfills
Category No 6	**Solid Waste** (Items contaminated with blood, and body fluids including cotton, dressings, soiled plaster casts, lines, beddings, other material contaminated with blood)	Incineration/ autoclaving/ microwaving
Category No. 7	**Solid Waste** (wastes generated from disposable items other than the waste sharps such as tubings, catheters, intravenous sets etc).	disinfection by chemical treatment/ autoclaving/ microwaving and mutilation/ shredding
Category No. 8	**Liquid Waste** (waste generated from laboratory and washing, cleaning, housekeeping and disinfecting activities).	disinfection by chemical treatment and discharge into drains
Category No. 9	**Incineration Ash** (ash from incineration of any bio-medical waste)	disposal in municipal landfill

Category No. 10	**Chemical Waste** (chemicals used in the production of biologicals, chemicals used in disinfection, as insecticides, etc.)	Chemical discharge into drains for liquids and secured landfill for solids

Air Pollution: Buildings may pollute the air both inside and outdoors. The three types of biomedical waste created as a result of air pollution are biological, chemical, and radioactive waste (Patil & Pokhrel, 2005).

In-door Air Pollution: Diseases discovered in the garbage can enter and linger in the air for a long time as spores or infections. Waste separation, pre-treatment at the source, and other steps can all assist to reduce the situation to some extent. In addition to minimising biological indoor air pollution, sterilising the rooms will help to reduce biological indoor air pollution (Babu et al., 2009)Indoor air pollution caused by the aforementioned contaminants, along with inadequate ventilation, causes Sick Building Syndrome (SBS). With appropriate building design and well-maintained air conditioners, SBS may be decreased. Chemicals must be used in accordance with the regulations. Excessive usage of chemicals should be avoided (Saurabh Gupta & Boojh, 2006).

Out-door Air Pollution: Outside, pathogens can damage the air we breathe. When biomedical waste is transported outside of the institution without being prepared or placed in open areas, pathogens can reach the environment. Outdoor air pollution is caused by two principal sources of chemical pollutants: open burning and incinerators. The most dangerous method is to burn biological waste in the open. When inhaled, it can lead to respiratory problems. Dioxins and furans, for example, are carcinogenic organic gases (Patil & Pokhrel, 2005). The design parameters and upkeep of such treatment and disposal technologies should adhere to the established guidelines (Saurabh Gupta & Boojh, 2006).

Radioactive Emissions: Small amounts of radioactive gas may be produced during research and radio-immunoassay procedures. Gaseous radioactive material should be removed to the outside as soon as possible. The usage of such a device necessitates trap maintenance and off-gas monitoring (Chatterjee, 2018).

Water Pollution: If liquid waste is dumped into sewers without being adequately handled, it can pollute the water supply. Water contamination can change pH, BOD, DO, COD, and other parameters. Dioxins have been found in water bodies around incineration factories in the past. Airborne dioxins infiltrate the water body (Babu et al., 2009), (Saurabh Gupta & Boojh, 2006)

Radioactive Effluent: Chemical or biological research, bodily organ imaging, decontamination of radioactive spills, patient's urine, and scintillation liquids used in radioimmunoassay can all produce radioactive waste in liquid form. Urine and faeces may be treated as non-radioactive waste in most cases, as long as the patient's room is frequently checked for radioactive contamination (Chatterjee, 2018); (Mandal & Dutta, 2009).

Land Pollution: Infectious waste, abandoned pharmaceuticals, chemicals used in treatment, and ash and other waste created during treatment operations all contribute to bio-medical waste soil contamination. Heavy metals found in the garbage, such as cadmium, lead, and mercury, are absorbed by plants and can subsequently enter the food chain. Pollutants such as nitrates and phosphates can be found in landfill leachates. Excessive concentrations of trace nutritional elements, as well as other elements such as heavy metals, in soil, are detrimental to crops, animals, and humans (Babu et al., 2009).

Waste Management Practices

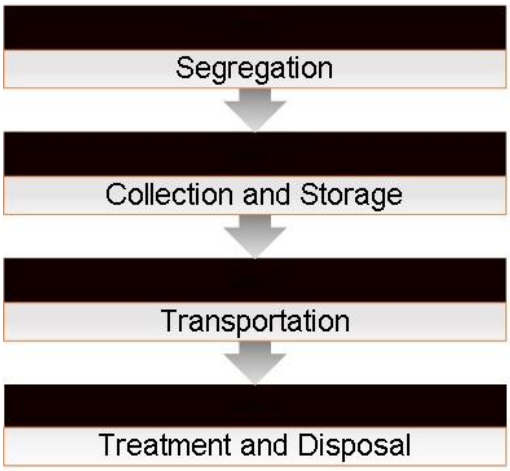

Figure 4.20 Waste Management Process

Step 1: Segregation

Bio-Medical waste is separated firstly in Healthcare Institutions. For the segregation, a colour coding process is adopted for this separation process. Each type of waste must be maintained segregated in a designated container or bag, depending on the treatment choices specified in the guidelines. According to the CPCB and the Bio-medical Waste Management Rules of 2016, bio-medical waste must be separated into four color-coded waste types.

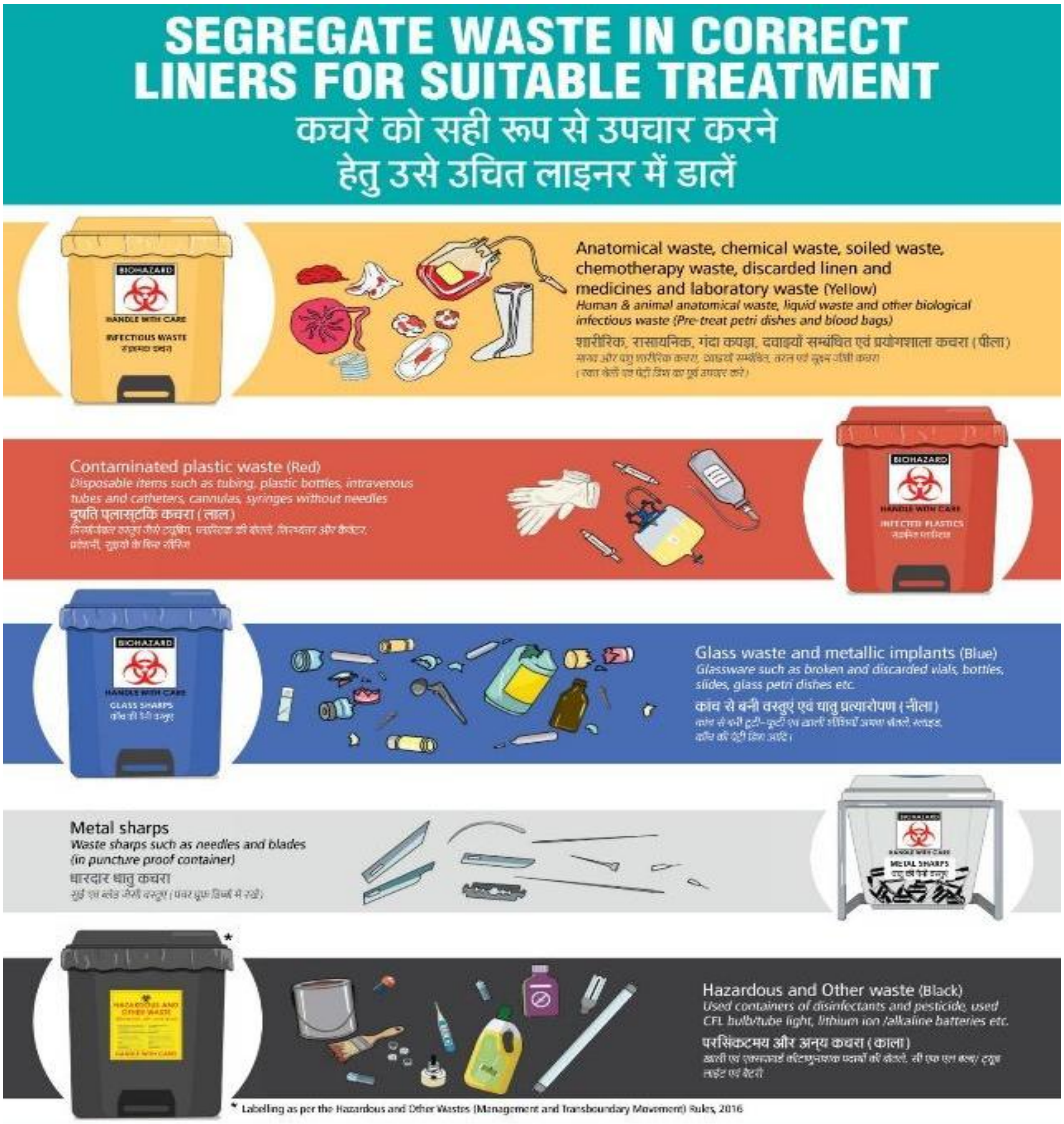

Figure 4.21 Waste Segregation at Source in Correct Liners (CPCB, 2019)

The following characteristics should be present in such a container or bag: 1. It must be strong enough to hold the waste's maximum volume and weight without causing harm.2. It should be free of any punctures or leaks. 3. The container should have a cover that may be operated by foot, if possible. If plastic bags are to be used, they must be firmly fastened into a container in such a way that they remain in place during lid opening and shutting and can be easily withdrawn. 4. Sharps must be kept in puncture-resistant sharps containers. However, before they are placed in the containers, they must be maimed with a needle cutter and placed in the department/ward.

ULBs should collect MSW generated by hospitals and other health care establishments after ensuring that such waste streams are not contaminated with biomedical wastes (Ibrahim Dincer Pouria Ahmadi, 2019).

Table 4.4 Color Coding of BM Waste Dustbins (BMWM Rules, 1998) (CPCB, 2019)

Color Coding	Type of Container	Waste Categories	Items Includes
Yellow	Plastic Bags	Cat. 1 Human Anatomical Waste Cat. 2 Animal Waste Cal. 3 Microbiological Waste Cat. 6 Solid Waste	Human Tissues, Plaster, Cotton, Untidy Bandages, Blood Bags, Placenta, Amputated Parts of Human Beings
Red	Disinfected Container, Plastic Bags	Cat. 3 Microbiological Cat. 6 Soiled Dressing	Tubing, Catheters, Gloves, Intravenous Sets, Urine Bags, Plastic Bottles, Syringes
Blue/White	Plastic Bags, Puncture Proof Containers	Cat. 4 Waste sharp Cat.7 Plastic disposable	Blades & Sharp Waste, Vials & Ampoules, Broken Glass & Bottles
Black	Plastic Bags, Puncture Proof Containers	Cat. 5 Discarded medicines Cat. 9 Incineration ash Cat 10 Chemical Waste	Discarded Medicine Incineration Ash Chemical Waste

Step 2: Collection and Storage

Figure 4.22 BMW Collection Bins

Depending on the volume of the trash, it may be temporarily held at the hospital's central storage facility before being delivered in bulk to the final disposal location once or twice a day. Before disposal, HCF should double-check that waste bags/containers are sealed and labelled appropriately with information regarding the point of production. The disposal color coded bags should not be filled, allowing them to be taken up by the neck for additional handling. Hence the bags should be sealed when they are three-quarters full. To limit the danger of needle prick injury and infection, manual handling of waste bags should be avoided. Clean the container, including the lid, with a suitable disinfectant after removing the bag. Waste bags and containers should be collected from wards and outpatient departments (OPDs) daily, or even more frequently if necessary (as in Operation Theatres, ICUs, labour rooms). Waste bags should be transported in covered wheeled containers or covered trolleys with big bins. Untreated biomedical waste must not be stored for more than 48 hours as per the guidelines. Within the health care institution or research centre, a storage place for medical waste should be specified. The wastes, in bags or containers, should be stored in a separate area, room, or building that is large enough to accommodate the volume of trash produced and the frequency with which it is collected (Ibrahim Dincer Pouria Ahmadi, 2019).

Step 3: Transportation

Biomedical wastes should be carried within a hospital or other institution using wheeled trolleys, containers, or carts that are not being utilized for anything else and fulfil the following requirements: It must be simple to load and unload; they should have no sharp edges that might harm trash bags or containers during loading and unloading, and it must be easy to clean. The cars should be cleaned and cleaned daily with an appropriate disinfectant. All trash bags or containers should be labelled with basic composition and waste producer information. Vehicles used for BMW transportation must display the International Infectious Substance Symbol as shown in the figure and should not be utilized for any other purpose. Vehicles or containers used to carry healthcare waste should not be utilized to transport any other type of trash.

Figure 4.23 (International Infectious Substance Symbol) Biohazard sign

Parking Lot for Collection Vehicles: Carts, trolleys, covered vehicles, and other waste collection and transportation vehicles should be stored in a shed with fencing. To prevent cross-contamination, separate sheds for hazardous and non-hazardous waste should be provided. Awash area with ample water jets, drainage, an elevated platform, and good drainage should be included in both sheds.

Step 4: Treatment and Disposal

Due to improper treatment and disposal, infections such as TB, hepatitis, enteric fever, HIV infection, and even AIDS can spread. The 'Bio-Medical Waste (Management and Handling) Rules, 1998' are having detailed categorization and disposal methods for 10 different categories of trash generated in healthcare institutions. The essential concept of biological waste treatment is that mutilation or shredding must be capable of preventing illegal reuse. Chemical treatment begins with a one-per cent hypochlorite solution. Incineration, on the other hand, does not require any kind of pre-treatment.

Only towns with a population of fewer than 5 lakhs are obliged to follow the deep burial procedure (MoEFCC, 2016).

The Detailed Methods of Treatment of Bio Medical Waste with technological interventions are:

Incineration: It's a well-regulated combustion process in which trash is oxidized and any hazardous bacteria are killed or denatured at a high temperature to transform waste into inert materials and gases. Three types of incinerators are in use for hospital waste: multiple hearth type, rotary kiln, and air types (Wahid, 2013).

Plasma Pyrolysis: Waste materials when used directly as combustion fuel or indirectly processed into another type of fuel to assist harness the energy contained in them. Pyrolysis has been identified as a similar kind of thermal treatment in this setting, in which high temperatures are utilised to treat waste materials with restricted oxygen supply. It is an environmentally beneficial technique that converts organic waste into economically valuable by-products (WHO, 2014)

Autoclaving: Autoclaving is a low-heat thermal technique that disinfects waste by bringing steam into direct contact with it in a regulated manner and for a long enough time. The system should be horizontal in design and specially built for the treatment of bio-medical waste for convenience and safety in operation (Babu et al., 2009).

Hydroclaving: It is identical to autoclaving, with the exception that the waste is heated indirectly by steam in the outer jacket. During the procedure, the trash is continually tumbling in the chamber.

Landfills*:* Infectious healthcare waste becomes non-risk waste after disinfection or burning, and may then be disposed of in landfills. However, following disinfection, many forms of healthcare waste, such as anatomical waste, can have an unpleasant visual impact, which is culturally unacceptable in many nations. As a result, such wastes should be rendered unidentifiable before disposal, such as by incineration. If this isn't an option, these wastes should be put in containers before being disposed of (WHO, 2014).

Shredding: Sharps (needles, blades, glass, etc.) and plastic (I.V. bottles, I.V. sets, syringes, catheters, etc.) should be shredded following chemical treatment/microwaving/autoclaving. Needle destroyers can be used to dispose of needles without having to treat them chemically.

Scenario outside Country

In 2012, the World Health Organization (WHO) performed a survey on the status of BMWM in 24 West Pacific nations, including Japan, China, Australia, New Zealand, the Philippines, Malaysia, Vietnam, Cambodia, the Republic of Korea, Micronesia, Nauru, and Kiribati. A literature search, study of publications, newspaper stories, and other sources of information were all used in the study. Management, training, policy and regulatory framework, the technology utilised, and financial resources were all considered in determining each country's standing. Except for Micronesia, Nauru, and Kiribati, all West Pacific nations performed well in terms of administration, training, and policies related to BMWM. Only Japan and the Republic of Korea employ BAT (best available technology) for BMW logistics and treatment, and these systems are well-maintained and tested regularly. The majority of countries lacked or had insufficient financial resources to support BMWM. As a result, HCWM in most West Pacific nations is still far from ideal, and more funding for the extension of HCWM systems in nations is critical to ensuring that safe HCWM systems are implemented within the next decade. In Canada, various jurisdictions have varied medical waste management methods. The processing and disposal of medical waste are not regulated in all provinces. However, it appears that Canada's hospitals are moving away from on-site incinerators and toward centralised state sterilisation facilities for BMWs (Mishra et al., 2016).

Scenario in Country

In India, the BMW problem was exacerbated by the existence of scavengers who sort out open, unprotected healthcare waste for recycling without gloves, masks, or shoes, and second, syringe reuse without proper sterilising. The International Clinical Epidemiology Network investigated existing BMW practices, setup, and structure in basic, intermediate, and tertiary health care facilities (HCF) throughout 20 Indian states from 2002 to 2004. They discovered that there was no reliable BMWM system in 82 per cent of primary, 60 per cent of secondary, and 54 per cent of tertiary HCFs in India. Around 240 persons in Gujarat, India, developed hepatitis B after using unsterilized needles in 2009. This and other studies reveal that, despite India being one of the first countries to take steps toward safe BMW disposal, there is a pressing need to expand current system capacity, boost financing, and raise commitment to BMW disposal safety. There is a strong need for the effective management of Bio-Medical waste for healthy humans and a cleaner environment. Safe and sustainable Bio-Medical Waste Management is the responsibility of the persons managing and owning the Healthcare Facilities.

CPCB published an Annual Report on Biomedical Waste Management for 2019 based on data compiled and reported by all SPCBs. According to the report the total BMW generated in the country is 614 TPD (tonnes per day) from 2,70,416 HCFs. Unfortunately, only 447 TPDs are treated, leaving 37 untreated. There are 200 CBMWTF in operation and 28 under construction (Mishra et al., 2016).

Annual Report Information has been submitted by every RSPCB for as per the compiled annual report information for the year 2019, there are 5974 no. of Health Care Facilities (HCFs) which generate 22502.57 kg/day bio-medical waste. There are 09 no. of CBWTFs in operation (07 under construction) (RSPCB, 2019). Normally the waste is collected in open containers without disinfection. Bandages, cotton, and other absorbent materials are gathered in plastic or other non-specific containers. Waste is gathered in a mixed state. Some hospitals around the country have created their colour coding scheme. Sharps are dumped without being disinfected or mutilated, which might lead to them being re-used and transmit an illness. The waste collection and transportation workers in the hospital segregate the recyclable material for sale. Similarly, all disposable plastic items are segregated by the waste pickers, from where the waste is deposited either inside the hospital grounds or outside in the community waste bin for further disposal, transportation along with the municipal solid waste. Since the infectious waste gets mixed with municipal solid waste, it has the potential to make the whole lot infectious in adverse environmental conditions (CPCB, 2016)

Scenario in State

There are 193 Urban Local Bodies (ULBs), 295 Panchayat Samitis, and 9,892 Gram Panchayats throughout Rajasthan's 33 districts (GPs). According to the 2011 Census, the state's population is 6.86 crores, with 24.78 per cent living in urban areas and 75.13 per cent in rural areas. Annual Report Information has been submitted by RSPCB for the compiled annual report information for the year 2019, there are 8100 no. of Health Care Facilities (HCFs) which generate 20685.65 kg/day bio-medical waste. There are 08 no. of CBWTFs in operation (07 under construction) (RSPCB, 2019). The 78.9% of waste generated is treated per day. Rajasthan's government has designed and implemented a plan to handle this crucial issue, and the Dept. of Medical & Health Science is responsible for it.

Hospital Waste Management Plan, Ministry of Health and Family Welfare

Hospital waste disposal is a complicated operation in which the many processes listed below are highly interrelated on both a technical and organisational level. The following are the governing principles in general terms:

A. Generation / Minimization: - Waste created in hospitals is categorised into ten different categories, including human anatomical waste, animal waste, microbiology and biotechnology waste, waste sharps, discarded pharmaceuticals, and cytotoxic pharmaceuticals, according to the rules. Soiled waste, solid trash, liquid waste, incinerator ash, and chemical waste are all examples of waste. Adherence to the 3 R's, i.e., Reduction, Recycle, and Reuse, encourages the significant reduction of waste created in healthcare institutions.

B. Segregation of Waste: - Segregation is the most crucial phase in the bio-medical waste category, and it is followed for each form of waste. It is done at the point of generation, for example, in all patient activity areas, diagnostic service areas, operating rooms, labour rooms, and treatment rooms. The generators of bio-medical waste, such as physicians and nurses, are responsible for segregation.

C. Collection: - Only non-chlorinated plastic collecting bags are utilised in the bins and receptacles. This prevents rag pickers from recycling or repurposing the products. Every day, waste is collected and delivered to a designated storage facility or deep burial pits. After 2/3 of the bags have been filled with biomedical waste, they are removed.

D. Transportation: - Garbage routes and transfer times are established within the hospital to minimise waste passing through congested and patient-care areas. To transfer the plastic bags to the storage / deep burial location, dedicated wheeled containers, trolleys/carts are used. The containers are designed in such a way that trash may be conveniently discharged into them, and the foot-operated lid securely shuts the diseased waste inside.

E. Storage: - Storage, according to the Bio-Medical Waste Rules, is defined as keeping biomedical waste for a specified amount of time before it is treated and disposed of. Inside the facility, there is a specific storage site for hospital waste collection. The garbage is collected in bags or containers and stored in a designated place.

F. End Treatment and Disposal: - The Department of Local Bodies, which is part of the GoR's Local Self Government (LSG), has been tasked with establishing Common Treatment Facilities (CTFs) in number of cities and towns. CTFs are in charge of trash collection and transportation from hospitals, as well as treatment and destruction when needed, and ultimate disposal at the CTF site. Before installing the equipment and treatment processes, the owner of CTF obtains permission from the appropriate authority under the BMW Rules, particularly the Rajasthan Pollution Control Board (RPCB). For project-supported facilities exclusively, there is a provision for payment of CTF hiring charges to CTF operators through RHSDP at the rate of Rs. 1000/- per bed per year. The CTF recruiting fees are paid via RMRS, which is repaid on an as-needed basis. This refund of CTF connection expenses is available until the end of the project duration (September 2011), after which it becomes liable (CPHEEO-Part I, 2016).

Monitoring of the Health Care Waste Management Activities

The Director-Hospital Administration at the Department of Medical, Health, and Family Welfare has chaired a Coordination, Monitoring, and Evaluation (CM&E) Committee for health care waste management. This committee is in charge of overseeing all actions relating to the management of medical waste. For the sustainability and convergence of all HCWM activities and practises with the Department of Medical and Health, Government of Rajasthan, regular cooperation between the RHSDP, DM&HS, and NRHM authorities is underway (TERI, 2014).

Governance and Management Structure

The various concerned institutions involved in the process of Bio-Medical Waste Management are Central Pollution Control Board, Ministry of Environment, Forest and Climate Change, Central Public

Health and Environmental Engineering Organisation (CPHEEO), Department of Medical, Health & Family Welfare, Rajasthan, The Energy and Resource Institute (TERI) and Ministry of Housing and Urban Affairs.

Roles and Responsibilities

Functions of the Central Board at the National Level

Provide advice to the Central Government on any topic relating to water and air pollution prevention and control, as well as air quality enhancement., Develop and implement a national programme for the prevention, control, or abatement of water and air pollution; Coordinate the operations of the State Board and resolve conflicts among them; Provide technical advice and direction to the State Boards, as well as conduct and fund investigations and research into water and air pollution issues, as well as their prevention, control, and abatement, Plan and organise training for those working on water and air pollution prevention, control, or abatement programmes, Organize a thorough mass awareness effort on the prevention, control, and abatement of water and air pollution through the media; Collect, compile, and publish technical and statistical data on water and air pollution, as well as the steps taken to effectively avoid, control, or abate it; Prepare manuals, rules, and recommendations for sewage and trade effluent treatment and disposal, as well as stack gas cleaning equipment, stacks, and ducts, Disseminate information in respect of matters relating to water and air pollution and their prevention and control; Lay down, modify or annul, in consultation with the State Governments concerned, the standards for stream or well, and lay down standards for the quality of air; and Perform such other function as may be prescribed by the Government of India (CPCB, 2016);(Patidar et al., 2014)

Rules and Regulations

The irresponsible dumping of infectious and hazardous waste from hospitals, nursing homes, and pathology labs has caused major environmental degradation, resulting in disease spread and exposing individuals to some highly contagious and transmission-prone disease vectors. This has aroused significant worry for the environment.

Bio Medical Waste (Management and Handling) Rules, 2016

The erstwhile Ministry of Environment and Forests issued the first Bio-Medical Waste (hereafter referred to as BMW Rules) guidelines to the Government of India in July 1998 under the Environment (Protection) Act, 1986. In the years 2000, 2003, and 2011, the BMW 1998 regulations were amended. Because of a lack of consensus on classification and criteria, the draught BMW Regulations 2011 remained a draught and was not announced. In March 2016, the Ministry of Environment, Forestry, and Climate Change revised the BMWM guidelines (Ibrahim Dincer Pouria Ahmadi, 2019).

To reduce pollution, these new guidelines have expanded coverage, simplified classification and authorisation, and improved segregation, transportation, and disposal techniques.

The new BMWM Rules 2016 states the guidelines, effective implementation, techniques and eco-friendly methods. These rules are proposed to improve the segregation-transportation-disposal methods by reducing environmental pollution. A collective teamwork approach with committed government support in terms of finance and infrastructure development, dedicated healthcare workers and healthcare facilities, continuous monitoring of BMW practices, tough legislation, and strong regulatory bodies is needed to effectively dispose of BMWM. State governments have made steps to establish Common Biomedical Waste Treatment Facilities (CBWTFs) for waste treatment and disposal. Segregation at the source and waste minimization are the cornerstones of BMWM.

Furthermore, tight procedures have been established to prevent pilferage of recyclable items, secondary handling, or animal dispersal or spillage during delivery from the HCFs to the shared BMW treatment plant (CBMWTF). Waste collection, sorting, transportation, and disposal are all being improved. Simultaneously, by adopting new rules for incinerators and improving their operations, the function of incinerators in increasing environmental air pollution has been controlled (Balasubramanian, 2018; Sachan & Chaurasia, 2006).

“Any waste generated during the diagnosis, treatment, or immunization of humans or animals, or during related research, or the production or testing of biologicals,” according to India's Biomedical Waste (Management and Handling) Rules, 1998. The responsibility of medical administrators as regards proper handling and disposal of this category of waste has now become a statutory requirement with the promulgation of the Government of India.

Following rules have been followed for Bio-Medical Waste Management (CPHEEO, 2000)*:*

In compliance with Bio-Medical Waste (Management and Handling) Rules, 1998, the health care facilities are required to obtaining authorization/renewal of authorization certificate from State Pollution Control Board (SPCB).

As informed by Central Pollution Control Board and as per Bio-medical Waste Management Rules, 2016, Bio-medical waste is required to be segregated into 4 colour coded Red (infected dressing, pop casts), Yellow (body parts), Blue (syringes), White (needles, cut glasses) waste categories, and the same is treated and disposed of as per the specified methods of disposal prescribed under Schedule I of the Rules (CPHEEO, 2000).

The following are some of the act's most notable features:

The Act requires the authorized operator of a Common Bio-Medical Waste Treatment and Disposal Facility (CBWTF) to take all reasonable steps to ensure that bio-medical waste collected from the occupier is transported, handled, stored, treated, and disposed of in a safe and environmentally friendly manner. Local governments, such as gram panchayats, municipalities, and corporations, are required by Schedule III of the Bio-medical Wastes Management Rules, 2016 to provide or allocate suitable land for the establishment of a Common Bio-Medical Waste Treatment Facility in their jurisdictions, as per the CPCB guidelines.

Solid Waste Management rules, 2016 -Requirements on Bio-Medical Waste

Bio-medical wastes, industrial wastes, e-waste, and domestic hazardous wastes must be handled according to specific rules framed for their management, and domestic hazardous waste may be handled as directed by the state pollution control board or pollution control committee, according to the SWM Rules, 2016. The biological waste shall be disposed of as per the Bio-medical Waste Management Rules, 2016, as revised from time to time, based on the criteria for site selection outlined in Schedule I (x) of the SWM Rules, 2016. Local governments, such as gram panchayats, municipalities, and corporations, are required by Schedule III of the Bio-medical Wastes Management Rules, 2016 to provide or allocate suitable land for the establishment of a Common Bio-Medical Waste Treatment Facility in their jurisdictions, according to CPCB guidelines. Collect other solid waste (not bio-medical waste) from health care institutions as per the SWM Rules, 2016 or as amended from time to time (CPCB, 2016).

Environmental Concern

The following are the primary environmental risks about incorrect bio-medical waste disposal:

A. Infection and disease spread by vectors (fly, mosquito, insects, etc.) that impact both the in-house and surrounding populations. B. Infection spreads through contact/injury among medical/non-medical professionals and sweepers/rag pickers, particularly from sharps (needles, blades). C. Infection spreads through unlicensed recycling of disposable objects such as hypodermic needles, tubes, blades, and bottles. The reaction is caused by the usage of expired medications. D. Toxic emissions from incinerators that are malfunctioning or inefficient, as well as indiscriminate disposal of incinerator ash and leftovers (Patil & Pokhrel, 2005).

Best Practices

Disposal in three stages

1. Primary Level

At this level, if plants are located in the urban area. The problem of air pollution will be a concern, so we replace the incinerators with the plasma pyrolysis system which are capable to destroy the dioxin and furan, which are the carcinogenic compound emitted during improper combustion. For improvement the capacity we replace the autoclave with Hydroclave, by using Hydroclave we can increase the speed and efficiency. At this level, the focus should be on proper segregation and avoid mixing of kitchen waste resulting in a decrease in the incinerated waste. Adaptation of GPS tracker in the vehicle also used for proper collection Transport vehicle will be as per motor vehicle act.

2. Secondary Level

The prime aim is the collection of waste from the suburban and village area and the disposal of the waste. As the plant is located in a non-residential area so there is not required advanced system because it will result inexpensive. The plant will consist of an incinerator and autoclave. Collection and Transportation purpose collection points are created. Local HCEs will collect their waste at the centres. Transport vehicles will collect the waste from the plant.

3. Tertiary Level

The prime aim is the disposal of the waste Area is remote so the old burning using the Brick masonry incinerator and old container can be used to dispose of the waste.

4.1.5 Hazardous Waste Management

Hazardous waste is any kind of waste that presents a health concern to humans and the environment alike when disposed of without proper care. It can come in many forms, and, it can be created from all kinds of human activities, like industrial projects and factory work and can even be found in household waste. It is important to have a clear, concise plan that can be followed to minimize hazardous waste while properly segregating, treating and disposing of the waste, ensuring that humans and the environment are safe from the danger it presents.

“Hazardous waste” means any waste which because of characteristics such as physical, chemical, biological, reactive, toxic, flammable, explosive or corrosive, causes danger or is likely to cause danger to health or environment, whether alone or in contact with other wastes or substances, and shall include - a) waste specified under column (3) of Schedule I of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; b) waste having equal to or more than the concentration limits specified for the constituents in class A and class B of Schedule II or any of the characteristics as specified in class C of Schedule II of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016; and c) wastes specified in Part A of Schedule III in respect of import or export of such wastes or the wastes not specified in Part A but exhibit hazardous characteristics specified in Part C of Schedule III of Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 (Karthikeyan et al., 2018)

"Domestic hazardous wastes are defined as discarded paint drums, pesticide cans, CFL bulbs, tube lights, expired medicines, broken mercury thermometers, used batteries, used needles and syringes, contaminated gauge, etc. generated at the household level" (CPHEEO, 2016b).

Hazard Classification

Physical Hazards

Physical hazards or those chemical substances causing physical property damage have been categorised by the GHS as follows:

Table 4.5 Classification of Physical Hazards

HAZARD CLASS	NO. OF CATEGORIES	GHS SYMBOL
Explosives: An explosive substance (or mixture) is a solid or liquid substance (or mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings.	Unstable explosives – 1 Explosives Division 1.1-1.6	
Self-heating substances and mixtures is a solid or liquid substance or mixture, other than a pyrophoric liquid or solid, which, by reaction with air and without energy supply, is limbic to self-heat. It differs from a pyrophoric liquid or solid in that it will ignite only when in large amounts (kilograms) and after long periods (hours or days).	Two Categories: 1 and 2 classified in accordance with test N.4 under GHS	
Substances and mixtures which, in contact with water, emit flammable gases arc substances or mixtures which, by interaction with water, are liable to become spontaneously flammable Of to give off flammable gases in dangerous quantities.	Three Categories: 1, 2 and 3 classified in accordance with test N.5 under GHS	

Oxidizing liquid: A liquid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.	Three Categories: 1, 2 and 3 classified in accordance with test O.2 under GHS	
Oxidizing solids: A liquid which, while in itself not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.	Three Categories: 1, 2 and 3 classified in accordance with test O.1 and O.3 under GHS	
Organic peroxides: Liquid or solid organic substances which are thermally unstable substances or mixtures, which may undergo exothermic self-accelerating decomposition. In addition, they may be liable to explosives.	Seven categories: Types A - G divided based on principles under Chapter 2.15	 
Flammable gases: A gas having a flammable range with air at 20 degree Celsius and a standard pressure of 101.3 kPa. They are differentiated from pyrophoric gases and chemically unstable gases. A pyrophoric gas is a flammable gas that is liable to ignite spontaneously in air at a temperature of 54 degree Celsius or below. Whereas, a chemically unstable gas is a flammable gas that can react explosively even in the absence of air or oxygen.	Three categories - 1A, 1B and 2	
Aerosols are non-refillable receptacles made of metal, glass or plastics and containing gas compressed, liquefied or dissolved under pressure, with or without a liquid, paste or powder and fitted with a release device allowing the contents to be ejected as solid or liquid particles in suspension in a gas, as a foam, paste or powder or in a liquid state or a raucous state. Aerosols should be considered for classification as Flammable if they contain any component which is classified as flammable according to the GHS criteria.	Three categories- 1, 2 and 3	

Oxidising Gases: An oxidising gas is classified under a single category and is any gas that may, generally by providing oxygen contribute to the combustion of other material more than air.	One Category	
Gases under pressure: Gases which arc contained in a receptacle at a pressure not less than 200 kPa at 20 degrees Celsius or as a refrigerated liquid.	Four Categories: Compressed gases, Liquefied gases, Dissolved gases and refrigerated liquefied gases.	
Corrosive to metals: A substance or a mixture that is corrosive to metal is a substance or a mixture which by chemical action will materially damage, or even destroy, metals.	One category	
Desensitized Explosive: They arc solid or liquid explosive substances or mixtures that are rendered less sensitive to suppress their explosive properties in such a manner that they do not mass explode or do not burn too rapidly and therefore are exempted from the hazard class of 'explosives'.	Four categories: 1, 2, 3 and 4 based on 'burning rate test'	

Environment Hazards

Under environmental hazards, chemical substances and mixtures have been categorised under different heads depending upon the part of the environment that they affect such as the aquatic environment, the ozone layer. The chemical substances have been categorised by the GHS as follows:

Table 4.6 Classification of Environment Hazards

HAZARD CLASS	**NO. OF CATEGORIES**	**GHS SYMBOL**
Hazardous to the Aquatic Environment		
Acute aquatic toxicity is the intrinsic property of a substance to be injurious to an organism in a short-term exposure to that substance. Chronic aquatic toxicity – potential or actual properties of a substance to cause adverse effects to aquatic organisms during exposures which are determined in relation to the life cycle of the organism.	Short term (acute) hazards are out under three categories: Acute 1, Acute 2 and Acute 3. Long term (chronic) hazard is further classified based on the availability	

	of adequate toxicity data.	
Hazardous to the Ozone Layer		
Ozone Depleting Potential is an integrative quantity, distinct for each halocarbon source spouts, that represents the extent of ozone depletion in the stratosphere expected from the halocarbon on a mass-for-mass relative to CFC-11.	One Category.	

Governance and Management Structure

Concerned Stakeholders

The stakeholders for Solid Waste Management are as follows:

- Government Departments
- Waste Generators (Residential and Bulk Waste Generators)
- Producers Manufacturers &Brand Owners
- Industrial Units

Roles and Responsibilities

According to Solid Waste Management Rules, 2016 the duties of various stakeholders are as follows:

Duties of Ministry of Urban Development

The Ministry of Urban Development shall coordinate with State Government Administrations to take a periodic review of the measures taken by the states and local bodies for improving solid waste management practices and execution of solid waste management projects funded by the Ministry and external agencies, formulate national policy and strategy on solid waste management including, promote research and development in the solid waste management sector, undertake training and capacity building of local bodies and other stakeholders; and provide technical guidelines and project finance to states and local bodies on solid waste management to facilitate meeting timelines and standards (GOR, 2019).

Duties of Department of Fertilisers, Ministry of Chemicals and Fertilisers

The Department of Fertilisers through appropriate mechanisms shall provide market development assistance on city compost, ensure the promotion of co-marketing of compost with chemical fertilisers in the ratio of 3 to 4 bags: 6 to 7 bags by the fertiliser companies to the extent compost is made available for marketing to the companies (GOR, 2019).

Duties of Ministry of Agriculture

The Ministry of Agriculture shall provide flexibility in Fertiliser Control Order for manufacturing and sale of compost, propagate utilisation of compost on farmland, set up laboratories to test the quality of compost produced by local authorities or their authorised agencies and issue suitable guidelines for maintaining the quality of compost and ratio of use of compost vis-a-vis chemical fertilizers while applying compost to farmland (GOR, 2019).

Duties of the Ministry of Power

The Ministry of Power through appropriate mechanisms shall decide tariff or charges for the power generated from the waste to energy plants based on solid waste (GOR, 2019).

Duties of Ministry of New and Renewable Energy Sources

The Ministry of New and Renewable Energy Sources through appropriate mechanisms shall facilitate infrastructure creation for waste to energy plants and provide appropriate subsidies or incentives for such waste to energy plants (GOR, 2019).

Duties of the Secretary-in-charge, LSG or Local Self Government Department and the Secretary-in-charge of Gram Panchayats or Rural Development Department

The Secretary, LSG in the State through the Commissioner or Director of Municipal Administration or Director of local bodies or the Secretary-in-charge of Gram Panchayats or Rural Development Department in the state shall prepare a state policy and solid waste management strategy for the state or the union territory in consultation with stakeholders including representative of waste pickers, self-help group and similar groups working in the field of waste management consistent with these rules, national policy on solid waste management and national urban sanitation policy of the ministry of urban development, in a period not later than one year from the date of notification of these rules; while preparing State policy and strategy to solid waste management, lay emphasis to waste reduction, reuse, recycling, recovery and optimum utilisation of various components of solid waste to ensure minimisation of waste going to the landfill and minimise impact of solid waste on human health and environment; state policies and strategies should acknowledge the primary role played by the informal sector of waste pickers, waste collectors and recycling industry in reducing waste and provide broad guidelines regarding integration of waste picker or informal waste collectors in the waste management system.

They shall also ensure implementation of provisions of these rules by all local authorities and conduct regular meetings of State Level Advisory Body (SLAB), as constituted through the Administrative Reforms Department through Environment Department (GOR, 2019).

Duties of District Magistrate or District Collector

The District Magistrate or District Collector shall facilitate identification and allocation of suitable land for setting up solid waste processing and disposal facilities to local authorities in his district in close coordination with the Secretary-in-charge of State Urban Development Department, review the performance of local bodies, and take responsibility for Constitution of District Level Committee and Special Task Force for SWM, as per NGT Order (GOR, 2019).

Duties and Responsibilities or Local bodies and Gram Panchayats

Apart from the duties and responsibilities prescribed for gram panchayats, the priority/ key duties are to prepare a Solid and Liquid Resource Management (SLRM) Plan, arrange for door-to-door collection of segregated solid waste from all households, set up material recovery facility, i.e. Resource recovery centres (RRC) with sufficient space for sorting of recyclable materials and to educate workers, including contract workers and supervisors for door to door collection of segregated waste and transporting the unmixed waste during primary and secondary transportation to processing or disposal facilities. (GOR, 2019).

They also have to ensure safe storage and transportation of the domestic hazardous waste to the hazardous waste disposal facility or as may be directed by the State Pollution Control Board or the Pollution Control Committee, direct street sweepers not to burn tree leaves collected from street sweeping and store them separately and handover to the waste collectors or agency authorised by the local body, provide training on solid waste management to waste-pickers and waste collectors, collect waste from vegetable, fruit, flower, meat, poultry and fish market on day to day basis and promote setting up of decentralised compost plant or bio-methanation plant at suitable locations in the markets or the vicinity of markets ensuring hygienic conditions. Incentives may be provided to recycling initiatives by the informal waste recycling sector.

They have to facilitate construction, operation and maintenance of solid waste processing facilities and associated infrastructure on their own or with private sector participation or through any agency for optimum utilisation of various components of solid waste adopting suitable technology including the following technologies and adhering to the guidelines issued by the Ministry of Urban Development (GOR, 2019).

Duties of State Pollution Control Board

The State Pollution Control Board shall enforce these rules in their State through local bodies in their respective jurisdiction and review the implementation of these rules at least twice a year in close coordination with concerned Directorate of Municipal Administration or Secretary-in-charge of LSG, and monitor environmental standards and adherence to conditions as specified under the Schedule I and Schedule II for waste processing and disposal sites.

The State Pollution Control Board shall, after giving reasonable opportunity of being heard to the applicant and for reasons thereof to be recorded in writing, refuse to grant or renew an authorisation. In case of new technologies, where no standards have been prescribed by the Central Pollution Control Board, State Pollution Control Board, shall approach Central Pollution Control Board for getting standards specified.

The State Pollution Control Board shall monitor the compliance of the standards as prescribed or laid down and treatment technology as approved and the conditions stipulated in the authorisation and the standards specified in Schedules I and II under these rules as and when deemed appropriate but not less than once in a year. The State Pollution Control Board may give directions to local bodies for safe handling and disposal of domestic hazardous waste deposited by the waste generators at hazardous waste deposition facilities. The State Pollution Control Board shall regulate the Inter-State movement of waste and prepare IEC/ BCC plan and its implementation in various districts involving ULBs/ GPs & other stakeholders (GOR, 2019).

Duties of Waste Generators (Residential and Bulk Waste Generators)

Every waste generator shall segregate and store the waste generated by them in three separate streams namely bio-degradable, non-biodegradable and domestic hazardous wastes in suitable bins and handover segregated wastes to authorised waste pickers or waste collectors as per the direction or notification by the local authorities from time to time, wrap securely the used sanitary waste like diapers, sanitary pads etc., in the pouches provided by the manufacturers or brand owners of these products or in a suitable wrapping material as instructed by the local authorities and shall place the same in the bin meant for dry waste or non- bio-degradable waste, store separately construction and demolition waste, as and when generated, in his own premises and shall dispose of as per the Construction and Demolition Waste Management Rules, 2016; and store horticulture waste and garden waste generated from his premises separately in his own premises and dispose of as per the directions of the local body from time to time.

No waste generator shall throw, bum or hurry the solid waste generated by him, on streets, open public spaces outside his premises or in the drain or water bodies.

All waste generators shall pay such user fees for solid waste management, as specified in the State SWM Bye-laws, 2019 as amended from time to (GOR, 2019).

Duties of Industrial Units

All industrial units using fuel and located within one hundred km from a solid waste based refused derived fuel plant shall make arrangements within six months from the date of notification of Solid Waste Management Rules 2016 to replace at least five per cent of their fuel requirement by refuse-derived fuel (RDF) so produced (GOR, 2019).

Rules and Regulations

The regulatory framework for Rajasthan's SWM Policy consists of the various legal and regulatory roles and responsibilities outlined for the various organizations, institutions and local bodies under the various waste management rules and regulations. These provide a framework for solid waste management across the state.

The duties and responsibilities to be carried out by various institutions, bodies, groups and individuals shall be in accordance with the below rules and guidelines or any other waste management rules notified from time to time: Hazardous and Other Wastes (Management and Trans-boundary Movement) Rules, 2016; Guidelines of CPCB; Rajasthan Municipalities Act, 2009; and any other waste management rules/ guidelines provided by an authorized and competent authority from time to time (GOR, 2019).

Enforcing Authorities

According to the Solid Waste Management Rules, 2016 (Rule 16. a) prescribed by the Ministry of Environment, Forest and Climate Change (MoEF& CC), the Rajasthan State Pollution Control Board (RSPCB) will be the enforcing authority of these rules in the State through local bodies in their respective jurisdiction and review the implementation of these rules at least twice a year in close coordination with concerned Directorate of Local Bodies or Secretary-in-charge of State Urban Development Department. The ULBs in urban areas and GPs in rural areas, respectively, will perform the implementation of these rules.

Guidelines

Environment Department Guidelines

To regulate the hazardous wastes generated, the Hazardous Wastes (Management and handling) Rules, 1989 were notified by the Central Government. The Rules of 1989 was enacted to ensure safe handling and management of hazardous wastes in an environmentally benign manner. However, these Rules were repealed, and a new set of rules came into place. The new rules focused on hazardous waste and its transboundary movement. The Rules titled Hazardous Wastes (Management, Handling and Transboundary Movement) Rules, 2008 were more specifically designed to align it with the objectives enshrined in the Basel Convention on Control of Transboundary Movements of Hazardous Wastes and its disposal 84. Thereafter, the Central Government framed the Hazardous and Other Wastes (Management and Transboundary Movement) Rules of 2016, which were recently amended in 2019 (GOI, 1986).

Application

The Environment (Protection) Act, 1986, under Section 886 explicitly bars any person from handling hazardous substances except in accordance with such procedure and after compliance of such safeguards as may be prescribed. This provision is to be read along with Rule 13 of the Environment (Protection) Rules, 1986. The Central Government in the year 2016 notified the new Hazardous and Other Wastes (Management and Transboundary Movement) Rules, 2016 ('2016 Rules' for short), by replacing the older Rules framed in 2008 (GOI, 1986).

Swachh Bharat Urban Guidelines

Some wastes are harmful to health and can pollute and spoil the environment if mixed with other waste. These should be stored for collection every 1-3 months: used tube-lights and CFLs (because they contain mercury), paint cans (which have oils and harmful lead, cadmium etc.), torch cells, button cells and batteries. cosmetics and hair dyes (which contain lead), oily rags from cleaning vehicles, and many others listed as follows: Aerosol cans, batteries from flashlights and button cells, bleaches and household kitchen and drain cleaning agents, car batteries, oil filters and car care products and consumables, chemicals and solvents and their empty containers, cosmetic items, chemical-based, injection needles and syringes after destroying them both, insecticides and their empty containers, light bulbs, tube-lights and compact fluorescent lamps (CFL), medicines, paints, oils, lubricants, glues, thinners, and their empty containers, pesticides and herbicides and their empty containers, photographic chemicals, styrofoam and soft foam packaging from new equipment, thermometers and mercury-containing products.

Best Practices

Waste Minimization through Co-Processing:

Co-processing is that the use of waste as a staple, as a source of energy, or both to exchange natural resources and fossil fuels like coal, petroleum and gas (energy recovery) in industrial processes, mainly in energy-intensive industries like cement, lime, steel, glass, and power generation.

In Gujarat, the use of hazardous waste as an alternative fuel and input material in cement kilns increased by 35 times between 2009/2010, from 15,693 tons once a year, to 543,569 TPA in

2013/2014. In 2013/2014, the quantity of waste utilized by cement plants rose by 185% from 190,707 TPA in 2012/2013 (Karthikeyan et al., 2018).

Treatment, Processing, and Disposal Facilities in Gujarat

Following the regulations to contain HW insecure sites, large stocks of hazardous or partially treated HW are stockpiled within the vicinity of commercial sites. These wastes must be disposed of appropriately. Failing to manage such wastes results in groundwater pollution, leading to a hazard to members of the general public, who use groundwater because of the source of their domestic water supply and for irrigation (Karthikeyan et al., 2018).

Role of Gujarat Government in Hazardous Waste Management

Gujarat was the primary state to deal with the hazardous waste issues and caused a unique concept of common treatment stabilization and disposal facility (TSDF) for the cluster of Industries. Gujarat is the foremost in the country in the development of TSDF sites. The state has eight TSDF among 27 TSDF sites in the country (Karthikeyan et al., 2018).

Common Hazardous Wastes Incineration Facility (CHWIF):

Specific non-biodegradable wastewater and liquid hazardous waste (toxic) are recommended to be disposed of in an environmentally safe manner. The process of detoxification for the treatment of non-biodegradable wastewater is not economically possible. In late 1990, the concept of individual common incinerators for the safe disposal of toxic hazardous waste was adopted. As of now, State has five common hazardous incineration facilities and 83 individual incineration facilities (Karthikeyan et al., 2018).

The Clean-up of Old Waste Dump Sites in Gujarat:

34,395.40 MT of Hazardous waste was lifted and shifted to a landfill site (TSDF). The Board continues clean-up of illegal dumpsites across the State; shifting about 9172 MT of illegally dumping waste (Karthikeyan et al., 2018).

Public-private partnership Common TSDFs have come up:

Common TSDFs have come up with capital investment subsidies provided by the State Government and in some cases with assistance from the Government of India. Land at concessional rates allotted by State Industrial Development Corporation and financial participation by industrial units and institutional financial support helped this development.

Green industries formation in Gujarat:

A list of 100 small and cottage Industries having no pollution potential was published under the circular of the Gujarat Pollution Control Board. These industries are exempted from obtaining NOC (No Objection Certificate) from the Board for establishing such industries and for conversion of land to 'non-agricultural' use (Karthikeyan et al., 2018).

4.1.6 E-Waste Management

The advancement in the field of science and technology has led the way for major developments and the industrial revolution. This has significant impacts on each of our lives, at the same time, these have led to manifold problems including the problem of the massive amount of hazardous waste and other wastes generated from electric products. Waste from WEEE or E-waste can be defined as any appliance using an electronic power supply that has reached its end-of-life period (OCED-Organization for Economic Cooperation and Development). The electronic industry is one of the world's largest and fastest-growing manufacturing industries and thus E-waste is an arising global issue that needs to be addressed. Some several conventions and initiatives discussed the significance of e-waste management and the current scenarios. The Basel convention is one of the first global initiatives in this topic which aimed at tackling the issues related to E-waste generation, transportation and introduced ideas of reuse and recycling and methods of trading. Some of the definitions arrived at few of these initiatives have been given below:

Table 4.7 Definitions of E-waste

Conventions	Definition
EU WEEE Directive (EU, 2002a)	"Electrical or electronic equipment, which is waste including all components, subassemblies & consumables, which are part of the product at the time of discarding." Directive 75/442/EEC, Article 1(a) defines "waste" as "any substance or object which the holder disposes of or is required to dispose of pursuant to the Provisions of national law in force."
Basel Convention Action Network (Puckett & Smith, 2002)	"E-waste encompasses a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air-conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users."
OECD (2001)	"Any appliance using an electric power supply that has reached its end of life."
Sinha (2004)	"An electrically powered appliance that no longer satisfies the

	current owner for its original purpose.”
StEP (2005)	E-waste refers to “the reverse supply chain which collects products no longer desired by a given consumer and refurbishes for other consumers recycles or otherwise processes wastes.”

Sources and generators

Electronic waste comprises waste that is not fit for its originally intended use. It includes a computer and its accessories, monitors, keyboards, printers, central processing units; typewriters, mobile phones and chargers, compact discs, remotes, headphones, batteries, LCD/Plasma TVs, air conditioners, refrigerators and other household appliances. E-Waste contains toxic substances and chemicals, which are likely to have an adverse effect on the environment and health directly or indirectly, if not handled properly. India is among the top five e-waste producing countries in the world with an estimated annual production of 1.8 million tons.

E-waste is generally collected from four major sources that are individual households, small business sectors, original manufacturing sectors and large corporations, institutions and governmental sectors.

Material components in E-waste

E-waste generally contains complex combinations of materials and components that could even be microscopic. It contains over 1000 different substances of which many are toxic and potentially hazardous to the environment and human health, if not handled in an environmentally sound manner (MoEF, 2011). The important toxic components are Printed circuit boards, Cathode ray tubes (CRTs), Switches & flat-screen monitors, Computer batteries, Capacitors and transformers, Printed circuit boards, plastic casings cable and Cable insulation/coating. The constituents present in them are Lead and cadmium, Lead oxide and Cd, Mercury, Cadmium, PCB, Brominated flame retardant and PVC. E-waste contains several precious metals, rare earth metals, ferrous and non-ferrous metals, plastic, wood and glass. Iron and steel occur for about 50% of the waste, followed by plastics (21%), non-ferrous metals (13%) and other constituents.

Scenario in Country

It is estimated that more than 50 MT of E-waste is generated globally every year and it is the fastest-growing component of municipal waste across the world today. It is observed that in the coming years the developing countries would rise as major E-waste generators because of their increasing consumer base and an anticipated rise in the sales of economic products due to heavy prospective demand and rapid economic and industrial growth. The United States of America holds the first position in E-waste generation and three Asian countries are included in the top five list including India in the fifth position.

India is the fifth-largest producer of E-waste on a global level but is not among the top 15 E-waste generators per capita. India produces 1.8 million tons of E-waste every year that is roughly 4 per cent of E-waste generated annually. The collection of E-waste is done along with the other garbage in India hence the documented data available on the quantity of e-waste generated and disposed of each year are near to non-existent. This indicates that the data available on the environmental and health sector is also not documented. There are only estimations based on independent studies conducted by NGOs or government agencies. The yearly growth rate of E-waste in India is 30 per cent.

E-Waste Sources

The major sources of E-waste are the manufacturer, Consumer and imports from other countries. In 2005, the Central Pollution Control Board (CPCB) estimated India's e-waste at 1.8 million tonnes or 0.573 MT per day. According to reports, 70 per cent of the total E-waste is generated by just 10 states in the country, while 65 cities generate more than 60 per cent of the total e-waste in India. Among the 10 largest E-waste generating States, Maharashtra ranks first followed by Tamil Nadu, Andhra Pradesh, Uttar Pradesh, West Bengal, Delhi, Karnataka, Gujarat, Madhya Pradesh and Punjab. Mumbai ranks first followed by Delhi, Bengaluru, Chennai, Kolkata, Ahmedabad, Hyderabad, Pune, Surat and Nagpur.

Electronic waste in India is mainly generated in the government, public and private (industrial) sectors, which is responsible for almost 70 per cent of total waste generation. At the same time, the total contribution of individual households is relatively small at about 15 per cent; the rest being contributed by manufacturers.

An Indian Market Research Bureau (IMRB) survey of 'E-waste generation at Source' in 2009 found that out of the total e-waste volume in India, the major category of product or equipment is televisions and desktops including servers. Together they make around 68 per cent and 27 per cent respectively. Imports and mobile phones comprised 2 per cent and 1 per cent respectively.

The important contributors to this are the computer and computer components segment; consumer electronics segment majorly television, telecommunication segment, changing consumption patterns etc.

The State of Maharashtra tops the list generating 20,270 tons of e-waste annually. Rajasthan generates about 6326.9 tons of e-waste annually.

E-Waste management in India

According to a report from ASSOCHAM, India recycles only 1.5 per cent of the E-waste generated through an 'institutional process'. The total E-waste produced in a year is 1.8 million and the amount undergoing E-waste treatment is 4000 tons. This leaves us with an average of 1.6 million tons of untreated e-waste every year.

The informal sector handles more than 90 per cent of the E-waste management system i.e., the collection, recycling etc. and the formal sector account for less than 10 per cent of the recycling business. Indian cities produce alarming rates of E-waste with no organized system available present on which Mumbai tops the list with 11000 tons of E-waste, Delhi with 9000 tons, Bangalore 8000 tons and Chennai 5000-6000 tons each year.

The Ministry of Environment & Forests (MoEF) of the government of India is responsible for environmental legislation and its control. The Central Pollution Control Board (CPCB) also plays an important role as an autonomous body under the MoEF, in drafting guidelines and advising the MoEF on policy matters regarding environmental issues. According to the Ministry of Environment and Forest (MoEF), at present, there are 28 operational Treatment, Storage and Disposal Facilities (TSDFs) for hazardous

The project, entitled, "Development of processing technology for recycling and reuse of electronic waste" has successfully been implemented at National Metallurgical Laboratory, Jamshedpur, India - an R&D laboratory under the Council of Scientific and Industrial Research (CSIR) in March 2011. In this project, indigenous technology has been developed to recover metal contents from e-waste with a recovery rate of 90%. The process is free from the generation of toxic gases and harmful effluents. Thus, it would reduce the environmental hazards that are attributed to e-waste recycling units in unorganized sectors.

The rising quality of life and high rates of resource consumption patterns has had a negative and unintended impact on the environment through the generation of wastes which is far beyond the handling capacities of governments and agencies. Also, E-waste recycling is still an alien concept in India where it is practised only in very few urban areas of the country.

Some of the Indian Enforced Agencies involved in E-waste are the Ministry of Environment and Forests, Government of India, Central Pollution Control Board, State Pollution Control Board, Port and Customs Authorities, The Directorate General of Foreign Trade etc.

The Ministry of Electronics and Information Technology (MeitY) has initiated an e-waste awareness program under Digital India, along with industry associations from 2015, to create awareness among the public about the hazards of e-waste recycling by the unorganized sector, and to educate them about alternate methods of disposing of their e-waste. The program stresses the need for adopting environment friendly e-waste recycling practices. The program has adopted the best practices for e-waste recycling available globally so that this sector could generate jobs as well as viable business prospects for locals. Institutional infrastructures, including e-waste collection, transportation, treatment, storage, recovery and disposal, need to be established, at national and/or regional levels for the environmentally sound management of e-waste. These facilities should be approved by the regulatory authorities and if required provided with appropriate incentives. The MeitY has developed affordable technologies to recycle valuable materials and plastics in an environmentally sound manner, including two exclusive PCB recycling technologies, viz 1000 kg/ day capacity (~35 MT e-waste) and 100kg/batch (~3.5MT e-waste) processes, with acceptable environmental norms. The 1000kg PCB/day continuous process plant would be suitable for creating an eco-park in the country, whereas the 100kg PCB/batch process plant would be suitable for the informal sector. This could be done by upgrading and transforming the present state of affairs of informal sectors. E-waste also contains plastic, up to nearly 25 per cent of its weight. Novel recovery and conversion of e-waste plastics to value-added products have also been successfully developed. The developed process is capable of converting a majority (76 per cent) of the waste plastics into suitable materials, which could be used for virgin plastic products. The technology has already been transferred for commercialization.

Scenario in State

As per the Country-level WEEE assessment study by International Resource Group Systems South Asia Pvt. Ltd, Rajasthan produces 6326.9 tons of WEEE in 2005. The Rajasthan State Pollution Control Board has implemented the authorization of generation, handling, collection, reception, storage, transportation, refurbishing, dismantling, recycling, treatment and disposal of e-waste under the provision of E-waste management Rules, 2016. For this, they have developed an online system for the submission of the application. There is 26 authorized Dismantler/ Recycler located in the state with a total capacity of 90769 MTA.

There is a Policy for condemnation of IT Equipment and disposal under the Department of Information Technology & Communication, which describes certain rules for the disposal of IT equipment such as

Servers, PCs, Dumb Terminals, Printers, UPS, Laptop, Package Software, Mouse, LAN cabling 100 MBPS or below, Dialog Modems with less than 33 KBPS speed etc.

This policy applies to all government departments under the Government of Rajasthan, all autonomous bodies and all PSUs under the Government of Rajasthan.

The government along with the state pollution control board, Indian Oil, Instacash, and Greenspace, has started a campaign to create public awareness and improve understanding of e-waste and plastic so that a common man is made aware of the importance of e-waste management.

The government has also set up 20 collection points for e-waste and plastic bags at the Indian Oil petrol pumps in Jaipur, where one can simply come and deposit their e-waste and plastic bags. While cash will be given against e-waste, a jute bag will be provided in exchange for plastic bags.

Governance and Management Structure

Some of the Indian enforced Agencies involved in E-waste are the Ministry of Environment and Forests and Climate change, Central Pollution Control Board, State Pollution Control Board, Port and Customs Authorities, The Directorate General of Foreign Trade, Department of Environment Science and Technology, Local Self-Governing Bodies, Department of Information Technology & Communication, NGOs etc.

Roles and Responsibilities

Central Pollution Control Board

They are responsible for regulating and controlling and overlooking the procedures done and also identifying the impacts on the environment and health. Some of the responsibilities are to grant and Renewal of Extended Producer Responsibility - Authorization and monitoring of its compliance, maintain information on Extended Producer Responsibility, set and revise targets for collection of e-waste from time to time, coordinate with State Pollution Control Boards, prepare of Guidelines for Environmentally Sound Management of e-waste, conduct random sampling of electrical and electronic equipment placed on the market to monitor and verify the compliance of Reduction of Hazardous Substances provisions and the cost for sample and testing shall be borne by the Producer, publish the methods for sampling and analysis of Hazardous Substances, conduct random inspection of dismantler or recycler or refurbished, documentation, compilation of data on e-waste and uploading on websites of Central Pollution Control Board, actions against violation of these rules. Conducting training programs, submit Annual Report to the Ministry, enforcement of provisions regarding reduction in the use of hazardous substances in the manufacture of electrical and electronic equipment, interaction with IT industry for reducing hazardous substances, set and revise targets for compliance to the reduction in the use of the hazardous substance in the manufacture of electrical and electronic equipment from time to time and other function delegated by the Ministry under these rules from time to time (GOI, 2011).

State Pollution Control Board

They overlook the situations on the state level and also divide the responsibilities among the urban local bodies. The important responsibilities are to Inventorize E-waste, grant and renewal of authorization to manufacturers, dismantlers, recyclers and refurbishes, monitoring and compliance of Extended Producer Responsibility - Authorization as directed by CPCB and that of dismantlers, recyclers and refurbishes authorization, conduct random inspection of dismantler or recycler or refurbished, maintain online information regarding authorization granted to manufacturers, dismantlers, recyclers and refurbishes, implementation of programs to encourage environmentally sound recycling, action against violations of these rules and other function delegated by the Ministry under these rules (MoEFCC, 2017).

State Government

Several departments bear responsibility for the overall well-functioning of the system. Some of them are the Department of Industry, which have to ensure the earmarking or allocation of industrial space for E-waste processing in the existing or upcoming industrial park, estate and industrial clusters. The other one is the Department of Labour which has to ensure recognition and registration of workers involved**,** assist the formation of groups of workers, undertake skill development activities and conduct annual monitoring and ensure safety and health of workers involved. It should also prepare an integrated plan for effective implementation and submit an annual report to the Ministry of Environment, Forest and Climate Change

Urban Local Bodies (Municipal Committee or Corporation)

Responsible for effective implementation at the grass root level. Some of the responsibilities are to ensure that e-waste if found to be mixed with Municipal Solid Waste is properly segregated, collected and is channelized to authorized dismantler or recycler and also to ensure that e-waste pertaining to orphan products is collected and channelized to authorized dismantler or recycler.

Port Authority

As there are multiple level legal and illegal imports of E-waste happening, the Port Authority plays an important role. The responsibilities are to verify the Extended Producer Responsibility-Authorization, inform the Central Pollution Control Board of any illegal traffic for necessary action and to take action against the importer for violations under the Indian Ports Act, 1908.

Rules and Regulations

The impacts of these materials were identified in earlier stages and guidelines were implemented to protect the environment from their effects. E-waste management was clubbed along with hazardous substances earlier and was held under environmental protection. The rules are mentioned in chronological order.

Factories Act 1948**:** Several contaminants are arising out from the manufacturing or recycling of electronic components and are listed in this Act.

Environmental Protection Rules 1986 (amended till 2004)**:** There is no direct standard, which can address pollutants from electronics manufacturing or recycling industries. However, certain PCB units fall in the electroplating category and are therefore required to be abiding by the effluent disposal norms as given in schedule 1 of this rule (GOI, 1986).

***Hazardous waste (Management and Handling) rules 1989, amended in 2003*:** Schedule 2 of this act can be applied for the disposal of e-waste. It stated that authorization is to be obtained by the generator or collection receptor, treatment, storage and Disposal of Hazardous waste in an environmentally sound manner. Electrical and electronic assemblies are not valid for direct reuse but recycling.

***Hazardous Waste (Management, Handling and Transboundary movement) rules, 2008*:** It consists of a list of e-waste applicable for import with prior informed consent and also deals with a list of e-waste applicable for import and export not requiring prior informed consent. The site for the collection, reception, storage and disposal of the environment shall be approved by the competent authority. It also describes the regulations for the import-export of hazardous waste (MoEF&CC, 2008).

Policy for Condemnation of IT Equipment and disposal

The IT equipment can be condemned when they have completed 5 years and are currently not in working condition, third party software/ books/ manuals for which the technical support or service is currently no longer available, when the cost of repair is high compared to the current rate, damage due to fire or any other similar reason.

The policy states that once the equipment is condemned it should be removed from the office and taken for alternate use if there is any or for disposal with proper bio-friendly techniques.

E-Waste Management Rules, 2016

A combined exclusive set of rules for E-waste was implemented in the year 2012 by the Ministry of Environment and Forest named as E-waste (Management and Handling) Rules, 2012. This was amended in the year 2016 and 2018 for further additions. The Central Pollution Control Board Swatch Bharat Abhiyan Mission keeps these guidelines as a base for waste treatment.

Ministry of Environment and Forests (MoEF), Government of India is the nodal agency for policy, planning, promotion and coordinating the environmental program including electronic waste. E-waste Management Rules, 2016 was applied for every producer, consumer or bulk consumer involved in the manufacture, sale, and purchase and processing of electrical and electronic equipment or other components, collection centres, dism4ntler and recycler of e-waste although it is primarily based on the principle of Extended Producer Responsibility (EPR). It excluded batteries, micro and small enterprises and radioactive wastes as they all are separately covered in their Acts or guidelines. It defines responsibilities for each group involved from the producer, collection centre, bulk consumer, dismantler, recycler etc. It has also assigned duties for Central Pollution Control Board, Delhi, State Pollution Control Boards/ Committees of Union territories and Urban Local Bodies (Municipal committee/ Council/ Corporation).

Responsibility of Manufacturer

The primary responsibility of Manufacture is to Collect e-waste generated during the manufacture of any electrical and electronic equipment and channelize it for recycling or disposal. Also, Authorization from State Pollution Control Board should be taken to ensure that no damage is caused to the environment during storage and transportation of e-waste, to maintain records of the E-waste generated, handled and disposed of and make them available for State Pollution Control Boards for scrutiny and file annual returns records to the State Pollution Control Boards.

Responsibility of Producer

Extended Producer Responsibility (EPR): Authorization should comprise of a general scheme for the collection of e-waste, Electrical and Electronic Equipment from the Electrical and Electronic Equipment placed on the market earlier, such as through dealer, collection centres, Producer Responsibility Organization, through buy-back arrangement, exchange scheme, Deposit Refund System, etc. whether directly or through any authorized agency and channelizing the items so collected to authorized recyclers. It also includes collection and channelization of e-waste generated from the ‘end-of-life’ of their products or products with the same electrical and electronic equipment code and historical waste available, Pre-treatment is necessary for the volume reduction of waste before the treatment, storage and disposal facility. This is needed to immobilize the mercury, to ensure that the mechanism used for channelization of e-waste from ‘end-of-life’ products including those from their service centres to authorized dismantler or recycler shall be as per the Extended Producer Responsibility, providing contact details such as address, e-mail address, toll-free telephone numbers or helpline numbers to consumer(s) or bulk consumer(s) through their website and product user documentation to facilitate the return of end-of-life electrical and electronic equipment, Creating awareness through media, publications, advertisements, posters, or by any other means of communication and product user documentation accompanying the equipment, with regards to the hazardous constituents in the item, hazards on improper handling and disposal, Do’s and Don’ts etc., Provide information on Deposit Refund Scheme.

The EPR can be an individual or collective system where the producer includes other members for completing the process and make sure that the import of electrical and electronic products to be allowed only to producers having EPR authorization.

Responsibility of Collection centres

The collection centres should collect e-waste on behalf of producer or dismantler or recycler or refurbisher including those arising from Orphaned products, collection points or bins shall also be designed, ensure that the facilities are as per the standards and guidelines issued by CPCB, ensure that the e-waste collected is stored in a secured manner, ensure that no damage is caused to the environment during the time of storage or transportation, maintain records, have weighing equipment, Store the items categorically and loading, transportation and unloading, storage of end of life product should be carried out in such a way that there should not be any damage.

Responsibility of Dealers

The dealer should collect on behalf of the producer and shall collect the e-waste by providing the consumer a box, bin or a demarcated area to deposit it, or through a take-back system and send it to a collection centre or dismantler or recycler as designated by the producer. As per the take-back system, the amount shall be refunded. They also need to ensure no damage to the environment during the process.

Responsibility of Refurbisher

The Refurbisher should Collect E-waste generated during the process of refurbishing and channelizing the waste to authorized dismantlers or recycle through its collection centre. They need to ensure that no damage is caused to the environment or health during the refurbishing process, Safe transportation of E-waste and shall maintain records.

Responsibility of Consumer or Bulk Consumer

Consumers should have minimum awareness not to throw E-waste in municipal waste bins. They should ensure that the end-of-life electrical and electronic equipment are not admixed with E-waste containing radioactive material covered under Atomic Energy Act, 1962.

Responsibility of Dismantler

The responsibilities of Dismantler are to ensure that the facilities are as per the standards or guidelines prescribed by CPCB, obtain authorization from SPCB, ensure that no damage is happening for the environment, ensure that the dismantled E-waste are segregated and sent to the authorized recycling facilities for recovery of materials and ensure that non-recyclable or non-recoverable components are sent to authorize treatment storage and disposal facilities.

They should have facilities for destroying or permanently deleting data stored in the memory of end-of-life products (Hard Disk, Telephones, Mobile phones) either through hammering or through data eraser.

Responsibility of Recycler

Recyclers should ensure that the facilities are as per the standards or guidelines prescribed by CPCB, that no damage is happening to an environment that the residue generated during the recycling process is disposed of in an authorized treatment storage disposal facility.

Categorisation of Electronic items

Under the rule, the electrical items are categorized into two categories as shown below. This includes their components, consumables, parts and spares.

Table 4.8 Categorisation of items

Categories of Electrical and Electronic Equipment	Items
Information technology and telecommunication equipment	Centralized Data Processing, Mainframes, Minicomputers, Personal Computers, Laptop, Notebook, Notepad, Printers Including Cartridges, Copying Equipment, Electrical and Electronic Typewriters, User Terminals and Systems, Facsimile, Telex, Telephones, Pay Telephones, Cordless-Phones, Cellphones, & Answering Systems.
Consumer electrical and electronics:	Television sets, Liquid crystal display, Light-emitting-diode display, Refrigerator, washing machine, and Air conditioners, Fluorescent and other Mercury-containing lamps.

According to the rules modified, it shall apply to every producer, dealer, collection centre, refurbisher, dismantler, recycler, auctioneer, customer or bulk customer involved in the manufacture, sale, and purchase and processing of electrical and electronic equipment or components.

The producer of electrical and electronic equipment is responsible for any E-waste generated at the time of manufacture and also has to channelize the same for recycling or disposal. Dealers have to make provisions for collecting E-waste and get authorized from SPCB or CPCB, whichever may apply and ensure that the storage, transport, dismantling and refurbishing of E-waste cause no adverse effect on health or the environment.

Extended Producer Responsibility (EPR)

It is an environmental policy approach in which the producer's responsibility for a product is extended to the post-consumer stage of the product's life cycle, including final disposal. In principle, all of the categories share responses like consumer, manufacturer, suppliers etc.

Guidelines for Collection and storage

1. A well-functioning collection mechanism should be introduced by producers which could include take-back, collection centres etc.2**.** For collection, a producer can take help from Producer Responsibility Organization (PRO) or e-waste exchange**.** 3**.** If the take-back system is provided it should be accessible to all citizens.4**.** Every Producer, collection centre, dealer, dismantler, recycler and refurbisher may store the e-waste for a period not exceeding one hundred and eighty (180) days and shall maintain a record of collection, sale, transfer and storage of wastes and make these records available for inspection. The period of storage of one hundred and eighty (180) days may be extended by the concerned SPCBs/PCCs up to three hundred and sixty-five (365) days in case the e-waste needs to be specifically stored for research development of a process for its recycling or reuse. 5. Storage of end-of-life products may be done in a manner that does not lead to breakage of these products and safe to workers handling such products.6**.** The storage area should have a fire protection system, escape route in place.

Guidelines for Transportation of E-waste

The sender of E-Waste, that may be a producer, manufacturer, recyclers, dismantler, bulk consumer, refurbisher and collection centre should identify transporter or make arrangements for transporting e-waste in such a manner that environmental consequences of hazards associated with its transport could be kept at a minimum. Transport of E-waste should be carried out as per the provisions made in the rules.

Guidelines for Dismantling Process

1. Dismantler could perform De-dusting or Manual Dismantling. 2. Operation shall comprise of physical separation and segregation after opening the electrical and electronic equipment into the component by manual operations. 3. Manual dismantling operations should be carried out over the dismantling table with a space de-dusting system to maintain desirable work zone air quality. 4. The de-dusting system should consist of suction hoods over the dismantling table connected with a cyclone, bag filter and venting through a chimney of three-meter height above roof level. 5. Collection boxes should be placed near the dismantling table for keeping the dismantled components. 6. During dismantling operations, the workers should use proper personal protective equipment such as goggles, masks, gloves, helmets and gumboot etc. 7. Volume or size reduction shall be carried out

after the dismantling operation. For volume reduction, noise and dust controls should be installed. 8. Dismantlers should have adequate facilities for managing leakage of compressor oils, coolant/refrigerant gases such as CFCs/HCFCs and mercury from the end of life fluorescent and other mercury-containing lamps etc. 9. The premise for dismantling operation should fulfil the following requirements. 10. Waterproof roofing and impermeable surfaces needed to be provided. 11. Storage space for dissembled spare parts shall be given. 12. Separate containers for storage of batteries, capacitors containing PCBs shall be given. `

Guidelines for Environmentally Sound Recycling of e-Waste

The functions of the recyclers include dismantling along with recovery operation. They should install adequate wastewater treatment facility for the process of wastewater and air pollution control equipment

Noise control arrangement for equipment like crusher, grinder and shredder needs to be provided. Recovery of resources and particularly of precious metals present in the e-waste should be given importance. The following processes should be employed by recyclers:

a) Manual / semi- automatic / automatic dismantling operations

b) Shredding / crushing / fine grinding/wet grinding/ enrichment operations, gravity/ Magnetic /density /eddy current separation

c) Pyro metallurgical operations - Smelting furnace

d) Hydrometallurgical operations

e) Electro-metallurgical operations

f) Chemical leaching

g) CRT/LCD/Plasma processing

h) Toner cartridge recycling

i) Melting, casting, moulding operations (for metals and plastics)

Best Practices

e-Waste flow in India

At present, e-waste is disposed of in one of the four ways: landfilling, incineration, recycling or exportation. Each process has an environmental impact as well as affects the health and safety of the workers. The recycling process is considered as one of the best ways for disposing of electronic components only if the process employs environmentally sound recycling. The low employment status, lack of awareness, no or less technological development and lack of regulatory policies is increasing the unsafe e-Waste management practices in developing countries like India. The manufacturers and governments are not able to keep pace with the electronic waste policy and practice which makes the issue quite serious.

The informal sector handles more than 90 per cent of the E-waste management currently in India. The sources and various stakeholders form a very complicated system with formal and informal sectors involved which is nonscientific equally harmful to the environment and the health of the people involved and indirectly to the community. Most of the E-waste end up with scrap traders and dealers usually transfer it to the informal sector.

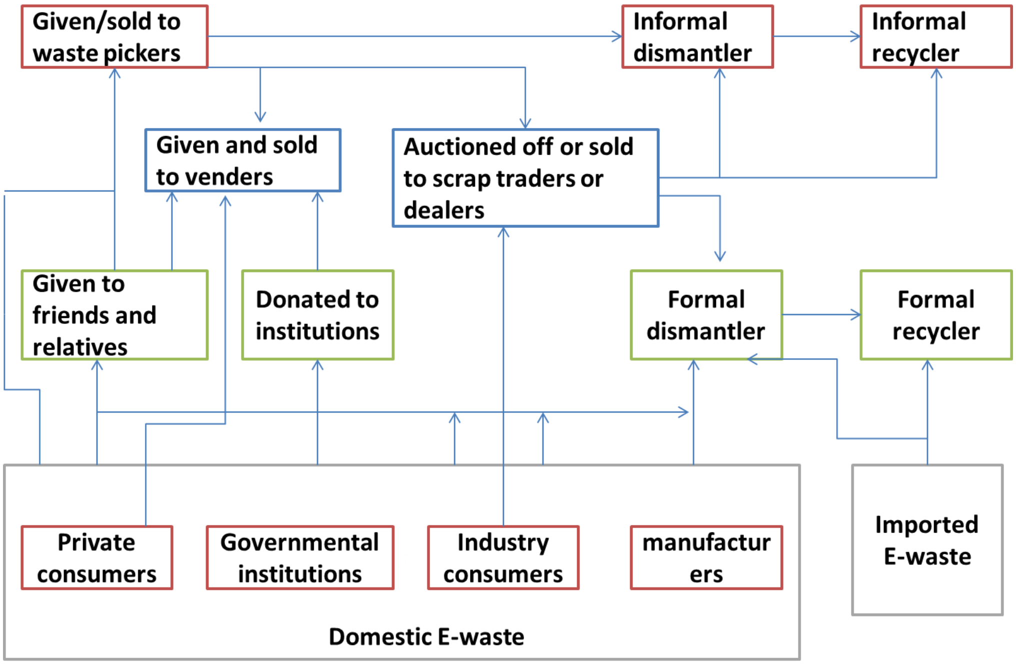

Figure 4.24 e-waste Flow in India

Eco-Assurance System

To enhance the recycling rate of E-wastes and to control the restrictions on the use of hazardous substances. It included precautionary policies that are to have Eco-friendly designs by restricting the use of hazardous substances, improving the quality of materials and structure, provision for recycling information and achieving of recycling possible rate. It also had a Recycling policy which included reinforcing the facility standards, setting up recycling methods and standards, achieving the recycling goals etc.

Table 4.9 Recycling Principles

Items	Recycling Principles
Common products	• Reuse and recycling of parts after processing treatment (disassembling, compression, crushing, and cutting) • Recovery of valuable metals from the printed circuit boards
Large scale appliances	• Recovery of chlorofluorocarbons from refrigerators, air conditioners, and vending machines • Implementation of mandatory recycling rate (weight base) of over 65% for the television (except for liquid crystal displays and plasma display panels), over 70% for refrigerators and vending machines, and over 80% for washing machines and air conditioners.
Office equipment	• Recycling of personal computers • Implementation of mandatory recycling rate (weight base) of over 65% for PCs, over 75% for printers, copiers, and fax machines, and over 70% for mobile phones
Medium-scale appliances	• Recovery of chlorofluorocarbons from electric water purifiers • Implementation-of mandatory recycling rate (weight base) of over 75%
Small scale appliances	• Recycling of electric heaters • Implementation of mandatory recycling rate (weight base) of over 75%

International Measures

The Basel convention

Mobile Phone Partnership Initiative (MPPI): To develop and promote environmentally sound management of used and end-of-life mobile phones. MPPI developed guidelines on awareness-raising, design considerations, collection, transboundary movement, refurbishment, material recovery/ recycling in the environmentally sound management of used and end-of-life mobile phones. It includes manufacturers like Alcatel, LG, Mitsubishi, Motorola, Nokia, Philips, Samsung, Sony Ericsson etc. and telecom operators like Vodafone, Orange, Bell Canada etc.

The objectives of the MPPI are to achieve better product stewardship, influence consumer behaviour towards more environmentally friendly and responsible actions, promote the best disposal /recycling /refurbishing options, organize political and institutional support for environmentally sound management, create an initiative that could be replicated to build new public/private partnerships which will help in the environmentally sound management of hazardous and other waste streams.

The StEP Initiative

It is led by the United Nations University. This was established to build and promote having an international platform between stakeholders, including, country representatives, and representatives from producer groups, recyclers, refurbishers, academia, NGOs and international organizations for the exchange of information about e-waste management systems to increase and coordinate worldwide efforts for sustainable management of e-waste. The objective is to initiate research studies, increase public awareness, scientific and business knowledge on optimization of the life cycle of electric and electronic products, improving the supply chain, closing material loops, reducing contamination and increasing utilization of resources.

UNEP DTIE

The objectives of the UNEP DTIE initiative are to support sustainable consumption and production, initiate voluntary actions to improve member's sustainability performance, implement integrated waste management programs and build capacities in developing countries and implement strategies that influence informed decision making through partnerships with other international organizations, NGOs, government authorities, business and industry.

Recommendations from CPCB

In India disposal of plastic waste is a serious concern, due to lack of technology and poor implementation however, several experiments have been conducted to reuse the plastic waste in road construction or co-processing of plastic waste in cement kilns etc. At present time, the most used plastic waste disposal method is incineration but, due to under graded kilns and their poor maintenance, they release harmful gases including dioxins and furans burning chlorinated and brominated plastic waste, therefore, raising several environmental issues.

Other interventions

Policy level

1. For Economic benefits, methods such as advanced recycling fee (ARF) or advanced disposal fee (ADF) on every unit of the product sold in the market can be introduced. It would relieve the producers of the physical responsibility of collection and the revenues generated could be used to

develop markets for the end-of-the-life products. 2. Subsidize consumers to deposit their e-waste at designated centres. 3. Assist informal sector workers in training or skill development and provide a better and effective social security net to the workers. 4. The development of indigenous technologies and/or technology transfer to encourage widespread application should be encouraged for environment-friendly e-waste recycling technologies. 5. In the absence of adequate infrastructure in the country for recycling, should consider banning or restricting all kinds of imports. 6. Progress should be made in the system to solve problems due to lack of resources, underdeveloped legal system, no penalties for non-compliance and target for collection or recycling. 7. Accountability, transparency and sustainability on E-waste management should be ensured at every stage of the process.

Informal sector

1. The present social and economic status of the informal sector is not satisfactory and thus must be reviewed, and recognition should be granted to the sector in providing legitimacy in access to waste collection and trade. 2**.** Review of current regulations to include a faster and more organized system.3**.** Waste intervention and data generation needs to be updated frequently. 4**.** Development of online systems for ease of work and documentation has to be done. 5**.** Skill development: Programs to upgrade the skill sets and build capacities of the sector in dismantling and segregating various kinds of e-waste are imperative. Training and skillset up-gradation of the informal sector to understand good environmental, safety and health practices will create environment-friendly e-waste recycling practices

Formal Informal partnership

As we discussed the role of the informal sector is inevitable and hence a partnership between both formal and informal sectors would be beneficial. The interventions can be on 1 collection and recovery of precious materials can happen effectively by cooperating with local interface agencies. 2. Launching reliable partnerships with larger collectors and aggregators can increase collection rates.3**.** Working out the right agreements, contracts and protocols (including payment systems) without any delay needs to be considered a priority. 4. Elaborate on the inclusive EPR plan. Providing information on formalizing of informal collectors in downstream processes can strengthen the credibility of EPR plans.

Updating partnerships and provide long-term support to partnering organizations and thus encouraging them and acknowledging their contribution.

Public awareness

Educating the customer during the time of purchase, from the manufacturers, through media channels, social media platforms etc. shall be done for proper maintenance of the system. Institutions responsible should run awareness campaigns at regular intervals through the grass-root level. Stricter guidelines/regulations to the producers shall be provided regarding the frequency and mode of these awareness campaigns

Consumer education: They have to be informed of their role in the system through a labelling requirement for items. Consumers to be educated to buy only necessary products that utilize some of the emerging technologies (i.e., lead-free, halogen-free, recycled plastics and from manufacturers or retailers that will `take back' their product) to be identified through eco-labelling.

Responsible purchasing: this comes from the notion that if customers are aware of the environmental impact of their purchase, they will be inclined to choose between manufacturers for the most environmentally friendly products. This can only happen by giving proper awareness to the public.

Mandatory labelling**:** Labelling products as ‘environmental hazard’ for Implementing for declaration of hazardous material content with a view identifying environmental hazards and ensuring proper material management and E-waste disposal.

Donating electronics**:** The donation of electronics for reuse extends the lives of products and keeps them out of the waste management system for a longer time. It helps the economically weaker sector to enjoy the benefits of these products.

Technological Advancements

Free cycle

It is based on internet-based technologies. Members use platforms like yahoo groups such as blogs, e-mails and distribution lists to post details of unwanted items, and other members can act in response to the offers. Similarly, Craiglist is where one posts unwanted electronic goods, and is bought by other personnel. This helps in the recycling and reusing of the products.

Design for the Environment (DfE)

It is a global initiative where DfE organizations work in partnership with a variety of stakeholders to reduce risk to people and the environment by preventing pollution. It aims at reducing chemical risks, energy efficiency to facilitate positive and sustainable changes in chemical assessment tools and expertise to inform companies of the substitute to safer chemistries.

Sustainable Practices

***Whole System Approach*: Itis a procedure, which involve links between sub-frameworks and frameworks and which employs one solution for multifaceted problems. It is developing cost-effective measures to reduce the environmental health impacts of e-waste.

Green IT: Multi-faceted approach to securing and maintaining sustainable operation in IT business capacity. An alternate thought is the idea of product-service systems: and is a sustainable or eco-efficient service. This idea urges clients to lease both hardware and software components whereas the vendor maintains the ownership and upkeep responsibility of the product.

Eco parks: can be set up to integrate the formal and informal sectors. This is to make sure scientific treatment and to reduce illegal processing of E-waste. The material flow could be streamlined from originators to the final destination of recycling centres at a few designated places.

Reuse and recycle are the most environmentally preferred alternative, which also benefits society. Proper technical support and skill set is critical to the reuse and recycling process of E-waste. Reuse can be recycled products informally either immediately or after discarding. Some of the technological interventions used in the process of recycling E-waste are discussed below.

Recycle

The process of E-waste enables the recovery of metals and/or scarce materials that serve as raw materials for the production of EEE. The e-waste recycling chain consists of three activities: collection; classification/dismantling and pre-processing (including sorting, dismantling and mechanical processing); and final processing. It is shown in the figure below:

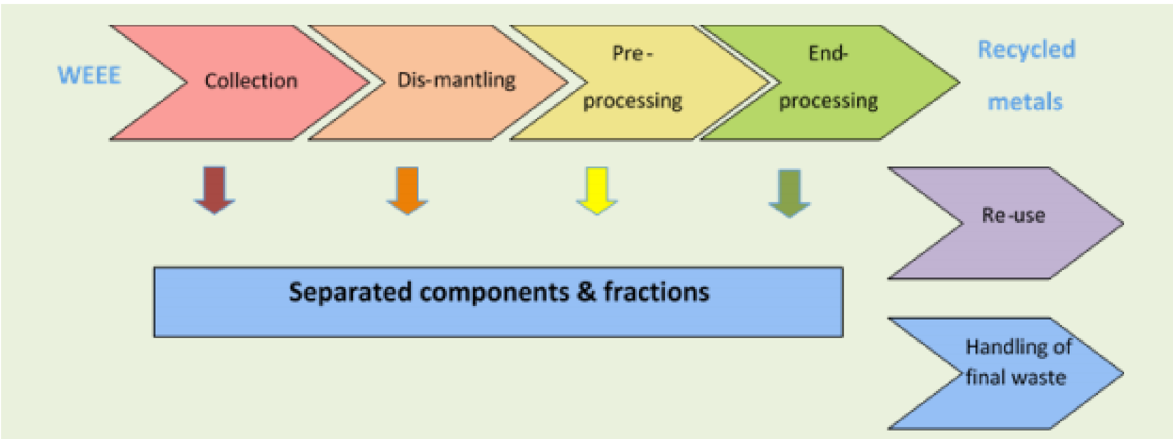

Figure 4.25 FE-waste recycling chain, (Source UNEP, Step initiative, 2009)

Some of the sustainable recycling approaches are discussed below:

Cementation Technology: Cementation technology is one of the solidification technologies, involving the use of a solidifying agent (i.e., cement, in this case) to trap hazardous E-wastes. They can also use a special powder mixture, special non-metal reinforcement or chemical crystallization treatment.

Nanotechnology: It can be effectively used to treat pollutants, especially the volatile organic components and persistent organic pollutants in E-waste.

Bio-Metallurgy: It is a biotechnological approach to solubilize metals from E-waste components and is considered as one of the promising technologies. It offers several advantages such as Low operating costs, Use of less hazardous chemicals, Eco-friendliness and Low energy requirement.

Rethink product design: New and better-conceptualized ideas shall be included. Better product design in terms of material choices, manufacturing process, product delivery and product support system. Use of non-renewable materials that are safer compared to the ones practiced needs to be introduced. A sustainable recycling process is shown in the figure below:

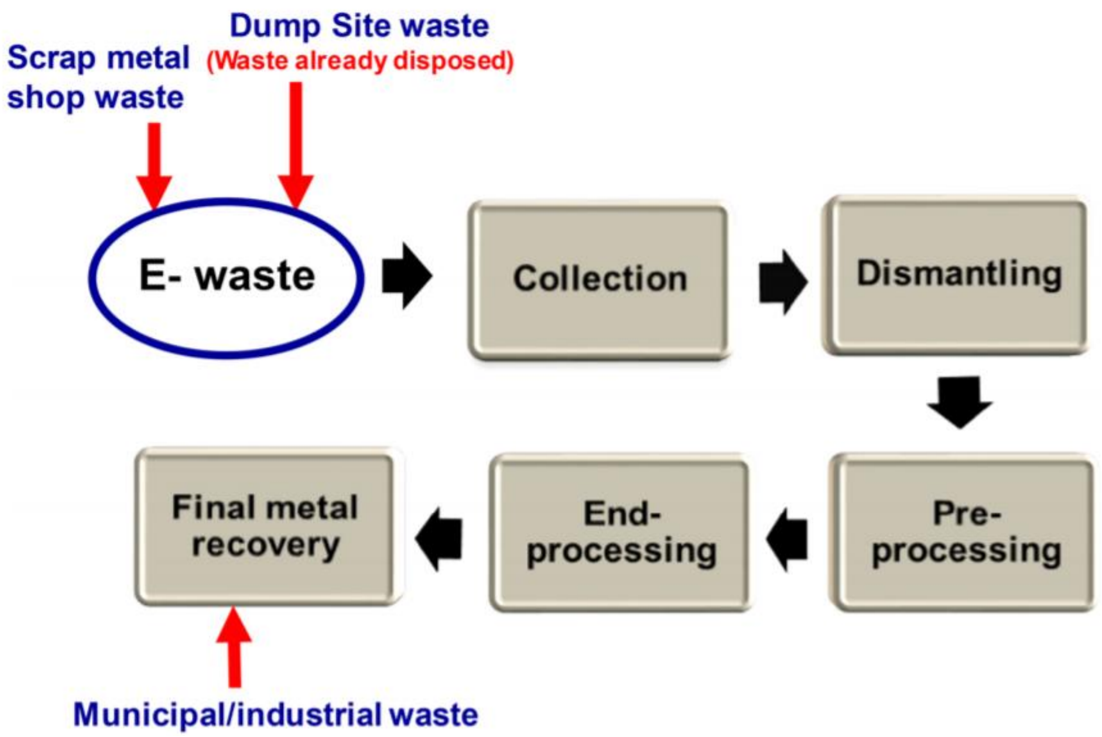

Figure 4.26 Strategic recycling process

Disposal

Integrated E-Waste Management Facility (IEWMF): This will reduce interventions in the existing regulatory institutional mechanism related to pollution prevention, abatement and control. Secured Land Filling (SCF) and Incineration solely for e-waste residues shall be permitted within the national regulatory framework as is being practiced for hazardous wastes. Land allocation: The government at the State level may encourage the allocation of land through various incentive schemes.

4.2 Present Scenario and Action Plan

4.2.1 Municipal Solid Waste Management

In Hanumangarh district, there are total 6 ULBs of which 5 are Nagar Palika namely Pilibanga, Sangaria, Rawatsar, Nohar, Bhadra and 1 Nagar Parishad namely Hanumangarh. The population distribution for Hanumangarh district as shown in the Table 4.10.

Table 4.10 Population distribution in all ULBs of Hanumangarh district

Population range	Name of ULB	Population as per census 2011
1-2 Lakh	Hanumangarh	1,51,104
50,000-1 Lakh	-	-
25000- 50,000	Nohar	49,835
	Bhadra	40,667
	Sangaria	36,667
	Pilibanga	37,288
	Rawatsar	35,133
Less than 25,000	-	

Data provided by ULBs

Inventory of Solid Waste

The total solid waste generation in the district currently stands at 151.4 TPD in which Hanumangarh city contributes around 60 TPD. The solid waste generated in the ULBs comes in the form of dry waste, wet waste, construction and demolition waste, waste coming through street sweeping and drain slits, hazardous waste and sanitary waste (Table 4.11). All ULBs in Hanaumangarh district have total 9 municipal solid waste dumping sites which currently store huge quantity of legacy waste. This legacy waste could be hazardous and impose a threat to the environment. Some of the ULBs e.g., Pilibanga and Rawatsar had started segregating the legacy waste and -have been trying to recover useful fractions.

The district has 2 bulk waste generators, which are in Hanumangarh city alone. All the ULBs should implement regulations for bulk waste generators. All the ULBs have made provisions for the 100 per cent door to door collection of solid waste in their administrative boundaries while also achieving 100 per cent sweeping in the ULBs. Only four ULBs, Bhadra, Sangaria, Rawatsar, Nohar have been able to achieve partial waste segregation done at source, whereas the remaining ULBs have not initiated segregation yet. Table 4.11 presents the total quantity of solid waste generated/collected, the number of dumpsites in each ULBs and the number of wards present in the respective ULBs.

Table 4.11 Inventory of Solid Waste in Hanumangarh District

S. no.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	Nagarparishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
	Inventory								
1	Total solid waste Generation	TPD	151.42	60	19	18	14	22.42	18
2	Qty. of Dry Waste segregated	TPD	38	15	11	0	4.76	7.39	Not Initiated
3	Qty. of Wet Waste segregated	TPD	56	45	7.5	0	1.42	2.1	Not Initiated
4	Qty. of C&D Waste segregated	TPD	7	1.25	0.5	0	0.8	3	1.5
5	Qty. of Street Sweeping	TPD	4	2.83	N.E	0.3	N.E	N.E	0.5
6	Qty. of Drain Silt	TPD	7	2.5	N.E	1.7	Not Estimated	Not Estimated	3
7	Qty. of Domestic Hazardous Waste (DHW) collected	TPD	0	0.25	0.001	0	0.001	0.001	No facility

8	No of bulk waste generators	Nos	2	2	0	0	0	0	0
9	Quantity of waste generated by BWG	TPD	0	0.02	0	0	0	0	0
10	Total waste processed by BWG	TPD	0	0.01	0	0	0	0	0
11	Total waste dumped untreated by BWG	TPD	0	0.01	0	0	0	0	0
12	No of composting machines installed by BWG	Nos	2	2	0	0	0	0	0
13	Qty. of Other Waste (Horticulture, sanitary waste, etc.)	TPD	0	0	N.E	0.01	0.001	0.003	N.E
14	No of Old dump sites	[Nos] or [None]	9	1	2	1	3	1	1
15	Qty stored in dumpsites	TPD	96946	62750	19	18	9994.4	24164.512	

16	No of Sanitary landfills	[Nos] or [None]	2	0	N.E	0	1	1	[None]
17	No of wards	[nos]	245	60	35	35	35	40	40
18	No of wards covered with D2D	[nos]	245	60	35	35	35	40	40
19	No of vehicles for D2D	[nos]	102	50	17	7	10	10	8
20	No of vehicles covered	[nos]	103	60	15	0	10	10	8
21	No of Households	[nos]	66460	33350	7472	8896	7503	9239	NA
22	No of wards with source segregation	[nos]	23	1	NA	0	12	10	0
23	No of wards partially covered with source segregation	[nos]	82	59	NA	0	12	10	1
24	No of wards not covered with source segregation	[nos]	112	0	NA	20	23	30	39

Litter Bins and Waste Bins storage

Litter bins are installed at vulnerable garbage points for waste collection. These garbage bins have twin compartments for the collection of segregated waste. As per Table 4.12, 163 litter bins have been installed in ULBs except for Bhadra. Zero garbage vulnerable points exist in the whole district.

Table 4.12 Litter Bins and Waste Bins Storage

S. No.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	Nagarparishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
1	No of twin bins installed in commerical and public areas	Nos	163	100	30	13	7	6	7
2	No of garbage vulenrable points (existing)	Nos	0	0	0	0	NA	NA	NA
3	No of garbage vulnerable points eliminated (Damaged to be replaced)	Nos	18	10	NA	NA	6	2	NA

Compliance in segregated waste Collection SW Collection

Waste segregation refers to the separation of dry and wet garbage, which paves the way for other concepts of waste management like composting, recycling and incineration. Its end goal is to reduce waste from landfills and eventually, prevent land, water and air pollution. As per Table 4.13, Segregated waste collection is not initiated in ULB Nohar and Bhadra.

Table 4.13 Report on compliance in segregated solid waste management

S.No.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	Nagarparishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
1	Total generation	TPD	151.42	60	19	18	14	22.42	18
2	Wet Waste	TPD	31.15	2	7.5	9.5	4.76	7.39	Not Inititated
3	Dry Waste	TPD	25.02	2	11	8.5	1.42	2.1	Not Inititated
4	C&D Waste	TPD	6.1	Not Initiated	0.5	1.8	0.8	3	Not Initiated

Waste Management Operations

Waste management (or waste disposal) includes the activities and actions required to manage waste from its inception to its final disposal. This includes the collection, transport, treatment and disposal of waste, together with monitoring and regulation of the waste management process and waste-related laws.

As per Table 4.14, Composting for wet waste and Material Recovery Facility (MRF) for dry waste are the commonly found processes with landfilling in the district. The ULBs have not started any reclamation of any old dumpsites except in Hanumangarh, Pilibanga and Rawatsar.

No NGOs are involved in the solid waste management process in any of the ULBs and no linkage is made with brand owners or waste generators. Few of the ULBs have initiated authorization and issuance of identity cards to the waste pickers.

Table 4.14 Waste Management operations in Hanumangarh District

S. No.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	**Nagarparishad HMH**	**Nagarpalika Pilibanga**	**Nagarpalika Sangaria**	**Nagarpalika Rawatsar**	**Nagarpalika Nohar**	**Nagarpalika Bhadra**
1	Door to Door Collection	%	100	100	100	100	100	100	100
2	Mechanical Road Sweeping	%	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated
3	Manual Sweeping	%	100	100	100	100	100	100	100
4	Segregated Waste Transport	%	Partial	100	Not Initiated	20	34	33	Not Initiated
5	Digesters (Bio-methanation)	% of WW	Not Initiated	5	Not Initiated	0	Not Initiated	Not initiated	Not Initiated
6	Composting operation	% of WW	17	80	Not Initiated	0	Not Initiated	Not Initiated	Not Initiated
7	MRF Operation	[MRF used] / [not installed]	Not Initiated	Initiated	Initiated	LAND NOT AVAILABLE	Not Initiated	Not Initiated	Not Initiated

8	Waste to energy (if applicable)	[Required] / [Nos. Available]	Not Initiated	no scientific landfill has been settled hence disposed of legacy waste is done by ULBs own segregation machine.	The work plan is being prepared for this land is available	The work plan is being prepared for this land is available	Ward no 21, Ganganagar Road, pilibanga has been reserved for setting up Scientific Landfill and Processing Plant	10 acres at Chak 21-22 dwd, Rawatsar has been reserved for setting up Scientific Landfill and Processing Plant	There is no scientific land.
9	Waste to RDF	[Required] / [Nos. Available]	Not Initiated	Not Initiated	Initiated	Not Initiated	Initiated	Not initiated	Not Inititated
10	Linkage with Waste to Energy Boilers / Cement Plants	[initiated] / [not initiated]	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Initiated	Initiated	Not Initiated
11	Linkage with Recyclers		Not Initiated	0	Not Initiated	Not Available	Not Initiated	Not initiated	Not Initiated
12	Authorization of waste pickers	[initiated] / [not initiated]	Not Initiated	Not Initiated	Initiated	Initiated	Initiated	Initiated	Initiated

13	Linkage with TSDF / CBMWTF	[initiated] / [not initiated]	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not initiated	Initiated
14	Involvement of NGOs	[initiated] / [not initiated]	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated
15	Linkage with Producers / Brand Owners	[initiated] / [not initiated]	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated	Not Initiated
16	Authorization of Waste Pickers		25	0	Yes	YES	17	25	Yes
17	Issuance of ID Cards	[initiated] / [not initiated]	25	Not Initiated	Initiated	Initiated	Initiated	Initiated	Initiated

Adequacy of Infrastructure

As per Table 4.15, Currently, the ULBs have 170 waste collection trolleys, 40 mini-trucks and 5 bulk waste trucks to collect and transport the solid waste generated. Except for Hanumangarh city, no other ULB has a transfer station and the collected waste is directly transported to the solid waste dumpsite. There is no requirement for a transfer station in ULBs as the population is less than 50,000. No data related to routes and fuel consumption of waste transporting vehicles has been provided.

Table 4.15 Report on the efficacy of infrastructure

S. No.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	Nagarparishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
1	Waste Collection Trolleys	[Nos. Required] / [Nos. Available]	195/170	25/25	2	4 Available	3 Available	3 Available	150 Available
2	Mini Collection Trucks	[Nos. Required] / [Nos. Available]	67/40	27/17	0	0	10 Available	10 Available	7 Available
3	Segregated Transport	[yes] / [no] / [% area covered]	YES	100	no	Yes	Yes [100%]	Yes [100%]	No
4	GPS enabled vehicles	[Yes] / [No]	7/5	2/2	1Req	0 Req	1 Req	1 Req	Yes
5	No of compartmentalized vehicles	Nos	60	60	NA	NA	NA	NA	5
6	No of non-compartmentalized vehicles	Nos	NA	NA	NA	NA	NA	NA	3
7	Bulk Waste Trucks	[Nos. Required] / [Nos. Available]	8 Req	NA	1 Req	1 Req	1 Req.	5 Req.	1 req.

8	Waste Transfer points	[Nos. Required] / [Nos. Available] /[Not available]		Yes	yes	Yes	Yes	Yes	NA
9	Bio-methanation units	[Nos. Required] / [Nos. Available]	75	50	7	7	6	5	NA
10	Composting units	[Nos. Required] / [Nos. Available]	9	0	0	0	4	5	NA

Material Recovery Facilities

Table 4.16 provides the details of material recovery facilities in various ULBs.

Table 4.16 Report on Material Recovery Facility

S. No.	**Parameters**	**Units**	**District**	**Urban Local Bodies**					
			Hanumangarh	**Nagarparishad HMH**	**Nagarpalika Pilibanga**	**Nagarpalika Sangaria**	**Nagarpalika Rawatsar**	**Nagarpalika Nohar**	**Nagarpalika Bhadra**
1.	**Material Recovery Facility**			MRF 90% work is completed Meanwhile biodegradable waste (Approx. 1 TPD) is being composted through a windrow composting. Composting inoculum Clover-SW is being used for faster decomposition of waste. 3.Amount of Solid Waste Collected- 60 TPD, A4.mount of wet waste	The work plan is being prepared for this land is available	For MRF plant established land not available Yet.	10 acres of land has been identified for setting up solid waste processing plant in which MRF facility will be constructed.	Call the Tender for MRF Construction and issued the work Order by ULB. This ULB temporary MRF installed and waste Pickers are collected the plastic waste. Because the MRF is tender processing.	MRF building Constructed but not in working Temporary MRF installed and waste Pickers are collected the plastic waste. Because the

				processed- 2 TPD, Amount of dry waste processed- 2 TPD, Amount of waste untreated- 56 TPD, No. of Composting machine installed by BWG- 0, Capacity of Composting machines installed by BWG- 0 Kg each ULB has Operated two composting machines each 500 kg. Capacity.			The Tender for Constructio n of MRF has been called on 30.12.2019 and The work has not been started by the contractor. Retender called by ULB.		MRF is tender processing.
2.	**Waste to energy (if applicable)**	[Requ ired] / [Nos. Avail able]	not available	not available	not available	not available	not available	not available	not available
3.	**Waste to RDF**	[Requ ired] / [Nos. Avail able]	not available	Total Dry Waste generated in the city (TPD):- 42 TPD Total Dry Waste Processed (TPD) :- 02 TPD Total RDF gave to Cement Factory:- NILL RDF shall be sent to cement Plant:- NILL	There is no RDF plant. Plastic carry bags seized are sent to Nagar Parishad Hanumang arh	There is no RDF plant. Plastic carry bags seized are sent to Nagar Parishad Hanumangar h. For further transportation to cement	Cement Plants have been Identified and the RDF will be provided to the Cement plants after installation of Waste	Cement Plants have been Identified and the RDF will be provided to the Cement plants after installation of Waste Processing Facility in Nohar ULB, 82.5 Kg of	There is no RDF plant. Plastic carry bag seized by Municipal Sangaria and sent to Nagar Parishad Hanumangar h. For further transportatio

						factory at RDF	Processing Facility in Rawatsar ULB, 62 Kg of Seized plastic has been sent to cement plants.	Seized plastic has been sent to cement plants.	n to the cement factory at RDF.

Adequacy of Financial Status of ULB

Table 4.17 shows the Capital cost and operation and maintenance cost that is being required by the respective ULBs.

Table 4.17 Report on financial adequacy of ULB

S. No.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	Nagar Parishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
1	CAPEX Required	Crore per annum	21.5	Not Req	Not Req	Not Req	6.5	7.5	7.5
2	OPEX	[INR per Year] / [% of requirement]	0.6	Not required	No	NIL	20%	20%	20%
3	Adequacy of OPEX	[Yes] / [No]	No	No	No	No	No	No	No

Notification and Implementation of By-Laws

The by-laws have provisions, which if implemented properly, should lead to transformational changes. The by-laws emphasise the generator's responsibility to segregate solid waste at the source. All ULBs have initiated the implementation of by-laws except Nagarpalika Pilibanga

Table 4.18 Report on Notification and Implementation of by-laws

S. No.	Parameters	Units	District	Urban Local Bodies					
			Hanumangarh	**Nagarparishad HMH**	**Nagarpalika Pilibanga**	**Nagarpalika Sangaria**	**Nagarpalika Rawatsar**	**Nagarpalika Nohar**	**Nagarpalika Bhadra**
1	Notification of By-laws	[done] / [in progress] / [not initiated]	In progress	Done	In progress	Done	Done	Done	In progress
2	Implementation of by-laws	[done] / [in progress] / [not initiated]	In progress	Done	In progress	In progress	Done	Done	In progress

Inferences for the present scenario

The following pie charts show the population and waste generation distribution for all ULBs of Hanumangarh district.

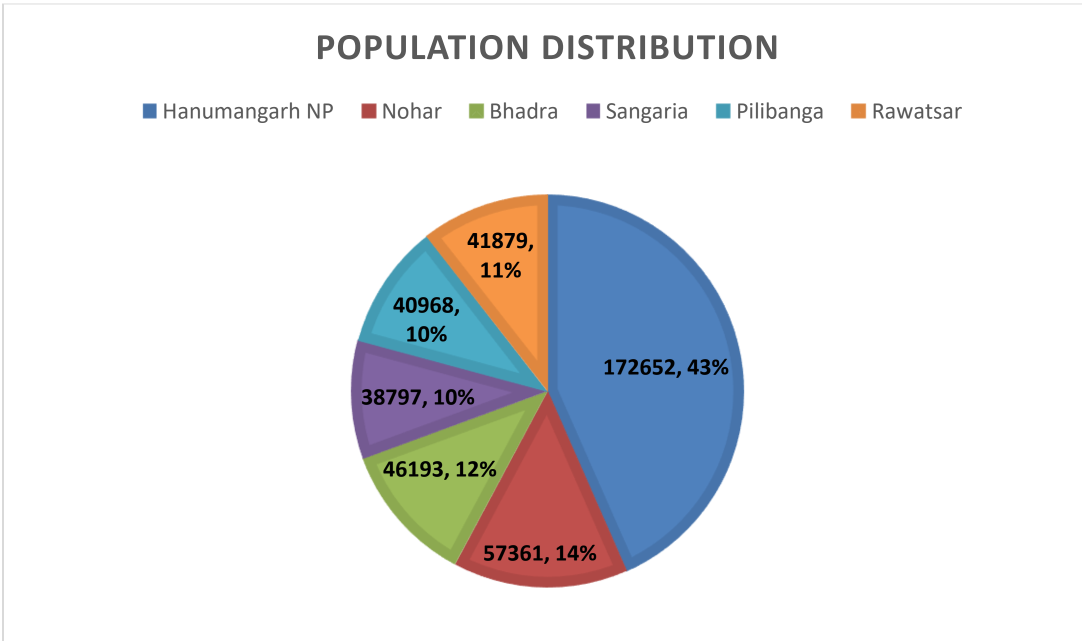

Figure 4.27 Population Distribution for all ULBs of Hanumangarh District

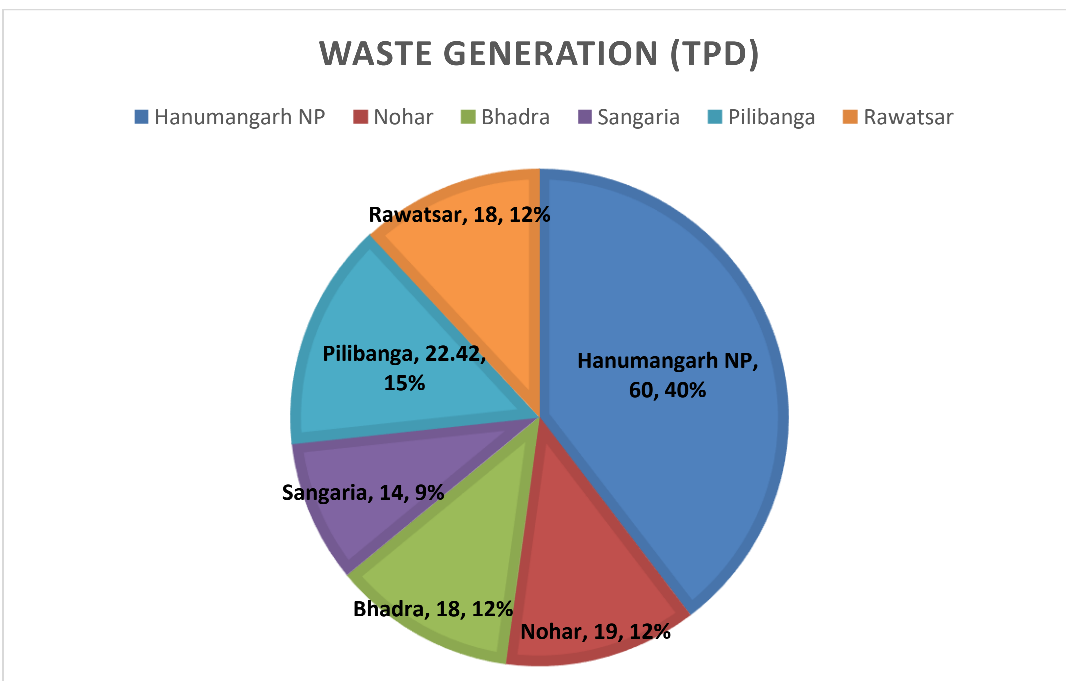

Figure 4.28 Waste Generation for All ULBs in Hanumangarh District

This section presents the inferences compiled from the data provided by the ULBs in the Hanumangarh district.

The total solid waste generation in the district currently stands at 151.4 TPD in which Hanumangarh city contributes around 60 TPD. The solid waste generated in the ULBs comes in the form of dry waste, wet waste, construction and demolition waste, waste coming through street sweeping and drain slits, hazardous waste and sanitary waste. Waste collected from different ULBs also has a fraction of other waste i.e C&D waste, domestic hazardous waste. The quantity of C&D waste segregated from this waste is 7 TPD. The district has 2 bulk waste generators, which are in Hanumangarh city alone.

All the ULBs have made provisions for the 100 per cent door to door collection of solid waste in their administrative boundaries while also achieving 100 per cent sweeping in the ULBs. Only four ULBs, Hanumangarh, Sangaria, Rawatsar, Nohar have been able to achieve partial waste segregation done at source, whereas the rest of the ULBs have not initiated segregation yet.

Litter bins are installed at vulnerable garbage points for waste collection. These garbage bins have twin compartments for the collection of segregated waste. Currently, the ULBs have 170 waste collection trolleys, 40 mini-trucks and 5 bulk waste vehicles to collect and transport the solid waste generated. Except for Hanumangarh city, no other ULB has a transfer station and the collected waste is directly transported to the solid waste dumpsite.

Waste Processing and Disposal

The processing of solid waste collected is important for resource recovery from the waste. There are several options for resource recovery e.g., composting, vermicomposting, anaerobic digestion and incineration. Several advanced treatment methods are also available e.g., hydrothermal carbonization. These methods are yet to be employed extensively in the field.

Composting for wet waste and Material Recovery Facility (MRF) for dry waste are the commonly found processes with landfilling in the district. The bio-methanation process is only established in Hanumangarh ULB.

Figure 4.29 Segregation Unit at Hanumangarh ULB Dump Site

Figure 4.30 Waste Dump Site at Hanumangarh ULB

Figure 4.31 Composting Unit at Hanumangarh ULB

Figure 4.32 Google map view of composting unit site

Figure 4.33 Google Map View of Dump Site in Hanumangarh

Figure 4.34 Waste Dump Site at Hanumangarh ULB

Figure 4.35 Animals at Hanumangarh ULB dump site

Figure 4.36 Waste pile at the dump site in Hanumangarh

Hanumangarh ULB has a composting facility for treating wet waste. All ULBs in the Hanaumangarh district have municipal solid waste dumping sites which currently store lacs of tons of legacy waste. All the ULBs had started segregating the legacy waste and have been trying to recover useful fractions.

4.2.2 Action Plan for Municipal Solid Waste Management

Collection and Transportation

Collection of segregated solid waste from individual households and establishments is accomplished through the use of containerized pushcarts, tricycles or small mechanized vehicles, compartmentalized vehicles, or tipping vehicles depending on the terrain of the locality, width of streets, and building density.

Considering the method of collection, all the six ULBs are having 100 % door-to-door collection. A slight improvement of including the houses/commercial establishments present on the fringes of a ULB may be made by all the ULBs.

The most important aspect of the collection is the availability of source-segregated waste for subsequent transportation, processing and disposal. Only four ULBs, Hanumangarh, Sangaria, Rawatsar, Nohar have been able to achieve partial waste segregation done at source, whereas the rest of the ULBs have not initiated segregation yet. For ensuring the availability of source-segregated waste from households, commercial establishments and institutions, a robust awareness program must be initiated in all the ULBs. The awareness program may be more fruitful if conducted in primary schools. The experts from diverse disciplines ranging from science and engineering to humanities should be consulted to plan the awareness program. The awareness program may also be combined with other missions of the state/central government e.g., Swachh Bharat Abhiyan, Unnat Bharat Abhiyan etc.

Collection frequency of the waste should be decided depending on the degradation/nuisance potential of the waste stream. For this report, the following streams may be considered for the household waste: dry waste (paper, plastic, metal, textile, rubber), wet waste (kitchen/food waste, garden/yard waste), sanitary waste (baby diapers, sanitary napkins etc), domestic hazardous waste (batteries, insecticide bottles/containers, electronic waste). While dry waste and domestic hazardous waste may be easily stored without creating any nuisance, wet waste and sanitary waste must be collected daily. Following the philosophy, dry waste and domestic hazardous waste can be arranged to be collected weekly. Although waste collection centres are generally the norm for domestic hazardous waste but collecting and transporting it separately may result in better management of domestic hazardous waste. After collection, it is of utmost importance to transport the segregated waste separately either using a separable vehicle (which may be too costly) or using compartmentalized vehicles.

In terms of technological improvement, ULBs may be encouraged to introduce ICT and IoT based monitoring of Door-to-Door waste collection. This should be implemented in all the ULBs for ensuring 100% waste collection and better efficiency in operations. The user charges may be levied on the end-user using smart home cards. The smart card can also be used to update the waste collection status of all users. Except for Bhadra ULB, all other have already initiated implementing this technology. Similarly, the compactor bins may also be geo-tagged and installed with a smart card for monitoring of bin lifting process.

Transfer stations are the intermediate stops between the point of collection and the processing/disposal facilities in a city. The establishment of intermediate transfer stations is determined by the distance between secondary waste collection points and the final treatment and disposal point. If the distance from the city jurisdiction to the final treatment and disposal points exceeds 15 km, transfer stations may be established or as per availability and requirement of land (GOR, 2019). Yet another measure may be utilizing biofuel-powered vehicles for collection purposes.

Environmental pollution is a big concern today. To address environmental pollution, it is important to evaluate the composition of our waste streams intensively. Other stakeholders e.g., higher education institutions and research institutes should be asked to participate in these exercises requiring advanced equipment and expertise. Some of the contaminants that should be regularly tested are heavy metals, pesticides and insecticides.

Last, but not the least, aspect is to maintain the records. The records should be maintained for collection and at processing/disposal facilities. At the collection level, the records may start with the vehicle number and number of trips made for the collection for each day.5

Processing and Disposal

For Indian conditions with cheap labour, manual segregation of recyclable fractions into different components like paper, plastic etc. may be more suited. Waste Transfer points should be established for all ULBs. Currently, only for Hanumangarh ULB waste transfer points are marked.

The adoption of processing technologies largely depends upon the quantity and characteristics of the waste generated. It is essential to quantify and characterize the waste generated in the local body before adopting any processing and treatment technology. Ragpicker may be employed for separating the recyclables into different categories. So, the processing should concentrate on recyclables first processing (up to 50% in the first 3 years). On the other hand, a smaller fraction of 25% of wet waste should be used for composting for the next 3 years. In the subsequent three years, the number of recyclables and the wet waste being processed can be doubled.

The informal sector, comprising of kabadi system and waste pickers, plays an important role in the SWM value chain by recovering valuable material from waste. Home composting presents some potential environmental benefits such as the avoidance of collection, transportation and management of biowaste.

Decentralised composting (bin and box composting), composting machines; and Vermicomposting should be practiced where small quantity of wet waste is generated. All ULBs of Hanumangarh district have a large amount of legacy waste at old dump site. Reclamation work of this waste should be initiated. The treatment and disposal of Legacy waste can be done by the process of Bioremediation and Bio-mining. Before starting the process of Bio-remediation and Bio-mining, a survey or mapping of the site must be done. The ULBs tend to use fine fractions for land application. This should be practiced with caution as the old legacy waste may have harmful constituents owing to the disposal of mixed waste together on dump sites. For provision of a sanitary landfill, a cluster of ULBs may be formed and suitable piece of land may be allotted for the waste disposal from the cluster. To avoid the mismanagement of cluster landfill, a separate entity may run the landfill independent of ULBs.

Regular monitoring and data collection are essential for designing an efficient SWM framework system. Research institute should be involved in providing scientific creativity.

As shown in Figure 4.65 all the ULBs of Hanumangarh district are connected through a road network that is in a straight path. The most populated ULB Hanumangarh is in a 28 km radius with two other ULBs where the Bhadra ULB is farthest from Hanumangarh. As per the map, Rawatsar ULB is at an intermediate distance with other ULBs.

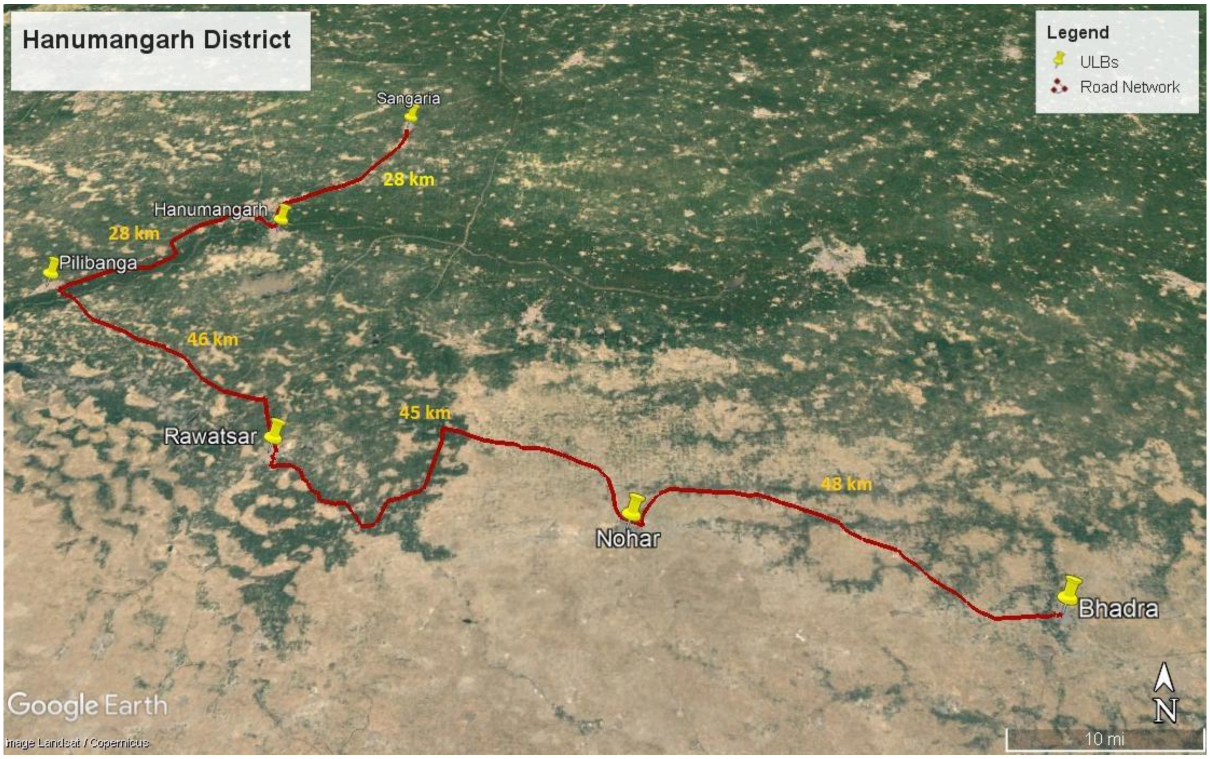

Figure 4.65 Road Connectivity for all ULBs in Hanumangarh district (Source- Google Earth)

Table 4.19 ULB wise action plan for Hanumangarh district

ULBs action area	Nagar Parishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
Collection	• Source- segregation of the waste • Awareness programs for the general public especially at the school level and institution levels (e.g., all bulk waste generators may be first directed to segregate their waste) • Collection frequency of the waste as per waste type e.g. daily collection of wet waste and sanitary waste; weekly collection of dry waste and domestic hazardous waste • Inclusion of the houses/commercial establishments present on the fringes of a ULB in waste collection program • Introduction ICT and IoT based monitoring of Door-to-Door waste collection, ensuring 100% waste	• Source- segregation of the waste • Awareness programs for the general public especially at the school level and institution levels (e.g., all bulk waste generators may be first directed to segregate their waste) • Collection frequency of the waste as per waste type e.g. daily collection of wet waste and sanitary waste; weekly collection of dry waste and domestic hazardous waste • Inclusion of the houses/commercia l establishments present on the • fringes of a ULB	• Source- segregation of the waste • Awareness programs for the general public especially at the school level and institution levels (e.g., all bulk waste generators may be first directed to segregate their waste) • Collection frequency of the waste as per waste type e.g. daily collection of wet waste and sanitary waste; weekly collection of dry waste and domestic hazardous waste • Inclusion of the houses/commercial establishments present on the • fringes of a ULB in waste collection program. • Using electrical or	• Source- segregation of the waste • Awareness programs for the general public especially at the school level and institution levels (e.g., all bulk waste generators may be first directed to segregate their waste) • Collection frequency of the waste as per waste type e.g. daily collection of wet waste and sanitary waste; weekly collection of dry waste and domestic hazardous waste • Inclusion of the houses/commercial establishments present on the • fringes of a ULB in waste collection program. • Using electrical or	• Source- segregation of the waste • Awareness programs for the general public especially at the school level and institution levels (e.g., all bulk waste generators may be first directed to segregate their waste) • Collection frequency of the waste as per waste type e.g. daily collection of wet waste and sanitary waste; weekly collection of dry waste and domestic hazardous waste • Inclusion of the houses/commercial establishments present on the • fringes of a ULB in waste collection program. • Using electrical or	• Source- segregation of the waste • Awareness programs for the general public especially at the school level and institution levels (e.g., all bulk waste generators may be first directed to segregate their waste) • Collection frequency of the waste as per waste type e.g. daily collection of wet waste and sanitary waste; weekly collection of dry waste and domestic hazardous waste • Inclusion of the houses/commercial establishments present on the • fringes of a ULB in waste collection program. • Using electrical or biofuel-powered vehicles for

	collection and better efficiency in operations • Using electrical or biofuel-powered vehicles for collection	in waste collection program. • Using electrical or biofuel-powered vehicles for collection	biofuel-powered vehicles for collection	biofuel-powered vehicles for collection	biofuel-powered vehicles for collection	collection
Processing	• Mechanised MRF with the full capacity of 50 tons/day for dry waste • Inclusion of rag-pickers in MRF operations • Mechanised composting plant of 70 tons/day for wet waste • Sanitary waste to be disposed of on daily basis by an incinerator; • Integrated domestic hazardous waste management centre in Hanumangarh for recovering recyclables from domestic hazardous waste and final disposal into a hazardous waste landfill • Regular testing of heavy metals, pesticides and	• Mechanised MRF with the full capacity of 15 tons/day for dry waste • Inclusion of rag-pickers in MRF operations • Mechanised composting plant of 20 tons/day for wet waste • ULB to start a local collection and storage facility centre for domestic hazardous waste • Regular Monitoting and Compilation of Data	• Mechanised MRF with the full capacity of 15 tons/day for dry waste • Inclusion of rag-pickers in MRF operations • Mechanised composting plant of 20 tons/day for wet waste • ULB to start a local collection and storage facility centre for domestic hazardous waste • Regular Monitoting and Compilation of Data	• Mechanised MRF with the full capacity of 20 tons/day for dry waste • Inclusion of rag-pickers in MRF operations • Mechanised composting plant of 20 tons/day for wet waste • ULB to start a local collection and storage facility centre for domestic hazardous waste • Regular Monitoting and Compilation of Data	• Mechanised MRF with the full capacity of 20 tons/day for dry waste • Inclusion of rag-pickers in MRF operations • Mechanised composting plant of 25 tons/day for wet waste • ULB to start a local collection and storage facility centre for domestic hazardous waste • Regular Monitoting and Compilation of Data	• Mechanised MRF with the full capacity of 20 tons/day for dry waste • Inclusion of rag-pickers in MRF operations • Mechanised composting plant of 20 tons/day for wet waste • ULB to start a local collection and storage facility centre for domestic hazardous waste • Regular Monitoting and Compilation of Data

	insecticides in waste collected, compost and RDF produced • Regular Monitoring and Compilation of Data					
Disposal	• Legacy waste treatment to be completed as soon as possible; Apply extreme precaution in disposing of the different fractions of legacy waste • Engineered landfill for the cluster of Hanumangarh and Sangaria • Establishing linkages with a hazardous waste landfill in the region for disposing off residue ash from incinerator and residue from Integrated domestic hazardous waste management	• Legacy waste treatment to be completed as soon as possible; Apply extreme precaution in disposing of the different fractions of legacy waste • Engineered landfill for the cluster of Pilibanga and Rawatsar	• Legacy waste treatment to be completed as soon as possible; Apply extreme precaution in disposing of the different fractions of legacy waste • Engineered landfill for the cluster of Hanumangarh and Sangaria	• Legacy waste treatment to be completed as soon as possible; Apply extreme precaution in disposing of the different fractions of legacy waste • Engineered landfill for the cluster of Pilibanga and Rawatsar	• Legacy waste treatment to be completed as soon as possible; Apply extreme precaution in disposing of the different fractions of legacy waste • Engineered landfill for the cluster of Nohar and Bhadra	• Legacy waste treatment to be completed as soon as possible; Apply extreme precaution in disposing of the different fractions of legacy waste • Engineered landfill for the cluster of Nohar and Bhadra

4.2.3 Plastic Waste Management

Data Provided by ULBs

Sustainable Inventory of Plastic Waste Generation

The estimated quantity for plastic waste generation is only provided for Sangaria, Rawatsar, Nohar, ULBs which is 0.03 TPD, 0.10 TPD and 0.15 TPD respectively. 100% door-to-door collection is implemented for all ULBs. 100% waste segregation is done for only Hanumangarh ULB. Plastic waste generation data for Hanumangarh, Pilibanga and Bhadra ULBs is not provided. Plastic waste generation data for ULB- Pilibanga and Rawatsar does not match although they have almost equal population. Authorization of plastic waste picker is not initiated for Hanumangarh, Pilibanga and Sangaria ULBs.

Table 4.20 Report on Inventory of Plastic Waste Generation

Sl. No.	Parameters	District	Urban Local Bodies					
		Hanumangarh	Nagar parishad	Nagarpalika				
			HMH	Pilibanga	Sangaria	Rawatsar	Nohar	Bhadra
A	**Inventory**							
1	Estimated Quantity of plastic waste generated in District (TPD)	0.28	NE	NE	0.03	0.10	0.15	NE
B	**Implementation of collection**							
1	Door to Door collection (%)	100	100	100	100	100	100	100
2	Segregated Waste collection (%)	Partial	100	0	Partial	34	33	0
3	Plastic waste collection at Material Recovery Facility	Not Installed	90% work completed	Not Installed	Not Installed	Not Installed	Not Installed	Not Installed
4	Authorization of PW pickers (Nos.)	117	Not Initiated	Not Initiated	Not Initiated	17	25	75
5	PW collection Centres (Nos.)	1	1	Not Established	Not Established	Not Established	Not Established	Not Established

Establishment of Linkage with Stakeholders and Availability of Facilities for Recycling or Utilization of Plastic Waste

The concept of PRO is recognized in plastic waste management primary burden on the producer for the collection of waste plastic products. They need to establish a system for collecting back the waste generated due to their products. Linkages with PROs (Producer Responsibility Organization) of produces and NGOs are not established for ULBs. Plastic waste recycler is only assigned for Sangaria ULBs. No plant for Plastic pyrolysis is established in the Hanumangarh district. Co-processing of plastic waste in cement kiln is only done in all ULBs except Hanumangarh. The use of plastic waste in road construction is only done in RawatsarULBs. Implementation of PW Management Rules, 2016 and Implementation of Extended Producers**.**

Responsibility (EPR) Through –Producers/Brand-Owner

The Central Government, in its 2016 Plastic Waste Management Rules, had banned the manufacture and usage of single-use plastic that is thinner than 50 microns. Action on Sealing of units producing < 50-micron plastic is partially done in Hanumangarh district. EPR puts the financial and/or physical onus on manufacturers--meaning plastic producers, importers and brand-owners--for the treatment, recycling, reuse or disposal of products after a consumer has used and disposed of them. No action is taken for the implementation of Extended Producers Responsibility in the Hanumangarh district.

Table 4.21 Report on Establishment of linkage with stakeholders and Availability of facilities for recycling or utilization of Plastic waste

Sl. No.	Parameters	District	Urban Local Bodies					
		Hanumangarh	Nagarparishad	Nagarpalika				
			HMH	Pilibanga	Sangaria	Rawatsar	Nohar	Bhadra
C	**Establishment of linkage with Stakeholders**							
1	Established linkage with PROs of Producers	Not Established	Not Established	Not Established	Not Established	Not Established	Not Established	Not Established
2	Established linkage with NGOs	Not Established	Not Established	Not Established	Not Established	Not Established	Not Established	Not Established
D	**Availability of Facilities for Recycling or Utilization of Plastic Waste**							
1	No. of PW recyclers (Nos.)	2	Nil	0	2	0	0	0
2	No Manufacturers (Nos.)	0	Nil	0	0	0	0	0
3	No of pyrolysis oil plants (Nos.)	0	Nil	0	0	0	0	0
4	Plastic pyrolysis (Nos.)	0	Nil	0	0	0	0	Quantity in 0 MT sent per Month
5	Use in road making (Nos.)	40.34 MT	Nil	0	0	313 Kg	0	Quantity in 0 MT sent per Month
6	Co-processing in Cement Kiln (TPD)	0.02	Nil	.01 MT/DAY	23 Kg	62 Kg	82.50 Kg	Quantity in 0 MT sent per Month

Table 4.22 Report on Implementation of PW management rules, 2016 and Implementation of extended producers' responsibility (ERP)

Sl. No.	Parameters	District	Urban Local Bodies					
		Hanumangarh	Nagarparishad	Nagarpalika				
			HMH	Pilibanga	Sangaria	Rawatsar	Nohar	Bhadra
E	**Implementation of PW Management Rules, 2016**							
1	Sealing of units producing < 50-micron plastic	Partial	Partial	No Action	Action taken	Partial	Partial	No Action
2	Prohibiting sale of Carry bags < 50 micron	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited	Prohibited
3	Ban on Carry bags and other single use plastics as notified by State Government	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented	Implemented
F	**Implementation of Extended Producers Responsibility (EPR) through Producers / Brand-owners**							
1	No of Producers associated with ULBs (Nos.)	None	None	None	None	None	None	None
2	Financial support by Producers / Brand owners to ULBs	None	None	None	None	None	None	None
3	Amount of PRO Support (INR)	None	None	None	0	0	0	0
4	Infrastructure support by Producers / Brand owners to ULBs	None	None	None	None	None	None	None
5	No of collection centres established by Producers / Brand owners to ULBs(Nos.)	None	None	None	None	0	None	None

Inferences from Present Scenario

The estimated quantity of plastic waste generated is not estimated in Hanumangarh Nagarparishad, Pilibanga, and Bhadra Nagarpalikas.

Door to door waste collection system has been implemented 100% within all the ULBs. Segregated waste collection is done 100% only in Hanumangarh Nagarparishad ULB whereas, in Sangaria Nagarpalika ULB it is partially implemented. In Bhadra and Pilibanga Nagarpalikas ULBs, 0 % segregated waste collection is being carried out. Further, Plastic waste collection at the Material Recovery Facility has not installed any of the ULBs.

Authorization of 25 PW pickers in Nohar Nagarpalika, 17 PW pickers in Rawatsar Nagarpalika and 75 PW pickers in Bhadra has been done whereas, it is not initiated in Sangaria and Nohar Nagarpalikas and, in Hanumangarh Nagarparishad. Further, one plastic waste collection centres are established in Hanumangarh ULBs. Plastic waste collection centres have not been established in Rawatsar, Pilibanga, Sangaria, Nohar and Bhadra Nagarpalikas.

The establishment of linkages with stakeholders (PROs and NGOs) has not been established in any of the ULBs. There are no Manufacturers and Pyrolysis oil plants present in any of the ULBs. Nowhere plastic waste is used for construction roads whereas, co-processing in cement kilns is carried out in Pilibanga Nagarpalika and Rawatsar, Sangaria, Nohar ULBs.

Enforcements have been carried out in some of the ULBs as per the Plastic Waste Management Rules 2016. Sealing of units producing < 50-micron plastic has been partially implemented in Hanumangarh, Rawatsar, Nohar. Prohibition of sale of carry bags <50 micron is completely implemented in all ULBs. Further, a ban on carry bags and other single-use plastics as notified by State Government has been implemented within all ULBs.

None of the Extended Producers Responsibility (EPR) through Producers/Brand-Owners has been implemented in any of the ULBs.

4.2.4 Action Area for Plastic Waste Management

For Hanumangarh district, the action plan for plastic waste management includes activities door-to-door plastic waste collection and plastic waste segregation at source, immediate actions like ban on carry bags and other single use plastics as notified by State Government and ensuring no open burning and littering. It also incorporates the management by waste generator through EPR and PRO to be implemented in all the ULBs of Hanumangarh District and future implementations to be done such as utilization of non-recyclable plastic waste (road construction, waste to fuel, waste to energy, alternative uses identification etc.

Table 4.23 Action Plan for Plastic Waste Management

Sl. No.	Action Area	Timeline	Department/ Agencies
1	Door to Door plastic waste collection	Regular activity	Hanumangarh Nagarparishad ULB, Pilibanga Nagarpalika ULB, Sangaria Nagarpalika ULB, Rawatsar Nagarpalika ULB, Nohar Nagarpalika ULB and Bhadra Nagarpalika ULB.
2	Plastic waste segregation at Source.	Regular activity	Hanumangarh Nagarparishad ULB, Pilibanga Nagarpalika ULB, Sangaria Nagarpalika ULB, Rawatsar Nagarpalika ULB, Nohar Nagarpalika ULB and Bhadra Nagarpalika ULB.
3	Management by waste generator through EPR and PRO	Implement in all ULBs	Hanumangarh Nagarparishad ULB, Pilibanga Nagarpalika ULB, Sangaria Nagarpalika ULB, Rawatsar Nagarpalika ULB, Nohar Nagarpalika ULB and Bhadra Nagarpalika ULB.
4	Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc.	Implemented in future	Hanumangarh Nagarparishad ULB, Pilibanga Nagarpalika ULB, Sangaria Nagarpalika ULB, Rawatsar Nagarpalika ULB, Nohar Nagarpalika ULB and Bhadra Nagarpalika ULB.
5	Ban on Carry bags and other single-use plastics as notified by State Government.	Immediate	State Government/ ULBs including Hanumangarh Nagarparishad ULB, Pilibanga Nagarpalika ULB, Sangaria Nagarpalika ULB, Rawatsar Nagarpalika ULB, Nohar Nagarpalika ULB and Bhadra Nagarpalika ULB.
6	Ensuring no open burning and littering.	Immediate	Hanumangarh Nagarparishad ULB, Pilibanga Nagarpalika ULB, Sangaria Nagarpalika ULB, Rawatsar Nagarpalika ULB, Nohar Nagarpalika ULB and Bhadra Nagarpalika ULB.

4.2.5 Construction and Demolition Waste Management

Data provided by ULBs

Inventory of C&D Waste

Table 4.24 presents the total quantity of C&D waste generated/ collected, amount of C&D collected and dump in each ULBs and number of wards present in the respective ULBs. At present total C&D waste generated in Hanumangarh district is 3100 kg/day. Generated quantity for all ULBs is estimated but for Hanumangarh it is not. For ULBs Pilibanga, Sangaria, Nohar, Bhadra and Rawatsar amount of C&D waste collected is very less than generated waste.

Table 4.24 Inventory of C&D waste

S. No.	Parameters	District	Urban Local Bodies					
		Hanumangarh	Nagar Parishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
A	Inventory							
1	Estimated Quantity (Kg/day)	3100.5	Not estimated	0.5	500	800	3000 kg	1800
2	Amount of C&D collected (TPD)	6.9	1.25	0	0.05	0.8	3	1.8
3	Amount of C&D dump (TPD)	6.9	1.25	0	0.05	0.8	3	1.8
4	Amount of C&D recycled/treated (TPD)	0	0	0	0	0	0	0
5	No of vehicles of C&D waste collection and transportation	6	1	1	1	1	1	1

Implement scheme for permitting bulk waste and C&D Waste deposition centre

Table 4.25 presents the information about the scheme for bulk waste generator and C&D waste deposition centre. All ULB provided the data about the implementing scheme for permitting bulk waste. Only Pilibanga, Rawatsar, Nohar ULBs provided the data about the establishment of C&D waste deposition Centres.

Table 4.25 Scheme for bulk waste generator and C&D waste deposition centre

S. No.	Parameters	District	Urban Local Bodies					
		Hanumangarh	**Nagarparishad HMH**	**Nagar Palika Pilibanga**	**Nagarpalika Sangaria**	**Nagarpalika Rawatsar**	**Nagarpalika Nohar**	**Nagarpalika Bhadra**
A	**Implement scheme for permitting bulk waste**							
1	Issuance of Permissions by ULBs	Not initiated	Not initiated	Initiated	Not Initiated	Initiated	Not Initiated	Not Initiated
B	**Establishment of C&D waste deposition centers**							
1	Establishment of Deposition Points	No	No	Yes	No	Yes	Yes	No
2	C&D Deposition point identified	No	No	Yes	No	Yes	Yes	No

Implementation of By-Laws for C&D Waste Management and C&D Waste recycling plant

Table 4.2 By-laws and recycling plant for C&D waste presents the data about the Implementation of By-Laws for CD Waste Management and C&D Waste recycling plant. All the 6 ULBs have provided the data about the implementation of By-Laws and the collection of deposition/disposal charges. C&D Waste Recycling Plant and Capacity of C&D Waste Recycling plant is not existing in any of the ULBs.

Table 4.26 By-laws and recycling plant for C&D waste

S. No.	**Parameters**	**District**	**Urban Local Bodies**					
		Hanumangarh	**Nagarparishad HMH**	**Nagarpalika Pilibanga**	**Nagarpalika Sangaria**	**Nagarpalika Rawatsar**	**Nagarpalika Nohar**	**Nagarpalika Bhadra**
A	**Implementation of By-Laws for CD Waste Management**							
1	Implementation of By-laws	Notified	Notified	Notified	Notified	Notified	Notified	Notified
2	Collection of Deposition / disposal Charges	Initiated	Initiated	Not Initiated	Initiated	Initiated	Initiated	Initiated
B	**Establishment of C&D Waste recycling plant or linkage with such facility**							
1	Establishment CD Waste Recycling Plant	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist
2	The capacity of CD Waste Recycling Plant	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist	Not Exist

Inferences for the present scenario

This section presents the inferences compiled from the data provided by the ULBs in the Hanumangarh district.

The estimated quantity of C&D waste is not known for Hanumangarh ULB. Pilibanga ULBs has provided the data about the amount of C&D dump. No ULB have the data about the amount of C&D waste recycled/treated. Four ULBs have provided the data about the number of vehicles of C&D waste collection and transportation i.e., Nohar, Bhadra, Rawatsar and Sangaria having 1 vehicle each.

Only 1 ULB i.e., Pilibanga had issuance of permission by ULB to implement a scheme for permitting bulk waste. Three ULBs i.e., Nohar, Pilibanga and Rawatsar have the issuance of permission by ULB for the establishment of C&D waste deposition center. Three ULBs i.e., Nohar, Pilibanga and Rawatsar having C&D waste deposition points are identified and all other 3 ULBs have not been issued permission by ULB for the establishments of C&D waste deposition center and are not identified there.

All 6 ULBs have implemented by-laws for C&D waste management and it has been notified there. Collection of deposition or disposal charges has been initiated by 5 ULBs i.e., Hanumangarh, Nohar, and Bhadra, Sangaria, Rawatsar. No ULB have established C&D waste recycling plant.

4.2.6 Action Areas for C&D Waste Management

ULBs should make bye-laws as well as special arrangements for storage, transportation, processing and disposal of Construction and Demolition waste.

Small municipalities under 1 Lakh population should make simple arrangements as under (ULBs – Pilibanga, Sangaria, Rawatsar, Nohar and Bhadra):

Notify locations, preferably in each zone (North, South, East, West) and centre of the city, where waste generators having small quantities of C&D waste under 1 MT load should be allowed to deposit their waste. Construct an enclosure at each notified location for storage of small quantities of waste or place a tractor trolley at each such location for storage of C&D waste.

Arrange for transportation of C&D waste deposited at collection centres through covered tractor trolleys or trucks to the area designated for bulk storage. Citizens to avail of the facility at designated locations and refrain from the disposal of C&D waste at any other location or in MSW bins.

Plan for reuse and recycling of such waste with private sector participation or use the same for land reclamation by filling in low lying areas or for carrying out bio engineering works to prevent mosquito breeding, by using C&D waste to fill in areas where stagnant water is repeatedly observed.

In cities above 1 Lakh population, the municipality should make elaborate arrangements as under (Hanumangarh ULB):

Notify suitable locations in different parts of the city where waste generators having small quantities of C&D waste under 1MT load can deposit their waste conveniently. Create a system of renting skips or containers for storage of C&D waste at source departmentally or through an authorised private operator, where the generation of such waste is greater than 1 MT.

Prescribed rates for collection and transportation of C&D waste to be published or notified. Citizens to avail of the facility and refrain from the disposal of small quantities of C&D waste anywhere else.

Arrange for transportation of C&D waste through skip lifting system departmentally or designated contractor. Normally 4.5 cu.m open skips and 10 cu.m roll on and roll of open containers (to be hauled by hook loaders are suitable for C&D waste. Plan for reuse and recycling of such waste with private sector participation. The rejects from these plants (soft fines) are used for filling in low lying areas.

While depositing waste in the bins, care should be taken by the small generators to see that waste material is not dumped outside the bin or skip. These bins or skips should be periodically inspected by the municipal authority to ensure that they are cleared before they overflow. Littering should be strictly prohibited; particularly C&D waste should never be allowed to be deposited in open or covered drains.

Large generators who are provided with open skips or tractor trolleys on rent by the local body or its authorised private operators should inform the municipal authority or concerned agency when the containers are likely to be full to replace the filled skip or trolley with an empty one and transport the waste at a designated site. In case of very large generators responsible for demolition, renovation, construction of infrastructure projects like bridges, fly-over, roads, large commercial or housing complex or demolition of unauthorised structures by municipality etc., the area should be screened and cordoned off and the material should be stacked systematically without obstructing traffic or causing any hindrance to the neighbourhood. Different waste components may be segregated and stored separately. Segregated material should be loaded into tipper lorries or tractors with the help of front-end loaders or back hoes and transported to designated sites for further processing or other use. The private sector may be encouraged to facilitate the reuse and recycling of C&D waste.

The ULB should fix and notify charges for doorstep collection and transportation of C&D waste, based on the volume generated.

Placement of Skips on Public Roads: Normally for bulk generators dedicated hook loader bins or skips may be provided at a cost wherever required and should be kept within the construction sites. The ULB should notify bye-laws about the management of C&D waste and the safety requirements of such containers on public roads.

Table 4.27 Action points for C&D waste management

Sr. No.	Action Area	Timeline	Department/ Agencies
1	Proper collection, transportation, processing and disposal of C&D Waste	Regular Activity	ULBs/ Waste Generator i.e., Hanumangarh Nagar Parishad , Nohar, Bhadra, Sangaria, Pilibanga, and Rawatsar
2	Approval of Waste Management Plan submitted by Waste Generators before Construction starts.	Immediate	ULBs i.e., Hanumangarh Nagar Parishad , Nohar, Bhadra, Sangaria, Pilibanga, and Rawatsar
3	Provisions for using materials made by C&D Waste in Construction Activity like paving blocks, lower layers of road pavements, colony and rural roads etc.	Immediate	ULB/Urban/Road Department i.e., Hanumangarh Nagar Parishad , Nohar, Bhadra, Sangaria, Pilibanga, and Rawatsar
4	Collection of deposition charges should be initiated in all ULBs.	Immediate	ULBs i.e., Hanumangarh Nagar Parishad , Nohar, Bhadra, Sangaria, Pilibanga, and Rawatsar
5	Deposition point for waste shall be established	Shall be established in future	ULB i.e., Hanumangarh Nagar Parishad , Nohar, Bhadra, Sangaria, Pilibanga, and Rawatsar
6	Information, Education & Communication (IEC) for C&D waste management.	Regular Activity	ULBs/Development Authority/ NGOs/Education department

4.2.7 Biomedical Waste Management

With a total population of 3,50,694 in the 6 statutory towns, the district has 11 healthcare facilities of which 7 of them are bedded while 4 are non-bedded facilities. The district also has 14 veterinary hospitals distributed in all the ULBs. There is a Common Bio-medical Waste Treatment and Disposal Facility (CBWTF) for Hanumangarh and Sriganganagar district.

The total waste generated in Hanumangarh District in the year 2017, 2018 & 2019 was 430.84, 298.40 & 358.50 Kg/Day respectively (RSPCB, 2019).

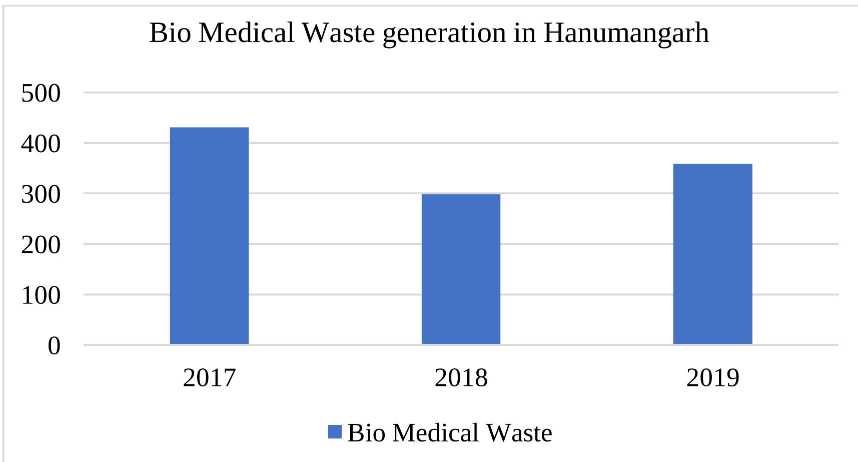

Figure 4.37 Total Bio-Medical Waste Generation in Hanumangarh District

Data Provided by ULBs

Data for different action areas are collected from the heath department. These data include details of a number of hospitals (HCFs, clinics, blood bank etc), amount of waste generated per day and, CBMWTFs in Hanumangarh district.

Table 4.28 Report on Inventory of Biomedical Waste Generation, 2019

S. No.	Action Areas	Details of Data Requirement	Measurable Outcome	
	Name of ULB		**[name of ULB]**	**Hanumangarh District**
	Population		[Nos as per 2011 census]	3,50,694
A	**Inventory of Biomedical Waste Generation**			
		Total no. of HCFs	Nos	11
	1	Total no. of Bedded Hospitals	[Nos] / [No inventory]	7
	2	Total no. of non-bedded HCF	[Nos] / [No inventory]	4
	3	Total no. Clinics	[Nos] / [No inventory]	
	4	No of Veterinary Hospitals	[Nos] / [No inventory]	52
	5	Pathlabs	[Nos] / [No inventory]	
	6	Dental Clinics	[Nos] / [No inventory]	
	7	Blood Banks	[Nos] / [No inventory]	3
	8	Animal Houses	[Nos] / [No inventory]	
	9	Bio-research Labs	[Nos] / [No inventory]	
	10	Others	[Nos] / [No inventory]	
B	**Authorization of HCFs by SPCBs / PCCs**			
	1	Bedded HCFs	[Nos Authorized]	7
	2	Non-bedded HCFs	[Nos Authorized]	4
C	**Biomedical Waste Treatment and Disposal Facilities (CBMWTFs)**			

	1	No of CBMWTFs	[Nos] / None	NONE
	2	Linkage with CBMWTFs	[Yes] / [no linkage]	B.Tech Projects Hanumangarh-Sriganganagar
	3	Capacity of CBMWTFs	[Adequate] / [Not adequate]	Nil
	4	Requirements of CBMWTFs	[Require] / [not required]	required
	5	Captive Disposal Facilities of HCFs	[Nos] / [None]	none
D	**Compliance by CBMWTFs**			
	1	Compliance to standards	[Meeting] / [Not meeting] / [NA]	meeting
	2	Barcode tracking by HCFs / CBMWTFs	[100%] / [Partly %] / [None]	under development
	3	Daily BMW lifting by CBMWTFs	[Kg / day]	430 kg/day
E	**Status of Compliance by Healthcare Facilities**			
	1	Pre-segregation	[100%] / [partly %] / [None]	
	2	Linkage with CBMWTFs	[100%] / [partly %] / [None]	

Table 4.29 Report on Inventory of Biomedical Waste Generation, 2008

Parameters	Units	District	Urban Local Bodies					
		Hanumangarh	Nagar Parishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
Inventory								
Total no. of Bedded Hospitals	Nos.	7	2	1	1	1	1	1
Total no. of non-bedded HCF	Nos.	4	3	0	0	0	1	0
Total no. Clinics	Nos.	0						
No of Veterinary Hospitals	Nos.	0						
Pathlabs	Nos.	0						
Dental Clinics	Nos.	0						
Blood Banks	Nos.	3	3					
Animal Houses	Nos.	0						
Bio-research Labs	Nos.	0	0					
Others	Nos.	0	0					
Authorization of HCFs by SPCBs / PCCs								
Bedded HCFs	Nos.	7	2	1	1	1	1	1
Non-bedded HCFs	Nos.	4	3	0	0	0	1	0
Biomedical Waste Treatment and Disposal Facilities (CBMWTFs)								
No of CBMWTFs	Nos.	0						

Linkage with CBMWTFs	Nos.	0						
Capacity of CBMWTFs	Nos.	0						
Requirements of CBMWTFs	Nos.	0						
Captive Disposal Facilities of HCFs	Nos.	11	5	1	1	1	2	1
Compliance by CBMWTFs								
Compliance to standards		Meeting	Meeting	Meeting	Meeting	Meeting	Meeting	Meeting
Barcode tracking by HCFs / CBMWTFs		50	1	1			1	
Daily BMW lifting by CBMWTFs	Kg/d	52	20	4	5	8	10	5
Status of Compliance by Healthcare Facilities								
Pre-segregation	Nos.	1	1	1	1	1	1	1
Linkage with CBMWTFs	Nos.	1	1	1	1	1	1	1

Inferences for Present Scenario of Hanumangarh

Although the whole district has linkages with a common treatment facility for managing biomedical waste, several issues may be improved for biomedical waste management. First, the inventory of all the entities producing biomedical waste should be completed. The practice of tracking biomedical waste using barcodes has not been followed strictly in the district. The other main concern is compliance with the common biomedical waste treatment facility in Hanumangarh.

4.2.8 Action Areas for Bio-Medical Waste Management

The action areas of the Strategy set out how the main goals of the Strategy will be achieved in terms of areas of need, timeline, and responsible agency. The action plan for segregation, collection, transport, disposal and data management with timeline and the responsible department is given in the table below.

Table 4.30 Action Plan for Bio-Medical Waste Management

S.No.	Action Area	Timeline	Department/ Agencies
1	Segregation of Bio Medical Waste (BMW) at source of generation in specified Color-Coded bags	Regular Activities	Health Department/ HCFs
2	Inventorisation of Medical facilities producing Bio-Medical Waste	Immediate	Health Department
4	Collection of Solid Waste other than BMW from HCFs	Regular Activities	CBWTFs
5	Captive Disposal Facilities of HCFs shall be established.	Immediate	Health Department/ HCFs
6	Authorization to HCFs and Occupiers and Submission of Annual report to CPCB.	Immediate	RPCB
7	GPS enabled vehicles for Biomedical wastes transportation	Immediate	Health Department/RPCB/ CBWTFs
8	Information, Education & Communication (IEC) for Bio-medical waste management.	Regular Activities	Health Department / NGOs/ Education Department
9	Monitoring compliance by common biomedical waste treatment facility	Regular activity	RO, SPCB

4.2.9 Hazardous Waste Management

Data provided by ULBs

Table 4.31 shows the Hazardous Waste Datasheet for the Hanumangarh district

Table 4.31 Hazardous Waste Datasheet

S.No.	Details of Data Requirement	Units	Outcome for District
A	**Inventory of Hazardous Waste**		
1	No of HW Generating Industry	[Nos.]	7
2	Quantity of HW	[MT/Annum]	384.79
3	Quantity of Incinerable HW	[MT/Annum]	0
4	Quantity of land-fillable HW	[MT/Annum]	0.52
5	Quantity of Recyclable / utilizable HW	[MT/Annum]	384.27
B	**Contaminated Sites and illegal industrial hazardous waste dumpsites**		
1	No of HW dumpsites	[Nos] / [None]	None
2	Probable Contaminated Sites	[Nos] (provide list)	-
C	**Authorization by SPCBs/PCCs**		
1	No of industries authorized	[Nos]	6
2	Display Board of HW Generation in front of Gate	[Nos]	6
D	**Availability of Common Hazardous Waste TSDF**		
1	Common TSDF	[Exists] / [No] / [Sent to Other District within State]	Sent to other District within State
2	Industries linkage with TSDF	[Nos.]	2
E	**Linkage of ULBs in District with Common TSDF**		
1	ULBs linked to Common TSDFs for Domestic Hazardous Waste	[Yes] / [No]	

Table 4.32 Details on Hazardous Waste Generation (Final ATR 2019-2020)

Details on Hazardous Waste Generation																			
Name of SPCB/PCC: Rajasthan State Pollution Control Board															Year: 2019-20				
Name of the District	Total Number of HW generating units	Number of Units possessing authorisation	Number of Units exempted from obtaining Authorisation	Number of HW Units submitted annual returns	Authorized Quantity of Hazardous Waste (Metric Tonne)				Total Quantity	*Quantity of Hazardous Waste generated as per Annual Return within the State/UT (Metric Tonne)				Total Quantity	Details on Import and Export of Hazardous Waste			
					Landfillable	Incinerable	Recyclable	Utilizable		Landfillable	Incinerable	Recyclable	Utilizable		Quantity of HW imported during the year (Metric Tonne)	Type of HW	Quantity of HW exported during the year (Metric Tonne)	Type of HW
Hanumangarh	7		0	7	22.33	0	4000	48.1	4070.43	0.52	0	377.39	6.89	384.79	0	0	0	0

Table 4.32 details the data on the Hazardous Waste generated in the district.

Table 4.33 details the data on the Hazardous Waste recycled and utilised in the district. Out of the 377.39 MT recyclable HW, 244.38 (65%) is recycled. 133.01 MT of imported HW is also recycled within the district.

Table 4.33 Details on Hazardous Waste Recycled and Utilised (Final ATR 2019-2020)

Details on Hazardous Waste Recycled and Utilized										
Name of the District	Recycling/Utilization of Hazardous waste (generation within the State/UT)							Recycling/Utilization of Hazardous Waste (received from other State/UT)		
	Quantity of waste Recycled (listed under Schedule IV Hazardous Waste (MT)		Quantity Utilized (MT)				Captive Utilization of hazardous and other wastes for which SOP has not been prepared by CPCB	Quantity of waste Recycled (listed under Schedule IV Hazardous Waste (MT)	Quantity Utilized (MT)	
			Co-processing in Cement plant		Non-captive & Captive utilization based on CPCBs SOPs				Co-processing in Cement plant	Non-captive & Captive utilization based on CPCBs SOPs
	Generated within state	Imported	Generated within state	Imported	Generated within state	Imported				
Hanumangarh	244.38	0	0	0	13.11	0	0	133.01	0	0

Table 4.34 details the data on the Hazardous Waste disposed of in the district. Even though the authorized quantity of land fillable HW is 22.33 MT, the quantity of HW being disposed of in landfill is 142.75 MT and despite the authorized quantity of incinerable HW being 0, the quantity of HW being disposed of through incineration is 1.54 MT.

Table 4.34 Details on Hazardous Waste Disposed of (Final ATR 2019-2020)

Details on Hazardous Waste Disposed					
Name of the District	Disposal of hazardous waste (generated within the State/UT)				Disposal of hazardous waste (received from other State/UT)	
	Quantity Disposed of in Secured Landfill (MT)		Quantity Disposed of through Incinerator (MT)		Quantity Disposed of in common (MT)	
	Common	Captive	Common	Captive	SLF	Incinerator
Hanumangarh	142.75	0	1.54	0	0	0

Table 4.35 details the data on the Hazardous Waste stored at occupier premises in the district. The total quantity of HW stored at the beginning of the financial year (1st April) is 13.64 MT and the total HW stored at the end of the financial year (31st March April) is 7.56 MT.

Table 4.35 Details on Hazardous Stored at Occupier Premises (Final ATR 2019-2020)

Details on Hazardous Waste Stored at Occupier Premises								
Name of the District	Total Quantity of HW stored at Occupier premises at the beginning of the financial year i.e. 1st April (MT)				Total Quantity of HW stored at Occupier premises at the end of financial year i.e. 31st March (MT)			
	Land fillable	Incinerable	Recyclable	Utilizable	Land fillable	Incinerable	Recyclable	Utilizable
Hanumangarh	1.84	0	0	11.8	1.98	0	0	5.58

Inferences for the present scenario

The district has seven authorized industries capable of generating hazardous waste, generating 384.79 MT per annum of hazardous waste. The district recycles/utilizes around 384.27 MT/annum hazardous waste. Out of 384.79 MT hazardous waste generated by 7 HW generating units, 384.27 (99.8%) is recyclable. The number of authorised industries is 6, thus one HW generating unit is still unauthorized. As for common TSDF, there is no data of how much HW is being exported to other districts.

4.2.10 Action Areas for Hazardous Waste Management

Hazardous Waste Management Rules are notified to ensure safe handling, generation, processing, treatment, package, storage, transportation, use reprocessing, collection, conversion, and offering for sale, destruction and disposal of Hazardous Waste. This action should be completed on a timeline by the responsible department.

Table 4.36 Action Plan for Hazardous Waste Management

S. No.	Action Area	Timeline	Department/ Agencies
1.	Hazardous waste segregation at Source	Regular activity	All ULBs
2.	Circular economy approach may be followed in the industries e.g. modifications in input side leading to changes in resulting waste compositions circular economy as one that is restorative, and one which aims to maintain the utility of products, components and materials and retain their value	5-years	RSPCB (help from technical institutes may be sought)
3.	More opportunities my be searched for utilization of hazardous waste	5-years	RSPCB (help from technical institutes may be sought)
4.	Information on domestic hazardous waste generated should be collected and maintained	Implemented in future	All ULBs
6.	Education on Identification of different HW classification and their respective handling and storing methods	Immediate	All ULBs

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4.2.11 E-Waste Management

Data Provided by ULBs

Details for different parameters of E-Waste management i.e., collection centers, authorized recyclers/ dismantler etc are provided by district authorities. Table 4.37 gives details regarding e-waste management in the district.

Table 4.37 Report on E-Waste Management

Sl.no	Details of data required	Outcome for District
A	**Status of facilitating authorized collection of E-waste**	**No data**
1	Are the citizen able to provide E-waste through Toll-free numbers in the district	YES
2	Collection centers established by ULB in District	YES
3	Collection centers established by Producers or their PROs in the District	NO
4	Does the district has linkage with authorized E-Waste recyclers / Dismantler	NO
5	No authorized E-Waste recyclers / Dismantler	NO
B	**Status of Collection of E-Waste**	**NO**
1	Authorizing E-Waste collectors	100%
2	Involvement of NGOs	NO
3	Do Producers have approached NGOs/ Informal Sector for setting up Collection Centers	NO
4	Does ULBs have linkage with authorized Recyclers / Dismantlers	NOT
C	**Control E-Waste related pollution**	
1	Do informal trading, dismantling, and recycling of e-waste exists in District	
2	Does the administration close illegal E-Waste recycling in the District	THE CAMPAIGN IS BEING RUN BY THE MUNICIPALITY
3	No actions were taken to close illegal trading or processing of E-Waste	
D	**Creation of Awareness on E-Waste handling and disposal**	
1	Do PROs / Producers conducted any District level Awareness Campaigns	THE CAMPAIGN IS BEING RUN BY THE MUNICIPALITY
2	Does District Administration conduct any District level Awareness Campaigns	

Inferences from Present Scenario

There is no E-waste management infrastructure in the Hanumangarh district. No Collection centres were established by Producers or their PROs in the District. The creation of Awareness on E-Waste handling and disposal has not been taken up vigorously by any of the ULBs.

The generation of e-waste is going to be increased in the future. So, it is important to spread awareness about the harmful effect of the disposal of e-waste. Collection centres for disposed of e-waste should be installed. ULBs should start the process of establishing linkages with authorized PROs for proper management of discarded e-waste.

ULBs should establish Toll-free number helpline where a citizen can contact for deposition of their e-waste. An awareness programme should be initiated by the ULBs and NGOs. A common recycling/dismantle facility may be established at the district level as ULB except Hanumangagh have small population.

4.2.12 Action Plans for E-Waste Management

The lack of primary data is the major concern faced by all the institutions. So, to formulate a site-specific action plan, firstly requires the data regarding the site. This includes data regarding the generation, current status of collection of E-waste, the facilities provided by the district used by the citizens, availability of collection centre under ULBs, status of dismantlers, involvement of formal informal sectors, about trading, recycling and illegal activities surrounding this etc. Based on these data an action plan has been formed to the better functioning with the timeframes and requirement pattern with regards to infrastructural development of the area.

Table 4.38 Action Plan for E-Waste Management

Sl. No	Action Points	Departments/Agencies
1	Collection, Segregation and Channelization of e-waste pertaining to orphan products to recyclers/dismantlers	ULBs
2	Segregation of E-waste at source from MSW	ULBs/Nagar Nigam/ Waste Generator
3	Ensuring no illegal processing of e-waste and no dumping of e-waste, HW & other wastes on banks of river and no illegal transportation of e-waste.	District Administration /ULBs/SPCB/RTO
4	Industrial skill development activities for workers in dismantling and recycling units.	Labor Department
5	Monitoring & Compliance of Extended Producers Responsibility (EPR) - Authorization issue by CPCB.	SPCB
6	Information, Education & Communication (IEC) for E-waste Management.	ULBs/ SPCB/ Development Authority/ NGOs/Education
7	Authorization to Manufacturers, Dismantlers, Recyclers, Refurbishers and Action against defaulters.	SPCB

8	Integrated plan for implementation of EWM Rules, 2016.	SPCB
9	Earmarking or allocation of industrial space or shed, abandoned mills/factories for e-waste dismantling/recycling units in industrial clusters	Department of Industries
11	Recognition and Registration of workers of dismantling and recycling units.	Labor Department
12	Implementation of EPR from producers.	Department of Industries/SPCB

4.3 Summary

4.3.1 Municipal Solid Waste Management

In summary, the current state of solid waste management revealed that there are significant issues with unauthorized waste disposal practices due to the lack of proper waste management process. This has significantly impacted on the natural environment. The lack of public waste bins and proper waste collection processes have significantly affected the unauthorized waste disposal practices. Moreover, the absence of sanitary land filling and inadequate processes are significant issues with SWM. The absence of practical usage of regulation and laws is identified as a barrier to residents engaging in proper waste management processes with recycling and waste separation because the council could not enforce these practices. Lack of knowledge, awareness and cooperation have been identified. As more and more waste is generated yearly, it is evident that this increasing trend is unacceptable in the long run. Landfills and recycling can only temporarily mitigate the immediate consequences of this large waste production. However, if the problem of municipal solid waste is to be truly addressed, the root of the issue must be looked at first. If less waste is generated in the first place, the challenge of finding environmentally feasible ways of disposing of waste will be much easier.

Table 4.39 Summary of present status, future projection and action points for solid waste management in all the ULBs of Hanumangarh District

ULBs	Aspect	Collection and Transportation	Processing and disposal
Nagar Parishad HMH	Present Status	100% door to door collection Waste is first transferred to the transfer station and then to the dumpsites 100% efficiency in segregated waste transport	80% of the waste is used for composting Material Recovery Facility has been initiated Recycling of waste is not done Sanitary landfill is not present One dumpsite is present
	Action points	Source Segregation of waste. Educating the general public at school level. Modification in collection frequency of waste based on the type of waste. Incorporation of households on the extremity in waste collection programme. Use of ICT and IoT in waste collection operations. Use of electrical or biofuel-powered vehicles.	Mechanised MRF with capacity of 20 TPD for dry waste Mechanised composting plant of capacity 30 TPD for wet waste Integrated domestic hazardous waste management centre for recovering recyclables from hazardous waste Incineration of sanitary waste on daily basis Completion of treatment of legacy waste as soon as possible Engineered landfill for the cluster of Hanumangarh and Sangaria
Nagarpalika Pilibanga	Present Status	100% door to door collection No transfer station is present, so waste is directly dumped to dumpsites Segregated waste transport is not initiated	No composting unit is present but 20% of the waste is used for composting operations Material Recovery Facility has been initiated Recycling of waste is not done Sanitary landfill is not present Four dumpsites are present
	Action points	Source Segregation of waste. Educating general public at school level. Modification in collection frequency of waste based on type of waste. Incorporation of households on the extremity	Mechanised MRF with capacity of 15 TPD for dry waste Mechanised composting plant of capacity 20 TPD for wet waste Local collection and storage facility for domestic hazardous waste Incineration of sanitary waste on daily basis

		in waste collection programme. Use of electrical or biofuel powered vehicles.	Completion of treatment of legacy waste as soon as possible Engineered landfill for the cluster of Pilibanga and Rawatsar
Nagarpalika Sangaria	Present Status	100% door to door collection No transfer station is present, so waste is directly dumped to dumpsites Partial segregated waste transport is initiated	No composting unit is present Material recovery facility has been initiated Recycling of waste is not done One sanitary landfill site is present No old dumpsite is present
	Action points	Source Segregation of waste. Educating general public at school level. Modification in collection frequency of waste based on type of waste. Incorporation of households on the extremity in waste collection programme. Use of electrical or biofuel powered vehicles.	Mechanised MRF with capacity of 15 TPD for dry waste Mechanised composting plant of capacity 20 TPD for wet waste Local collection and storage facility for domestic hazardous waste Incineration of sanitary waste on daily basis Completion of treatment of legacy waste as soon as possible Engineered landfill for the cluster of Hanumangarh and Sangaria
Nagarpalika Rawatsar	Present Status	100% door to door collection No transfer station is present, so waste is directly dumped to dumpsites 20% efficiency in segregated waste transport	No composting unit is present Material recovery facility has been initiated Recycling of waste has been initiated Zero sanitary landfill site is present Two dumpsites are present
	Action Points	Source Segregation of waste. Educating general public at school level. Modification in collection frequency of waste based on type of waste. Incorporation of households on the extremity in waste collection programme. Use of electrical or biofuel powered vehicles.	Mechanised MRF with capacity of 20 TPD for dry waste Mechanised composting plant of capacity 20 TPD for wet waste Local collection and storage facility for domestic hazardous waste Incineration of sanitary waste on daily basis Completion of treatment of legacy waste as soon as possible Engineered landfill for the cluster of Pilibanga and Rawatsar
Nagarpalika Nohar	Present Status	100% door to door collection No transfer station is present, so waste is directly dumped to dumpsites	No composting unit is present but 2% of the waste is utilized in composting operations Material recovery facility has been initiated

		100% efficiency in segregated waste transport	Recycling of waste has not been initiated Zero sanitary landfill site is present One dumpsite is present
	Action Points	Source Segregation of waste. Educating general public at school level. Modification in collection frequency of waste based on type of waste. Incorporation of households on the extremity in waste collection programme. Use of electrical or biofuel powered vehicles.	Mechanised MRF with capacity of 20 TPD for dry waste Mechanised composting plant of capacity 25 TPD for wet waste Local collection and storage facility for domestic hazardous waste Incineration of sanitary waste on daily basis Completion of treatment of legacy waste as soon as possible Engineered landfill for the cluster of Nohar and Bhadra
Nagarpalika Bhadra	Present Status	100% door to door collection No transfer station is present, so waste is directly dumped to dumpsites Segregated waste transport is not initiated	No composting unit is present Material recovery facility has not been initiated Recycling of waste has not been initiated Zero sanitary landfill site is present One dumpsite is present
	Action Points	Source Segregation of waste. Educating general public at school level. Modification in collection frequency of waste based on type of waste. Incorporation of households on the extremity in waste collection programme. Use of electrical or biofuel powered vehicles.	Mechanised MRF with capacity of 20 TPD for dry waste Mechanised composting plant of capacity 20 TPD for wet waste Local collection and storage facility for domestic hazardous waste Incineration of sanitary waste on daily basis Completion of treatment of legacy waste as soon as possible Engineered landfill for the cluster of Nohar and Bhadra

4.3.2 Plastic Waste Management

ULBs should incorporate personnel from the informal sector, improve their skills via training and seminars, and increase material recovery facilities in cities. ULBs should integrate these informal employees into formal chains through waste management concessionaires, self-help groups, or non-governmental organizations (NGOs), ensuring that these workers of last resort are elevated and relocated to formal jobs.

Waste segregation at the source is a critical component that can improve material recovery and recycling rates. Once garbage is identified at the source as dry, moist, or hazardous, there is a considerable possibility to recover plastics from dry waste in material-recovery facilities. As a result, citizen involvement and engagement in plastics management are equally important.

The table below highlights the current status and future action plan for all ULBs in order to handle plastic waste efficiently.

Table 4.40 Summary about Plastic Waste Management for all the ULBs of Hanumangarh District, highlighting Present status and Action plan for future

Name of ULB	Present Status	Action Plan for future
Hanumangarh Nagar parishad ULB	Quantity of plastic waste generated has not been estimated. There is 100% provision of door-to-door collection of waste. 100% waste segregating is carried out during waste collection. Plastic waste collection at Material Recovery Facility has not been installed. There are no authorized PW in ULB. There is one PW collection centers. Linkages with PROs & NGOs have not been established. There are no PW recyclers, Manufacturers, Pyrolysis oil plants and Plastic pyrolysis plants. Nowhere plastic is utilized for road construction and neither co-processed in cement kiln. Units producing <50 micron carry bags are partially sealed. Sale of carry bags <50 micron is strictly prohibited. Ban on carry bags and other single use plastics as notified by State Government is implemented. The EPR through Producers/Brand-Owner has not been implemented. No producers are associated with ULB, no financial or infrastructure support is given, and no collection centres have been setup.	Implementation of Management by Waste Generator through EPR and PRO. Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc. to be implemented. Strict violations on open burning and littering.
Pilibanga Nagarpalika ULB	The estimated quantity of plastic waste generated is 0.05 TPD. There is 100% provision of door-to-door collection of waste. Only 20% waste segregation is done during waste collection. Plastic waste collection at Material Recovery Facility is not installed. There are 19 authorized PW pickers, and no PW collection centers in the ULB. Linkages with PROs & NGOs have not been established. There are 19 PW recyclers but, no Manufacturers, no Pyrolysis oil plants, and no	Plastic waste segregation should be done at source as a regular activity. Implementation of Management by Waste Generator through EPR and PRO. Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc. to be implemented.

Name of ULB	Present Status	Action Plan for future
	plastic pyrolysis plants in the ULB. Nowhere plastic is utilized for road construction but, about 0.01MT/day of plastic is co-processed in cement kiln. No action has been taken for sealing of units producing <50-micron plastic. Sale of carry bags <50micron is strictly prohibited. Ban on carry bags and other single use plastics as notified by State Government is implemented. The EPR through Producers/Brand-Owner has not been implemented. No producer is associated with ULB, no financial or infrastructure support is given, and no collection centres have been setup.	Strict violations on open burning and littering.
Sangaria Nagarpalika ULB	Quantity of plastic waste generated has not been estimated. There is 100% provision of door-to-door collection of waste. Partial waste segregating is being out during waste collection. Plastic waste collection at Material Recovery Facility is not installed. There are no authorized PW pickers in the ULB. PW collection centers are not established. Linkages with PROs & NGOs have not been established. There are no PW recyclers, Manufacturers, Pyrolysis oil plants and Plastic pyrolysis plants. Nowhere plastic is utilized for road construction and neither co-processed in cement kiln. Units producing <50 micron carry bags are totally sealed. Sale of carry bags <50micron is partially prohibited. Ban on Carry bags and other single use plastics as notified by State Government is implemented. The EPR through Producers/Brand-Owner has not been implemented. No producer is associated with ULB, no financial or infrastructure support is given, and no collection centres have been setup.	Plastic waste segregation at source should be done effectively as a regular activity. Implementation of Management by Waste Generator through EPR and PRO. Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc. to be implemented. Strict violations on open burning and littering.
Rawatsar	The estimated quantity of plastic waste generated is 14.00 TPD. There is 100%	Plastic waste segregation at source should be

Name of ULB	Present Status	Action Plan for future
Nagarpalika ULB	provision of door-to-door collection of waste. Only 20% waste segregating is carried out during waste collection. Plastic waste collection at Material Recovery Facility is not installed. There are 18 authorized PW pickers and one PW collection center in the ULB. Linkages with PROs & NGOs have not been established. There are 18 PW recyclers but, no Manufacturers, no Pyrolysis oil plants, and no plastic pyrolysis plants in the ULB. Nowhere plastic is utilized for road construction but, about 0.01MT of plastic is co-processed in cement kiln. No action has been taken for sealing of units producing <50-micron plastic. Sale of carry bags <50micron is strictly prohibited. Ban on carry bags and other single use plastics as notified by State Government is implemented. The EPR through Producers/Brand-Owner has not been implemented. No producer is associated with ULB, no financial or infrastructure support is given, and no collection centres have been setup.	done effectively as a regular activity. Implementation of Management by Waste Generator through EPR and PRO. Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc. to be implemented. Strict violations on open burning and littering.
Nohar Nagarpalika ULB	Quantity of plastic waste generated has not been estimated. There is 100% provision of door-to-door collection of waste. Segregating waste collection is not being carried out. Plastic waste collection at Material Recovery Facility is not installed. Authorization of PW pickers has not been initiated. PW collection centers have not been established. Linkages with PROs & NGOs have not been established. There are no PW recyclers, Manufacturers and Pyrolysis oil plants. Nowhere plastic is utilized for road construction and neither co-processed in cement kiln. Units producing <50 micron carry bags are partially sealed. Sale of carry bags <50micron is partially prohibited. Ban on Carry bags and other single use plastics as	Plastic waste segregation at source should be done effectively as a regular activity. Implementation of Management by Waste Generator through EPR and PRO. Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc. to be implemented. Strict violations on open burning and littering.

Name of ULB	Present Status	Action Plan for future
	notified by State Government is implemented. The EPR through Producers/Brand-Owner has not been implemented. No producer is associated with ULB, no financial or infrastructure support is given, and no collection centres have been setup.	
Bhadra Nagarpalika ULB	Quantity of plastic waste generated has not been estimated. There is 100% provision of door-to-door collection of waste. Segregating waste collection is not being carried out. Plastic waste collection at Material Recovery Facility is not installed. There are 75 authorized PW pickers in the ULB. PW collection centers are not established. Linkages with PROs & NGOs have not been established. There are no PW recyclers, Manufacturers and Pyrolysis oil plants. Nowhere plastic is utilized for road construction and neither co-processed in cement kiln. No action has been taken for sealing of units producing <50-micron plastic. Sale of carry bags <50micron is strictly prohibited. Ban on carry bags and other single use plastics as notified by State Government is implemented. The EPR through Producers/Brand-Owner has not been implemented. No producer is associated with ULB, no financial or infrastructure support is given, and no collection centres have been setup.	Plastic waste segregation at source should be done effectively as a regular activity. Implementation of Management by Waste Generator through EPR and PRO. Utilization of Non-recyclable plastic waste (Road Construction, Waste to Fuel, Waste to energy, alternative uses identification etc. to be implemented. Strict violations on open burning and littering.

4.3.3 Construction and Demolition Waste Management

The inventory of C&D waste suggests that a significant proportion of construction waste can be recycled and reused and brought back to construction to substitute naturally sourced material. This demands a circular economy that can turn C&D waste into a resource. This can help reduce energy intensity and environmental footprints of buildings and infrastructure.

Management of construction and demolition waste in the state shall be done as per the Construction & Demolition Rules 2016. Each local body shall issue detailed directions to the generators and others involved in the process on proper management of construction and demolition waste within its jurisdiction as per the provisions of these rules. Each ULB shall make a reasonable estimate on the quantity of construction and demolition waste generated in its jurisdiction and also work out the projections for future years. The ULBs shall ensure separate storage, collection and transportation of construction and demolition wastes. The ULBs shall make arrangements for the collection and transportation of Construction & Demolition waste either through their own resources or by appointing private operators.

Every ULB shall develop the collection centre or alternate collection mechanism for construction and demolition waste and hand it over to the authorized processing facility of construction and demolition waste.

ULB shall also keep a track of the major generation of construction and demolition waste within its jurisdiction and establish a data base and update once in a year. ULBs shall create a sustained system of information, education and communication for construction and demolition waste through collaboration with expert institutions and civil societies and also disseminate through their own website;

Table 4.41 Summary of present status, future projection and action points for C&D waste management in all the ULBs of Hanumangarh District

ULBs	Present Status	Action Points	Strategy and Approach
Nagar Parishad Hanumangarh	1. Estimated quantity of C&D waste is not mentioned properly. 2. Amount of C&D waste collected, dump is calculated. 3. Implement scheme for permitting bulk waste is not being issued by ULB. 4. Issuance of permission by ULB for establishment of C&D waste deposition is not being initiated and C&D waste deposition is not identified there. 5. Implementation of By-Laws for C&D waste management is being notified. 6. Collection of deposition/disposal charge is being initiated. 7. C&D recycling plant doesn't exist.	Inventory of C&D waste generation	1.Survey and Investigate the C & D generators under the jurisdiction of ULB. 2. Identify regular bulk waste generators (Contractors or Builders) 3. Distribution of Staffs in Collecting, Transporting and Processing of C & D 4. Treatment of C & D Wastes or Transformation
		Implement scheme for permitting bulk waste generators	1. Contractors/Builders should have registration id in the ULBs to collect & transfer the C & D Wastes to the C & D Deposition Center for treatment. 2. The Generators should contact the ULB staffs or Constructors/Builders. 3. The generators should be charged as per by law.
		Establishment of C&D Waste Deposition centers	1. Identify the transportation point.
		Establishment of C&D Waste recycling plant or linkage with such facility	1. Involve NGOs or to startups to establish a C&D Waste recycling plant, 2. ULB of Hanumangarh should established C&D recycling plant in the form of cluster with Hanumangarh, Pilibanga, and Sangaria
Nohar	1. Estimated quantity of C&D waste is not mentioned properly. 2. Amount of C&D waste collected and dump is not calculated. 3. Implement scheme for permitting bulk waste is not being initiated by ULB. 4. Issuance of permission by ULB for establishment of C&D waste deposition is not being initiated and C&D waste deposition is not identified there.	Inventory of C&D waste generation	1.Survey and Investigate the C & D generators under the jurisdiction of ULB. 2. Identify regular bulk waste generators (Contractors or Builders) 3. Distribution of Staffs in Collecting, Transporting and Processing of C & D 4. Treatment of C & D Wastes or Transformation
		Implement scheme for permitting bulk waste generators	1. Contractors/Builders should have registration id in the ULBs to collect & transfer the C & D Wastes to the C & D Deposition Center for treatment.

	5. Implementation of By-Laws for C&D waste management is being notified. 6. Collection of deposition/disposal charge is being initiated. 7. C&D recycling plant doesn't exist.		2. The Generators should contact the ULB staffs or Constructors/Builders. 3. The generators should be charged as per by law.
		Establishment of C&D Waste Deposition centers	1. Identify and allocation of land for deposition center 2. Construction and fencing of deposition center. 3. Identify the transportation point.
		Establishment of C&D Waste recycling plant or linkage with such facility	1. Involve NGOs or to startups to establish a C&D Waste recycling plant, 2. C&D recycling plant will be established in Nohar and can be performed in the form of cluster with Rawatsar, Bhadra, and Nohar.
Bhadra	1. Estimated quantity of C&D waste is not mentioned properly. 2. Amount of C&D waste collected and dump and recycled is not calculated. 3. Implement scheme for permitting bulk waste is not being initiated by ULB. 4. Issuance of permission by ULB for establishment of C&D waste deposition is not being initiated and C&D waste deposition is not identified there. 5. Implementation of By-Laws for C&D waste management is being notified. 6. Collection of deposition/disposal charge is being initiated. 7. C&D recycling plant does not exist.	Inventory of C&D waste generation	1.Survey and Investigate the C & D generators under the jurisdiction of ULB. 2. Identify regular bulk waste generators (Contractors or Builders) 3. Distribution of Staffs in Collecting, Transporting and Processing of C & D 4. Treatment of C & D Wastes or Transformation
		Implement scheme for permitting bulk waste generators	1. Contractors/Builders should have registration id in the ULBs to collect & transfer the C & D Wastes to the C & D Deposition Center for treatment. 2. The Generators should contact the ULB staffs or Constructors/Builders. 3. The generators should be charged as per by law.
		Establishment of C&D Waste Deposition centers	1. Identify and allocation of land for deposition center 2. Construction and fencing of deposition center. 3. Identify the transportation point.
		Implementation of By-Laws for C & D Waste Management	1. Publish notification for registration of C & D Waste generators, generator charge, transportation cost, selling price, etc. By-Laws.
		Establishment of C&D Waste recycling plant or	1. Involve NGOs or to startups to establish a C&D Waste recycling plant,

		linkage with such facility	2. C&D recycling plant will be established in Nohar and can be performed in the form of cluster with Rawatsar, Bhadra, and Nohar.
Sangaria	1. Estimated quantity of C&D waste is not mentioned properly. 2. Amount of C&D waste collected and dump is 14 TPD. 3. Implement scheme for permitting bulk waste is not being initiated by ULB. 4. Issuance of permission by ULB for establishment of C&D waste deposition is not being initiated and C&D waste deposition is not identified there. 5. Implementation of By-Laws for C&D waste management is not being notified. 6. Collection of deposition/disposal charge is not being initiated. 7. C&D recycling plant is not established.	Inventory of C&D waste generation	1.Survey and Investigate the C & D generators under the jurisdiction of ULB. 2. Identify regular bulk waste generators (Contractors or Builders) 3. Distribution of Staffs in Collecting, Transporting and Processing of C & D 4. Treatment of C & D Wastes or Transformation
		Implement scheme for permitting bulk waste generators	1. Contractors/Builders should have registration id in the ULBs to collect & transfer the C & D Wastes to the C & D Deposition Center for treatment. 2. The Generators should contact the ULB staffs or Constructors/Builders. 3. The generators should be charged as per by law.
		Establishment of C&D Waste Deposition centers	1. Identify and allocation of land for deposition center 2. Construction and fencing of deposition center. 3. Identify the transportation point.
		Implementation of By-Laws for C & D Waste Management	1. Publish notification for registration of C & D Waste generators, generator charge, transportation cost, selling price, etc. By-Laws.
		Establishment of C&D Waste recycling plant or linkage with such facility	1. Involve NGOs or to startups to establish a C&D Waste recycling plant, 2. ULB of Hanumangarh should established C&D recycling plant in the form of cluster with Hanumangarh, Pilibanga, and Sangaria.
Pilibanga	1. Estimated quantity of C&D waste is calculated i.e., 2500Kg/Day. 2. Amount of C&D waste collected and dump is 3 and 2 TPD respectively. 3. Implement scheme for permitting bulk	Inventory of C&D waste generation	1.Survey and Investigate the C & D generators under the jurisdiction of ULB. 2. Identify regular bulk waste generators (Contractors or Builders) 3. Distribution of Staffs in Collecting, Transporting and

	waste is not being initiated by ULB. 4. Issuance of permission by ULB for establishment of C&D waste deposition is being initiated and C&D waste deposition is identified there. 5. Implementation of By-Laws for C&D waste management is being notified. 6. Collection of deposition/disposal charge is not being initiated. 7. C&D recycling plant is not established.		Processing of C & D 4. Treatment of C & D Wastes or Transformation
		Implement scheme for permitting bulk waste generators	1. Contractors/Builders should have registration id in the ULBs to collect & transfer the C & D Wastes to the C & D Deposition Center for treatment. 2. The Generators should contact the ULB staffs or Constructors/Builders. 3. The generators should be charged as per by law.
		Establishment of C&D Waste Deposition centers	1. Identify and allocation of land for deposition center 2. Construction and fencing of deposition center. 3. Identify the transportation point.
		Implementation of By-Laws for C & D Waste Management	1. Publish notification for registration of C & D Waste generators, generator charge, transportation cost, selling price, etc. By-Laws.
		Establishment of C&D Waste recycling plant or linkage with such facility	1. Involve NGOs or to startups to establish a C&D Waste recycling plant, 2. ULB of Hanumangarh should established C&D recycling plant in the form of cluster with Hanumangarh, Pilibanga, and Sangaria.
Rawatsar	1. Estimated quantity of C&D waste is calculated i.e., 2500Kg/Day. 2. Amount of C&D waste collected, and dump is 2.5 and 0 TPD respectively. 3. Implement scheme for permitting bulk waste is being initiated by ULB. 4. Issuance of permission by ULB for establishment of C&D waste deposition is being initiated and C&D waste deposition is identified there. 5. Implementation of By-Laws for C&D waste management is being notified.	Inventory of C&D waste generation	1.Survey and Investigate the C & D generators under the jurisdiction of ULB. 2. Identify regular bulk waste generators (Contractors or Builders) 3. Distribution of Staffs in Collecting, Transporting and Processing of C & D 4. Treatment of C & D Wastes or Transformation
		Implement scheme for permitting bulk waste generators	1. Contractors/Builders should have registration id in the ULBs to collect & transfer the C & D Wastes to the C & D Deposition Center for treatment. 2. The Generators should contact the ULB staffs or Constructors/Builders.

	6. Collection of deposition/disposal charge is not being initiated. 7. C&D recycling plant is not established.		3. The generators should be charged as per by law.
		Establishment of C&D Waste Deposition centers	1. Identify and allocation of land for deposition center 2. Construction and fencing of deposition center. 3. Identify the transportation point.
		Implementation of By-Laws for C & D Waste Management	1. Publish notification for registration of C & D Waste generators, generator charge, transportation cost, selling price, etc. By-Laws.
		Establishment of C&D Waste recycling plant or linkage with such facility	1. Involve NGOs or to startups to establish a C&D Waste recycling plant, 2. C&D recycling plant will be established in Nohar and can be performed in the form of cluster with Rawatsar, Bhadra, and Nohar.

4.3.4 Bio-Medical Waste Management

The need for proper biomedical waste management has been recognized by both government agencies and non-governmental organizations. There are several hazards and dangerous objects that should be handled and disposed of with care. Inadequate and inefficient segregation and transportation networks may constitute a severe hazard to society, necessitating the installation of safeguards and laws in writing. All of these circumstances enhance the likelihood of biomedical hazards being exposed to employees, patients, and the general public.

To accelerate the creation of appropriate processing and management processes, timely regulatory and legislative rules and procedures are required. To be properly separated, processed, and isolated, wastes must be well-characterized, which is difficult. Handling biomedical waste properly and effectively is not just a legal requirement, but also a social obligation.

Table 4.42 Summary about Bio-Medical Waste Management for all the ULBs of Hanumangarh District, highlighting Present status and Action plan for future

Name of ULB	Present Status	Action Plan for future
Hanumangarh District	• Quantity of Bio Medical waste generated at each ULB has not been provided for the latest data. There is only data available for the year 2008. • There is 100% provision of segregation at source and collection of non-hazardous waste in Municipal Solid Waste. • Common Bio-Medical Waste Treatment Facility has not been installed. One CBMWTF present at sri-ganganagar is being used. • Barcode on Colour Coded Bags are not being placed for tracking of waste in Sangaria, Rawatsar and Bhadra Nagarpalika.	• GPS enabled vehicles for Biomedical wastes transportation • Authorization to HCFs and Occupiers and Submission of Annual report to CPCB. • Authorization to HCFs and Occupiers and Submission of Annual report to CPCB. • Compliance of regulation by common biomedical waste treatment facility

A lack of caring among people working in the sector, a lack of motivation, a lack of awareness, and a cost aspect are some of the challenges encountered in proper hospital waste management. To perform complete surveys of waste management processes in various practices, it is required to undertake thorough surveys of waste management processes in various practices. There is a need for more education about the consequences of improper waste disposal.

Given the lack of understanding of biomedical waste management at all levels of healthcare employees, an effective communication strategy is critical.

4.3.5 Hazardous Waste Management

To summarize, the district has seven authorized industries capable of generating hazardous waste and recycles/utilizes around 384.27 MT/annum hazardous waste. The focus should be on industrial waste documentation in individual ULBs, hazardous waste segregation at source and maintaining a detailed hazardous waste profile.

Table 4.43 Summary of present status and action points for Hazardous Waste Management in all the ULBs of Hanumangarh

Present status	Action Points	Strategy and approach	Stakeholder responsible
Total quantity of hazardous waste generated in the district is 384 tonnes; Out of this landfill-able waste is 0.52 tonnes and rest is all recyclable.;	Hazardous waste reduction measures; Proper management of domestic hazardous waste	Recycle more waste rather than disposal; Documentation of hazardous waste profile; Stricter registration of hazardous waste generating industries; record-keeping for household hazardous waste	SPCB, waste generators

4.3.6 E-Waste Management

Currently there is nothing done for the E-waste management at any of the ULB.

Table 4.44 Action Plan for E-Waste Management ULBs

Name of district	Present Scenario	Action Plan for future
Hanumangarh district	No data is being kept for e-waste.	• Proper collection of newly generated E-waste and orphaned E-waste products; • Establishing collection centers; • Practice Scientific segregation and dismantling method; • Strategic recycling methods to be used; • EPR to be followed by the producers; • Monitoring with reference to E-waste Management rules, 2016; • Licensing and authorizing producers and institutions according to the guidelines.; • Safety measures to be followed at all levels including collection, segregation, transportation etc; • Develop Public awareness about the dangers of E-waste through social media campaigns and other resources; • Stricter rules to prohibit dumbing of E-waste mixed with other municipal wastes; • Legal rigidity against illegal transportation and imports of E-waste; • Acknowledging the rights of the workers and ensuring their safety.

E-waste management should be considered as an urgent need and measures have to be taken. The future projection for each ULB shows that there is a considerable increase in the quantity of E-waste generated. The lack of grass root level data on management system including quantification, characteristics and existing disposal practices makes detailed assessment of the current and future scenario very difficult. A holistic approach which is also self-sustained to manage the system from the generation to disposal will be effective in handling the issue. It can make use of technological advancements and create a sustainable consumer culture where the public is aware of the environmental and health hazards caused by E-waste. Care should also be taken to ensure the E-waste policy is functional and strengthening the legal aspects of the system.

5. Water Quality Management

5.1 Water Quality Monitoring

The term "water quality" is defined as those physical, chemical or biological characteristics of water by which the user evaluates the acceptability of water. According to the Constitution of India, water supply is a state subject while The Union Government is only responsible for setting water quality standards. To address the emerging need to decentralise water quality monitoring in India Rajiv Gandhi National Drinking Water Mission (RGNDWM) initiated a programme on community-based water quality monitoring (CBWQM); An initiative that seeks to ensure safe water through a comprehensive surveillance process, incorporating monitoring, data processing, evaluation, sanitary monitoring, evaluation, sanitary surveys, public health assessment and remedial and preventive action throughout the length and breadth of the country (R. K. Sharma et al., 2017).

The water quality management plan is made to reduce the discharge of pollutants into urban runoff from the development projects. This can be done by reducing or eliminating the source of pollutants and managing site run off volumes and flow rates through the application of the best management practices.

5.1.1 Literature review

Water quality is deteriorating all over the world, in both developed and developing countries. The types, extents and magnitudes of water quality problems differ from country to country and sometimes within the same country. In the global context, at least 4 billion people in the world do not have access to safe drinking water. In the entire South Asian region of over 1.7 billion people, the majority of people think tap water is safe to drink. World Health Organization's data report that 3.4 million people die due to water-borne diseases. Ground water quality measures should be ensured to prevent water-borne diseases, harm to the environment, soil degradation and damage to sensitive crops. The global focus was always been on the water as a human right; the quality of water was not the main concern. In a developing country, fewer than 10% of people have access to wastewater collection and treatment. Water Quality monitoring is not a simple task (R. K. Sharma et al., 2017).

Water quality was listed as one of the primary challenges in Asia in the next century by the United Nations System (1997) in its recent analysis of global water scarcity. The most visible evidence of water quality degradation in most of the Asian countries is of serious human health issue which is linked to the discharge of pathogens into drinking water resources. Along with human health, it is causing severe impact on aquaculture in surface water resources which can be observed by the spread of algae on surface water, eutrophication of lakes and fish kills. Waste water discharge is causing destructive influence in near-shore and off-shore marine environments in Asia. The status of water quality should form the basis for a national action programme on water quality management in the developing countries in Asia and Pacific. Countries in the Asia Pacific region faces many problems in water quality monitoring such as parameters used for water quality monitoring is out-of-date, methodology used is very old, data collected is sometimes unreliable and it is not converted into data products that can be used for decision making (Castonguay et al., 2018).

According to the government sources of India in 2016, 21 million people in over 23,500 habitations were affected by arsenic and fluoride contaminated groundwater. In December 2018, the Minister of State for Drinking Water and Sanitation mentioned that out of 25,000 odd habitations across 16 states, 15,811 were affected by arsenic, and 9,660 were affected by fluoride.

The groundwater is being exploited excessively in several ways and this is increasing the amount of the chemical contamination. This is the reason why the drinking water schemes have been introduced wherein the use of groundwater has been decreased whereas the use of surface water has increased.

The government of India has come up with National Water Policy in year 2012 (GOI, 2012). To ensure an integrated approach to water resource development, with rational and equitable resource distribution and priority for the poor and unserved, a comprehensive policy structure is required. Efficient policy mechanisms regard water as a scarce and fragile resource over the long term and address the entire water cycle. They even keep an eye on main behavioural functions at all times (GOI, 2012). They also keep track of critical behavioural functions at all stages. Establishing standards and objectives, as well as a mechanism to track and use them as benchmarks for planning and management, should all be part of an effective policy process. The government's goals and strategies for achieving them should be stated in a national water sector strategy. It will provide investment and project planning recommendations, to ensure that water supply development takes into account water resource management and environmental factors, such as fair allocation of water resources and pollution prevention.

Governance and Management Structure

Rajasthan State Pollution Control Board

The Rajasthan State Pollution Control Board was constituted under section 4 of the Water (Prevention and Control of Pollution) Act, 1974 on 7th February 1975, with the objectives of prevention, and control of water pollution and maintaining or restoring of wholesomeness of water. Water (Prevention and Control of Pollution) Cess Act, 1977 has been enacted to make the State Board financially independent. Under this act, the State Board has been given powers to collect cess based on water consumed by the industries etc. Enactment of the Environment (Protection) Act, 1986 has further widened the scope of the activities of the Board. This Act being umbrella legislation, different rules for addressing the problems of various sectors have been enacted under this Act. The State Board is engaged in the implementation of the rules made under the Environment Protection Act, 1986.

Public Health Engineering Department

PHED is responsible for providing potable water to every citizen of Rajasthan state. PHED is shifting from ground water-based schemes to surface water source-based schemes in a phased manner. PHED is using the resources available to tackle the water problems of the state which includes erratic rainfall, depleting water table and degraded quality of natural water available.

Best practices for Water Quality Management

Integrated Urban Water Management (IUWM)

Integrated Urban Water Management (IUWM) is an approach that builds on planning, managing and maintaining the water sector in cities by considering entire urban water loop and closing it. IUWM is been acknowledged in India since the year 2015 as the robust solution to manage urban water sector. City's hydrology, economy, institutional mechanisms, governance and social structure need to take in consideration while adopting the integrated approach for water sector in India. The framework can be divided into three major parts namely environment, institutional arrangements and management instruments. Different agencies which are working in the water sector of city helps in adopting this framework. Coordination among these agencies needs to be improved. Closing the loop of water sector will help in sustainable development of the cities. It ensures the water supply, sewage management, solid waste management and storm water management. This framework is analyzed for a city of Delhi by analyzing Delhi's enabling environment for IUWM, analyzing institutions and analyzing management instruments.

Waste Water Management

One of the major causes of degradation in the surface water quality is waste water which is directly disposed into the surface streams or lakes. To manage the pollution caused by these sources, Waste Water Management is necessary.

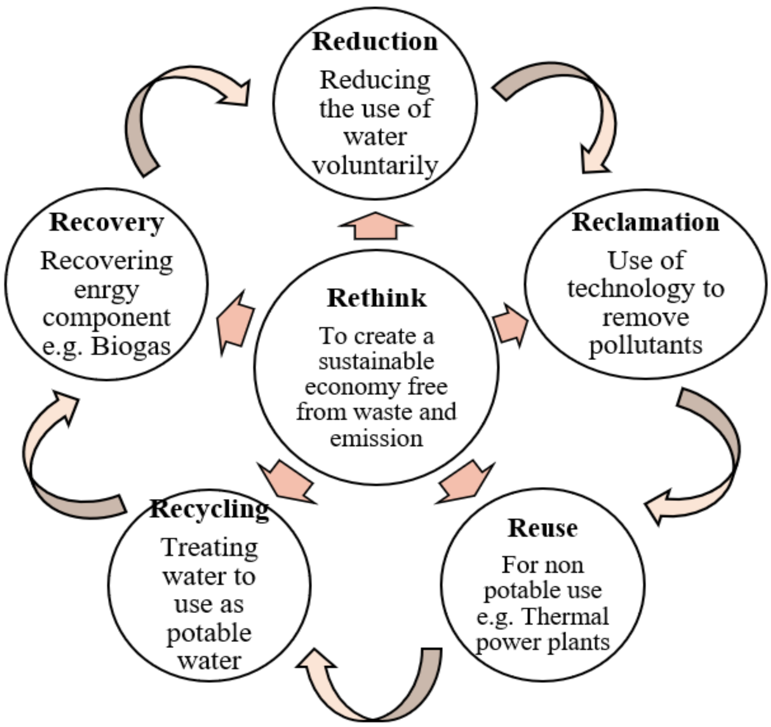


Figure 5.1 Circularity in Waste water Management

A transition from a linear economy to a circular economy will be helpful in the adoption of waste water reuse in the community. Reclaimed water reuse is adopted by many countries in the world, but the proportion of water reuse in total waste water is still very less. The circular economy will help to achieve sustainable development goals. Circularity in waste water management can be achieved by reduction, reclamation, reuse, recycling, recovery and rethink (Figure 5.1). These practices will ensure awareness in the public, reduce the quantity of waste water and reduce the cost of treatment of waste water which will finally lead to Zero Liquid Discharge (ZLD). ZLD will ensure to recover all the water and contaminants are converted into solid waste. This will decrease the waste volume produced.

5.1.2 Present Scenario and Gap Identification

Climatic Condition

Hanumangarh possesses the characteristics of semi-arid to arid climatic conditions except for southwest monsoon season during the period June to mid-September, which is followed by the post-monsoon period till the end of November. The winter season lasts from December to February which is then followed by summer from March to June. The temperature of the Hanumangarh district varies from 20.5°C during January to 42.2°C during June.

The climate in the district is mostly arid and it turns extremely hot during the summer and extremely cold during winters. The maximum average temperature ranges from 18°C to 48°C and minimum average temperature ranges in between 2°C to 28°C.

Table 5.1 Month-wise Average Climatic Condition for Hanumangarh District

Climatic Attributes / Month	January	February	March	April	May	June	July	August	September	October	November	December
Maximum Temperature (°C)	24.2	29.2	36.1	41.8	45.3	45.3	41.2	38.1	37	34.9	31.3	25.4
Minimum Temperature (°C)	5.2	7.8	14.7	19.1	22.5	22.1	27.1	26.1	22.2	17.9	11.9	4.3
Average Temperature (°C)	13	17.5	23.6	29.6	33.5	33.5	31.5	31.7	29.7	25.7	20.2	13.8
Precipitation (2008-13) (mm)	6.1	6.1	3.4	6.3	14.3	21.3	60.3	60.4	62.2	1.3	10.7	1.5
Wind Velocity (km/h)	1.6	2.7	3.3	3.8	4.4	5.5	5.2	4.3	3.5	1.6	1.0	1.0

(Source: Meteorological Department, Jaipur 2018)

Soil Profile

The district is located in the transition zone where Aravalli Mountain ranges end and a vast arid plain start forming part of the Thar Desert characterized by sand dunes and scanty outcrops with little vegetation. The northern part of the district is covered by arid soils which are characterized by alluvial soils. These soils are loamy. Entisols i.e. desert soil id found in the central part of the district which is loamy along the Ghaggar river. The southern part of the district is characterized by arid soils i.e. non-calcic brown desert. The district is a part of the Thar Desert and is covered by a thick layer of alluvium and wind-blown sand.

Land Utilization Pattern

Land form, slope, soil typology and availability of natural resources are the important factors that direct the land utilization pattern of a settlement. The most dominant land use in district is agriculture which encompasses 83.76 percent of TGA. With significant differences in percentage, Built-up class stands second after agriculture.

Table 5.2 Percentage of Land Use with respect to Total Geographic Area of Hanumangarh

Land Use Classes / Year	1977 (%)	1989 (%)	1999 (%)	2008 (%)
Agriculture	87.51	89.04	87.71	83.76
Barren	5.94	3.74	2.91	4.40
Built-Up	2.91	3.16	4.43	5.46
Forests	1.62	2.00	2.42	3.59
Water-Bodies	2.02	2.06	2.53	2.79

Drainage Pattern in Hanumangarh District

The only marked surface water drainage is Ghaggar river which flows from North east direction to South West direction of the district. It is an ephemeral river which means lasts for very short time of duration mostly in monsoon season. Sometimes it gets flooded during monsoon.

Irrigation water is supplied with the help of three canals in the district, namely Bhakra Canal System, Indira Gandhi Nahar Pariyojana and Sidmukh Canal System. The canal water is also used for domestic purpose. Bhakra Canal system derives water from Sutlej and Beas rivers. Bhakra canal System provides 2096 mcm/year of water to Rajasthan state which irrigates 372,000 hectares of land in the state. The length of canal network in the state is 1,949 Km. Northern parts of the Hanumangarh district is irrigated by branches of Bhakra Canal System.

Indira Gandhi Nahar Pariyojana is a multidisciplinary irrigation project conceived to use 10.69 Billion Cubic Metres per year of water available from Ravi and Beas rivers, to cultivate 1087 million hectares of the land in Thar Desert of western Rajasthan. Sidmukh Nohar Canal Syatem is an irrigation project planned to provide irrigation in Nohar and Bhadra tehsils by utilizing Rajasthan's share in Ravi and Beas waters.

Surface Water

The only major river in the district is Ghaggar River which is locally known as Nali. The course of Ghaggar river is northeast to southwest, which finally enters into the Pakistan. It is an ephemeral stream i.e. it lasts for very short duration of time. Sometimes river get flooded in the monsoon. River bed is cultivated by nearby farmers throughout the year. Due to development of canal network in the district area has become water rich, which is leading to water logging problems in some of the parts of district. Three major canal networks namely Bhakra Canal System, Indira Gandhi Nahar Pariyojana and Sidmukh Nohar Canal System made this region one of the prominent agricultural areas.

Surface water Quality

Ghaggar river is the only natural surface resource for the district. Due to less rainfall water flow in the river is almost negligible. Water quality during the monsoon period in 2011 is shown in the table below.

Table 5.3 Ghaggar River Water Quality at Hanumangarh District, 2011, Source: (Central Ground Water Board, 2020)

Sr. No.	Parameter	Concentration
1.	DO (mg/l)	5.0
2.	pH	7.3
3.	Electrical Conductivity (µs/cm)	390
4.	BOD (mg/l)	2.8
5.	Nitrate (mg/l)	0.14
6..	Faecal Coliform (MPN/100 ml)	4
7.	Total Coliform (MPN/100 ml)	20

Ground Water: Definition and Casual Factors

Groundwater is water that exists underground in saturated zones beneath the land surface. The upper surface of the saturated zone is called the water table (USGS, 2019). Ground water occurs under unconfined to semi-confined condition. The porosity and permeability of a geologic formation controls its ability to hold and transmit water. Both natural and human-induced artificial factors act on the availability and quality of groundwater. The accessibility to groundwater as a water source depends principally upon the surface and subsurface geology, climate and Land Use Land Cover (LULC).

Groundwater varies with the evolution of a settlement. Primarily, the groundwater existence patterns, over the years, are studied to determine the rate of augmentation or deterioration which might have happened due to natural occurrences or human interferences.

Status of Groundwater in Hanumangarh District

The availability, occurrence and movement of ground water are mainly controlled by the topographic features, physical characteristics and structural features present in the geological formations. Ground water occurs under water table condition but at some places, it occurs under semi-confined condition due to the presence of over lying impermeable clay horizons. Hanumangarh district is divided into two units namely Younger Alluvium and Older Alluvium. Younger alluvium covers maximum area of the district in comparison to older alluvium, which covers only the southern part of the district.

Existing Aquifer System

Aquifers are determined based on the absence or presence of water table positioning and are classified into confined, unconfined, leaky aquifers and fractured aquifers. The properties of an aquifer depend on the physical characteristics of the existing materials, porosity, permeability, cultivation yield, storage, and hydraulic conductivities, which are determined by techniques like resistivity surveys and pumping tests followed by remote sensing and geographic information system for better information on the groundwater system.

Table 5.4 Ground Water Level Index with Status and Class for Hanumangarh District

Year	Ground Water Level Index (G.WL.I)	Status	Class
2019	0.876	Good	B
2020	0.878	Good	B
Average of 2019 % 2020	0.877	Good	B

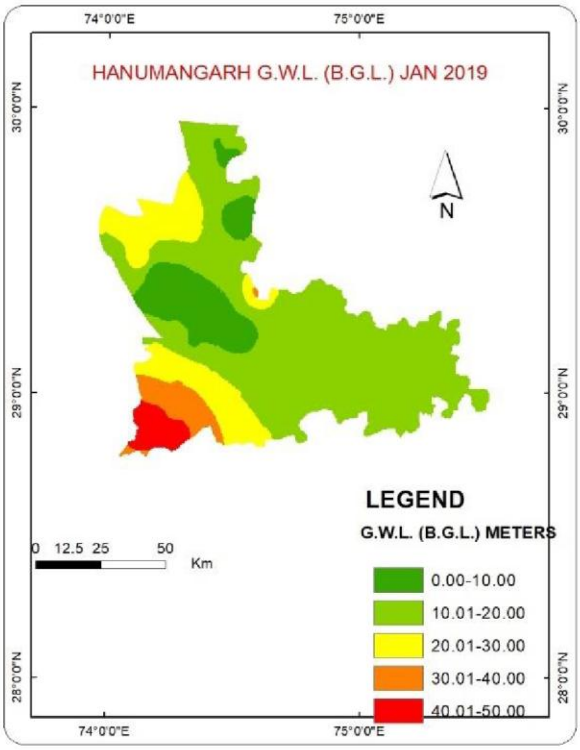
Younger alluvium comprises unconsolidated to loosely consolidated sediments of sand, silt, clay and kankar. All the potential zones of the district fall in younger alluvium making it the principal aquifer. Except for Rawatsar almost all tehsils have younger alluvial formation. Older alluvium comprises of sandy and gypseous clay with kankar. It does not contain any potential zone.

Groundwater in Aquifer

Central Ground Water Board periodically monitors the National Hydrograph Network Stations (NHS) located at Hanumangarh district, four times a year i.e., in January, May (Pre-monsoon), August and November (Post-monsoon). State Ground Water Board also monitors the ground water with the help of 53 dug wells and 52 piezometers in the district.

According to the pre-monsoon study in the year 2020 depth of water level varied from 1.35 m to 44.8 m during pre-monsoon, 2019. It was observed in 24 observation wells that the water level reached to 20 m in the South eastern and north western part of the district. This is shown with the help of the figure. Central part of the district shows 2 to 5m water level variation and remaining area of the district ranges 10 to 20 MBGL.

A study was conducted on a ground water table level below the ground level for Hanumangarh district. Depth range of ground water level for the year 2019 and 2020 is analyzed for the four months i.e. January, May, August and November. Based on results obtained Ground Water Level Index is calculated. The data for the years 2019 and 2020 shows the district condition is GOOD.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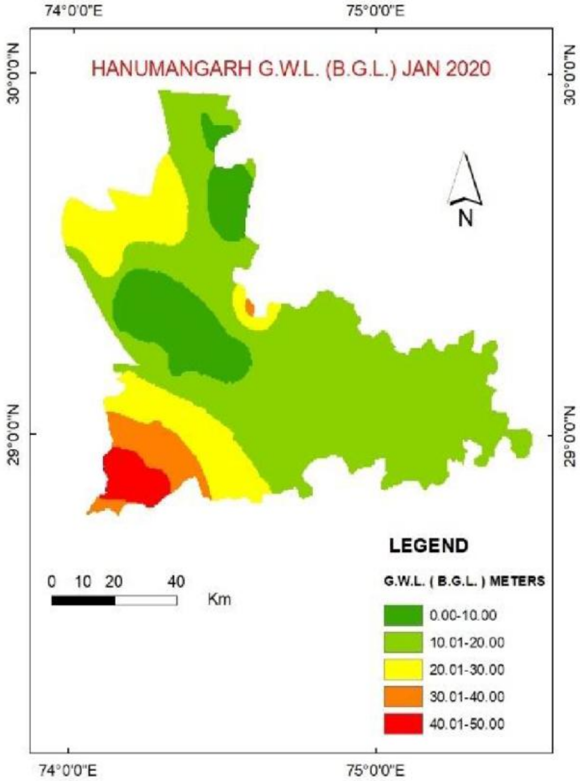
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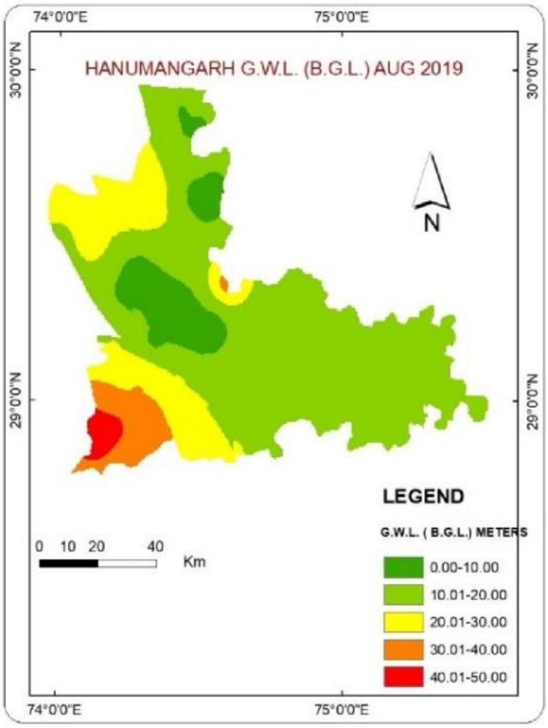
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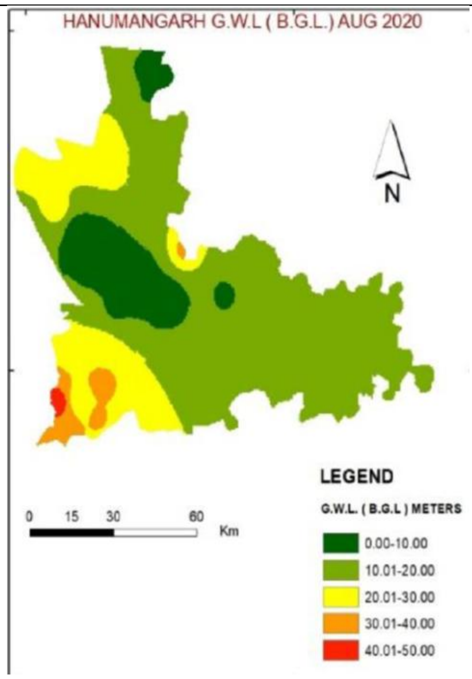
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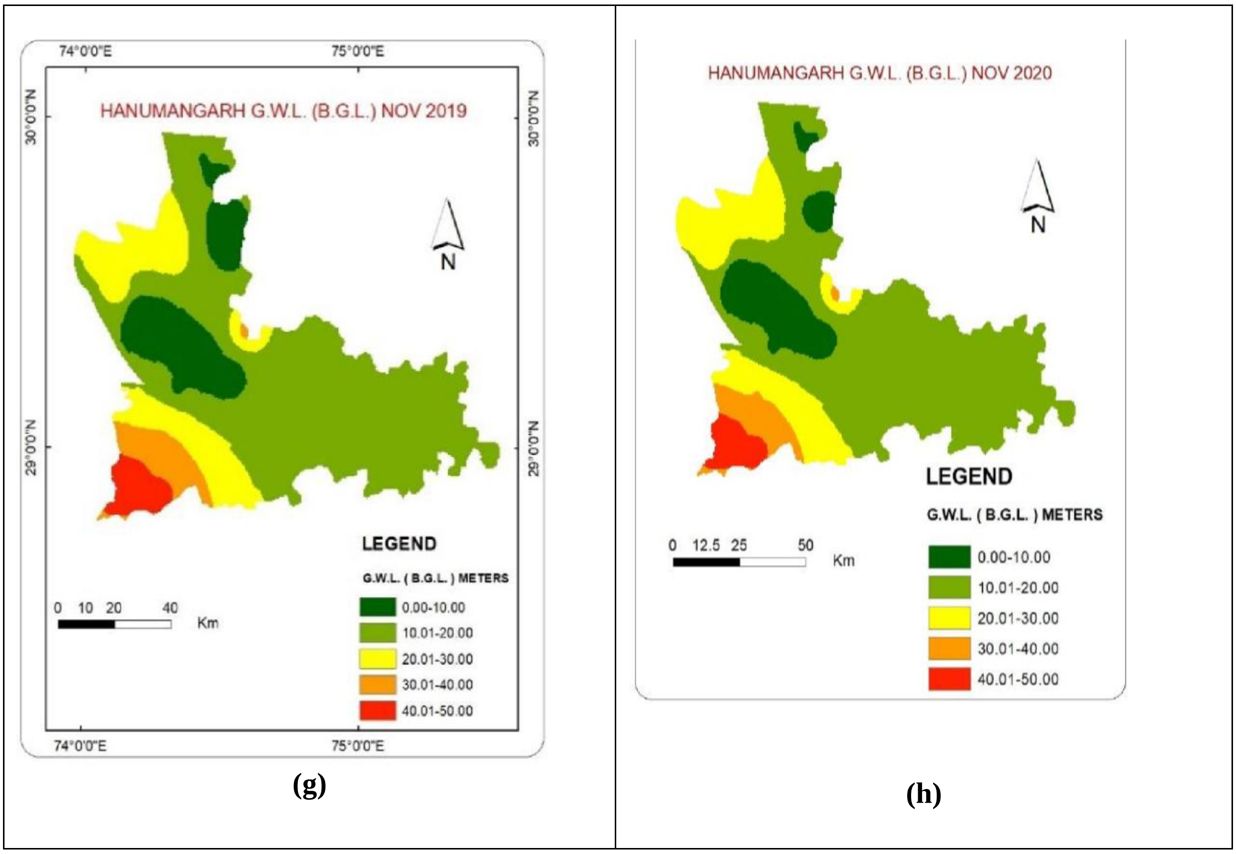
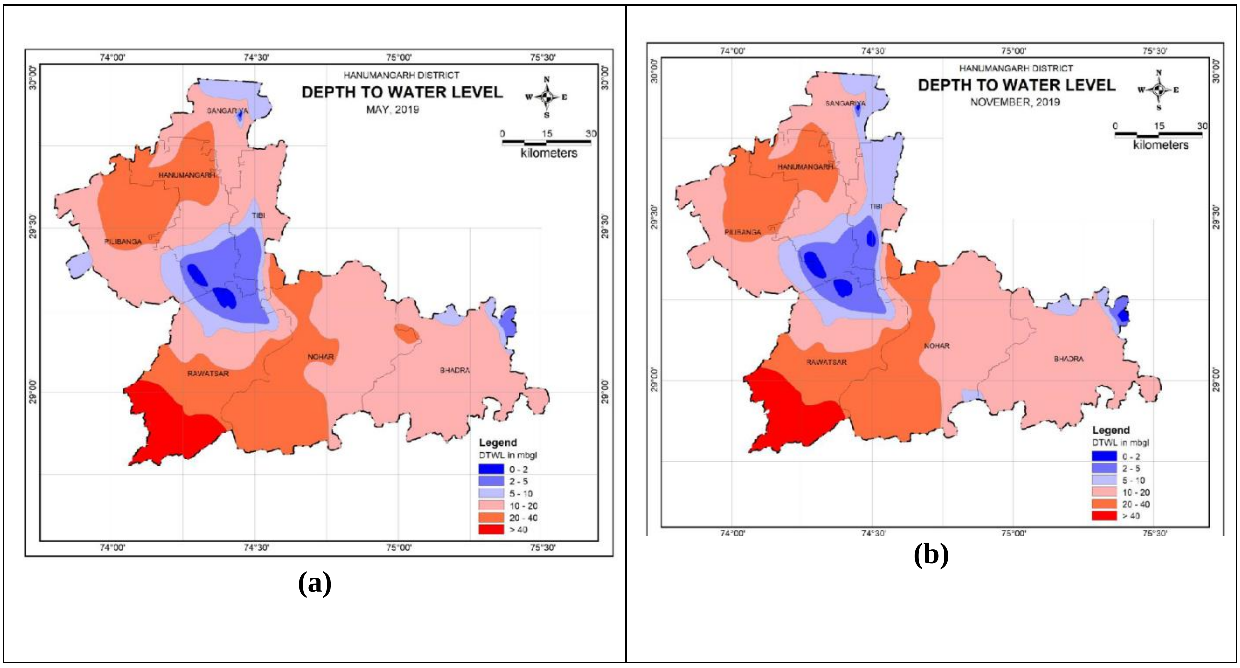


(g) (h)

Figure 5.2 Pre-Monsoon and Post Monsoon Ground water level in Hanumangarh District in (a) and (b) Januanry 2019,2020 (c) and (d) May 2019,2020 (e) and (f) August 2019,2020 (g) and (h) November 2019, 2020 (Source: Jain, 2021)



(a) (b)

Figure 5.3 Depth to water Level map of (a) May 2019 and (b) November 2019 in Hanumangarh District

A total of 141 wells were analyzed post-monsoon 2019 and the depth of water level varied from 0.29 to 48.92 m. This is shown with the help of the figure. Water level scenario of the district divides it into two parts vertically. Western part of the district have a deeper water level which ranges between 10 to 20 m as analyzed from 34 wells. Ground water reaches below the 20 m in 14 wells in some of the areas whereas; in some of the areas, it goes below 40 MBGL in 2 wells in south eastern part of the district.

Ground water Quality:

Many factors affect the quality of surface and groundwater. Water moving over or under the land surface can undergo physical and chemical changes. These changes may be caused by either natural factors or human activities. The concentration of various gases and ions dissolved in water from the atmosphere, soil strata and minerals and rocks with which it comes is the characteristics of water. The presence of gases and ions ultimately decides the quality of ground water. The ions and gases which are responsible for acidic and basic nature of water are CO_3^{2-}, HCO_3, $OH^-$and H^+. The presence of ions like Ca^{2+} and Mg^{2+} makes it soft or hard. Presence of Na^+ and Cl^- in high concentrations makes water saline. The amp below shows the water quality sampling locations in the Hanumangarh district.

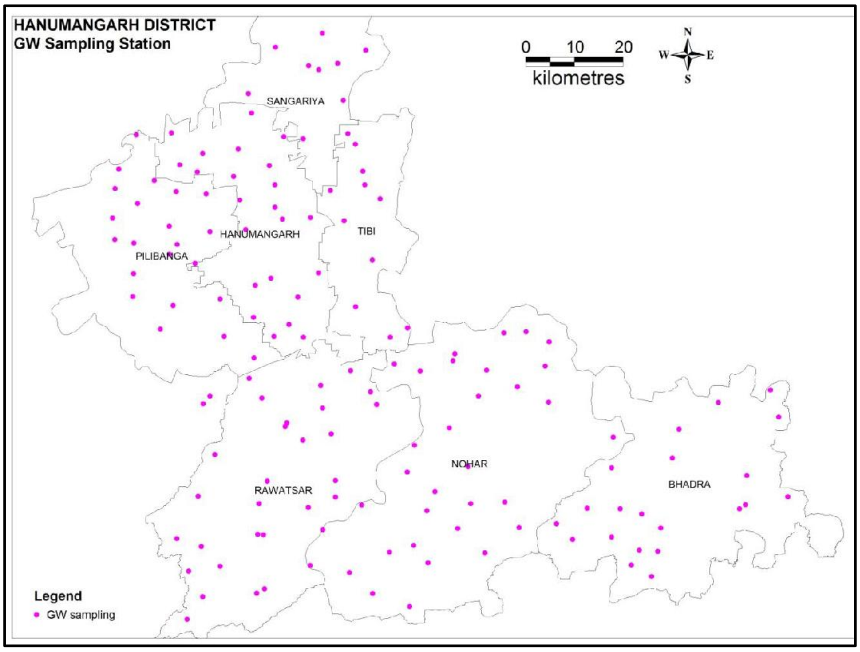


Figure 5.4 Map Showing Water Quality Sampling Locations in Hanumangarh District

Ground Water Quality Parameters:

Electrical Conductivity:

Electrical conductivity is a measure of total mineral contents of dissolved solids in water. It depends upon the ionic strength of the solution. Electrical conductivity of water increases with increase in dissolved solids. There is spatial variation in electrical conductivity. The values < 2000 μs/cm at 25°C has been observed in 55% of ground water samples.

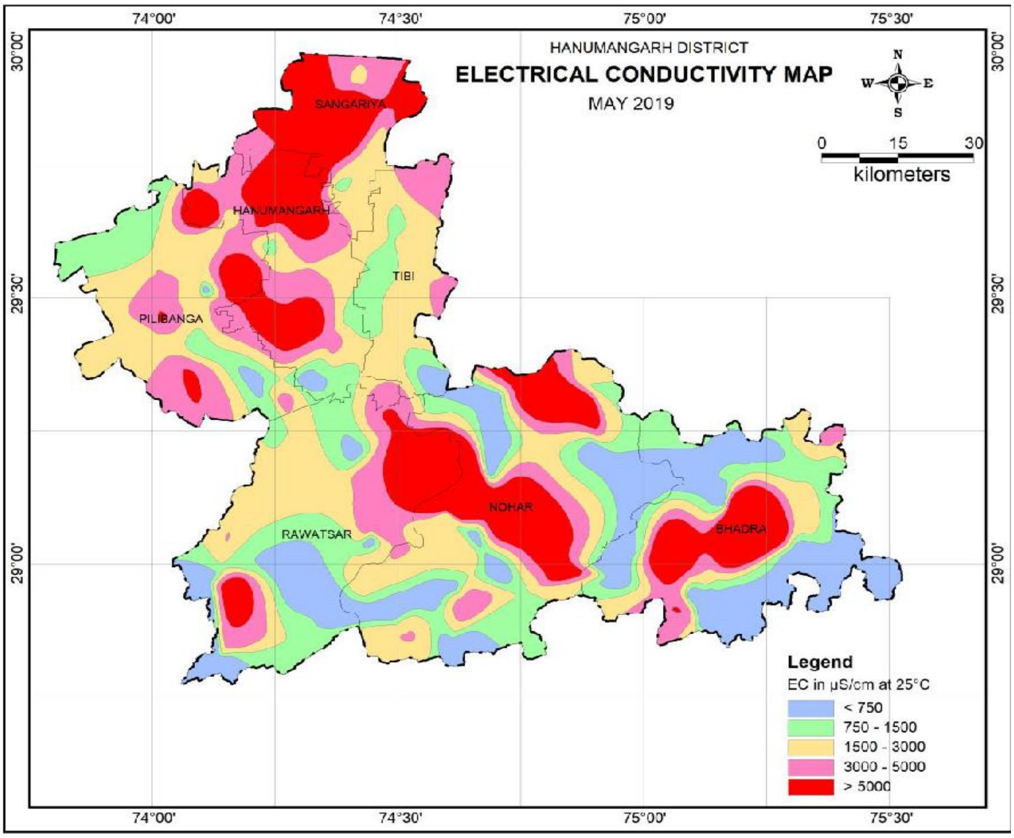


Figure 5.5 Map Showing EC Variation in Hanumangarh District Source: (CPCB, 2020)

Nitrate

Nitrate concentration in the district ranges between < 1 mg/l to 775 mg/l. Nitrate concentration marginally exceeds the maximum permissible limit of 45 mg/l in drinking water prescribed by BIS in around 28% of the total ground water samples. All the blocks in Hanumangarh district exceeds maximum permissible limit for nitrate. Excess of nitrate in drinking water can cause methaemoglobinaemia in infants, gastric cancer, goiter, birth malformations and hypertensions.

Table 5.4 Statistical Analysis of Chemical Quality of Hanumangarh District Source: (Central Ground Water Board, 2020)

Chemical Constituents	Range		BIS 10500 Limits	
	Minimum	Maximum	Desirable	Permissible
pH	1.54	8.93	6.5	8.5
EC (mmhos/cm at 25°C)	240	41830	500	2000
CO_3 (ppm)	0	96	-	-
HCO_3 (ppm)	49	1305	-	-
Cl (ppm)	7	8862	250	1000
SO_4 (ppm)	0.4	7608	200	400
NO_3 (ppm)	0	775	45	45
Ca (ppm)	8	1200	75	200
Mg (ppm)	1.87	1117	30	100
Na (ppm)	5	6138	-	-
K (ppm)	0.509	233	-	-
Total Hardness (ppm)	40	7600	300	600

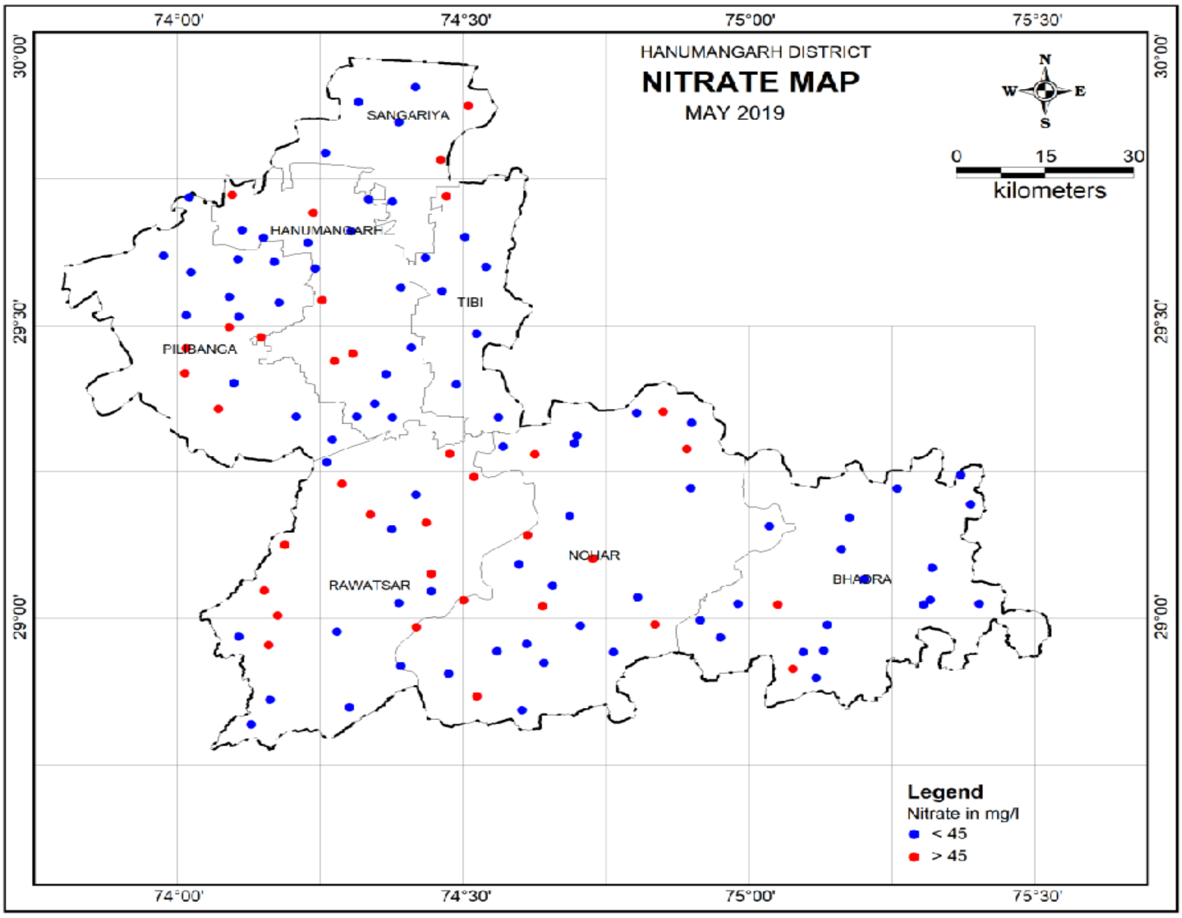


Figure 5.6 Map showing Nitrate Variation in Hanumangarh District Source:

(Central Ground Water Board, 2020)

Fluoride

Higher concentration of fluoride can likely to cause many medical issues such as dental and skeletal fluorosis, mottling of teeth, deformation of ligaments and bending of spinal cord. Fluoride is also an essential element to maintain normal development of healthy teeth and bones. The fluoride concentration exceeds permissible limits in 36% of total analyzed samples.

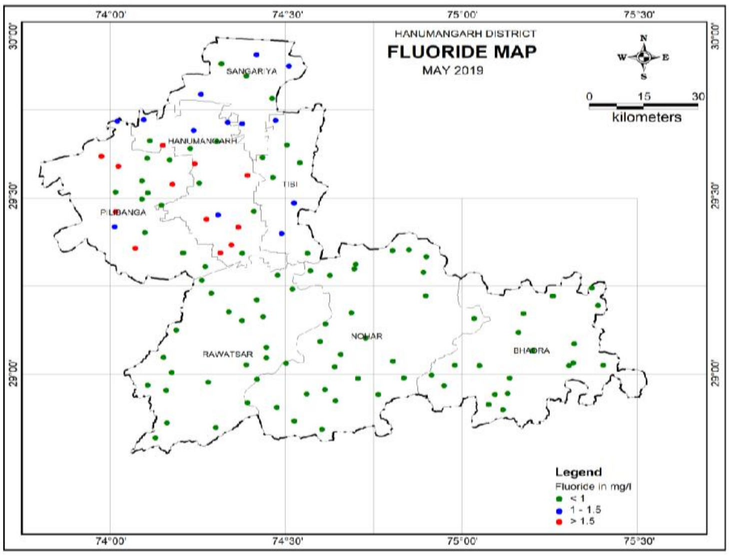


Figure 5.7 Distribution of Fluoride in Hanumangarh District Source: (Central Ground Water Board, 2020)

Total Hardness (TH)

High Hardness may cause precipitation of calcium carbonate and encrustation on water supply distribution systems. Total Hardness in the district varies in the range of 50 mg/l to 1650 mg/l indicating soft to very type of ground water. More than 56% of sample was observed to be having hardness more than 300 mg/l.

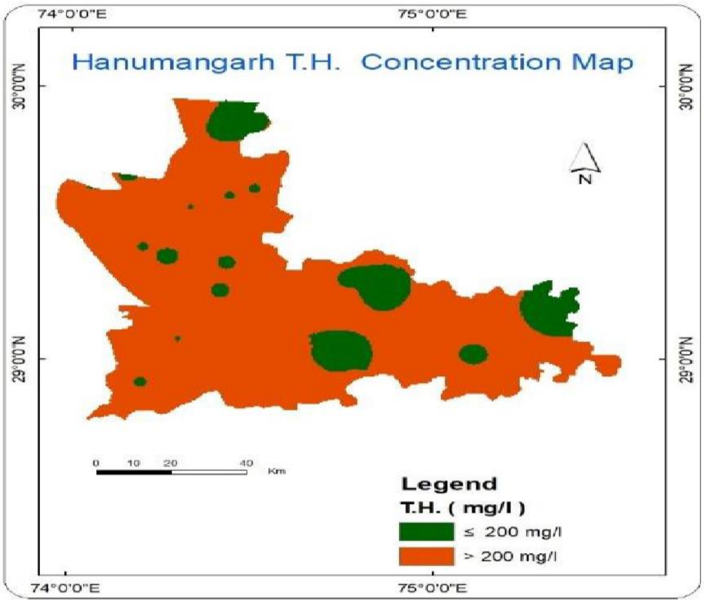


Figure 5.8 Area of Hanumangarh District having Total hardness more than Desirable Limit

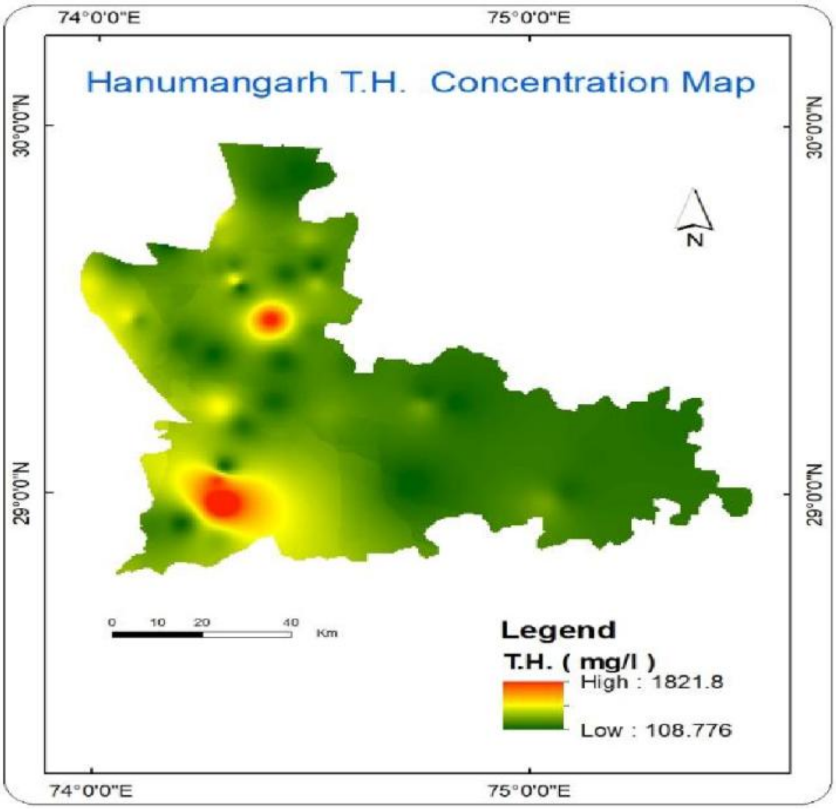


Figure 5.9 Variation of Total Hardness in Hanumangarh District

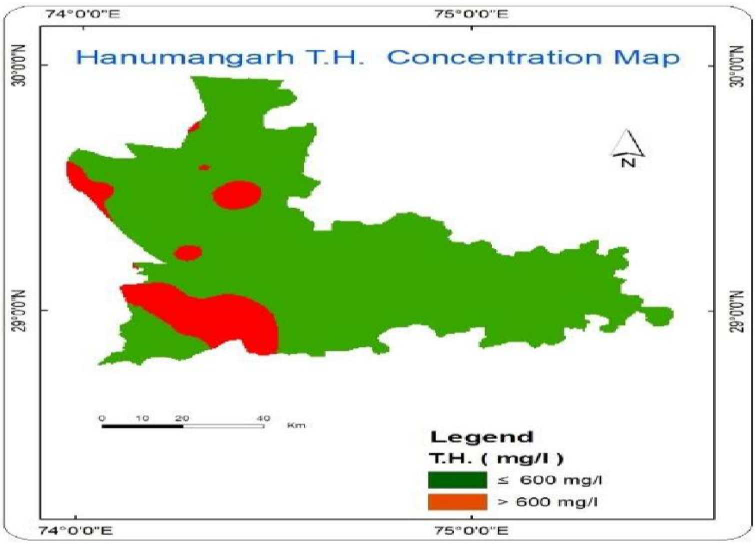


Figure 5.10 Area of Hanumangarh District having Total hardness more than Maximum Permissible Limit (Source: Jain, 2021)

Total Dissolved Solids (TDS)

TDS in water include all dissolved material in solution, whether ionized or not. It is expressed in mg/l and is the numerical sum of all mineral constituents dissolved in water. Total Dissolved Solids present in the ground water can be controlled by mineral dissolution rate, Chemical character of ground water and ionic saturation solution of ground water. The range of TDS varies from 153 mg/l to 26771.2 mg/l. It is observed from collected sample that around 77% of water samples falls in category of fresh water and 21% of water which have TDS in the range of 3000 to 10000 mg/l falls in the category of brackish water. It was observed that most of the brackish water samples collected was from the block Sangariya (>45%).

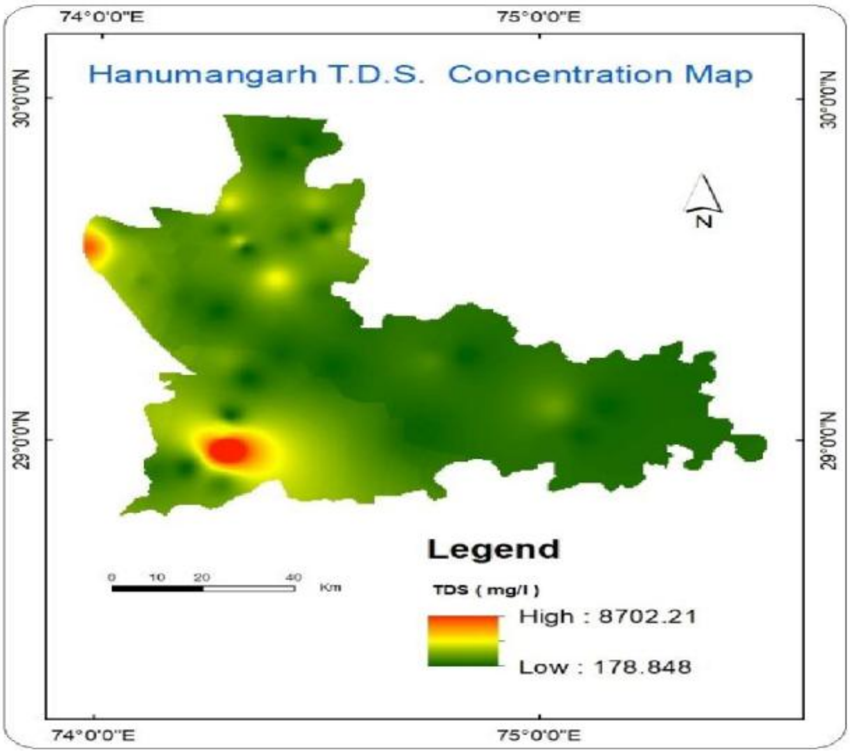


Figure 5.11 Variation of Total Dissolved Solids in Hanumangarh District

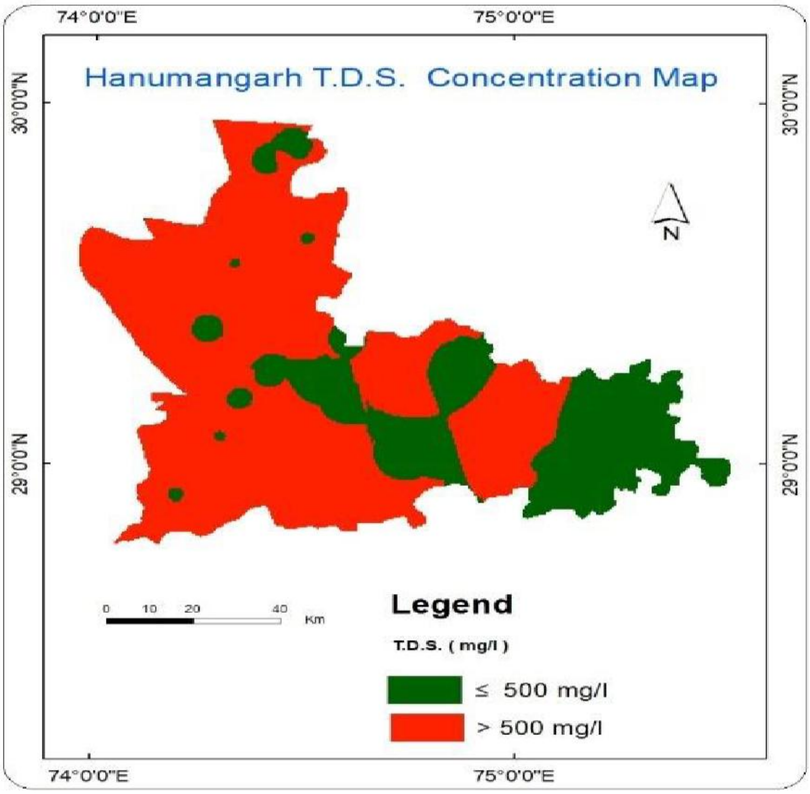


Figure 5.12 Area of Hanumangarh District having Total Dissolved Solids more than Desirable Limit

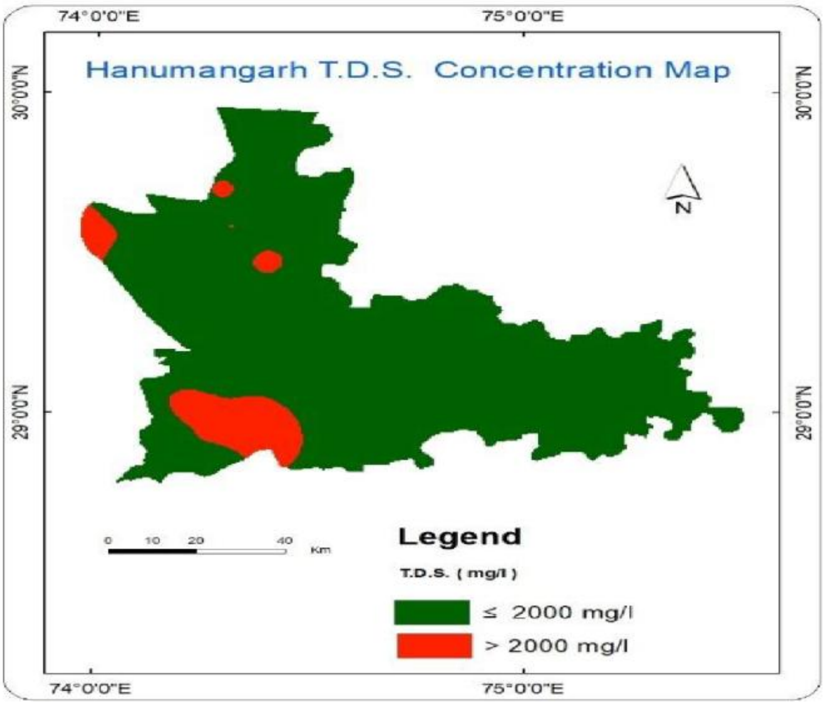


Figure 5.13 Area of Hanumangarh District having Total Dissolved Solids more than Maximum Permissible Limit (Source: Jain, 2021)

Sulphate Concentration

The range of Sulphate concentration in the district varies from 2 mg/l to 1404 mg/l. Sulphate concentration exceeds the desirable limit in almost all parts of the district of 200 mg/l except Tehsil Bhadra. In some isolated pockets of Rawatsar, Hanumangarh, Tibbi and Nohar Sulphate concentration exceeds maximum permissible limit of 400 mg/l. Map below shows the variation of Sulphate concentration in the district, blocks exceeding desirable limits and blocks exceeding maximum permissible limits.

Chloride Concentration

Chloride concentration of district ranges from 14mg/l to 3422 mg/l. Chloride concentration of almost all the blocks in the district exceed the desirable limit of 250 mg/l except Bhadra block. In some isolated pockets of Rawatsar and Pilibanga the chloride concentration exceeds maximum permissible limit of 1000 mg/l. Map below shows the variation of Sulphate concentration in the district, blocks exceeding desirable limits and blocks exceeding maximum permissible limits.

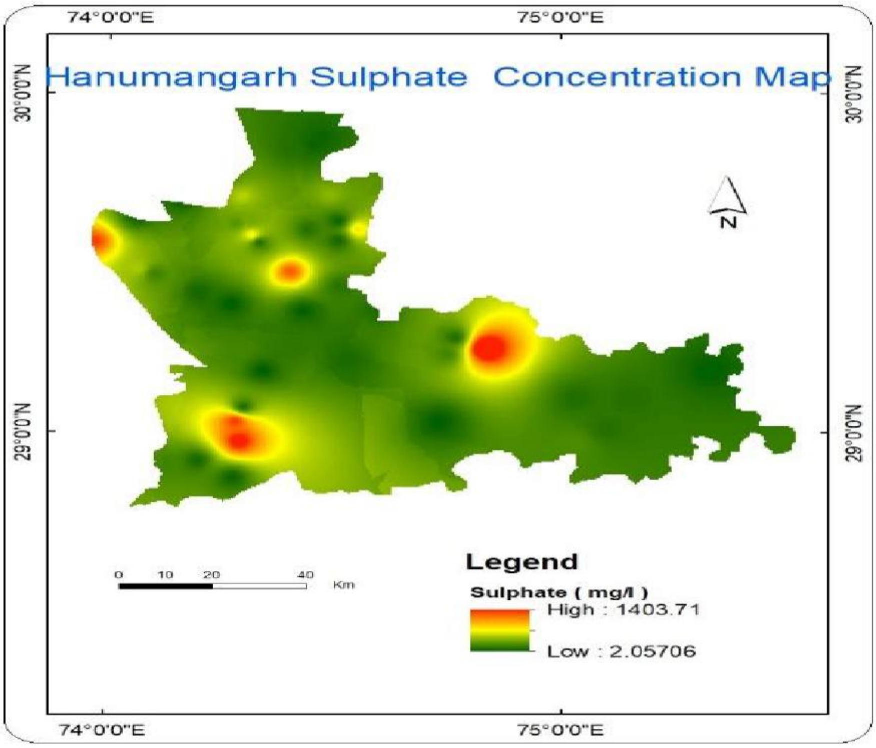


Figure 5.14 Variation of Sulphate Concentration in Hanumangarh District

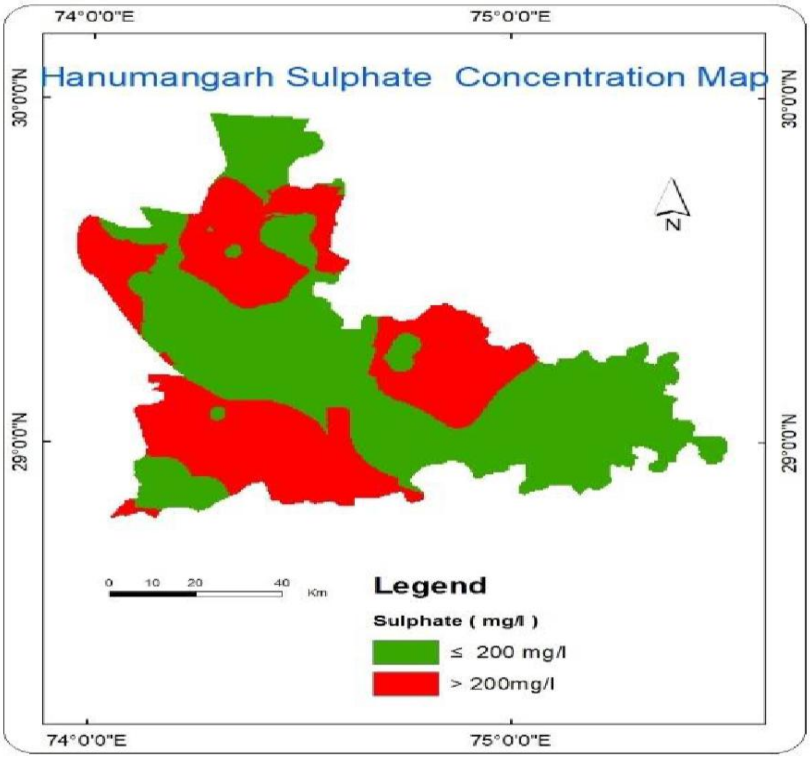


Figure 5.15. Area of Hanumangarh District having Sulphate Concentration more than Desirable Limit

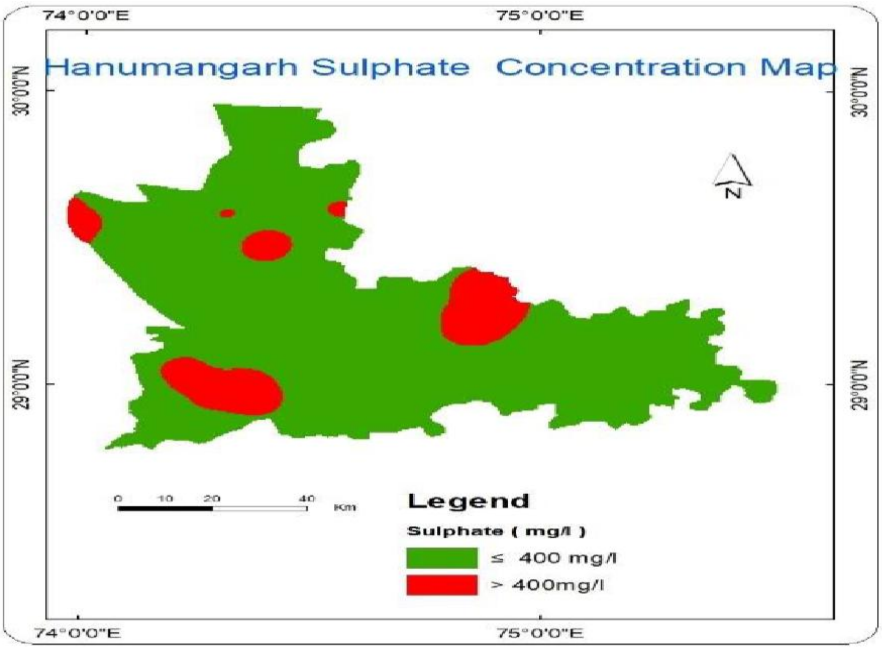


Figure 5.16 Area of Hanumangarh District having Sulphate Concentration more than Maximum Permissible Limit (Source: Jain, 2021)

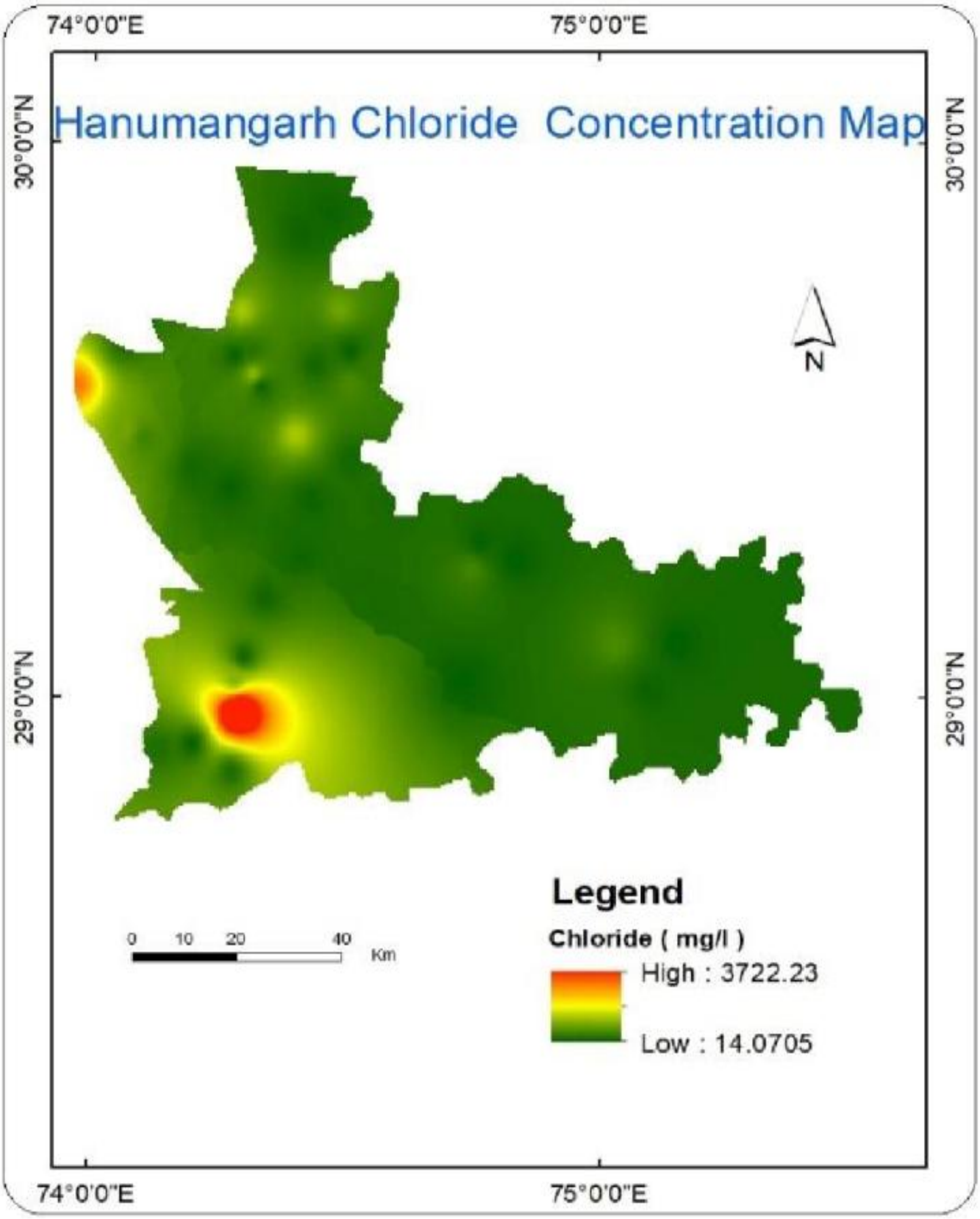


Figure 5.17. Variation of Chloride Concentration in Hanumangarh District

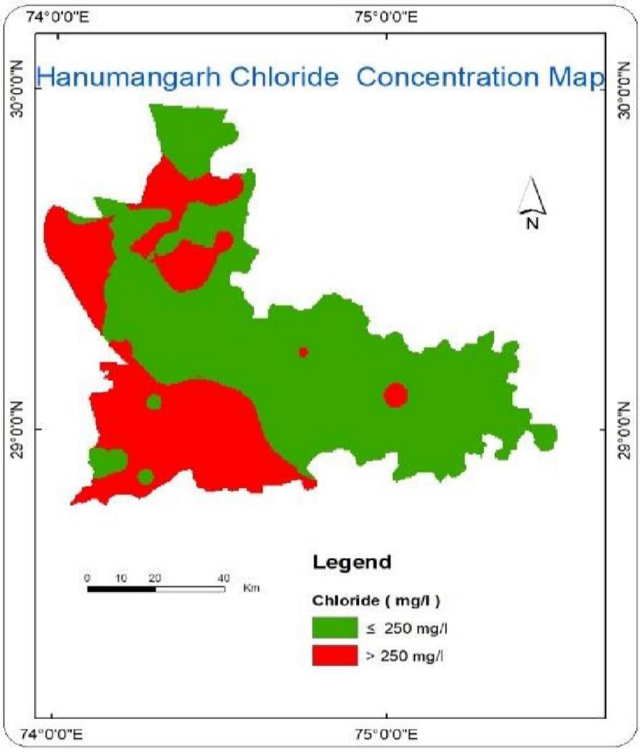


Figure 5.18 Area of Hanumangarh District having Chloride Concentration more than Desirable Limit

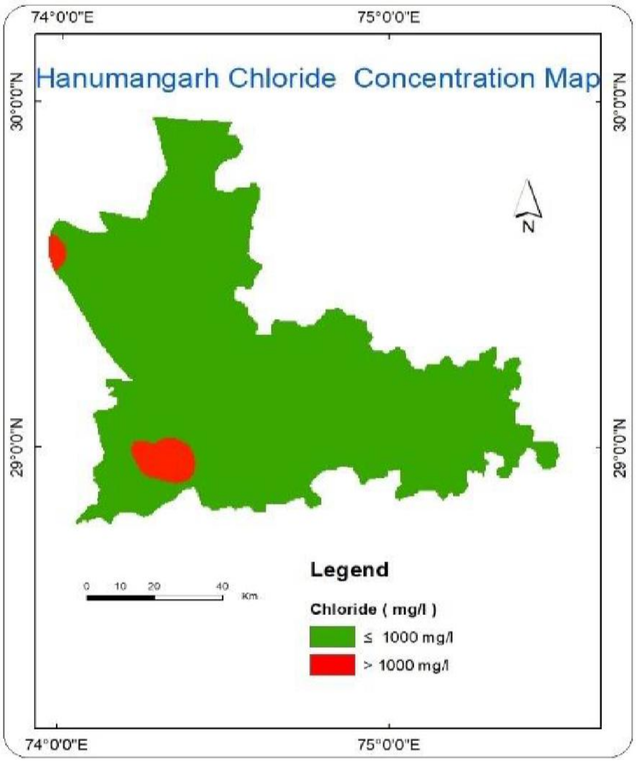


Figure 5.19 Area of Hanumangarh District having Chloride Concentration more than Maximum Permissible Limit (Source: Jain, 2021)

Calcium Concentration

Calcium concentration of Hanumangarh district ranges from 20 mg/l to 523 mg/l. Calcium concentration of almost all the parts in the district exceeds desirable limit of 75 mg/l. In some isolated pockets of Rawatsar block calcium concentration exceeds the maximum permissible limit of 200 mg/l.

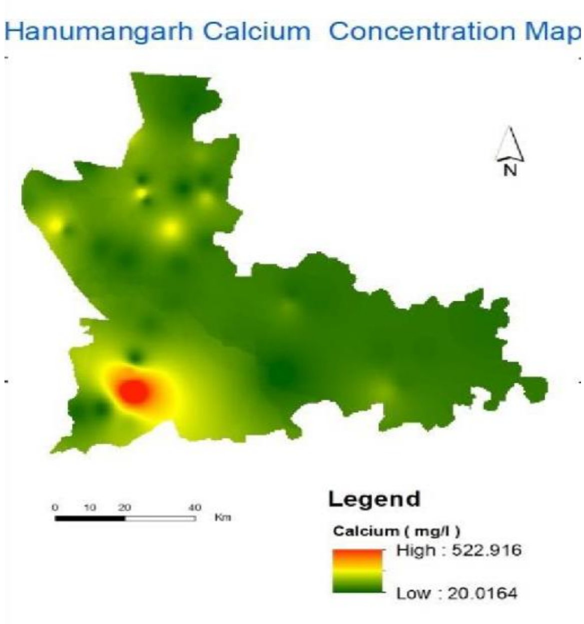


Figure 5.20. Variation of Calcium Concentration in Hanumangarh District

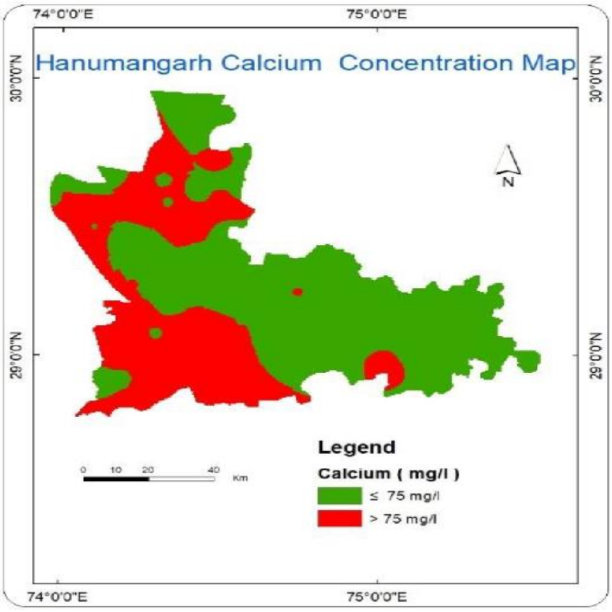


Figure 5.21 Area of Hanumangarh District having Calcium Concentration more than Desirable Limit

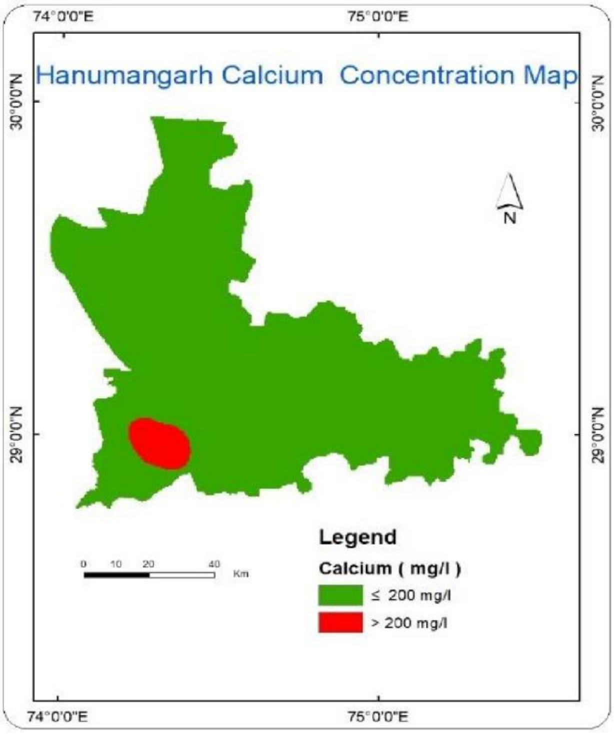


Figure 5.22 Area of Hanumangarh District having Calcium Concentration more than Maximum Permissible Limit (Source: Jain, 2021)

Magnesium Concentration

Magnesium concentration in the district ranges from 5 mg/l to 522 mg/l. It is found exceeding desirable limit of 30 mg/l in all parts of Rawatsar, Hanumangarh, Pilibanga, Tibbi and Sangariya and some parts of Nohar and Bhadra block. It crosses maximum permissible limit of 100 mg/l in some isolated pockets of Rawatsar, Pilibanga and Hanumangarh block.

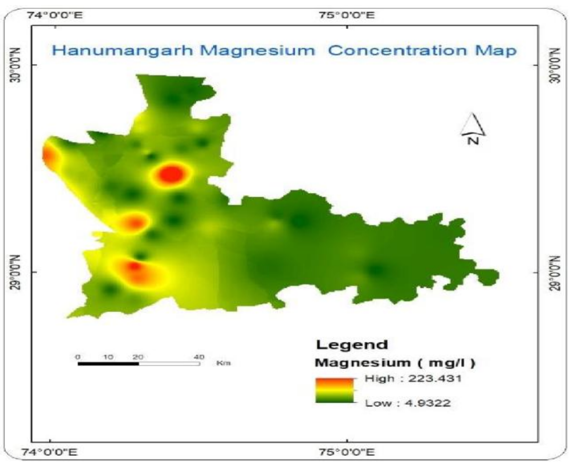


Figure 5.23 Variation Magnesium Concentration in Hanumangarh District

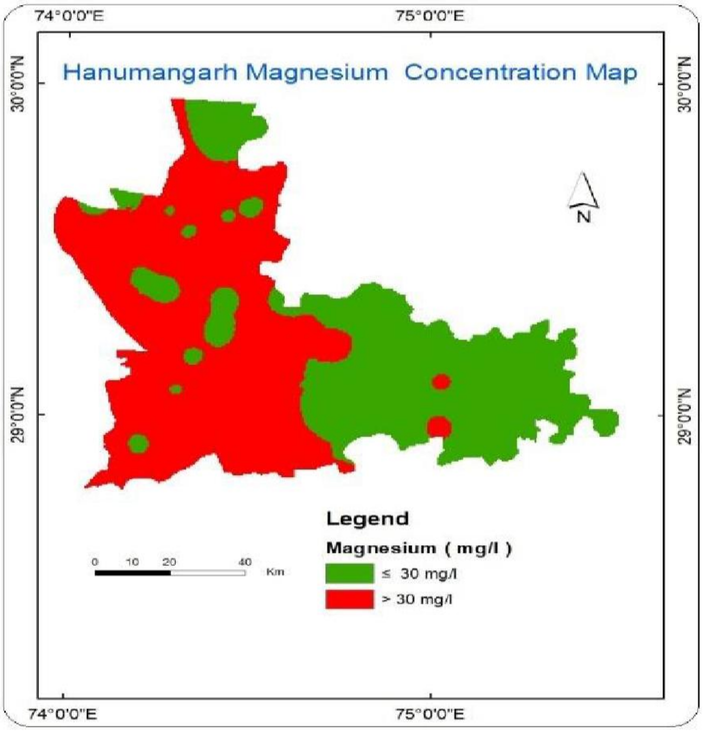


Figure 5.24 Area of Hanumangarh District having Magnesium Concentration more than Desirable Limit

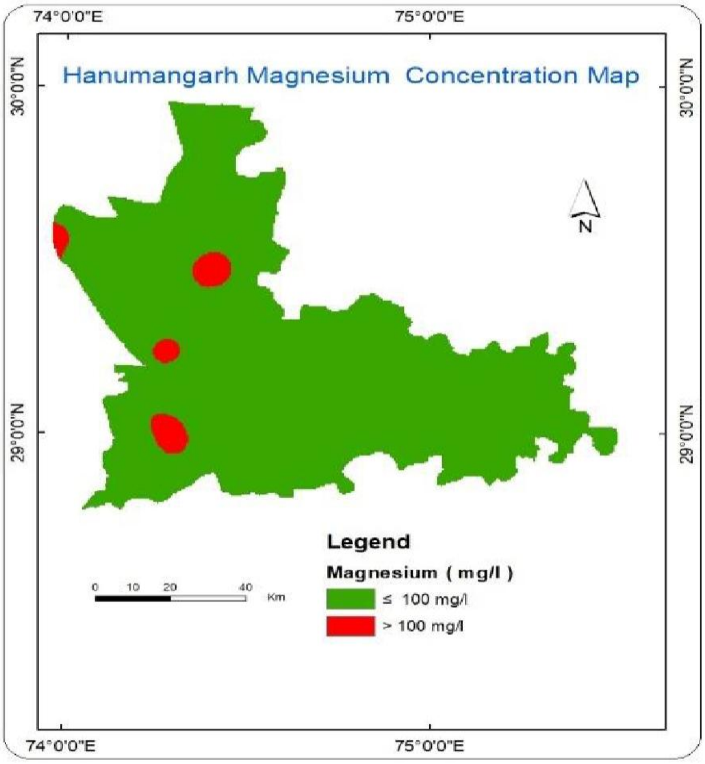


Figure 5.25 Area of Hanumangarh District having Magnesium Concentration more than Maximum Permissible Limit

pH Value

pH value in the Hanumangarh district ranges from 7 to 8.5. All blocks in the district have pH value in the desirable range of 6.5 to 8.5.

Total Alkali Concentration

The range of alkali concentration in the district varies from 82 mg/l to 580 mg/l. Total alkali concentration exceeds desiarable limit of 200 mg/l in almost all the parts of Rawatsar, Pilibanga, Tibbi, Hanumangarh and Sangariya and in some parts of Nohar and Bhadra block. Total alkali concentration do not exceed maximum permissible limit of 600 mg/l in any part of the district.

Iron Concentration

Iron concentration of almost all the blocks in the district exceeds desirable limit of 0.3 mg/l except Rawatsar. In some isolated pockets of Rawatsar block iron concentration exceeds desirable limit.

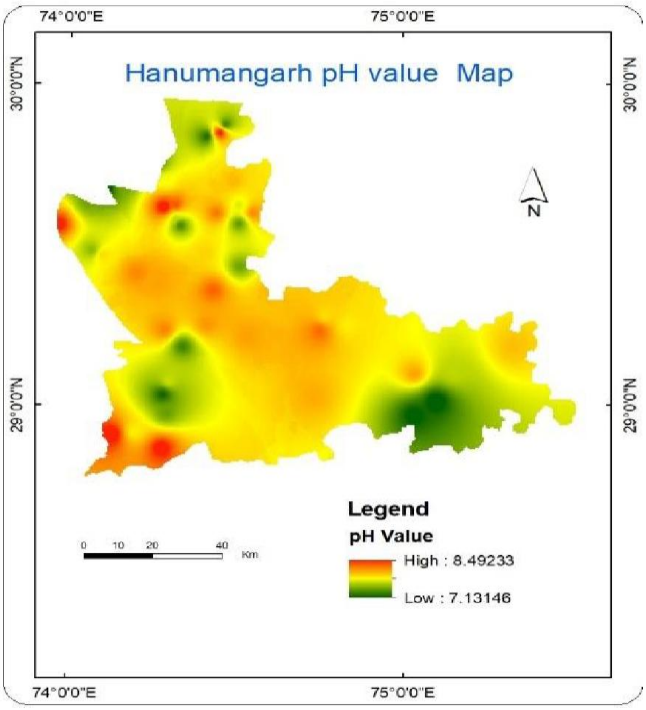


Figure 5.26 Variation of pH value in Hanumangarh District

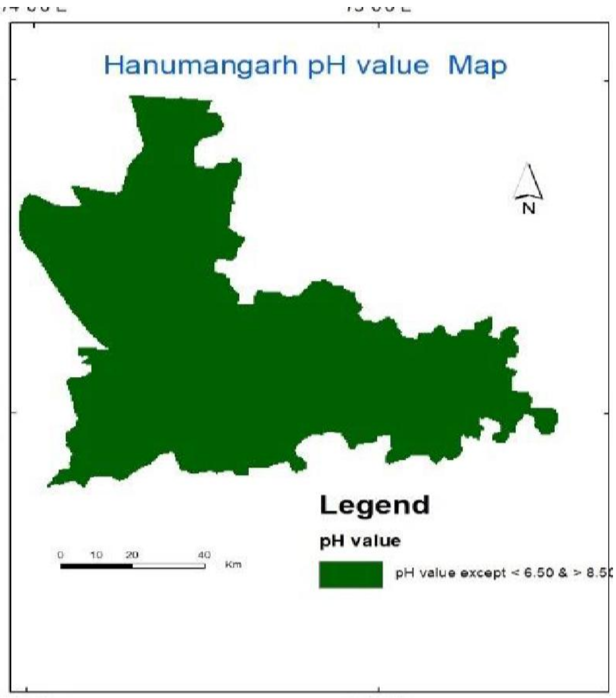


Figure 5.27. Area of Hanumangarh District having pH Value more than Desirable

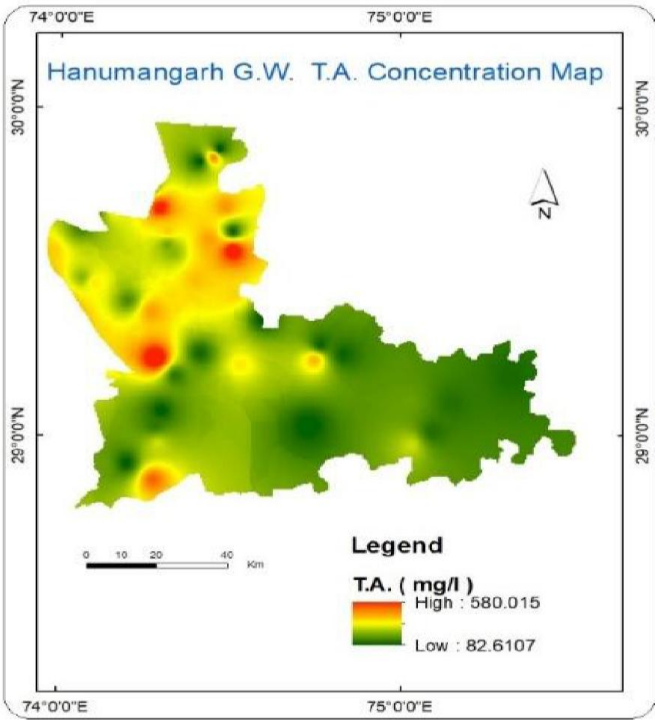


Figure 5.28 Variation of Total Alkali Concentration in Hanumangarh District

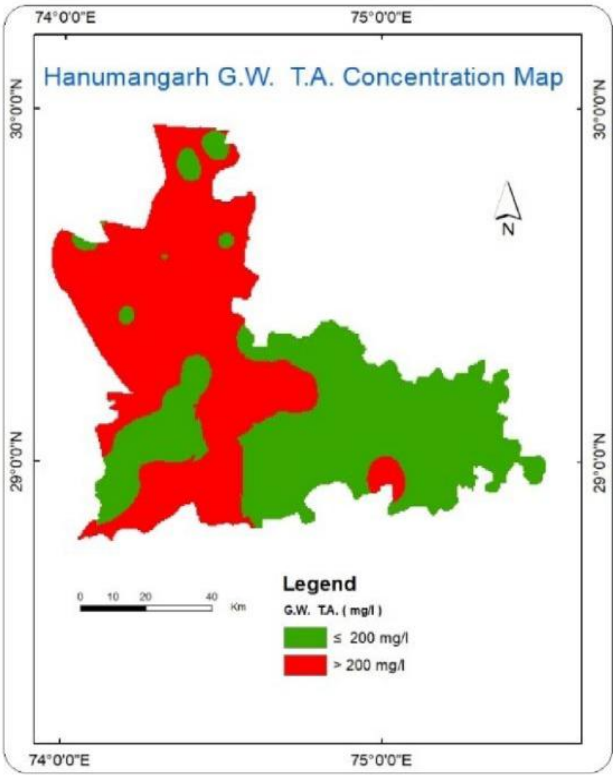


Figure 5.29 Area of Hanumangarh District having Total Alkali Concentration more than Desirable Limit

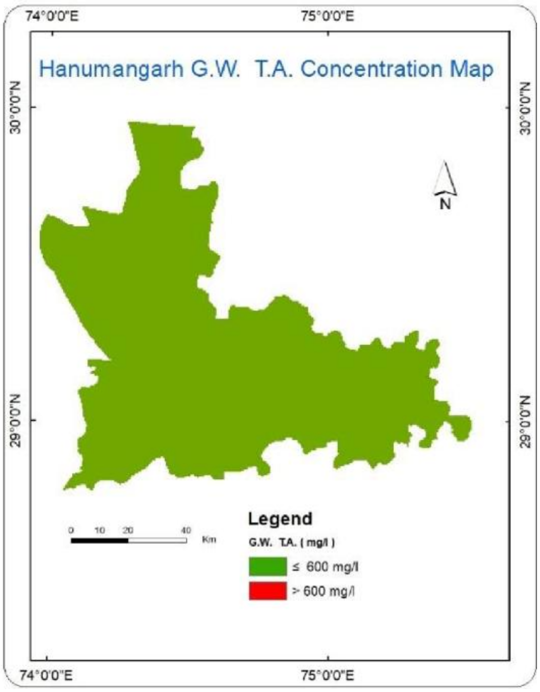


Figure 5.30 Area of Hanumangarh District having Total Alkali Concentration more than Maximum Permissible Limit (Source: Jain, 2021)

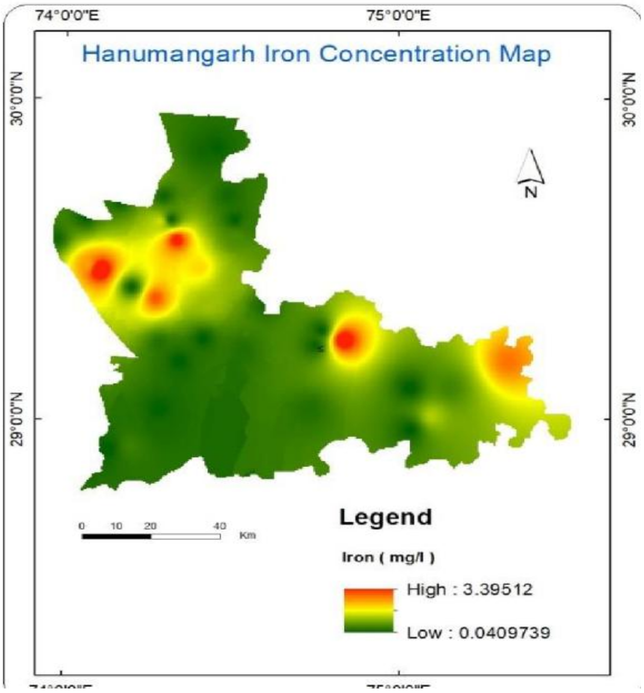


Figure 5.31 Variation of Iron Concentration in Hanumangarh District

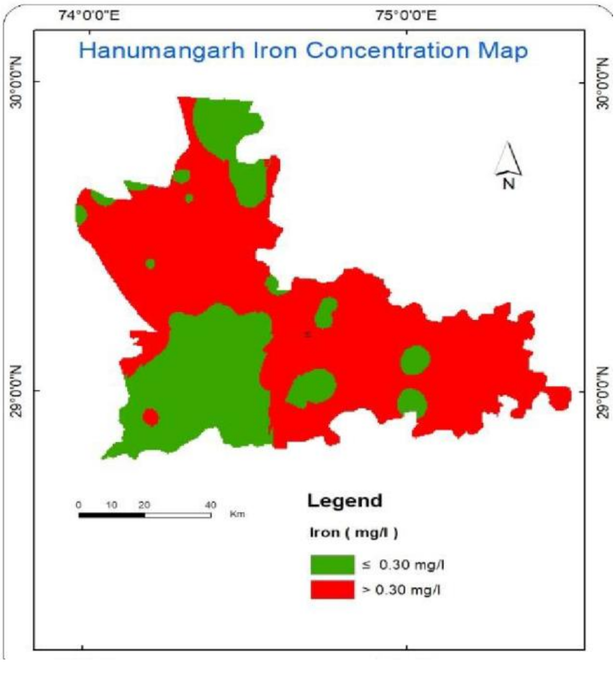


Figure 5.32 Area of Hanumangarh District having Iron Concentration more than Desirable Limit

Water Quality in Deeper Aquifers

Water samples collected from deep aquifer shows that salinity increases with the depth. The salinity was found to be very high in deep aquifers and water was not suitable to use for any purpose.

Irrigation Pattern

The canal is the main source of irrigation in the Hanumangarh district, though some areas are irrigated by wells or tube wells. The primary source of irrigation is surface water which is utilized from the canal network in the district.

Quality of Irrigation water

The main source of irrigation is surface water which is about 98% of the total irrigated area. The area where canal water is not accessible irrigation is carried out with the help of ground water and this area is about 2% of total irrigated area. Rawatsar and Pilibanga are the blocks where the contribution of ground water is 10% and 5% respectively.

Table 5.5 Means of Irrigation and their Respective Coverage Areas (Source: Dursun, 2012)

Means of Irrigation	Irrigated Area (in Hectares)	
	Gross Area	Net Area
Canals	622370	361603
Tube wells	8959	6170
Wells	4871	2894
Other Sources	184	179

The factors which influence the water quality and its suitability for irrigation purposes are namely Electrical Conductivity (EC), Sodium Absorption Ratio (SAR) and Residual Sodium Carbonate (RSC). The quality of irrigation water is decided based on the presence of dissolved salts and their concentrations.

Based on the criteria of Electrical Conductivity 41% of the sample collected were very highly saline having salinity greater than 2250 µs/cm. This water with EC >2250 µs/cm is not suitable for irrigation under ordinary condition. The samples were tested for SAR and it was found that almost 80% of sample had low sodium content and it was classified as excellent. Low sodium water can be used on almost all types of soils with little danger of the development of harmful levels of exchangeable sodium. The analysis RSC value was done on the samples to know the block wise suitability of ground water for irrigation. It was observed from the data collected that groundwater in southern block of the district is more suitable than the northern blocks viz. Bamanwas, Gangapur City and Bonli.

In isolated pockets of Rawatsar and Pilibanga block SAR value ranges between 18 to 26 and which is classified as doubtful to use for irrigation purpose. No blocks in the district are observed having SAR value more than 26. In maximum parts of the district SAR value are less than 18 indicating medium sodium water and water is classified as good. RSC value in some isolated parts of Rawatsar, Tibbi and Sangariya block exceeds the maximum permissible limit of 2.60 meq/l, making unsuitable for irrigation purpose.

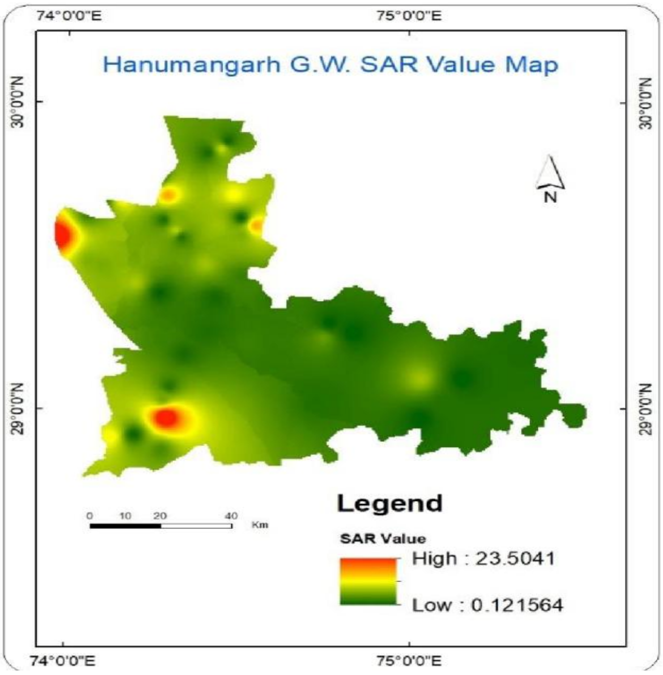


Figure 5.33 Variation of SAR value in Hanumangarh District

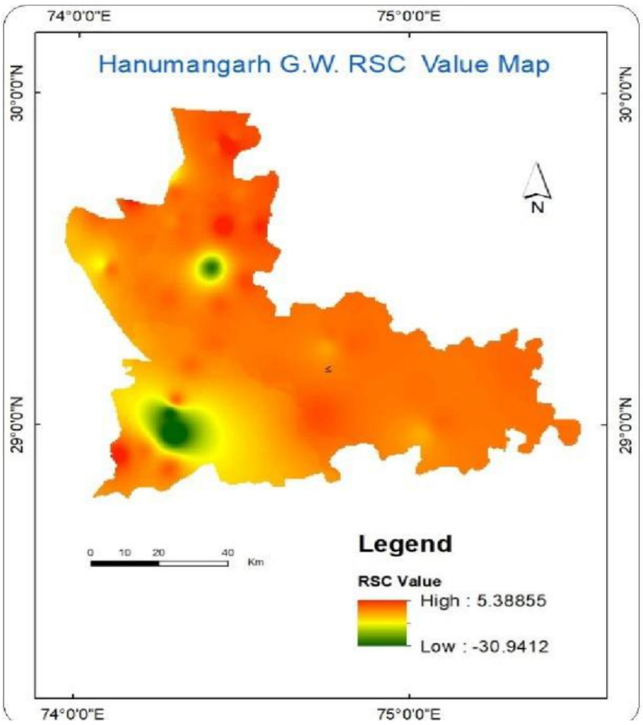


Figure 5.34 Variation of RSC value in Hanumangarh District

The information regarding water supply connections, sources of water supply have been provided by PHED as given in the tables (5.5 to 5.8) below.

The number of house connections provided by the department in various ULBs of Hanumangarh are provided in Table 5.5.

Table 5.5 Number of water supply connections as provided by PHED

City	Water supply connections				
	Domestic	**Non-Domestic**	**Industrial**	**State / Center Govt.**	**Total**
Sangaria	8049	667	52	233	9001
Pilibanga	5646	246	58	137	6087
Hanumangarh	30328	1981	150	294	32753
Rawatsar	6418	739	8	101	7266
Nohar	14147	716	133	133	15129
Bhadra	9253	359	0	208	9820
	73841	**4708**	**401**		**80056**

The population being served by the water suppy in various ULBs of Hanumangarh are provided in Table 5.6.

Table 5.6 Number of populations served by water supply connections (as provided by PHED)

City	Present Population	Population served by PWS	Fraction of population served by PWS
Sangaria	42000	38000	0.90
Pilibanga	43000	38000	0.88
Hanumangarh	174000	148000	0.85
Rawatsar	40000	37000	0.93
Nohar	57000	52000	0.91
Bhadra	46000	40000	0.87
	402000	**353000**	0.88

The water quantities of water being supplied in various ULBs along with the sources have been given in Tables below.

Table 5.7 Sources of water supply (as provided by PHED)

City	Source	Production of water in KLD		Total Production in KLD
		Surface Source	Ground water	
Sangaria	Sadul Branch (Bhakhra canal System)	3400	600	4000
Pilibanga	PBN Dist. (Bhakhra canal System)	3600	600	4200
Hanumangarh	Sadul Branch (Bhakhra canal System)	8700	6000	14700
Rawatsar	KWD (IGNP Canal system)	4000	0	4000
Nohar	RWD (IGNP Canal system)	7500	400	7900
Bhadra	AMS Branch (Bhakhra Canal System)	3200	600	3800

Table 5.8 City-wise/PHED circle water quality data

City	Bact. Quality (Total Coliform per 100 ml)	Chemical Quality ((Min - Max)					
		Fluoride Min	Fluoride Max	TDS Min	TDS Max	Nitrate Min	Nitrate Max
Sangaria	Nil	0.25	0.26	290	310	2	2
Pilibanga	Nil	0.26	0.26	290	310	2	2
Hanumangarh	Nil	0.25	1.18	290	1440	1	30
Rawatsar	Nil	0.24	0.3	270	290	2	2
Nohar	Nil	0.25	0.26	290	300	2	2
Bhadra	Nil	0.25	0.26	290	300	2	2

Inferences from Present Scenario

In more than 40% area of Hanumangarh district have salinity more than 2250 µs/cm. Very high saline water is not suitable for irrigation under ordinary conditions. Nohar block in the district have highest TDS value which is 26771.2 mg/l. TDS value of almost all the blocks of the district exceeds the permissible limits of 2000 mg/l. Residual Sodium Carbonate analysis was carried out on samples and it is inferred from that most parts of the district has medium to high salinity. It was also observed that ground water has excellent to good Sodium Absorption Ratio making the water suitable for irrigation purpose. The crops having high salt-tolerant ratio can be cultivated in this area.

The fresh water availability in the district is limited and nearly 87 % of the area of the district is saline. Patches of very high EC are observed in southern and western parts of the Nohar block and northern western part of Hanumangarh block. In the entire district the confined aquifer is saline except locally. Due to shallow ground water level nitrate concentration and sulphate concentration has significantly increased in the all parts of the district. It was observed that nearly 28 % of the samples have high nitrate value exceeding permissible limit of 45 mg/l. Along with nitrate sulphate concentration is also high in the district. It was observed after analyzing the samples that nearly 35 % of samples have high sulphate concentrations exceeding permissible limit of 400 mg/l. Iron concentration in central and eastern part of the Hanumangarh block, eastern part of Nohar block and western part of Bhadra block was found to exceed the permissible limit of 1 mg/l.

The average ground water trend of the Hanumangarh district is declining at the average rate of 1.44 m/year in the pre-monsoon season and in post-monsoon season the rate of decline was observed to be 1.45 m/year. The maximum fall in water table level was observed in Nohar block in the year 2010 to 2019 and the fall of nearly 11.8 m was noted.

The depression located on the west side of Hanumangarh district is act as storage for excess flood water of Ghaggar River. The area around the depression experience sudden rise in ground water table in the monsoon season causing water logging in nearby areas. The area which is affected by water logging problems is west and southwest of Baropal, southeast and southwest of Manaktheri, southeast of Rangmahal, southwest of Kalanwali Dhani. Excess flood water of Ghaggar river is the main reason for water logging. The unlined canals from the saddles have further added to problem.

5.1.3 Action Plan

Institutional Reform

There is no close interaction between agricultural managers and water quality managers; it leads to non-availability of data base which is needed to assess agricultural impacts. If the Government-operated programmes are inefficient the project can be outsourced with appropriate Q&A control, use of Public-Private Partnership, fee-for-service and income generation models can be selected.

Table 5.6 Action Area Plan in Different ULBs and Timelines

S. No.	Action point	Deficiency in present status and, planning for future	Timeline	Stakeholders responsible
1	Ground water depletion	1. Rawatsar and Nohar block has the deepest level of groundwater availability 2. The average ground water trend of the Hanumangarh district is declining at the average rate of 1.44 m/year in the pre-monsoon season and in post-monsoon season the rate of decline was observed to be 1.45 m/year. 3. Artificial recharge of ground is needed in this block. Rainwater harvesting should be encouraged in this are by constructing anicuts, bunds and check dams. Roof top rain water harvesting techniques should be promoted in this area. 4. Ground water development programme should be launched in the Ghaggar flood plain, as the quality of ground water in this area is suitable for irrigation purpose.	Immediately in these blocks	ULBs- Rawatsar, Nohar block Nagar Parishad

2	Quality of ground water	1) In more than 40% area of Hanumangarh district have salinity more than 2250 µs/cm. Nearly 87% of the area of the district is saline. 2) Nohra block in the ditrict have highest TDS value. In all the blocks of the district water TDS exceeds the permissible limit. 3) There excess nitrate concentration in the district. 4) Concentration of sulphate exceeds the permissible limit 5) Iron concentration in central and eastern part of the Hanumangarh block, eastern part of Nohar block and western part of Bhadra block was found to exceed the permissible limit of 1 mg/l. 6) Patches of high EC are observed in southern and western parts of Nohar block and northern western part of Hanumangarh block 7) Quality of ground water based on fluoride, nitrate and iron should be measured on regular basis. 8) Saline ground water available in the district can be used for agriculture by by blending with canal water.	Over the 3-5 years	ULBs- Bhadra, Hanumangarh, Pillbanga, Nohara, Rawatsar, Sangariya, Tibbi Nagar Parishad
3	Required water quality for irrigation purpose	1. The EC concentration of nearly 41% of water samples are observed to be more than 2250 µs/cm making it unsuitable for irrigation purpose under normal conditions. (Bhadra, Hanumangarh, Pillbanga, Nohara, Rawatsar, Sangariya, Tibbi) 2. Irrigation water must be applied in excess to provide considerable leaching. 3. High water requirement crops need to be discouraged. Knowledge of low water requirement crops should be given to farmers. 4. Modern agricultural management techniques have to be adopted for effective and optimum utilization of the water resources.	Over the 5-7 years	ULBs- Bhadra, Hanumangarh, Pillbanga, Nohara, Rawatsar, Sangariya, Tibbi Nagar Parishad Nagar Parishad

4	Water logging	1. Water logging problem is observed in the west and southwest of Baropal, southeast and southwest of Manaktheri, southeast of Rangmahal, southwest of Kalanwali Dhani area 2. Anti water logging measures should be taken to avoid further water logging issues in the nearby areas. 3. In areas where water level is shallow (<10 m) skimming wells are recommended	Over the 3-5 years	ULB- Hanumangarh

5.1.4 Summary

Deteriorating water quality is matter of concern in all over the world in developing countries. Tap water is considered as safe to drink without treating it. In developing countries fewer than 10% of people have access to wastewater collection and treatment. Degradation in the water quality in Asian countries is causing serious human health issues. Along with human health it is causing ill impact on aquaculture in surface water resources. The parameters on which the water quality in India is checked are very less. For better water quality monitoring number of these parameters should be increased. Water quality monitoring requires a trained worker; it is necessary to improve the system which manages the water quality management.

Taking into consideration the present scenario of ground water quality in Hanumangarh district, it is observed that there is decrease in the ground water level over the years. Near the Ghaggar river basin water logging problem is observed in monsoon season due to excess flood water from Ghaggar river which gets stored in depression in the west side of the district. The fresh water availability of Hanumangarh district is limited and nearly 87% of the area the district is saline. District has high concentration of nitrates and sulphates which is very harmful chemical constituents in the water. TDS value of all the blocks in the district exceeds the permissible limits.

By adopting some artificial measures ground water can be recharged. As surface water is the main water resource for the district it is necessary to take into consideration the measure polluting agents. Sewage water coming from the cities should be treated before it is disposed into the nalas. Adoption of some modern techniques in agriculture will help in getting more yields. Modern agricultural management techniques have to be adopted for effective and optimum utilization of the water resources.

Table 5.7 Summary of Water Quality Management for all the ULBs of Hanumangarh District

Name of ULB	Present Status	Action Plan for future
Hanumangarh	The deepest ground water level in this block is observed between 20 to 30 m below ground level The EC concentration is more than the desirable limit hence unsuitable for irrigation purpose under normal conditions. Patches of high EC are observed in northern western part of Hanumangarh block Iron concentration in central and eastern part of the Hanumangarh block exceeds permissible limit of 1 mg/l. Water logging problem is observed in the west and southwest of Baropal, southeast and southwest of Manaktheri, southeast of Rangmahal, southwest of Kalanwali Dhani area. The concentration of Fluoride, Sulphate, Chloride, Calcium, Nitrate, Magnesium, total alkali exceeds the desirable limits. Total Hardness exceeds the desirable limit in all parts of the district. Total Dissolved Solids value exceeds the desirable limit in the block. The SAR and RSC value of the block is within permissible limit.	Survey and Identification of the area Artificial recharge of ground water using rainwater harvesting, anicuts and check dams. Water should be treated before providing to community for drinking purpose Modern agriculture management techniques have to be adopted for effective and optimum utilization of water resources. Identify fresh water aquifers through borehole logging to avoid failure of tube wells in saline belt.
Sangariya	The deepest ground water level in this block is observed in between 10 to 20 m below ground level The EC concentration of nearly 41% of water samples are observed to be more than 2250 µs/cm making it unsuitable for irrigation purpose under normal conditions. The concentration of Fluoride, Sulphate, Chloride, Calcium, Magnesium, Iron and Total Alkali exceeds desirable limit in major parts of the block. In isolated pockets of the block concentration of the Nitrate exceeds desirable limit. Total Hardness exceeds the desirable limit in all parts of the block. Total Dissolved Solids value exceeds the desirable limit in the block.	Survey and identification of the area Cement sealing should also be invariably done precisely to seal off the saline aquifer. Identify fresh water aquifers through borehole logging to avoid failure of tube wells in saline belt. Modern agriculture management techniques have to be adopted for effective and optimum utilization of water resources. Water should be treated before providing to community for drinking purpose

Tibbi	The ground water level in the block is at 10 to 20 m below ground level in pre-monsoon season. The EC concentration is more than desirable limit hence unsuitable for irrigation purpose under normal conditions. The concentration of Calcium, Magnesium, Iron and Total Alkali exceeds the desirable limit. In isolated pockets of the block concentration of the Fluoride, Sulphate, Chloride, Nitrate exceeds the desirable limit. Total Hardness exceeds the desirable limit in all parts of the block. Total Dissolved Solids value exceeds the desirable limit in the block.	Survey and identification of the area Modern agriculture management techniques have to be adopted for effective and optimum utilization of water resources. Identify fresh water aquifers through borehole logging to avoid failure of tube wells in saline belt Water should be treated before providing to the community for drinking purpose.
Pilibanga	The deepest ground water level in this block is observed in between 20 to 30 m below the ground level. The EC concentration is more than desirable limit hence unsuitable for irrigation purpose under normal conditions. Concentration of Fluoride, Sulphate, Chloride, Calcium, Magnesium, Iron and Total Alkali exceeds the desirable limit in major part of the district. In isolated pockets of the block concentration of Nitrate exceeds desirable limit. Total Hardness exceeds the desirable limit in all parts of the block. Total Dissolved Solids value exceeds the desirable limit in almost all the parts of the block.	Survey and identification of the area Identify fresh water aquifers through borehole logging to avoid failure of tube wells in saline belt Modern agriculture management techniques have to be adopted for effective and optimum utilization of water resources. Water should be treated before providing to community for drinking purpose
Rawatsar	The deepest ground water level in this block is observed in between 40 to 50 m below the ground level. The EC concentration is more than desirable limit hence unsuitable for irrigation purpose under normal conditions. Concentration of Sulphate, Chloride, Calcium, Nitrate, magnesium and Total Alkali exceeds the desirable limit in major part of the district. In isolated pockets of the block concentration of Fluoride and Iron exceeds the desirable limit. Total Hardness exceeds the desirable limit in all parts of the block. Total Dissolved Solids value exceeds the desirable limit in almost all the parts of the block.	Survey and identification of the area Modern agriculture management techniques have to be adopted for effective and optimum utilization of water resources Cement sealing should also be invariably done precisely to seal off the saline aquifer. Water should be treated before providing to community for drinking purpose

Nohar	The deepest ground water level in this block is observed in between 10 to 20 m below the ground level. Concentration of Fluoride, Sulphate and Iron exceeds the desirable limit in major part of the block. In isolated pockets of the block concentration of Chloride, Calcium, Magnesium and Total Alkali exceeds the desirable limit. Total Hardness exceeds the desirable limit in all parts of the block. Nohar block in the district have highest Total Dissolved Solids value.	Survey and identification of the area Cement sealing should also be invariably done precisely to seal off the saline aquifer. Water should be treated before providing to community for drinking purpose Cement sealing should also be invariably done precisely to seal off the saline aquifer.
Bhadra	The deepest ground water level in this block is observed in between 10 to 20 m below the ground level. The EC concentration is more than desirable limit hence unsuitable for irrigation purpose under normal conditions. Concentration of Fluoride and iron exceeds the desirable limit in major parts of the block. In isolated pockets of the block concentration of Sulphate, Chloride, Calcium, Magnesium and Total Alkali exceeds the desirable limit in some part of the block. Total Hardness exceeds the desirable limit in all parts of the block. Total Dissolved Solids value exceeds the desirable limit in small part of the block.	Survey and identification of the area. Water should be treated before providing to community for drinking purpose. Cement sealing should also be invariably done precisely to seal off the saline aquifer. Modern agriculture management techniques have to be adopted for effective and optimum utilization of water resources

5.2 Rainwater Harvesting

Rainwater Harvesting is referred to as the collection of rain water in household tanks and tunkies, local surface storages like dams or tanks and anicuts and subsurface aquifers through roof-water harvesting constitute a fair source of water supply to fulfil our needs. Shekhawati region is known for having different water storage structures through centuries. The surface water harvesting structures as local tanks and ponds or exclusive storage for water supply should not only be developed but also maintained properly in all district towns and villages (Singhai et al., 2019). The ground water structures should also be supported through additional recharge on a sustainable basis. An integrated approach to water management is essential for sustainable water supply (G. Singh, 2012).

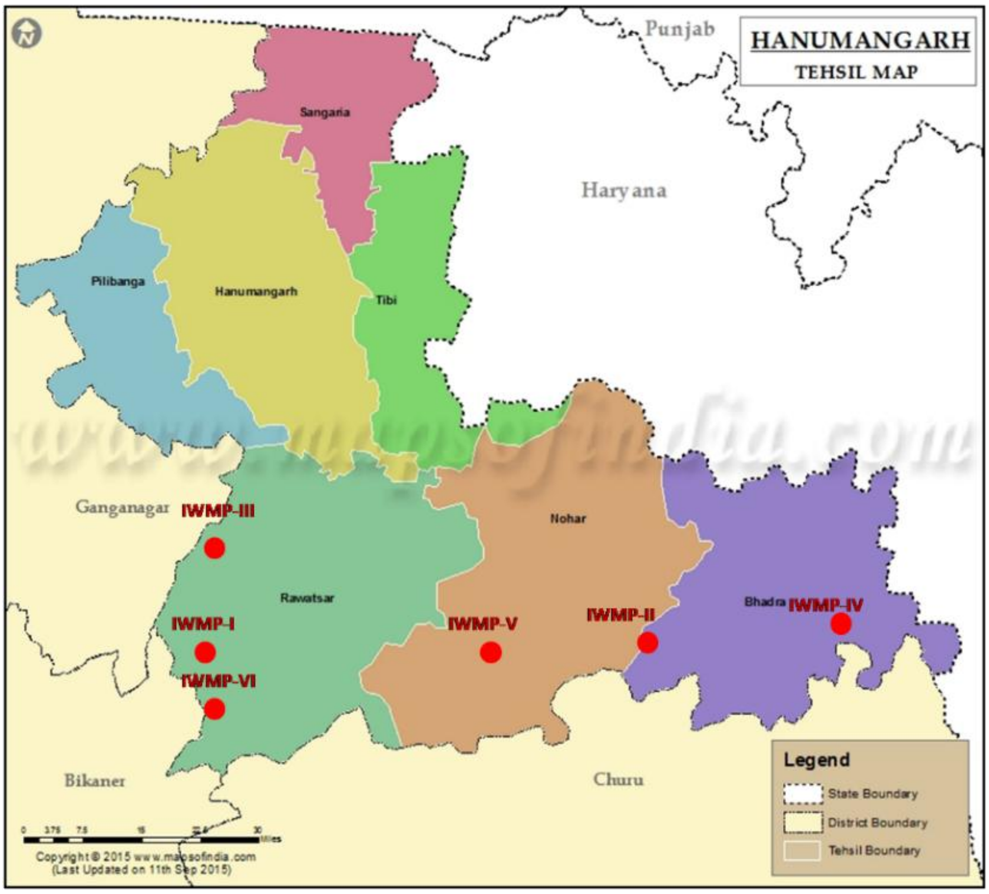


Figure 5.35 Locations of Water shed Structures in Hanumangarh

Watershed Structures

Check dams/ Ponds and Anicuts Water harvesting structures should be maintained on priority by people's participation, sharing with them locally generated resources in terms of water, fodder, vegetation, wood and land on rent or lease. Large scale watershed structures may be planned and implemented as per real site-specific design requirements. Hanumangarh district has various watershed and soil conservation structures shown in Figure 5.47.

Table 5.9 Locations of Watersheds in Hannumangarh

IWMP No.	Location, (Hanumangarh)	Area (ha)
IWMP-I	Sirasar, Rawatsar	5333
IWMP-II	Kikrali, Bhadra	8128
IWMP-III	Bannasar, Rawatsar	5353
IWMP-IV	Shyorani, Nohar	3778
IWMP-V	Sherda, Bhadra	3955
IWMP-VI	Malasar, Rawatsar	2797

Surface Water Structures

Anicuts, Tanks and Dams These water structures are divided between Panchayat department and the Irrigation department. Normally irrigation tanks of more them 50 mcft capacity are with Irrigation department. Panchayat department should get activated to manage planning, design, construction and maintenance of their water structures by arranging money (budget) and manpower on priority. All structures need proper maintenance and management through people's active participation/Water User Associations (WUAs) who should be properly educated and equipped with the intervention of government and NGOs. There is a need of large-scale planning and implementation of small tanks & dams.

Ground Water Structures

These water structures are completely under the fold of private farmers except that of drinking water structures under PHED. Farmers are more anxious to drill new bore wells or replace open wells by bore wells at high cost, which is a dangerous/ negative economic trend and need to be curbed due to over exploitation and mining of ground water at great environmental risks. Over 121 pumping of ground water should be checked & controlled through education restriction in power supply and legislative regulation & control. Feasibility of deep bore well drillings should be checked.

Water Supply Structures

Water Supply Structures run by the Public Health Department (PHED) should also develop their surface water tanks/ dams or renovate existing tanks at their own cost and maintain, protect and manage drinking water wells & bore wells/ tube wells and avoid depletion of the water table and pollution. Pump houses need to be constructed on drinking water tube wells (mobile or permanent as per the health of the structure). PHED may monitor water levels and quality of all its wells, hand pumps, bore wells and anicuts.

5.3 Domestic Sewage Management Plan

5.3.1 Literature review

Domestic sewage is the wastewater generated from households, commercial establishments and institutions in an area. It carries wastewater from kitchens, toilets and sinks of various establishments. Domestic wastewater is commonly described as any of three forms: (i) Black water – water grossly contaminated with human excreta e.g., toilet water, composting toilet leachate; (2) Grey water – water that can be contaminated by human excreta, but does not contain human excreta from a toilet, grey water is directly from the kitchen, bath/shower and laundry. (3) Sewage – a combination of both black and grey water (Biswas & Tortajada, 2019).

Improper management of domestic sewage may result into a number of environmental effects. If the sewage is not treated before discharging, then it results into degradation of surface water bodies. After the self-purification capacity of surface waters is exceeded, sewage degrades the quality of surface water. Groundwater may also be contaminated by sewage as a result of poorly-built facilities. The contamination of surface water and groundwater leads to outbreak of water-borne diseases e.g. cholera, typhoid and polio (Yoder and Rankin, 1998).

It is estimated that 22,900 million litres per day (MLD) of domestic wastewater is generated from urban centres against 13,500 MLD industrial wastewater. The treatment capacity available for domestic wastewater is only for 5,900 MLD, against 8,000 MLD of industrial wastewater. Thus, there is a big gap in treatment of domestic wastewater. The per capita wastewater generation is around 121 litre/capita/day based on the average wastewater generation observed during the three studies carried out by CPCB. Based on the projected population for the year 2051 the wastewater generation is going to be around 132000 MLD.

There is a linear relationship between per capita water supply and sewage generation. As per CPHEEO estimates about 70-80% of total water supplied for domestic use gets generated as wastewater. The per capita wastewater generation by the Class-I cities and Class-II towns, representing 72% of urban population in India, has been estimated to be around 98 lpcd.

Rajasthan state has installed 16 STPs in selected towns with the total treatment capacity of 384.5 MLD as per the Central Pollution Control Board Study. Another 11 STPs has either been constructed or is under construction with a capacity of 149.3 MLD. In addition to this, another 36 STPs of 322.12 MLD capacity is proposed to be constructed *(NIUA, 2019)*.

Technologies for Domestic Sewage Waste Management

Sewage Collection Systems

The traditional centralized sewerage system with deep sewers and manholes in the midst of highways is a legacy of advanced countries with significant water consumption. Although theoretically feasible, such technologies are not economically viable, especially in O&M in Indian conditions, due to high capital and O&M expenses and significant amounts of water used. Alternative technologies are some of the technologies that can be used to.

Sewage Treatment Technologies

Traditional sewage treatment technologies such as the Activated Sludge Process (ASP), Waste Stabilization Pond (WSP), Up Flow Anaerobic Sludge Blanket (UASB) Reactor, and others are routinely used in sewerage systems to treat wastewater up to secondary levels following effluent requirements. JNNURM projects have authorized technologies such as Sequencing Batch Reactor

(SBR) and Moving Bed Biofilm Reactor (MBBR)/ Fluidized Aerobic Bioreactor due to its advantages such as low land requirements, high effluent quality, and so on *(CPHEEO, 2012)*.

Sequencing Batch Reactor (SBR)

On a timed cycle, this variation of ASP technology combines primary settling, aeration, secondary settling, and decanting the treated sewage in a succession of sequential and perhaps simultaneous reactions in the same basin. As a result, multiple basins are used, with one tank settling and discharging the treated sewage in a cyclically repeated process while the other basin is in another stage of the cycle, such as aeration. Fine bubble non-clog membrane diffused aeration with high efficiency is preferred. The bio-kinetic response rate in this non-steady state batch process needs to be examined for its greater rate or otherwise, as opposed to the well-known reaction kinetics of continuous flow steady state ASP for our sewage characteristics. Schematic diagram of Sequencing Batch Reactor (SBR) process is shown in (Fig 5.36) (CPHEEO, 2012).

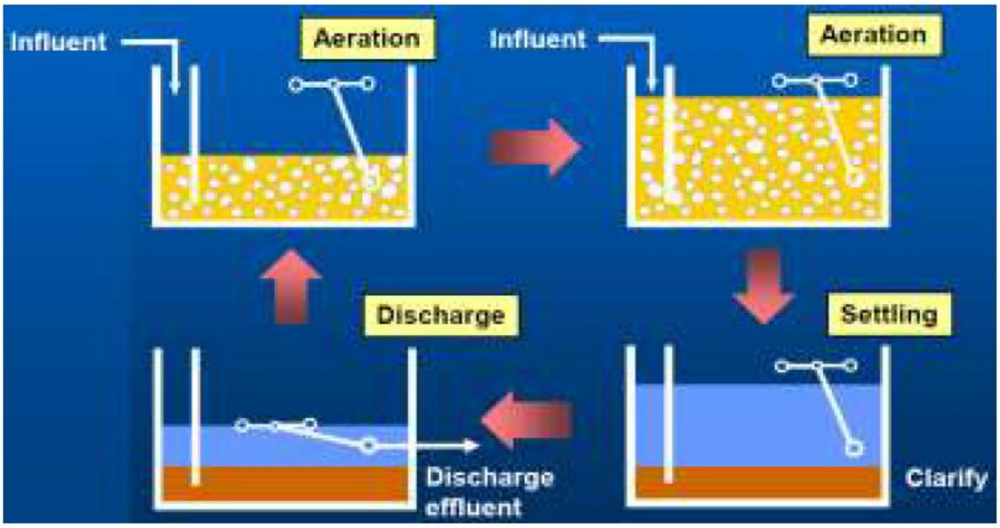


Figure 5.36 Schematic diagram of Sequencing Batch Reactor (SBR) process

Moving Bed Bio Reactor (MBBR) / Fluidized Aerobic Bioreactor (FAB)

This technology is similar to activated sludge except that the media suspended in the reactor provides additional surfaces for the microbes to grow on. This, in turn, maximizes the growth of microbes in a given volume of aeration tank compared to conventional aeration without the media, and it appears to be preferable in that regard. Of course, diffuse aeration is required. FAB technique is similar to MBBR only the media is kept fixed and fluidized in the aeration tank rather than suspended. Schematic flow diagram of MBBR process is shown in the figure. (CPHEEO, 2012).

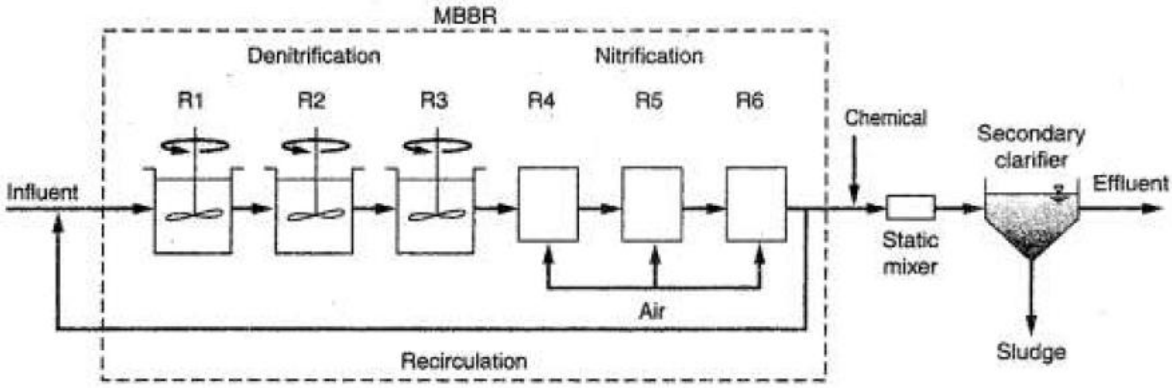


Figure 5.37 Schematic flow diagram of MBBR process s (Source: urbanindia.nic.in)

Membrane Bio Reactor (MBR)

By sucking out the aerated mixed liquor through membranes instead of settling in a separate downstream tank, this system integrates the aeration and secondary clarifier in one tank, it does produce treated sewage with virtually no BOD and suspended solids, making it clear and nearly transparent, as well as its claimed ability to hold and sustain mixed liquor suspended solids (MLSS) three to four times greater than what is possible in conventional aeration tanks, reducing the treatment plant's footprint. Of course, diffuse aeration is required. The membrane is a subject of propriety, and the throughput per membrane module given by many vendors varies, as do the shapes of membranes advocated by each vendor, such as flat sheet, cross flow, dead end flow, and so on, making universal validated standard design criteria problematic. Schematic flow diagram of Submerged Membrane Bioreactor process is shown in Fig. 5.38 (CPHEEO, 2012).

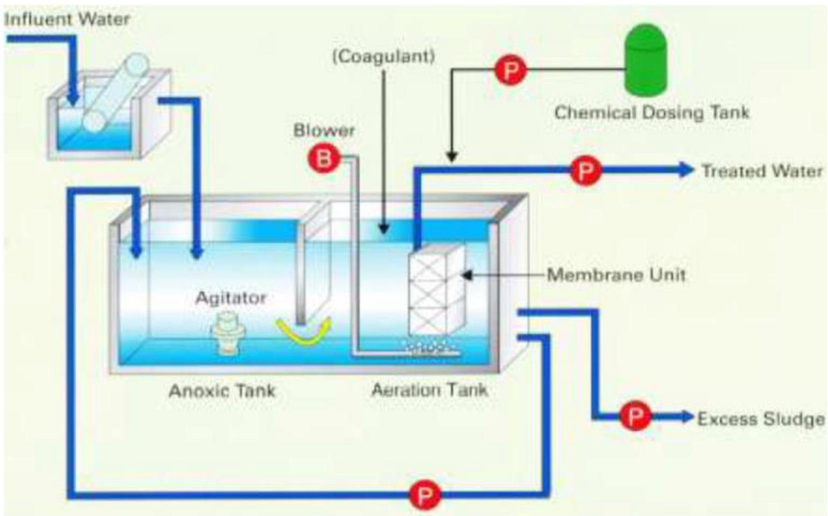


Figure 5.38 Schematic flow diagram of Submerged Membrane Bioreactor process *(Source: urbanindia.nic.in)*

Approach towards Recent Technologies

A techno-economic feasibility analysis of all conventional technologies such as Activated Sludge Process, UASB, WSP, and other technologies such as SBR, MBBR, and others approved under JNNURM may be carried out when formulating the DPR for STPs and the most appropriate technology may be proposed in the DPR suiting the local conditions. Life cycle costs for all of these technologies can be calculated during the techno economic analysis, taking into account capital costs, operating and maintenance costs for a set period, land costs, and so on. Other factors to consider are influent quality, effluent quality standards, effluent quality for reuse, and resource recovery (gas/electricity generation). A thorough cost estimate for the STP can be created using either the schedule of rates or the previously awarded cost of similar capacities of STPs (average cost of different STPs) based on these technologies in the relevant State.

Constructed wetlands

Although the concept of constructed wetlands is the same as in other treatment technologies, they have some unique advantages. It is organic wastewater treatment system that improves the effectiveness of the processes which help to purify water same as naturally occurring wetlands. There is requirement of water, aquatic plants (i.e.: reeds, duckweed), naturally occurring microorganisms and a filter bed (usually of sand, soils and/or gravel) for the system. Secondary or tertiary wastewater treatment can be done by constructed wetlands. There are various options in design, technology and materials that help the constructed wetland to be adapted as per land availability and local conditions.

The basic concept of this technology is that the plants, microorganisms and substrates together act as a purification system. First, to allow sedimentation of solids, water is slowed while it enters the wetland. Meanwhile the larger particles present in the wastewater are removed by plant roots and the substrate. Pollutants and nutrients present in wastewater are then broken down naturally and taken up by the bacteria and plants. The retention time in the wetland, along with UV radiation and plant secretion of antibiotics also kill the pathogens present in wastewater. Then water can be safely released into surface waters or used various purposes.

Wetland technology has various salient features: Cost efficient in terms of construction, operations and maintenance; effectively treats wastewater from human waste, agricultural runoff, storm water and some metals or pollutants from mining and industry; provides a habitat for plants and animals, contributing to environmental protection uses simple technology which is easy to understand and manage; operations require low energy consumption; treated water can be reused; helps in maintaining groundwater and surface water levels; means of water storage; pleasing natural aesthetics.

Faecal Sludge & Septage Management:

Faecal Sludge and Septage Management (FSSM) assumes significance in Indian scenario as about 60% households are dependent on on-site sanitation systems. Since FS&S possess strong polluting capacity and can harm humans and environment alike, there is a necessity to manage it properly till its safe disposal/end-use. Cost of poor sanitation to the nation is humongous which further necessitates the proper management of fecal Sludge and Septage collected from onsite sanitation systems (OSS) like septic tanks and leach pits. Recycling and Reuse can be done for Agricultural application as oil conditioner, and as a fertilizer.

Faecal Sludge & Septage Value Chain

FS&S value chain begins with the user interface i.e., toilets (Individual Toilets, Community & Public Toilets) followed by the containment systems, emptying, transport, treatment and ends at reuse/disposal. Once managed, domestic FS&S is a resource. A valuable soil conditioner, FS&S contains nutrients that can reduce reliance on chemical fertilizers for agriculture. Process followed in faecal sludge treatment is shown in Figure 5.39.

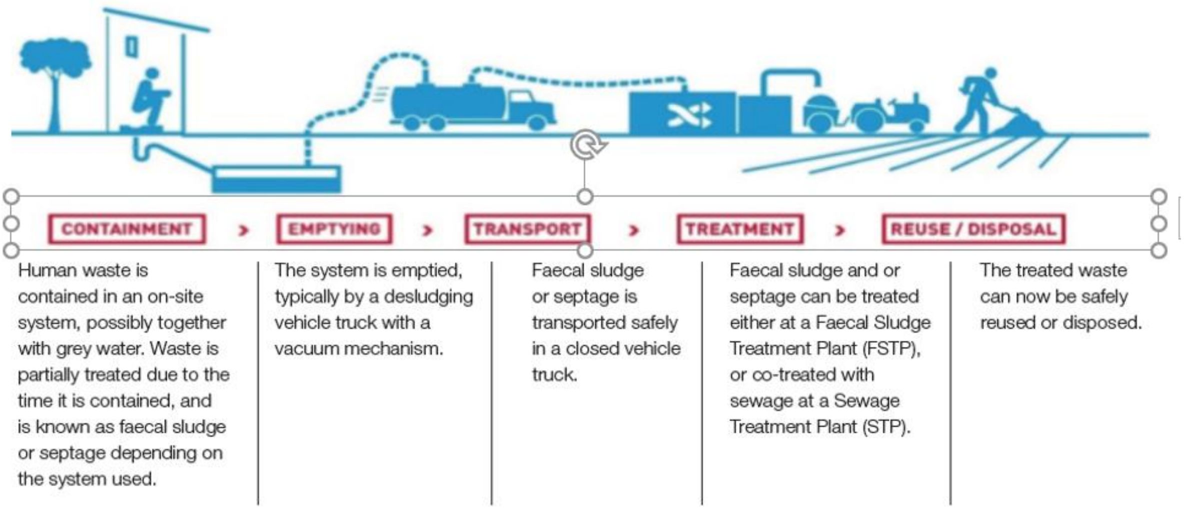


Figure 5.39 Process followed in faecal sludge treatment *(Source: cpeeho.gov.in)*

Financial Sustainability of Sewerage and Sewage Treatment Services

For a variety of causes, the majority of India’s urban municipal governments are financially strapped and unable to carry out their mandated tasks. Sanitation, including sewerage and sewage treatment, has received little attention. Sanitation services, according to the findings of a study conducted by NIUA, either earn no money or generate a tiny amount of cash. Because current sewage tariff levels in

India are too low and do not reflect the true economic cost of providing sewage collection, treatment, and disposal services, raising tariffs to a level that ensures the sewerage system generates sufficient revenues to cover capital and operating costs and becomes self-sustaining may not be possible in one fell swoop. This could be achieved by increasing tariffs gradually over some time.

It is advised that tariffs be set in the early years to guarantee that they cover at least the sewer system's O&M expenditures. The user acceptability of a tariff rise by ULBs would improve after operational efficiency is established with the infusion of private sector participation.

The rates can then be raised to cover both capital and operating and maintenance costs. In the case of a PPP, the concession should be constructed to support a rising tariff scenario, with obligations from the private partner to boost service levels and commitments from ULBs to raise tariffs in the future.

Governance and Management

The City Sanitation Plan (CSP) as per the guidelines in National Urban Sanitation Policy (NUSP), 2008 forms the basis for planning of wastewater management projects in urban areas. The management could be a combination of approaches like conventional sewerage system, decentralized wastewater management systems or on-site sanitation.

- Elimination of Open Defecation
- Conversion of insanitary toilets to sanitary ones
- Retrofitting of on-site containment/treatment structures like septic tanks as per recommended specifications
- In areas where water supply is inadequate, provision for decentralized wastewater management system including treatment and non-conventional sewers (settled or simplified sewers/small bore sewers)
- Fecal sludge and septage management in areas dependent on on-site sanitation in the form of leach pits, twin pits, septic tanks with/without soak pits etc. – desludging of containment units, transportation, treatment and reuse/disposal
- Mechanization of cleaning of sewers and emptying of septic tanks, safety gear for sanitation workers
- Planning for conventional sewerage system in areas with a minimum of 135 lpcd water supply or where contemplated
- Plan for recycling and reuse of treated wastewater and sludge
- Provision of public toilets with appropriate containment/treatment systems

Urban Local body

The Rajasthan Government has formulated a detailed State Sewerage and Wastewater Policy (SSWWP) to address the problems of centralized sanitation mentioned. The important provisions of this policy are as follows:

- All ULBs will prepare City Sanitation Plans (CSP) in accordance with\the Central Public Health and Environmental Engineering Organization (CPHEEO) revised Manual on Sewerage and Sewage Treatment published in 2013.
- These plans have to be following the overall town plans to avoid mismatches in development and ensure the proper treatment and reuse of wastewater.
- Technologies such as Geographical Information Systems (GIS), Ground Penetrating Radar (GPR) and Total Station Surveyors (TSS) should be used to prepare detailed maps of the sewer network. These maps should be updated every ten years and linked to an MIS (Management Information Systems) detailing the assets and their parameters.

Best Practices

This section describes case studies from specific regions/cities. Surat city is located on the west coast of India, in the southern part of Gujarat state. SMC has undertaken numerous initiatives to improve the city environment in various ways and the results are visible in the city's sewage treatment capabilities. It has expanded sewerage networks in urban areas and upgraded existing STPs to provide for secondary treatment processes under JnNURM. Sewage gas generated during the anaerobic process of sludge treatment is utilized as a fuel to run gas engines to produce electrical energy that replaces grid electricity required to run the sewerage system. The main focus of the co-benefit approach followed by SMC is the actions taken for climate change mitigation resulting in the reduction of GHG emissions and any additional benefits that may be associated with the action.

Planning and design of wastewater treatment facilities offer more possibilities for energy conservation. After sewage treatment, a particular amount of sludge is generated. It consists of residual organic matter and dead bacteria used in the treatment process. This can be used for agricultural purposes as manure after primary and secondary treatment. It can help in reduction of usage of chemical fertilizers. An initiative of good sewage treatment also helps in the reduction of water pollution. Sewage generated from households, restaurants usually contain microorganisms such as bacteria, virus, fungus or parasites which may create water-borne diseases. Treated sewage will help to reduce the chances of the above consequences. It will also help to increase the chances of better public health and reduction in mortality rate (Espíndola & Presents, 2020).

5.3.2 Present scenario and gaps identification

Data Provided by ULBs

Inventory of Sewage Management

As per the data provided in the table below the district has three Class II and Class III towns based on the Census classification of towns. Hanumangarh being the most populous city also produces the highest amount of domestic sewage (12.5 MLD) in the district.

Table 5.10 Report on Inventory of domestic sewage

S. No.	Parameters	District	Urban Local Bodies					
		Hanumangarh	Nagar Parishad	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
1	Total Quantity of Sewage generated in District from Class II cities and above (MLD)	18.5	12.5	1.5	0	0	0	4.5
2	No of Class-II towns and above	3	-	1	0	0	0	2
3	No of Class-I towns and above	0	-	0	0	0	0	0
4	No of Towns needing STPs	3	-	1	0	0	0	2
5	No of Towns STPs installed	3	1	0	0	0	0	2
6	Quantity of treated sewage flowing into Rivers (directly or indirectly) (MLD)	6.5	5	1.5	0	0	0	0
7	Quantity of untreated or partially treated sewage (directly or indirectly) (MLD)	0.05	-	0.5	NIL	0	0	[Automatic]
8	Quantity of sewage flowing into lakes (MLD)	1	-	1	0	0	0	0
9	No of industrial townships	2	1	1	0	0	0	0

Adequacy of available infrastructure for Sewage Treatment

It is clear from the data provided in table provided below that even for those ULBs (i.e.,Hanumangarh and Bhadra) which are having STP(s), only Hanumangarh is treating all the wastewater generated. Other ULS i.e., Pilibanga need more treatment capacity for treating all of their wastewater.

Table 5.11 Adequacy of available infrastructure for sewage treatment and sewerage network in Hanumangarh district

S. No.	Parameters	District	ULB					
		Hanumangarh	Nagarparishad HMH	Nagarpalika Pilibanga	Nagarpalika Sangaria	Nagarpalika Rawatsar	Nagarpalika Nohar	Nagarpalika Bhadra
1	% sewage treated in STPs (%)	7.5	0.45	0	0	0	0	[Automatic]
2	Total available Treatment Capacity (MLD)	17	12.5 MLD	0	0	0	0	[4.5 MLD]
3	Additional treatment capacity required (MLD)	9.5	5 MLD	2MLD	0	0	0	[2.5MLD]
4	No of ULBs having partial underground sewerage network	3	1	1	0	0	0	1
5	No of towns not having sewerage network	1	-	0	0	0	0	1
6	% Population covered under sewerage network (%)	12.5	0.65	0.1	0	0	0	[Automatic]

Inferences from Present Scenario

Wastewater generation in the district is about 18.5 MLD as per the data received from all ULBs. The wastewater quantities being generated currently from all the ULBs are shown in Figure below. However, estimations based on a report from National Clean Ganga Mission (NCGM, 2020), the wastewater generation is different (as shown in future projections below).

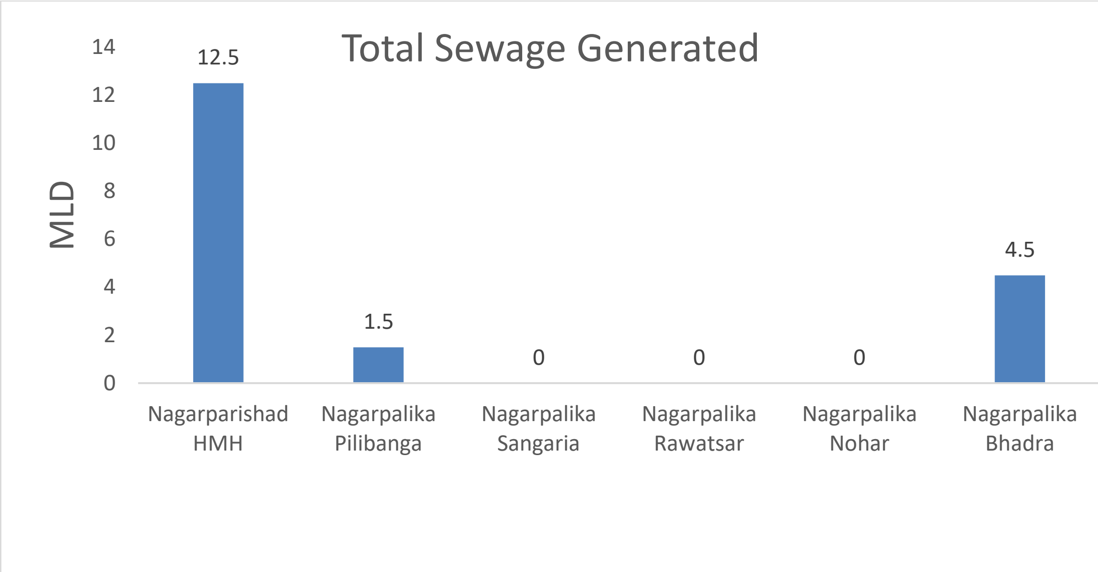


Figure 5.40 Sewage currently being generated in ULBs of Hanumangarh district (as estimated)

STPs are operational only in two ULBs i.e. Hanumangarh and Bhadra. Moreover, the capacities of these STPs are not being utilized in full as the sewer network does not cover the city/towns completely.

As the population of Hanumangarh ULB is the highest, the wastewater being generated in Hanumangarh is the highest. However, all of this wastewater is not being collected by using sewer network. Sewer network is partially available in some of the ULBs only i.e., Hanumangarh and Pilibanga.

Data has not been collected about faecal sludge management. It is quite clear that there are no facilities for faecal sludge management.

Future Projection

For looking into the future, projections have been made for wastewater generation in individual ULBs and the whole district. Table 5.6 shows the projected quantities for Hanumangarh district. Currently, total wastewater generation in the district is about 41.1 MLD but it would be reaching about 51.2 MLD in 2051. At such huge quantities, it becomes of paramount importance that the wastewater is properly conveyed through a sewer network to a sewage treatment plant.

Table 5.12 Projection of wastewater generation in the whole district

Year	Total WW generated day (million liter /day) in district
2021	41.1
2031	44.5
2041	47.9
2051	51.2

The projections for wastewater generations in individual ULBs have also been made. The figure below represent the wastewater generation in individual ULBs in grouped manner.

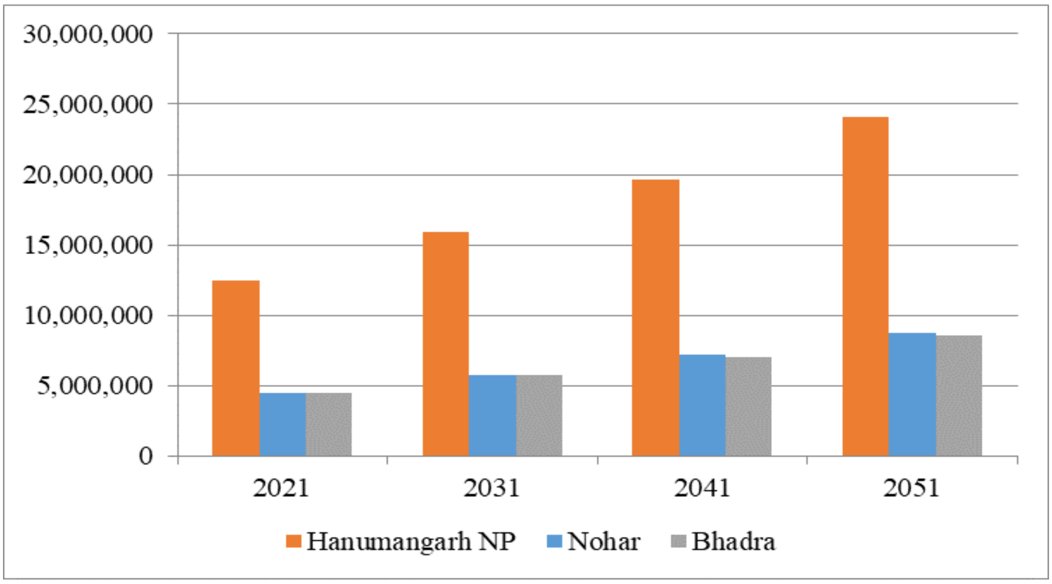


Figure 5.41 Projections for sewage generation in Hanumangarh, Nohar and Bhadra

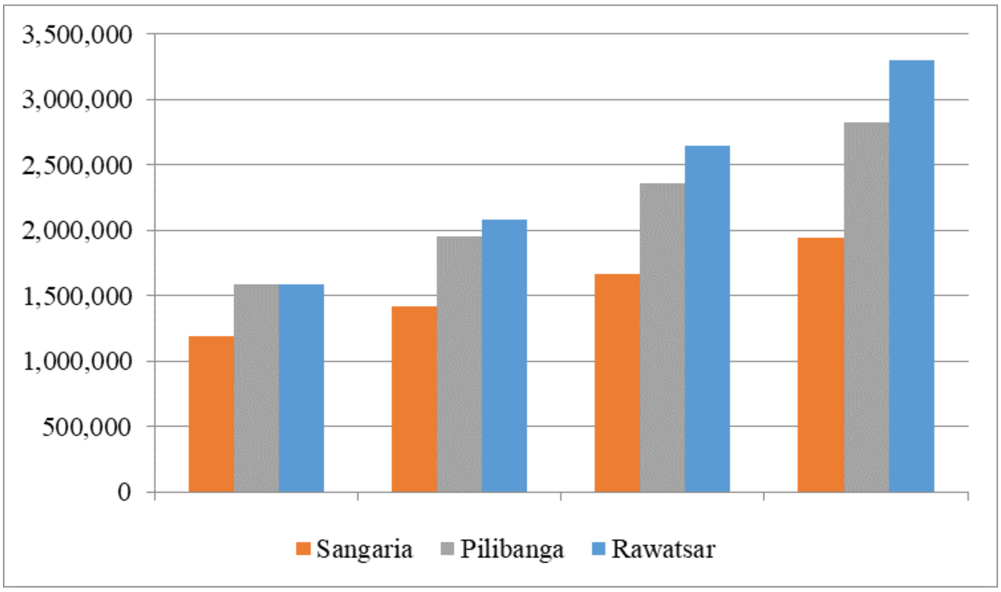


Figure 5.42 Projections for sewage generation in Sangaria, Pilibanga and Rawatsar

Hanumangarh, being the most populous, ULB would have the highest wastewater generation of 24 MLD in year 2051. All the other ULBs i.e., Nohar and Bhadra would be producing sewage less than 10 MLD in year 2051. While Pilibanga, Sangaria, Rawatsar would be producing sewage less than 20 MLD in year 2051. Collection of generated wastewaters is the first step towards minimization of risk from sewage for the population and the surrounding environment. For collection, every household and establishment should be connected with the sewer network.

5.3.3 Action Plan

To avoid the harmful effects of wastewater, it becomes important to treat the wastewater generated in a ULB. Although 100 % of the wards in a municipality may be connected to sewer network, the whole arrangement without a STP would be posing a serious risk to the general public and the environment. Sewage Treatment plants are used to treat sewage generated from residential, institutional, commercial and industrial establishments which includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. In India, different treatment technologies like ASP, UASB, Oxidation Pond and advanced technologies like SBR, MBR are adopted for the treatment of sewage. Based on a country-wide study done in India, CPCB concluded that 816 number of STPs (including operational, non-operational, under construction and proposed) are available having a treatment capacity of 23,277 MLD equipped with different technologies like ASP, OP, USAB, SBR etc. It was also find out that maximum STPs having ASP-based treatment technology and nowadays SBR based technology widely used for treatment of sewage (CPCB, 2015)

Treatment wetlands are also promising technologies with a number of advantages (e.g., low cost and maintenance), especially for ULBs with smaller population (IWA, 2017). Costs associated with the construction of the treatment system can be divided into direct costs (land acquisition, earthwork, pipes and fittings, pumps, filter media, liner, and plants) and indirect costs (site evaluation, permitting, and start-up services). In Europe, capital costs of small treatment wetlands (excluding costs for land) are in the same range as packaged treatment plants. This is mainly due to high labour costs, because more labour is required to construct a treatment wetland than, for example, a sequencing batch reactor (SBR) or similar kind of wastewater treatment system. Main O&M cost components include energy to run pumps (when necessary), compliance monitoring, maintenance of access roads and berms, and replacement or repair of mechanical components. If the wetland system can be loaded via gravity, no external energy is required and thus no pumping costs occur. Costs for vegetation management depend on items such as harvesting and pest control. Current design guidelines for VF wetlands foresee cutting of plants and removal of litter every two to three years. In general, less labor is required for O&M of treatment wetlands compared to other wastewater treatment plants. Thus, O&M

costs of treatment wetlands are lower than those for other conventional wastewater treatment technologies

In Hanumangarh district, the sewage treatment plants have been constructed in the ULBs where sewer network have been laid. While Hanumangarh has total one plants and Bhadra is having two treatment plant. All the treatment plants are based on SBR technologies. From data available, it can be deduced that treatment plants are not being utilized for their full capacity as the sewer network has not reached all the wards in the municipality. For such ULBs, urgency should be demonstrated in laying the sewer network.

The ULBs which are yet to construct their STPs can go for a combination of technologies e.g., one plant may base on SBR, while a new one may be constructed based on treatment wetland technology. The ULBs having smaller population have the advantage of land availability and cheap labour (as the living cost is lower in these areas). Both factors vigorously support the treatment of wetland technologies. As most of the ULBs still do not have connectivity to wastewater collection system, it becomes important to plan the faecal sludge (FS) management. Compared to wastewater management, the development of strategies and treatment options adapted to conditions prevailing in developing countries have long been neglected with regards to faecal sludge – the by-products of on-site sanitation installations (EAWAG, 2008). The problems and challenges in FS management rest with all the components of the faecal sludge stream, namely pit/vault emptying, haulage, storage or treatment, and use or disposal.

Several health hazards are posed by manual emptying of fecal sludge. Individuals, small groups of individuals or micro-enterprises offer manual emptying, traditionally carried out with buckets. The workers step into the vault or pit to evacuate the sludge that has generally solidified to be scooped out. Hence, traditional manual emptying is associated with considerable health risks for the workers. The general public is also at risk as the emptied sludge is usually deposited into dwelling concessions, nearby surface drains or into lanes. Even when the fecal sludge is withdrawn using a 257 mechanized vehicle, the haulage routes tend to be rather long as metropolitan cities usually stretch out. Traffic congestion further aggravates the problem and renders haulage to designated discharge or disposal sites uneconomical and financially unattractive. This leads to uncontrolled dumping of collected FS at the shortest possible distance from the area of collection.

Compared to sludge from wastewater treatment plants or to municipal wastewater, FS characteristics differ widely according to location (from household to household, from city district to city district, from city to city). The factors influencing faecal sludge are tank emptying technologies and pattern, storage duration (months to years), the performance of septic tank, admixtures to FS (e.g., solid waste/ kitchen waste), temperature and intrusion of groundwater.

The properties of FS that require attention during treatment are BOD, Ammonia, suspended solids and pathogens. The treatment of FS includes solid-liquid separation first and then treating the liquid and solid streams separately. Solid-liquid separation can be done by: (i) drying beds, (ii) settling tank, (iii) settling pond, (iv) Anaerobic digestion, (v) co-treatment with sewage sludge. For the solid fraction, various technologies available are: (i) co-composting with organic solid waste (ii) natural drying. For the liquid fraction, treatment can be carried out using: (i) co-treatment with wastewater (ii) waste stabilization ponds and (iii) constructed wetland.

Table 5.13 Actions and timelines for domestic waste management

S. No.	Action point	Deficiency in present status and, planning for future	Timeline	Stakeholders responsible
1	Inventory of Sewage collection network	1) 100% households are not connected to sewer in anyone ULB. 2) 2) Survey and identification of all households to ensure proper drainage of sewage in all the ULBs.	1-year	Nagarparishad HMH, Nagarpalika- Pilibanga, Sangaria, Rawatsar, Nohar, Bhadra
2	Provision of Sewerage Network	1) Sewerage networks are to be laid in all the ULBs. 2) To take advantage of the sewerage network, quality assurance for the sewerage pipes should be an ongoing activity and not be limited to at the time of construction only. 3) For all new Greenfield developments, sewerage network should be designed and installed before the construction starts.	5-years	Nagarparishad HMH, Nagarpalika- Pilibanga, Sangaria, Rawatsar, Nohar, Bhadra
3	Adequacy of available Infrastructure for Sewage treatment	1) Presently STPs available are under-utilized in all the ULBs. 2) Efforts should be at priority to utilize the full capacity of these STPs. More areas have to be connected to sewer network and to STP in turn. 3) 3. A combination of technologies should be employed for treatment. The advantage may be in potential to treat domestic wastewater and other streams e.g. faecal sludge or leachate from the sanitary landfill.	3- years for utilizing the full capacity of STPS; 5-years for installing the treatment plants to the full capacity.	Nagarparishad HMH, Nagarpalika- Pilibanga, Sangaria, Rawatsar, Nohar, Bhadra
4	Faecal sludge management	A program should be undertaken by the ULBs inspecting tanks for leakages A regular monitoring program for groundwater across the ULB and subsequent analysis will also help understanding the relation between faecal sludge and groundwater quality. Regular emptying of tanks by awareness campaign Use of information and communications technology (ICT) for GPS tracking of trucks and mobile applications (apps) to centrally coordinate service providers Selection of appropriate technology for faecal sludge treatment	Immediate	State groundwater department and Regional office (State Pollution Control Board), Nagarparishad HMH, Nagarpalika- Pilibanga, Sangaria, Rawatsar, Nohar, Bhadra

5.3.4 Summary

As of now almost partial of urban population is covered with sewerage system and remaining is serviced on onsite sanitation facilities. In the areas, where sewerage system is yet to come, States are encouraging ULBs to expeditiously cover it by putting in place a mechanism for desludging of septic tanks periodically linked with adequate treatment of Fecal Sludge and Septage either at standalone FSTPs or through co-processing in STPs. This is in spite of fact that FSTPs so installed takes care of only around 1% of influent sewage pollution load.

A plan should be prepared to cover all aspects of On-site and Off-site sanitation options including conveyance, treatment and recycle and reuse for implementation. It also contains a Decision-Making. Tree for selection of suitable sanitation option for an area and also the comparison of different conveyance and treatment options to suit different set of conditions of cities.

Table 5.14 Summary about Domestic Sewage Management for all the ULBs of Hanumangarh District, highlighting present status and action plan for future

Name of ULB	Present Status	Action Plan for future
Nagarparishad Hanumangarh	The estimated quantity of domestic sewage generated in Nagar Parishad is 12.5 MLD. There is 1 STPs installed here which is fully operational. The full capacity of this STP is 12.5 MLD. Quantity of wastewater reaching in the STPs is 5.625 MLD, so 6.875 MLD of wastewater remains untreated or partially treated. There is provision of partial underground sewage network which covers 65 % of the population.	Survey and identification of all households to ensure proper drainage of sewage Efforts for full utilization of existing STP Inspection of STPs
Nagar Palika Pilibanga	The estimated quantity of domestic sewage generated in Pilibanga is 1.5 MLD. There are no STPs installed and one STP is needed in town. 1.5 MLD of wastewater is discharged into river. 0.5 MLD of wastewater remains untreated or partially treated sewage. There is provision of partial underground sewage network which covers 10 % of the population in ULB.	Survey and identification of all households to ensure proper drainage of sewage Initiate combination of technologies like faecal sludge or leachate from sanitary landfill Sewerage networks are to be laid
Nagarpalika Sangaria	No data available	Survey and identification of all households to ensure proper drainage of sewage Sewerage networks are to be laid Initiating faecal sludge management Inspection of leakage in tanks

Nagarpalika Rawatsar	No data available	Survey and identification of all households to ensure proper drainage of sewage Sewerage networks are to be laid Initiating faecal sludge management Inspection of leakage in tanks
Nagarpalia Nohar	No data available	Survey and identification of all households to ensure proper drainage of sewage Sewerage networks are to be laid Initiating faecal sludge management Inspection of leakage in tanks
Nagarpalika Bhadra	The estimated quantity of domestic sewage generated in Bhadra is 4.5 MLD. There are 2 STPs installed here with treatment capacity of 4.5 MLD and additional treatment capacity of 2.5 MLD is required. Quantity of wastewater reaching in the STPs is 0.7 and 0.21 MLD, so 5.52 MLD of wastewater remains untreated or partially treated. There is provision of partial underground sewage network in ULB.	Survey and identification of all households to ensure proper drainage of sewage Sewerage networks are to be laid Initiating faecal sludge management Inspection of leakage in tanks
Hanumangarh district	The estimated quantity of domestic sewage generated in Hanumangarh district is 18.5 MLD. There are 3 class- II towns in district There are 3 STPs installed in whole district. Total available treatment capacity in the district is 17 MLD and additional capacity required is 9.5 MLD. 6.5 MLD from total generated wastewater is discharged in river. 12.5 % of population is covered under sewerage network	Survey and identification of all households to ensure proper drainage of sewage Sewerage networks are to be laid Initiating faecal sludge management Inspection of leakage in tanks

6. Air and Noise Pollution Management Plan

6.1 Air Quality Management

6.1.1 Literature Review

Air quality is referred to as the degree to which the ambient air is pollution-free, assessed by measuring several indicators of pollution. It affects our health, the livability of our cities and towns, and our environment. Air pollution, particularly from human activity, can cause health problems that affect the heart and lungs, and can cause cancer. Even short-term exposure to air pollution can cause health problems. Children, the elderly and people with existing heart and lung conditions are especially affected by air pollution. Air quality of an area is of utmost importance for its residents e.g., a person ingests about 2-4 liters of water per day whereas total quality of air inhaled per day is about 15,000 liters/day. Air quality monitoring provides information regarding the status of present air quality. It helps in evaluating the existing policies and their effective implementation. One of the important components of any air quality monitoring program is planning, design and establishment of monitoring network based on the air quality objectives *(Gulia et al., 2015).)*.

Air pollution has been a major source of concern for India, a developing economy, which is struggling to strike a balance between development on one hand and environment protection on the other. To this effect, India recognizes the fundamentals of sustainable development as the cornerstone for the sustained economic progress of a nation and is working towards addressing the all-important issue of air quality management (Kapoor, 2012).

The Air (Prevention and Control of Pollution) Act, 1981, was enacted under Article 253 of the Constitution to implement the decisions taken at the United Nations Conference on Human Environment held in Stockholm in June 1972, in which India participated. Sustainable development, in terms of the enhancement of human well-being, is an integral part of India’s development philosophy. India has been going through a phase of accelerated industrial activities for the past three decades. The associated growth in terms of industrialization and urbanization has led to a manifold increase in pollution issues, more specifically air pollution issues. In recent years, medium and small towns and cities have also witnessed an increase in pollution, thus getting fast reflected in the non-attainment cities of India. Air pollution has increasingly become a serious concern, predominantly because of its health impacts *(Sundaray et al, 2020).*

Since the enactment of the Air Act 1981, air pollution control programs have focused on point and area source emissions, and many communities have benefited from these control programs. Nonetheless, most cities in the country still face continuing particulate non-attainment problems from aerosols of unknown origin (or those not considered for pollution control) despite the high level of control applied to many point source (M. Sharma, 2020).

India is committed to creating a clean environment and pollution-free air and water. India's commitments and obligations to environmental conservation and protection within the ambit of the targeted goals on environmental sustainability under the Sustainable Development Goals (SDGs) is manifested in the fact that several administrative and regulatory measures, including a separate statute on air and water pollution are under implementation since long (Sundaray et al, 2020).

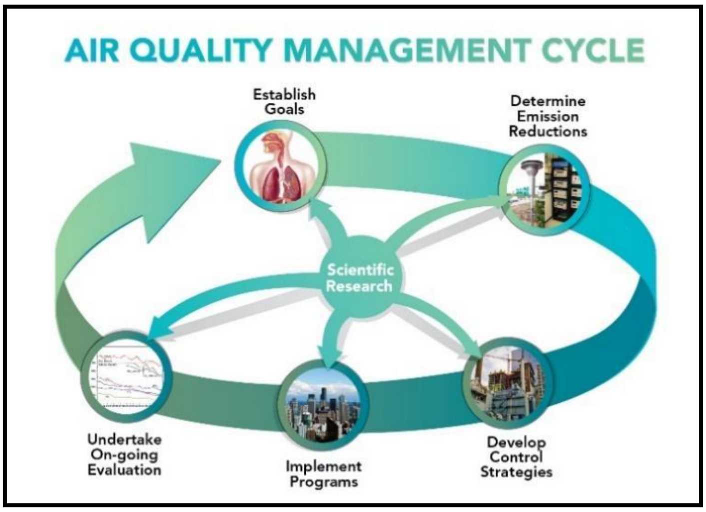


Figure 6.1 Air Quality Management Cycle

Air quality management refers to all the activities a regulatory authority undertakes to help protect human health and the environment from the harmful effects of air pollution. The process of managing air quality can be illustrated as a cycle of inter-related elements as represented in Figure 6.1, Air Quality Management Cycle *(EPA, 2020).*

Air Quality Management Plan is an integrated assessment methodological scheme for the evaluation of air pollution control measures that are put forward to reduce air pollution levels in urban areas. This approach brings together air quality modeling and mathematical programming techniques provides a decision support system for the determination of optimal bundles of air pollution control options according to the particular features and needs of the areas examined *(Gulia et al., 2015).*

Air quality modeling plays an important role in formulating air pollution control and management strategies by providing guidelines for efficient air quality planning. Its main objective is to predict ambient air pollutant concentrations of one and more species in space and time as related to independent variables such as emission and meteorological parameters *(Gulia et al., 2015)*

In terms of Air Quality Measurements; approximately five air quality measurements have been prevailing in the district namely, PM10 (particulate matter of size less than and equal to 10 µm diameter), PM2.5 (particulate matter of size less than and equal to 2.5 µm diameter), SO_2, NO_2, VOCs (volatile organic compounds) etc. The vehicle emission contribution is significant for CO, NOx, PM10 and PM2.5. There is a relatively large contribution of diesel vehicles (trucks, buses, LCVs, cars, etc.) to PM10, PM2.5 CO, SO_2, and NOx. Out of about 7 t/d emission of PM10 and PM2.5 from vehicles, over 80% is from diesel vehicles, especially from trucks and buses. Therefore, control measures have to focus on advanced technological intervention for diesel vehicles or change in fuel to CNG (compressed natural gas) especially local transport of buses and light commercial vehicles (M. Sharma, 2020).

Air Quality Index

An AQI is defined as an overall scheme that transforms weighted values of individual air pollution-related parameters (SO2, CO, visibility, etc.) into a single number or set of number *(CPCB, 2021).*

AQI Category (Range)	PM_{10} 24-hr	$PM_{2.5}$ 24-hr	NO_2 24-hr	O_3 8-hr	CO 8-hr (mg/m^3)	SO_2 24-hr	NH_3 24-hr	Pb 24-hr
Good (0-50)	0-50	0-30	0-40	0-50	0-1.0	0-40	0-200	0-0.5
Satisfactory (51-100)	51-100	31-60	41-80	51-100	1.1-2.0	41-80	201-400	0.6 –1.0
Moderate (101-200)	101-250	61-90	81-180	101-168	2.1- 10	81-380	401-800	1.1-2.0
Poor (201-300)	251-350	91-120	181-280	169-208	10.1-17	381-800	801-1200	2.1-3.0
Very poor (301-400)	351-430	121-250	281-400	209-748*	17.1-34	801-1600	1201-1800	3.1-3.5
Severe (401-500)	430 +	250+	400+	748+*	34+	1600+	1800+	3.5+

**One hourly monitoring (for mathematical calculation only)*

Figure 6.2 Breakpoints for AQI Scale 0-500 (units: µg/m^3 unless mentioned otherwise)

Rajasthan lies in the arid and semi-arid agro-climatic zone of the country and hence the presence of dust due to dry climatic conditions coupled with strong hot air movement is common. The presence of Particulate Matter in the atmosphere goes particularly high during summer months and winter when the phenomenon of thermal inversion occurs. The yearly average from January to December 2019 reveals that both the particulate pollutants, PM 2.5 and PM 10 are mostly above permissible limits at all CAAQMS sites.

Governance and Management

Policy makers in India started taking an interest in air pollution control policies after the Stockholm Conference on the Human Environment in year 1972 and identified that the nation was in need of environmental legislation to control air pollution. As a result, the Air (Prevention and Control of Pollution) Act 1981 came into force with the goal of prevention, control, and abatement of air pollution. It is a very comprehensive legislation and empowers Central and State Pollution Control Boards (SPCBs) to declare pollution control areas, to put restrictions on certain industrial units to limit their emissions of air pollutants and to enter, inspect and carrying out monitoring. In addition, CPCB provides technical assistance and guidance to the SPCBs and carry out and sponsor investigations and research related to air pollution.

The first ambient air quality standards for three criteria pollutants (SO_2, NO_2 and SPM) separately for industrial, residential and sensitive areas were adopted in year 1982 by the CPCB under this Act. The NAAQS were later revised in 1994 with the addition of three more pollutants for daily and annual averages (except CO which is 8-hour average). The latest NAAQS were again revised in year 2009 for a total of 12 pollutants *(Gulia et al., 2018).*

Ambient air quality monitoring is an important aspect of Urban Local Air Quality Management which assesses the current air quality status as well as evaluates existing policies. Air quality monitoring is used to identify and declare the NAAs by comparing pollutant concentrations with standards. The protocol for ambient air quality monitoring including real time continuous monitoring, has already been developed by CPCB (2011). Figure 6.3 depicts the integrated global to local framework for air quality monitoring *(Brauer et al., 2019).*

Central Government

India has 793 operating stations in 344 cities/towns in 28 states and 7 Union Territories of the country under the National Air Monitoring Programmes (NAMP). There are 261 continuous Ambient Air Quality Monitoring Stations in 134 Cities covering 23 States & Union Territories connected to the web-based system providing Real-Time Ambient Air Quality details.

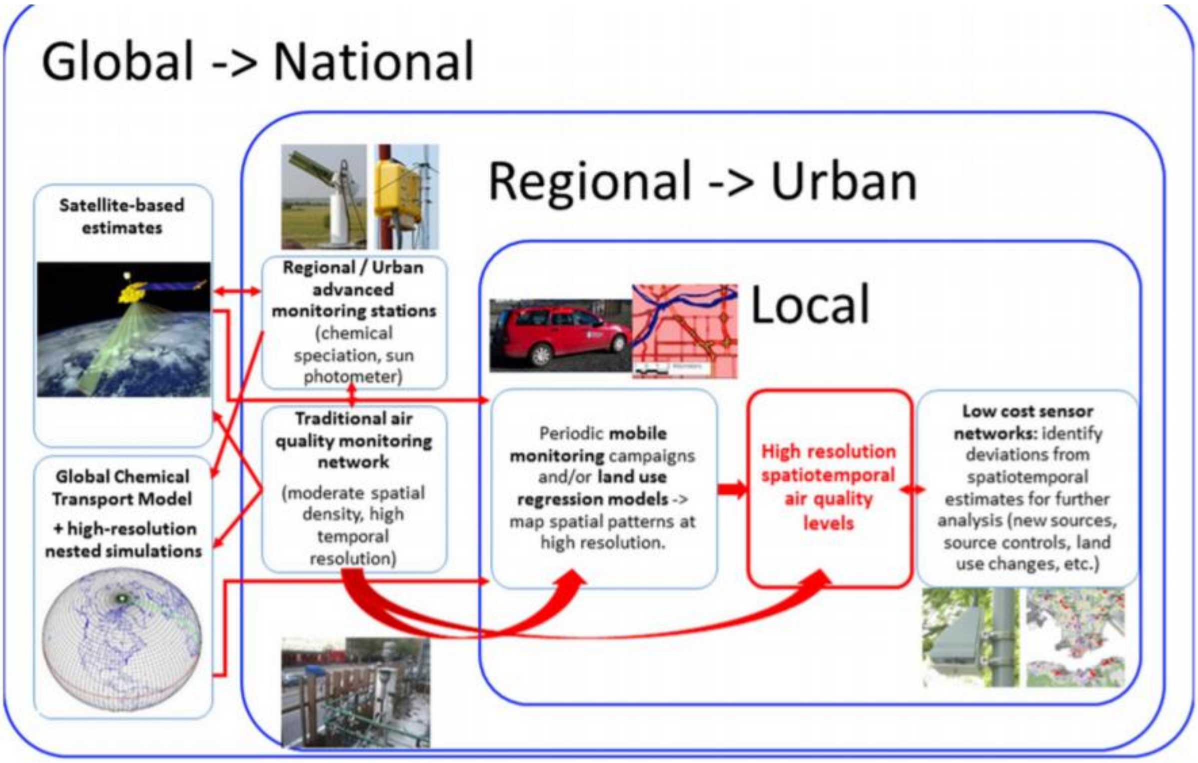


Figure 6.3 Schematic of an integrated global to the local framework for air quality monitoring.

City-specific action plans have been prepared and implemented in 122 non-attainment cities which were identified by CPCB based on air quality levels exceeding National Ambient Air Quality Standards (NAAQS) from 2014-2018. City action plans include actions to control vehicular emission, road dust, biomass/crop/ garbage/MSW burning, construction activities, industrial emission and other city specific sources *(MoEFCC, 2020).*

CPCB low estimate assumes ~ 4 monitors per 100,000 population (for urban areas) which is the minimum monitor density in the CPCB document and is comparable to monitor density in the USA and several high-income countries with similar population density. CPCB high estimate includes higher monitor density in larger cities, following guidance in the CPCB document; achieving this high estimate would require India to be the most densely monitored country in the world (Brauer et al., 2019).

Rules and regulation for air quality management has been defined under different laws which are specified in the Table 6.1.

Table 6.1 Other Applicable rules and regulations for the district

Law	Description	Requirement
Environment (Protection) Act, 1986 and CPCB Environmental Standards.	Emissions and discharges from the facilities to be created or refurbished or augmented shall comply with the notified standards	
Rajasthan State Environment Policy, 2010 including And Rajasthan Environment Mission and Climate Change Agenda for Rajasthan (2010-14)	Follows the National Environment Policy, 2006 and core objectives and policies are: - Conserve and enhance environmental resources; assure environmental sustainability of key economic sectors; and, improve environmental governance and capacity building - it recommends specific strategies and actions to address the key environmental issues: water resources, desertification and land degradation, forest and biodiversity, air quality, climate change: adoption and mitigation, mining, industry, tourism, energy, urban development, etc. - Establishment of Environment Mission under the chairpersonship of the Chief Minister and a Steering Committee under the chairpersonship of Chief Secretary, Government of Rajasthan Tasks force set up for six key areas.	Project implementation should adhere to the policy aims of: conservation & enhancement of environmental resources, integration of environmental concerns into projects/plans, and capacity building in environmental management - under water sector, major concerns, as the policy notes, are: huge water losses & wastage, declining water availability, pollution reuse and recycling.

State Government

In India, 28 states have SPCBs (State Pollution Control Boards) and 7 Union Territories have PCCs (Pollution control Committees) respectively. Functions of the State Pollution Control Board include; To advise the State Government on matter relating to pollution and on siting of industries; To plan programs for pollution control; To collect and disseminate information; To carry out inspection; To lay down effluent and emission standards; To issue consent to industries and other activities for compliance of prescribed emission and effluent standards.

Other functions of State Pollution Control Boards i. To plan a comprehensive program for the prevention, control or abatement of air pollution and to secure the execution thereof; ii. To advise the State government on any matter concerning prevention, control or abatement of air pollution; iii. To collaborate with CPCB in organizing training of persons, engaged or to be engaged in a program relating to prevention control or abatement of air pollution and to organize mass-education programs relating thereto; iv. To inspect, at all reasonable times, any control equipment, industrial plant or manufacturing process and to give, by order, such direction to such persons as may considered necessary to take steps for the prevention, control or abatement of air pollution; v. To inspect air pollution control areas at such intervals as it may think necessary, assess the quality of air therein, and take steps for prevention control or abatement of air pollution in such areas; vi. To lay down, in consultation with CPCB and having regard to the standards for the quality of air it lays down, standards for emissions of air pollutants into the atmosphere from industrial plants and automobiles or for the discharge of any air pollutant into the atmosphere from any other source whatsoever not being a ship or an aircraft; vii. To advise the State government for the suitability of any premises from time to time, entrusted to it by CPCB or the State government to do such other things and to perform such other acts as it may think necessary for the proper discharge of its functions and generally to carry into effect the purposes of the Act *(MoEF&CC, 2016)*

The state government in consultation with SPCBs have powers to designate particular areas as ―air pollution control areas. State governments, in consultation with SPCBs, may impose certain conditions on such areas, by making a notification in the official gazette, to prohibit the use of any fuel or appliance other than approved ones or the burning of any material (other than fuel) such as garbage and other waste products which may cause or is likely to cause air pollution. It is further provided under Section 21 of the Air Act that a person has to get the previous consent of a SPCB for establishing or operating any industrial plants in the air pollution control areas. Similarly, Section 22 prohibits a person from operating any industrial plant in any air pollution control area to discharge or cause or permit to be discharged the emission of air pollutants above the standards laid down by the SPCB concerned *(Kapoor, 2012).*

Urban Local body

The RSPCB has established thirteen regional offices in different parts of the state to keep in check the implementation of various provisions including The Air (Prevention and Control of Pollution) Act, 1981 and its rules. For Hanumangarh, the regional office is in Bikaner. The regional office in Bikaner has Bikaner, Hanumangrah and Sriganaganagr under its area of jurisdiction.

Figure 6.4 Air Quality Monitoring Stations in Rajasthan and their proximity with Hanumangarh

Best Practices for Air Quality Management

Air Quality Management Planning is often based on results from a number of assessments, combined in an Air Quality Management System (AQMS). The AQMS depends on the following set of technical and analytical tasks: i. Creating an inventory of polluting activities and emissions. ii. Monitoring air pollution and dispersion parameters. iii. Calculating air pollution concentrations with dispersion models. iv. Assessing exposure and damage. v. Estimating the effect of abatement and control measures. vi. Establishing and improving air pollution regulations and policy measures. These activities, and the institutions necessary to carry them out, constitute the prerequisites for establishing a functioning AQMS.

An AQMP describes the current state of air quality in an area, how it has been changing over recent years, and what could be done to ensure clean air. The development and implementation of an AQMP is a dynamic process involving the following six steps as shown in the Figure 6.5: i. Goal setting. ii. Baseline air quality assessment. iii. Air quality management system (AQMS). iv. Intervention strategies. v. Action plans implementation. vi. Evaluation and follow up *(Sivertsen & Bartonova, 2012).*

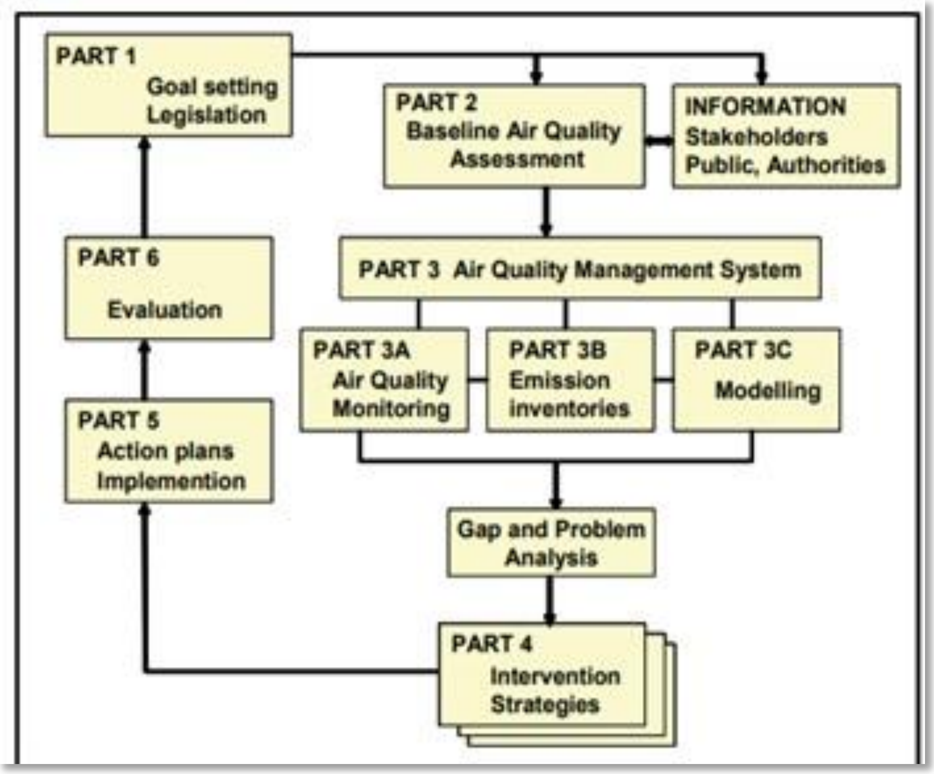


Figure 6.5 AQMP 6 step procedure

Multi-pollutant control programs can save money and time, and achieve significant health, environmental and economic benefits, while reducing costs and burdens on sources of air pollution.

Many pollution sources (e.g., industrial facilities) emit several different pollutants that directly cause health and environmental impacts or react in the environment to form other harmful pollutants. Some control technologies can reduce emissions of multiple pollutants. It can be more efficient to develop integrated control strategies that address multiple pollutants rather than separate strategies for each pollutant individually.

Air quality managers can consider multiple policy goals in developing an air pollution management plan. Policy goals that could be considered in such a program include: reducing concentrations of ozone, particulate matter, and hazardous air pollutants (HAPs) such as mercury; planning to address transportation and energy needs; mitigating and adapting to climate change.

EPISODIC URBAN AREA QUALITY MANAGEMENT PLAN

The e-UAQMP (Figure 6.6) deals with the consequences of 'extreme' concentrations of pollutant, mainly occurring at urban 'hotspots' e.g., traffic junctions, intersections and signalized roadways and are also influenced by complexities of traffic generated 'wake' effects. The e-UAQMP (based on probabilistic approach), also acts as an efficient preventive measure to predict the 'probability of exceedances' to prepare a successful policy response in relation to the protection of urban environment as well as disseminating information to its sensitive ‘receptors’ *(Gokhale & Khare, 2007)).*

As a cost-effective approach to provide more detailed air quality information at national to local scales in a manner whereby local data can be linked to global satellite-based estimates and a global network, the integrated air shed framework could help fill current information gaps and provide a foundation for more efficient routine network expansion over time (Brauer et al., 2019)

India has been following the Command and Control ‘(CAC) approach for constraining polluting activities from each source by setting uniform standards for technologies, processes and emissions. By enforcing standards and regulating the emissions, the government seeks to abate pollution, while this approach is effective to keep the pollution under control; however, it doesn’t provide any incentive for the polluter to stop polluting. It has been observed through several empirical studies that CAC approach is sub-optimal as it doesn’t account for social costs in its entirety i.e., they do not in general yield optimal pollution-abatement outcomes which equate the social marginal benefit of abatement with its social marginal cost.

Several economic instruments have been introduced to internalize the external costs of pollution, make the polluter pay, and at the same time minimize the cost of a given level of abatement under given conditions about production and abatement costs.

Tradable permits, emission and effluent charges, subsidies for competitive outputs, and sustainable environment-friendly inputs are all examples of economic instruments a combination of which along with taxes not only generate revenue but also provide incentives for environmental improvements. India is looking forward to formulating the suitable combination of these instruments to both penalize the polluter and incentivize pollution abatement *(*Kapoor, *2012*).

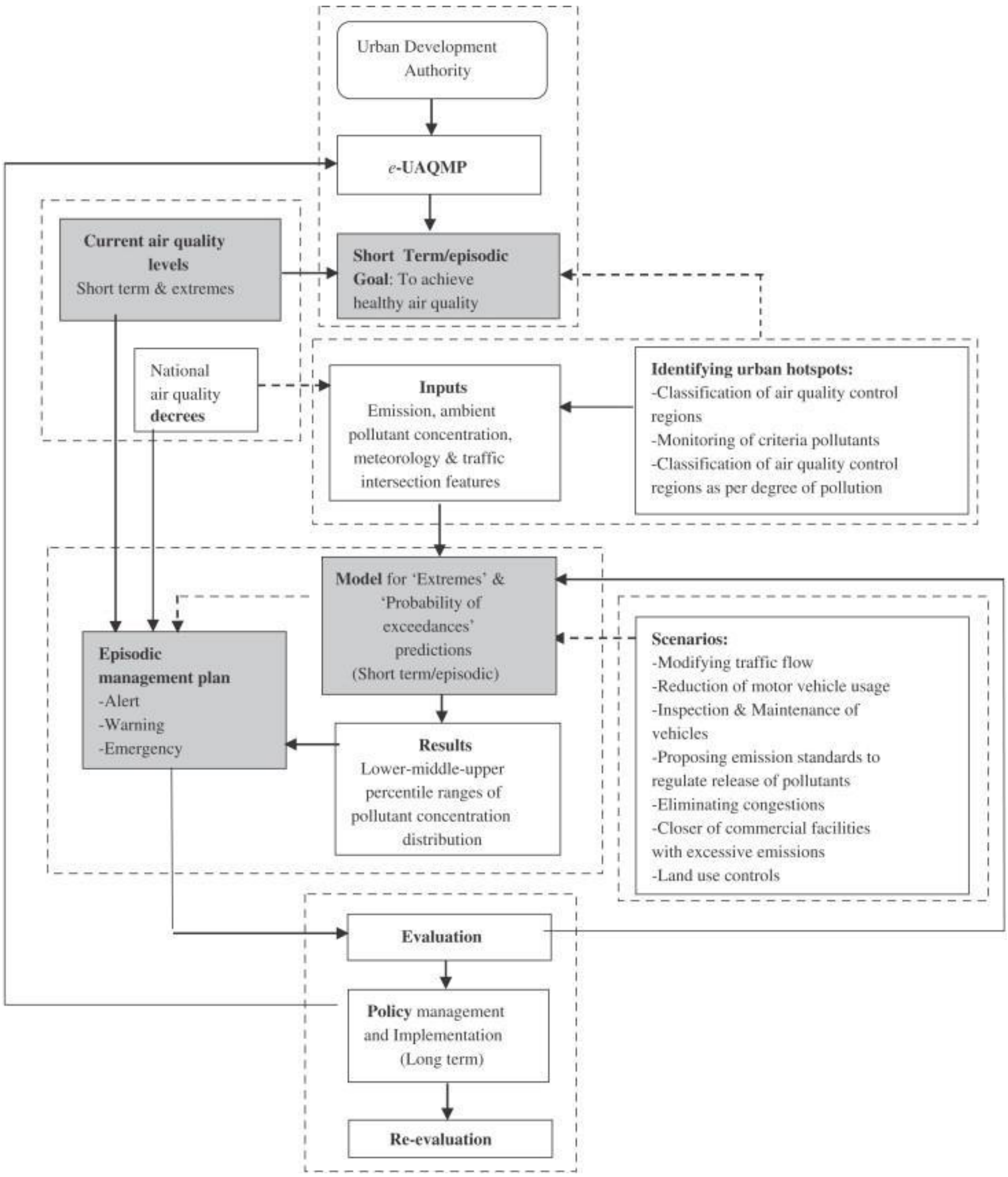


Figure 6.6 Episodic Urban Area Quality Management Plan (Gokhale & Khare, 2007)

Strategies for Control of Air Pollution in Urban centers via City Planning and Management

To an extent, pollution can be abated by urban design, topography, and meteorological factors, other than control of emissions. City planners can effectively plan spatial distribution of point sources of pollution, such as industries, landfills, treatments plants, transportation routes, open spaces, which impact the quality of air in an urban region. Regional and metropolitan strategies that are long range should go together with the small-scale short-range location and design strategies. Regional physical structure—shape, density, and organization of settlement areas; orientation and composition of subareas; pattern and type of transportation systems; and shape and location of open spaces—have major implications on air pollution. While selecting from several urban growth forms, emphasis must be laid on patterns that have potential for improving air pollution dispersion efficiency and reducing motorized travel. Adopting a balanced sub-regional approach for regional and metropolitan development with integration of mass transit is found to be helpful in reducing trip lengths, motorized travel, and urban sprawl. Land use planning with plans of reduced population density around industrial zones or in downwind direction can help in reducing exposure to the pollutants released from industries. This requires comprehensive studies of local meteorology and topography in order to improve spatial arrangements of industrial, commercial, and residential areas. Open spaces acting as buffer zones are also important but often such planned buffer strips get absorbed for other land use applications during the lifetime of the development plan and therefore require strong laws and enforcement for their retention. Planning and siting of solid waste management sites also needs to be done carefully and proactively. For large projects, mandatory requirement of prior environmental approval provides mechanisms for mitigating key adverse environmental impacts.

Updating of State/UT Town and Country planning acts as per the suggested updates provided in the URDPFI (Urban and Regional Development Plans Formulation and Implementation) guidelines, 2014. Few urban design interventions may also be implemented through appropriate modifications in development regulations and building bye-laws. Master Plan/Development plans including City Development plans, city mobility plans and other special plans to strongly focus on optimizing the land use integration with transportation planning and some of the points mentioned above. Use of appropriate tools and techniques (also mentioned in the URDPFI guidelines) including simulation tools can greatly facilitate in selection of better alternatives (plan proposals).

Supply of cleaner fuels, stoves to rural areas and urban slums: There is a need to widen the access of LPG or PNG and, wherever appropriate, smaller packaging and safe refilling options. Several government schemes designed to increase LPG/ PNG access across India have successfully enhanced the use of clean fuel in urban areas. Urban households using LPG has increased from 44.2 per cent to 68.4 per cent during 2000–12. Fuel-efficient biomass-based improved cook stoves can bring down exposure level relatively close to cleaner fuels. Even as the government aims at providing LPG to all, it is evident that several million households will continue to depend on traditional biomass for cooking due to economic, supply, and delivery constraints. There is a need for more efficient use of biomass as a cooking fuel through the improved stoves with efficiencies ranging between 30 and 40 % as compared to 8 and 10 % of traditional cook stoves. The reductions in indoor concentrations of pollutants due to use of improved cook stoves in comparison to the traditional ones. Equally important is the need for research on development of more efficient processed fuels that have relatively higher calorific value and less smoke (Fullerton et al., 2008).

Solar lighting options to rural areas and urban slums: For lighting, 7 per cent urban households still use kerosene in India (Census 2011). Until they connect with electricity, they could benefit from solar lamps, which can continue to be used even after grid-based electricity is provided (IEP 2008). There is need for an adequate institutional mechanisms and delivery channels for sale and after-sales service. Solar lanterns should be promoted to households in urban slums and rural un-electrified regions that use kerosene (for lighting) while simultaneously phasing out the kerosene subsidy.

Awareness generation: Programs to generate awareness are needed to increase adoption of simple household level measures such as improved ventilation and selection of cleaner traditional fuels.

Other Strategies include controlling refuse burning, Maintaining quality and cleanliness of roads, Dust control at construction sites, travel demand management (TDM), Fuel quality and vehicle emission norms etc *(Seth Block, 2018).*

Scientific studies based on monitoring and modelling

Monitoring requirements: The air quality monitoring network in India is not sufficient as there are about 600 monitoring stations under the National Ambient Air Quality monitoring programmes of the CPCB for the whole country. Bureau of Indian standards (BIS) has listed the criteria for minimum number of stations in a city. Based on this, 3,300 monitoring stations in 605 Indian cities (having more than 50 thousand residents), will be required. The monitoring network needs to be improved gradually not only in terms of number of stations but also for quality of monitoring. Presently, air quality monitoring is carried out in cities only, which should be extended to rural and regional scales. This is essential for pollutants such as ozone, which are generally found to be higher in regions outside cities. The present network monitors PM10, SO_2, and NOx regularly across all stations and does not cover all the pollutants listed in the National Ambient Air Quality Standards. Corporate funding can be sought under the CSR activities to extend monitoring networks with enhanced monitoring capability.

Emissions, simulation, and forecasting: Other than monitoring of pollutants, modelling capabilities need to be built for understanding of current and future air quality. There is presently no database of emissions at the national/regional scales. These inventories need to be developed and maintained. TERI has developed national scale inventories for India for current and future years based on energy and emission models (Sharma and Kumar 2016). These inventories can be further refined for development of national database of emissions for India. While there has been a number of urban scale air quality modeling studies in India, studies on simulation of air quality at the regional/national scale are limited. TERI has simulated air quality at the national scale using state of the art models to predict PM 2.5 and ozone concentrations in India, which shows increase in pollutant concentrations that may happen in future following a business-as-usual trajectory. It also shows the regions under severe pollution levels and the contributing factors. Accordingly, action plans may be drafted for air quality control at regional scale.

The air quality management plan (AQMP) at city level should be drafted by research institutes identified to carry the source apportionment studies by MoEFCC and CPCB in consultation with SPCBs Institutional strengthening of SPCBs is a must to ensure successful and effective implementation of strategies listed in AQMP. This will call for higher budget allocations, recruitments of scientific professional, and trainings on air quality monitoring, and modelling tools. Institutional tie-ups can be made for regular trainings of the board officials *(Seth Block, 2018).*

Inferences for Best Practices

There are common driving forces, although with differences in shares, in deteriorating air quality in various cities of India. Every city needs to adopt strategies discussed in this brief based on their priorities and findings of source apportionment studies. A stepwise approach to derive air quality management in cities is presented below in Figure 6.7 *(Seth Block, 2018).*

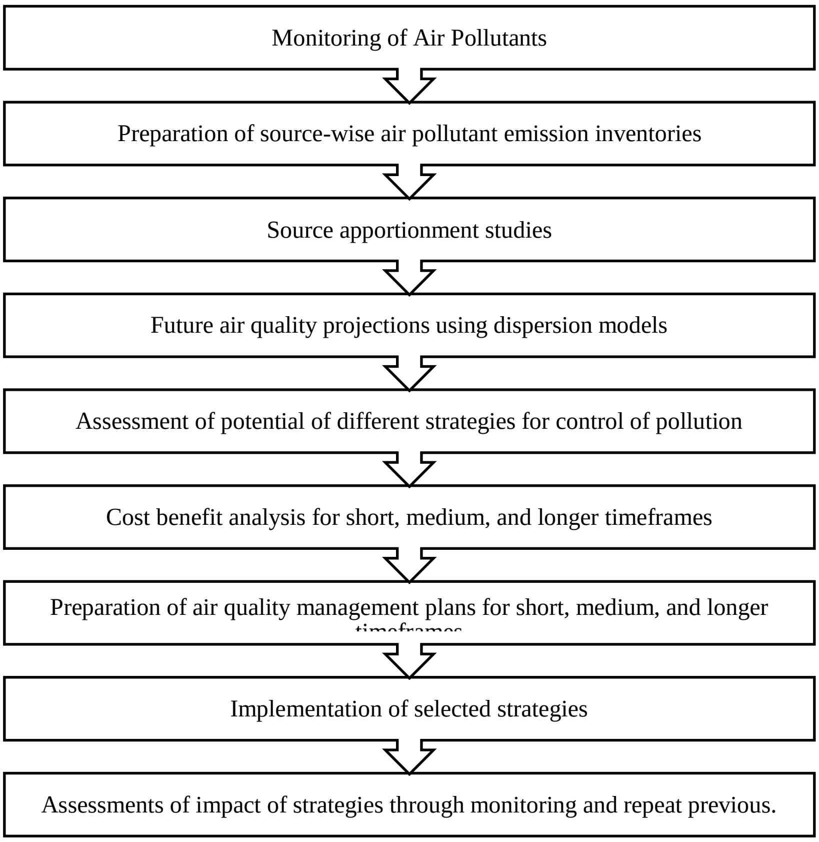


Figure 6.7 Best Practices as Policy Brief (Seth Block, 2018)

6.1.2 Present Scenario

Amidst all the other pressing environmental concerns, air pollution is surging ahead to be one of the most daunting environmental threats the country faces today. Air pollution is not only an environmental issue but also has mortality related health implications for human beings. Therefore, India is under immense global and national pressure to improve the air quality and address this issue with seriousness. Despite the urgency, the piecemeal approach of the government in tackling the problem is leading to un-sustained short-term benefits and a fragmented air quality management framework. *(Kapoor, 2012)*

Data provided by ULBs

The data provided by the various ULB's in the district of Hanumangarh is hereby formulated in Table 6.2. Details of data regarding availability of air quality monitoring network in district, different sources of pollution, number of industries meeting standards etc.

Table 6.2 Air Quality Management Datasheet

No.	Action Areas	Measurable Outcome	Outcome
A	**Availability of Air Quality Monitoring Network in District** 4 Stations per 1 Lakh of Population (CPCB)		
1	Manual Air Quality monitoring stations of SPCBs /CPCB	[Nos] / [None]	None
2	Automatic monitoring stations Operated by SPCBs / CPCB	[Nos] / [None]	None. Installation of 1 CAAQMS in Hanumangarh is proposed
B	**Inventory of Air Pollution Sources**		
1	Identification of prominent air polluting sources	[Large Industry] / [Small Industry] / [Unpaved Roads] / [Burning of Waste Stubble] / [Brick Kiln] / [Industrial Estate] / [Others] (Multiple selection)	Sanjog Sugars & Eco Power Pvt. Ltd.; Besides this approx 650 other Units are established in Hanumangarh district, major of them are Brick Kilns (435 Units), Plaster of Paris (101 Units) and Cotton Ginning industries (44).
2	No of Non-Attainment Cities	[Nos / [None]	None
3	Action Plans for non-attainment cities	[Prepared] / [Not yet prepared]	NA
C	**Availability of Air Quality Monitoring Data at DMs Office**		
1	Access to air quality data from SPCBs & CPCB through Dashboard	[Available] / [Not yet Available]	Not yet available
D	**Control of Industrial Air Pollution**		
1	No of Industries meeting Standards	[Nos]	Nearly all the industries are complying with prescribed standards.
2	No of Industries not meeting discharge Standards	[Nos]	Nil

E	**Control of Non-industrial Air Pollution sources**		
1	Control open burning of Stubble –during winter	[Nos of fire incidents]	nil
2	Control Open burning of Waste – Nos of actions Taken	[Nos]	nil
3	Control of forest fires	[SoP available] / [No SoP]	Not Applicable
4	Vehicle pollution check centers	[% ULBs covered]	Not Applicable
5	Dust Suppression Vehicles	[% ULBs covered]	Not Applicable
F	**Development of Air Pollution complaint redressal system**		
1	Mobile App / Online based air pollution complaint redressing system of SPCBs.	[Available] / [Not available]	Not available yet

District should collect data regarding emissions from brick kilns which exist in a large number in the area. District needs to have air quality monitoring stations. As per the table all industries in the district are meeting the air quality standards. However, 383 are not meeting standards. A number of data are missing for the district such as Control open burning of Stubble, Control Open burning of Waste, Control of forest fires, Vehicle pollution check centers and Dust Suppression Vehicles

Inferences from data provided

The air quality monitoring data is not available for Hanumangarh district as there are no monitoring stations available in the district. The industrial sources of air pollution include one sugar mill and 650 other industries. These other industries include 435 brick kilns, 101units of plaster-of-Paris and 44 cotton ginning units.

6.1.3 Action Plan

The action plan for air pollution control needs to take into account various sources present in a region. Table 6.3 presents the action plan for air quality management in Hanumangarh. Looking at the number of brick kilns in the district, controlling the air pollution from brick kilns becomes of paramount importance.

Table 6.3 Action Plan for Hanumangarh Air Quality Management

Source group/Activity	Action Points	Implementation period	Responsible agency
Air Quality Monitoring	Performance monitoring of major air polluting industries for assessment of compliance of the notified air emission standards.	3 Years	Rajasthan State Pollution Board
	(i) Installation of additional real Time Continuous Air Quality Monitoring System in such a direction and location that it is able to capture pollutants from industries. (ii) For the time being, manual air quality stations have been proposed and are going to be installed	3 Years	Rajasthan State Pollution Board

Source group/Activity	Action Points	Implementation period	Responsible agency
	soon for Hanumangarh ULB. (iii) For other ULBs, manual air monitoring may be for different seasons in a year.		
Vehicles Emission Control	1. Launch extensive drive against polluting vehicles for ensuring strict compliance and regular checking of vehicular emission and issue of PUC certificate	Short Term	Dept. of Transport, Traffic Police
	2.Launch Public awareness campaign for air pollution control, vehicle maintenance, minimizing use of personal vehicle, lane discipline, etc.	Short Term	Traffic Police
	3. Prevent parking of vehicles in the non-designed areas.	Long Term	Dept. of Transport
	4. Initiate steps for retrofitting of particulate filters in diesel vehicles, when BS-V fuels are available.	Short Term	Dept. of Food & Supplies
	5. Prepare action plan to check fuel adulteration and random monitoring of fuel quality data.	Mid Term	LSG, Development Authorities Municipal, Corporations UITs in their jurisdiction
	6. Prepare plan for widening of road and improvement of Infrastructure for decongestion of road.	Long Term	NHAI, PWD
	7. Prepare plan for construction of expressways/bypasses to avoid congestion due to non-destined vehicles	Short Term	Dept. of Transport
	8. Steps for promoting battery operated vehicles/ Promotion & operationalization of E-rickshaw	Long Term	NHAI, PWD
	9. Install weigh in motion bridge at boarders of cities/towns and States to prevent overloading of vehicles	Long Term	Traffic Police
	10. Synchronize traffic movements /Introduce intelligent traffic systems for lane-driving.	Long Term	Traffic Police
	11.Installation of remote sensor based PUC system	Long Term	Dept. of Transport
	12. Restriction on plying & phasing out of 15 years old commercial diesel driven vehicles.	Long Term	Dept. of Transport , Food &Supplies
	13. Introduction of cleaner fuel for CNG/LPG vehicles	Mid Term	Dept. of Transport

Source group/Activity	Action Points	Implementation period	Responsible agency
	14. Plan for restriction on the registration on diesel driven Auto-rickshaw & Tempo	Mid Term	Dept. of Transport
	15. Monitoring on vehicle fitness	Mid Term	Dept. of Transport
	16. Periodic calibration test of vehicular emission monitoring instrument	Long Term	UDH Development authorities in their jurisdiction
	17. Preparation of plan for development Multi level Parking	Mid Term	NHAI, PWD, Urban local body
Re-Suspension of Road Dust and Other Fugitive Emission Control	1. Prepare plan for green buffers along the traffic corridors.	Mid Term	NHAI, PWD, Urban local body
	2.Maintain potholes free roads for free roads for free flow of traffic	Mid Term	NHAI,PWD, and Urban local body
	3. Introduce water fountain at major traffic intersection wherever feasible	Mid Term	Urban local body, Development Authorities Municipal Corporations UITs in their jurisdiction
	4. Greening of open areas, gardens, community places, schools and housing societies	Mid Term Short Term	Urban local body, Dept of Education
	5. Blacktopping metaled road including pavement of road shoulders.	Mid Term	NHAI, PWD, Urban local body
	6. Widening of roads and construction of pucca footpath along main roads (RIICO Industrial Areas)	Long Term	RIICO as per requirement and feasibility
	7. Regular cleaning of road (RIICO and other areas)	Long Term	RIICO, UDH
	8. Tree plantation along the roads (RIICO Industrial Areas)	Long Term	RIICO
Control of Emissions from Biomass/Crop Residue/Garbage /Municipal Solid Waste burning	1.Launch extensive drive against open burning of bio-mass, garbage, leaves, etc.	Short Term	Urban local body
	2. Regular check and control of burning of municipal solid waste.	Short Term	Urban local body
	3. Ensure ban on burning of agriculture waste and crop residues and its implementation	Long Term	Department of Agriculture Revenue
	4. Construction of advanced waste management Site.	Mid Term	Urban local body
	5. Restriction on open burning of municipal solid waste biomass and plastic (RIICO Industrial Areas)	Short Term	RIICO
	6. Restriction on open burning of biomass and plastic	Short Term	Urban local body
	7. Immediate lifting of solid waste generated from desilting and cleaning of drains for its disposal	Short Term	RIICO, Urban local body

Source group/Activity	Action Points	Implementation period	Responsible agency
	8. Transportation of solid waste, construction material and debris in covered system.	Short Term	RIICO, Urban local body
Control Of Industrial Emissions	1. Identification of brick kilns and their regular monitoring including use of designated fuel and closure of unauthorized units.	Mid Term	State Pollution Control Board
	2. Conversion of natural draft brick kilns to induced draft.	Mid Term	State Pollution Control Board
	3. Action against non-complying industrial units.	Short Term	State Pollution Control Board
	4. Regulation on setting up of new air polluting industries in industrial areas located in urban limits of these 5 cities.	Mid Term	State Pollution Control Board, RIICO
Control of emissions from brick kilns	1. Switching to more efficient technologies, mainly during brick firing,	Mid Term	State Pollution Control Board
Control of Air Pollution from Construction and Demolition activities	1. Enforcement of Construction and Demolition Waste Rules	Short Term	Urban Local Bodies; Development authorities under their jurisdiction
	2. Control measures for fugitive emissions from material handling-conveying and screening operations through water sprinkling, curtains, barriers and dust suppression units.		
	3. Ensure carriage of construction material in closed / covered vessels	Short Term	Urban Local Bodies, RIICO
	4. Covering of construction sites and Restriction on storage of construction materials along the road	Long Term	RIICO, Urban local body
	5. Restriction on storage of construction materials along the road.	Short Term	RIICO, Urban Local Bodies
Other Steps to control Air Pollution	1. Air Quality Index to be calculated and disseminated to the people through website and other media.(on maximum weekly basis for manually operated monitoring stations and real-time basis for continuous monitoring stations)	Short Term	State Pollution Control Board
	2. Establish an Air Quality Management Division at SPCB/PCC Head Quarters to oversee air quality management activities in the State and interact CPCB.	Short Term	State Pollution Control Board
	3. Set-up and publicize helpline in each city/town as well as SPCB/PCC HQ for complaints against reported non-compliance	Short Term	State Pollution Control Board
	Engage with concerned authorities on a continual basis for maximizing coverage of LPG /PNG for domestic and commercial cooking with target of 100% coverage.	Short Term	State Govt.
	Monitoring of DG sets and action against violations.	Short Term	State Pollution Control Board
	Involvement of industrial associations in awareness program (RIICO Industrial Areas)	Mid Term	RIICO
	Development/maintenance of green areas, gardens and parks (RIICO Industrial Areas)	Long Term	RIICO

Source group/Activity	Action Points	Implementation period	Responsible agency
Hotels/ Restaurants	Restaurants of sitting capacity more than 10 should not use coal and shift to electric or gas-based appliances.	1 year	
	Link Commercial license to clean fuel	1 year	
	Ash/residue from the tandoor and other activities should not be disposed near the roadside.	1 year	
Domestic Sector	LPG to all. Slums are using wood as cooking fuel.	2 years	
	By 2030, city may plan to shift to electric cooking or PNG.	2 years	
Municipal Solid Waste (MSW) Burning	Any type of garbage burning should be strictly stopped.	Immediate	State Pollution Control Board
	Surveillance is required that hazardous waste goes to TSDF.		
	Desilting and cleaning of municipal drains		
	Waste burning in Industrial area should be stopped.		
	Daily, Monthly mass balance of MSW generation and disposal		
	Sensitize people and media through workshops and literature distribution.		
Construction and Demolition	Wet suppression	Immediate	State Pollution Control Board
	Wind speed reduction (for large construction site)		
	Enforcement of C&D Waste Management Rules. The waste should be sent to construction and demolition processing facility		
	Proper handling and storage of raw material: covered the storage and provide the windbreakers.		
	Vehicle cleaning and specific fixed wheel washing on leaving the site and damping down of haul routes.		
	Actual construction area should be covered by a fine screen.		
	No storage (no matter how small) of construction material near roadside (up to 10 m from the edge of the road)		
	Builders should leave 25% area for green belt in residential colonies to be made mandatory.		
	Sensitize construction workers and contract agency through workshops.		
	The silt load in Hanumangarh varies from 4 to 32 g/m2. The silt load on each road should be reduced under 3 gm/m2. Regular vacuum sweeping should be done on the road having silt load above 3 gm/m2.		

Source group/Activity	Action Points	Implementation period	Responsible agency
Road Dust	Convert unpaved roads to paved roads. Maintain pot hole free roads.		
	Implementation of truck loading guidelines; use appropriate enclosures for haul trucks and gravel paving for all haul routes.		
	Increase green cover and plantation. Undertake greening of open areas, community places, schools and housing societies.		
	vacuum assisted sweeping carried out four times in a month, this will reduce road dust emission by 71% (Resultant emissions: PM2.5=4 ton/day)		
For Vehicles	Diesel vehicle entering the city should be equipped with DPF which will bring a reduction of 40% in emissions (This option must be explored once Bharat stage VI fuel is available.)	3 years	Dept. Of Transport
	Industries must be encouraged to use Bharat stage VI vehicles for transportation of raw and finished products	Immediate	
	Restriction on plying and phasing out of 10 years old commercial diesel driven vehicles.	2 years	
	Introduction of cleaner fuels (CNG/ LPG) for vehicles.	2 years	
	Check overloading: Expedited installation of weigh-in-motion bridges and machines at all entry points to Hanumangarh.	Immediate	
	Electric/Hybrid Vehicles should be encouraged; New residential and commercial buildings to have charging facilities. Buses should be CNG or Electric.	1 year	
	Depot spaces should be rationalized to ensure more efficient utilization. Multi-modal, multi-use bus depots to be developed to provide high-class bus services and terminal experience to passengers. Should include well-equipped maintenance workshops. Charging stations shall be set-up.	1year	
	Enforcement of bus lanes and keeping them free from obstruction and encroachment.	1 year	
	Ensure integration of the existing metro system with bus services.	1 Year	
	Route rationalization: Improvement of availability by rationalizing routes and fleet enhancement with requisite modification.	1 year	
	IT systems in buses, bus stops and control center and passenger information systems for the reliability of bus services and monitoring.	1 year	
	Movement of materials (raw and product) should be allowed between 10 PM to 5 AM.	1 year	

Source group/Activity	Action Points	Implementation period	Responsible agency
	Ensuring emission standards in industries. Shifting of polluting industries.	1 year	
Industries and DG Sets	Strict action to stop unscientific disposal of hazardous waste in the surrounding area	1 year	
	There should be separate Treatment, Storage, and Disposal Facilities (TSDFs) for hazardous waste.		
	Industrial waste burning should be stopped immediately	2 years	
	Follow best practices to minimize fugitive emission within the industry premises, all leakages within the industry should be controlled	Immediate	
	Area and road in front of the industry should be the responsibility of the industry	Immediate	
	Category A Industries (using coal and other dirty fuels)		
	boilers and furnaces in Hanumangarh are running over coal, wood, and other dirty solid fuels which should be shifted to natural gas and electricity		
	Almost all rotary furnaces having significant emissions are running on coal that needs to be shifted to natural gas and electricity		
	Multi-cyclones should be replaced by baghouses. Ensure installation and operation of air pollution control devices in industries.	2 years	
	Category B Industries (Induction Furnace)	2 years	
	Recommended Fume gas capturing hood followed by Baghouse should be used to control air pollution		
	Diesel Generator Sets	2 years	
	Strengthening of grid power supply, uninterrupted power supply to the industries		
	Renewable energy should be used to cater the need of office requirement in the absence of power failure to stop the use of DG Set	2 years	
Decongestion of Roads at High Traffic Areas	Strict action on roadside encroachment.	2 years	Dept. of Transport
	Disciplined Public transport (designate one lane stop).	6 months	
	Removal of free parking zone		
	Examine existing framework for removing broken vehicles from roads and create a system for speedy removal and ensure minimal disruption to traffic.		
	Synchronize traffic movements or introduce intelligent traffic systems for lane-driving.		
	Introduction of one-way traffic in selected areas to reduce the traffic density		

Source group/Activity	Action Points	Implementation period	Responsible agency
Implementation of Traffic Master Plan	Banning entry of heavy commercial vehicle inside the city to reduce vehicular pollution	1 year	Dept. of Transport
	Issuing licenses to LPG based autos as per notification dated 22/12/2010	1 year	
	Continuous monitoring of vehicles by flying squads of transport department to check PUC	1 year	
	Regular monitoring of the quality of the fuel being used by the vehicles	1 year	
	Periodic education and awareness campaigns for the public, drivers, transporters and other stakeholders	1 year	
	Removal of encroachment on the roadside	1 year	
	Development of parking arrangements by traffic management near the commercial areas by concerned ULB	1 year	
	Widening of main roads for reducing the traffic congestion and periodic maintenance of Road	1 year	
	Development of roadside bushes	1 year	

6.1.4 Summary

There are a number of government initiatives such as the National Air Quality Monitoring Programme, National Clean Air Action Plan, CPCB Guidelines, TERI Policy etc. which focuses on short-term and long-term measures from broader to local air quality management. As there is no data available for the Hanumangarh district, it is very difficult to comment on the air quality of the region. The monitoring stations should be installed as soon as possible. In the meantime, the focus of mitigation may be on major sources e.g. vehicular sources, brick kilns, MSW burning and other industries. Planning and monitoring for brick kiln should be done immediately. The Hanumangarh district doesn’t have a district environment plan yet, it has various regulations for environmental clearances for industries and other major infrastructure facilities such as urban transport and need environment clearances including air quality management for its functioning. The inventory for air quality measurements is not updated which is essential to begin with air quality control and last official document stating the measurements was till 1995. The districts lack in air quality monitoring stations and have one regional pollution board which is accountable for the air quality management along with other environment controls.

Table 6.4 Summary for Air Quality Management Hanumangarh

S.No.	Urban Local Body	Present Status	Strategies and Action Plan
1.	Nagar Parishad Hanumangarh	No Data Available	• Air Quality Monitoring Control Action • Source based control action for hotels/ restaurants, vehicles, industries and DG sets, construction and demolition, domestic sector etc. • Decongestion of roads in high congestion areas and implementation of traffic management plans.
2.	Nagar Palika Pilibanga	No Data Available	• Air Quality Monitoring Control Action • Source based control action for hotels/ restaurants, vehicles, industries and DG sets, construction and demolition, domestic sector etc. • Decongestion of roads in high congestion areas and implementation of traffic management plans.
3.	Nagar palika Sangaria	No Data Available	• Air Quality Monitoring Control Action • Source based control action for hotels/ restaurants, vehicles, industries and DG sets, construction and demolition, domestic sector etc. • Decongestion of roads in high congestion areas and implementation of traffic management plans.
4.	Nagar Palika Rawatsar	No Data Available	• Air Quality Monitoring Control Action • Source based control action for hotels/ restaurants, vehicles, industries and DG sets, construction and demolition, domestic sector etc. • Decongestion of roads in high congestion areas and implementation of traffic management plans.
5.	Nagar Palika Nohar	No Data Available	• Air Quality Monitoring Control Action • Source based control action for hotels/ restaurants, vehicles, industries and DG sets, construction and demolition, domestic sector etc. • Decongestion of roads in high congestion areas and implementation of traffic management plans.
6.	Nagar Palika Bhadra	No Data Available	• Air Quality Monitoring Control Action • Source based control action for hotels/ restaurants, vehicles, industries and DG sets, construction and demolition, domestic sector etc. • Decongestion of roads in high congestion areas and implementation of traffic management plans.

6.2 Noise Pollution Management

6.2.1 Literature Review

Sound that’s unwanted or that disrupts one’s quality of life is named as noise. Once there’s a load of noise within the surroundings, it is termed as sound pollution. A personality’s being cannot handle noise quite 85 decibels (dB) Sound becomes undesirable once it disturbs the conventional activities like operating, sleeping, and through conservations. Its associate underrated environmental drawback is attributable to the very fact that we tend to can’t see, smell, or style it. World Health Organization state that “Noise should be recognized as a serious threat to human well-Being”.

The classification of noise pollution is as follows: (i) Community Noise: Community noise (also referred to as environmental noise, residential noise or domestic noise) is outlined as noise emitted from all sources, except at the economic work place. Main sources of community noise embrace road, rail and traffic, construction and public work, and also the neighbourhood. Typical neighbourhood noise comes from live or recorded music; from stock like barking dogs; (ii) Occupational Noise: There square measure several sources of noise is industrial machinery and processes that include: rotors, gears, turbulent fluid flow, impact processes, electrical machines, internal combustion engines, pneumatic equipment, drilling, crushing, blasting, pumps and compressors. What is more, the emitted sounds square measure mirrored from floors, ceiling and instrumentality; (iii) Aircraft Pollution: Noise from craft flying over residential areas impairs people's ability to figure, learn at school and sleep, and consequently additionally ends up in lowered property values in affected areas. As passenger volume increases and new and bigger airports square measured engineered, noise is changing into even a lot of priority; (iv) Roadway noise pollution: Roadway noise is that the collective sound energy emitting from motor vehicles and cars; (v) Under water noise pollution (UNP): UNP is intense human-generated noise within the marine atmosphere. It's caused by the use of explosives, oceanographic experiments, geology analysis, underwater construction, ship traffic, intense active sonars and air guns used for unstable surveys for oil and connected activities; (vi) Constructions: The noise from the development of highways, urban streets, and buildings may be a major contributor to the urban scene. Construction noise sources embrace gas hammers, air compressors, bulldozers, loaders, dump trucks (and their back-up signals), and pavement breakers.

Chronic noise exposure might cause noise-induced hearing disorder for human beings. Older males exposed to vital activity noise demonstrate considerably reduced hearing sensitivity than their non-exposed peers. Unwanted noise will injury physiological and psychological health. Pollution will cause annoyance and aggression, cardiovascular disease, high stress levels, tinnitus, hearing disorder, sleep disturbances, and different harmful effects. High noise levels will contribute to vessel effects and exposure to moderately high levels throughout one eight-hour amount causes an applied math rise in blood pressure of five to ten points and a rise in stress and constriction resulting in the increased blood pressure noted above as well as to increased incidence of coronary artery disease.

Noise will have a damaging impact on animals, increasing the chance of death by dynamical the fragile balance in predator or prey detection and dodging, and meddling the utilization of the sounds in communication particularly in relevancy replica and in navigation. An effect of noise on animal life is that the reduction of usable surround that noise areas might cause, that within the case of species could also be a part of the trail to extinction. Pollution has caused the death of bound species of whales that aground themselves when being exposed to the loud sound of military measuring system. Other effects on life & aquatic animals are: Hormone Imbalance, Chronic Stress, Panic & Escape

Behavior, Abandonment of Offspring, Injury, Increase in Loudness of lay to rest species communication.

Scenario in country

In Indian state of affairs, pollution may be a regular development, particularly in urban areas. Typically, illustrious sources of pollution square measure conveyance or traffic connected or mill or activity pollution. Such responsible pollution is a component of day after day life, and no one is basically looking to be disquieted regarding it. The sources of noise pollution square measure typically multiply throughout festivals like Diwali during which hearth haywire square measure answerable for pollution. Publicly festivals similarly as in celebrations of marriages, birthdays, election victories, creating noise pollution looks to be traditional. Earlier days hearth haywires, bands were vital sources of pollution, however in previous few years another factors square measure additional to form unwanted sound.

During public competition events and private celebrations like marriages, birthdays, election victories, the typical image seen is walls of big speakers together with hearth haywires and bands. Most horrific of these is walls of big speakers sounding at the same time, unceasingly with noisiest music, the intensity is such a lot that you just will feel the vibrations around you, you will feel the palpitations not withstanding you are simple passing by. To your surprise, you will see that solely adults, however additionally youngsters around such noisy atmosphere for hours performing arts and enjoying the tunes created by it. Such reasonably exposure positively ends up in health similarly as social hazards and particularly innocent youngster's square measure most suffering from it. Though their square measure legislations regulation pollution, however non-implementation of legislations ends up in ever-rising rather multiplying pollution with the addition of the latest equipment of pollution.

Governance and Management Structure

The various concerned institutions involved in the process of Noise Management are: Central Pollution Control Board, Rajasthan State Pollution Control Board, sustainable goals given by world health organization.

Roles and Responsibilities

The responsibility of Central Pollution Control Board for regulating and controlling noise producing sources aiming to maintain the ambient air quality standards.

State Pollution Control Board responsible for regulation and controlling of noise producing sources and noise monitoring in the state

Sustainable Development Goals

The goal of noise management is to take care of low noise exposures, such human health and well-being square measure protected (Greenberg & Schneider, 2019) The precautionary principle is in all cases, noise ought to be reduced to the bottom level realizable in an exceedingly explicit scenario. Wherever there's an inexpensive chance that public health is broken, action ought to be taken to shield public health while not awaiting full scientific proof. The Polluter Pays Principle is the full prices related to sound pollution (including observance, management, lowering levels and supervision) ought to be met by those answerable for the supply of noise.

The interference Principle is action ought to be taken where it's potential to scale back noise at the supply. Land-use coming up with ought to be radio controlled by associate degree environmental health impact assessment that considers noise still as alternative pollutants.

The Responsibility on enforcement and social management of sound pollution control measures is the noise levels in any space / zone shall not exceed the close air quality standards in respect of noise as per the Schedule. The authority shall be liable for the {enforcement | social management} of sound pollution control measures and therefore the due compliance of the close air quality standards in respect of noise.

National Rules and Regulation for Noise Pollution (Ministry of Environment & Forests, 2017)

Section three of the environmental protection act of 1986 let to noise regulations rules (2000). The Environmental Protection Agency is that the umbrella legislation to influence each dynamic issue in relevance environmental protection. The foundation regulates noise levels in Table 6.4.

The rules conjointly assign administrative body for these standards to the native district courts. Some necessary observations from the foundations are: No permission may be granted by any authority to be used of public address system within the open when 10 PM and before 6 AM. No exception is feasible. After permission has been procured the sound should fall within the sound limits prescribed within the Noise Rules. This may be measured on a sound meter. Any individual violating the foundation is vulnerable to be in remission beneath the provisions of the Environmental Protection Agency. If the authorities don't act to Prevent violation of the Noise Rules, the subject Who has filed a criticism will approach the Court together with his criticism when sixty days' notice and therefore the Court will initiate prosecution. The rules conjointly fix totally different close air quality levels for firecrackers and industrial activities.

Table 6.4 Ambient air quality standards in respect of noise for different areas/zones

Sr. No.	Category of Area/Zone	Limits in dB(A)	
		Day	Night
1	Industrial area	75	70
2	Commercial area	65	55
3	Residential area	55	45
4	Silence Zone (near hospitals, schools etc.)	50	40

The Noise restriction on vehicles is Luxury Limousine 77 dB, small passenger car 79 dB, Miniature passenger car 84 dB, Sports car 91 dB, Motor-cycle (2-cylinder 4 stroke) 94 dB, Motor scooter (1-cylinder-2-stroke) 80 Db. Rajasthan State Rules for Noise Pollution: In exercise of the powers given by Section nine of the Rajasthan Noises Management Act, 1963 (Rajasthan Act 12 of 1963) at intervals that not everybody shall use or play a loud-speaker or sound electronic equipment for broadcasting any speech, sermon, music or radio-Programme or attach identical to any wireless radio receiver or phonograph, shall be as state against every, namely-

Table 6.5 Rajasthan Noises Management Act, 1963

1.	From hospital or from a building during which there's a phone exchange	150 meters
2.	From any educational institution managed, maintained, recognized or controlled by the authorities or a University established beneath any law for the nowadays good or a neighbourhood authority, throughout the hours or operating of such establishment.	150 meters
3.	From any hostel maintained or recognized by the one hundred fifty meters authorities or University or government agency once such hostel is within the use of scholars.	150 meters
4.	From a building during which a court or Government workplace is controlled throughout the hours of operating of such court or office	150 meters

Best Practices

Noise Abatement Approaches (SCU, 2017)

Road traffic noise is caused by a combination of rolling noise (due to vibrations and interactions between the tyre of the vehicle and the road surface) and propulsion noise (emanating from the engine itself). Rolling noise dominates noise emissions when cars are travelling above approximately 30 kilometers per hour (km/h), while propulsion noise is the major source of noise below this speed. Quieter engines, Low-noise Road surfaces, Low-noise tyres, Electric vehicles, Traffic management and engineering can control the traffic noise effectively.

The most effective strategy to tackle railway noise is to reduce the wheel roughness, for example by replacing cast iron brake blocks. A new type of low-noise brake block (LL-blocks) can easily replace noisy, cast iron blocks and can reduce noise from freight trains by up to 12 dB (on a well-maintained track). It can also be beneficial to isolate the wheel tread from the wheel web and optimize the size and shape of the wheel to reduce vibration, although this is only possible for new vehicles. On the track side, the roughness of the rail line can be reduced using acoustic grinding, which has been shown to reduce sound levels by 2.5–5 dB. Using firmer rail pads can also reduce the vibration of the rail, while adding a rail damper can further reduce noise by up to 3 dB(A), although concerns remain regarding their cost and safety

The main sources of airport noise are from the aircraft itself, which generates noise on the ground while parked, while taxiing, during run up, take-off, flight and landing. Noise originates from three major sources: aerodynamic noise (due to the airflow around the main body of the aircraft, increasing with speed and at low altitudes), engine/mechanical noise (due to the jet engines, which predominates during take-off and climb), and noise from aircraft systems (from the auxiliary power unit, which is used to start the main engines and provide power while the aircraft is on the ground).

Reduction of noise at source: new technologies, Noise standards, Fleet evolution, Air traffic management can be considered for the reduction of aircraft noise at source.

The Land-use planning and management comprises of Zoning controlling development, such as preventing noise-sensitive land-uses (e.g., residential buildings, schools, hospitals) near to an airport or flight path. Mitigation: e.g. facade insulation of nearby noise sensitive buildings, Tax incentives and financial charges.

The noise abatement operational procedures are Noise-preferential routes or runways, Limited engine running while on the ground, displaced landing thresholds: Changing where on a runway planes can land to reduce noise emissions for sensitive areas. Reducing power/drag, the continuous descent approach (CDA), whereby the aircraft is at a higher altitude throughout most of the descent than the conventional 'stair step' approach, which reduces noise pollution for communities below.

Cross-functional noise abatement approaches: Although some noise abatement approaches are specific to particular noise sources, several can be applied across noise types:

Noise barriers: A popular noise abatement strategy is the use of noise barriers. Noise barriers are an effective means of significantly reducing high noise levels, such as those near to large roads. They limit noise by preventing direct propagation between the source and the receiver.

A. Noise Barrier **B. Sonic Crystal**

Figure 6.8 Different type of Noise Barrier

Building design: During the planning stages, architects can make significant improvements to the noise levels within a building. One way of achieving this is to locate less noise-sensitive rooms, such as the kitchen or a storage room, towards a potential noise source such as a road, and more noise-sensitive rooms such as bedrooms and the living room away from the noise source. It can also be beneficial to consider noise interactions when designing the geometry of entire buildings. Certain orientations can reduce reflections of noise onto a building. Extra design features can also aid noise abatement. For example, orientating windows away from the noise source and protecting them with wing walls can significantly cut internal noise exposure. Balconies also have a significant noise reduction potential (5–14 dB), depending on their parameters.

There is no dedicated data of individual Land-use planning or 'zoning' involves considering the location of future developments in the context of other areas, such as residential areas and green space. Proper planning can help to identify noise-sensitive and quiet areas that should be protected against noise in the future. This could mean designing a large enough distance between areas to prevent noise transmission, or implementing noise abatement as part of new development programmes.

Building sound insulation: Sound-insulated windows can achieve reductions in the order of 30 dB, which is around the same as solid doors. Special sound reducing windows can reduce emissions by up to 40 dB, although this depends on the characteristics of the building and the windows, and of course is only effective when the windows are closed.

Sonic crystals: Sonic crystals can prevent the transmission of sound waves at specific frequencies, which can be tailored by changing the size and geometry of the crystals.

For people working in noisy areas ear protection aids like ear plugs, muffs, noise helmets, headphones etc. should be provided to reduce occupational exposure. Proper lubrication has to be done for old machines to reduce the noise. Increased distance between source and receiver by zoning of noisy industrial areas like bus stands and railway stations away from silence zones near residential areas, educational institutions and hospitals. Planting of trees and shrubs along roads, hospitals and educational institutions help in noise reduction to a considerable extent.

6.2.2 Present Scenario and Gap Identification

There are 6 ULBs in Hanumangarh district namely Nagar Parishad Hanumangarh, Nagar Palika Pilibanga, Nagar Palika Sangaria, Nagar Palika Rawatsar, Nagar Palika Nohar, Nagar Palika Bhadra. The very less information that is available regarding noise in Hanumangarh district is shown in the table below. Inferences from present scenario

There is no dedicated data of individual ULBs. Sign boards in towns and cities in silent zones should be installed. Noise measuring devices should be provided to the district administration. Noise monitoring study should be carried out in all ULBs.

Table 6.6 Present Scenario in Hanumangarh district

S. No.	Details of Data Requirement	Units	Outcome for District
1	No. of noise measuring devices with district administration	Nos.	
2	No. of noise measuring devices with SPCBs	Nos.	01 noise measuring device is available with RO, RSOCB, Bikaner which is used for noise monitoring of the whole Hanumangarh District.
3	capability to conduct noise level monitoring by State agency / District authorities	[Available] / [Not available]	NA
4	No of complaints received on noise pollution in last 1 year	[Nos]	Nil
5	No of complaints redressed	[Nos]	Nil
6	Implementation of Ambient noise standards in residential and silent zones	[Regular Activity] / [Occasional] / [Never]	Regular Activity
7	Noise monitoring study in district	[carried out] / [not carried out]	Not carried out
8	Sign boards in towns and cities in silent zones	[Installed] / [Partial] / [Not Installed]	Information related to Local Bodies

6.2.3 Action Plan

The action plan for noise pollution management in Hanumangarh district is shown in the table below.

Table 6.7 Action Plan for Noise Pollution Management

S. No.	Action points	Time Frame for implementation	Suggested Responsible stakeholders/ Agency involved
1.	Monitoring the noise pollution especially in residential and silence zones	1- year	RSPCB
2.	Monitoring the noise levels in areas of traffic congestion/ commercial areas	1-year	RSPCB
3.	Strict implementation of noise control from vehicles in terms of honking or engine noise	3-years	Traffic police
4.	Determining the level of noise control required in different areas of an ULB	3-years	RSPCB (technical institutes may also be employed for the same)
5.	Installation of noise barriers e.g. planting vegetation and earth barriers for areas where source control is difficult	5-years	ULB (Nagar Parishad Hanumangarh, Nagar Palika Pilibanga, Nagar Palika Sangaria, Nagar Palika Rawatsar, Nagar Palika Nohar, Nagar Palika Bhadra)

6.2.4 Summary

The noise abatement strategy typically starts with the development of noise standards or guidelines and the identification, mapping and monitoring of noise sources and exposed communities. A powerful tool in developing and applying the control strategy is to make use of modeling. These models need to be validated by monitoring data. Noise parameters relevant to the important sources of noise must be known. There is no detailed or proper information regarding the noise levels in Hanumangarh and in all particular ULBs. Therefore, the action plan suggested in the study is more focused on noise monitoring but not on the controlling measures. Hence it is required to conduct noise survey in the district to know the intensity of the noise so that an effective action plan can be framed and implemented in the district. The monitoring suggested in the action plan is more focused on residential and silence zones since they are more susceptible to noise pollution. The focus is also made on traffic noise since the proportion shared by vehicles in producing noise is higher than any other noise producing source. Noise barriers are recommended in the action plan because there are some situations where source control is not possible hence, we have to take certain control measures at least not to transfer the noise to the surroundings. There is a range of approaches available to reduce noise exposure locally, from well-established methods such as insulation and speed limits to more novel strategies such as low-noise road surfaces. In conclusion, a mix of mitigation at the source and noise abatement at the receiver end will be important to target noise hotspots.

Table 6.8 Summary for noise management in Hanumangarh district

Name of the ULBs	Present Scenario	Action Plan for future
Nagar Parishad Hanumangarh Nagar Palika Pilibanga Nagar Palika Sangaria Nagar Palika Rawatsar Nagar Palika Nohar Nagar Palika Bhadra	● There is no data about noise measuring devices with district administration. ● There are only 1 noise measuring device with SPCB. ● No data regarding the capability to conduct noise level monitoring by State agency/ District authorities. ● No data regarding the number of complaints received and number of complaints redressed. ● No data regarding the implementation of ambient noise standards in residential and silent zones ● Noise monitoring study in district is not carried out. ● No data about sign boards in towns and cities in silent zones.	● Monitoring the noise pollution especially in residential and silent zones for 1 year by RSPCB. ● Monitoring the noise levels in area of traffic congestion/commercial areas for 1 year by RSPCB. ● Strict implementation of noise control from vehicles in terms of honking or engine noise for 3 years by traffic police. ● Determining the level of noise control required in different areas of an ULB for 3 years by RSPCB. ● Installation of noise barriers e.g. planting vegetation and earth barriers for areas where source control is difficult for 5 years by ULBs

7. Industrial Waste Management

7.1 Literature Review

Industrial waste includes all types of waste created by local industries, whether it be wastewater, air, or solid garbage. Furthermore, because industrial waste might be toxic, it is even more critical to handle industrial trash scientifically. Improper solid waste management can lead to toxins contaminating the soil, air, and water. Large and medium-sized businesses in designated industrial zones still have solid waste disposal plans in place. As a result, local governments, in collaboration with the State Pollution Control Board (SPCB), must devise a strategy for properly collecting and disposing of industrial solid waste (Jadhav & Hocheng, 2012).

India's urbanization is undergoing a rapid transformation, with the number of people living in cities increasing from 14 per cent in the 1940s to almost 33 per cent in 2000. The much-needed boost to industrial development has resulted in massive residuals that are having negative impacts on the environment - air, water, and land - that are out of proportion to their contribution to total economic growth. The iron and steel sector, for example, provides 55 per cent of the entire particulate matter burden while contributing 16 % of overall industrial production. The Chemical and food processing sectors provide up to 86 % of the overall industrial BOD load, compared to the industry's contribution of 25 % to overall industrial production (Brueckner et al., 2014).

Scenario in Country

Every year, India generates about 74.6 lakh tons of hazardous garbage from various sectors. Waste that can be disposed of in landfills accounts for approximately 34.1 lakh tons or 46% of the total. 33.5 lakh tons of recyclable hazardous trash, or 45 per cent of the total, are recycled. India should enhance its waste recycling processes since recyclable hazardous waste accounts for a significant portion of the total. Industrial Hazardous waste is generated in India by a variety of industrial facilities. Hazardous trash was also transported into India for reprocessing and recycling from developed nations such as Malaysia and Saudi Arabia until the newly revised laws of 2016 put an end to it. Currently, the majority of India's hazardous waste is disposed of in conventional trash dumping dumps rather than specially constructed landfills particularly for the disposal of industrial hazardous waste (Gautam et al., 2017).

In India, the volume of wastewater is rising dramatically, and the limited freshwater sources are being contaminated due to a lack of effective treatment and management. The dumping of industrial effluent into the environment renders the available water supply useless. The industry creates about 13468 MLD of wastewater, of which only 60% is processed, with large scale industries accounting for the majority (Raveesh et al., 2015). Due to regional water shortages, several companies have been discovered to use water recycling technologies. Common Effluent Treatment Plants (CETP) have been built up for clusters of small size companies that may not be able to pay the expense of a wastewater treatment facility (CPCB, 2005). Dissolved air floatation, dual media filter, activated carbon filter, sand filtration and tank stabilization, flash mixer, clariflocculator, secondary clarifiers, and Sludge drying beds are some of the treatment processes used in these facilities. Traditional wastewater treatment technologies are costly and complicated to operate and maintain (Dhingra et al., 2015).

Scenario in State

In Rajasthan State, there are in all 33 districts, 193 Urban Local Bodies (ULBs), 295 Panchayat Samitis and 9,892 Gram Panchayats (GPs). As per the Census 2011, the state has a population of 6.86 crores, from which 24.78% resides in urban regions and 75.13% in rural areas. Groundwater pollution has been observed in several regions of Rajasthan as a result of the discharge of untreated industrial effluents (Nandan et al., 2017).

Governance and Management Structure

The various concerned institutions involved in the process of Industrial Waste Management are Central Pollution Control Board; Department of Environment Science and Technology; Ministry of Environment, Forest and Climate Change; Central Public Health and Environmental Engineering Organization; the Energy and Resource Institute and; Ministry of Housing and Urban Affairs.

Roles and Responsibilities

Central Pollution Control Board

Responsibilities include regulating and managing noise-producing sources to maintain acceptable levels of ambient air quality.

Department Of Environment, Science and Technology

Responsible for planning, coordinating, promoting/overseeing environmental, science and technology, pollution prevention, abatement, and control activities and programmes for environmental protection, conservation, and enhancement using innovative technologies through regulation, policy formulation, and supervision and monitoring.

Ministry of Environment, Forest and Climate Change (MoEF&CC)

Responsible for the effective implementation of legislation, with an emphasis on waste reduction, source segregation, recycling, and the participation of waste pickers, recyclers, and waste processors in the collection of plastic waste fractions from households and other sources of generation.

The Energy and Resource Institute (TERI)

Dedicated to creating technologies and solutions that both minimize garbage production and transform all rubbish into useable commodities. Its objectives include promoting the circular economy through resource-efficient and clean production in industries, as well as improving resource recovery and recycling for landfill-free communities.

Ministry of Housing and Urban Affairs (MoHUA)

Responsible for increasing the ability of Urban Local Bodies (ULBs) through infrastructure development, capacity building, and communication, with a focus on diverse elements of solid waste management and holistic sanitation, such as wastewater treatment.

Responsibility of Local Body

Urban local bodies may undertake collection, transportation and disposal of solid waste on a cost recovery basis as per existing rules and may identify suitable sites for final treatment and disposal of industrial solid waste as per existing rules and regulations.

Responsibility of State Pollution Control Board (As Per Rule 12)

Management of Industrial Solid Wastes-Coordination (RSPCBs & Local Bodies) (CPHEEO, 2016): Inventorisation of industries could be attempted through Rajasthan State Pollution Control Board (RSPCBs) or industries department for characterization of wastes. Rajasthan State Pollution Control Board (RSPCBs) may take necessary actions for issuance of consents/Authorizations to the industries under relevant Acts and Rules. The State Pollution Control Board's primary goal is to enhance air quality, promote water body purity, and avoid pollution (CPHEEO, 2016a).

Rules and Regulations

The water (prevention and control of pollution) act 1974

Allow the SPCBs to establish and maintain site and source-specific wastewater discharge standards. The real enforcement mechanisms, such as fines, imprisonment, and so forth, are limited to source-specific regulations for particular polluters(GOI, 1974).

The air (prevention and control of pollution) act 1981

The Board is responsible for preventing, reducing, and regulating air pollution in the country, as well as providing advice to the Central Government. It is in charge of creating and executing a national plan for air pollution prevention, control, and reduction. The goal is to advise the Central government on matters about air and air pollution. Advice and support State Boards in carrying out their functions. Carry out research related to air pollution. Through mass media, spread awareness and information about air and air pollution(GOI, 1981).

The Environment (Protection) Act, 1986

The Environment (Protection) Act of 1986 gives the federal government the authority to protect and improve environmental quality, control and reduce pollution from all sources, and prohibit or restrict the development and/or operation of any industrial facility for environmental reasons (GOI, 1986).

Hazardous Waste Management Rules, 2016

To distinguish between Hazardous Waste and other wastes, rules have been established. Trash tires, paper waste, metal scrap, old electronic products, and other wastes are all recognized as resources for recycling and reuse. These resources enhance industrial operations while reducing the burden on the country's virgin resources. The hierarchy of waste management has been integrated, with the top priorities being prevention, minimization, reuse, recycling, recovery, co-processing, and safe disposal. The essential need for infrastructure to protect public health and the environment from the waste processing sector has been established as Standard Operating Procedures (SOPs), which must be followed by all stakeholders and ensured by the SPCB/PCC when giving such authorization. The procedure for establishing a hazardous waste disposal facility and importing other wastes has been streamlined by combining all permissions into a single-window clearance. The following are the state government's responsibilities for ecologically solid waste disposal of hazardous and other wastes: Set up/ allocate industrial space or sheds for hazardous or other trash recycling, pre-processing, and other uses. Workers participating in recycling, pre-processing, and other useful operations must be registered. To establish labour groups to make the installation of such facilities easier. To carry out industrial skill development operations while also ensuring worker safety and health (GOI, 2016).

Environment (Siting for Industrial Project) Rules-1999

The Environment (Siting for Industrial Projects) Rules, 1999, contain detailed provisions relating to areas to be avoided for industrial project siting, site selection precautions, and environmental protection aspects that should have been incorporated during the implementation of industrial development projects(GOI, 1999).

The National Environment Appellate Authority Act, 1997

An Act to create a National Environment Appellate Authority to hear appeals relating to the restriction of areas in which any industries, operations, processes, or processes shall not be carried out or shall be carried out subject to certain safeguards under the Environment (Protection) Act, 1986, and for matters related there to (GOI, 1999).

Best Practices

This section describes the best practices with respect to Common Effluent Treatment Plants (CETP). Rapid industrialization is crucial for a country's economic progress, particularly in emerging countries, but it also has a worldwide impact on the environment. If industrial wastewater is not adequately handled, it can have negative consequences for the environment. Adoption of cleaner manufacturing technology and waste reduction activities are promoted to alleviate pollution emitted by industry. CETPs (Common Effluent Treatment Plants) are one of the possible methods for effective wastewater treatment for small and medium businesses (H. D. Sharma et al., 1995). The main objective of establishing CETP is to reduce the treatment cost for individual units while protecting the environment, To achieve 'Economies of scale' in waste treatment, thereby reducing the cost of pollution abatement for individual factory, To minimize the problem of lack of technical assistance and trained personnel as fewer plants require fewer trained personnel, To solve the problem of lack of space as the centralized facility can be planned to ensure that adequate space is available, To reduce the problems of monitoring for the pollution control boards, To organize the disposal of treated wastes and sludge and to improve the recycling and reuse possibilities as once individual units are required to pay for waste treatment/disposal, they tend to adopt means to reduce waste generation. Till 1990, India had only one CETP in Jeedimetla near Hyderabad (Andhra Pradesh). Till 2005, around 88 CETPs had been established across the nation. The number of CETPs rose to more than 150 by the year 2011 (DOIFODE & MATANI, 2015).

Effluent Treatment Technologies

Wastewater depending on its characteristics is subjected to different treatment options.

To remove coarse particles and other big items from raw wastewater, preliminary treatment is necessary. Screens and grates are used to remove big materials, comminutors are used to grind coarse particles, and pre-aeration is used to regulate smell.

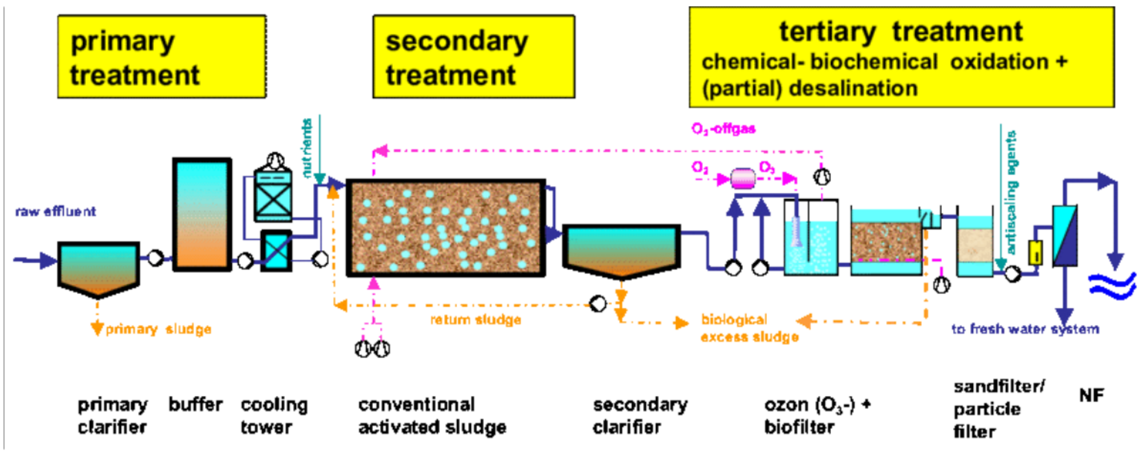


Figure 7.1 Effluent Treatment Technologies

Member industries may perform preliminary treatment on-site before delivering the effluent to CETP for further processing. Individual member industries can increase CETP's performance by implementing preparatory treatment or pre-treatment.

Primary clarifiers are used to physically separate suspended materials from wastewater. Total suspended solids (TSS) and related biochemical oxygen demand (BOD) levels can be reduced with this method. The goal of primary treatment is to remove organic and inorganic solids that settle by sedimentation and floatable materials (scum) by skimming. During primary treatment, 25 to 50% of the incoming biochemical oxygen demand (BOD5), 50 to 70% of the total suspended solids (TSS), and 65 per cent of the oil and grease are removed.

Microbes decompose suspended and dissolved organic materials in wastewater during this process. Activated sludge or biological filtration procedures are the most often utilized biological treatment techniques. Biological therapy can be aerobic, in which microorganisms require oxygen to grow, anaerobic, in which microorganisms can grow in the absence of oxygen, or facultative, in which germs can grow in the presence or lack of oxygen. Microorganisms can be adhered to the surface, as in a trickling filter, or they can be suspended in a liquid suspension, as in the activated sludge process. The activated sludge process is an aerobic biological treatment method that utilises the suspension development of aerobic bacteria to break down organic pollutants.

Anaerobic Treatment Systems does not use oxygen and hence save on the power requirement for oxygen generation and/or transfer. These mechanisms are slower than aerobic breakdown, and they produce toxic hydrogen sulphide gas when sulphur is present. Although the initial investment is considerable, a portion of it can be offset by biogas recovery. Except for sludge stabilization, they are not typically employed in wastewater treatment systems for CETPs.

Tertiary treatment is the last step in the wastewater treatment process, and it enhances the quality of the wastewater before it is reused, recycled, or released into the environment. Tertiary treatment is used to polish effluent (BOD, TSS), remove nutrients (N, P), and remove toxins (pesticides, VOCs, metals), among other things. Physical-chemical separation techniques like as activated carbon adsorption, flocculation/precipitation, membrane filtration, ion exchange, de-chlorination, and reverse osmosis can all be used in tertiary treatment.

7.2 Present Scenario and Data Gap

Main industries in the Hanumangarh district are the manufacture of Rice milling, edible oil, dal milling, flour milling, cotton ginning, Bricks & Tile, P.O.P. confectionery ice cream, cotton ginning etc. Micro and small-scale industries based on available resources like Gypsum Grinding, Plaster of Paris, Cotton Ginning and Processing, Cotton Spinning Mill, Solvent Extraction Plant, Particle Boards from cotton Stocks, Roller Flour mill, Straw Board, Processed Food/Achar and Murabba, Mini Dal Mill, Oil Refinery, Cattle Feed.

Data Provided by ULBs

As per the data provided, 39 industries are discharging wastewater of quantity 0.078 MLD. One CETP is proposed for the district. Details for CETPs proposed for the industrial area is not provided.

Data for soil quality, ground and surface water, air quality should be provided for environmental assessment of Industrial Clusters based on the Comprehensive Environmental Pollution Index (CEPI)

Table 7.1 Inventory of industrial wastewater Generation in Hanumangarh

S. No.	Details of Data Requirement	Units	Outcome for District
1	No of the Industries discharging wastewater	Nos.	39
2	Total Quantity of industrial wastewater generated	MLD	0.078
3	Quantity of treated IWW discharged into Nalas / Rivers	MLD	Nil
4	Quantity of un-treated or partially treated IWW discharged into lakes	MLD	Nil
5	Prominent Type of Industries [Agro based] / [Chemical – Dye etc.] / [Metallurgical]		Dairy Product- 10 Agro Base-6 Automobile-2 Pharma-1
6	Common Effluent Treatment Facilities	Nos.	No CETPs (1 Proposed)

Presents the current status of compliance by industries and action taken in treating wastewater that shows there is a number of industries not meeting discharge standards is zero.

Table 7.2 Status of compliance by Industries and action taken in treating wastewater

S. No.	Details of Data Requirement	Units	Outcome for District
1	No of Industries meeting Standards	Nos.	39
2	No of Industries not meeting discharge Standards	Nos.	NIL
3	No of complaints received or number of recurring complaints against industrial pollution in last 3 months	Nos.	NIL
4	No industries closed for exceeding standards in last 3 months	Nos.	Nil
5	No of industries where Environmental Compensation was imposed By SPCBs	Nos.	Nil

Inferences from Present Scenario

This section presents the inferences compiled from the data provided by the ULBs in the Hanumangarh district. During the site visit to Hanumangarh, the industrial waste was observed to be scattered in the open (Figs. 7.2 to 7.5). Industrial waste is more hazardous as compared to municipal solid waste. However, it is confined to industries and hence can be easily managed.

Moreover, the data provided to MNIT indicates that the industrial waste is being properly managed. But the situation on the ground dictates otherwise. This situation should be taken as an emergency and dealt with urgently.

Figure 7.2 Industrial Waste dumped in open near Hanumangarh ULB

Figure 7.3 Canal adjacent to industrial waste dump

Figure 7.4 Stagnant untreated industrial waste water and accumulation of sludge

7.3 Action Plan

The future action plans from different agencies for all the ULBs in have been summarized in table provided below with time frame for implementation.

Table 7.3 Action Area for Industrial Waste Management

S. No.	Action points (Including source and mitigation measures)	Time frame for implementation	Suggested Responsible stakeholders/ Agency involved
1.	Monitoring of soil and Groundwater quality where industrial waste has been discarded without any scientific measures	Urgent	State Groundwater Board
2.	Installation of Flow meter / Water mater with each industrial unit for monitoring of compliance of the permitted discharge quantity.	Urgent	Industrial Association, RIICO
3.	Periodic water audit of industries	Urgent	RSPCB and ULB
4.	Provision of potable water for affected villages, if any	Urgent	PHED
5.	Inventory of Industrial emission by doing survey of all industries to ensure inventory of emission	3-years	RSPCB
6.	Adequacy of Available Infrastructure for Pollution Control: (i) Air Pollution Monitoring and Control (ii) Industrial Waste water monitoring and Control (iii) Hazardous Waste Monitoring and Control	5-years	RSPCB
7.	Environment Compensation	21-year	RSPCB

There is a need for proper monitoring of the management of industrial waste so that further deterioration of the soil and water quality in the area can be prevented.

Suggested Interventions

It is necessary to close the gap between wastewater treatment technology vendors and industry professionals. For industries, the water metering and accounting system should be made stricter. Auditing of water and wastewater should be made mandatory. Industrial locations should be chosen with the least environmental and social effect in mind, and e-filing of the quantity of water utilized and wastewater released should be done. Industries should be permitted to collect water from the downstream and dump it in the upstream. This will compel businesses to properly treat their effluent. Industries should be informed about the most recent advances in wastewater treatment technology on the market. Desalination, ultrafiltration, Nano filtration, membrane bioreactors, and other sophisticated effective technologies should be rewarded with incentives. Subsidies for wastewater recycling and reuse should be made available to businesses.

It is necessary to do proper monitoring of scattered waste littered on the open ground. If this waste is already there, then it should be sent to landfill and if it discharged somewhere else it should meet the standards set by regulatory authority.

7.4 Summary

In summary the current state of industrial waste management for all ULBs of Hanumangarh district. There are no industries not meeting discharge standards. According to ULBs One CETP is proposed for the district. Details for CETPs proposed for the industrial area is not provided. If no CEPI is there how the industries are characterized on environmental quality.

The uncollected garbage that generally makes its way to the landfill Cattle eat the way in sewers, or it's left to decay in the open or burned on the side of the road. As we fight environmental challenges, we must figure out how to protect the environment without slowing down commerce.

You may dramatically lower your risk of contributing to pollution and become stewards for environmental stewardship in your industry by implementing a comprehensive waste management strategy that can be readily monitored and maintained. Of course, we humans require a clean and secure environment as well.

Table 7.4 Summary about Industrial Waste Management in Hanumangarh District

Name of District	Present Status	Action Plan for future
Hanumangarh District	• Total Quantity of industrial wastewater generated in Hanumangarh district is 0.078 MLD. There is only data available for the Hanumangarh District industries. • 39 industries are discharging waste water in Hanumangarh district. • Quantity of untreated and treated IWW is nil. • Common Effluent Treatment (CETP) Facility has not been installed and one CETP is proposed.	• Monitoring of soil and groundwater quality • Installation of Flow meter / Water mater with each industrial unit for monitoring of compliance of the permitted discharge quantity. • Periodic water audit of industries • Inventory of Industrial emission by doing survey of all industries to ensure inventory of emission • Utilization of Environment Compensation for pollution Control • Provision of potable water for affected villages.

8. Mining Activity Management Plan

8.1 Literature Review

A mineral is an element or chemical compound that is normally crystalline and that has been formed as a result of geological processes (Aznar-Sánchez et al., 2018). Mining is among the oldest industries on Earth, along with agriculture. The history of mineral extraction in India dates back to the days of the Harappa civilization. The wide availability of the minerals in the form of abundant rich reserves made it very conducive for the growth and development of the mining sector in India. The minerals and mining industry is a key segment of the Indian economy, with India being highly endowed with vast mineral resources. The country's accelerated growth rate warrants a rapid development of the mining sector, on which most of the basic industries in the manufacturing sector depend. Extraction and development of minerals are closely interlinked with other natural resources like land, water, air, and forest (Scoble et al., 2003). Hence, the management of this precious resource and its optimal and economical use are matters of national importance. The primary purpose of a Mining Activity Management Plan is to formalize the actions to be taken and strategies to be implemented, that combined, will manage impacts to the environment to acceptable and sustainable limits over both the short and long-term. Fig. 8.1 explains the waste generation in mining activities. Environment baseline studies have to be conducted in respect of micrometeorology, air quality, ambient noise levels, biological environment (flora & fauna), water quality, soil quality & socio-economics in the core and buffer zone of 10 km radius (Lèbre et al., 2017).

Environmental Impacts of Mining projects

Impacts on water resources

The most significant impact of a mining project is its effects on water quality and availability of water resources within the project area. As the major impact on water resources are Acid mine drainage and contaminant leaching, Erosion of soils and mine wastes into surface waters which led to the loss in potential of soil and sediment eroding into and degrading surface water quality is a serious problem (Nickel & Mandarino, 1987).

Impacts of mining projects on air quality

Airborne emissions occur during each stage of the mine cycle, but especially during exploration, development, construction, and operational activities. Mining operations mobilize large amounts of material, and waste piles containing small size particles are easily dispersed by the wind. Incidental releases of mercury, Noise, and vibration are also some serious problems.

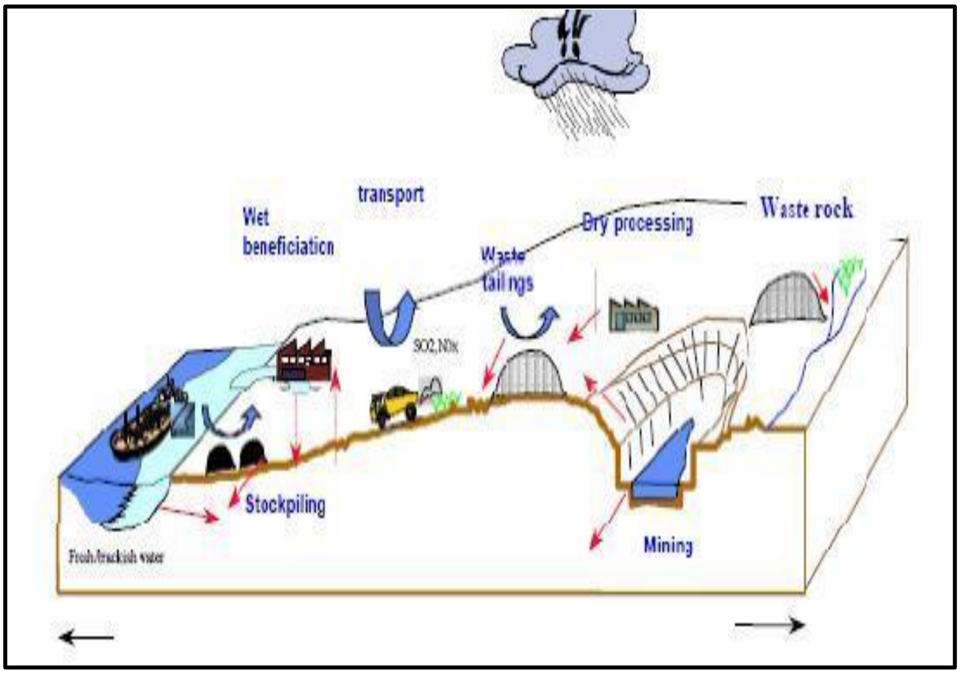


Figure 8.1 Waste Generation in Mining Cycle

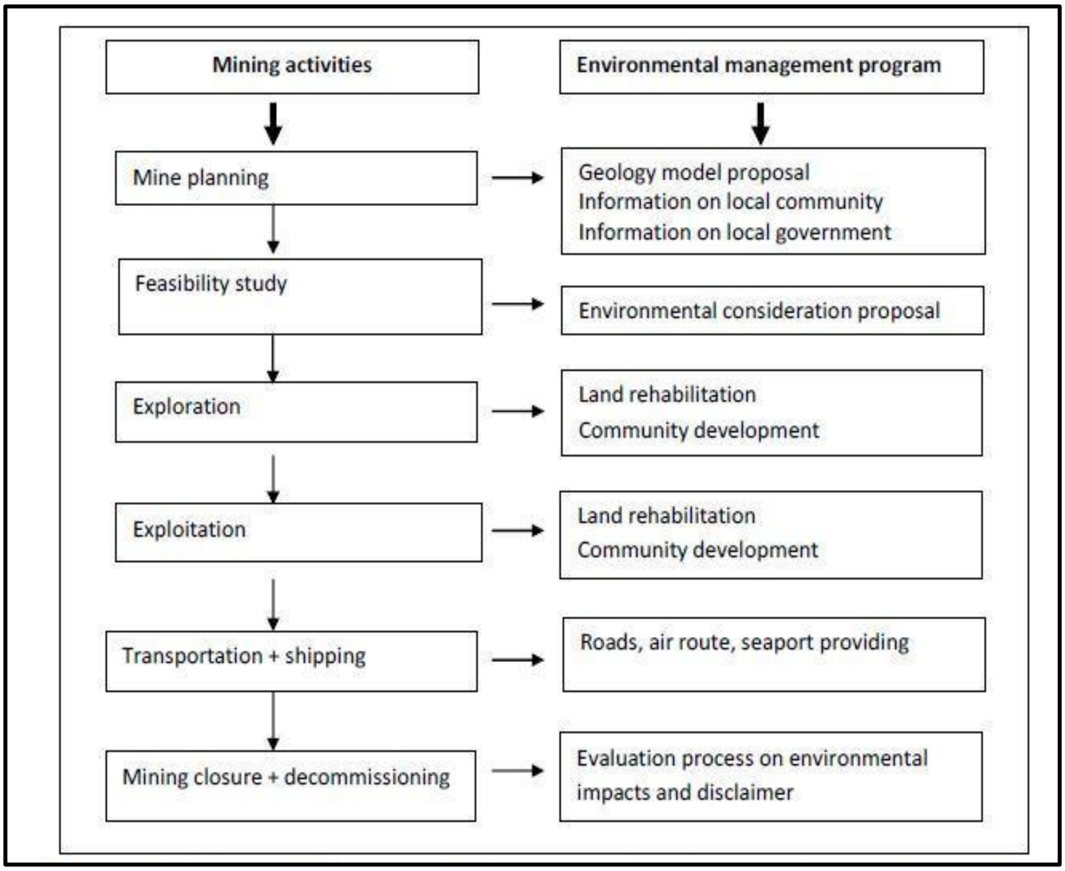


Figure 8.2 Methodology applied to good mining practice (Source: Problems of mining wastes management in India, 2012)

Impacts of mining projects on wildlife, Habitat fragmentation

Mining affects the environment and associated biota through the removal of vegetation and topsoil, the displacement of fauna, the release of pollutants, and the generation of noise. Habitat fragmentation occurs when large areas of land are broken up into smaller and smaller patches, making dispersal by native species from one patch to another difficult or impossible, and cutting off migratory routes.

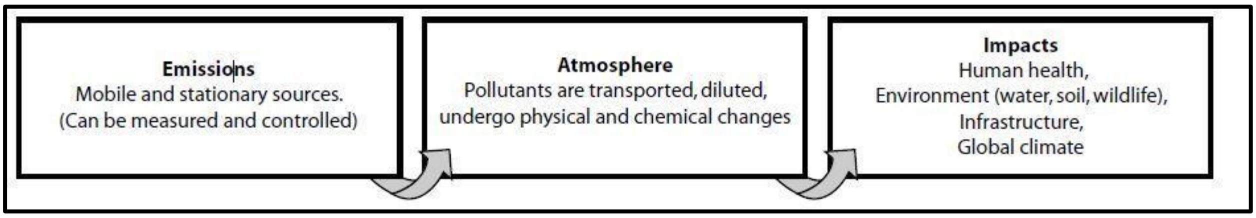


Figure 8.3 Impacts of mining projects on wildlife, Habitat fragmentation (Source: U.S. Environmental Protection Agency)

Impacts of mining projects on soil quality, social values

Mining can contaminate soils over a large area. Agricultural activities near a mining project may be particularly affected. Erosion of exposed soils extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination.

Human displacement and Resettlement, Lost access to clean water, impacts on public health, impacts on livelihoods

The displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development. Entire communities may be uprooted and forced to shift elsewhere, often into purpose-built settlements not necessarily of their own choosing. Besides losing their homes, communities may also lose their land, and thus their livelihoods.

Climate change Considerations

Large-scale mining projects have the potential to alter global carbon in at least the following ways: Many large-scale mining projects are proposed in heavily forested areas of tropical regions that are critical for absorbing atmospheric carbon dioxide (CO_2) and maintaining a healthy balance between CO_2 emissions and CO_2 uptake.

Suggestive Interventions for Mining Waste Management

There are two major problems encountered during waste dump construction. First is the availability of suitable land (which is technically, environmentally and economically viable) than the control over its construction. Technically suitable means the land can accommodate the quantity of waste and can withstand the ground bearing pressure. Environmentally suitable means allowable contamination to ground/surface water; restoration of top soil both area of disposal and area of mining etc. Tailing and other finer waste can be disposed of in various ways. By order of importance, the disposal of tailings is generally by:

Terrestrial Impoundment: Terrestrial deposition is the predominant method for tailings disposal. It concerns fine waste and slurries such as mill tailings. The principle of tailings dams (or ponds) is to dispose of the tailings in an accessible condition that provides for their future reprocessing (once improved technology or a significant increase price makes it profitable)

Underground Backfilling: This method is possible only for ore deposits without communication with an aquifer. Such an operation is usually costly and will be carried out for stability and safety reasons.

Deep Water Disposal: The disposal of tailings and solid waste directly into bodies of water although sometimes used in past operations, is rapidly becoming non-authorized as a standard practice due to the significant

Recycling: Coarse mining waste and especially barren rock is sometimes considered as materials for roads, building foundations or cement factories, depending on its geotechnical and geochemical characteristics. Recycling is not classified as disposal. In the German Potash Industry, the solid waste is 22% recycled, 58% dumped and 7% backfilled; the liquid waste is 8% deep well disposal and 5% discharged into rivers. Waste rock may have no market at the moment occurs. If a market will emerge later, the rock stored temporarily can be sold as aggregate when environmental specifications are met. With new techniques, the tailings can be reprocessed. This method requires specific conditions and specific impact assessments. There seems to be a consensus among scientists that an appropriately designed underwater disposal of sulphide tailings is the ideal solution from an environmental point of view in the short term with control of the level of water (Gadd, 2007).

Scenario in Country

India ranked 4th amongst the mineral producer countries, behind China, United States and Russia, based on volume of production, as per the Report on Mineral Production by International Organizing Committee for the World Mining Congress, it, however, ranked 8th based on value of Mineral production, during 2009. The Mining sector, therefore, is one of the important sectors in India's economy and contributes about 2% to our GDP. However, the contribution of the sector to India's GDP has been on the decline. The mining sector contributed 3.4% of India's GDP in 1992-93. This declined to 3.0% in 1999-2000, and further to 2.3% in 2009-10. And with the sector contracting in absolute terms in the last couple of years, the contribution of the mining sector to India's GDP has come down to 2% in 2012-13.

India produces as many as 87 minerals, which includes 4 fuel minerals, 10 metallic minerals, 47 non-metallic minerals, 3 atomic minerals and 23 minor minerals (including building and other materials). After clocking an average growth rate of 4.8% over the 5 years between 2006-07 and 2010-11, the sector has witnessed negative growth of 0.6% for two consecutive years now (2011-12 and 2012-13). There are close to 3000 mines in India. There are 560 Coal mines (19% of total number), 553 limestone mines (19% of total number) and 316 iron ore mines (11 % of total number). They comprise about half of the total number of reporting mines. The number of mines engaged in extraction was also significant in cases of bauxite (189), manganese (141), dolomite (116) and Steatite (113).

Scenario in State

In Rajasthan State, there are in all 33 districts, 193 Urban Local Bodies (ULBs), 295 Panchayat Samitis and 9,892 Gram Panchayats (GPs). As per the Census 2011, the state has a population of 6.86 crores, from which 24.78% resides in urban regions and 75.13% in rural areas. Today Rajasthan is considered as a museum of minerals, both metallic and non-metallic including renowned building stones. It has a vantage position in having significant resources of Radioactive minerals, Lignite, Petroleum and Natural Gas. Rajasthan is the richest state in terms of availability and variety of minerals in the country and produces about 57 different minerals. Rajasthan is the sole producer of lead & zinc ores, selenite and wollastonite. Rajasthan was the sole producer of garnet (gem) till 2004-05. Almost entire production of calcite, natural gypsum and silver in the country comes from Rajasthan. The State is a major producer of ball clay, calcite, clay, copper ore/conc., feldspar, fireclay, limestone, ochre, phosphorite/rock phosphate and steatite. The State is also an important producer of marble, granite, sandstone & Kota stone of various shades. Makrana area is the world-famous centre for marble mining. The State possesses substantial share of the total resources of potash (94%), lead & zinc ore (89%), wollastonite (88%), silver ore (88%), gypsum (82%), ochre (81%), bentonite (75%), fuller's earth (74%), diatomite (72%), feldspar (66%), marble (63%), asbestos (61%), copper ore (54%), calcite (50%), talc/steatite/soapstone (49%), ball clay (38%), rock phosphate (31%), fluorite (29%), and tungsten (27%).

The State contributed about 12% to the total value of mineral production in the country and occupied second position among the States in 2014-15. It was the sole producer of lead and zinc ores and concentrate, selenite and wollastonite. Almost entire production of silver in the country was also reported from the State during 2014-15. Rajasthan was the leading producer of gypsum accounting for 99%, calcite 96%, phosphorite 95%, ball clay 92%, ochre 89%, talc/soapstone/steatite 82%, fireclay 36% and limestone 21% of the total production of respective minerals in the country. Besides, it was the second leading producer of copper concentrates contributing 41%, petroleum (crude) 24% and kaolin 16% of the nation's output for the year 2014-15.

Governance and Management structure

Concerned Institutions

The Ministry of Mines (MoM), Government of India is responsible for the entire minerals and mining sector in the country that includes legislation, administration, policy formulation etc. in respect of all mines and minerals other than coal and lignite, natural gas and petroleum, but including offshore minerals. In India, the minerals are classified as minor minerals and major minerals. The power to frame policy and legislation relating to minor minerals is entirely delegated to the State Governments while policy and legislation relating to the major minerals is dealt by the MoM. The Ministry is responsible for the administration of the Mines and Minerals (Development and Regulation) Act, 1957 and rules made there under in respect of all mines and minerals other than coal, natural gas and petroleum. MoM through its attached office, Geological Survey of India (GSI), facilitates exploration, geological mapping and mineral resource assessment in the country. Indian Bureau of Mines (IBM), a subordinate office of the mom is mainly responsible for regulation of mining in the country. The Ministry also administers the Offshore Areas Mineral (Development and Regulation) Act, 2002 and rules made there under. Mineral concessions in India are granted to Indian nationals or entities incorporated in India only.

Attached Office / Subordinate Office: Geological Survey of India (Headquarters at Kolkata) is an attached office and Indian Bureau of Mines (Headquarters at Nagpur) is a subordinate office of the Ministry. Public Sector Undertakings: There are three Public Sector Undertakings under the Ministry of Mines, namely:-National Aluminum Company Limited (NALCO), Bhubaneswar Hindustan Copper Limited (HCL), Kolkata Mineral Exploration Corporation Limited (MECL), Nagpur Autonomous Bodies There are three Research Institutions which are Autonomous Bodies of this Ministry: Jawaharlal Nehru Aluminum Research Development and Design Centre (JNARDDC), Nagpur; National Institute of Rock Mechanics (NIRM), Kolar Gold Fields, Karnataka, and National Institute of Minerals Health (NIMH), Nagpur.

Roles and Responsibilities

National Mineral Policy, 1993

In pursuance of the reforms initiated by the Government of India in July, 1991 in fiscal, industrial and trade regimes, the National Mineral Policy was announced in March, 1993. The National Mineral Policy recognized the need for encouraging private investment including Foreign Direct Investment (FDI), and for attracting state-of-art technology in the mineral sector. The policy stressed that the Central Government, in consultation with the State Governments, shall continue to formulate legal measures for the regulation of mines and the development of mineral resources to ensure basic uniformity in mineral administration so that the development of mineral resources keeps pace, and aligns with the national policy goals.

Rajasthan Mineral Policy, 2015

The Policy aims at the Development of economically sound and stable mining, minerals, metal and mineral reclamation industries, Orderly and economic development of domestic mineral resources, reserves, and reclamation of metals and minerals to help assure satisfaction of industrial, security and Environmental needs, Study and development of methods for the disposal, control, and reclamation of mineral waste products, and the reclamation of mined land, so as to lessen any adverse impact of mineral extraction and processing upon the physical environment that may result from mining or mineral activities.

Rajasthan State Mines and Minerals Limited (RSMML)

Rajasthan State Mines & Minerals Ltd. is a company based in Rajasthan, India (A Govt. of Rajasthan Enterprise). With a corporate headquarters in Udaipur and a registered office in Jaipur, the company is involved in the mining and related business of various minerals, primarily Rock Phosphate, Lignite, Limestone, Gypsum, and other minerals. Rajasthan State Mines & Minerals Limited (RSMML) is one of the state's most innovative and forward-thinking businesses. It occupies a place of pride in production and marketing of non-metallic minerals in India. RSMML is multi mineral and multi-location enterprise engaged in mining of Rock Phosphate, Lignite, SMS grade Limestone and Gypsum. RSMML is a national leader in the mining and sale of Rock Phosphate and Gypsum, as well as a global pioneer in open-cast mining and mineral beneficiation of Carbonate Rock Phosphate. RSMML has also ventured into the energy sector, constructing a 106.30 MW installed capacity Wind Power Project in Jaisalmer, Rajasthan.

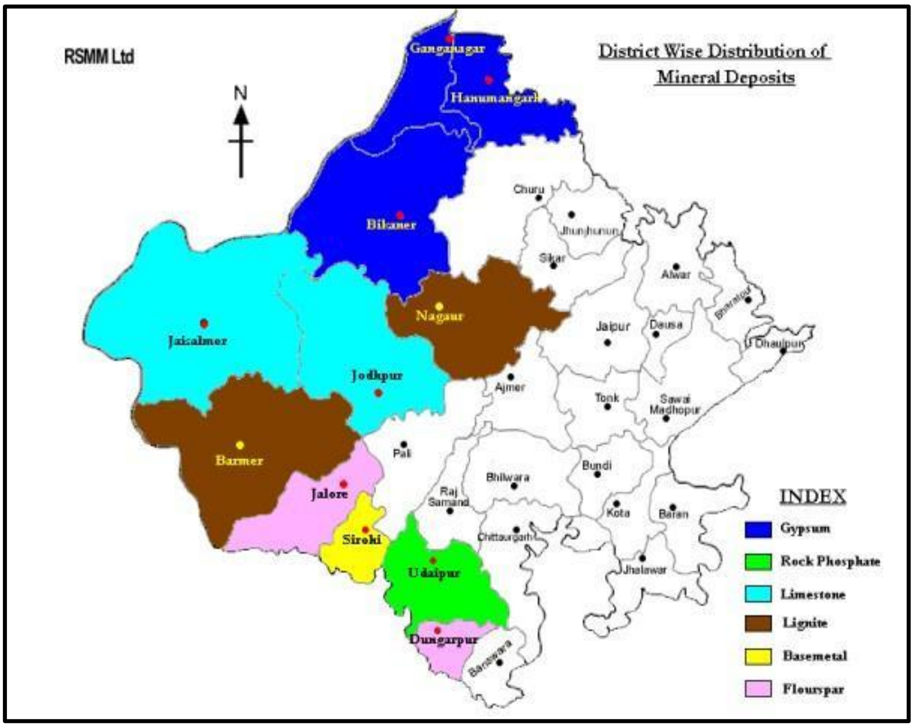


Figure 8.4 District wise distribution of mineral deposits (Source: Rajasthan State Mines and Minerals Limited, India)

Mines and Minerals Development and Regulation (MMDR) Bill, 2011

The Bill seeks a complete and holistic reform in the mining sector with provisions to address issues relating to sustainable mining and local area development, benefit sharing mechanism to the people affected by mining operations also aims to ensure transparency, equity, elimination of discretions, effective redressal and regulatory mechanisms along with incentives encouraging good mining practices. The Bill's main features are: it establishes a simple and transparent mechanism for granting a mining lease or prospecting license through competitive bidding in areas where mineralization is known, and on the basis of first-in-time in areas where mineralization is unknown; it establishes a simple and transparent mechanism for granting a mining lease or prospecting license through competitive bidding in areas where mineralization is not known; and it establishes a simple and transparent mechanism for granting a mining lease or prospect; It enables the central government to promote scientific mineral development, through mining plans and mine closure plans enforced by a central technical agency namely the Indian bureau of mines, as well as the regulatory authorities and tribunals; It empowers the state governments to cancel the existing concessions or debar a person from obtaining concession in future for preventing the illegal and irregular mining.

Geological Survey of India

The GSI is the principal agency responsible for the assessment of geological and regional mineral resources of the country. Its areas of operation encompass scientific surveys and research, for locating mineral resources. GSI operates through six regional offices and four specialized wings – marine, coal geophysics, airborne surveys and training. The GSI has to its credit geological mapping, covering an area of approximately 3.146; million sq. km, or 94 percent of the area of India. The maps are on a 1:63,360/ 1:50,000 scale, the data having been synthesized to produce 1:2,000,000 scale geological maps of India, which have been correlated with the global set up as per international standards. The GSI is also actively involved in the research and development of mapping and exploration techniques. It has set up a chain of modern petrological paleontological, chemical, mineralogical, geochronological, geotechnical and geophysical laboratories in its different operational bases, and offers its facilities and services on payment. Geological maps and data are available with GSI on a commercial basis.

Indian Bureau of Mines

A committee has been constituted in the Ministry of Mines for reviewing and restructuring of functions and role of Indian Bureau of Mines (IBM) in terms of the Policy directions given in the National Mineral Policy, 2008. The Committee has prepared a draft report which has been put up on the website of the Ministry for inviting comments of the stakeholders. The geological services of IBM include survey and preparation of mine plans, preparation of geological plans, preliminary geological appraisal of mineral properties, including the formulation of an initial scheme of detailed exploration with estimate of cost and preliminary reconnaissance, quick survey to determine potential areas out of large properties, etc. IBM also performs regulatory functions, namely: enforcement of Mines and Minerals (Regulation and Development) Act, Mineral concession Rules, Mineral Conservation and Development Rules and compliance with Environmental Protection Act. Separately, the IBM had obtained administrative clearance to fill up 86 scientific and technical previewed posts in various groups. Of these 29 posts have been filled up. The remaining posts are at various stages of being filled up.

Public Sector Undertaking (PSUs)

Mineral Exploration Corporation Ltd. (MECL): MECL is responsible for detailed exploration of various minerals/ ores by drilling and exploratory mining and proving reserves for their eventual exploitation. National aluminum Company Limited (NALCO), Bhubaneswar, Bharat Aluminum Company Limited (BALCO), New Delhi; Hindustan Zinc Limited (HZL), Udaipur; Hindustan Copper Limited (HCL), Kolkata; Mineral Exploration Corporation Limited (MECL), Nagpur; Bharat Gold Mines Limited (BGML), Kolar Gold Fields (Karnataka); Sikkim Mining Corporation (a Company jointly owned by the State Government of Sikkim and the Central Government); Research Institutions.

State Directorate of Mining and Geology

Keeping in view the increase in royalty revenues to the State Governments after revision of royalty rates in August 2009, the State Governments have been requested to prepare Action Plan for strengthening of the State Directorate of Mining and Geology in line with the recommendation of the National Mineral Policy. This item is regularly reviewed in the meeting of Central Coordination-cum-Empowered Committee meetings in the Ministry of Mines where the State Governments, also, participate.

Geological Programming Board

Coordination of the regional exploration work by government agencies is at present being done by the Central Geological Programming Board of the GSI. The disaggregated projects are generally discussed in the State Level Committees and other technical forums before being incorporated into the annual Programme. The National Mineral Policy 2008 (NMP) required that the existing arrangement shall be revamped to ensure that projects and programmes are prioritized in line with the national policy goals and are chalked out after taking into account the exploration work undertaken by the private sector. The Central Geological Programming Board has, since, been revamped and the Board will meet at least twice a year as part of the process to strengthen the linkage between the Central Geological Programming Board and the State Geological Programming Boards. The CGPB has held its latest meetings on 2nd and 3rd February, 2012. Accordingly, it is expected that the Central Board will effectively articulate the policy and programmatic requirements in a technically feasible and scientifically desirable manner so that projects and programmes are prioritized in line with national policy goals and take into account and facilitate the exploration work of the private sector (MoM, 2008).

Initiatives/new developments for the mining sector

Mining Tenement System (MTS)

The MTS has been envisaged to automate the various processes associated with the mineral concession regime. The objective of the Scheme is to develop an online National Mineral Information. System for investors by linking Central and State organizations engaged in the administration of mineral resources in the country. The Mining Tenement System (MTS) would have graphical information database (GIS) as well as information in textual form. These two databases, i.e., non-special database and special database would be seamlessly integrated to retrieve graphical information as well as relevant textual information. The system will be thus web-enabled and access to the system will be given online to prospective investors, government organizations and private-public through Internet as per the policy of the Government. This would not only give an impetus to the decision-making process but is also expected to bring transparency and efficiency. The MTS will not only enable the online filing of applications but will also help to identify the areas for various types of mineral concessions. IBM has been nominated by the Ministry as the Nodal Implementing Agency for the project. Detailed Project Report (DPR) of MTS had already been approved by the Core Committee. Further, an RFP document for the selection of an implementation agency for the design, development, maintenance and operation of MTS was issued. Thus, the retendering of Request for proposal (RFP) for selection of an implementing agency for design, development, maintenance and operations of Mining Tenement System is under process (MoM, 2017).

Mining within a Sustainable Development Framework (SDF)

The Sustainable Development Framework 2011 (SDF) for the mining sector with appropriate compensation to those affected by mining related operations is an important feature of the National Mineral Policy 2008 which finds a mention in the MMDR Act after its amendment. The SDF framework is developed keeping in view the approach of the International Council for Metals and Mining (ICMM) and incorporates the following 7 principles: Incorporate environmental and social sensitivities in decisions on leases. Undertake a strategic assessment of key Mining Regions at periodic intervals. Manage impacts at the mine level through sound management systems. Address land, R&R and other social impacts upfront Promote community engagement, benefit sharing and contribution to socio-economic development. Ensure orderly mine closure planning and implementation and post-closure activities; and put in place systems for assurance and credible reporting.

Mining related activities need to be closely integrated with the economy at multiple levels, including aligning exploration and mining to maximize long-term efficient mineral production; increasing the efficiency of the interface between mineral extraction and metal production to increase potential for manufacturing and jobs, as well as resource use efficiency; and promoting and incentivizing investments (MoM, 2011).

Mining Lease

An application for grant of mining lease in respect of any land in which minerals vest in the Government should be made to the District Collector of the State Government concerned along with the prescribed fee. Every such application should also include with it the consent of the land owner and any person having occupation rights over the land. Mining Lease is granted for undertaking operations for winning any mineral. It allows for the development and production of minerals from ore bodies discovered by prospecting or exploration operations. A Mining Lease for any mineral or prescribed group of associated minerals is granted for a minimum period of 20 years and a maximum period of 30 years. A Mining Lease can be renewed for periods not exceeding 20 years each. In a State, a person can be granted a maximum area of 10 sq. kms in one or more Mining Leases, but if the Central Government is of the opinion that in the interest of development of any mineral it is necessary to do so, the maximum area limit can be relaxed (GOI, 1957).

Central Government

The Central Government is bound to take steps for the conservation and systematic development of minerals in India and the protection of the environment by preventing and controlling pollution, which may be caused by prospecting or mining operations. For this purpose, the Central Government makes rules such that conservation and development of minerals are ensured without unduly affecting the environment (Section 18). The Government has the power of search, entry and inspection of mines and recovery of amounts due as arrears of land revenue (Sections 23B, 24 and 25) (GOI, 1957).

Sustainable development (SD)

Sustainable development (SD), an all-inclusive, somewhat ambiguous concept means economic and social development that endures over the long-term and its core ethic is intergenerational equity. Sustainability principles have application for all stages of mine life cycle – exploration, mine planning, construction, mineral extraction, mine closure and post-closure reclamation and rehabilitation. The Central Government shall take all such steps as may be necessary for the conservation of strategic mineral resources in the national interest and the scientific development and exploitation of all mineral resources. The Central Government to facilitate the scientific development and exploration of mineral resources and to ensure the protection of the environment and prevention and control of pollution from prospecting and mining-related operations, shall cause to be developed a National Sustainable Development.

In Canada, constitutional law requirements require the government and mining firms to hold meaningful consultations with Aboriginal communities that live on property where mineral extraction is envisaged. In South Africa, mineral rights holders must also make plans for a socio-economic development plan in the area of their mining project. The mining law (Nickel & Mandarino, 1987) stipulates that a Social and Labor Plan must be submitted before mining and production rights may be granted. In the Indian mining sector, the most pressing need is to guarantee that existing mining and environmental legislation are administered effectively, efficiently, and purposefully to ensure scientific mining, optimal mineral resource utilization, and environmental integrity The dual central and state control over mineral administration, as well as the multitude of regulatory bodies with insufficient people and budget, appear to be the greatest impediment to the mining industry's long-term development (GoSA, 2012).

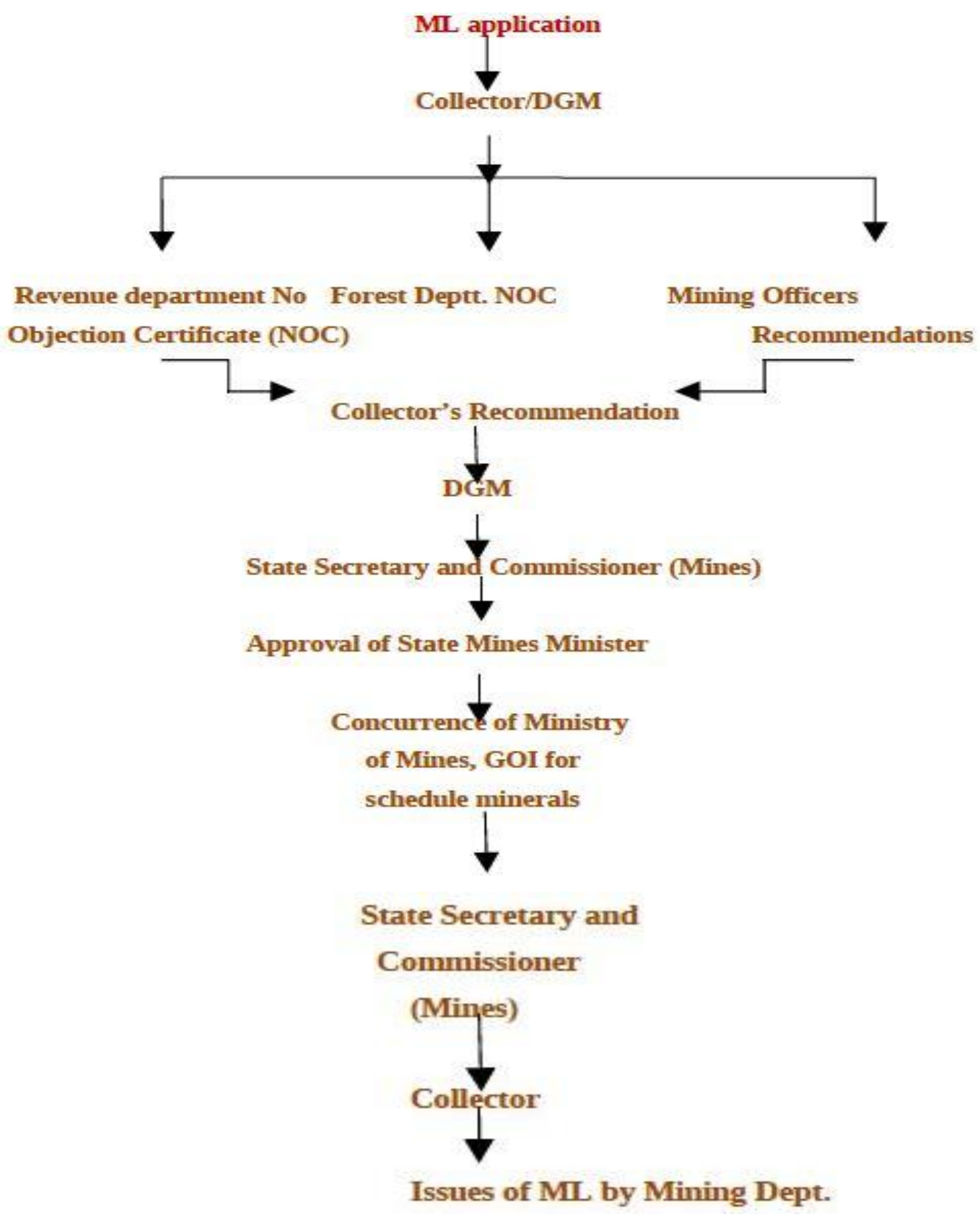


Figure 8.5 Issue of Mining Lease by Mining Department

Issues of resource efficiency and resource security in mining

One of the major concerns in Indian mining is the extraction efficiency of mineral resources. "Exploring in India" for "Making in India": In particular, emphasis needs to be given to co-production of by-product metals from base metal ores through process R&D so that the country's needs of so-called Technology Metals and Energy Critical Metals are effectively met, and provide raw material security on the one hand and competitive edge on the other for the country's manufacturing sector. Creation of a venture-capital funded process R&D setup is clearly required to extract metals of strategic value which occur in small concentrations. Introduction of the "Large Area Prospecting License (LAPL) specifically for minerals other than iron ore, bauxite, limestone etc. (bulk or surficial minerals) and for deep exploration, and providing a separate channel that allows the LAPL concessionaire to claim assured and direct mining rights (including transferability thereof) is necessary in the interest of extraction efficiency and resource security(TERI, 2019).

8.2 Present Scenario and Gap Identification

Data provided by ULBs

Data has been provided by the department of mining in Hanumangarh district. It includes the information regarding brick earth and Gypsum. Type of mining activities and other geographical details of the district.

Table 8.1 Brick Earth Mining

S.No.	Details of Data Requirement	Units	Outcome for District
A	**Inventory**		
1	Brick earth	Brick kiln-386	4149180 mt (yearly)
2	Gypsum	Gypsum-50	352016 MT (Yearly)
3	Type of Mining Activity	[Sand Mining] / [Iron Ore] / [Bauxite] / [Coal] / Other [specify]	Brick Earth/manual/machine/gypsum
		Multiple selection in order of magnitude of operations	Open cast mining
4	No of Mining licenses given in the district	[Nos]	Brick Earth - 386
			Gypsum Permit - 50
5	Area covered under mining	[Sq Km]	Brick Earth - 12.51 Km^2
			Gypsum - 1.04 Km^2
6	Area of District	[Sq Km]	9656 Km^2
7	Sand mining	[yes] / [no]	No
8	Area of sand Mining	[River bed] / [Estuary] / [Non -river deposit]	Nil
B	**Compliance to Environmental Conditions**		
1	No of Mining areas meeting Environmental Clearance Conditions	Nos.	Not applicable
2	No of Mining areas meeting Consent Conditions of spcbs / pccs	Nos.	50
C	**Mining related environmental Complaints**		
1	No of pollution related complaints against Mining Operations in last 1 year	Nos.	No
D	**Action against non-complying mining activity**		

1	No of Mining operations suspended for violations to environmental norms	Nos.	No
2	No of directions issued by spcbs	Nos.	No
3	Provision of pollution abatement (Air/water/noise) budget allocated for environmental Protection		water spray, plantation in mining area by permit holder

Inferences from present scenario

This section presents the inferences compiled from the data provided by the ULBs in Hanumangarh district. There is no mining operations suspension for violations the environmental norms. To prevent pollution by mining industry in the district, there is provision of providing spray, plantation in mining area by permit holders. Also, as per data provided by the mining department (Figure 8.6), all the operations are meeting environmental clearance conditions.

Table 8.2 Brick Earth Production from 2016-2020

Year	**Production (In Tons)**	**Area (Ha)**
2016-2017	3953200	--
2017-2018	3367140	846
2018-2019	3479700	846
2019-2020	3716580	--

Figure 8.6 Department of Mines, Hanumangarh

Mining impacts society in several ways in the Hanumangarh district. The positive contribution may be noticed in the form of increased income source, job creation increasing employment, migration, community formation, population growth and maintenance of social activities. The negative impacts include labor migration, loss of cultural heritage, and risk of health hazards and change of local population of the area by inviting labor from outside leading to income inequality among the employees, which further leads to community conflicts, and environment concerns. In addition to these, the removal of vegetation, topsoil, waste and ore bring inevitable natural consequences such as deforestation, climate change, erosion, and air and water pollution. The most noticeable impacts on the ecosystem are degradation of land, deforestation, displacement of wildlife, effects on aquatic ecosystem, loss of habitat for biodiversity including rare flora and fauna. These impacts included land degradation, damage to water quality, pollution, and harm to livestock and wildlife biodiversity.

The lack of effective or adequate employee training compounds the negative impacts of closure, including inadequate job creation. Unemployment, loss of social services and amenities, pollution, disturbance of the landscape, the loss of land utility and increased risks to health and safety. The society living near mining industry is at higher risk of facing adverse effects of unplanned mine closure in near future illustrated abandoned mine sits after the closure of mining activities continue to pose potential threat to human safety, health and environment.

8.3 Action Plan

Suggested Interventions/ Strategies

To accomplish asset productivity, the Indian mining area is now anticipating receive progressed mine studying and investigation advancements (utilizing geophysics applications utilizing 2D and 3D seismic overviews) alongside the use of programming arrangements by using 3D programming bundles. Various literature indicates that improved mine closure and mine site rehabilitation planning are best mining procedures, identifies mining for closure as a sustainability issue, and is no longer simple an environmental issue.

After the closure mine, mining sites should be reused as recreational land, visitor attractions, creative gardens and lakes with the collaboration of mining companies, investors, and land use planners etc. to enhance the job opportunities for the local people. Mining must be environmentally sustainable by innovative methods that decrease the environmental impact caused by mining activities. These methods include parameters such as decreasing water and energy utilization, minimizing land mismanagement, water and air pollution at mine sites and maintaining prosperous mine closure and reclamation activities.

To eliminate these negative impacts or at least to minimize their effects, it is recommended to establish a geological study and advanced mining exploration at the deposits to be exploited future as well as evaluate their mining potential before the start of exploitation. This will facilitate the choice of the exploitation method, better start mining operations, and ensure good ore recovery rate. Follow an exploitation technic well adapted to the morphology of the ore deposit. The chosen method must consider the different geometric and geotechnical parameters of the mineralization. Since the majority of deposits are favonian with high dip and competent surrounding rock, it is recommended to use the method of cut-and-fill mining and sublevel stopping. It will allow a good ore recovery rate and avoid having long and deep trenches that alter the appearance of the area. Cut-and-fill mining is suitable for a steeply dipping mineral deposit contained in a rock mass with good to moderate stability. It removes the ore in horizontal slices starting from a bottom cut and advances upwards, allowing the stop boundaries to be adjusted to follow irregular mineralization. Sublevel stopping (SLOS) is used for mining mineral deposits with; steep dip where the footwall inclination exceeds the angle of repose; stable rock in both hanging wall and footwall; competent ore and host rock; and regular ore boundaries. SLOS recovers the ore in large open stopes, which are normally backfilled to enable the recovery of pillars. The orebody is divided into separates topes, between which ore sections are set aside for pillars to support the roof and the hanging wall. Pillars are normally shaped as vertical beams, across the ore body. Horizontal sections of ore are also left as crown pillars. These conditions correspond perfectly to that of the studied mines. Rehabilitate mining sites at the end of their life. The authorities should require operators to rehabilitate abandoned sites for example by making a fence around the mine. It is also possible to transform the old mines into geoparks by their rehabilitation, thereafter; they can be open to tourists.

Table 8.3 Responsibility of the district with plan of Action

Responsibly of the district Committee/ Action Areas	Plan of Action	Responsibility
Preventing illegal mining	Identification of stretches where there are chances for illegal mining. Frequent checks in those stretches by the Taluk Level Task Force and submit reports to District Level Task Force fortnightly. To infuse greater transparency and enhance efficiency in grant of mining activity.	Department of mining
Mining related environmental complains.	District Level Task Force shall meet once in a month to discuss the illegal mining /transporting /damage caused to the environment and send report to State Level Proper policies, and regulations that govern Environment during mining and after mine closure.	Department of mining; RSPCB
No of Mining operations suspended for violations to environmental norms	District Level Task Force shall meet once in a month to discuss the illegal mining /transporting /damage caused to the environment and send report to State Level. No of Mining areas meeting Environmental Clearance Conditions	Department of mining; RSPCB
Closure of mines	Mining sites should be reused as recreational land, visitor attractions, creative gardens and lakes with the collaboration of mining companies, investors, and land use planners etc. to enhance the job opportunities for the local people.	Department of mining; RSPCB

To avoid these negative effects of barite exploitation on the environment, it is recommended to establish a geological study and advanced mining exploration at the deposits to evaluate their mining potential before the start of exploitation; follow an exploitation technic well adapted to the morphology of the ore deposit like cut-and-fill mining and sublevel stopping methods. Role of Government in Forest Conservation: Although the government of every country is very particular about the conservation of its forest resources and has several rules and laws for the protection of forests but, they are not implemented effectively. Both national and provincial governments can take some steps in this direction, such as passing acts for the conservation of forests, Survey of the forest resources, Categorization of forest areas and proper delimitation of reserved forest areas, Find out the areas where reforestation can be done, Regulate the commercial use of forest products, Protect forest from pre, mining and other natural calamities, Develop national parks, Encourage forests developmental activities like social forestry, etc., and Prepare master plans.

8.4 Summary

The district has mining activities related to Gypsum and brick earth. The mined quantities of brick earth for the year 2019-2020 is 3716580 tons. The summary of mining activities and action plans for the future has been provided in Table 8.5.

Table 8.4 Summary Table for Mining Activity Management for Hanumangarh district

Name of district	Present Status	Action Plan for future
Hanumangarh	No of Brick kilns-386; Brick earth - 4149180 mt (yearly); Gypsum – 352016 MT (Yearly) Type of Mining Activity- Brick Earth/manual/machine/gypsum; No of Mining licenses given in the district: Brick Earth - 386, Gypsum Permit - 50 Area covered under mining: Brick Earth - 12.51 Km², Gypsum - 1.04 Km² Area of District: 9656 Km² Sand mining: No Area of sand Mining: Nil	● Proper policies, and regulations that govern Environment during mining and after mine closure. ● Identification of stretches where there are chances for illegal mining, frequent checks in those stretches by the Taluk Level Task Force and submit reports to District Level Task Force fortnightly. ● District Level Task Force shall meet once in a month to discuss the illegal mining /transporting /damage caused to the environment during mining and after mine closure. Also send report to State Level regarding number of Mining areas meeting Environmental Clearance Conditions. ● Mining sites should be reused as recreational land, visitor attractions, creative gardens and lakes with the collaboration of mining companies, investors, and land use planners etc. to enhance the job opportunities for the local people.

9. Rural Environment Management Plan

This chapter aims to discuss the best practices for solving environmental problems in rural areas. It also discusses the soil and land management practices and their effects.

Waste generation and other problems in urban and rural areas are different. In rural areas, services do not exist at all in many cases and economic and social barriers prevent many people from accessing basic services. However, realizing the value of small or intermittent waste streams also has great potential benefits for rural communities. For example, decentralized resource recovery systems can be developed, especially sewage, food, livestock and agricultural waste (Baguma et al., 2010). Villagers have been recovering resources from the waste stream for a long time, but it cannot be done systematically. Soon, population growth and improved living standards will hinder people's food, water and energy supply. Innovation is needed to increase supply, improve distribution, reduce waste, increase efficiency, and reduce demand in rural areas. Because the relationship between food, water and energy is so closely intertwined, possible solutions or needs in one area are often reflected in another area. Rural communities actively participated in cooperation with village committees and regional administrative departments, and many successful cases were produced.

9.1 Literature Review

9.1.1 Soils of India

India is a country of varied conditions of geology, relief, climate and vegetation. Therefore, India has a large variation in soil groups, particularly different from one another. Indian soils classification is based on various criteria: -geology, relief, fertility, chemical composition and physical structure, etc. The formation of the soil in a particular climate is so perfect that each climate type has its soil type.

The Indian Council of Agricultural Research (ICAR) is responsible for setting up an All-India Soil Survey Committee in 1963 which divided the Indian soils into eight major groups: **i)** Alluvial soils **ii)** Black soils **iii)** Red soils **iv)** Laterite and Lateritic soils **v)** Forest and Mountain soils **vi)** Arid and Desert soils **vii)** Saline and Alkaline soils and **viii)** Peaty and Marshy soils.

These Indian soils classification has gained wide acceptance over the years.

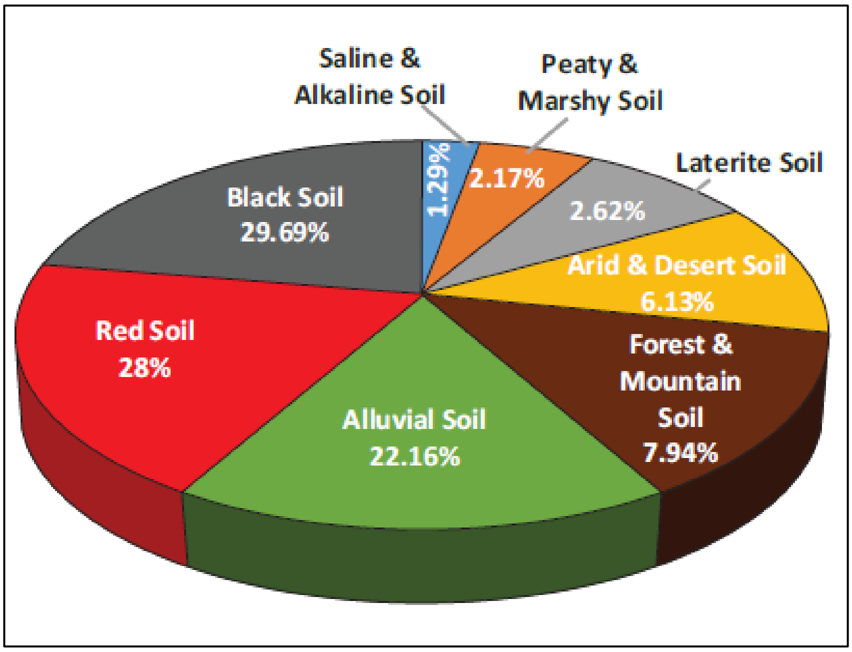


Figure 9.1: Major Soil types and their percentage in India

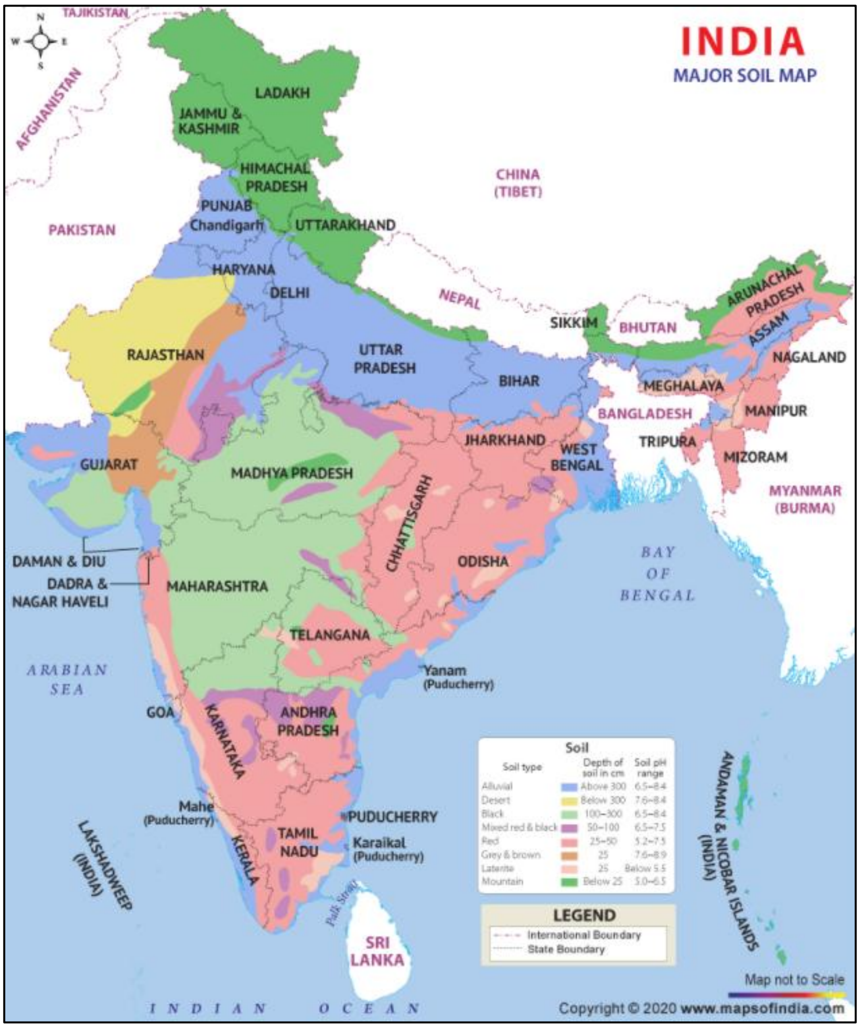


Figure 9.2 Soil Map of India (Maps of India, 2021)*)*

9.1.2 Agriculture in India

India's economic security has been majorly dependent upon the agriculture sector, and the situation is unlikely to alter in the estimative future. At the time of independence, about 75% of the population was dependent on agriculture and even to date, agriculture is the support system for 58% of the population. During this period, the contribution of agriculture and the allied sector to the Gross Domestic Product (GDP) has fallen from 61 to 19%. To date, India provides a support system to 16.8% of world's population based on 2.3% of global land and 4.2% of the world's water resources. And per caput the availability of resources is about 4 to 6 times less as compared to the overall world's average. This is likely to further decrease due to increasing demographic pressure and consequent diversion of the land for non-agricultural uses.

As compared to 11% of the world average, around 51% of India's geographical area is already under cultivation. The current value of cropping intensity of 136% has recorded an upsurge of only 25% since independence. Also, out of the total net sown area, 65% is constituted by rain fed dry lands. Along with the fall in the rate of growth of total factor productivity, there is also an exceptional dilapidation of land (107 million ha) and groundwater resources. This slowing down needs to be attended and agricultural efficiency has to be doubled to meet growing demands of the population by 2050. Efficiency-mediated upgrading in productivity is the most feasible option to raise production.

India recorded remarkable achievements in agriculture during three decades, ever since the onset of green revolution in the late sixties, thus enabling the country to overcome extensive hunger and starvation; achieving self-sufficiency in food; reducing poverty and bringing economic alteration in millions of rural families. However, this situation started turning contrary for the sector around mid-nineties, with slowdown in growth rate of output, which then resulted in inactivity or even decline in farmers' income leading to agrarian anguish, which is dispersing and turning increasingly serious.

The provider for sustainable production, natural resource base of agriculture, is shrinking and degrading, and is adversely affecting production capacity of the ecosystem, however, the demand for agriculture is rising rapidly with increase in population and per caput income and also for the growing demand from industrial sector. Thus, there is an urgent need to identify severity of problems faced by the agriculture sector, to re-establish its vigour and put it back on higher growth trajectory. The problems, are however surmounted, particularly when upgraded and fresh tools of science and technology have started proposing great opportunities for application in agriculture.

The projected production requirements of various agricultural commodities in India by 2020-21:

Table 9.1 Projections of various food products demand in India for 2020-2021(million tonnes) (Ch. Srinivasa Rao & Sumanta, 2014)

Commodity	**Base year (2004-2005)**	**Projection (2020-21)**
Cereals	192.8	262.0
Pulses	14.2	19.1
Food Grains	207.0	281.1
Milk and Milk Products	91.0	141.5
Egg(number billion)	44.1	81.4
Meat	6.0	10.9
Fish	5.9	11.2
Edible Oilseeds	35.5	53.7
Vegetables	90.6	127.2
Fresh Fruits	52.9	86.2
Sugar (in terms of Cane)	262.3	345.3

In comparison to many parts of the world, yield gaps in India have been much higher. Due to changes in management, soil type, climatic parameters, varietal performances and many more, yield performances of crops at diverse places may vary extensively. A yield gap equal to present national average yield, is being faced by major cereal and pulse crops of India, as observed in multi-location demonstrations and simulation models.

Agricultural zones in India

As a part decision of the Seventh Plan, the Planning Commission, has divided the country into fifteen wide-ranging agro-climatic zones based on physiography, soils, geological formation, Climate, cropping patterns, and improvement of irrigation and mineral resources for broad agricultural planning and developing future strategies. These zones are further divided into more homogeneous 72 sub-zones. In these, fourteen regions are in the main land and the remaining ones in the islands of Bay of Bengal and the Arabian Sea.

The integration of plans of the agro-climatic regions with the state and national plans for enabling and enhancing policy development based on techno-agro-climatic criterion and considerations, was the main objective of the planning commission. Further sub-regionalization based on agro-ecological parameters, is possible in the agro-climatic regional planning (PCI, 1989).

Table 9.2 Yield Gaps in dryland agriculture in India (Ch. Srinivasa Rao & Sumanta, 2014)

Crop	Average Yield (t/ha)		Yield Gap (t/ha)
	National Demonstration	National Average	
Cereals			
Kharif	1.40	0.78	0.62
Rabi	1.73	0.92	0.81
Millets	0.92	0.61	0.31
Pulses	0.75	0.35	0.40
Oil Seeds			
Edible Oilseeds	0.60	0.34	0.26
Castor Bean	0.52	0.23	0.29

ICAR launched National Agricultural Research Project (NARP) for the objective of initiating agricultural research in the agro-climatic zones of the country. The main persistence of NARP was the setting up or up gradation of a zonal research station in every agro-climatic zone, for producing location specific, need based research data, particularly targeting the specific agro-ecological situations. The main focus was on scrutinizing agro-ecological conditions and cropping patterns and emerge with a programme directly targeted to solve the major hold-ups of agricultural growth in a particular zone, based on natural resources, major crops, farming systems, production restrictions and socio-economic conditions dominant in the zone. More stress was implied upon the generation of technology. As per NARP, the division of the country was into 127 agro-climatic zones.

Table 9.3 Agro-climatic Regions/zones in India (Commission, 1989)

S.No.	Agro-climatic region / Zone	States Represented
1	Western Himalayan Region	Himachal Pradesh. Jammu and Kashmir, Uttarakhand
2	Eastern Himalayan Region	Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura, West Bengal
3	Lower Gangetic Plain Region	West Bengal
4	Middle Gangetic Plain Region	Uttar Pradesh, Bihar
5	Upper Gangetic Plain Region	Uttar Pradesh
6	Trans Gangetic Plain Region	Chandigarh, Delhi, Haryana, Punjab, Rajasthan
7	Eastern Plateau and Hills Region	Chhattisgarh, Jharkhand, Madhya Pradesh, Maharashtra, Odisha, West Bengal
8	Central Plateau and Hills Region	Madhya Pradesh, Rajasthan, Uttar Pradesh
9	Western Plateau and Hills Region	Madhya Pradesh, Maharashtra
10	Southern Plateau and Hills Region	Andhra Pradesh, Karnataka, Tamil Nadu
11	East Coast Plain and Hills Region	Andhra Pradesh, Odisha, Puducherry, Tamil Nadu
12	West Coast Plain and Ghat Region	Goa, Karnataka, Kerala, Maharashtra, Tamil Nadu
13	Gujarat Plain and Hills region	Gujarat, Dadra & Nagar Haveli, Daman & Diu
14	Western Dry Region	Rajasthan
15	Island Region	Andaman & Nicobar Islands, Lakshadweep

Agro-ecological regions by the National Bureau of Soil Survey & Land Use Planning (NBSS & LUP):

Another classification for the agro-ecological zones was suggested by the National Bureau of Soil Survey & Land Use Planning (NBSS&LUP) which came up with twenty zones based an integrated criteria of soil groups and effective rainfall. Adjustment to district boundaries was done with respect to these delineated boundaries, with a minimal number of regions. Further sub- division of these twenty agro-ecological zones, resulted in the formulation of 60 sub-zones.

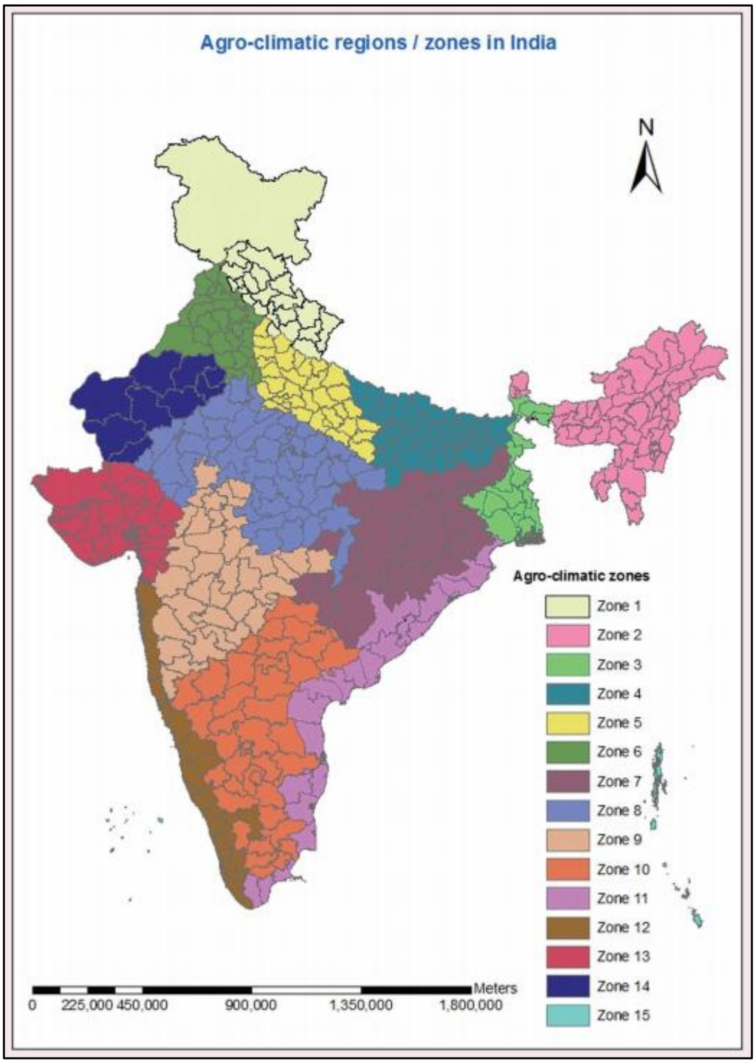


Figure 9.3 Agro-climatic Regions/zones in India as per the planning commission (Commission, 1989)

9.1.3 Present Scenario in Rajasthan

Soils and Agro-climatic zones of Rajasthan

Our state of Rajasthan has been divided into 10 agro-climatic zones by the Indian Council of Agricultural Research. These zones are classified on the basis of agro-climatic parameters like rainfall, temperature regime, topography, soil characteristics, cropping pattern and irrigation availability.

Agriculture in Rajasthan

Being the largest state of India, Rajasthan is gifted with assorted soil and weather conditions which comprise of several agro-climatic situations thereby helping the state to adopt differentiated and diverse cropping and agricultural implementation pattern. Apart from being India's largest production house of mustard, pearl millet (bajra), Rajasthan is also the largest producer of three spices (coriander, cumin, and fenugreek), cluster beans, and isabgol. The state is also the second-largest producer of maize in the country. The state of Rajasthan encompasses a substantial area for vegetable crops. The state also comprises of the second largest herd of livestock amongst all the other Indian state, thereby contributing to about 10 per cent of the country's milk and 30 per cent of the country's mutton produce. This diversification helps the state in the management of wide range of risks linked with dryland agriculture. The state, however, faces many hindrances that are to be systematically addressed for the facilitation of sustainable development of the sector (Hussain, 2015).

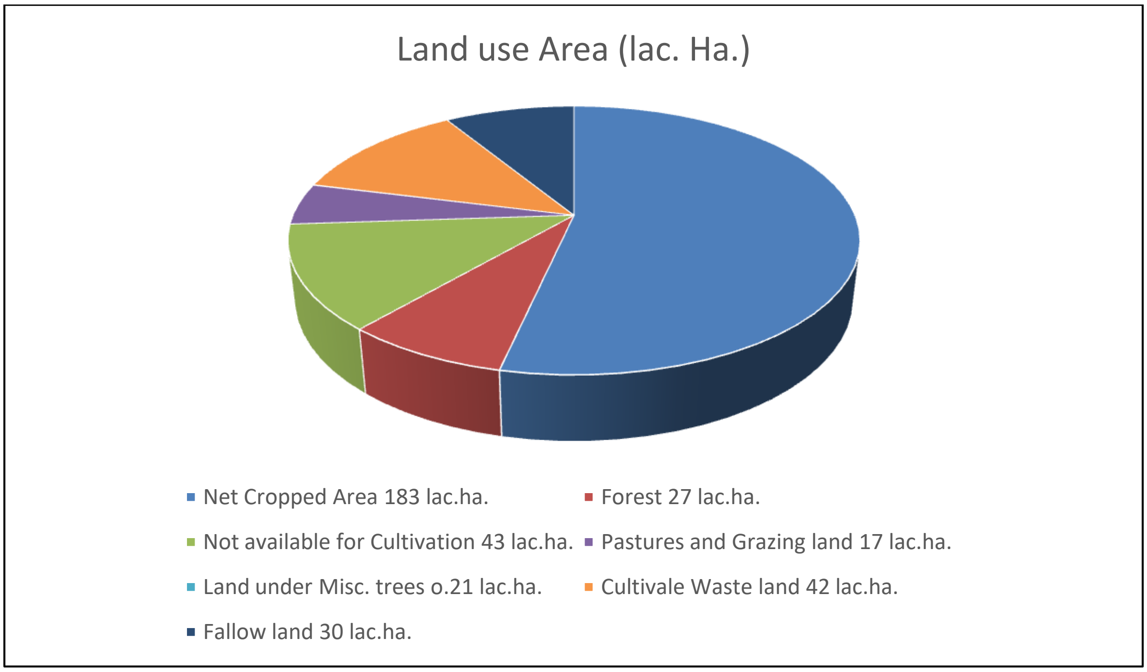


Figure 9.4 Land use pattern in Rajasthan (as per 2016 Statistics) (DoA, 2021)

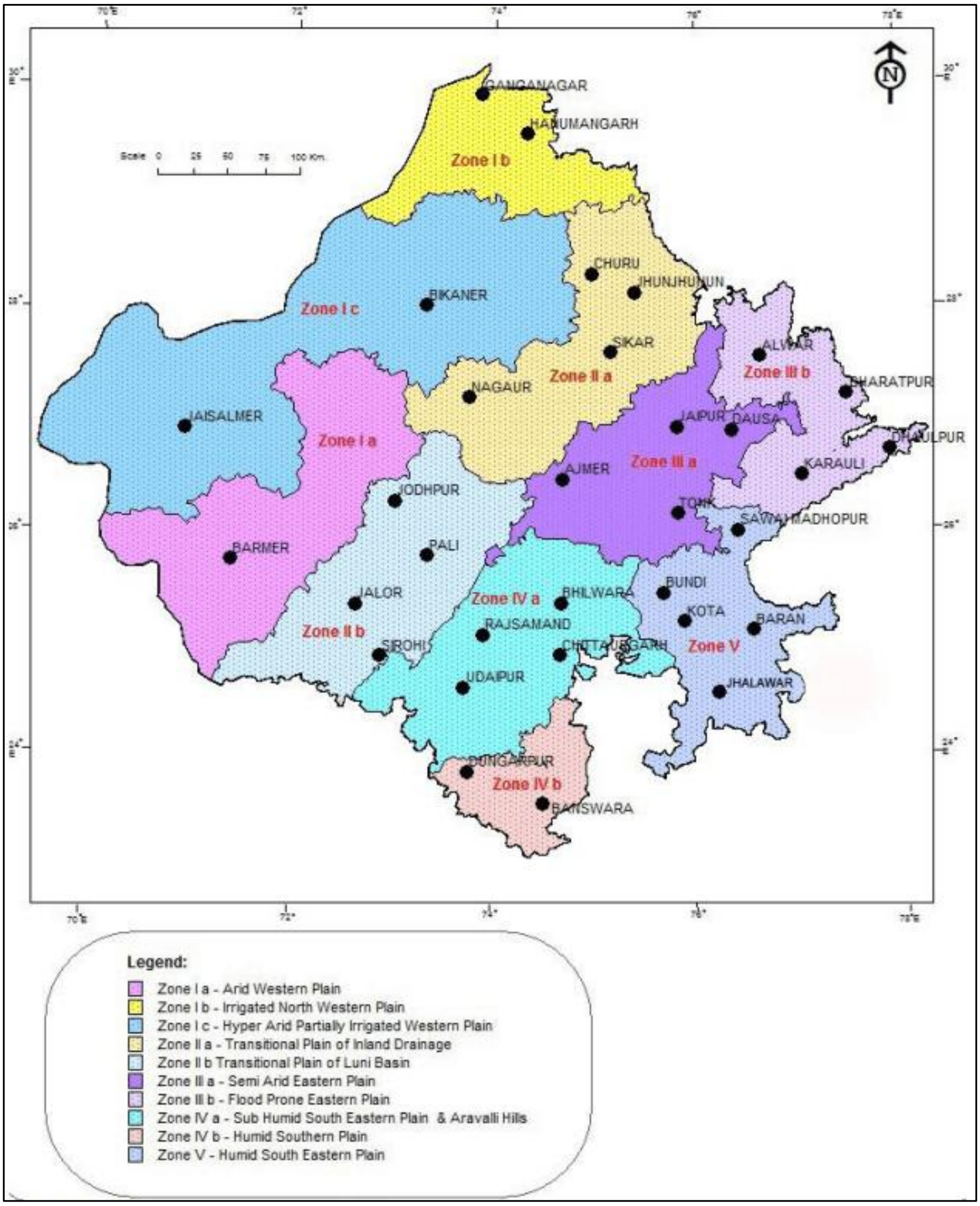


Figure 9.5 Agro-climatic Regions/zones of Rajasthan (DoST, 2010)

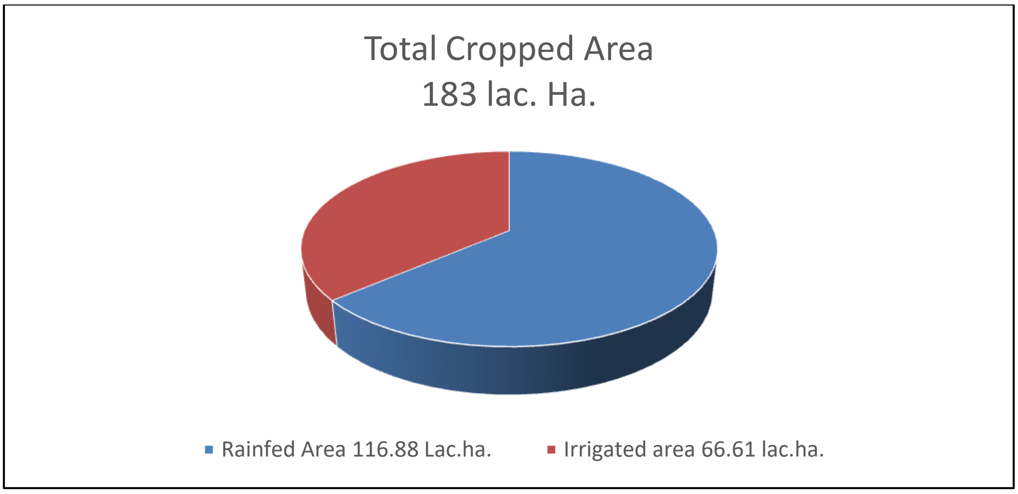


Figure 9.6 Cropped area in Rajasthan (as per 2016 Statistics) (DoP, 2017)

As underlined in the Draft State Agriculture Policy, major challenges for agriculture sector in Rajasthan are as follows: i) Death of animals, decline in productivity and reduced performance, due to frequent droughts. ii) Climate change and global warming; iii) Strengthening of comprehensive technology based developmental approach to promote dry land/ arid agriculture; iv) Deteriorating soil health including imbalanced use of fertilizers, micronutrient deficiency, lack of organic matter content, inadequate soil microbial flora and fauna etc.; v) Disparaging prices, little productivity and virtually very little value addition, distress sales, and rising cost of cultivation; vi) Lack of efforts for stabilization of sand dunes and for greening the desert through agro-forestry programs; vii) Missing mechanisms of export promotion, adherence to sanitation and phyto-sanitation (SPS) standards and measures for minimizing the export rejections; viii) Lack of integrated farming approach; xi) Lack of up-scaling of farm-validated modern technologies and agricultural Innovations; x) Gender mainstreaming in agriculture; and xi) Proper O&M (institutional mechanisms and organizational and management) alterations for incapacitating the felt restrictions coming in the way of farmland prosperity in the state (GoR, 2013).

Hanumangarh District falls under category IB which is Irrigated North Western Plain. Main characteristics of this zone are: i) Rainfall: The zone has average rainfall of 100-350mm. ii) Area: The irrigated north western plain extends in the northern part of the state in Hanumangarh, Ganganagar and north western part of Bikaner district. iii) As the zone is irrigated by the Indira Gandhi Canal, it is intensively cultivated. iv)Soil: This plain is primarily covered by medium and high textured to very deep texture soils. Alluvial deposits which are Calcareous, High soluble salts and exchangeable sodium is present in the soil.

9.1.4 Governance and Management Structure

Institutions concerning Soil management

Department of Agriculture, Co-operation and Farmers' Welfare, Government of India**,** Department of Agriculture, Government of Rajasthan**,** Department of Science and Technology(DST), Government of India**,** Ministry of Environment, Forest and Climate change, Government of India**,** Indian Council of Agricultural Research(ICAR), Ministry of Agriculture and Farmer’s welfare**,** Department of Agricultural Research and Education**,** Indian Agricultural Statistics Research Institute**,** NITI Aayog, Government of India**,** National Bureau of Soil Survey and Land Use Planning, Indian Council of Agricultural Research **,** Krishi Vigyan Kendra

Roles and Responsibilities of various departments

Department of Agriculture, Co-operation and Farmer’s Welfare, Government of India

The Department aims towards enhancing productivity and production of agricultural commodities to ensure food security of the Nation and also to make agriculture a sustainable and viable occupation. The mission of the department is to achieve targeted growth rate for agriculture sector with the help of State Governments and other Departments of the Government of India by the enhancement of agricultural production and making sure the farmer’s welfare by effective implementation of Ministry's schemes(DoA, 2016). As per the department’s objectives, the department aims at the functions as provided in Table 9.4.

Table 9.4 Roles and Responsibilities of the Department of Agriculture, Govt. of Rajasthan (DoA, 2016)

Self-sufficiency achievement in food production.
Increase in Agricultural production and hence the income of farmers and farm laborers.
Promotion of viable use of Natural Resources such as Land and Water.
Incorporation and promotion of Soil Health Management and Integrated Nutrient Management applications.
Crop Diversification.
Soil and water testing, hence recommending suitable agricultural inputs.
Assurance in quality of agricultural inputs and availability.
Promotion and application of Organic Farming.
Use of Integrated Pest – Disease Management system.
Transfer and promotion of education for modern agriculture technique developed by technical institutes and scientists.
Promoting timely agricultural operations by use of agricultural mechanization.
Promotion of mixed-intensive farming for increase in employment opportunities and income per unit area.
Development of scientific farming techniques for making agriculture more rewarding for farmers.
Increase in the production of certain agricultural commodities, ensuring availability of raw material for industries, in order to increase exports.

Reduction in cultivation cost and striving for holistic development of farmer.
Providing crop insurances to protect farmer against monsoon failure and other natural disasters.
Initiation of various programs for helping to increase per capita income of farmers in back ward areas as well as for scheduled castes and tribes.
Promotion of women empowerment in agriculture.
Organizing training programs on various traits of agro techniques for their mass broadcasting.
Providing quick and effective solutions of problems faced by farmers in day-to-day practices.

Department of Science of Technology, Government of India

With reference to Soil and Agriculture, the Department of Science and Technology aims at the following: (i) Policy formulation for matters relating to Science and Technology. (ii) Resolving problems and matters involving the Scientific Advisory Committee of the Cabinet (SACC). (iii) To promote new areas of Science and Technology with distinct prominence on incipient areas. (iv) Various processes involving research and development through its research institutions or laboratories for development of indigenous technologies concerning bio-fuel production, its processing, standardization and applications, in harmonization with the concerned Ministry or Department; (v) Promoting utilization of by-products to development value-added chemicals by perusing research and development activities in this field.

Ministry of Environment, Forest and Climate Change Government of India

The broad objectives of the Ministry are: i) Proper survey and its implementation for the conservation of flora, fauna, forests and wildlife. ii) Prevention and control of pollution. iii) Afforestation and regeneration of degraded areas. iv)Protection of the environment. v)Ensuring the welfare of animals.

Indian Council of Agricultural Research (ICAR), Ministry of Agriculture and Farmer's welfare

Responsible for co-ordinating, guiding and managing research and education in agriculture, ICAR is the top body for co-ordinating, guiding and managing research and education in agriculture and its practices. This is one of the largest national agricultural systems in the world, with 101 ICAR institutes and 71 agricultural universities spread across the country. With the help of its research and technology development, the council plays a trailblazing role in marshalling Green Revolution and its successive expansions in agriculture in India, Thus, the country has been enabled to increase the production of various commodities such as i) Fish by 16.8 times. ii)Horticultural crops by 10.5 times. iii) Food grains by 5.6 times. iv) Milk by 10.4 times. v) Eggs by 52.9 times. (Since 1950-51 to 2017-18)

Thus, ICAR has been impacting the national food and nutritional security to a great extent. The council has played a key role in endorsing excellence in higher education in agriculture. With internationally acknowledged scientists as part of it, ICAR is involved in radical areas of science and technology development in various fields. (ICAR, Ministry of Agriculture and Farmer's Welfare, Govt. of India)

Department of Agricultural Research and Education

The major responsibilities of the Department of Agricultural research and Education are as follows: i) Up keeping all aspects of the agricultural research and Education such as, horticulture, natural resources management, agriculture engineering, agricultural extension, animal science, economic statistics and marketing and fisheries, and all agricultural practices that involves coordination between the central and state agencies. ii) Attending to all the matters concerning expansion of new technology in agriculture, horticulture, natural resources management, agriculture engineering, agricultural extension, animal science, economic statistics and marketing and fisheries, as well as such functions as plant and animal introduction and exploration and soil and land use survey and planning. iii) Co-operation of various institutions in the field of agricultural research and education including relationship with foreign and international agricultural research and educational institutions and organizations, including participation in international conferences, connotations and other bodies dealing with agricultural research and education and follow-up decisions at such international conferences etc. iv) Applied, fundamental and operational research and higher education together with co-ordination of such research and higher education in agriculture such as agro forestry, animal husbandry, dairying, fisheries, agricultural statistics, economics and marketing (DoA, 2021).

Indian Agricultural Statistics Research Institute

The major responsibilities of the Indian Agricultural Statistics Research Institute are as follows: i) Undertaking research, education and training in agricultural statistics. ii) Use of computer applications and bioinformatics for agriculture research. iii) To arrange for advisory/consultancy services/ methodological support and computational solutions to NARES/NASS (National Agricultural Research and Education System/ National Agricultural Statistics System) (IASRI, 2015)

Niti Aayog, Government of India

The NITI Aayog (abbreviation for National Institution for Transforming India) is a public policy think tank of the Government of India, established to achieve sustainable development goals. The Aayog works with cooperative federalism by adopting the involvement of State Governments of India in the economic policy-making process using a bottom-up approach. Apart from various other enterprises, formulation of agriculture reforms such as Model Land Leasing Law, Reforms of the Agricultural Produce Marketing Committee Act, Agricultural Marketing and Farmer Friendly Reforms Index for ranking states, etc., comes under the functions of Niti Aayog.

***National Bureau of Soil Survey and Land Use planning, ICAR* (ICAR, 2020a)**

The main responsibility of the National Bureau of Soil Survey and Land Use planning is to conduct and promote research in the National Agriculture Research System in the areas of Soil Survey, Pedology, Geomorphology, Remote Sensing, Geographic Information System, Cartography, Land Evaluation, Land Use Planning.

Krishi Vigyan Kendra(s)

Usually associated with a local agricultural university, Krishi Vigyan Kendra(s) or "farm science Centres" serve as the definitive link between the Indian Council of Agricultural Research and farmers. These centres aim to apply agricultural research in a practical and more localized setting.

9.1.5 Rules and Regulations

The Rajasthan Soil and Water Conservation Act, 1964

The Rajasthan Soil and Water Conservation Act, came into being to provide for the preservation and enhancement of soil and water resources in the State of Rajasthan. Major regulations formulated by the act for conservation of soil are as follows: (i) Notification of areas: The State Government may, by notification in the Official Gazette, declare an area to be a notified area for this Act, in case it appears to the State Government that the area is desirable to provide for soil and water conservation ; (ii) Power to regulate, restrict or prohibit certain matters within notified areas: The State Government may, by order published in the Official Gazette, regulate, restrict or prohibit certain activities in respect of any notified area**.**

The issues to be addressed in soil and water conservation schemes are: (i) Maintaining and constructing 'mends', 'dauls', and 'bundhis' and planting of munja, sarkanda or other soil binding grasses or plant; (ii) Land levelling, land grading and irrigation layouts. (iii) Adaptation of contour cultivation. (iv) Growth of row crops to be prohibited. (v) Cultivating quick-maturing leguminous crops and close cultivating crops during rainy season; (vi) Adaptation of green manuring and application of bulky organic manures, e.g. Compost, farm-yard manures, etc (GoR, 1964).

The Rajasthan Land Revenue Act, 1956

Under the act, use of Agricultural Land for Non-agricultural Purpose may be regulated as follows: (i) No person holding any land for agriculture, and no transferee of such land or any part thereof, shall use the same or any part thereof, by the construction of buildings thereon or otherwise for any other purpose except with the written permission of the State Government obtained din the manner hereinafter laid down and otherwise that in accordance with the terms and conditions of such permission. (ii) Any such persons desiring to use such land or any part thereof for any purpose other than that of agriculture shall apply for the requisite permission in the prescribed manner and to the prescribed officer or authority and every such application shall contain the prescribed particulars. (iii) The State Government shall, after making or causing to be made due inquiry in the prescribed manner, either refuse the permission applied for or grant the same subject to the prescribed terms and conditions (GoR, 1956).

Under the act, allotment of land for agricultural purposes may be done as follows: (i) As otherwise provided elsewhere by this Act, lands for agricultural purposes shall be allotted by such authority and in such manner as may be prescribed by rules made by the State Government in this behalf. (ii) All allotment of land under this section shall be subject to the payment of rent fixed at such rates as may be fixed according to custom or by usage or any law on the subject. (iii) If there be more than one person requiring the same land, the allotment shall be made in the following order – (a) To co-sharer of the holding if it forms part of a compact block or is irrigated from the same source, preference amongst such co-sharers being given to one having land less than the area prescribed by rules made under the Rajasthan Tenancy Act, 1955 (Rajasthan Act 3 of 1955); (b) To persons residing in the village in which land be situated, preference amongst such persons being given to persons having no land or less than the area prescribed by the said rules; (c) By drawing lots: Provided that the area so taken together with the area held by him does not exceed the area prescribed by the said rules (GoR, 1955).

Notwithstanding anything here in force contained the State Government shall have power to allot land for the purpose of an industry or for any purpose of public utility on such conditions as it deems fit.

9.1.6 Literature Case Studies

The Use of Subsidies for Soil and Water Conservation- A case Study from Western India

This paper discusses the use of subsidies for soil and water conservation (SWC) in the KRIBHCO (Krishak Bharti Co-operative Ltd.), Indo-British Rain fed Farming Project being implemented in degraded areas of western India. The basis for, and impact of, embracing subsidies are summarised. Even though both project staff and farmers agree on the significance of SWC measures, only a few farmers can meet the expense of the investment of time and money.

This is mainly because production in the specified area is so little that most farmers are forced to look for off-farm work during the dry season. As this is the time when most SWC work is commenced, there is a need to balance the opportunity cost to farmers of prior employment prospects for appliance of SWC activities. Profits ascending from the practice of subsidies comprise priming of savings and credit groups and a temporary decline in annual migration levels. Major disadvantages of this approach are potential lack of equity and low level of sustainability.

The paper concludes by conversing other aid provisions including loans, differential subsidies and other such incentives. It proposes that for private farmland, farm families are subsidised with fixed land enhancement grants (rather than paying those who take part in the SWC work). Farmers and their community members should discuss how the money would best be utilised. A fixed subsidy per unit area is suggested for communal land enrichment and while watershed management is led on a village basis. A village work plan, based on the reserves available, would be articulated by the group of villagers in consultation with project team (Smith et al., 1999).

9.1.7 Environmental Management in rural areas

Solid and Liquid Waste Management under Swachh Bharat Mission (Gramin) (MoDWS, 2017)

Solid and Liquid Waste Management (SLWM) is one of the key components of Swachh Bharat Mission (SBM), released to bring development in cleanliness, hygiene and the overall quality of lifestyles in rural areas. SLWM is the collection, transportation, processing, recycling, treatment, and disposal of waste material in a scientific manner. SBM focuses on creating and supplying community-controlled sanitation structures. To put in force SLWM tasks economically and efficiently, ownership at grassroot level and community involvement at all levels are critical. Information, Education, and Communication (IEC) interventions ought to attention to SLWM to create a call for a sustainable system. This should result in setting up structures for waste disposal in one of these manners that it has tangible effect on the population. The community/Gram Panchayat (GP) must be recommended to return ahead and call for one of these systems, which they could in the end operate and maintain. Awareness and training campaigns must aim at panchayat officials, elected representatives, schools, non - governmental organizations (NGOs) operating in villages, shop keepers, families, and general public. The GP functionaries could be accountable for design, implementation, operation and maintenance (O&M) of SLWM structures with support from respective state governments. Mechanisms concerning 0.33 events in creation and control sports under GP and network supervision may be explored. In such cases, absolute readability in the roles and duties of diverse stakeholders in managing SLWM structures is a must. Community contribution and suitable person fees for sustainable SLWM tasks also are desirable.

Solid Waste Management in Rural Area

In rural regions typically the waste material is Kitchen Waste, Agriculture Waste, Horticulture Waste and domestic animal dung. All those substances are getting used for making manure by the farmers. Present statistics to be had on stable waste generated in the vicinity are to be accumulated. If possible, the existing portions of wastes – dangerous family wastes, digital wastes, biomedical and non-dangerous generated withinside the examine are to be accumulated and presented. In Rural regions of Hanumangarh, there is no collection this trouble is causing danger in present and future. Collection and disposal of wastes are expensive on a small scale so that wastes are both now no longer collected, or the disposal sites are improperly managed, with resulting health and pollutants problems. So, we need to mix device for collecting solid waste and process it for two to five regions (NIRDPR, 2016).

Sanitation Programme

The term " total sanitation programme" includes seven important elements, as provide 100% sewage and drainage systems in all cities, and safely treat/recycle sewage that is ultimately used for irrigation, and completely prohibit discharge into sewers/rivers. In fact, an efficient sewer system constitutes the backbone of the urban sewer system. 100% disposal of urban and rural solid waste and final waste recycling. The coverage rate of sanitary toilets in rural households and suburbs is 100%. All open spaces in urban and rural communities are paved or asphalted. All streets are paved with concrete blocks or cobblestones. Urban and rural areas do not tolerate landfills or solid waste landfills, mainly paper and plastic. Absolutely resist the stagnation of sewage or other sewage in urban or rural areas. Daily cleaning of streets, streets or public places in rural and urban areas.

Steps to Make a Village Open Defecation Free strongly

Following are the steps in making a village open-defecation free, the following points should be considered: (i) Efficient fund flow system- Direct Beneficiary Transfer (DBT) and capacity building. (ii) Community-Led Total Sanitation (CLTS) approach. (iii) Weekly review meeting of different stakeholders by the District Magistrate. (iv) High impact campaigns and Information Education Communication (IEC) activities. (v) Involvement of locals and preparing a list of dos and don'ts. (vi) Identifying vulnerable people. (vii) Raise ODF sustainability as a topic in meetings. (viii) Put together a taskforce to promote ODF sustainability (MoDWS, 2017).

Water Management

Canals, tanks, etc. must be desilted regularly during the summer months. People should be encouraged to revive the ancient practice of protecting trees around tanks. Afforestation of barren, hilly slopes on a war footing should be carried out. Trees withstand drought better than crops. They check dust, replenish streams, provide shade to cattle and man and give fodder for cattle. They provide innumerable uses for man. Denuding the land of trees without compensatory afforestation is a suicidal and short-sighted approach to solving immediate needs. Creation of small reservoirs and percolation tanks to hold run-off water must be implemented and maintained well.

Rain Water Management in Rural Areas

Rain in these regions can be irregular from season to season and from year to year. Since most rural areas have little water storage capacity, dry periods can result in serious water shortages which hamper development, and can create serious public health problems. Destruction of forest cover has caused many formerly perennial streams to stop flowing in the dry season. Given the declining water level, various structures such as recharge pits, recharge trenches, recharge shaft, Trench with recharge well, shaft with recharge well, recharge through abandoned hand pumps, abandoned tube well, recharge well, percolation tank, and roof top rain water harvesting systems should be promoted.

Roof water harvesting rural schools, Rainwater Harvesting (RWH) from roofs is a easy low cost method that has been practiced for loads of years in the wilderness regions of India. A supply of potable water, specifically during the dry season (4- five months) Year-round water provision to enhance hygiene, e.g. low-flush public toilets.

Land Use Land Cover

In rural regions, efficient land is usually the maximum important resource for local people. It should be used successfully to fulfil the desires of the human beings for water, food, constructing materials and affordable quality of life, and to hold the functioning of natural systems on which a majority of these depend. This requires complete making plans and careful allocation of land to the maximum suitable use or aggregate of uses. Wastelands ought to be afforested on a large scale related to neighbourhood human beings. Substitutes for furnishings material and packing instances should be used. This might ease the stress on standing forests. Catchment regions or water-sheds should be thickly vegetated. This would keep rain water and recharge springs, rivers, etc. Tanks should be desilted, check dams built and small ponds created to keep run-off water. Shifting agriculture should get replaced by settled agriculture.

9.2 Present status and gap identification

9.2.1 Present status of soil and agriculture

The district of Hanumangarh comes under the Agro-climatic zone 1B (Irrigated north western plain). Therefore, one may find hot summer, cool winter, unreliable rainfall and great temperature variation. The rainfall is mostly limited to the rainy season. Monsoon usually comes in the first week of July and regresses in the last week of September.

As Hanumangarh is a part of great Thar Desert, it is covered with thick mantling sand, i.e. 4 to 5 metres high longitudinal dunes treading north east to south west and general slope varies from south to north. The general texture of the soil is deep to very deep from fine to coarse textures (Table 9.5). The northern irrigated Ghaggar Plain is dominated by fine and moderately fine textured soil. In southern rain fed zone, the major soil group are sandy to loamy sand at places underlined by line concretion and gypsiferous strata.

The Overall fertility (quantity and quality of Nitrogen, Phosphorus and Potassium) of the soil throughout the district is very less. The fertility status is as under: (i) Nitrogen: Very low; (ii) Phosphorus: Medium; (iii) Potassium: Medium; For enhancement in the health of the soil, sound agronomic procedures such as addition of organic measures, green manuring and crop rotation with emphasis on legumes and other processes which help in boosting the soil's humus content are recommended.

Although the soil depth in 80 % of the area is above 90 centimetres, the topography of the land is mainly plain. Alluvial Plain and Southern Part are under undulated and comprises of sand dunes. The soil texture of the district being course sandy to very light, has very high permeability, low moisture holding capacity, overall low fertility (qualities of NPK). The general texture of the soil being light and coarse sandy, highly permeable and without any streams contributing runoff, no water erosion is reported, but large amount of wind erosion takes place (Development, 2010).

Table 9.5 Soil types and their characteristics (Hanumangarh District) (ICAR, 2020b)

S. No.	Soil type	Characteristics	Area (ha.)
1	Canal irrigated light & medium soil	Sangaria and Hanumangarh Tehsil sandy loam to loamy sand having good drainage properties and calcascious sub soil. Organic matter and nitrogen level low. P_20_5 low to medium K_20 medium to high. Ground water is Saline.	353514
2	Ghaghar Flood Prone Soil	Tibbi & Hanumangarh tehsil loam to salty loam soil, Saline, alkaline problematic soils. Paddy, Wheat, Mustard & Gram.	21790
3	Rain Fed area	Nohar & Bhadra tehsil fine sand to loam sand soil, sand dunes found in the area. Guar, Bajra, kharif pulses Gram, Taramira, Barley & Wheat crops.	422077
4	Salt Affected Soil	Tibbi, Rawatsar, Nohar and Bhadra. Sandy and alkaline soil. Saline ground water, not suitable for irrigation, Paddy wheat mustard, Toria and fodder crops.	15440

Table 9.6 represents the crops and the area under various crops in Hanumangarh district. In the district, Rabi crops include Mustard, Wheat, Barley, Gram, Fodder, whereas Kharif crops consist of cotton, Guar, Paddy, Moong, Moth, Til, Groundnut, Caster and Fodder.

Table 9.6 Details of crops and area under various crops in Hanumanagrh district (ICAR, 2020b)

Yearly details of cropping pattern	Rabi Crops	Mustard, Wheat, Barley, Gram, Fodder
	Kharif Crops	Cotton, Guar, Paddy, Moong, Moth, Til, Groundnut, Caster, Fodder
Yearly details of Land Area under each crop for the district (In hectares)	Desi cotton	5120
	American cotton	8200
	BT cotton	193630
	Bajra	44510
	Paddy	36950
	Moong	50500
	Moth	48340
	Guar	324460
	Ground Nut	14640
	Til	2810
	Caster	2330
	Mustard	125740
	Gram	188420
	Barley	15210
	Wheat	250820
	Taramira	14770

Table 9.7 gives information about the environmental parameters related to agriculture. As per information from the department of agriculture, Hanumangarh district, there is no land area affected with seepage from canals. However, reports from other sources such as the newspapers indicate otherwise (Iqbal, 2018). The department also claims to reclaim about 5000 hectares of land for agriculture. The quantities of various fertilizers used in the district are in the range of 1200 tons to 1,25,000 tons. Yearly total quantity of pesticides used in the district is 217 tons of technical grade material.

Table 9.7 Information regarding environmental parameters related to agriculture

Area of agriculture land affected with seepage from Canals in each ULB		NIL
Details of Land reclaimed for agriculture (Hectares)		5000
Yearly details of Fertilizer use for the district (MT)	Urea	125000
	DAP	50000
	SSP	24600
	MOP	2900
	NPK	1200
Yearly details of pesticides/insecticides used in the district (class of pesticides and the quantity used – tonnes of technical grade material used)		217.56

As environment management practice, the department is encouraging chemical-free farming by forming organic farming clusters under PKVY and Zero Budgeting natural Farming scheme. To prevent burning of crop residue, high-tech agricultural machinery is being provided to the farmers on grant and for this, various training programs are being organized by the department. There is provision of penalty - Rs 2500 For 2 Acre; Rs 5000 For 2-5 Acre; & Rs.15000 For 5 Acre and above – for stubble burning under Prevention and control of Pollution Act, 1981.

9.2.2 Present status of rural environment

The present status of rural environment is depicted in Table 9.8. The total population of panchayats in Hanumangarh district is about 15 lacs. As the data available from Zila Parishad, total wastewater generated in the rural areas is 1,63,818 kilolitre per day (KLD). Out of the total wastewater generated in the district, 1,08,138 kilolitre per day (KLD) of wastewater is treated. There is no data provided on technologies being used for treatment of the wastewater.

Table 9.8 Present Status of waste management in Rural areas of Hanumangrah district (ICAR, 2020b)

Rural area of Hanumangarh	Units	Value
Environmental management practice/policies of the department		-
Provision of pollution abatement (air/water/noise)		-
Updates on implementation environmental management policies		-
Budget allocated for environmental protection		-
Total population of panchayat		1540070
Total wastewater generated in panchayat samitis	Kilolitre per day	163818
Total wastewater treated in panchayat samitis	Kilolitre per day	108138
Total wastewater left untreated in panchayat samitis	Kilolitre per day	55680
Total solid waste generated in panchayat samitis	Kilogram	322278
Total solid waste treated in panchayat samitis	Kilogram	16146
Total solid waste left untreated in panchayat samitis	Kilogram	306132

As the data available from Zila Parishad, total quantity of solid waste generated in the rural areas is 322278 kilograms. About 16146 kg of solid waste has been reported as treated by the concerned department. There is no information provided on technologies being used for processing of the solid waste.

9.3 Action plan for rural environment

The suggested interventions for agriculture have been clearly defined by Krishi Vigyan Kendra, Hanumangarh. Some of the interventions suggested have been provided by in Table 9.9. In addition, following measures may be taken to ensure proper management of rural environment: (i) Ensure food and fodder security. (ii) Ensuring and enforcement that agricultural land is owned by actual cultivators principally in IGNP command area. (iii) Ensure that land is actually used for the purpose for which it is allotted. (iv) Efficient management of agricultural resources including judicious use of water for irrigation, adoption of suitable cropping pattern and crop rotation, need based and market oriented diversified farming/alternate land use systems, optimal rain water harvesting, insect pest management and development of post-harvest technologies. (v) Rehabilitation, efficient management and proper use of degraded land. Quality grain storage to sustain market price for the farmers and ensure greater food security. (vi) Development of dairy and meat industry through improved pastures/rangelands and livestock production. (vii) Promotion of Indigenous traditional/technical knowledge (ITK) and bringing more are under forest cover. (viii) Intensive and regular training to farmers. Improved and well-timed weather forecast, drought vigilance and mitigation. (ix) Creation of stronger linkages amongst farm and off-farm income generating actions and activities. (x) Agri-business, ago-processing, and value addition of agricultural products as per market needs. (xi) Creation of consortia of RD institutions, line departments, NGO and farmers for orienting government programme as land-based activities for sustainable livelihood and sustainable land management.

Table 9.9 Suggested Contingency measures for Droughts-Rain fed situation (ICAR, 2020b)

Condition			**Suggested Contingency measures**		
Early Season Drought (delayed onset)	Major Farming Situation	Normal crop/ cropping system	Change in crop/cropping system	Agronomic measures	Remarks on Implementation
Delay by 2 weeks (July 4th week)	Rain fed (deep light yellowish brown loamy soils)	Guar/ Mung bean/ Moth bean/ Bajra	Guar (RGC-936, RGC 1002) Moth bean (RMO-40, RMO 435, CAZRI moth 3) Bajra (HHB 67, RHB 30,HHB 60) Mung bean (SML 668, RMG 62, RMG 268)	Normal recommended agronomical practices	Seed source 1.NSSC 2.RSSC 3.NSP
	Rain fed (deep yellowish brown sandy soil)	Guar/Mung bean/ Moth bean/ Bajra	Guar (RGC-936, RGC 1002) Moth bean (RMO-40, RMO 435, CAZRI moth 3) Bajra (HHB 67, RHB 30,HHB 60) Mung bean (SML 668, RMG 62, RMG 268)	Normal recommended agronomical practices	
	Rain fed (medium light yellowish brown soil)	Guar/ Mung bean/ Moth bean/ Bajra	Guar (RGC-936, RGC 1002) Moth bean (RMO-40, RMO 435, CAZRI moth 3) Bajra (HHB 67, RHB 30, HHB 60) Mung bean (SML 668, RMG 62, RMG 268)	Normal recommended agronomical practices	
	Rain fed (other soils)	Guar/ Mung bean/ Moth bean/ Bajra	Guar (RGC-936, RGC 1002, RGC 1003, RGM 112) Moth bean (RMO-40, RMO 435, CAZRI moth 3) Bajra (HHB 67) Mung bean (SML 668, RMG 62, RMG 268)	Normal recommended agronomical practices	

9.4 Summary

Economic development and population growth in rural areas have led to many problems, such as pollution, land degradation, resource depletion, loss of biodiversity, loss of income, and health risks. In rural areas, there is often a lack of resources to take the necessary measures. Low population density and scattered households are not enough to implement many management strategies related to centralized and urban areas. The development of the rural economy and environmental protection must be coordinated. Regions are strategies for environmental, social and economic sustainability. Sustainable environmental management development based on integrating economic, environmental and social considerations can raise awareness of these environmental challenges and provide solutions, reduce nitrogen and phosphorus losses caused by agricultural activities, adapt to climate change, and reduce greenhouse gas emissions in rural areas. Protect the rural ecosystem, optimize and control the process of pollution reduction in rural areas, use agricultural resources and rural land management and planning.

In spite of a delicate ecosystem and many restrictions and indecisions, arid western Rajasthan still has lands and avenues for development and progress by Efficient conservation, Use and competent management of surface and ground water resources; Increasing cropping intensity, Crop diversification and crop productivity of vast chunk rain fed cropland through animal-tree-crop-farming system; Control of land degradation actors and rehabilitation and development of degraded lands; Enhancement of forest cover and biomass production; Infrastructure development; Intensive training of farmers and effective extension agencies; Formulation of rationales and enabling land use policy along with bringing land use legislation into the scenario.

10. Forest Conservation Practices and Management Plan

10.1 Literature Review

A forest alluded to as a wood or the forested area, is a region with a high thickness of trees. Forests may fluctuate fundamentally in size and have various characterizations as per how and what the forest is created. Tree forests cover around 9.4 per cent of the world's surface (or 30% of the complete land region), however, they once covered considerably more (around 50% of the absolute land region). They work as environment for creatures, hydrologic stream modulators, and soil monitors, establishing perhaps the most significance parts of the biosphere (Viña et al., 2016).

Forest ecosystems are a critical component of the world's biodiversity as many forests are more bio diverse than other ecosystems. Forests cover 31 per cent of the global land area. Approximately half the forest area is relatively intact, and more than one-third is primary forest (i.e. naturally regenerated forests of native species, where there are no visible indications of human activities and the ecological processes are not significantly disturbed). The total forest area is 4.06 billion hectares or approximately 5 000 m^2 (or 50 x 100m) per person, but forests are not equally distributed around the globe. More than half of the world's forests are found in only five countries (the Russian Federation, Brazil, Canada, the United States of America and China) and two-thirds (66 per cent) of forests are found in ten countries (Kimdung et al., 2013).

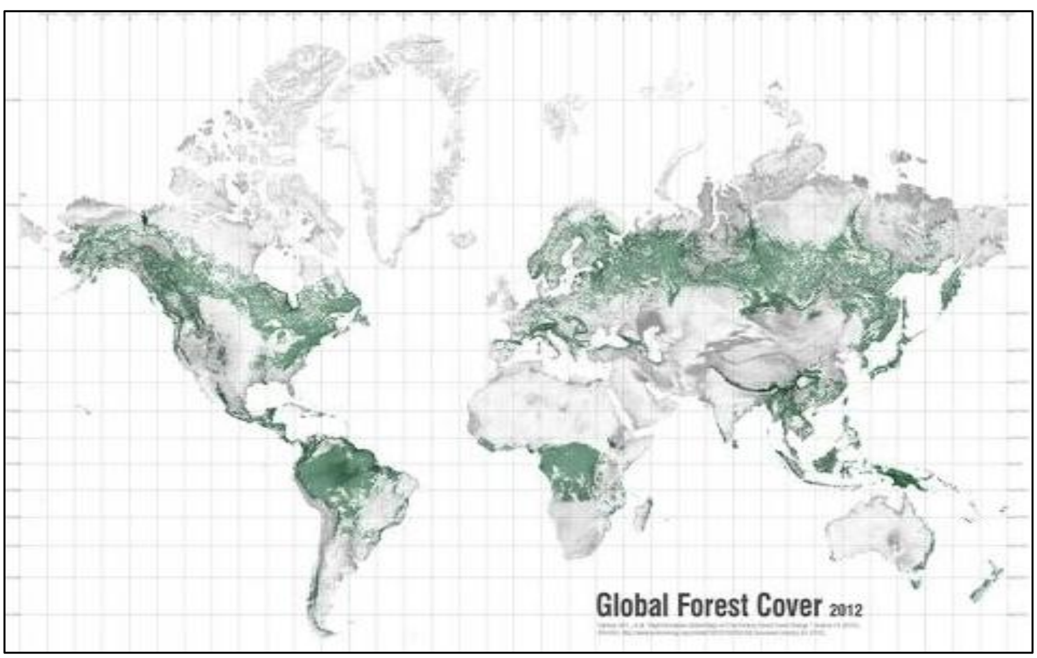


Figure 10.1 Share of forest in the world

Deforestation and forest degradation is occurring at disturbing rates, which contributes essentially to the continuous loss of biodiversity. Since 1990, it is assessed those 420 million hectares of woodland have been lost through transformation to other land uses, albeit the pace of deforestation has decreased in the course of recent many years. Somewhere in the range of 2015 and 2020, the pace of deforestation was assessed at 10 million hectares each year, down from 16 million hectares each year during the 1990s. The space of essential forests worldwide has decreased by more than 80 million hectares since 1990.Agricultural development keeps on being the primary driver of deforestation and forest degradation and the related loss of woodland biodiversity. Large-scale commercial agriculture represented 40% of tropical deforestation somewhere in the range of 2000 and 2010, and nearby means agribusiness for another 33% (Kugonza et al., 2009).

Forest gives various advantages. They bring down the air temperature by delivering water fume into the air. At day time trees create oxygen and store carbon dioxide, which assists with cleaning air. Forests draws in natural life and offer food and assurance to them. Forests offer security, decrease light reflection, offer a sound wall and help to direct wind heading and speed. Trees offer imaginative capacities, for example, making a back ground, outlining a view, supplementing engineering, etc. Well oversaw backwoods supply better water with less contamination than water from different assets. Some backwoods raise all out-water stream; however, this isn't valid for all timberlands, woodlands help in controlling the level floods. Forest gives distinctive sort of wood which are utilized for various purposes like creation of furniture, paper/pencils, etc. Forests help in keeping climate sound and lovely. Woodlands likewise limit commotion contamination. They store carbon, help in directing the planetary environment, refine water and moderate normal risks like floods and avalanches. Backwoods additionally contain around 90% of the world's earthly biodiversity (Chaudhary, 2000).

Scenario in Country

As per the ISFR 2019, the top five states in terms of increase in forest cover are Karnataka (1,025 sq. km.), Andhra Pradesh (990 sq. km.), Kerala (823 sq. km.), Jammu & Kashmir (371 sq. km.) and Himachal Pradesh (334 sq km). In terms of area, Madhya Pradesh has the largest forest cover in the country followed by Arunachal Pradesh, Chhattisgarh, Odisha and Maharashtra. In terms of forest cover as a percentage of their total geographical area, the top five states are Mizoram (85.41 percent), Arunachal Pradesh (79.63 percent), Meghalaya (76.33 percent), Manipur (75.46 percent) and Nagaland (75.31 percent). The report also highlighted that there are 62,466 wetlands in the country and amongst the states, Gujarat has the largest area of wetlands (within the RFA) in the country followed by West Bengal. The report has identified wetlands of more than one-hectare area within the RFAs. The ISFR 2019 also showed that the mangrove cover in the country has increased by 54 sq. km. as compared to the previous assessment. The maximum increase was in Gujarat which recorded an increase of 37 sq. km followed by Maharashtra (16 sq. km.) and Odisha (8 sq. km.) but it marked a decrease of mangrove cover in Tamil Nadu (four sq. km.), West Bengal (two sq. km.) and Andaman and Nicobar Islands (one sq. km.). *(India, Indian Council of Forestry Research and Education, 2021)*

Forest cover: Includes all lands having trees more than one hectare in area with tree canopy density of more than 10%, irrespective of ownership, legal status of the land and species composition of trees. Very Dense Forest: All lands with tree canopy density of 70% and above. The relative composition of forest cover under this category is 3.02%. Moderately Dense Forest: All lands with tree canopy density of 40% and more but less than 70%. Forest cover under this category is 9.39%. Open Forest: All lands with tree canopy density of 10% and more but less than 40 %. Forest cover of 9.26% falls under this category. Scrub Forest: Lands with canopy density less than 10%. Geographical area under this category is 1.41%. Non-forest: Lands not included in any of the above classes (includes water). Geographical area under the non-forest category is 76.92%.

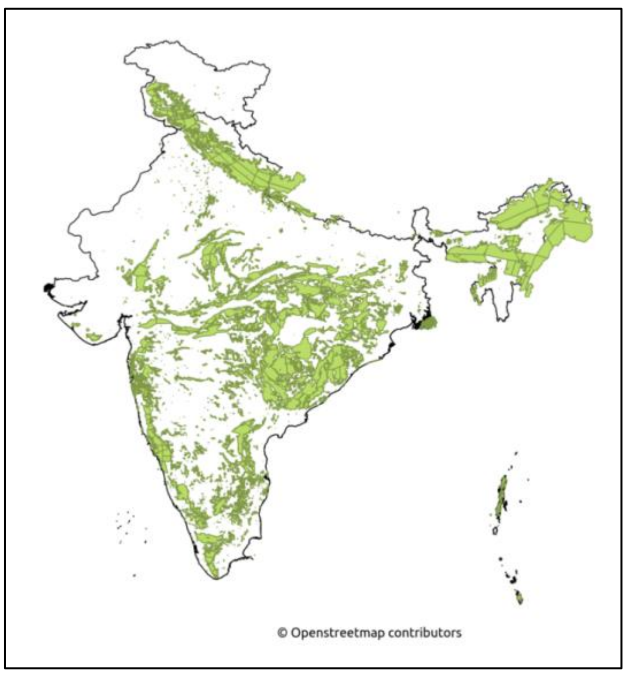


Figure 10.2 Forest Cover in India, 2015 *Source**Invalid source specified.***

Scenario in State

Situated in the north-western part of the country, the largest state of the country, Rajasthan covers an area of 3,42,239 sq km, which is 10.40% of the geographical area of the country. The geographical extent of the State is bounded by 23°4'N to 30°11'N latitude and 69°29'E to 78°17' E longitude. The State has 4 distinct regions namely, Western Desert with Barren Hills, Level Rocky and Sandy Plains, the Aravalli Hills and South-Eastern Plateau. The climate of the State varies from semi-arid to arid. Western part of the State, including Thar Desert (also known as The Great Indian Desert), is relatively dry and infertile whereas in the south-western part, the land is wetter, hilly, and more fertile. The average annual temperature ranges between 0°C to 50°C and the average annual rainfall is in the range of 500 mm to about 750 mm. The State is drained by a number of rivers which include Banas, Chambal, Luni and Mahi.

The State has 33 districts. As per the 2011 Census, Rajasthan has a population of 68.55 million accounting to 5.66 percent of India's population. The rural and urban population constitute 75.10% and 24.90% respectively. The population density is 200 per sq km which is much lower than the national average of 382 persons per sq km. The 19th Livestock census 2012 has reported a total livestock population of 57.73 million in the State. Rajasthan, ranks 15th in terms of forest deficient State. Recorded Forest Area (RFA) in the State is 32,737 sq km of which 12,475 sq km is Reserved Forest, 18,217 sq km is Protected Forest and 2,045 sq km is Unclassed Forests. As per the information receive from the State during the last two years, a total of 42,633 ha of plantations were raised Five National Parks, 25 Wildlife Sanctuaries and 11 Conservation Reserves constitute the Protected Area network of the State covering 2.92% of its geographical area. There are 3 Project Tiger (Ranthambhore, Sariska and Mukundra Hills) and two Ramsar (Keoladeo Ghana sanctuary and Sambhar Lake) sites.

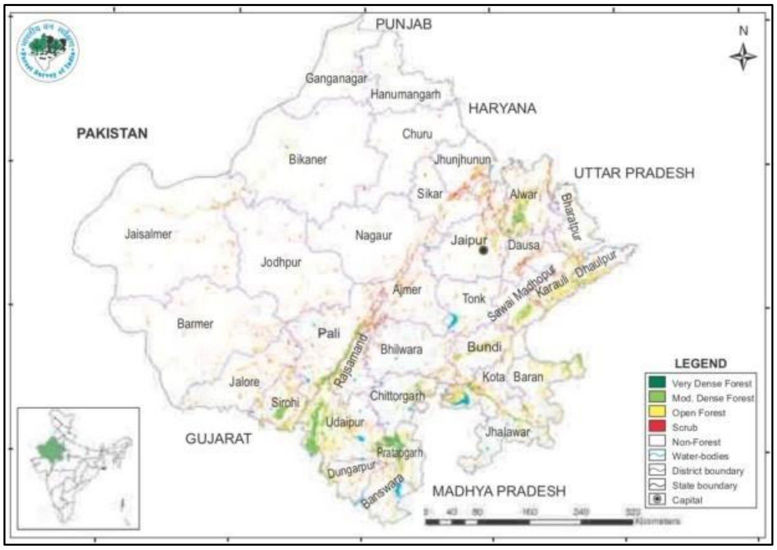


Figure 10.3 Forest cover in Rajasthan, 2015

Based on the interpretation of IRS Resourcesat-2 LISS III satellite data of the period Oct to Dec 2017, the Forest Cover in the State is 16,629.51 sq km which is 4.86 % of the State's geographical area. In terms of forest canopy density classes, the State has 77.81 sq km under Very Dense Forest (VDF), 4,341.90 sq km under Moderately Dense Forest (MDF) and 12,209.80 sq km under Open Forest (OF). Forest Cover in the State has increased by 57.51 sq km as compared to the previous assessment reported in ISFR 2017.

Governance and management

Ministry Of Environment, Forest and Climate Change

The Ministry of Environment, Forest and Climate Change (MoEF&CC) is the nodal agency in the administrative structure of the Central Government for the planning, promotion, co-ordination and overseeing the implementation of India's environmental and forestry policies and programmes.

The Ministry also serves as the nodal agency in the country for the United Nations Environment Programme (UNEP), South Asia Co-operative Environment Programme (SACEP), International Centre for Integrated Mountain Development (ICIMOD) and the follow-up of the United Nations Conference on Environment and Development (UNCED). The Ministry is also entrusted with issues relating to multilateral bodies such as the Commission on Sustainable Development (CSD), Global Environment Facility (GEF) and of regional bodies like Economic and Social Council for Asia and Pacific (ESCAP) and South Asian Association for Regional Co-operation (SAARC) on matters about the environment. (MOEF & CC, 2019)

The broad objectives of the Ministry are: 1) Conservation and survey of flora, fauna, forests and wildlife 2) Prevention and control of pollution 3) Afforestation and regeneration of degraded areas 4) Protection of the environment and 5) Ensuring the welfare of animals. These objectives are well supported by a set of legislative and regulatory measures, aimed at the preservation, conservation and protection of the environment (GOI, 2021)

Indian Council of Forestry Research and Education

ICFRE with its Headquarters at Dehradun is an apex body in the national forestry research system that promotes and undertakes need based forestry research extension**.** The Council has a pan India presence with its 9 Regional Research Institutes and 5 Centers in different bio-geographical regions of the country. The regional research Institutes are located at Jodhpur, Dehradun, Shimla, Hyderabad, Coimbatore, Ranchi, Bengaluru, Jorhat and Jabalpur, and the centres are at Agartala, Aizawl, Allahabad, Chhindwara and Visakhapatnam. (India, Indian Council of Forestry Research and Education, 2021)

Vision: To achieve long-term ecological stability, sustainable development and economic security through conservation and scientific management of forest ecosystems.

Mission: To generate, advance and disseminate scientific knowledge and technologies for ecological security, improved productivity, livelihoods enhancement and sustainable use of forest resources through forestry research and education.

Objectives were: 1) to undertake, aid, promote and coordinate forestry research, education and extension leading to scientific and sustainable management of forest resources in the country. 2) To align forestry research programs in the council with national priorities including achievement of Sustainable Development Goals and combating climate change. 3) To provide scientific advice and policy support to the central and state governments aiding informed decision making in forestry matters of national importance and international commitments. 4) To act as a repository of scientific knowledge related to forestry, environment and climate change, and disseminate such knowledge to various stakeholders. 5) To provide technical assistance and support to states, forest- based industries, tree growers, farmers and others for forest protection, afforestation, agro- forestry and allied activities. 6) To develop appropriate forest-based technologies, processes and products for sustainable resource use, 7) to provide livelihood support to forest dependent communities through transfer of scientific knowledge and appropriate forest-based technologies 8) To develop technically qualified human resources for forestry sector (ICFRE, 2021).

Forest Survey of India

Forest Survey of India (FSI) is a premier national organization under the union Ministry of Environment and Forests, responsible for the assessment and monitoring of the forest resources of the country regularly. The main objective of PISFR was to ascertain the availability of raw materials for establishment of wood-based industries in selected areas of the country. In its report in 1976, the National Commission on Agriculture (NCA) recommended the creation of a National Forest Survey Organization for a regular, periodic and comprehensive forest resources survey of the country leading to creation of FSI. After a critical review of activities undertaken by FSI, Government of India redefined the mandate of FSI in 1986 to make it more relevant to the rapidly changing needs and aspirations of the country (FSI, n.d.).

Department of Forest Government of Rajasthan

The department is headed by Principle Chief Conservator of Forests & Head of Forest Force as the technical head and administratively lead by Principal Secretary to the Government of Rajasthan

Rajasthan State Biodiversity Board

The Convention was opened for signature at the Earth Summit in Rio de Janeiro on 5 June 1992 and entered into force on 29 December 1993. After becoming a party to the Convention on Biological Diversity in 1994, the Government of India has taken many important steps to further strengthen the existing framework. The Biological Diversity Act, 2002 (No. 18 of 2003) was enacted by the Ministry of Law and Justice, Government of India after approval of the Parliament and the assent of the president on the 5th February 2003. This Act provides for the conservation of biological resources and their diversity, sustainable use of its components and fair and equitable sharing of the benefits arising out of the use of biological resources, knowledge and for matters connected therewith or incidental thereto. In exercise of the powers conferred under subsection (1) of Section 63 of the Biological Diversity Act, 2002, the Government of Rajasthan framed 'Rajasthan Biological Diversity Rules, 2010', vide notification dated 02 March 2010. As per provision of Section 22 of this Act, the State Government (s) shall establish State Biodiversity Board for this Act. Accordingly, the Government of Rajasthan has established the Rajasthan State Biodiversity Board, vide Government order number: F.4 (8) Forest/2005/Part 1 Jaipur dated: 14 September 2010 (GoR, 2021).

Acts and rules:

Forest conservation Act, 1980

The Forest Conservation Act 1980 was enacted to help conserve the country's forests. It strictly restricts and regulates the de-reservation of forests or use of forest land for non-forest purposes without the prior approval of central government. To this end the act lays down the pre-requisites for the diversion of forest land for non-forest purposes.

This act has been passed with a view to check deforestation which has been taking place in the country on a large scale and which had cause ecological imbalance and thus led to environmental deterioration. The president of India promulgated the forest (Conservation) Ordinance on 25 October 1980. It simply aims at putting restriction on the DE reservation of forests or use of forest-land for non-forest purposes. The Act is intended to serve a laudable purpose as is evident from the statement of objects and reasons of the Act, which reads:

Deforestation causes ecological imbalance and leads to environmental deterioration. Deforestation had been taking place on a large scale in the country and it had caused widespread concern. Intending to check further deforestation, the president promulgated on 25Th October, 1980 the forest (Conservation) Ordinance, and 1980 (GOI, 1980).

Indian Forest Act, 1927

The Indian Forest Act, 1927 consolidates the law relating to forests, the transit of forest-produce and the duty liable on timber and other forest-produce. The Indian Forest Act,1927 aimed to regulate the movement of forest produce, and duty leviable forest produce. It also explains the procedure to be followed for declaring an area as Reserved Forest, Protected Forest or a Village Forest. This act has details of what a forest offence is, what are the acts prohibited inside a Reserved Forest, and penalties leviable on violation of the provisions of the Act. After the Forest Act was enacted in 1865, it was amended twice (1878 and 1927) (GOI, 1927).

This Act impacted the life of forest-dependent communities. The penalties and procedures given in this Act aimed to extend the state's control over forests as well as diminishing the status of people's rights to forest use.

The village communities were alienated from their age-old symbiotic association with forests. Further amendments were also made to restrain the local use of forests mainly by forest-dependent communities. It was enacted to make forest laws more effective and to improve the previous forest laws.

The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006

It recognizes the rights of forest-dwelling Scheduled Tribes and other traditional forest dwellers over the forest areas inhabited by them and provides a framework for according the same (GOI, 2006)

Rajasthan Forest Act, 1953

An Act to consolidate the law relating to forests the transit of forest produce and the duty leviable on timber and other forest produce. Be it enacted by the Rajasthan State Legislature as follows: received the assent of the President on 3'1st of March, 1953, published in the Rajasthan Gazette No. 10 Part. lV A, dated the 18th April, 1953 (GoR, 1953).

Rajasthan State Forest Policy, 2010

The Rajasthan government has proposed a new draft forest policy that will drive the management and protection of forest in the largest state of India in the next 10 years. The policy aims to have measures to increase forest area under protected area network, control mining activities, strengthen biodiversity conservation, increase afforestation and ensure proper management of grasslands. The forest policy proposes to create a "secret fund to deal with organized forest crimes and illegal mining and be used to award whistleblowers/informers." While promising strict action against illegal mining, it emphasized that mining will be permitted in the forest areas only after proper clearance.

The main aim of the Rajasthan Forest policy is to: Conserve and enhance environmental resources; Assure environmental sustainability of key economic sector; Improve environmental governance and build capacity (GoR, 2010).

Table 10.1 Regulations regarding forest conservation

Law	Description	Requirement
Forest (Conservation) Act, 1980	The Forest (Conservation) Act prohibits the use of forest land for non-forest purposes without the approval of Ministry of Environment and Forests (MoEF), Government of India	Not applicable; none of the components of the subproject are located in forest.
Rajasthan Forest Act, 1953 and Rajasthan Forest Rules, 1962	This Act makes the basis for declaration of Reserved Forests, constitution of village forest committees, management of reserved forests and penalties and procedures.	Not applicable

Best practices

The following inferences can be drawn a) Conservation of forest is a national problem so it must be tackled with perfect coordination between forest department and other departments; b) People's participation in the conservation of forests is of vital importance. So, we must get them involved in this national task; c) The cutting of trees in the forests must be stopped at all costs; d) Afforestation or special programme like Van Mahotsava should be launched on grand scale; e) Celebrations of all functions, festivals should precede with tree-plantation; f) Cutting of timber and other forest produce should be restricted; g) Plantation forestry with proper joint forest management plan can be useful; h) Community forest management can be benefitted and can help restore the forest land.

STRATEGY

i) Area under Forests **ii)** Treatment of Forest Areas **iii)** Forest protection and conservation **iv)** Afforestation on Government land, Community land and Private land **v)** Demand and supply of Forest Produce **vi)** Enhancement of Productivity **vii)** Checking Land Degradation **viii)** Combating desertification **ix)** Wild life and biodiversity conservation **x)** Pasture Development **xi)** People's Participation **xii)** Monitoring and Evaluation **xiii)** Review of Implementation of Forest Policy

Preserve forests and biodiversity for the benefit of the global climate and dignified livelihoods of rural communities and indigenous peoples in and around the forests.

The figure shows the root problem and the Strategic Priorities to achieve our objectives. The following steps should be taken for the conservation of forests:

A) Regulated and Planned Cutting of Trees

One of the main reasons for deforestation is the commercial felling of trees. According to an estimate, about 1,600 million cubic metres of wood have been used for various purposes in the world. Although trees are considered as a perennial resource, when exploited on a very large scale, their revival cannot be possible.

Therefore, cutting should be regulated by adopting methods like: (i) Clear cutting, (ii) Selective cutting, and (iii) Shelter wood cutting.

The clear-cutting method is useful for those areas where the same types of trees are available over a large area. In that case, trees of the same age group can be cut down in a selected area and then marked for replantation. In selective cutting only mature trees are selected for cutting. This process is to be followed in rotation. Shelter wood cutting is where first of all useless trees having been cut down followed by medium and best quality timber trees. The time gap between these cuttings is helpful in re-growth of trees. In regulated cutting only one-tenth of the forest area is selected for use and a rotational system is always followed for their protection. The forest can be managed in such a way that a timber crop may be harvested indefinitely year after year without being depleted. This technique is called the ‘sustained yield’ method adopted by many countries of the world.

B) Control over Forest Fire

Destruction or loss of forest by fire is fairly common; because trees are highly exposed to fire and once started it becomes difficult to control. Sometimes, the fire starts by natural process, i.e., by lightning or by friction between trees during speedy winds, while in most cases it is started by man either intentionally or unintentionally. In order to save forests from fire it is necessary to adopt latest techniques of firefighting. Some of the fire suppression techniques are to develop three metre wide five lanes around the periphery of the fire, back fires, arrangement of water spray, fire retardant chemicals should be sprayed from back tank and if possible by helicopters. There must be a trained staff of firefighters to control the fire.

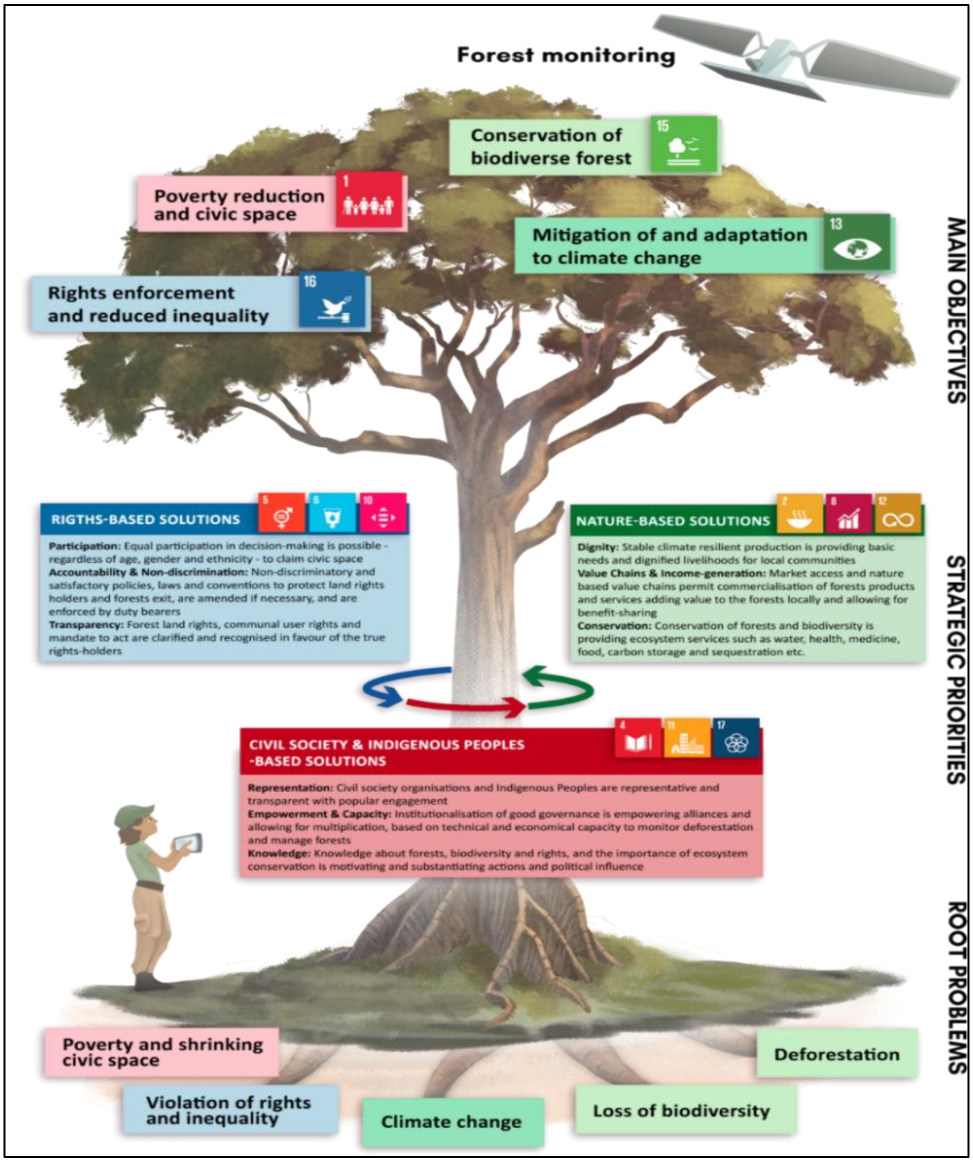


Figure 10.4 The Strategic Priorities to Achieve Our Objectives and Problems

C) Reforestation and Afforestation

The sustained yield concept dictates that whenever timber is removed, either by block cutting or by selective cutting, the denuded area must be reforested. This may be done by natural or artificial methods. Similarly, any forested land which has been destroyed by fire or mining activities should be reforested. In rugged terrain aerial seeding is the method of choice. Besides all this, fresh afforestation programmes should be started. New plantations will not only increase the forest cover but also help in making up the eco-balance. For afforestation, selection of trees should be done according to local geographical conditions and care must be taken during initial growth of the trees.

D) Check over Forest Clearance for Agricultural and Flabitation Purposes

Most of the present-day agricultural land was once forested and then cleared for the use of agriculture. But now it has reached the stage where further clearance will be dangerous for the entire ecosystem. Similarly, for the development of villages, towns and cities, forest lands have been cleared and this process continues to this day causing loss of forest cover. This also should be checked and green belts around cities should be developed.

E) Protection of Forest

The existing forests should be protected. Apart from commercial cutting, unorganized grazing is also one of the reasons. Several forest diseases are resulting from parasitic fungi, rusts, mistletoes, viruses and nematodes which destroy trees. The forests should be protected either by use of chemical spray, antibiotics or by the development of disease resistant strains of trees.

F) Proper Utilization of Forest Products and Forests

Generally, forests have been cut for logs and rest of the tree – stump, limbs, branches and foliage, etc., are left out in the forest as worthless debris. Further waste occurs at the saw mill. There is a need to use all this waste material. Now several uses have been developed and products like waterproof glues, board, etc., can be obtained.

G) Role of Government in Forest Conservation

Although the government of every country is very particular about the conservation of its forest resources and has several rules and laws for the protection of forests, they are not implemented effectively. Both national and provincial governments can take some steps in this direction, such as: (i) passing acts for the conservation of forests, (ii) Survey of the forest resources, (iii) Categorization of forest areas and proper delimitation of reserved forest areas, (iv) Find out the areas where reforestation can be done, (v) Regulate the commercial use of forest products, (vi) Protect forest from fire, mining and other natural calamities, (vii) Develop national parks, (viii) Encourage forests developmental activities like social forestry, agro-forestry, etc., and (ix) Prepare master plans.

H) Forest Management

Management of forest resources is the key to all conservation efforts. In forest management, the following aspects should be taken into consideration: (i) Survey of forest, (ii) Categorization of forest. (iii) Economic use of forest, (iv) Administrative setting for forest management, (v) Training programmes for persons engaged in forest conservation activities, (vi) Use of forest land as tourist centers, (vii) Social and agro-forestry, (viii) Development of new techniques for the conservation of forests, (ix) Research for efficient use and conservation of forest, and (x) Policy decisions and their proper implementation. In brief, conservation of forest resources can be done by cooperative efforts of the government, non-government organizations and the public through a proper management system.

Similarly, forests can easily be used or developed as tourist centers. By using them as tourist centers the country can earn substantial foreign exchange. This practice has been adopted by many countries, both developed and developing.

The concepts of 'national park' and 'game sanctuary' have now become popular and every state has developed its unique forest area as a 'national park'. In India alone, there are as many as 21 national parks. This scheme is a good method of forest conservation.

10.2 Present Scenario and Gap Identification

District Hanumangarh is a part of great Thar Desert. Owing to its location in the Thar Desert region with arid, dry climate, scanty rainfall, high infiltration and low water bearing capacity of soils, and existence of sand dunes, there are no natural forests in Hanumangarh. It is mainly covered with thick mantling sand i.e., 4 to 5-meter-high longitudinal dunes treading north-east to south-west and general slope varies from south to north. The North west – south of the district have large shifting sand dunes which is characterized by high velocity winds, high shifting and rolling sand dunes, high diurnal variation of temperature, very low rainfall and high rate of evaporation. The area is scanty in natural vegetation cover. The terrain of district is largely plain covered with thick layer of alluvium and wind-blown sand. It has a general slop which displays westward gradient of about 4 to 5 meters height. Few isolated patches are of calcareous and sandy sediments containing gypsite/gypsum. The Ghaggar river ephemerally flows into the district which is locally known as "Nali" and has northeast to southwest course near the town.

The district has a very adverse xerophytic climatic condition with temperature extremes. The mean annual rainfall in the area is around 286.1 mm and the average number of rainy days during monsoon and during the entire year lies in the range of 15-19 days and 19-27 days, respectively in the district. The area is scanty in natural vegetation cover. The arrival of canal water however gradually, but significantly, changed the landscape. Forest plantations are taken up along and on the banks of canals (main, distributaries and minor canals) and species such as Seesham (*Dalbergia sissoo*), Mulberry

(*Morinda citrifolia*), *Eucalyptus*, etc., have been grown. Roadside plantation has also been taken in large scale to improve the green cover in the area. Phoge (*Calligonum polygiionoides*), khimp (*Leptadenia pyrotechnica*) and Kair bushes and Khejri, Royara and Babul trees are mainly found on the sand dunes. Shrubs like "Aak", "Bawali", "Gekhru", grow sparsely. As the lands are extensively cultivated, there is no natural habitat left in and around Hanumangarh. There are no ecologically sensitive areas or wildlife habitats in the area.

Conservation through laws

In Rajasthan, The Rajasthan Forest Act, 1953 classifies the forest land into three main legal terms: Reserved Forest (RF), Protected Forest (PF) and Unclassified Forest (UF) (Table 10.2).

Table 10.2 Details of Total Forest area in Hanumangarh Forest Division

Reserved Forest		**Protected Forest**		**Un-classified Forest**		**Total Forest Land**	
No. of Forest Blocks	Area	No. of Forest Blocks	Area	No. of Forest Blocks	Area	No. of Forest Blocks	Area
0	0	89	11337.16	250	12608.84	339	23946.00

Table 10.3 Details of Range- wise Forest area in Hanumangarh Forest Division

S.No.	**Name of Range**	**Associated Panchayat Samiti region**	**Forest Area (in Ha.)**		
			Protected Forest	Un-classified Forest	Total
1.	Hanumangarh	Hanumangarh	3090.40	100.04	3190.44
2.	Pilibanga	Pilibanga	2787.007	303.70	3090.707
3.	Rawatsar	Rawatsar	5296.65	2633.25	7929.90
4.	Bhadra	Bhadra	0.00	3824.15	3824.15
5.	Nohar	Nohar	28.10	5748.203	5776.303
6.	Tibbi	Tibbi Sangaria	134.50	0.00	134.50

Table 10.4 Commonly found Wild life in Hanumangarh District (as per 2020 Census data)

S No.	Common name	Zoological name	count
Carnivores			
1.	Jackal	*Canis aureus*	927
2.	Jungle Cat	*Felis chaus*	454
3.	Fox	*Vulpes bengalensis*	505
		Total	1886
Herbivore			
4.	Black Buck	*Antelope cervicapra*	1574
5.	Nilgai	*Boselaphus tragocamelus*	3928
6.	Chinkara or Indian Gazella	*Gazella bennettii*	2521
7.	Wild Pig/Boar	*Sus scrofa*	363
8.	Indian procupine	*Hystrix indica*	173
		Total	8559
Birds			
9.	Peacock	*Pavo cristatus*	2038
		Total	2038
Reptiles			
10.	Spiny Tailed Lizard	Uromastyx hardwickii	2070
		Total	2070
		Grand total	14553

Current status related to afforestation

According to ISFR 2019, the total forest cover of the state is 16629.51 sq km which is 4.86 % of the geographical area of the state. Hanumangarh district has second last position in the state with regards to forest cover. The forest cover in the district is as follows: -

Table 10.5 Details of Forest Cover in Hanumangarh District (area in Sq. Kms.)

Geographical Area	ISFR 2019 Assessment			% of GA	Change w.r.t. 2017 assessment	Scrub
	Very Dense Forest (VDF)	Moderately Dense Forest (MDF)	Open Forest (OF)			
9659	1.00	7.00	81.96	0.93	-0.04	1.00

Forest nursery is the central unit to perform forestry practices to improve green cover of any area. The special plantation drives and greening activities have substantially increased the demand for plants. Therefore, to improve forest cover in the district Hanumangarh, 17 permanent and temporary forest nurseries have been established in which about 51.80 lacs plant seedlings/saplings/cutting etc. can be propagated at a time. These nurseries are managed by department at each range office level and the saplings are prepared under different financial schemes. The plants prepared in these nurseries are made available for large scale departmental plantation and local distribution.

Table 10.6 List of Nurseries in Hanumangarh Division

Name of Nursery	Name of Range	Associated Panchayat Samiti region	Permanent/ Temporary	Plant raising capacity
Nursery Sadulbranch 128 RD	Hanumangarh	Hanumangarh	Temporary	3.00 Lacs
Nursery Division Office	Hanumangarh	Hanumangarh	Temporary	2.00 Lacs
Nursery Kohla	Hanumangarh	Hanumangarh	Permanent	5.00 Lacs
Nursery Doualtawali	Pilibanga	Pilibanga	Permanent	2.50 Lacs
Nursery 18 SPD	Pilibanga	Pilibanga	Permanent	4.00 Lacs
Nursery Sahwa Lift 4 KM	Rawatsar	Rawatsar	Permanent	4.00 Lacs
Nursery Sahwa Lift 10 KM	Rawatsar	Rawatsar	Permanent	4.00 Lacs
Nursery Pallu	Rawatsar	Rawatsar	Permanent	2.00 Lacs
Nursery Bhadra	Bhadra	Bhadra	Permanent	1.80 Lacs
Nursery Ajeetpura	Bhadra	Bhadra	Temporary	2.00 Lacs
Nursery Dungrana	Bhadra	Bhadra	Temporary	1.50 Lacs
Nursery Thalarka	Nohar	Nohar	Permanent	5.00 Lacs
Nursery Sonari	Nohar	Nohar	Permanent	5.00 Lacs
Nursery Ramgarh	Nohar	Nohar	Permanent	2.50 Lacs
Nursey Khuyian	Nohar	Nohar	Temporary	2.00 Lacs
Nursery Masitawali Head	Tibbi	Tibbi	Permanent	3.00 Lacs
Nursery Sangaria	Tibbi	Sangaria	Permanent	2.50 Lacs
			Total Capacity	**51.80 Lacs**

Table 10.7 Number of plant seedlings raised in Nurseries during 2020-2021

S.No.	Name of Nursery	Name of Range	Number of Plants (in lakhs)		
			For Local Distribution	For Departmental Plantations	Total
1	Nursery Sadulbranch 128 RD	Hanumangarh	31000	50000	81000
2	Nursery Division Office	Hanumangarh	10000	0	10000
3	Nursery Kohla	Hanumangarh	46000	60000	106000
4	Nursery Doualtawali	Pilibanga	0	15000	15000
5	Nursery 18 SPD	Pilibanga	22000	77500	99500
6	Nursery Sahwa Lift 4 KM	Rawatsar	12000	95500	107500
7	Nursery Sahwa Lift 10 KM	Rawatsar	18000	125000	143000
8	Nursery Pallu	Rawatsar	25000	0	25000
9	Nursery Bhadra	Bhadra	20000	0	20000
10	Nursery Ajeetpura	Bhadra	10000	0	10000
11	Nursery Dungrana	Bhadra	5000	5000	10000
12	Nursery Thalarka	Nohar	44000	25000	69000
13	Nursery Sonari	Nohar	50000	30000	80000
14	Nursery Ramgarh	Nohar	63000	35800	98800
15	Nursery Masitawali Head	Tibbi	60000	50000	110000
16	Nursery Sangaria	Tibbi	24000	50000	74000
		Total	440000	618800	1058800

Other than forest protection, the forest department has a vital role of forest development. The forest development through departmental plantation is an ever-running activity of the department. Depending on the geographical set-up of the district and global environment protection, the forestry projects in the district are primarily focused to Sand Dune Stabilization under Climate Change Scheme, replantation on canal side harvested lands on IGNP system under Replanting Scheme, plantation on canal side fresh lands on Gang-Bhakhra system under Bhakhra Scheme, compensatory afforestation on forest lands under CAMPA Scheme. Details of running plantations (year 2015-16 to 2021-22) are given below under which about 21.74 lacs plants have already been planted in last five years and about 8.37 lacs plants will be planted.

Table 10.8 Range-wise running plantation under different schemes from the year 2015-16 to 2021-22

Name of Range	Name of Scheme	Allotted Plantation works		No. of plants planted/ to be planted	
		Number of works	Area in Ha./RKM	Planted	To be planted
Hanumangarh	Replanting	30	359.40	293170	122000
Bhadra	Replanting	2	31.66	24750	0
Pilibanga	Replanting	0	0	0	0
Rawatsar	Replanting	34	493.77	330050	112950
Tibbi	Replanting	13	119	310100	17500
Nohar	Replanting	11	95.75	76800	17500
Hanumangarh	Bhakhra	11	203.6	123500	7500
Bhadra	Bhakhra	18	226.32	169750	12500
Pilibanga	Bhakhra	2	23.33	17500	55000
Rawatsar	Bhakhra	0	0	0	0
Tibbi	Bhakhra	25	335.33	252503	115500
Nohar	Bhakhra	32	334.16	250625	237500
Hanumangarh	Climate Change	1	50	30000	0
Bhadra	Climate Change	3	65	39000	0
Pilibanga	Climate Change	8	170	102000	48000
Rawatsar	Climate Change	8	185	111000	15000
Nohar	Climate Change	2	30	18000	15000
Hanumangarh	MJSA Urban	1	15	3750	0
Bhadra	MJSA Urban	1	10	2500	0
Pilibanga	MJSA Urban	1	3	750	0
Nohar	MJSA Urban	1	2.49	625	0
Bhadra	CAMPA	1	3.70	740	0
Pilibanga	CAMPA	1	3.00	600	0
Nohar	CAMPA	0	0	0	4892
Hanumangarh	CAMPA	0	0	0	6980
Rawatsar	CAMPA	0	0	0	10000
Rawatsar	Silvi Pestrol	0	0	0	15000
Bhadra	Silvi Pestrol	0	0	0	4000
Nohar	Silvi Pestrol	0	0	0	21000
Hanumangarh	NAREGA	1	50	10000	0
Bhadra	NAREGA	6	9	1800	0
Nohar	NAREGA	2	16.00	5000	0
	Total	**215**	**2834.51**	**2174513**	**837822**

Figure 10.5 Preparation of saplings for plantation in Sangaria Nursery, Range Tibbi.

Figure 10.6 Afforestation activity: Plantation work in Range Tibbi, division Hanumangrh.

Figure 10.7 Afforestation activity: Plantation work in Range Tibbi, division Hanumangrh

Trees outside forests (TOF) are the prime source of tree-based fuel, fodder, food and fiber for local needs. The TOF is an important part of green cover of any specific area and therefore it has been considered in ISFR in calculating total green cover. In addition to the departmental plantations, Hanumangarh Forest Division makes available plant saplings for the local departments and local people for free of cost/at nominal cost to increase TOF. Forest department motivates and offers technical assistance to them as much possible to increase TOF. As per statistics of year 2020-21 and 2021-22, forest department distributes about 1.28 to 1.30 lacs plant saplings in the district.

Table 10.9 Distribution of Plants to different Departments of Hanumangarh District (upto 31.03.2021)

Department	Hanumangarh	Pilibanga	Rawatsar	Bhadra	Nohar	Tibbi	Total
PHED	20	13	16	10	16	15	90
Police	180	0	10	5	10	5	210
Railway	1000	0	0	0	145	0	1145
Irrigation	58	0	0	0	0	0	58
Vidyut	79	0	0	0	0	0	79
Schools	9500	3000	3200	2560	3000	4000	25260
Nagarpalika	1350	0	0	0	0	0	1350
Gram Panchayat	11000	7000	9500	9500	8000	5650	50650
Health	225	0	0	0	0	0	225
Krishi Mandi	2100	900	500	400	260	400	4560
Collectorate	1950	0	0	0	0	0	1950
Farmers and Local people	12000	6000	7000	7500	5100	5518	43118
Total	**39462**	**16913**	**20226**	**19975**	**16531**	**15588**	**128695**

Table 10.10 Distribution of Plants under different schemes (Year 2020-2021)

Scheme	Target	Achievement
Farm Forestery	50000	50000
Toll Plant	40000	39000
NAREGA	40000	40000
Total	130000	129000

Development of Urban Forests

Urban Green Space

The urban forest or the Urban Green Space functions as the "Lungs of City". As the vehicular count is continuously increasing in the district and air pollution is increasing disproportionately, the need for

Urban Forests/Urban Green Spaces are of prime importance. These urban forests not only act as oxygen houses of the city but also are the seed banks of native trees species for the city. To develop urban forests in the district, a proposal has already been prepared to develop Nature Park in Bhadra under Range Bhadra. Based on the model of Kulish Samriti Van, JLN Marg Jaipur in Jhalana forest area, the plan for developing Mahatma Gandhi Samriti Van-Bhadra is prepared. This samriti van will offer an ample amount of opportunities for wildlife photography, adventure, education, learning and recreation. Samriti Van area is proposed to be developed on an unclassified forest block, namely, Beer Shyopura Bhadra which is spread over an area of 56.566 Hectare as per forest and revenue record. The proposals are ready and submitted for the approval and after approval it will take five years to develop the Samriti Van.

MJSA-Urban

Hanumangarh forest division has developed four Urban Plantations under MJSA Urban Scheme of the Rajasthan government. These four plantations are in Hanumangarh, Bhadra, Pilibanga and Nohar. With the provisions of 250 trees per hectare of area, 7590 plants have been planted in these four plantations in previous years. Forest department is now maintaining these MJSA Urban plantations to develop them as small forest patches in the city.

Reclaiming of degraded forests

Thar desert area faces extreme climatic condition as well as human pressure on forests. Soil and moisture conservation work are carried out to reclaim such degraded forest lands. The tree species adapted to the local climate are introduced to such lands. Efficient protection measures are undertaken and adequate funds are allocated.

IEC plans to increase environmental awareness among people

Information, Education and Communication plan is an essential component of success for any program or movement. It has a prime role to spread awareness among people through various means and methods. The IEC plan is already followed by Hanumangarh forest division in the form of Van Mahotswa, Wild Life Week and different environment related days celebrations like Ozon Day, Earth Day, Wetland Day, world Environment day celebration etc. During these celebrations forest department perform symbolic plantation to spread awareness among locals.

Figure 10.8 Awareness campaigning

Figure 10.9 Community participation

Avenue Plantation along State-Highways and Ring Pit plantation

Tree felling is sometimes inevitable for highways development. The situation became more critical with the movement of vehicles on the highways and contributing further release of Green house gases. To make National Highways eco-friendly, Government of India prepared the Green Highway (plantation, Transplantation, Beautification) Policy-2015. Under this policy, National Green Highway Mission is dedicatedly responsible for overall planning, implementing and monitoring of green highway projects. This policy makes a balance between highway development and environment protection. Hanumangarh forest Division has proposed Avenue plantation works along the State Highways passing through in district by convergence of department funds of PWD with MNREGA. All plantation works will be carried out in small stretches in 37 Gram Panchayat of Panchayat Samities Hanumangarh, Rawatsar, Nohar, Bhadra, Tibbi and Sangaria. The following state highways are included for this proposal: - i) SHW – 106 Rajgarh-Bhadra-Nohar Km 35/200 – 104/200 ii) SHW – 99 Talwara – Hanumangarh Km 0/00 – 32/00 iii) SHW – 07 Kishangarh – Sangaria Km 300/500 – 406/400 iv) SHW – 36 Sahwa – Nohar – Thaladka – Munda Shergarh Km 79/500 – 188/100

Under this proposal, about 1.70 Lacs plants of local species will be planted along these four highways in the financial year 2021-22 to 2026-27 after the sanctioning of this project. To involve the local community i.e. farmers those who have their agriculture fields along the highway corridor or property owners along the highway, grafted of good quality fruit bearing/timber plants will be distributed to the farmers and property owners. Additionally, shady and dense foliage plants will be distributed to Dhabas/Land owners to involve them in plantation drive.

Gap identification and action plans until recently

Table 10.11 Identification of gaps and Action Plan: -

S. No.	Action Points	Action Plan	Responsible Agency	Timeline for completion of action plan
1.	**Seedling Supply Chain (Nursery)**			
(i)	Plan to increase TOF	No. of plants for local distribution should be increased -No. of ornamental plant species should be increased. Plant species should be introduced according to local environmental conditions	Forest Department	Year wise
(ii)	Plan to increase Forest Cover	If No. of plantation under different schemes are more in year wise target, no. of good quality plant saplings must be increased	Forest Department	Year wise
(iii)	Involvement of NGOs	Plant saplings are being distributed to local NGOs for plantation drives	Forest Department	Year wise
2.	**Afforestation**			
(i)	Plan to increase TOF	Ring pit plantation, Road side plantation, plantation in every government offices and Individual house holds	All district departments	Year wise
(ii)	Plan to increase Forest Cover	Afforestation under different state level schemes are under progress. Year wise plantation target allocation followed	Forest Department	Year wise
(iii)	Involvement of NGOs	For small level of plantations like Vriksh Kunj, Panchwati etc, NGOs should be involved with budgetary provisions	Forest Department/District Collector Office	Year wise
(iv)	Agro-forestry practices	Hanumangarh has very less forest area. So agro-forestry must be promoted with subsidy to the farmers to promote large fruit bearing/shady trees in their own lands.	Forest Department, Agriculture department	Year wise

Future projection

We are basically dependent on forests for our survival. And so their conservation is of essential importance.

There is a dire need of forest conservation and need of increase of forest cover in the district. The forest in the Hanumangarh is already less of national average and looking at the scenario of the forest in the world and their depletion, we are on the verge of vanishing of the forest of what is left.

10.3 Action Plan

Identification of action area

The action plan shall be applicable on/within the limits of all Urban Local Bodies (ULBs), i.e. Municipal Corporations/ Councils/ Municipal Board of the district

Panchayati Raj Institutions (PRIs) i.e., Zila Parishads/ Panchayat Samitis/ Gram Panchayats involved in the district

To every community which are directly responsible for the forest in the district and also to every community which are responsible for the collection and appropriation of forest produce in the district.

10.4 Summary

Suggested intervention:

Forest preservation is the act of planting and keeping up forested regions for the advantage and sustainability of people in the future. The protection of forest likewise stands and focuses on a speedy change in the structure of trees species and age appropriation. Forest preservation includes the upkeep of the regular assets inside forest that are useful to the two- people and the climate.

In any case, presently forest cover is depleting quickly because of numerous reasons like a development of agribusiness, other land utilization, urbanization, development of roads, illegal mining and encroachments, comprises the greatest and extreme danger to the forest causing genuine natural harm. In this manner, there is need of public mindfulness.

Summary of present status, future projection and action plan for forest conservation and management in all the ULB's of Hanumangarh district:

In this way, we can conclude that, individuals as well as governments can do their part in protecting the forests of the world. Knowledge about the importance of forest needs to be spread so that people become aware of the danger to everyone and everything on the earth by deforestation. People's participation in the conservation of forests is of vital importance.

Finally, it is necessary to add that the methods, strategies and measures mentioned here for the conservation of forests are very simple so that every individual could follow them and act at their own level in order to achieve the goal of conservation of forests. If we do not start and act now, it might get too late for the cause of conservation of forests.

Table 10.12 Summary for Forest Conservation Practices and Management

Name of ULB	Present scenario	Action Plan	Action plan for future	Responsible Agency	Timeline for completion of action plan
Hanumangarh.	No acts/rules are applicable; none of the components of the subproject are located in forest.	No. of plants for local distribution should be increased -No. of ornamental plant species should be increased. Plant species should be introduced according to local environmental conditions	● Enforcement of acts/rules and regulation of forest conservation ● Commercialization of forest produces. ● Development of forest as a tourist centers and other recreational activities. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/societies for conservation and monitoring	Forest Department	Year wise
Rawatsar	No acts/rules are applicable; none of the components of the subproject are located in forest.	If No. of plantation under different schemes are more in year wise target, no. of good quality plant saplings must be increased	● Enforcement of acts/rules and regulation of forest conservation ● Reclaiming of Degraded Forest Land ● Commercialization of forest produces. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/societies for conservation and monitoring	Forest Department	Year wise
Sangaria	No acts/rules are applicable; none of the components of the subproject are	Plant saplings are being distributed to local NGOs for plantation drives	● Enforcement of acts/rules and regulation of forest conservation ● Commercialization of forest produces. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/	Forest Department	Year wise

	located in forest.		societies for conservation and monitoring		
Pilibangan	No acts/rules are applicable; none of the components of the subproject are located in forest.	Ring pit plantation, Road side plantation, plantation in every government offices and Individual house holds	● Enforcement of acts/rules and regulation of forest conservation ● Commercialization of forest produces. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/societies for conservation and monitoring ● Development of forest as a tourist centers and other recreational activities	All district departments	Year wise
Nohar	No acts/rules are applicable; none of the components of the subproject are located in forest.	Afforestation under different state level schemes are under progress. Year wise plantation target allocation followed	● Enforcement of acts/rules and regulation of forest conservation ● Commercialization of forest produces. ● Development of forest as a tourist centers and other recreational activities. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/societies for conservation and monitoring	Forest Department	Year wise
Bhadara	No acts/rules are applicable; none of the components of the subproject are located in forest.	For small level of plantations like Vriksh Kunj, Panchwati etc, NGOs should be involved with budgetary provisions	● Enforcement of acts/rules and regulation of forest conservation ● Commercialization of forest produces. ● Development of forest as a tourist centers and other recreational activities. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/societies for conservation and monitoring	Forest Department /District Collector Office	Year wise
Tibbi	No acts/rules are applicable; none of the components of the subproject are located in forest.	Hanumangarh has very less forest area. So agro-forestry must be promoted with subsidy to the farmers to promote large fruit bearing/shady trees in their lands.	● Enforcement of acts/rules and regulation of forest conservation ● Commercialization of forest produces. ● Development of forest as a tourist centers and other recreational activities. ● Management and monitoring of forest in the area ● Constitution of eco-clubs/societies for conservation and monitoring	Forest Department, Agriculture department	Year wise

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