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CLIMATE RESILIENT CITY ACTION PLAN NAGPUR MAHARASHTRA, INDIA

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01 BACKGROUND

1.1 Introduction

Since the beginning of this century, the global and national discourse on sustainable development and subsequently climate resilient development has been significantly shaping the development paradigm in cities, especially in developing countries.

The adoption of several international agreements such as Paris Agreement, 2030 Agenda for Sustainable Development and UN-Habitat's 2016 New Urban Agenda etc. marks a turning point where the role of local governments (LGs) in global climate action has been recognized as well as encouraged.

LGs are central to efforts towards tackling climate change, as has been acknowledged by major agendas such as sustainable development goals (SDGs) and the Paris Agreement. Cities can lead climate action by framing strategies and programmes, integrating such actions into ongoing urban development and forging partnerships necessary for effective climate responses.

Globally, cities are at the frontline of climate emergency, responsible for up to 70% of global greenhouse gas (GHG) emissions, 80% of global GDP and constituting 55% of the global population. With two-thirds of the global population expected to live in cities by 2050, cities will have to transform themselves into climate resilient and liveable places for people to live and work. The Intergovernmental Panel on Climate Change (IPCC) 2018 Special Report on Global Warming of 1.5°C (SR1.5) highlighted the need for coordinated actions by all actors including sub-national and non-state, as part of the crucial framework for achieving the 1.5°C goal.

The COVID-19 pandemic has compelled policy makers and other urban stakeholders to reimagine how people live, work and connect in cities. It also brought forth the vulnerability of cities, despite being the country's engines of economic growth. Undoubtedly, the urban growth policies and actions undertaken in the near future will be critical in achieving global climate and sustainability goals.

Indian cities will soon be home to about 600 million people, nearly twice the population of the United States. This enormous social, economic and spatial transformation could create unprecedented development opportunities if city growth is proactively managed to realize the benefits. The population of India is expected to increase from 121.1 Cr. to 151.8 Cr. during 2011-2036 - an increase of 25 percent in 25 years at the rate of one percent annually. Therefore, the density of population will increase from 368 to 462 persons per sq. km. Of the projected about 31 Cr., 17 Cr. or nearly 50 percent of India's demographic growth during 2011-2036 is projected to take place in five states, namely Bihar, Uttar Pradesh, Maharashtra, West Bengal and Madhya Pradesh[1].

India's urban population growth rate is one of the highest globally. According to India's National Commission on Population (NCP), roughly 38.6% of Indians (600 million) will live in cities by 2036. According to the UN, India's urban population will nearly double between 2018 and 2050, from 461 million to 877 million people.

Maharashtra is one of India's highly urbanised states and a major financial contributor to the country's economy. Nagpur, the second capital and third largest city of Maharashtra, is experiencing rapid urban growth due to its geographical position, which is almost the centre of India.

Nagpur is emerging as a major medical, logistics and education hub. Rapid urbanization here is accompanied by a number of challenges, including insufficient urban planning and management, lack of coordination among agencies, increased energy consumption and GHG emissions, insufficient solid waste and sewerage management, resultant environmental issues such as pollution etc. With climate change, these challenges and resulting impact are most likely to be exacerbated.

Globally, cities are at the frontline of climate emergency, responsible for up to 70% of global greenhouse gas (GHG) emissions, 80% of global GDP and constituting 55% of the global population

1 National Commission on Population, Ministry of Health & Family Welfare, 2019. *Population Projections for India and states 2011–2036, Report of the technical group on population projections.*

As climate change disproportionately affects poor and vulnerable populations, it is not only an environmental issue but inextricably linked to challenges the United Nations currently addresses i.e. the 17 interlinked SDGs.

In this regard, the development and implementation of the Climate Resilient City Action Plan or CRCAP for Nagpur will not only address systemic risks and pursue transformation over the long term, but also help meet immediate needs of creating sustainable jobs, improving urban service delivery and alleviating poverty.

The development of a climate action plan will help Nagpur to understand and effectively respond to climate change impact. Implementing the actions suggested in the plan will help Nagpur contribute towards national targets under the Paris Agreement and the SDGs, as well as attract international finance for a green economic recovery following the COVID-19 pandemic. Lastly, it will help distribute the benefits of climate action equitably amongst the city's citizens.

Overall, the CRCAP approach is to create an enabling ecosystem for mainstreaming climate action by creating necessary institutional mechanisms, technical capabilities and communication channels between stakeholders for horizontal and vertical integration. This would facilitate achieving climate compatible urban development that contributes to India's Nationally Determined Contributions (NDCs) and ensures achievement of SDGs.

Approach

ICLEI South Asia, in partnership with UN Habitat, is supporting the Nagpur Municipal Corporation (NMC) in implementing the Urban Low Emissions Development Strategy (Urban LEDS) Phase II, to transition the city into a low emissions, resilient, green, and inclusive urban economy. The Urban LEDS project is being implemented in more than 60 cities in eight countries: Brazil, India, Indonesia, South Africa, Bangladesh, Colombia, Lao PDR and Rwanda. In India, Nagpur and Thane are the two model cities part of the Urban LEDS project. The ClimateResilientCities is the guiding methodology used in planning for LED strategies in the Urban LEDS project cities.

The CRCAP for Nagpur is a step in the direction of achieving the long-term vision of integrating comprehensive and resilient approaches in the city's development objectives, planning and processes. Haphazard urbanization, high urban sprawl, increased infrastructure demand and fast-growing energy demand are contributing to environmental and urban service degradation in Nagpur. There is an urgent need for decisive actions on urban governance, technology, data and innovation in the city. The CRCAP for Nagpur provides a comprehensive assessment of urban issues, GHG emissions from urban activities and services, and impact of climate change on urban infrastructure; and suggests potential strategies and actions to increase urban climate resilience.

Indian cities will soon be home to about 600 million people, nearly twice the population of the United States. This enormous social, economic and spatial transformation could create unprecedented development opportunities if city growth is proactively managed to realize the benefits

1.2 Methodology followed to prepare the Climate Resilient City Action Plan

Defining Climate Resilience: Climate resilience is defined as the capacity for a socio-ecological system to (1) absorb stresses and maintain function in the face of external stresses imposed upon it by climate change and (2) adapt, reorganize, and evolve into more desirable configurations that improve sustainability of the system, leaving it better prepared for future climate change impacts (Folke 2006)[2]. Therefore, planning for urban resilience should involve considering the activities that release GHGs and proposing actions that not only help reduce the sources of emissions but also help the city to adapt to the challenges of climate change, such as sea level rise, temperature and precipitation changes or extreme events.

The CRCAP for Nagpur has been developed using the ClimateResilientCities methodology, tailor made for LGs, providing step by step guidance for developing a CRCAP that addresses climate change adaptation, mitigation, as well as the linkages therein.

Maharashtra is one of India's highly urbanised states and a major financial contributor to the country's economy

The process equips LGs to:

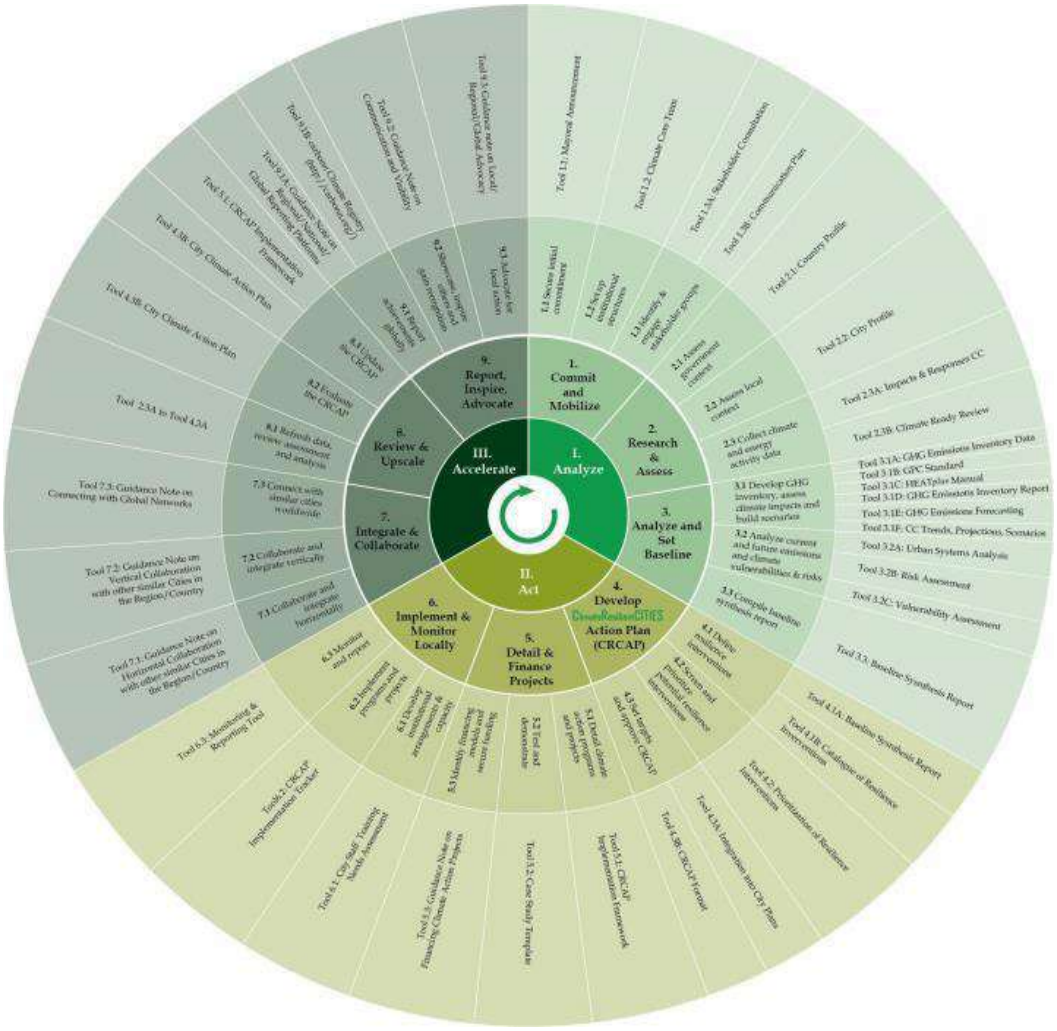
1. estimate the GHG emissions intensity of city activities;
2. assess the climate risks of various systems in the city in the context of urbanization and vulnerability;
3. identify actions to address existing and forecasted climate fragility; and
4. develop an implementation and monitoring plan which will not only help the city to adapt to existing and impending climate change impact but also steer the city's focus to climate change mitigation measures.

This process builds on ICLEI's flagship mitigation program i.e. Cities for Climate Protection (CCP) Campaign, the GreenClimateCities (GCC) program and ICLEI's adaptation tool-kit i.e. the ICLEI Asian Cities Climate Change Resilience Network (ACCCRN) Process or IAP toolkit.

Overview of ClimateResilientCities Methodology

The ClimateResilientCities methodology was followed to develop the CRCAP for Nagpur. The CRCAP is a 9-step process in 3 phases: ***Analyze, Act and Accelerate*** - each unfolding into three steps - outlining how climate fragility can be assessed and climate resilient options (to achieve low emissions and climate adaptive development) can be identified and integrated into urban development policies, plans and processes. It consists of a wide range of tools and guidance notes to support LGs to deliver effective local climate action. The figure below shows the steps and various tools used in the methodology.

2 Folke, C., 2006. Resilience: The emergence of a perspective for social–ecological systems analyses. *Global Environmental Change*, [online] 16(3), pp.253-267. Available at: <http://dx.doi.org/10.1016/j.gloenvcha.2006.04.002>.



The CRCAP is the result of implementing steps 1 to 4 in Nagpur. The tools provided in the toolkit have been adapted to suit the purposes of the city.

To institutionalize climate action planning and implementation, a City level Climate Core Team & Stakeholder Committee was was formed by NSSCDCL and NMC.

Step 1: Commit and Mobilize

1.1 Secure initial commitment – It is very important to ensure senior political and local government buy-in to kick-start the process for climate resilient development in the community and provide clear leadership. As political, executive and administrative support are required for successful planning and implementation of climate action plans, a project Memorandum of Understanding (MoU) was signed with NMC and ICLEI-South Asia as project partners, in the presence of the Mayor, Commissioner and other key officials. This indicates NMC's intent to address climate change through mitigation and adaptation measures.

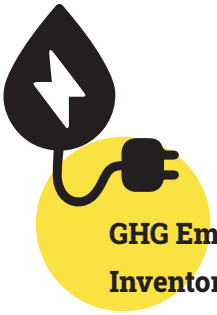
1.2 Set up institutional structures - A Climate Core Team was set up by Nagpur Smart and Sustainable City Development Corporation Limited (NSSCDCL) and NMC on 08 March 2019 using Tool 1.2 (Climate Core Team – See Annexure 1), which is comprised of 5 nominated officials from various relevant departments of NSSCDCL and NMC including the Municipal Commissioner, Chief Executive Officer and is chaired by the Mayor (See Annexure 1). This Team was involved at all steps of preparing the CRCAP and supporting internal institutional capacity building to effectively fulfil the long-term climate resilience plan requirements by effective integration of planned initiatives into the city's development plans.

1.3 Identify and engage stakeholder groups - The climate action planning process should be supported by consultation with other groups in the city, such as government agencies, local NGOs, community leaders, university partners and

private sector organizations, to appropriately share responsibilities and ensure ownership. A city level Stakeholder Committee was formed and notified by NSSCDCL and NMC using Tool 1.3A (Stakeholder Committee) (See Annexure 1) on 08 March 2019 comprising 40 members chaired by the Mayor for multi-way process of dialogue and deliberation within the Climate Core Team and with other stakeholders, as well as amongst stakeholders themselves. A Communication Plan was prepared for communication within the core team, with other departments of NMC and with the external Stakeholder Committee and the community at large.

Step 2: Research and Assess

2.1 Assess local context - It is very important to assess local policies, on-going projects and economic, social and environmental contexts at the local level, which would impact climate resilient development in the city. Local issues with respect to the environment and urban development (socio-economic status, demography, municipal services, energy consumption (electricity and fuel) within the city limit) were identified and discussed with the core team. A baseline assessment of the urban systems was conducted for assessment of climate change impact and influences urban development activities, and to identify the kind of support required by NMC to address such impact. Based on the information collected, a City Profile was developed for an assessment of climate vulnerable urban systems and carbon intensive activities using Tool 2.2 (City Profile) (See Chapter 2).



GHG Emissions Inventory for Nagpur is prepared considering stationary fuel and electricity consumption for community and government sectors for baseline year 2017-18

Step 3: Analyze and Set Baseline

3.1 Develop GHG emissions inventory, assess climate impact and build scenarios

- Base data was collected using Tool 3.1A (Energy and GHG Emissions Inventory – Data Format) for stationary fuel and electricity consumption by all community and government sectors. This necessitated collection of relevant data from NMC and external agencies such as utilities, which had the required information, as well as determining data gaps. NMC staff members engaged through meetings and letters with a number of municipal, local and sub-national stakeholders to source the relevant energy consumption data focusing on the large carbon emitters within the municipal area. Supply and demand-side data was collected and analyzed.
- A GHG emissions inventory report was developed to determine sources of GHG emissions in NMC operations and the whole community, using the Harmonized Emissions Analysis Tool plus (HEAT+) GHG emissions inventory online software tool and protocols using Tool 3.1B (Global Protocol for Community Scale GHG Emissions Inventories) or GPC and Tool 3.1C (HEAT+ Manual) (See Chapter 3 - Sections 3.1 & 3.2).
- The GPC inventory includes emissions from community/city-wide activities within the NMC jurisdiction, including emissions from NMC activities and use. This includes emissions from sources and/or activities from stationary units (residential, commercial/institutional, industrial, construction and agricultural), mobile transportation units and waste. This is a useful planning tool in developing mitigation actions for the entire community.
- The LG operations inventory includes emissions from all operations that NMC owns or controls. Sectors included in an LG operations inventory include NMC buildings; and facilities such as street lighting and traffic lighting, water, waste and sewerage facilities and municipal vehicle fleet.
- Energy consumption projection was done for medium term (until 2030-31) and long term (for 2040-41 & 2050-51) planning. Energy consumption from municipal services was forecasted based on population projections and municipal service delivery based on existing and future city planning. Based on a forecasting of the energy consumption, the corresponding GHG emissions were calculated through the HEAT+ software using Tool 3.1E (GHG Emissions Forecasting).

3.2 Identify fragile urban systems, climate vulnerabilities and risks - Core and secondary urban systems were examined to identify fragile urban systems and the impact of climate change on them using Tool 3.2A (Urban Systems Analysis). For each fragile urban system, key vulnerable areas (geographical areas) and the vulnerable population were assessed and identified. The qualitative information gathered from the stakeholder group through Shared Learning Dialogue (SLD) and quantitative information from the city was studied to assess vulnerability using Tool 3.2C (Vulnerability Assessment). The adaptive capacities of the urban systems were also assessed after consultation with stakeholders. Based on likelihood and consequences, the risk for all critical fragile urban systems was assessed after consultation with the Stakeholder Committee and the Climate Core Team. Some qualitative attributes of the fragile sectors were analyzed to identify climate risk for Nagpur using Tool 3.2B (Risk Assessment).

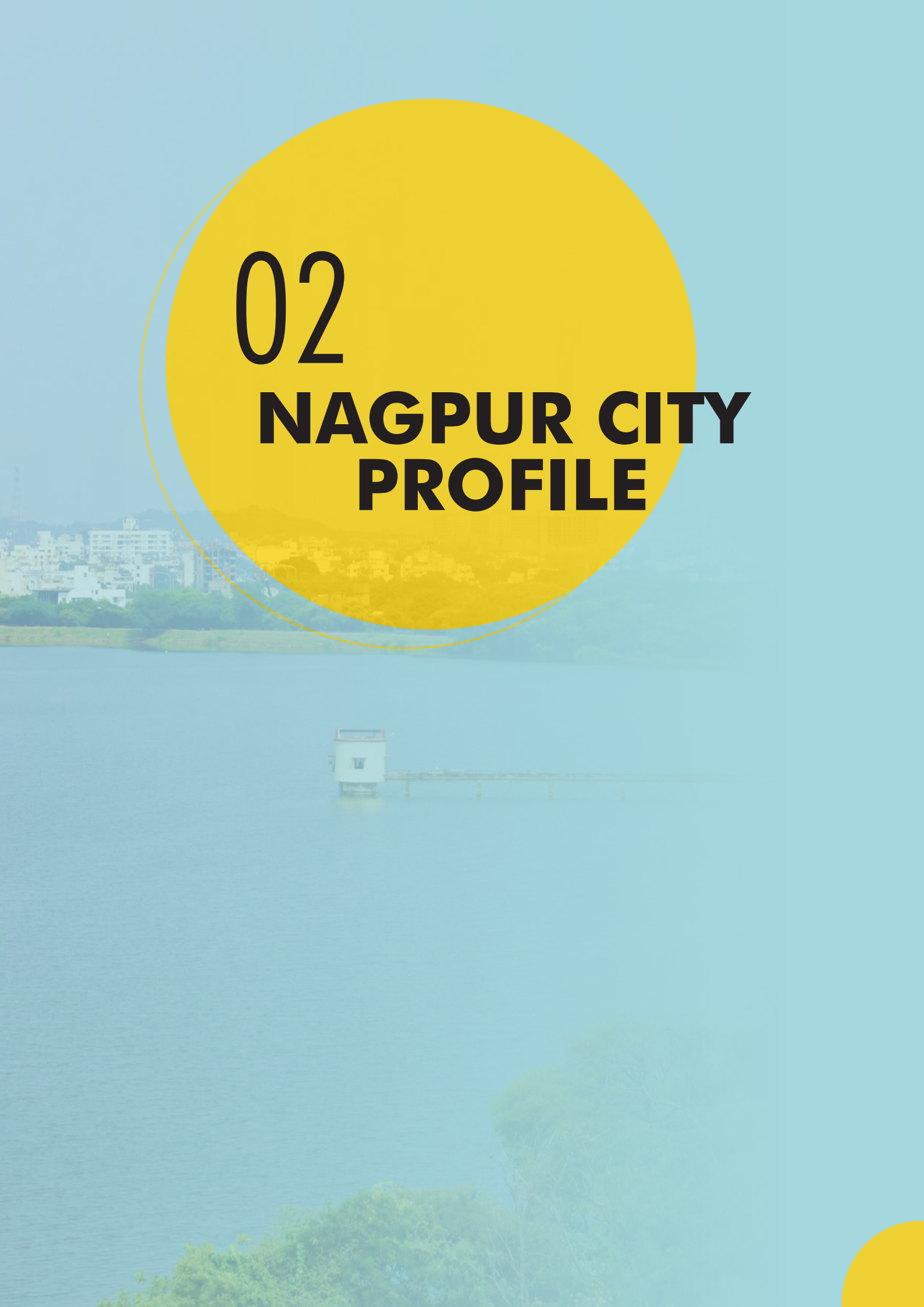
Step 4: Develop Climate Resilient Cities Action Plan

4.1 Define resilience interventions - Various mitigation and adaptation interventions were identified for Nagpur based on GHG emissions inventory and urban systems analysis in line with existing city planning. Mitigation and adaptation potential for each intervention along with financial aspect and implementation mode were identified in line with NMC's ongoing projects and future planning, using Tool 4.1A (Resilience Interventions).

4.2 Screen and prioritize potential resilience interventions - Based on feasibility and impact assessment, Resilience Interventions were prioritized using Tool 4.2 (Prioritization of Resilience Interventions).

4.3 Set targets and approve CRCAP - Interventions were linked to existing/ongoing/ planned initiatives within the city to assess possibilities of leveraging existing funding opportunities to implement the action plan, using Tool 4.3A (Integration into City Plans). Targets were set to move towards outcomes under the climate action plan, which can relate to GHG "avoidance" or "reduction" and/or achievement of adaptation measures and to socio-economic indicators.

A formal Council approval will provide an opportunity for political review, recommendations and adoption of the CRCAP.



02
NAGPUR CITY PROFILE

2.1 Location

Nagpur is the third largest city in Maharashtra. It serves as the winter capital of the state, hosts the winter session of the state assembly, and is thereby an important administrative centre. Nagpur has a population of approximately 2.4 million persons (Census 2011) with a density of roughly 11,000 persons/sq. km.

The name Nagpur is derived from the Nag River, which flows through the city. Nagpur, one of the greenest cities in India, is also known as Orange City for its leading position in the cultivation of orange fruit. The city is located between 78°30" to 79°30"E and 20°30" to 21°45"N latitude, which is at the exact geographical centre of India and has lowland features. It lies on the Deccan Plateau of the Indian Peninsula and has a mean altitude of 310.5 meters above sea level. A city with tropical wet and dry climatic conditions, Nagpur experiences seasonal weather patterns with an annual average rainfall of about 1,100 mm, and is known for its hot and dry summers where temperatures can go up to 48°C in May.

The name Nagpur is derived from the Nag River, which flows through the city. Nagpur, one of the greenest cities in India, is also known as Orange City due to Orange fruit cultivation in the region.

2.2 Connectivity

Given its central location in India, Nagpur has the inherent advantage of distance and connectivity with all the important Indian cities through various modes of transport. The city is well placed to serve as a transport hub, connecting major Indian cities to one another and to international destinations.

Figure 1: Nagpur city's road and railway network[3]

3 Comprehensive Mobility Plan (CMP), Nagpur

Nagpur city at Glance Size - 227.28 km² (square km)

Population - 2.4 Million (2011 Census)

Population growth rate (per annum) – 1.25%

Urbanisation rate - 100%
urbanization within the city limits

City annual budget (US dollars) – 2796.07
Cr proposed for 2021-22

Two important national highways, NH-7 (Varanasi-Kanyakumari) that connects north and south India and NH-6 (Mumbai-Sambalpur-Kolkata) that connects west and east India, pass through Nagpur. An ultra-modern, 701 km long and 120 meter wide, eight-lane expressway called 'Maharashtra Samruddhi Mahamarg' is under construction to connect Nagpur to Mumbai. The city also has arterial roads to improve connectivity with the Vidarbha region and inner and outer ring roads to help decongest city traffic.

Similarly, in case of rail network, Nagpur benefits from its strategic location at the intersection of nationally important broad gauge rail lines of the Central Railway and South Eastern Railway networks (Mumbai-Kolkata and Delhi-Chennai). The Nagpur Central Railway Station is thus an important railway junction and connected to other major metro cities of India via a fully electrified broad gauge railway track.

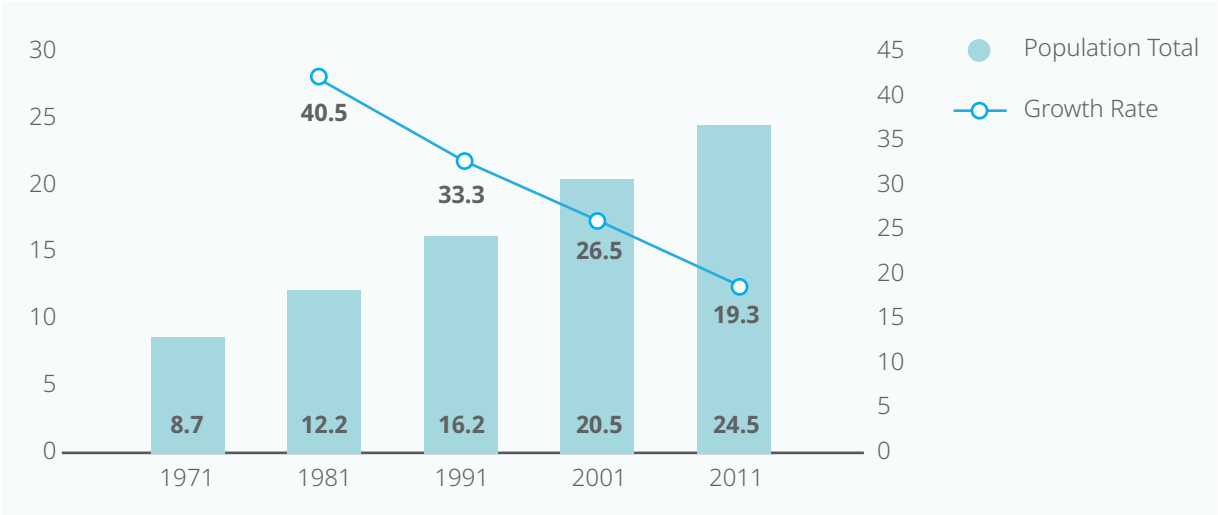
Apart from these metropolitan regions, Nagpur is also connected to other major cities of India like Ahmedabad, Hyderabad, Pune, Jammu, Amritsar, Lucknow, Varanasi, Kochi, Thiruvananthapuram, Bangalore, Mangalore and Visakhapatnam through 160 trains passing through the city. Within the city limits, there are smaller railway stations located at Ajni, Itwari, Kalamna, Kamptee and Khapri. Figure 1 shows the road and rail network in Nagpur city.

Nagpur has an airport located near Sonegaon, 7.5 km to the southwest of Nagpur city, connected to 37 destinations within India. It also caters to international destinations including Saudi Arabia, Sharjah, Doha, Dubai, Singapore and Bangkok. The Multimodal International Hub Airport (MIHAN) project envisages transforming this airport into an international passenger and cargo hub.

2.3 Demography

Nagpur is spread over an area of 227.28 sq. km. with a population of 2.4 million and average population density of 10,873 persons/sq. km. This is approximately 15% higher than the population density from the previous decade (9,400 persons/sq. km.). Although Nagpur's population has seen a steady increase since 1971 and has grown every decade, the decadal growth percentage has been on the decline. From Figure 2, it is evident that the last census (2001-11) saw less population growth than the previous. Further investigation revealed that during this decade, Nagpur witnessed only natural growth; the addition of migration population was nominal.

Figure 2: Population growth trend of Nagpur from 1971 to 2011[4]

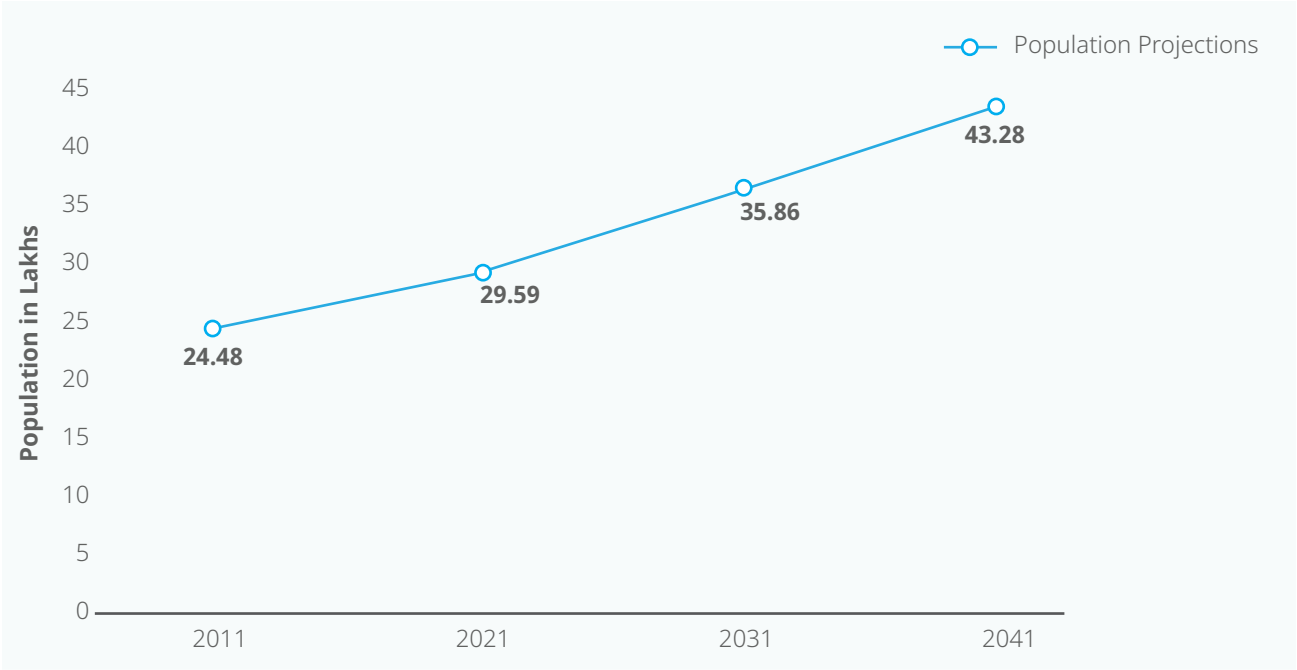


4 Census of India, 2011 and analysis by CRISIL

Declining growth rate in population is attributed to the limited economic opportunities in the city. Although Nagpur is a base for various economic activities, and is home to the much-awaited MIHAN project, with potential for development of IT parks and industries in the future, the economic growth potential has not been fully realised, affecting economic competitiveness vis-a-vis other cities.

Nagpur is the main hub for Vidarbha region's urbanization and serves as a growth centre for neighboring districts. The city has witnessed less in-migration during the period 2001-2011, indicating that perhaps Nagpur has been unable to provide adequate employment opportunities for the educated youth, which typically propels out-migration in an Indian context. Any climatic disruptions can have an additional negative impact on the city's growth and economy.

Figure 3: Population projection for Nagpur until 2041[5]



Based on the population trends during the last four decades and other factors, projections estimate that Nagpur's population would increase to 2.96 million in 2021, 3.59 million in 2031 and 4.33 million in 2041 (Figure 3). From the decadal change in the population projection, it is evident that population growth is expected to be at around 20% in coming decades.

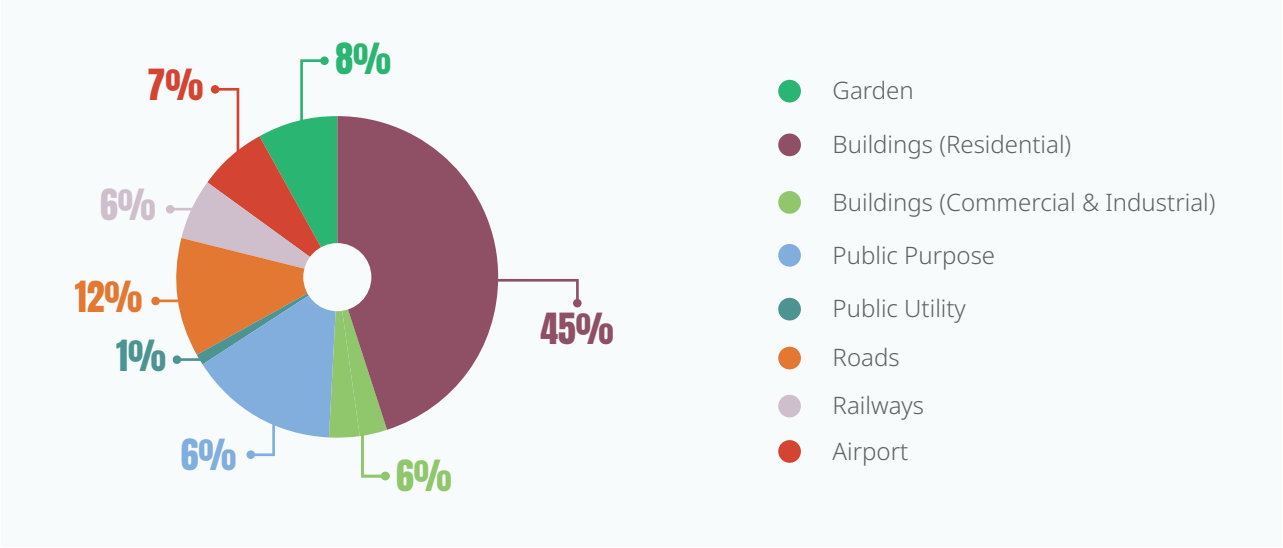
According to the Census of India, 2011, the literacy rate of the total population of Nagpur is 92%. Male literacy stands at about 90%, and female literacy at about 78%. The literacy rate has increased from 2001 to 2011 due to increase in school enrolments.

2.4 Land Use

Majority of the land in Nagpur is developed for residential purposes (45%), followed by the land under public use (41%), as of 2011 (Figure 4). Commercial and industrial developments occupy 6% of the city's land; 8% is under parks and gardens.

5 City Development Plan, Nagpur, 2015

Figure 4: Existing land use breakup of Nagpur - 2011[6]



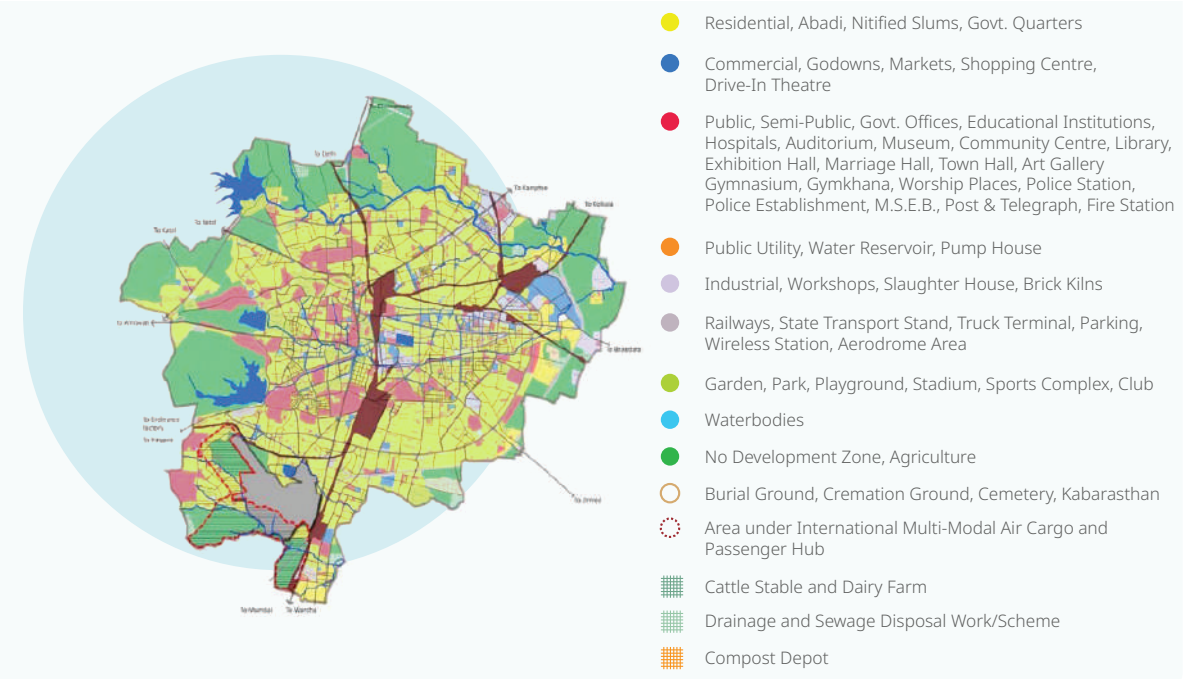
According to the Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines, the existing break up of land use conforms to the norms in the cases of land under residential use, commercial use and public use. The portion of land under industrial and recreational uses does not conform to URDPFI norms. Though land under recreational use is less than the prescribed norms, the large forest cover in the city adequately complements this.

Most of the development in the Nagpur Metropolitan Area (NMA) is either an outgrowth or expansion of Nagpur city. While Nagpur city's urban sprawl is taking place horizontally, it is important to note that the transportation corridors are key drivers of this expansion as they not only facilitate the city's development but also connect urban growth centres. The fringe areas of the city witness major urban growth along the transportation corridors. The corridors and the majority of the developed areas are sprawled outside the city on the south side near the outer ring road.

From Figure 5, it is clear that most of the development is taking place in the central areas. The peripheral areas of Nagpur are relatively less developed. The open spaces available within city limits are limited, and those available are scattered and are in the form of large land parcels. This is attributed to factors such as houses having a smaller footprint, presence of 424 slums covering 25% of the city, and around 62% of the land falling under the category of undevelopable land.

6 City Development Plan, Nagpur, 2015

Figure 5: Nagpur's existing Development Plan[7]



The revised Development Plan published in 2015 by NMC considers 235 sq. km. area, of which 227.28 sq. km. is under NMC jurisdiction and 7.72 sq. km. is located outside NMC limits. As part of the plan, an area of 17.65 sq. km. is earmarked for sewerage and drainage disposal schemes and the entire development area has been divided into 7 planning zones for preparing the development plan. The newly merged census town located outside city limits is spread over an area of 7.72 sq. km. and will be considered as a part of NMC area for future development under the revised Development Plan, 2015.

Table 1: Proposed land use for Nagpur city - 2021 and 2031[8]

Sr.No.	Land use	2021			2031		
		Area in Hectares	% of developed area	% of total area	Area in Hectares	% of developed area	% of total area
1	Residential	6,706	44	**30**	7000	47	**32**
2	Commercial	501	3	**2**	700	5	**3**
3	Industrial	495	3	**2**	800	5	**4**
4	Public Purpose	2,312	15	**11**	2312	15	**11**
5	Public Utility	149	1	**1**	150	1	**1**
6	Roads	1,754	12	**8**	1800	12	**8**
7	Railways	873	6	**4**	900	6	**4**
8	Airport	993	7	**5**	1000	7	**5**
9	Garden	1,251	8	**6**	1300	9	**6**
10	Developable Vacant Land	0	0	**0**	0	0	**0**
	Total	**15,033**	**100**	**69**	**15,962**	**100**	**73**
11	Agriculture Land	5,774		**27**	4,846		**22**
12	Water Bodies & Nallahs	463		**2**	463		**2**

7 Nagpur Metropolitan Area Development Plan 2012 - 2032
8 City Development Plan for Nagpur, 2041

Sr.No.	Land use	2021			2031		
		Area in Hectares	% of developed area	% of total area	Area in Hectares	% of developed area	% of total area
13	Non-Developable Land	0		0	0		0
14	Drainage & Sewage Disposal	141		1	141		1
15	Cattle Stable & Dairy Farm	212		1	212		1
16	Compost Depot	131		1	131		1
		6,723		31	5793		27
	Grand Total	21,756		100	21,756		100

2.5 Economic Activities

Primary sector

Nagpur district is mostly known for its agricultural land, with a cultivable area of 6,440 sq. km. out of 9,892 sq. km. The district is moderately rich in minerals, with deposits of coal, manganese ore, dolomite, limestone, iron ore, clay, copper ore, chromite, tungsten ore, zinc ore, quartz etc. Floriculture and fish farming are other prominent economic activities taking place here. The primary sector is not a key contributor to the city's economy as most of these activities happen outside the city.

Secondary sector

The peripheral areas of Nagpur are home to various industries such as chemicals, cement, electrical, electronics, textile, ceramics, pharmaceuticals, food processing, wood and paper-based industries. These contribute to the city's economy and support local economic development. The MIHAN project is an economic development project currently underway in Nagpur. It is expected to be spread over an area of 4,025 hectares at an estimated cost of INR 20,000 billion. Besides the airport, the proposed project involves a road-rail terminal, a special economic zone (SEZ) and other urban amenities which will boost employment and thereby the city's economy. As of March 2017, Nagpur region had 3,674 industrial units worth an overall investment of INR 160,570 million, operating in the industrial area developed by Maharashtra Industrial Development Corporation (MIDC).

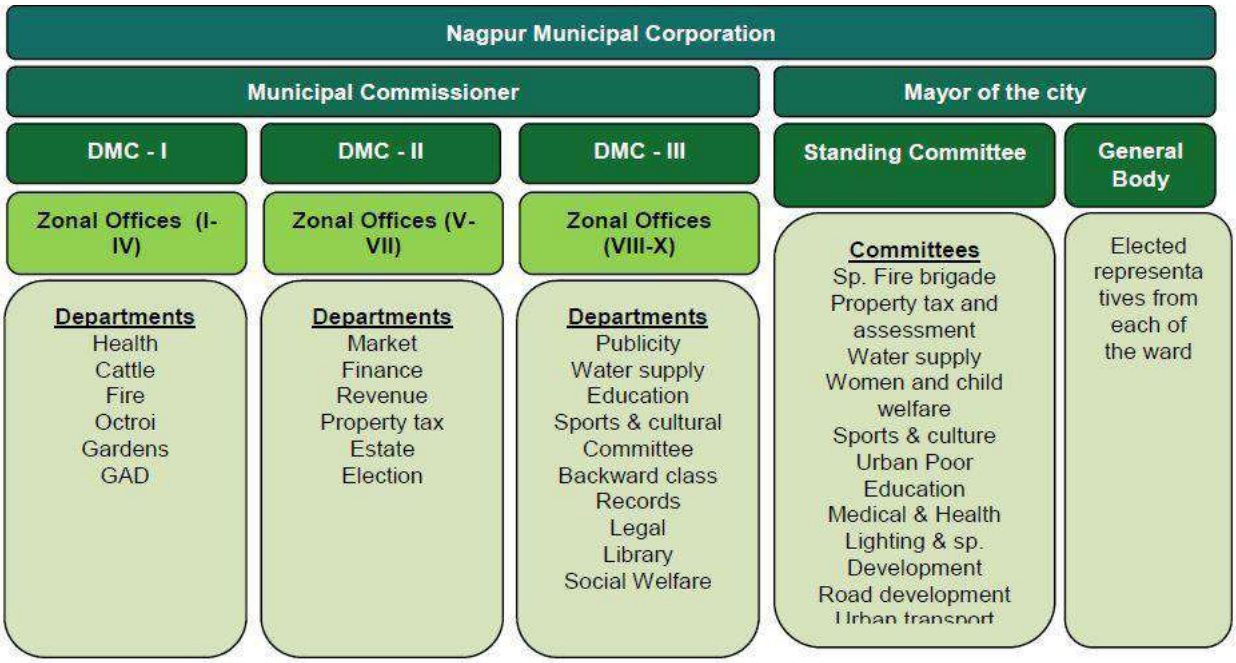
Tertiary sector

Markets (formal and informal) form an integral part of Nagpur's economic profile. Nagpur has a number of retail and wholesale markets with a variety of goods and services. These markets include small shops and hawkers. The Market Department of the NMC is tasked for looking after such establishments and is responsible for providing services like land allocation, maintenance, operation and construction of new markets. It also collects rents from vendors and shop owners. Nagpur has a few information technology (IT) industries within the city's jurisdiction limits with the potential to accommodate more IT parks.

2.6 Urban Governance - Nagpur

The NMC is the democratically elected civic governing body of Nagpur and the primary agency responsible for its urban governance. The city is divided into 10 administrative zones, further divided into 38 Prabhags, made up of 138 wards. The governing body of NMC comprises of the elected and the administrative wings. The elected political wing is headed by the Mayor and the administrative wing is headed by the Municipal Commissioner, who is the chief executive head and looks after city administration. The politically elected representatives together constitute the general body of the NMC. Figure 6 gives the organizational structure of NMC.

Figure 6: Organizational structure of NMC[9]



NMC is responsible for providing core urban services such as street lighting; construction and maintenance of roads, streets and flyovers; solid waste management (SWM); sewage treatment and disposal; public hygiene; disaster management; maintenance of parks and open spaces, cemeteries and crematoria; registration of births and deaths; conservation of heritage sites; disease control and immunization; and running of public municipal schools.

NSSCDCL is a Special Purpose Vehicle (SPV) established to implement the Government of India's (GoI) Smart Cities Mission (SCM) in Nagpur. NSSCDCL's main objective is to plan, design, and perform technical and financial appraisals; and construct, maintain and operate the projects envisaged in NMC's Smart City proposal approved by the GoI.

The Nagpur Improvement Trust (NIT) and Nagpur Metropolitan Region Development Authority (NMRDA) are the local planning authorities responsible for the development of the larger metropolitan area, including Nagpur city and its surrounding areas. NIT is responsible for carrying out the developmental works for improving civic infrastructure across the metropolitan area and for new urban areas coming up within NMC's jurisdiction. NIT ensures conformity of new building development with Development Control Regulations (DCRs). In cases where NIT develops building layouts and schemes, it also oversees planning and development of core civic functions such as water supply and construction of roads.

The city is divided into 10 administrative zones, further divided into 38 Prabhags, made up of 138 wards. The governing body of NMC comprises of the elected and the administrative wings

9 General Administration Department (GAD), NMC, Nagpur

2.7 Major Urban Systems

Water Supply

Present scenario

Water distribution - Nagpur's water supply is dependent on surface water/reservoirs, which are shared by the neighbouring state of Madhya Pradesh. NMC is the authority responsible for supplying adequate quality and quantity of water to its citizens. Maharashtra Water Resource Regulatory Authority (MWRRA) allocates water resources to all cities in Maharashtra. As per the regulations and results in 2017, Nagpur falls under the 'less than five million city population' criterion, and is required to supply 135 litres per capita per day (lpcd) to citizens.

Since 2017, the water quantity allocated to NMC through various resources is as follows:

1. Kanhan River: 65.71 million cubic metre (MMC)
2. Pench Reservoir, Navegaon Khairi
   a. Long-term allocation: 112 MMC
   b. Additional temporary supply until further decision: 78 MMC

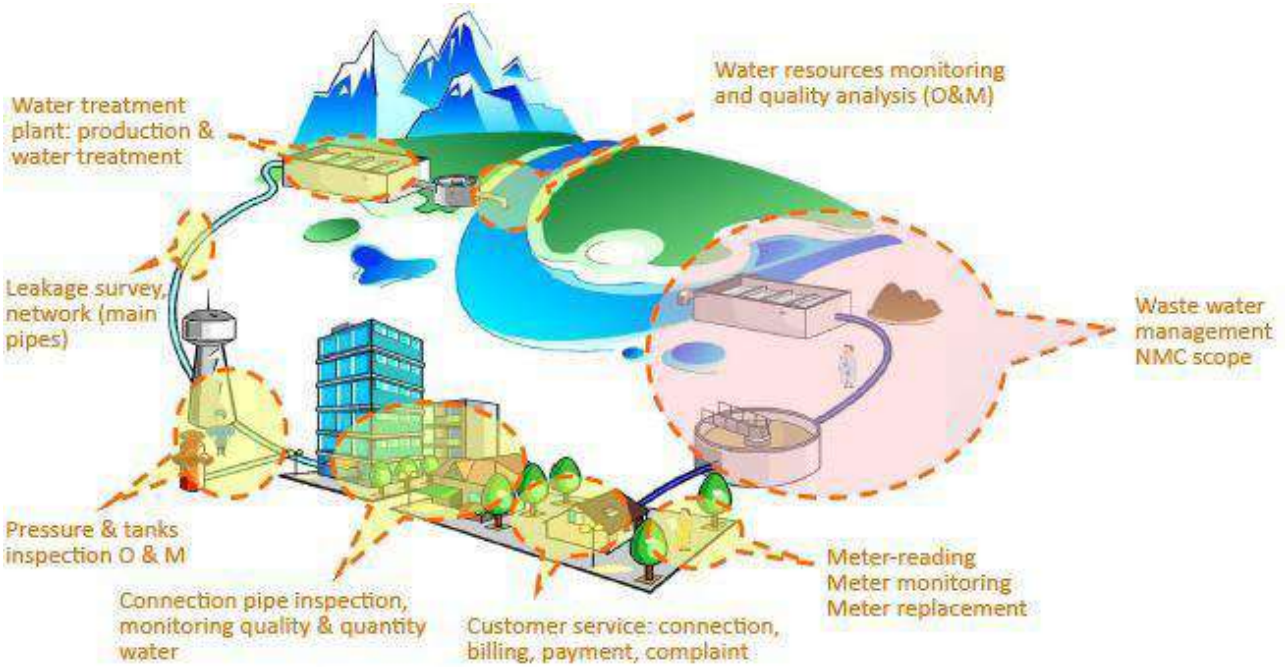
Total water allocation to NMC: 255.71 MMC

90% of the households have water supply connections. Daily supply of water is about 232 lpcd including losses, with average water supply of nine hours per day.

According to NMC data, 90% of the households have water supply connections. Daily supply of water is about 232 lpcd including losses, with average water supply of nine hours per day.

In November 2011, NMC initiated the 24x7 water supply project in collaboration with Orange City Water Private Limited (OCW) in PPP mode for 25 years through an NMC SPV called Nagpur Environmental Services Limited (NESL). NMC, NESL and OCW signed a tri-party agreement. The project successfully enhanced the water supply service in Nagpur, from water treatment to distribution, and operation & maintenance (O&M) to billing, using the SCADA system.

Figure 7: Responsibility of OCW under PPP for 24 x 7 Water Supply Project with NMC



In spite of the success of the 24*7 water supply project, Non-Revenue Water (NRW) remained high at approximately 50% as of FY 2018-19, when NMC supplied 645 MLD on an average, out of which only 334 MLD was billed water supply.

At present, 570,000 out of 625,000 properties are served with water supply; where about 368,022 are metered connections. The total distribution network spans 3,200 km. Before implementing the 24*7 project, NMC conducted water audits in identified areas and found that 37% of the reported leaks are from the household connection network. The tertiary network with a pipeline diameter below 150 mm has 90%+ reported leaks.

Nagpur has 5,244 bore wells and gets approximately 10 MLD ground water, used for non-drinking purposes like washing, animal cleaning etc.

Capacity of water supply - Total actual capacity of five water treatment plants (WTPs) in Nagpur is 786 MLD. The daily average of treated water produced is 645 MLD.

At present, 570,000 out of 625,000 properties are served with water supply; where about 368,022 are metered connections

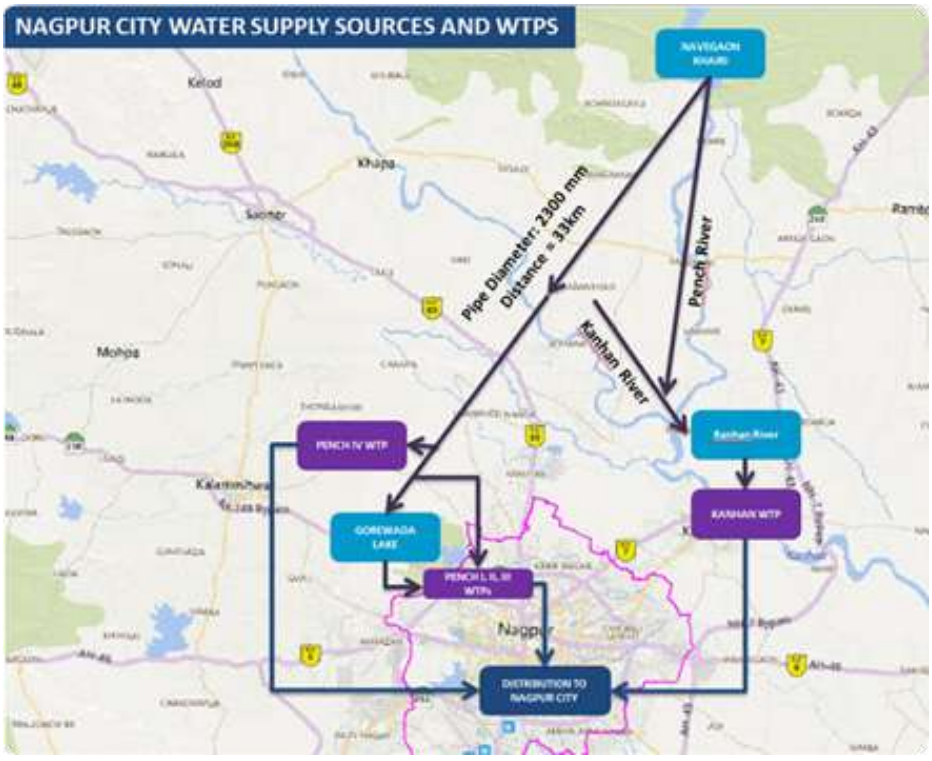
Table 2: Nagpur's existing water supply and treatment capacity

S No	Name of WTP	Water treatment capacity (MLD)	Existing water supply status (MLD)
1	Kanhan WTP - Kamti	240	185
2	Pench WTP - Phase 1 - Gorewada	136	145
3	Pench WTP - Phase 2 - Gorewada	175	120
4	Pench WTP - Phase 3 - Gorewada	120	105
5	Pench WTP - Phase 1 - Godhani	115	90
	Total	**786**	**645**

Source: Water Works Department, NMC, July 2019

Water treatment - Kanhan River and Pench reservoir are the primary sources of raw water for Nagpur city. NMC receives approximately 185 MLD water from Kanhan River (18 km from Nagpur) and 460 MLD from Nawegaon Khairi Pench reservoir (35 km from Nagpur), supplied to Pench - I, II, III - Gorewada & Pench IV - Godhani WTPs through 2,300 mm pipeline by gravity, then to households through Master Balancing Reservoirs (MBR)/Ground Storage Reservoirs (GSR)/ Elevated Service Reservoirs (ESR). Water is supplied to northern, eastern and some part of central Nagpur via the Kanhan pumping station and the remaining area is catered to by the Pench WTPs. Old Gorewada WTP (developed in 1911) with 16 MLD water treatment capacity was shut down in July 2017, due to age, leakage and increased O&M costs.

Figure 8: Water Treatment Plants in Nagpur



Source: Orange City Water

Consumers can pay their water bills through OCW's online billing payment portal. For O&M ease, OCW has divided Nagpur into 68 command areas and 10 zone-wise offices/facilitation centres for citizens to avail water supply related services

Water taxes - OCW is managing the entire city's water distribution system under the 24*7 water supply project. Consumers can pay their water bills through OCW's online billing payment portal. For O&M ease, OCW has divided Nagpur into 68 command areas and 10 zone-wise offices/facilitation centres for citizens to avail water supply related services. OCW has established a 24*7 help line for citizens to get information and lodge service-related complaints. OCW categorizes complaints into water quality (muddy water - mostly in monsoon), leakage, low-pressure water, water billing etc. and maintains a monthly record to monitor progress.

In 2018-19, 3% of the 20,095 water samples tested were unfit. Satranjipura, Ashi Nagar, Lakadganj, Lakshmi Nagar and Dhantoli zones face more issues than others in the city. This is primarily because the slum areas under NIT jurisdiction are outside NMC's jurisdictional control.

Table 3: NMC water supply consumer number status (metered)

Category	Consumer type	Numbers
R1	Independent house, flat scheme, religious places, row house etc.	261,445
S	Huts, RCC house up to 500 sq. ft.	96,007
IA	Private hostels, computer training institutes	1,641
IB	Charitable institutions, schools/colleges, banks, offices etc.	4,063
C1A	Bedded hospitals, hotels, marriage halls, lawns etc.	3,779
C1B	Petrol pumps, swimming pools, washing centres, construction sites etc.	1,035
C2	Bottling plants, amusement parks, ice factories, water parks etc.	52
	Total	**368,022**

Source: Water Works Department, NMC

Table 4: NMC's current water tariff

Rates/Month For Water Consumption			Monthly Water Charges As Per Size & Category Per Tenement In Rs.										
			15	20	25	40	50	80	100	150	200	250	300
Category	Billing Slab	Rs. Per Unit	Units	Units	Units	Units	Units	Units	Units	Units	Units	Units	Units
			10	20	30	60	85	150	215	425	725	1110	1580
Residential (R1)	1-20	7.75	77.57	155.13	279.24	791.19	1248.81	2761.37	4273.92	9160.58	16141.58	25100.49	36037.35
	21-30	12.41											
	31-80	17.08											
	Above 80	23.27											
Institutional (IA)	1-20	20.16	201.69	403.34	636.05	1334.16	1939.17	3754.21	5569.27	11433.30	19810.47	30561.16	43685.40
	21-80	23.27											
	Above 80	27.92											
Institutional (IB)	1-20	23.27	232.70	465.40	729.12	1520.29	2202.88	4219.62	6236.34	12751.91	22059.89	34005.12	48587.60
	21-80	26.36											
	Above 80	31.04											
Commercial (C1A)	1-20	38.79	387.83	775.66	1318.65	2947.52	4382.49	8920.15	13457.78	28117.82	49060.75	75937.52	108748.11
	21-80	54.31											
	Above 80	69.80											
Commercial (C1B)	1-20	38.79	387.83	775.66	1551.34	3878.32	6011.39	13574.11	21136.84	45570.27	80475.16	125269.75	179954.09
	21-80	77.57											
	Above 80	116.35											
Commercial (C2)	1-30	93.08	930.81	1861.59	2792.41	11169.57	18150.53	64224.99	118676.61	294597.23	545912.40	868433.54	1262160.63
	31-100	279.24											
	Above 100	837.72											
Slum (S)	1-20	7.75	Minimum Water Charges For Slum In Rs.										
	21-30	12.41	Hut						RCC Houses Up to 500 sq. ft. area				
	31-80	17.08	Up to 15 Units						Up to 20 Units				
	Above 80	23.27	46.54						77.57				

Source: Water Works Department, NMC

Ongoing/planned projects

- 24*7 water supply project: It was approved in 2009-10 under GoI's Jawaharlal Nehru National Urban Renewal Mission (JNNURM) scheme with a total budget of INR 387.86 Cr. (INR 393.09 Cr. revised) with GoI, Government of Maharashtra (GoM) and NMC's share being 20%, 44% and 36% respectively. NMC is implementing the project in PPP mode funding worth INR 116.36 Cr. and own funding worth INR 23.28 Cr. The financial progress of the project as of 2019-20 is at 82.3%. As the project is being implemented since 2011, major work such as augmenting WTP capacity, replacing pipeline of 2,000 mm diameter, repair/replacement of sluice gate, construction of Sitabuldi GSR, and replacing pipeline of length 676 km has been completed. NMC implemented this project in the pilot area at Dharampeth zone with 15,000 connections, leak detection, water audits etc., and expanded the project phase wise throughout the city. The following projects/activities are underway:

    1. 686.44 km pipeline replaced/laid, out of the 676 km proposed pipeline: OCW has laid/replaced the pipeline in new households/areas as well. The contract terms for OCW have been extended to enhance water supply services in additional areas of the city.
    2. Approximate size of pipelines and material used: Distribution line up to 315 mm - HDPE material and DI used for replacement work etc. up to 600 mm diameter; Above 600 mm diameter, MS material has been used.
    3. House service connections: Overall progress is approximately 75%
    4. Electromagnetic flow meter: 175 No - 125 No (71.42%) Electromagnetic type flow meters installed at elevated reservoirs outlets, feeder lines etc.
    5. P/L/L/J Butterfly valves at MBR, GSR and ESR: 337 No - 220 No (65.28%)
    6. Data Logger: 130 No - 80 No (61.54%)
    7. Construction of administrative building: Location to be finalized
    8. 2,000 mm diameter pipeline replacement completed from Back Pressure Tank (BPT) to Pench I, II, III & Gorewada which carries raw water MS pipeline - 2.312 km

- Water supply network in legal/illegal/slum areas of Nagpur: AMRUT - Cost INR 280 Cr – WAPCOS India Limited.
- Kolar-Kanhan Barrage: A barrage is proposed near NMC's existing Kamtee WTP where Kolar and Kanhan rivers meet, to fulfil January onwards water demand, which goes up due to water supply shortage. Kanhan River meets the demand from July to December. WAPCOS India Limited is working with NMC on a project, being implemented through NMC's yearly budget, to provide necessary technical support so NMC can increase its water sourcing from Kanhan River from 60 MMC to 109 MMC. The following projects are under progress as part of this project:

    1. Rohana water-lifting project: To reduce the Pench reservoir's burden of water supply to Nagpur by 60 MMC, water lifting from Kanhan River is proposed via the existing 2,300 mm pipeline, which crosses the river near Rohana village. WAPCOS India Limited was expected to complete this project by January 2021.
    2. Rahri barrage project: A barrage is proposed on Kanhan River, at approximately 35 km from Nagpur near Rahri village, to supply water to the eastern and southern part of the city.

- Under the Urban-LEDS II project, Nagpur has undertaken a technical study to identify potential areas for ground water recharge along with suitable technologies to augment the city's declining ground water table. Pilot projects are being implemented along with IoT based solutions to monitor ground water level and quality remotely.

Nagpur has undertaken a technical study to identify potential areas for ground water recharge along with suitable technologies to augment the city's ground water table.

Water storage capacity - NMC has 71 storage tanks established cross the city, of approximately 215 ML total capacity (Table 5).

Table 5: Details of elevated storage reservoirs

S. No.	Description of water tanks	Numbers	Storage capacity, ML
1	Existing (old)	43	150.79
2	Under Pench - IV phase	24	54.48
3	Completed	22	52.21
4	Functional	22	47.67
5	Near completion (NMC)	2	6.81
6	Under Construction (NIT)	4	12.47

Table 6: Future water demand

Year	Demand (Treated water)	Treated water Supply	Future source (MLD)
2011	532	470	113 (Pench-IV Additional + Kanhan Augmentation)
2021	670	650 (2019-20)	113 (Pench-IV) + 175 (Rahri-1)
2031	802	650 (2019-20)	113 (Pench-IV) + 175 (Rahri-I) + 175 (Rahri-II)
2041	975	650 (2019-20)	
As on 2019-20, total water availability is 766 MLD			

Issues identified

Condition of surface water

Nagpur's water supply situation has improved significantly in the period 2010-2020. Completion of work on the pipeline of diameter 2,300 mm and length approximately 25-30 km has considerably reduced system losses (savings of 130 MLD) and helped improve water quality. However, the city still faces NRW losses up to 50%, causing strain on the water supply system in terms of higher per capita supply than the set norms; illegal water connections; inadequate network and infrastructure etc.

Operation

Since 2011, NMC has successfully completed major works planned under the 24*7 water supply project, such as replacing old water pumps (installed before 2000), replacing canal water transmission with pipeline and saving approximately 130 MLD, increasing water treatment capacity through the new PENCH IV WTP, rehabilitating old pipelines, restoring old storage tanks, installing bulk water meters etc. NMC also undertook energy audits in coordination with Energy Efficiency Services Limited (EESL) to check energy savings' potential at various stages.

NMC has adopted a telescopic tariff structure, which enables consumers to monitor water consumption, thereby increasing awareness. Due to positive pressure in the feeder lines, the problem of external contamination has reduced.

NMC's Water Supply Department has divided Nagpur into 68 command areas to ensure consistent supply of quality water. However, approximately 25 command areas have been fully covered while others are not fully catered to, causing unequal water supply throughout the city.

Ground water

NMC has been promoting rainwater harvesting (RWH) and ground water recharge in Nagpur. To promote RWH, NMC has formed a committee under the guidance of the former Mayor. Properties with an RWH system are eligible for a 5% tax property rebate, as per building byelaws. However, the city does not have any monitoring mechanism to check if properties are adhering to the building byelaws or adopting necessary methods and technologies for proper ground water recharge without any contamination.

Solid Waste Management

Present scenario

At the dumping yard in the Bhandewadi area, at approximately 10 km from the city centre, NMC is reclaiming 50 acres of land on one of the land parcels through a bio-mining project, and intends to similarly clear another 30 acres from the remaining land parcels. Apart from a waste to compost facility that treats 200 TPD of waste, NMC does not have any waste treatment plant.

Under GoI's Smart City Mission, NMC has set up a Smart Strip in a specific area of 5 km length with about 20 bins equipped with volume-based sensors. The bins send signals to the command control centre, which assigns pickup trucks installed with GPS tracking system, for waste collection and transportation.

Waste generation and composition – The main sources of waste generation are households, institutions, markets and commercial establishments (hotels, restaurants, shops etc.), and vegetable and fruit markets.

A municipal solid waste (MSW) management feasibility study was undertaken in Nagpur in 2016-17 as part of the URBAN NEXUS project (funded by BMZ, implemented by GIZ). 34 samples were collected from all 10 zones in Nagpur in April/May 2017 and tested for physical and chemical composition analysis, including bio-methane potential. Results from the waste characterization indicate that the average waste composition for Nagpur includes organics (approximately 60%) along with plastics (16%), paper (11%) and inserts (2%). The remaining 11% consists of wood, metal, glass etc.

The MSW samples were also tested for chemical parameters such as pH, moisture content, Total Solids (TS), Total Volatile Solids (TVS), ash, calorific value, Chemical Oxygen Demand (COD), average density and C/N ratio. The waste from Nagpur has 24% COD; average waste density is 440 kg/m^3; C/N ratio is approximately 24; average moisture content is 56%, TS is 44%, TVS is 70%, ash content is 31% and calorific value is 1,089 kcal/kg. The samples were also analyzed for their bio-methane potential, which indicated a biogas yield of 93 m^3/tonnes of organic waste and an average methane yield of 45 m^3/tonne. The biogas methane percentage was estimated at around 49%.

The average waste composition for Nagpur includes organics (approximately 60%) along with plastics (16%), paper (11%) and inserts (2%). The remaining 11% consists of wood, metal, glass etc

Waste quantity - The total daily waste generated in Nagpur is approximately 1,200 MT/ day for 2019-20.

Waste segregation – Nagpur is called Bin-Free city as previous administrative heads eradicated bins because of the adverse effect on health and liveability. NMC is in contract with a private entity responsible for door-to-door waste collection and transportation. The entire vehicle fleet has separate compartments for dry, wet, hazardous waste etc. that ensure segregated waste collection. At present, 20% waste is being segregated in Nagpur. Although there are no byelaws mandating waste segregation for households, NMC has been creating awareness among people regarding waste segregation at source through citywide awareness programs under the Swachh Bharat Scheme. However, despite all efforts, the problem of waste segregation at source persists.

Household level coverage of SWM services – Door-to-door collection coverage is over 90%, although not all the wards are covered. Regular MSW dumping in open plots continues. NMC has awarded the work of collection and transportation of solid waste to two private entities.

In 2019, GoM mandated collection of user fee for door-to-door waste collection based on user categories (residential, commercial, educational, religious places, government offices etc.) and suggested fine for non-segregated waste but NMC is yet to implement this mandate. The suggested user fee for residential category is 60 INR and higher for other categories. NMC already collects fees from bulk consumers, to be revised after the mandate is in place. A proper user charges' collection system is not in place and less than 5% properties pay the charges, when levied.

Since 2004, NMC has collaborated with a private entity called Superb Hygienic in PPP mode for handling Nagpur's bio-medical waste for a period of 25 years. Superb Hygienic is in touch with most of the hospitals in Nagpur for collection and scientific disposal of approximately 2.5 MT/D of bio medical waste. However, across the city, some clinics/ hospitals continue to dump biomedical waste unscientifically in open areas. Superb Hygienics's operations have not been smooth although NMC has set up a committee (nuisance squad) to oversee bio-medical waste handling and take necessary action in the form of penalizing the relevant stakeholders.

Transportation - Waste from open plots and slums is transported manually and/or mechanically through a variety of vehicles. These areas are not covered while street sweeping. Tipper vans are used for primary door-to-door collection. Hydraulic Dumper, Hydraulic Dumper Placer, trucks etc. are used for transportation to the dumping site. However, illegal open dumping is still an issue. Waste dumping in storm water drains causes clogging and water pollution, leading to water borne diseases and adverse impact on health.

NMC's in-house staff, 7,000 at present, carries out street sweeping and drain cleaning. The total road length for street sweeping is about 3,400 km, carried out in morning (6 to 11 am) and evening (3 to 6 pm) shifts

NMC's in-house staff, 7,000 at present, carries out street sweeping and drain cleaning. The total road length for street sweeping is about 3,400 km, carried out in morning (6 to 11 am) and evening (3 to 6 pm) shifts. Each worker sweeps daily an average street length of 700 m (maximum 900 m, minimum 500 m depending upon population density). They use handcarts to transport silt from roads and open drains to the nearest collection centre for further transportation and disposal to the dumping site by KRML. NMC has issued GPS enabled wrist watches to track sweeper movements in allocated areas, to tackle the key challenge of insufficient supervisory staff and unsatisfactory supervision by the existing staff. NMC plans to introduce street sweeping machines for timely cleaning of streets and footpaths, though the tender is yet to be published.

Waste processing - Waste from Nagpur is disposed at the open dumping site at Bhandewadi, equipped with a 200 TPD compost and RDF facility. Nagpur has two dumping sites situated one km apart, at one of which, under a bio-mining project since 2019-end, sophisticated machinery is used to segregate solid waste, which is then utilized for different purposes. Combustible waste is transported to cement factories; coarse soil/stone aggregates are used to fill low-lying areas; fine soil is used for plantation/ afforestation; and metal/glass scrap is sent to relevant industries. It is planned to clear, through an agency, 50 acres of land to treat 10 lakh MT of waste in 2-4 years from this

dumping site. From the bio-mining project planned on the other dumping site, NMC will segregate more than 10 lakh MT of waste estimated to be dumped there and reclaim around 30-40 acre area. The tender is to be floated shortly.

Ongoing/planned projects

- 600 TPD waste to compost: NMC plans to establish a waste to compost plant near an existing landfill site. NMC and the Smart City team are finalising the project's tender specifications and funding mechanism. NMC will release its budget for 2021-22 in the first quarter of 2021.
- 380 TPD of centralized MRF and RDF plant and 150 TPD of C&D waste treatment plant: Tender documents of all the projects are ready; to be commissioned by 2022-23.
- Bio mining on existing dumping site: NMC has planned to initiate bio mining at one of the dumping sites to reclaim approximately 30-40 acre of land. 40 Cr. funds have been secured for the project.
- Garden waste compost: NMC is planning to install waste composters in large gardens of capacity 500 - 1,000 kg in 10 gardens to reduce the burden on landfills and prevent biomass burning. Funding for the project is yet to be decided but can be accessed through the SCM.

NMC has initiated bio-mining project to reclaim approximately 40 Acre of land by clearing 1 Mn MT of legacy waste.

Issues identified

- Segregation at source is a major issue in Nagpur. Under the Swachh Bharat Mission, NMC conducts several awareness programs among citizens so they segregate waste into dry and wet waste for collection by the door-to-door collection vehicles[10]. The performance is improving, with 20% waste segregated at present and expected to increase further.
- Nagpur lacks a waste treatment plant or a scientific landfill. Approximately 1,100 - 1,200 TPD waste is disposed at dumping yards, causing nuisance for surrounding areas. The planned treatment plants will be operational in 2022-23.
- Lack of proper user charges' collection system for waste management services being provided by the urban local body (ULB)
- Insufficient scientific handling and treatment of bio-medical waste

95% of households have access to a toilet while 5% use community toilets. About 65% of the properties are connected to the underground sewer line, although most of the gravity-based sewer lines are connected with open nullahs and rivers.

Wastewater and Stormwater Drainage

Waste water generation and coverage present scenario

NMC is responsible for developing a long-term perspective plan for water supply and sewerage; and rejuvenation of lakes, rivers and nullahs with reuse of storm water and RWH in the city. 95% of households have access to a toilet while 5% use community toilets. About 65% of the properties are connected to the underground sewer line, although most of the gravity-based sewer lines are connected with open nullahs and rivers. The total length of sewers in the city is 1,474 km with size ranging from 100 mm to 2,100 mm diameter with short stretches of larger rectangular brick sewers.

Total sewage generation in Nagpur is approximately 500 MLD against the current treatment capacity of 340 MLD. The untreated sewage is discharged into Nag, Pioli and Pora Rivers and their tributaries. Most of the sewer connections are quite old; upgradation has been carried out in a few areas of the city. These lines are not connected to the main lines, which carry the wastewater to treatment plants. Existing sewer lines are clogged due to solid waste dumping and encroachments in and around the nullahs. Central Nagpur has a good sewerage network and is well connected to the existing sewage treatment

10 In Swachh Survekshan 2019, Nagpur was ranked 58th (3,160 points out of 5,000); and 1,138 out of 1,250 in the Direct Observation category.

plant (STP) at Bhandewadi. The STP consists of a Conventional Activated Sludge Plant (CASP) with sludge digestion tanks and drying beds.

An inadequate sewerage system has led to an inefficient storm water drainage system in Nagpur. As the city undergoes rapid change with major projects like metro rail coming up, housing development changing with high-rise buildings replacing bungalows, and development of ring roads and new bridges, the natural water percolation process is being affected. With heavy rains and the clogged existing drainage system, flash floods occur in various areas of Nagpur, causing further wear and tear of existing infrastructure.

As the sewage and polluted storm water meet the rivers, Nagpur's ground water quality is deteriorating day by day. At present, storm water drains cover approximately 40% of the city's area.

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Baseline information in terms of user coverage and access

Table 7: Sewerage system coverage in terms of population and area covered

Zones	Total gross area (Hectare)	Total population (2011)	Sewered area (Hectare)	Population served	Percent of Sewered area	Percent of population served
North	8,419	824,489	4,126	634,082	56%	77%
Central	8,169	1,053,272	4,286	913,914	68%	87%
South	5,168	672,039	3,286	492,071	74%	73%
Total	**21,756**	**2,549,800**	**11,698**	**2,040,067**	**64%**	**80%**

Source: NMC DPR – Preparation of master plan for sewerage system of Nagpur

Existing sewage treatment plants, tariff structure and operation - NMC collects about 12% of property tax as sewerage charges annually. There are four functional STPs within NMC area; adequacy of sewage treatment capacity is 68%. NMC entered into a PPP agreement with a private firm for O&M of an STP with 200 MLD capacity for a period of 25 years. Near this plant, another STP with 130 MLD capacity is being operated by MAHAGENCO or Maharashtra State Power Generation Company Limited (MSPGCL), which uses the treated wastewater for the operation of a thermal power plant. This STP is funded partially under the AMRUT mission by GoI (50%) and state government (30%) and the remaining by MAHAGENCO under a PPP with NMC. NMC has allotted the land required for setting up the plant. NMC earns approximately INR 15 Cr. annually through sale of wastewater to MAHAGENCO. This unique project by NMC has been recognized by the GoI. Two other lower capacity STPs of 5 MLD each operate at different locations of Nagpur.

Storm Water Drainage present scenario:

There are three water streams Nag, Pioli and Pora River which carry storm water in Nagpur city, through major & minor nullahs. Pioli river flows from north-west to the eastern part of the city carrying stormwater from west & north Nagpur. Nag river starts from Ambazari lake on western end and flows towards east through the central part of the city carrying stormwater through all parts of the city surrounding it. Pora river is in southern region and carries southern part of stormwater drains.

As per the records of 2019 year, NMC maintains about 2950 km lengths of roads out of which only 1020 km of roads have covered storm water drains, which is merely 35 % of pucca storm water drains.

Issues Identified in Sewage sector:

- Inadequate sewerage network and ageing infrastructure
- Approximately 65% wastewater is being treated. Rest of the sewage flows directly to nullahs and rivers because of which the city's rivers are highly polluted, affecting allied ecosystems and services.
- Risks and hazards from clogging of storm water drains due to solid waste dumping and mixing of sewage and storm water drains

Issues identified in stormwater drains sector:

- Flooding of storm water drains in monsoon season due to inadequate stormwater drains coverage
- Mixing of sewage with storm water drains causing flooding of stormwater drains and creating unhealthy conditions.
- Heavy silting and blockage of storm water due to sewage mixing and solid waste disposal in open storm water drains.
- Polluted surface and ground water due to direct discharge of sewage & storm into fresh water streams.

Ongoing/planned projects

- NMC is working on the Nag River rejuvenation project includes establishment of STPs, laying/repairing of sewerage pipelines in the city. The total project cost is approximately INR 2,400 Cr., of which NMC's share will be 15% and the rest will be provided by JICA as a soft loan to GoI. The funds will be transferred to NMC via GoM.
- NMC has divided the city into three zones for planning sewage treatment and is planning to augment existing infrastructure in the central zone for which a private firm has prepared the draft plan.
- NMC is planning to conduct a citywide geographic information system (GIS) based survey to map existing sewerage network in Nagpur and will plan for 100% sewer network based on the results.
- For upgradation work, pipe material of Double Walled Corrugated Polyethylene (DWCPE), with a standard length of six meters (160 mm outer diameter to 315 mm inner diameter) is planned, to enable easy transportation and handling and reduce the number of joints required. SN-8 type pipes, which can hold load up to 8.0 KN/ m^2 are proposed in the collection system. RCC pipes for sewer depth greater than 3 meters, diameters exceeding 300 mm, RCC non-pressure pipes conforming to IS:458 are adopted. The diameter of RCC pipes ranges from 150 mm to 1,800 mm.
- NMC has prepared master plan for drainage systems and rejuvenation of lakes & rivers for the year 2041. NMC has initiated the work in phased manner, in southern-zone of the city by preparing detailed project report to revamp stormwater drainage system.

There are four functional STPs within NMC area; adequacy of sewage treatment capacity is 68%. NMC entered into a PPP agreement with a private firm for O&M of an STP with 200 MLD capacity for a period of 25 years

Transport

To promote clean mobility, NMC has converted 50+ of its diesel run buses with CNG and is planning to procure 40 E-Buses with 6 E-buses already in the fleet.

Present scenario

Being at the geographical centre of India, Nagpur has excellent connectivity of roads and railways. National highways 6, 7 and 69 are examples, connecting Nagpur with major Indian states. The upcoming state-of-the-art Samruddhi highway of around 700 km to connect Mumbai and Nagpur is expected to bring down the travelling time of 14-16 hours by 8 hours. A green field project of international standards, aimed at boosting the city's economy, is being constructed with smart and sustainable features such as surveillance network, lighting, RWH, landscaping etc.

As per the city's year 2019 data, total length of roads maintained by ULB is about 2950 km. Nagpur's internal road network is robust in terms of quality and connectivity. There are two ring roads, inner and outer ring road, which justify the city's radial growth. As per the Comprehensive Mobility Plan (CMP), most of the roads (almost 80%) have footpaths but these are unsuitable for pedestrians due to encroachments. Further, the lack of dedicated cycle tracks and pedestrian crossings, and unauthorized parking, add to the congestion.

In order to tackle the issue of traffic due to increasing number of private vehicles, the local administration, with financial support from Agence Française de Développement (AFD) and GoI, is developing a metro rail network. Two major lines (alignments) are open to the public but their use is rising only gradually as the shift from private to public transport is slow and intermediate metro stations are still under construction. Alignment 1 i.e. north-south corridor is 19.65 km in track length, with 18 stations. Alignment 2 i.e. east-west corridor is 18.55 km in track length, with 20 stations. 19 feeder routes stretching up to 160 km and equipped with feeder services such as shuttle buses, battery operated vehicles, pedestrian friendly infrastructure, public bicycle sharing facility etc. have been included in the project for first and last mile connectivity. The project is being co-financed by AFD through sovereign concessional loans amounting to Euro 130 million. AFD is also implementing Mobilize Your City (MYC) program in Nagpur with funding assistance from European Commission (EU) to provide technical assistance to the city to promote sustainable public transport, capacity building of local government officials via prefeasibility studies, various urban planning and mobility tools to effectively reduce transport related GHG emissions.

Nagpur' CMP was prepared in December 2013 by NIT in consultation with the Urban Mass Transit Company (UMTC). NMC is working with various international agencies such as International Urban Cooperation (IUC) and AFD to promote public transport and introduce bicycle tracks in Nagpur.

Nagpur's public transport includes city buses and bus rapid transit (BRT) buses for internal transportation. NMC has 332 public buses plying in various parts. The ridership of the city bus service is more than 1,48,000 per day with over 40,800 passengers using passes and 17,600 travelling on concessional rates.

NMC is working towards eco-friendly public transport to reduce air pollution. Under the guidance of the transport ministry, NMC recently set up two CNG filling stations. NMC has no LNG/CNG network like other metro cities such as Mumbai or Delhi. NMC is planning to convert 30-40 diesel buses to CNG in the next financial year, in addition to the approximately 50 already converted.

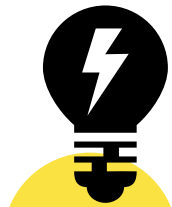
Nagpur is one of the few Indian cities to initiate public electric vehicles (EV) charging infrastructure. The city facilitated a private company in introducing a fleet of 200 e-taxis in the city. Nagpur has approximately five EV charging stations across the city, of which the one at Suresh Bhat Auditorium runs on solar energy. NMC also introduced 50 ethanol fuel-based buses to boost consumption of sustainable fuels like ethanol in India. These buses are no longer in operation as the contract between NMC and the operator has ended.

NMC has introduced six electric buses and plans to purchase approximately 40 more under the Faster Adoption and Manufacturing of (Hybrid &) Electric Vehicles- II phase (FAME II), scheme with funding assistance from GoI. By employing women conductors in these buses, NMC promotes women's empowerment. NMC is revising its public transport budget for the coming years.

To implement innovative ways to promote pedestrian friendly environment in major junctions of Nagpur, the city police have initiated a pedestrian only green signal at Variety Square, which halts vehicular traffic for 30 seconds, allowing pedestrians to cross the junction from all sides.

NSSCDCL has installed display boards at most of the bus stops, which mention the buses' estimated time of arrival.

Under India's Smart City Mission, NMC has established a command control centre in the main administrative building to monitor the city's public areas with the help of a CCTV network. Ten environmental sensors have been set up in a pilot area of the city to monitor air pollution via the command control centre.



As per Maharashtra State Electricity Distribution Company Limited (MSEDCL), residential (60%) and commercial buildings (35%) consume more energy in Nagpur as compared to industrial or other consumers, with average annual growth rate (AAGR) of 4% as per 5 years' data

Ongoing/planned projects

- Procurement of approximately 40 electric buses under the FAME II scheme and employing women as drivers and conductors to promote women's empowerment and safety: Ongoing in a phased manner through the grant received by the city
- Conversion of 30-40 diesel buses to CNG: On-going in a phased manner
- Development of dedicated bicycle tracks in the city to promote non-motorized transport (NMT): Detailed project report (DPR) under preparation
- Innovative traffic management mechanisms to promote pedestrian friendly areas: Pilot project completed on a 5 km road stretch under the SCM

Issues identified

- Public transport facilities such as bus services are inadequate considering the city's population and coverage.
- The metro rail project is under implementation and few routes are open to the public but last mile connectivity needs to be strengthened and NMT aspects to be considered.
- NMC's pace of converting fossil fuel based public bus services to CNG or adding new electric buses in the fleet is slow, compared to other cities in the region.

Buildings

Present scenario

Nagpur, the 3rd largest city in Maharashtra and 13th largest in India, is one of the cities witnessing rapid growth in the country. As per data from Maharashtra State Electricity Distribution Company Limited (MSEDCL), residential (60%) and commercial buildings (35%) consume more energy in Nagpur as compared to industrial or other consumers, with average annual growth rate (AAGR) of 4% as per 5 years' data. Nagpur consumed 1,822

million kWh in 2017-18 with peak demand of approximately 200 million kWh in April and May, which is almost double the winter consumption.

Nagpur witnesses very harsh summers. As the cooling demand peaks in summer, spreading the use of renewable energy (RE) technologies and improving building energy efficiency (EE) plays a crucial role. Almost 25% of the city's population i.e., about 0.8 Mn lives in slums in 424 slum pockets spread across the city. NMC has taken up various on ground initiatives such as implementing the Solar City project developed by the Ministry of New and Renewable Energy (MNRE), wherein rooftop solar PV systems have been installed on public buildings to promote RE uptake in Nagpur.

NMC encourages private stakeholders to adopt RE and EE aspects in built areas as well as in upcoming building development through rebates to the tune of 5% to 10% in property tax. For installing solar hot water systems on residential rooftops, NMC grants subsidies up to 50%. So far, 2,800 such systems have been installed in Nagpur.

The e-governance department of NMC, with the assistance of a private company using the GEO CIVIC Citizen Portal tool, is developing a digital map of all the properties in Nagpur. Through a unique ID number, the map will allow access to each property's details, including area, photograph, property tax details and status, energy bill etc. This exercise is helping NMC improve its tax collection efficiency, a primary factor for the city's revenue generation. This will improve transparency in property tax collection and overall property management by making accurate property and tax information accessible to citizens in real time.

NSSCDCL is developing affordable housing scheme based on Green Building principles. Under Building Efficiency Accelerator (BEA) project, housing scheme project designs were reviewd to

In terms of building EE improvements, NMC has replaced conventional tube lights (8,400) and fans (2,400) with energy efficient LED lights and power saving fans respectively, in NMC owned public buildings, zonal offices etc. Additionally, NMC has carried out energy audits in facility buildings such as WTPs to replace old water pumps with new ones, to correct power factors wherever required to improve overall system efficiency and has established SCADA system in the water supply sector.

NMC encourages citizens to take advantage of several schemes run by state nodal agencies like Maharashtra Energy Development Agency (MEDA) and national agencies like MNRE, which provides subsidies in the range of 30% for installing solar PV systems in their premises.

NMC collaborated with ICLEI South Asia and World Resources Institute (WRI) to implement the Building Efficiency Accelerator (BEA) project to improve building EE in Nagpur. NSSCDCL is coming up with an affordable housing scheme of 1,000 dwelling units, to be built with green building principles and applying the learnings from the BEA project. A technical guideline has been developed for residential schemes, which envisages including EE improvement aspects. The guideline is useful at various stages of the project such as building orientation, building materials, window sizing, window to wall ratios, cool-roofs, daylight saving, cross ventilation, centralized evaporative cooling etc. The guideline is customized to Nagpur's setting in terms of its geography, location and weather patterns.

NSSCDCL undertook benchmarking studies, walk through audits and investment grade audits in selected public buildings (NMC zonal offices), private buildings (medium sized hotels) and residential buildings (multi-storied apartments and bungalows) to understand Nagpur's energy consumption patterns, best practices, and EE improvement opportunities. A best practices document has been prepared, which includes recommendations across all building aspects such as building's electrical cabling, distribution and balancing, retrofitting with tentative costs and return on investments (ROIs), and possible financial models to implement the suggested measures.

Ongoing/planned projects

- Digital mapping of Nagpur's properties under the e-governance department: Ongoing
- Development of Guidelines for Climate Responsive and Energy Efficient Housing under the BEA project: Completed
- Policy level intervention addressing integration of the above Guidelines into the DCR for promoting green buildings: Ongoing
- Installation of rooftop solar PV systems on NMC owned buildings of cumulative capacity 28-30 MWp via RESCO mode: Yet to start

Water bodies

Nagpur is blessed with three natural water streams flowing from west to east, which defines the city's topography as one with a sloping nature from west to east. The major stream is Nag River, which originates from the largest lake called Ambazari Lake, one of the nine lakes in Nagpur. The other two streams are Pioli and Pora Rivers. Pora River flows from outside the city's limits. Nag River covers around 17 km within the city's jurisdiction and a total of 68 km when it meets the Kanhan River. Pioli and Pora are the tributaries of Nag River and Bor Nullah. Bor Nullah originates from Phutala Lake and meets Nag River near Yashwant Stadium in the city. Pioli River originates from the overflow of the Gorewada Lake situated at the north-western end of Nagpur and meets Nag River at the central-eastern end.

Nag River has 24 natural drains in Nagpur, the River's mean depth being 2 – 4.5 meters and width 12 - 40 meters, with catchment area of 5,620 hectares. Pioli River has around 14 natural drains with length 18 km and mean depth of around 1.1 to 6.5 meters and width 30 - 100 meters, with catchment area of 7,130 hectares.

NMC is working on the Nag River Rejuvenation Project to establish STPs of 102 MLD capacity at Nag and Pili Rivers at different locations to curb pollution in the streams

Issues Identified:

- Unfortunately, over the years, Nag River has been reduced to a heavily polluted stream carrying industrial waste, solid waste and sewerage. This has resulted in environmental degradation such as loss of ecosystems and biodiversity along with health issues such as increase in water borne diseases.
- Nagpur is known as the city of lakes as it hosts nine lakes with rich biodiversity and that are popular public spaces for city residents. However, the condition of these lakes is deteriorating day by day due to continuous infusion of polluted water from industries and allied human centric activities. Most of the lakes have seen ever-increasing encroachment along the periphery in terms of commercial activities and infrastructure development.

Ongoing/planned projects:

- Under the Nurturing Neighbourhood challenge proposed by the Ministry of Housing and Urban Affairs (MoHUA), Nagpur Smart City is working to rejuvenate one of the lakes in the city.
- Nagpur has a DPR prepared to rejuvenate all the lakes and water bodies in the city. However, the implementation is slow. Two lakes have been rejuvenated so far.

Biodiversity

Several national parks (tiger reserves) surround Nagpur district; and Nagpur city is one of the greenest Indian cities due to its tree cover, water bodies, agricultural land and urban forests. However, its image is rapidly changing as the city continues to witness a rise in major infrastructure, residential and commercial projects.

Table 8: Urban parks and gardens in Nagpur

Authority	No. of parks/ gardens	Area (acres)
NMC	127	150
NIT	52	100
Forest Department	1	50
Dr. Panjabrao Deshmukh Krishi Vidyapeeth	3	75
Total	**183**	**375**

Issues identified:

- Due to the on-going urban development, Nagpur city is gradually losing its green cover. Ecosystems such as lakes are encroached and polluted.
- As per the government mandate, NMC has not initiated the city-wide tree census. Latest tree census was done in the year 2011. Identification & mapping of native and exotic species is crucial to undertake essential actions.
- Nagpur's green cover is concentrated in the western and north-western parts of the city. Due to highest built-up and high population density area, the central and eastern parts of the city have very low tree cover causing urban heat island effect. These are the areas with most of the slum pockets; their residents are impacted by heat strokes.

Ongoing/planned projects:

- NMC has undertaken many plantations drives and initiatives to enhance green cover in the city and has adopted models such as the Miyawaki Urban Forest method. Due to upcoming and future projects like inter-model station at Ajni area, approximately 40,000+ trees will be cut in a phased manner starting with 4000+ trees, which include fair proportion of heritage and rare age-old trees, as per the local experts. Concerned government departments have proposed to transplant trees and plant new trees (5 times the number) in identified areas; however, local NGOs are opposing this proposal.
- Under the Urban-LEDS II project, NMC has prepared a Local Biodiversity Strategy Action Plan (LBSAP) to enhance and conserve the city's biodiversity. LBSAP will identify Nagpur's crucial ecosystems and propose strategies to conserve them. GoI announced Nagar Van (Urban Forests) scheme in 2020 in which forests will be developed near existing forest land or other vacant lands available with ULBs.
- Nagpur's Ambazari and Gorewada Lakes, being the prominent ones among the nine lakes of the city, serve as favourite public spaces for recreational activities, wild life and bird watching due to their biodiversity.

Due to highest built-up and high population density area, the central and eastern parts of the city have very low tree cover causing urban heat island effect. These are the areas with most of the slum pockets

Under the Urban-LEDS II project, NMC has prepared a Local Biodiversity Strategy Action Plan (LBSAP) to enhance and conserve the city's biodiversity. LBSAP will identify Nagpur's crucial ecosystems and propose strategies to conserve them

Health

NMC is the authority responsible for providing health related facilities in Nagpur. There are three hospitals, six health posts, two diagnostic centres, 22 polyclinics (seven allopathic centres, seven ayurvedic dispensaries, three homeopathic dispensaries, three unani dispensaries, one naturopathy dispensary, one panchkarma centre) under the purview of NMC. Under the National Urban Health Mission (NUHM), there are 26 Urban Primary Health Centres (UPHC) in Nagpur. Additionally, GoM operates two medical college hospitals and one ayurvedic college. There are 634 registered private hospitals in the city with 811 ambulances.

In government hospitals, there are a total of 4,553 beds, with 16 MBBS doctors, one surgeon and 101 staff members including midwife nurses, 'paricharika', ten lady medical doctors, eight ayurvedic doctors, two unani doctors, lab technicians and assistants. In private hospitals, there are 9,744 beds. While the numbers of beds in government hospitals remains more or less constant, the city's population growth rate is rising due to on-going development, more job opportunities and allied services. Significant influx of patients from villages, and neighbouring states such as Madhya Pradesh, Andhra Pradesh and Chhattisgarh, for better healthcare facilities, poses additional stress on Nagpur's existing systems.

NMC prepares Heat Action Plan yearly, undertakes capacity building activities, provides essential infrastructure and services to reduce the cases of heat strokes in extreme summer.

The hospitals are concentrated mostly in certain pockets of the city in central, south-western and south-eastern Nagpur. Areas such as Ashi Nagar, Satranjipura, Hanuman Nagar and Lakadganj lack any major medical facilities. The facilities in the private hospitals are quite satisfactory. However, the economically weaker sections (who are typically more vulnerable to climate change) can only afford public hospitals where there is no improvement in the facilities.

Additionally, the citizens of Nagpur face heat stress related disorders due to high temperature during summers, such as heat strokes, eye diseases like cataract and dry eyes, respiratory disorders and skin diseases. Table 9 indicates that incidences of heat strokes are ever-present. Number of deaths increase in summer compared to other seasons, however as per the NMC data, deaths are not directly linked to the heat waves and are reported as zero.

Table 9: Nagpur's heat stroke cases

	Attack			Death		
	2017	2018	2019	2017	2018	2019
Heat stroke	375	364	364	0	0	0

(Source: Health Department, NMC)

NMC prepares yearly Heat Action Plan with activities such as capacity building among government officials, teachers and local welfare groups regarding actions to be taken in the extreme summer season. NMC establishes cool shelters, drinking water outlets, and distributes awareness material among citizens along with oral rehydration salt (ORS) packets. Table 10 shows various activities undertaken in 2019 by NMC's health department.

Table 10: The Heat Action Plan activities undertaken in Nagpur

Step	Activity	15-03-2019 to 30-06-2019 (Summer Season)
1	**Govt. engagement at NMC**	4
	Local Body	41
	Officers	10
	Others	
2	**Zone level meetings**	10
	Governing Body	20
	Executive Committee	
3	**Vulnerable groups**	
	Slums	452
	Street dwellers	5,000
	Heavy work labourers	100,000
	Rickshaw pullers	5,000
4	Preparation of Heat Action Plan	JANUARY 19
5	Implementation and monitoring Agencies and Staff	NMC Zone Offices with Officers/Supervisors
6	**Capacity building**	
	Medical Officer	69
	Paramedical	340
	Teachers	560
	Anganwadi/Asha workers	907
	Social organization/others	932
	Students	10,388
7	Drinking spots	453
8	**Cool Shelter**	
	Gardens	154
	Others	191
9	**Community awareness**	
	Press Meet	8-03-2019
	Community awareness	On festivals of Hanuman Jayanti and Ram Navami
	Banners	750
	Stickers	2,196
	Posters	2,196
	Pamphlets	99,700
10	Heat waves cases	364
	Deaths	0
11	Temperature above 43°C	April - 13 days May - 30 days June - 13 days

Table 11: Issues and challenges in the health system

Issues	Challenges
The public healthcare facilities are not adequate and satisfactory.	Surrounding villages, urban poor of the city, even patients from neighbouring states are dependent on the health care facilities of Nagpur city. Thus, the service load on public facilities is more.
The condition of government-run health/medical facilities has deteriorated significantly in the city.	The state government must provide more funds for infrastructure and human resources.
The urban poor are unable to access healthcare facilities in private hospitals.	There are no subsidy programmes for urban poor to avail critical and super specialty services.

2.7.9 Nagpur Smart and Sustainable City Development project

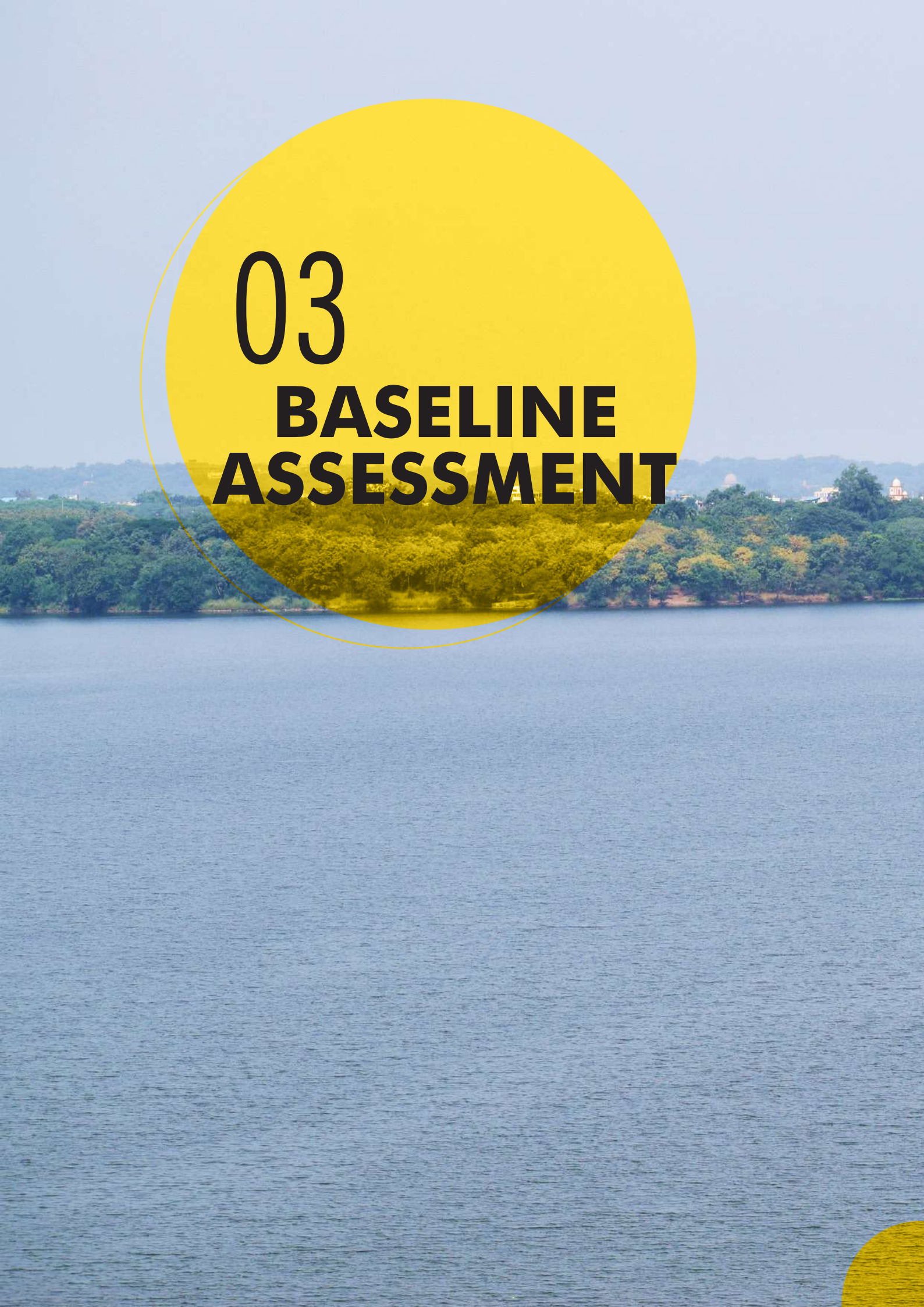
Along with area-based development under India's Smart City Mission, NMC and NSSCDCL have implemented several pan-city projects such as setting up 10 environmental sensors, GPS based waste bins with volume sensors for efficient solid waste transportation and management, adaptive streetlights and traffic management system in a pilot area. NSSCDCL has installed 40 kiosks in the city in various public spaces and buildings such as administrative offices, bus stops etc. to give information about various services provided by the ULBs and serve as an access point to utilize services such as property tax information, water services information, birth certificates, marriage certificate, online ticket issuing facility for railways, bus service, metro etc.

To enhance public safety, a new city-wide surveillance network of 3,698 Closed Circuit Television (CCTVs) in 660 locations was established in early 2018. 1,200 km of fibre optic network was laid down to enable central monitoring by a new Nagpur Police COC. The system is equipped with facial recognition, automatic number plate recognition and red-light violation detection systems to enable smooth management of traffic and ensure safety. Nagpur Police have been able to check a number of crimes and support a downward trend in the city's crime rate.

The COC helps plan swiftly during severe climate hazards. In 2018, Nagpur experienced unprecedented above average rainfall in a single day causing flooding in many areas of the city including the central assembly hall of the Vidhan Bhavan. Necessary actions such as rescue operations were planned and successfully executed due to the established surveillance network and timely monitoring from COC.

NSSCDCL is undertaking several initiatives such as creation of children centric climate resilient public spaces, dedicated cycle tracks, dedicated non-motor zones for citizens, etc. The initiatives are implemented as per the guidelines provided by Ministry of Housing & Urban Affairs under projects such as Nurturing Neighborhoods, Cycle 4 Change, and Streets 4 People, etc.

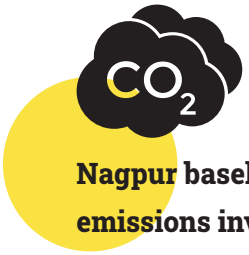
NSSCDCL has setup 10 air quality monitoring sensors, GPS based waste bins with volume sensors, and adaptive streetlights and traffic management system in a pilot area.



03
BASELINE ASSESSMENT

3.1 GHG Emissions Inventory

Nagpur's baseline inventory has been prepared based on energy consumption and municipal operation data for the period 2013-14 to 2017-18. The GHG emissions inventory has been prepared following the GPC created collaboratively by WRI, C40 Cities Climate Leadership Group and ICLEI - Local Governments for Sustainability. In particular, it complies with the BASIC level reporting which covers Scope 1 and Scope 2 emissions from stationery and transportation energy sources, as well as Scope 1 and Scope 3 emissions from waste.



Nagpur baseline GHG emissions inventory has been prepared based on energy consumption and municipal operation data for the period 2013-14 to 2017-18.

The GHG emissions inventory consists of two analyses, one for the emissions within the community determined by the geographical boundaries of the city's municipal jurisdiction and the other for urban services provided by NMC.

Community-level inventory is a useful tool to establish baseline status of GHG emissions and in developing mitigation actions for the entire city community. It includes emissions from community activities that occur within the municipal government's jurisdiction. This includes emissions due to activities such as residential buildings, commercial/institutional facilities, industrial units and processes, agriculture, forestry and land-use, and mobile transportation units.

LG inventory includes emissions from all local operations that NMC owns or controls. The various sectors considered for this inventory include LG buildings and facilities such as street lighting, traffic lighting, water, waste, sewerage and municipal vehicle fleet. Based on the inventory data for the baseline year, the municipal government can develop innovative approaches to provide sustainable urban services and can demonstrate leadership in pursuing emission mitigation efforts that illustrate the possibilities of different mitigation actions to the community.

A city's GHG inventory is not just the sum of GHG emissions from its community-level activities and from the operations carried out by the local government body to provide basic urban services. Usually, a major part of the emissions due to local government operations is a subset of the community level emissions. Often the community inventory data already accounts for the data pertaining to municipal government operations. Due care should be taken to avoid double accounting of emissions.

For example, the electricity consumption in municipal facilities for water supply, sewage treatment and street lighting may already be accounted in the community-wide electricity consumption data based on relevant customer/end-user categories as prescribed under the electricity distribution and tariff arrangements. Adding the electricity consumption data from such facilities, obtained from the respective departments within the LG, to the community-wide data again will result in double accounting of the emissions. Careful handling of data can prevent such overlaps.

However, it is necessary to acknowledge that analyzing community-level emissions presents its own challenges, as the natural flow of energy and materials is typically most accurate at the national level. Reducing the spatial area of analysis, from national to sub-national and local levels, results in a less accurate reflection of the material and energy flows. Community level GHG emissions accounting requires a combination of national and local area information to model the emissions. This report identifies the main energy carriers and the intensive GHG emitting sectors that contribute to the local carbon footprint and air pollution within the geographical boundary of NMC.

The GHG emissions inventory has been reported in terms of the total carbon dioxide equivalent (CO_2e) emission. To arrive at the CO_2e, the global warming potential (GWP) of each gas for a 100-year timeline is factored

3.1.1 Methodology for GHG Emissions Inventory

The GHGs considered in the GHG emissions inventory are carbon dioxide (CO_2), methane (CH_4) and nitrogen oxide (N_2O), gases that account for nearly 99% of global GHG emissions.

The GHG emissions inventory has been reported in terms of the total carbon dioxide equivalent (CO_2e) emission. To arrive at the CO_2e, the global warming potential (GWP) of each gas for a 100-year timeline is factored. The GWP reflects the climate change impact, in terms of the warming effect on the atmosphere, for each GHG with reference to CO_2. Table 12 presents the GWP values based on Intergovernmental Panel on Climate Change (IPCC's) Fourth Assessment Report (2007).

Table 12: 100 Year GWPs of GHGs with respect to CO_2

Gas	Lifetime (years)	GWP for 100 years
CH_4	12	25
N_2O	114	298

Emissions Factors

For estimating GHG emissions from the various activities or sources in a region, carrying out a direct physical measurement of GHGs emitted is not feasible. The common methodology for estimating GHG emissions is using the principle of emissions factor and the relevant activity data to estimate the emissions.

$GHG_A = EF_A \times D_A$

Where,

GHG_A = GHG emissions resulting from activity A
EF_A = emissions factor for activity A
D_A = data for activity A

The emissions factor for a particular activity is dependent on the energy use and the direct emissions of GHGs resulting from the activity. As the emissions factors are dependent on the energy use and the direct GHG emissions, they tend to vary over locations or even for different technologies. For example, the emissions factor per kWh of electricity used would vary over countries or regions due to the varying energy mix, characteristics of fuel used and the efficiency of electricity generation. The emissions factor per km travelled would vary depending on the fuel characteristics, the engine characteristics for the vehicle, the driving and traffic patterns prevalent. For accurately estimating a GHG emissions inventory, it is important to use the emissions factor best suited to the location.

For the present study, relevant emissions factors as available in HEAT+ were used to arrive at GHG emissions from activities in the region. HEAT+ contains numerous country specific emissions factors and energy densities for a wide range of fuels, combustion technologies and waste types. HEAT+ uses these values to calculate the GHG emissions resulting from electricity usage, fuel consumption and waste decomposition.

The emissions factor per km travelled would vary depending on the fuel characteristics, the engine characteristics for the vehicle, the driving and traffic patterns prevalent

3.1.2 Harmonized Emissions Analysis Tool plus (HEAT+)

ICLEI's Harmonized Emission Analysis Tool plus (HEAT+) is an online emissions accounting software package that helps local governments to account for GHG emissions and develop a comprehensive energy and carbon inventory of their respective cities. The tool helps them in making informed climate action decisions and was used to assist with the accounting of Nagpur's GHG emissions inventory. The HEAT+ tool incorporates the latest technical findings (IPCC, 2006) and incorporates international reporting requirements and standards outlined in the GPC. HEAT+ is GPC compliant, and also includes a local government module to reflect GHG emissions limited to municipal operations. HEAT+ helps Local Governments to:

1. create emissions inventory of GHGs as well as air pollutants such as nitrogen oxides, sulphur oxides, carbon monoxide, volatile organic compounds, and particulate matter;
2. forecast growth of these emissions for a future year;
3. evaluate policies and measures to reduce emissions of these pollutants; and
4. prepare action plans to reduce emissions.

HEAT+ tool supports cities in the implementation of ICLEI's Climate Action methodologies, including the ClimateResilientCities methodology as well as the Green Climate Cities. Decision makers from other levels of governments as well as from the private sector and NGOs will also find the tool useful. With an easy to navigate interface, numerous built-in reports, extensive IPCC and country-specific emissions coefficient data sets, HEAT+ provides a robust software environment for everything right from preparing city specific GHG emissions inventories to evaluating the benefits of individual policies and measures for developing comprehensive action plans.

3.1.3 Data Sources and Collection

The baseline year for the emissions inventory was financial year 2017-18. The data was collected for a period going back upto five years including the baseline year, i.e. up to 2013-14. A full inventory includes GHG emissions from energy, waste, forestry and land use change. However, due to limited resources and data constraints, the direct emissions from agriculture, land use change and forestry sectors were not included.

ICLEI South Asia and NMC staff members engaged through meetings and letters with a number of municipal, local and sub-national stakeholders to source relevant energy consumption data focusing on the large carbon emitters within the municipal area. Supply and demand side data was collected and analyzed. Table 13 elaborates the various sources of energy and other relevant data used in the report.

Table 13: Sources of the data used for GHG emissions calculation

Fuel type	Sector	Source of data
Electricity	Residential	MSEDCL
	Commercial/institutional	MSEDCL
	Manufacturing industry and construction	MSEDCL
	Municipal buildings; water supply (treatment and pumping); sewage (treatment and pumping); street lights	Electrical department, Town Planning Department, Water works department) - NMC
Diesel and Petrol	Community transport	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
	Manufacturing industry and construction	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
	Municipal vehicles	Workshop Department - NMC
LPG	Residential	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
	Commercial/institutional	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
	Auto LPG – transportation	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
Kerosene	Residential	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
Furnace oil and Light diesel oil	Manufacturing industry and construction	IOCL-Nagpur, HPCL-Nagpur, BPCL-Nagpur
Transport sector- Data on registered Vehicles in the city		Regional Transport Office (RTO) - Nagpur
SWM – Annual waste generation data		Health Department (Sanitation) - NMC
Municipal water supply		Water Works Department - NMC
Municipal wastewater treatment		Public Health and Engineering Departments (Formerly Known As-Pench Project Cell) - NMC
Municipal street lighting		Electrical Department - NMC

3.2 GHG Emissions Inventory Report

Table 14: Key Indicators – Economy-wide Energy Consumption and GHG Emissions

Total energy use[11]	19,044,340 GJ
Total GHG emissions	3,034,548 Tonnes of CO_2e
Per capita energy use	7.09 GJ
Per capita GHG emissions	1.13 Tonnes of CO_2e

Community Scale Energy Consumption and GHG Emissions

Figure 9: Sector wise share of energy consumption and GHG emissions 2017-18

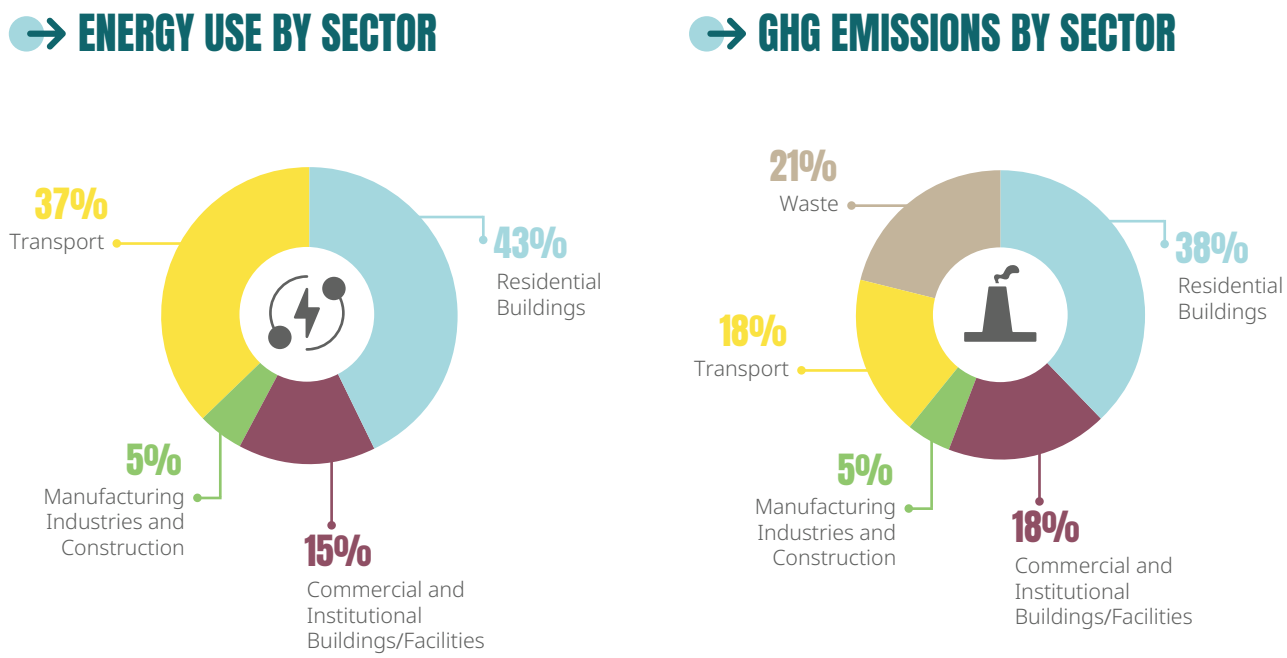


Table 15: Sector-wise Energy Consumption and GHG Emissions in 2017-18

Sector	Energy Use (GJ)	GHG emissions (tCO_2e)
Residential buildings	8,108,294	1,161,452
Commercial and institutional buildings/ facilities	2,858,715	556,180
Manufacturing industries and construction	1,038,318	133,282
Agriculture, forestry and fishing activities	2,664	609
Transportation	7,036,350	549,935
Waste	--	633,090

11 Includes direct energy use (combustion of fuels such as kerosene, LPG, petrol, diesel) and indirect energy use (consumption of grid electricity)

Figure 10: Trend of Energy Consumption from 2013-14 to 2017-18

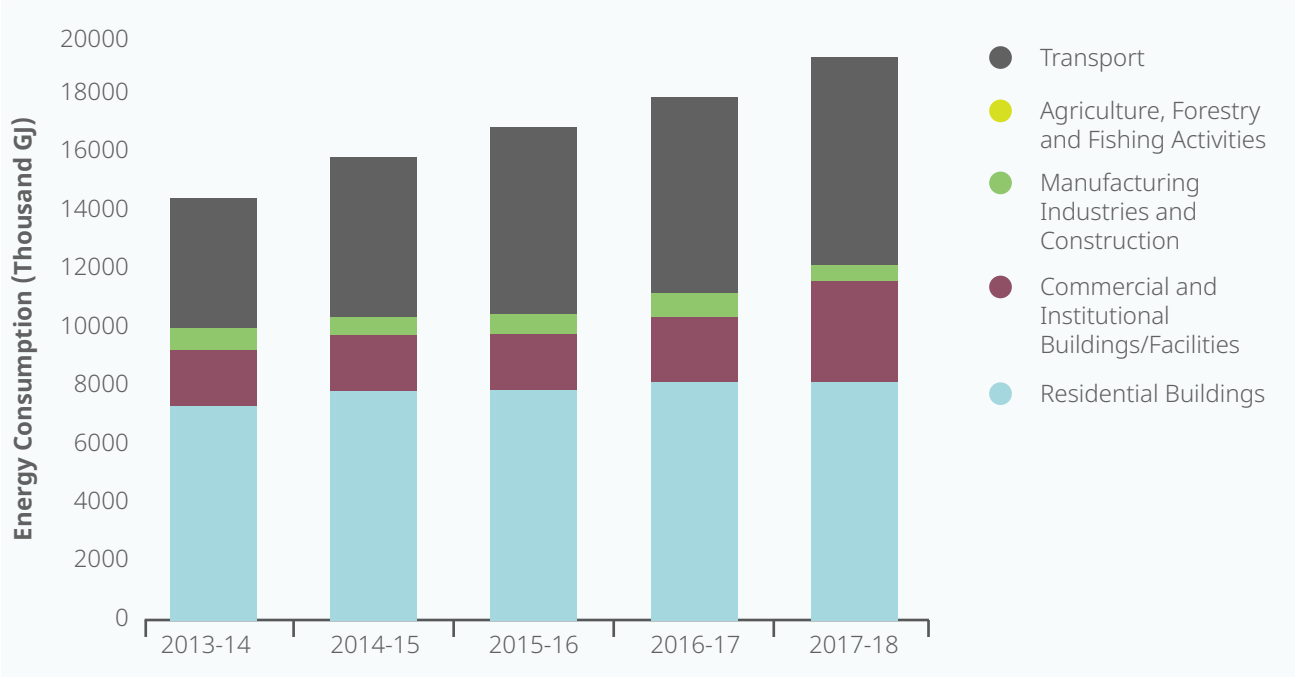
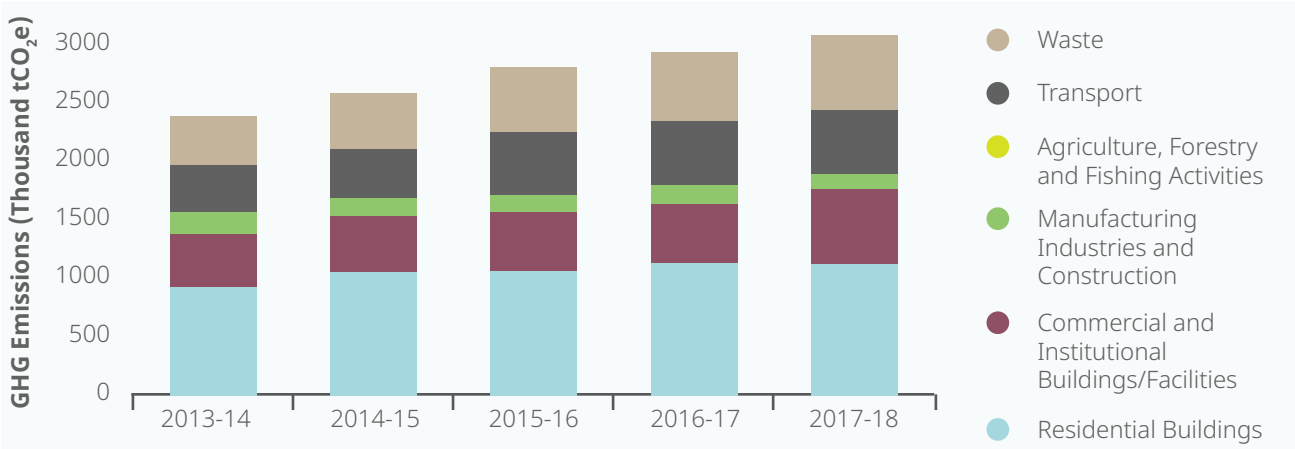


Figure 11: Trend of GHG Emissions GHG emissions – 2013-14 to 2017-18



- Largest energy consumers: Residential buildings (43%), Transportation (37%)
- Energy use trend: Rise of 29% since 2013-14 (at a CAGR of 5.8%)
- Largest GHG emitters: Residential buildings (38%), Waste (21%), Transportation (18%), Commercial and institutional buildings/facilities (18%)
- GHG Emissions' trend: Rise of 23.56% since 2013-14 (at a CAGR of 4.3%)

3.2.1 Snapshot of Energy Use and Resultant GHG Emissions by Energy Source

Figure 12: Share of Energy Use and GHG Emissions by Energy Source

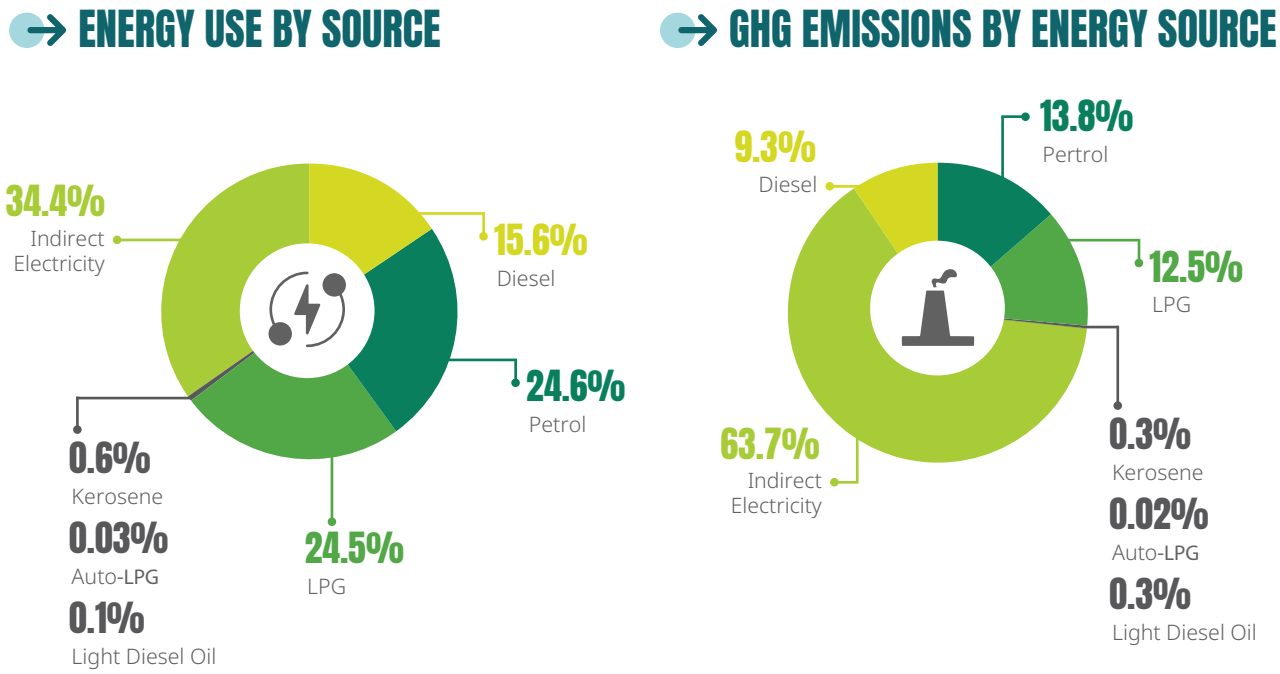


Table 16: Energy Consumption and GHG Emissions by Energy Source in 2017-18

Fuel/Energy source	Energy use (GJ)	GHG emissions (tCO_2e)
Diesel	2,969,244	220,775
Petrol	4,689,253	326,155
Furnace oil	6,981	542
LPG	4,667,266	294,760
Light diesel oil	20,939	1,557
Kerosene	126,562	9,132
Auto - LPG	6,141	387
Indirect electricity	6,557,954	1,498,828
Total	**19,044,340**	**2,352,196**

- Prominently used energy sources: Electricity (34.45%), Petrol (24.63%) and LPG (24.52%)
- Total community scale GHG emissions by energy source in 2017-18: 2,352,196 tCO_2e
- Largest GHG emitting energy sources: Electricity (63.74%), Petrol (13.87%) and LPG (12.54%)

3.2.2 Sectoral Electricity Consumption and Resulting Indirect GHG Emissions

Figure 13: Sector-wise Electricity Consumption and GHG Emissions in 2017-18

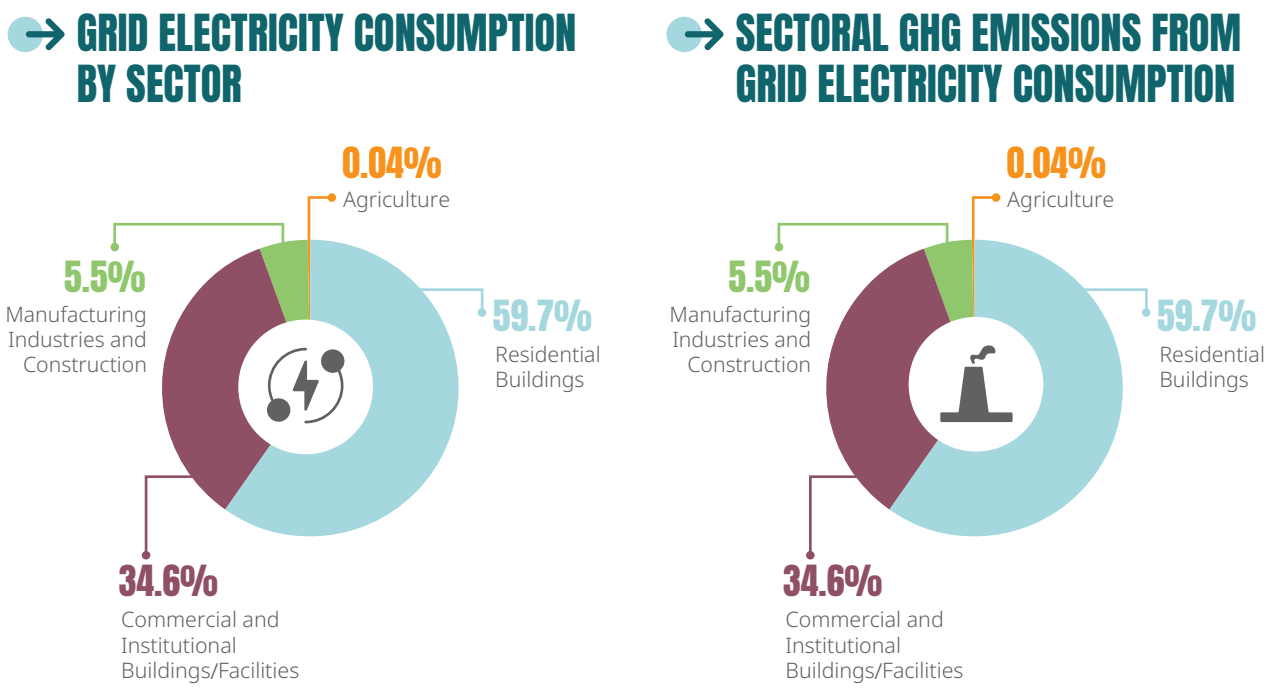


Figure 14: Trend of Grid Electricity Consumption

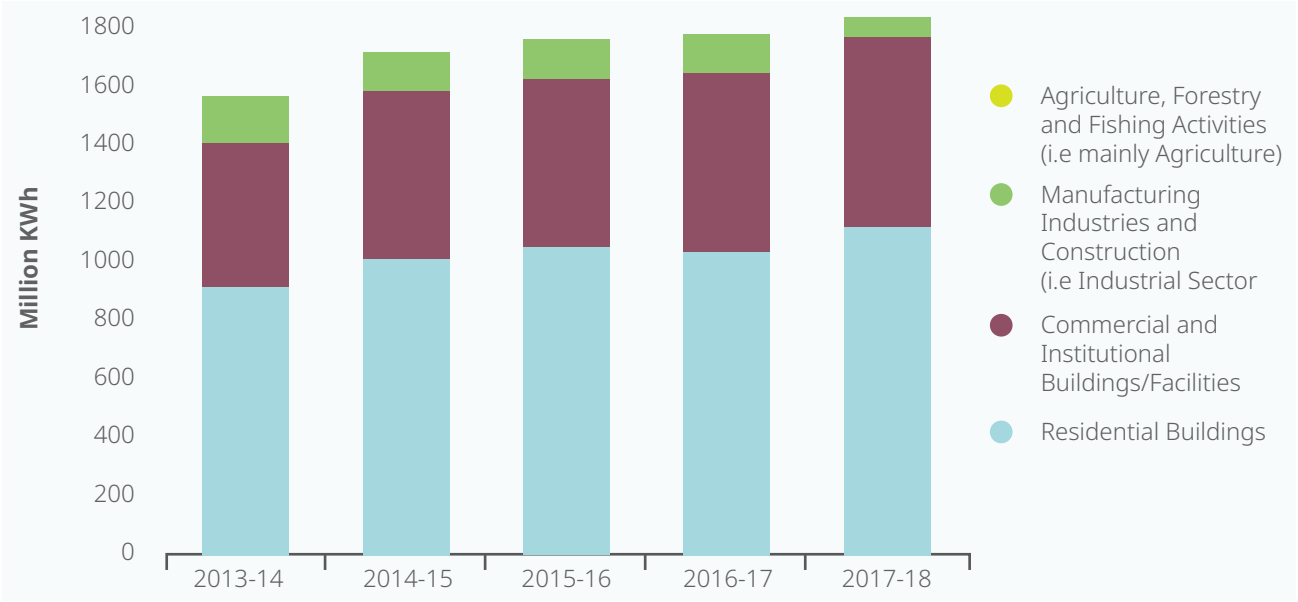
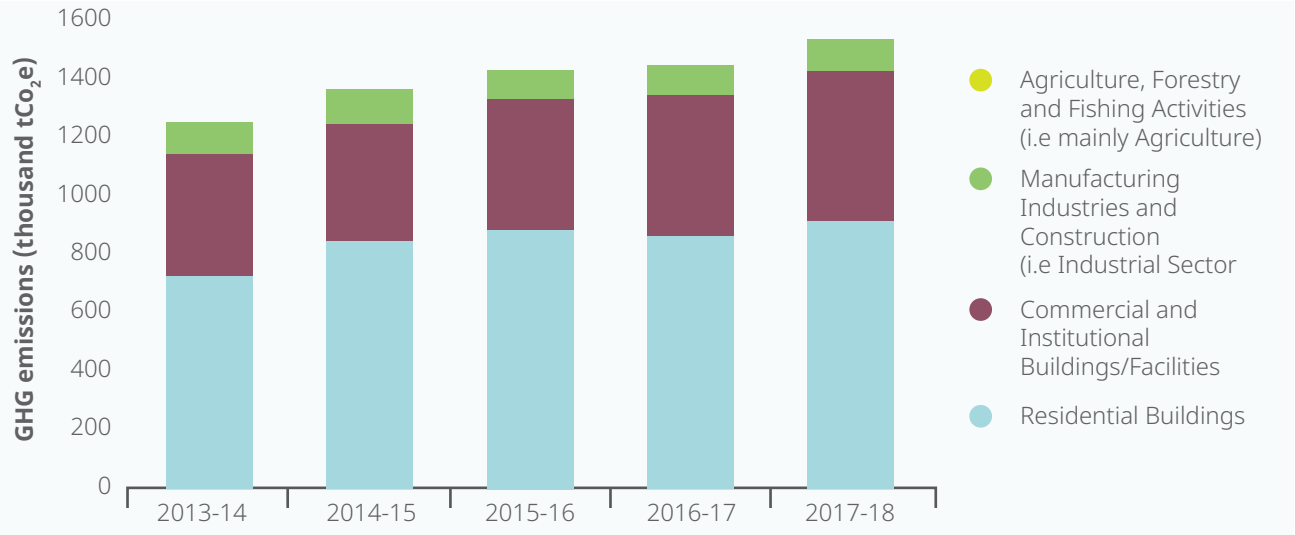


Figure 15: Trend of GHG Emissions from Grid Electricity Consumption

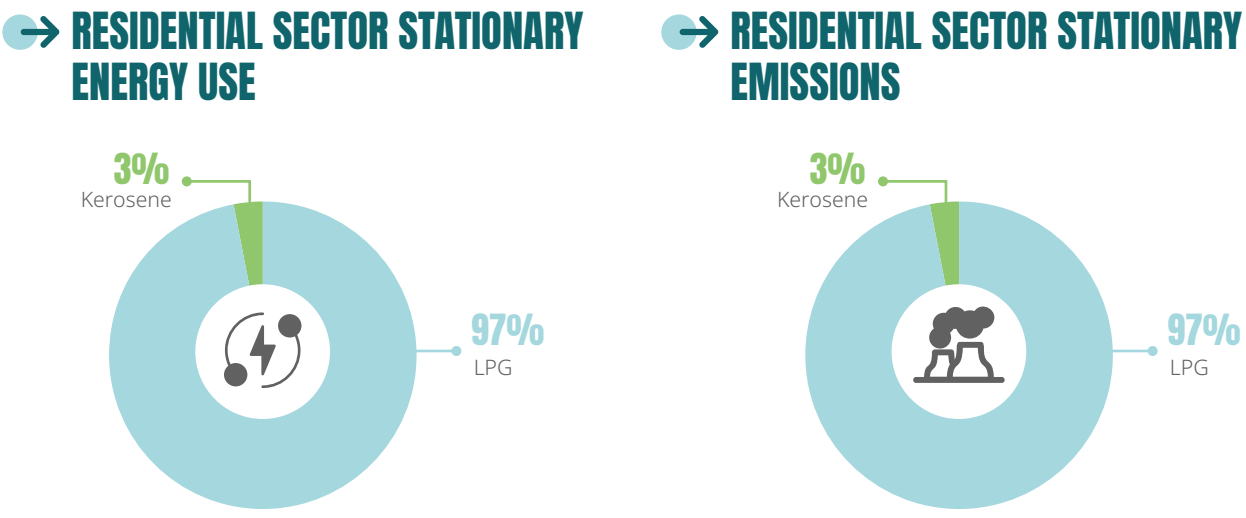


- Total electricity consumption in 2017-18: 1,822 million kWh
- Electricity consumption per capita: 645.49 kWh
- Largest electricity consumers: Residential buildings (59.76%), Commercial and institutional buildings/facilities (34.63%)
- Total GHG emissions from electricity consumption in 2017-18: 1,498,828 tCO_2e
- Largest GHG emitters: Residential buildings (59.76%), Commercial and institutional buildings/facilities (34.63%)

3.2.3 Trend of direct emission from stationary combustion at the community level

Residential Building Sector

Figure 16: Energy Use and Resultant GHG Emissions in Residential Buildings



- Total Energy Use from stationary fuel consumption in the sector: 4,189,010 Giga Joules (GJ)
- Energy Use Trend: rise of 8.81% (at a CAGR of 1.7%)
- Trend of Kerosene Consumption: decrease of 36.29% (at a CAGR of - 8.6%)
- Trend of LPG consumption: rise of 11.26% (at a CAGR of 2.2%)
- Total GHG emissions from stationary fuel consumption in the sector: 265,695 tonnes of CO_2e
- Largest GHG emitting Fuel: LPG (97%)
- Trend of GHG Emissions: rise of 8.48% (at a CAGR of 1.6%)

Commercial and Institutional Buildings/Facilities

Figure 17: Trend of Energy Use from Stationary Fuel Consumption in Commercial Sector

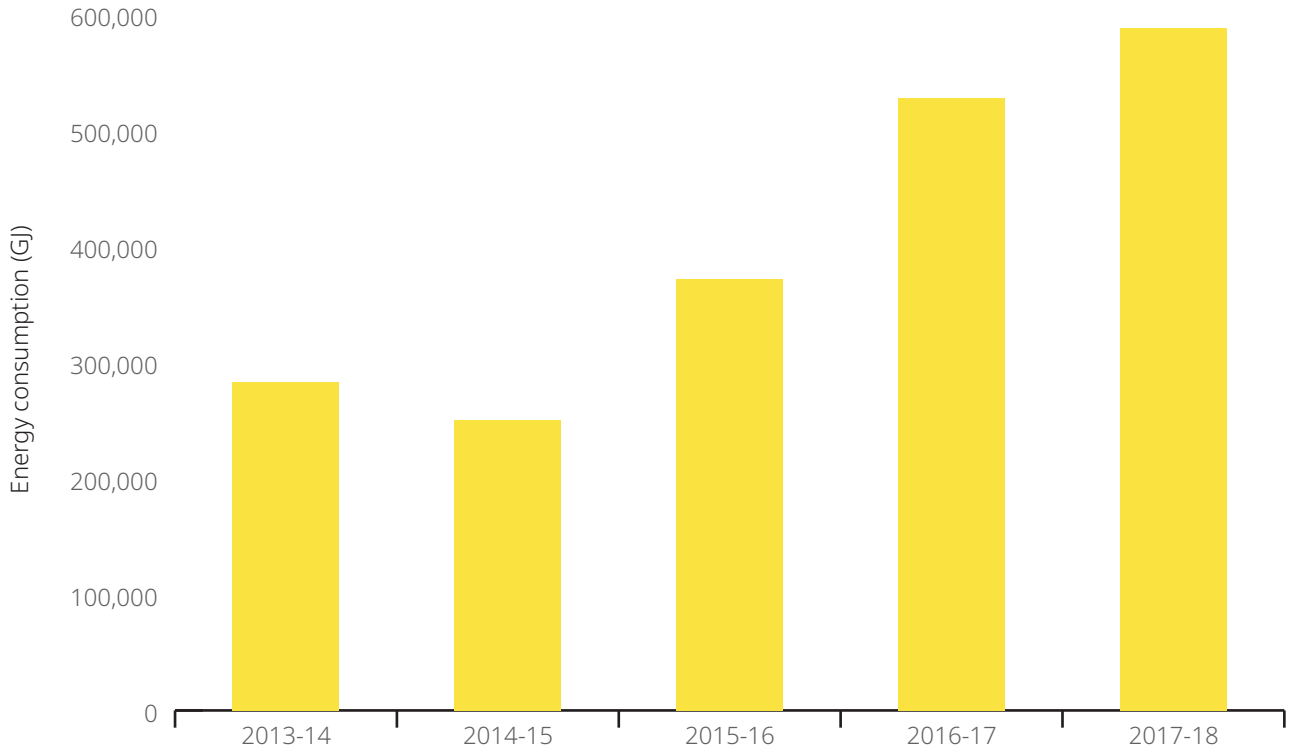
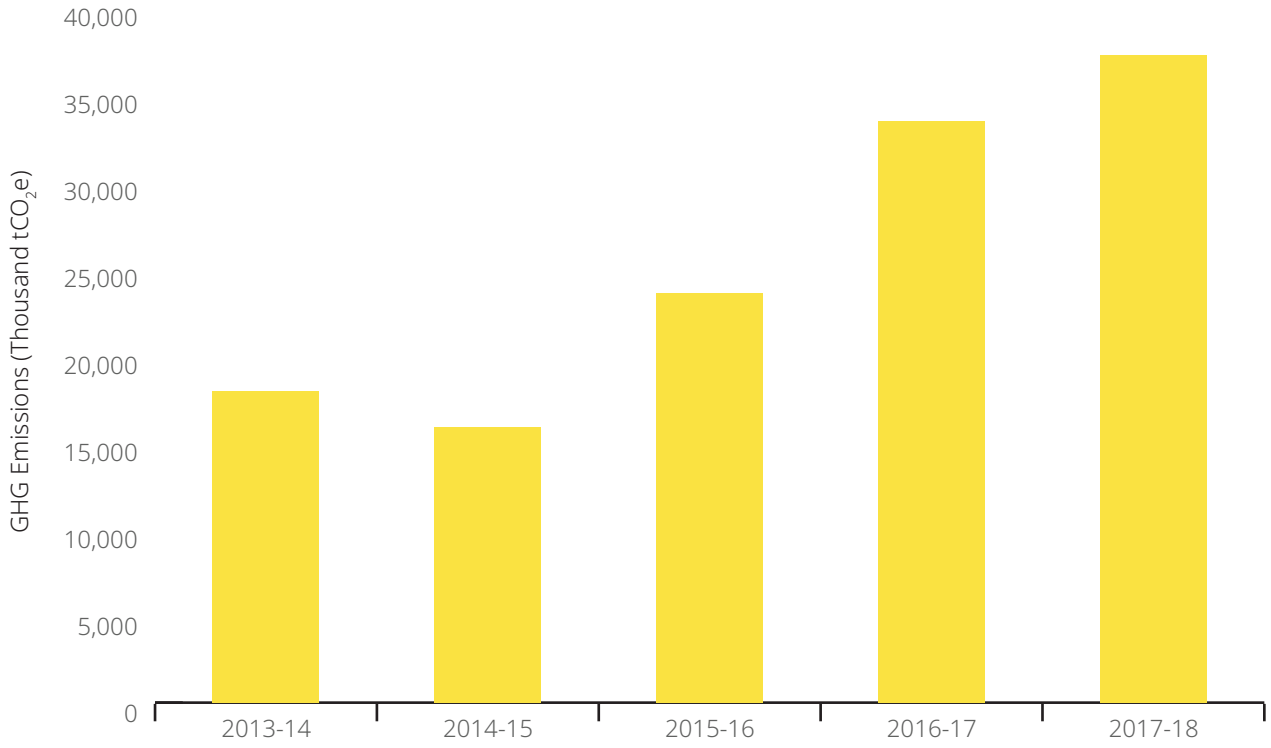


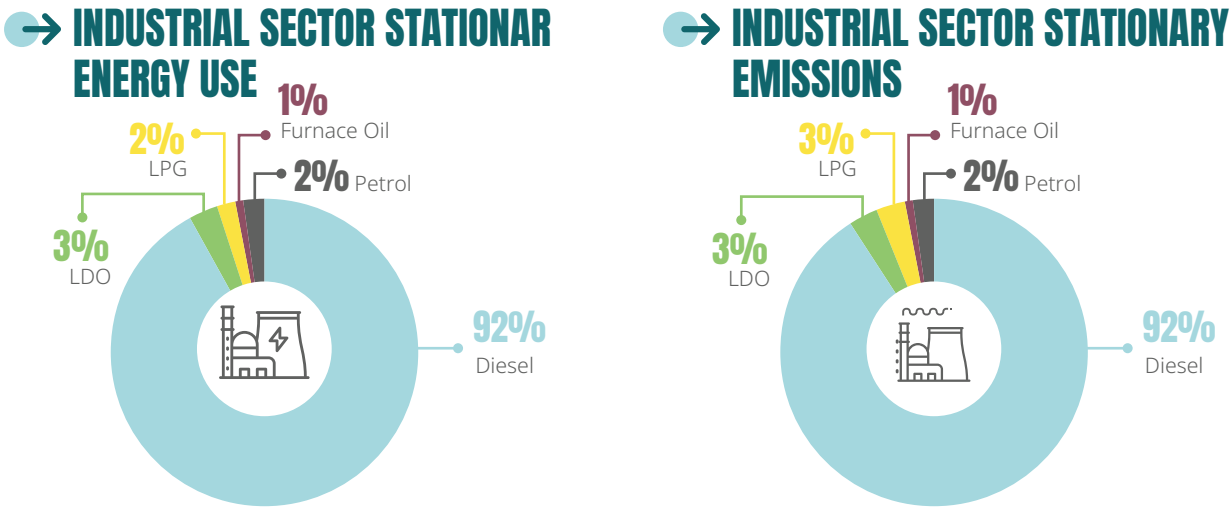
Figure 18: Trend of GHG Emissions from Stationary Fuel Consumption in Commercial Sector



- Total Energy Use from stationary fuel consumption in the sector: 587,929 Giga Joules (GJ)
- Energy Use Trend: rise of 107.76% (at a CAGR of 15.7%)
- Total GHG emissions from stationary fuel consumption in the sector: 37,189 tonnes of CO_2e
- Trend of GHG Emissions: rise of 107.76% (at a CAGR of 15.7%)

Manufacturing Industries and Construction Sector

Figure 19: Energy Use and Resultant GHG Emissions in Commercial Sector



- Total Energy Use from stationary fuel consumption in the sector: 673,098 Giga Joules (GJ)
- Energy Use Trend: rise of 50.21% (at a CAGR of 8.5%)
- Trend of Furnace Oil Consumption: decrease of 92.30% (at a CAGR of - 40.1%)
- Trend of Petrol consumption: decrease of 55.65% (at a CAGR of - 15%)
- Trend of Diesel Consumption: rise of 92.35% (at a CAGR of 14%)
- Trend of LPG Consumption: rise of 224.55% (at a CAGR of 26.5%)
- Total GHG emissions from stationary fuel consumption in the sector: 49,810 tonnes of CO_2e
- Largest GHG emitting Fuel: Diesel (91%)
- Trend of GHG Emissions: rise of 49.14% (at a CAGR of 8.3%)

Agriculture, forestry and fishing activities (i.e. mainly agriculture)

Figure 20: Trend of Energy Use in Agriculture Sector

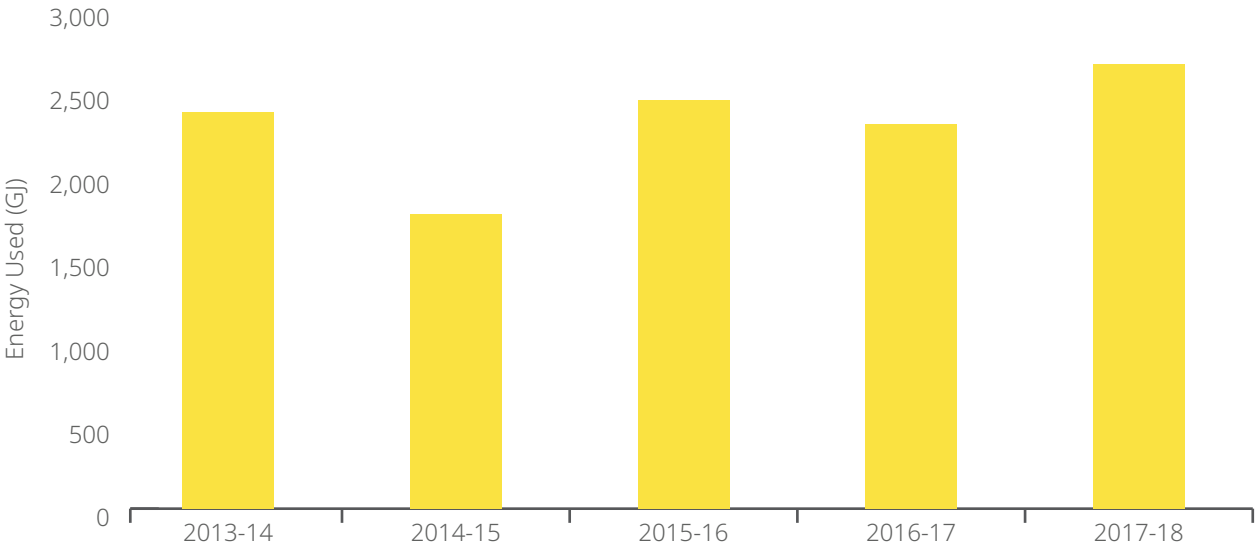
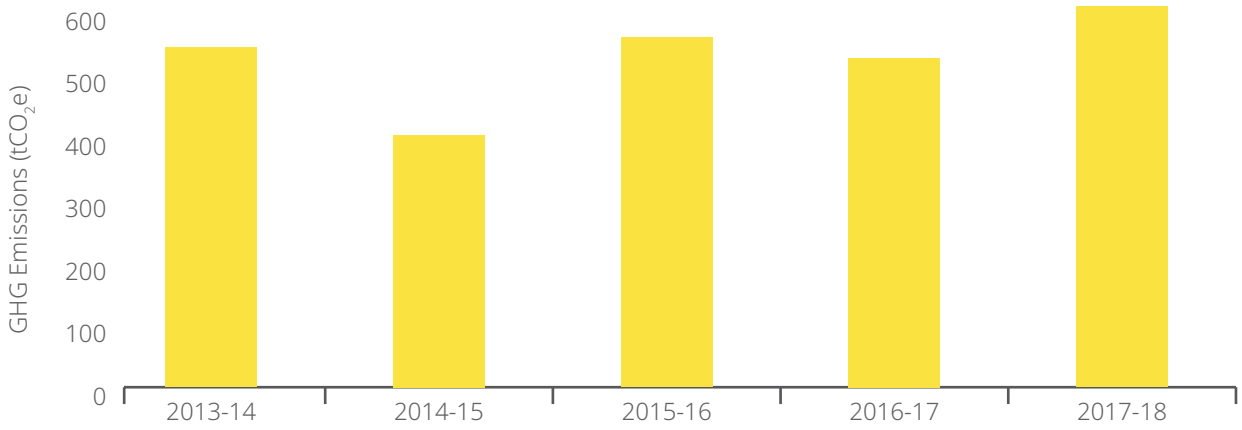


Figure 21: Trend of GHG Emissions in Agriculture Sector



- Total Energy Use from stationary fuel consumption in the sector: 2,664 Giga Joules (GJ)
- Energy Use Trend: rise of 12.12% (at a CAGR of 2.3%)
- Total GHG emissions from stationary fuel consumption in the sector: 609 tonnes of CO_2e
- Trend of GHG Emissions: rise of 12.12% (at a CAGR of 2.3%)

3.2.4 Fuel Use in Transport Sector and Resultant Direct Emissions

On-road transportation

Figure 22: Share of Energy Consumption by Fuel and GHG Emissions in On-road Transport

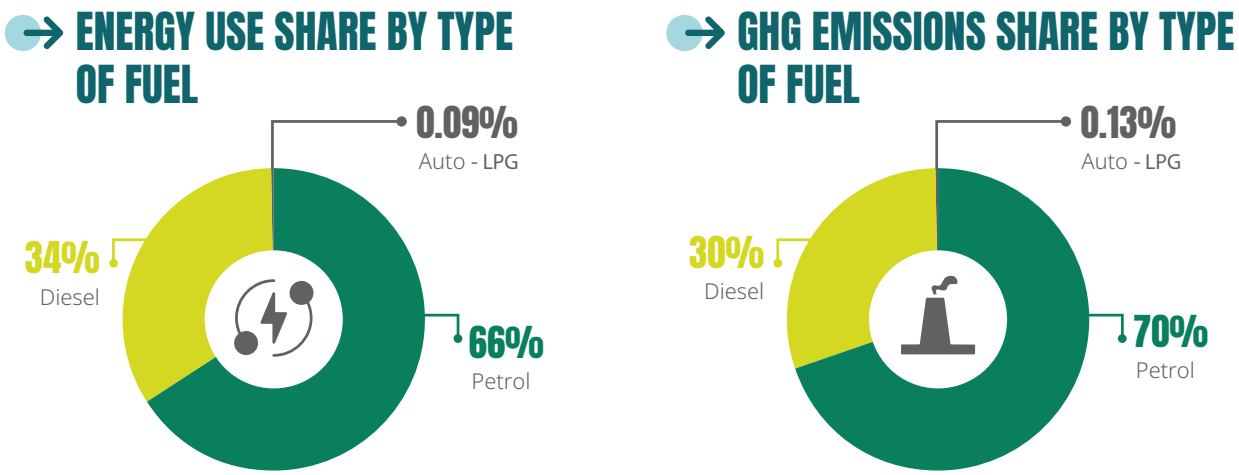
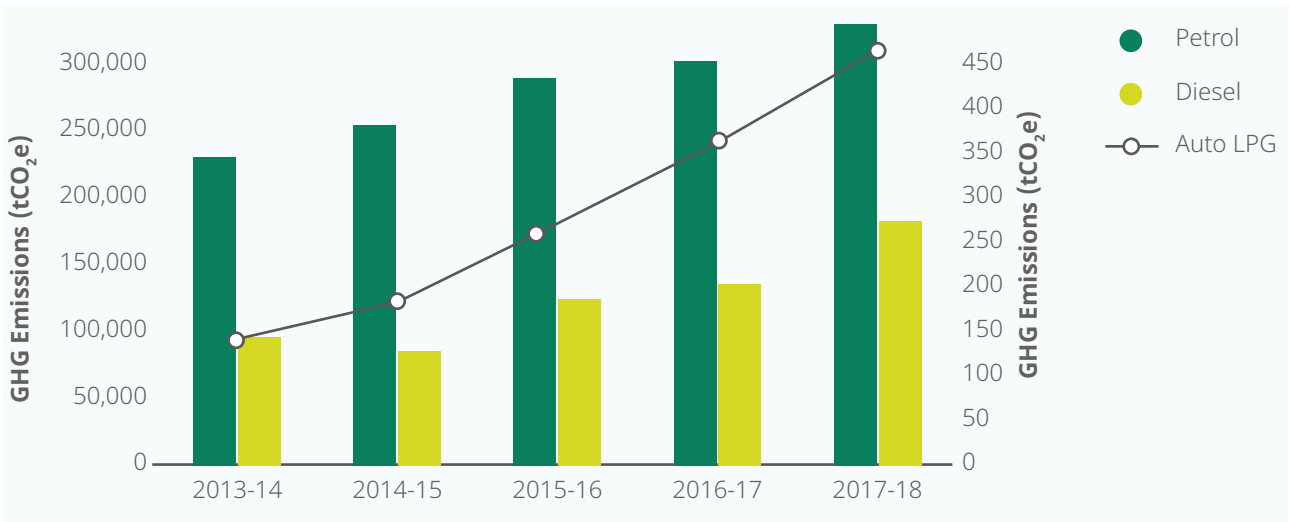


Figure 23: Trend of GHG emissions from on-road transportation



- Total energy consumption from on-road transportation in 2017-18: 7,036,350 GJ
- Total GHG emissions from mobile combustion in transportation in 2017-18: 500,673 tCO_2e
- Trend of emissions from petrol consumption: Rise of 38.72% since 2013-14
- Trend of emissions from diesel consumption: Rise of 79.31% since 2013-14
- Trend of emissions from auto-LPG consumption: Rise of 207.54% since 2013-14

Rail transportation emissions

Table 17: GHG emissions from rail transport

Year	2013-14	2014-15	2015-16	2016-17	2017-18
Total rail emissions (tCO_2e)	6,740	6,961	7,183	7,404	7,625

Aviation sector emissions

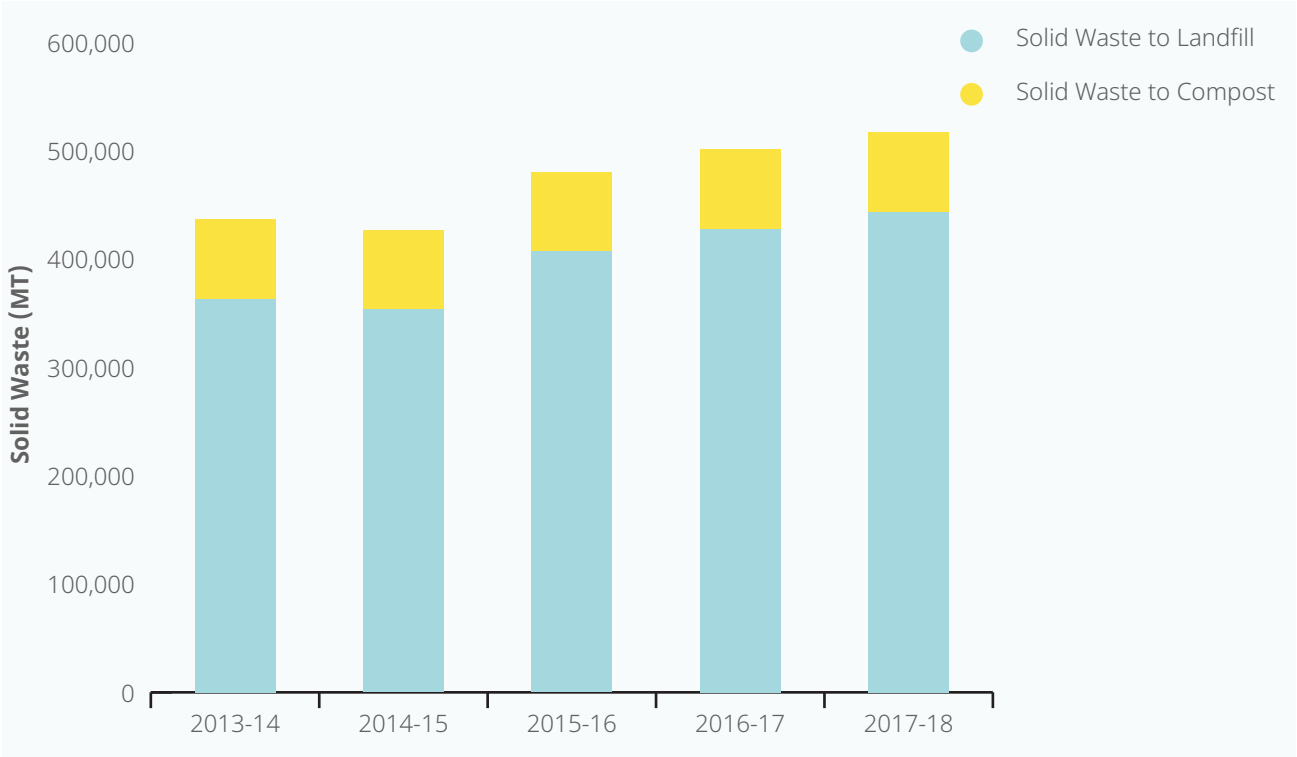
Table 18: GHG emissions from aviation sector

Year	2013-14	2014-15	2015-16	2016-17	2017-18
Total domestic landing and take-offs	12,510	13,498	12,576	14,656	15,5151
Total international landing and take-offs	480	544	840	1,406	1,364
GHG emissions (tCO_2e)	32,040.52	34,635.46	33,092.97	39,621.77	41,636.59

- Total GHG emissions from aviation in 2017-18: 41,637 tCO_2e
- GHG emissions' trend: Rise of 29.95% since 2013-14

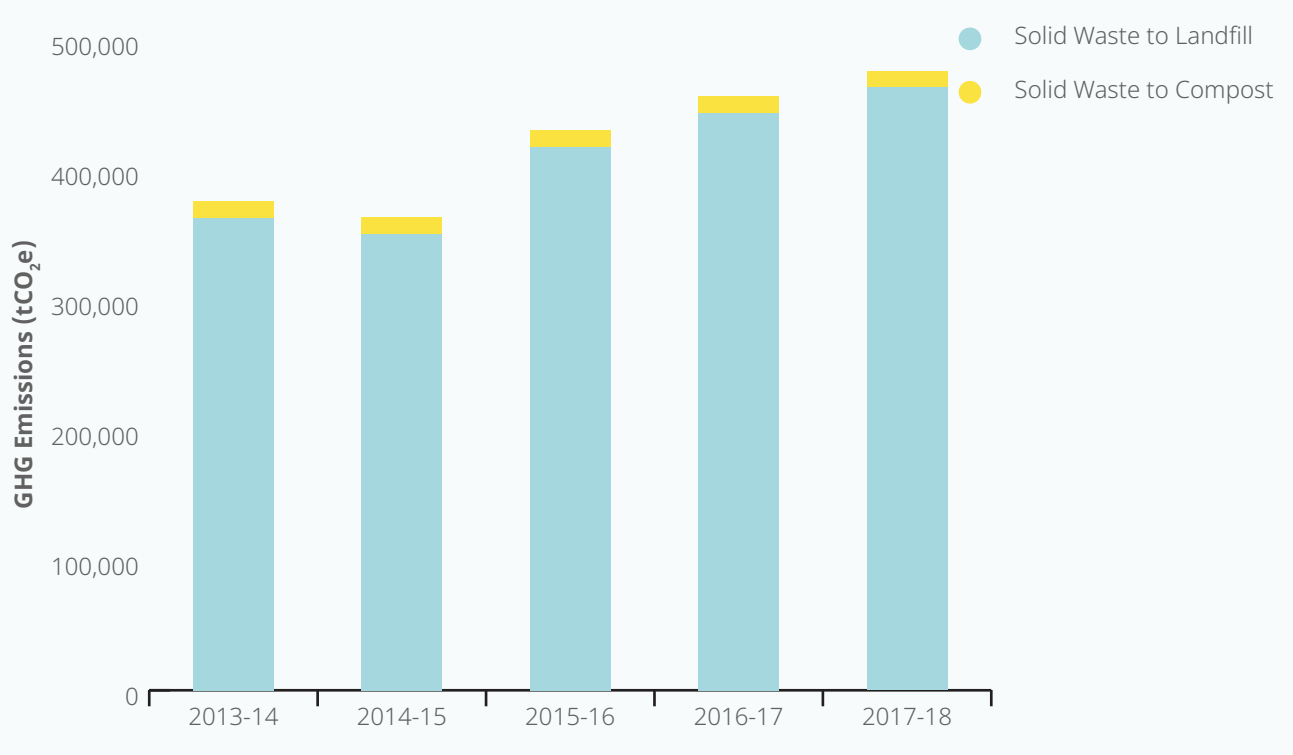
3.2.5 Waste Emissions

Figure 24: Trend of Annual Solid Waste Processing and Disposal in Nagpur



Emissions from MSW in Nagpur

Figure 25: Trend of GHG Emissions from Solid Waste Disposal and Processing

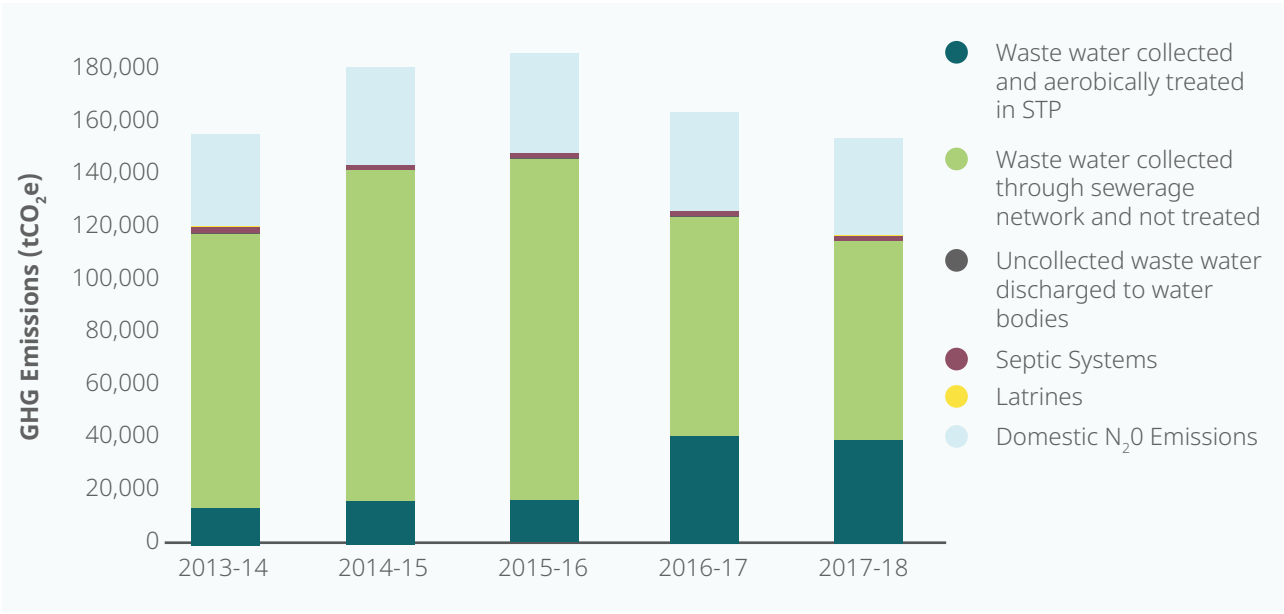


- Annual waste generation in 2017-18: 516,430 Tonnes
- Trend of annual waste generation: Rise of 18.39% since 2013-14
- Total GHG emissions from solid waste to landfill in 2017-18: 463,566 tCO2e
- Trend of emissions from solid waste to landfill: Rise of 27.64% since 2013-14
- Total GHG emissions from waste going to compost in 2017-18: 12,521 tCO_2e

Table 19: GHG Emissions from Domestic Wastewater Discharge and Treatment

Treatment/discharge pathway or system	GHG Emissions from domestic waste water (in tCO_2e)				
	2013-14	2014-15	2015-16	2016-17	2017-18
Waste water collected and aerobically treated in STP	14,732.21	15,727.41	15,440.48	40,349.11	40,230.30
Wastewater collected through sewerage network and not treated	1,04,115.45	1,20,624.14	1,23,423.27	82,209.60	77,017.88
Uncollected wastewater discharged to water bodies	485.38	126.59	232.80	266.25	283.26
Septic systems	2,358.50	1,660.71	1,961.60	2,018.86	1,979.34
Latrines	98.10	61.39	65.71	65.85	58.56
Domestic N_2O Emissions	34,784.29	35,435.41	36,093.91	36,759.97	37,433.78
Total	**156,573.93**	**173,635.65**	**177,217.77**	**161,669.65**	**157,003.13**

Figure 26: Trend of GHG emissions from domestic wastewater



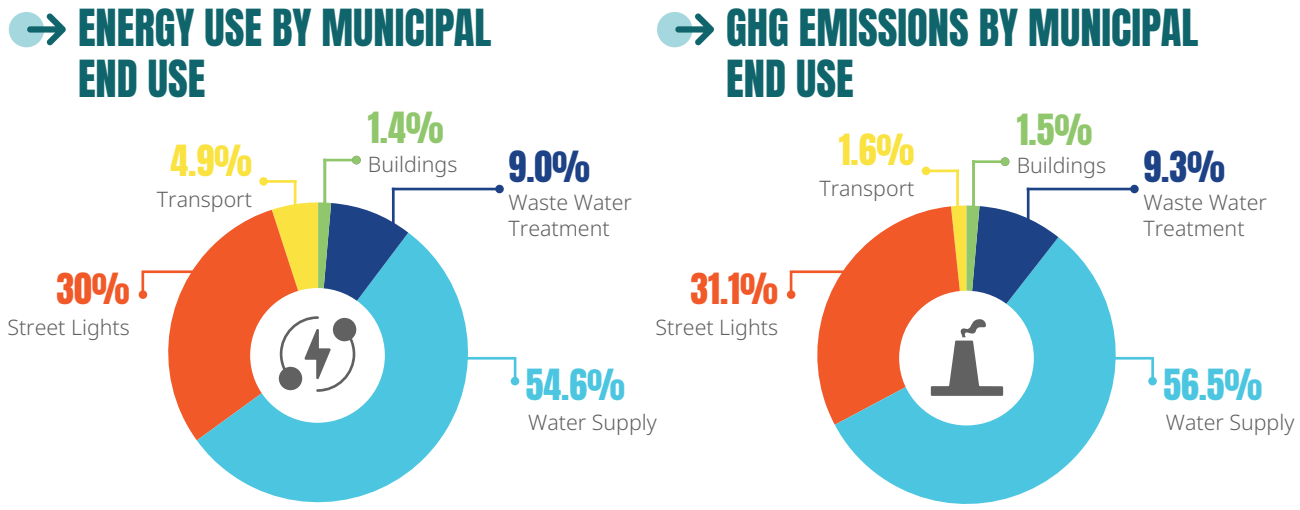
- Total emissions from wastewater treatment/discharge in 2017-18: 157,003 tCO_2e
- Trend of emissions from wastewater collected and treated: Rise of 173.07% since 2013-14
- Trend of emissions from wastewater collected and not treated: Decrease of 26.02 since 2013-14
- Trend of emissions from uncollected wastewater discharged into water bodies: Decrease of 41.6% since 2013-14
- Trend of emissions from N_20 emissions: Rise of 7.62%

3.2.6 Nagpur City Local Government: Energy Consumption and GHG Emissions (2017-18)

Total energy use[12]	643,455 GJ
Total GHG emissions	142,203 Tonnes GHG emissions as CO_2e

Snapshot of Energy use and GHG emissions from Municipal Operations

Figure 27: Share of Energy Use and Resultant GHG Emissions by Municipal End-use



12 Includes direct energy use from consumption of grid electricity for waste water treatment, street lighting, water supply and lighting in government buildings; and fuel consumption by government vehicles for transportation

Table 20: Break-up of Energy Use and GHG emissions in Municipal Operations

Sector	Energy use (GJ)	GHG emissions (tCO_2e)
LG buildings (electricity)	9,101	2,069
Facilities (electricity consumption - waste water treatment, water supply and street lighting)	602,978	137,811
Transportation (petrol and diesel)	31,367	2,322

- Largest energy consumers: Facilities (water supply) (54.6%); Facilities (street lighting) (30.0%)
- Largest GHG emitting sector: Facilities (water supply) (56.5%); Facilities (street lighting) (31.1%)

3.3 Energy and GHG Emissions Projections

The CRCAP is prepared for a period of 5 years, though the energy and GHG emissions are projected for a long-term vision of 30 years i.e., until 2050-51. Nagpur's business-as-usual (BAU) energy consumption and GHG emissions are projected using Tool 3.1E (GHG Emissions Forecasting) for medium term (yearly from 2018-19 to 2030-31) and long-term (every 5 years from 2040-41 to 2051-52) scenarios.

Fuel and electricity consumption has been projected by applying the geometric mean method for historic data of 5 years (2013-14 to 2017-18) for the community-level inventory sectors

Fuel and electricity consumption has been projected by applying the geometric mean method for historic data of 5 years (2013-14 to 2017-18) for the community-level inventory sectors. Energy consumption from facilities (water supply, sewerage, SWM, crematoria, street lighting) has been projected based on population growth (considering the Revised City Development Plan of Nagpur 2015) and factoring in NMC's future planning. Based on a forecast of the energy consumption, the corresponding GHG emissions are calculated using the HEAT+ software.

The projected citywide energy consumption as per the BAU scenario for 2050-51 is 749,892 thousand GJ which is more than 40 times of the 2017-18 baseline scenario. A stark increase is projected in the long-term, with GHG emissions rising by over 20-fold that of the baseline value by 2050-51. GHG emissions for Transport and Commercial sector are projected to increase 56 and 34 times respectively by 2050-51, due to the rapid increase in fuel consumption in transport along with energy and LPG consumption in commercial and municipal facilities. GHG emissions for the residential sector are projected to rise by over 80% of that in 2017-18 in the medium term (2030-31) (see Table 22).

Energy use in households and commercial and institutional buildings/facilities, particularly electricity consumption, is envisaged to be a key driver for rapid rise in future GHG emissions along with transport sector emissions due to increase in personal transport modes. LPG consumption in households and commercial and institutional buildings is also projected to increase significantly under the BAU scenario. Appropriate strategies need to be designed and implemented in the short, medium and long term to mitigate emissions from these sectors. The projected trajectory for energy and GHG emissions reiterates the need to prepare a CRCAP for Nagpur.

Figure 28: Sectoral energy consumption projections trend

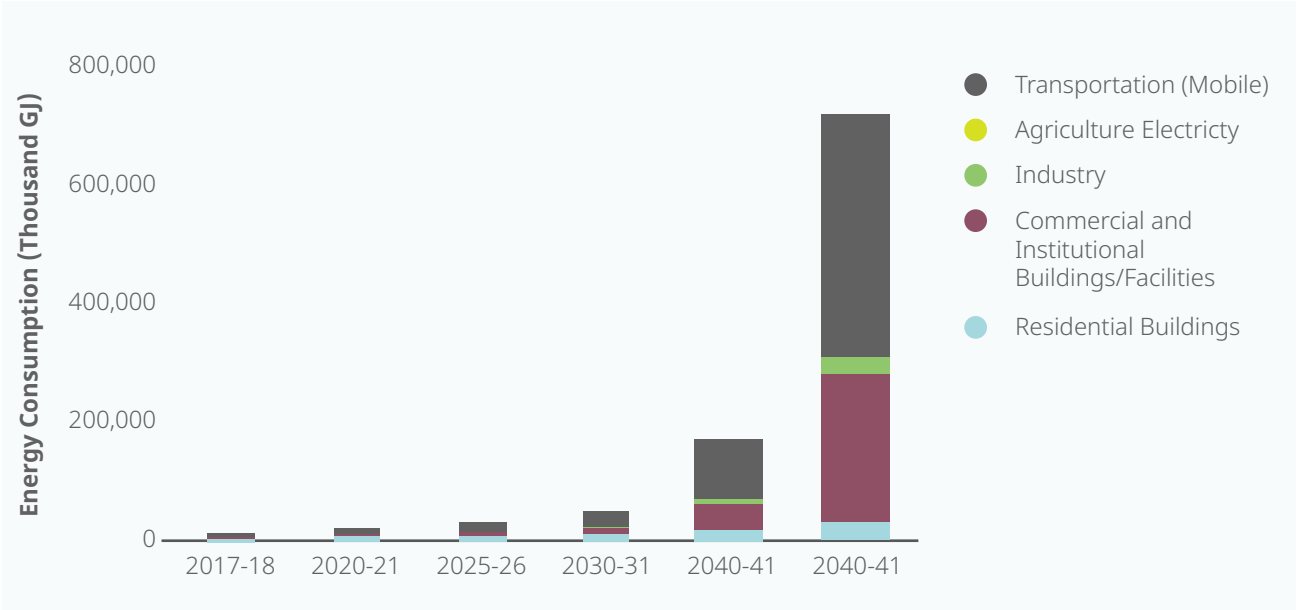


Figure 29: Sectoral GHG emissions projections trend

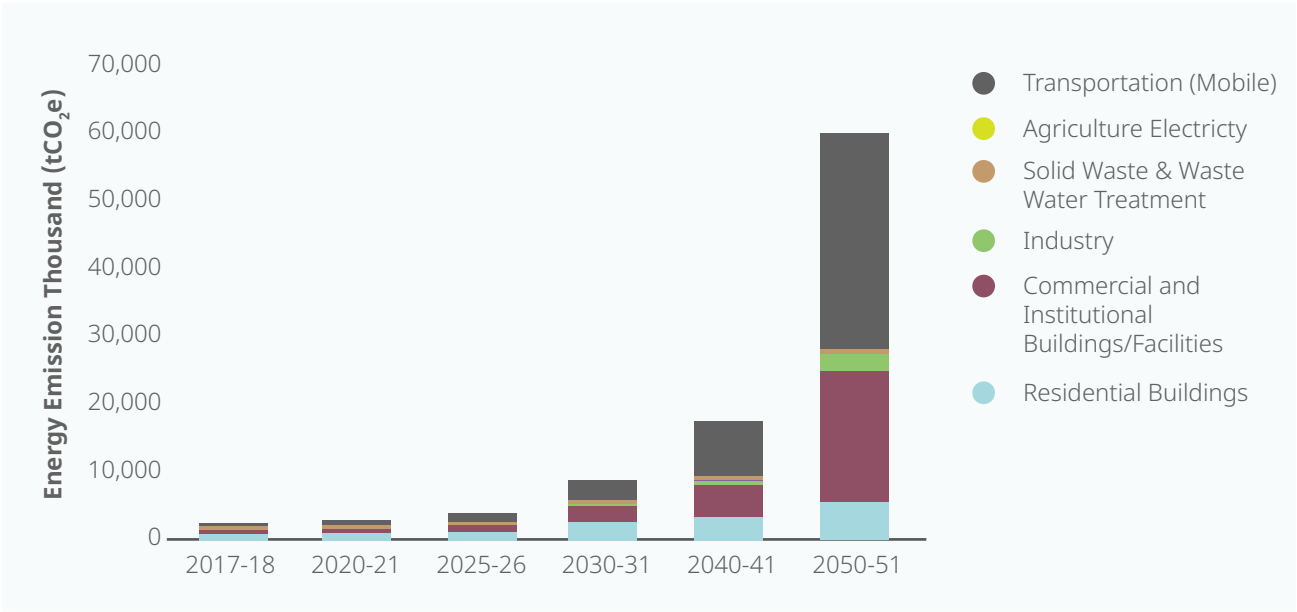


Table 21: Projection of Energy Consumption in the Medium-Term and Long-Term

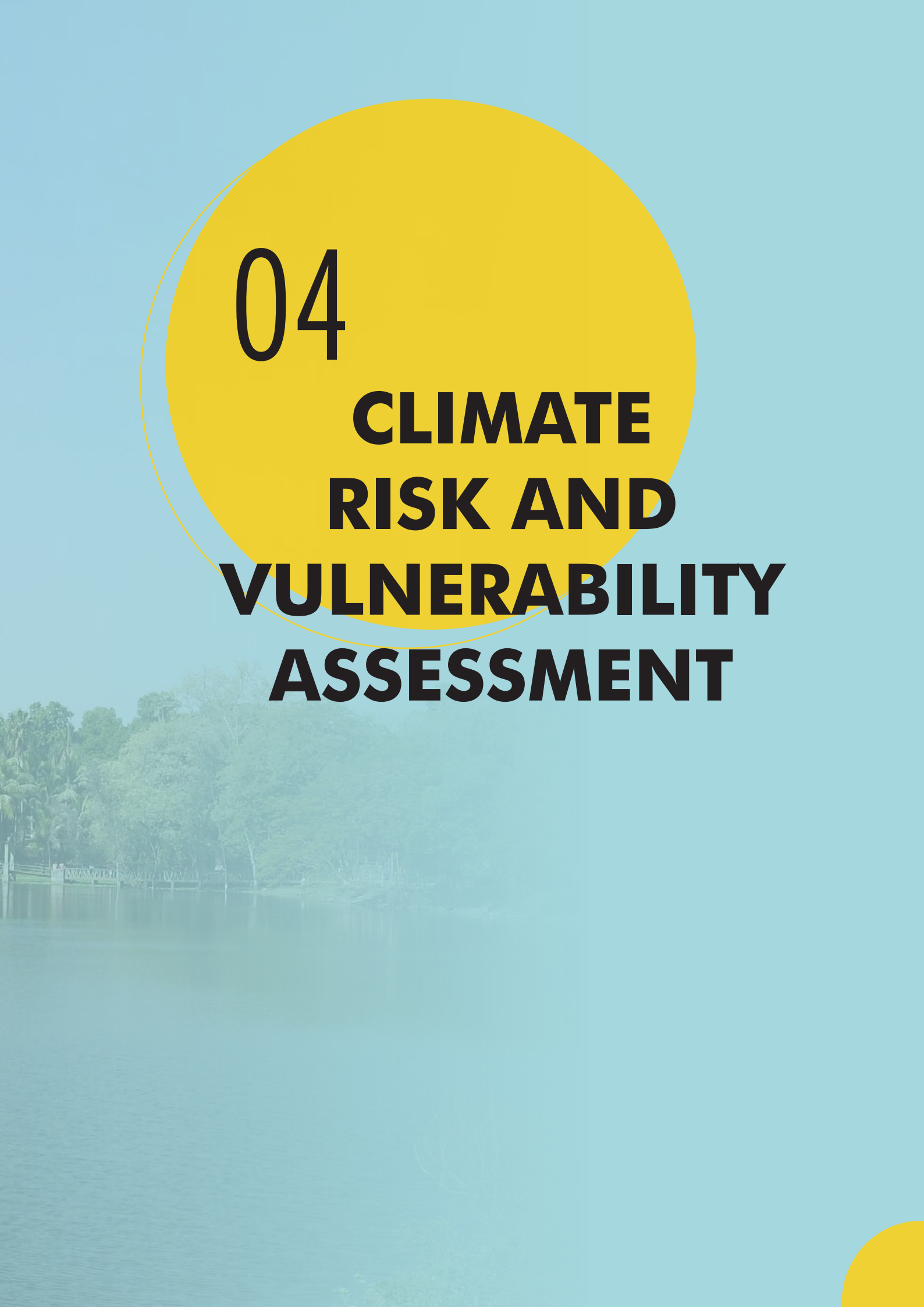
Sectors	Energy Source/Activity	Consumption (Thousand Gj)	Projected Energy Consumption (Thousand Gj) (Medium Term)			Projected Energy Consumption (Thousand Gj) (Long Term)	
		2017-18	2020-21	2025-26	2030-31	2040-41	2050-51
Residential Buildings	Electricity	3,919.28	4,561.25	5,873.26	7,562.67	12,539.09	20,790.12
	Kerosene	126.56	90.26	51.38	29.25	9.48	3.07
	LPG	4,062.45	4,401.05	5,029.26	5,747.13	7,504.93	9,800.35
Commercial and Institutional Buildings/Facilities	Electricity	1,658.77	2,001.14	2,735.87	3,740.36	6,991.17	13,067.29
	LPG	587.93	1,017.40	2,537.70	6,329.76	39,380.56	245,005.79
Facilities	Electricity	612.00	672.94	788.29	923.40	1,267.09	1,738.69
	Diesel	0.09	0.13	0.26	0.51	2.01	7.93
Manufacturing Industry and Construction (i.e. Industrial sector)	Electricity	365.22	306.00	227.85	169.67	94.08	52.16
	Furnace Oil	6.98	2.69	0.55	0.11	0.00	0.00
	Petrol	14.76	8.02	2.90	1.05	0.14	0.02
	Diesel	613.52	875.32	1,582.67	2,861.63	9,355.39	30,585.10
	LDO	20.94	16.96	11.94	8.41	4.17	2.06
	LPG	16.89	26.99	58.98	128.86	615.08	2,936.05
Agriculture Electricity	Electricity	2.66	2.90	3.35	3.86	5.14	6.85
Mobile (Transportation)	Auto - LPG	6.14	14.26	58.08	236.55	3,923.54	65,077.07
	Petrol	4,674.49	5,974.91	8,994.83	13,541.13	30,688.73	69,550.89
	Diesel	2,355.72	3,650.24	7,573.85	15,714.91	67,655.44	291,268.54
Total		**19,044.41**	**23,622.46**	**35,531.02**	**56,999.27**	**180,036.02**	**749,892.00**

Table 22: Projection of GHG emissions in the Medium-Term and Long-Term

Sectors	Energy Source/Activity	GHG Emissions (tonnes of CO2e)	GHG Emissions (tonnes of CO2e) (Medium Term)			GHG Emissions (tonnes of CO2e) (Long Term)	
		2017-18	2020-21	2025-26	2030-31	2040-41	2050-51
Residential Buildings	Electricity	895,757	1,042,480	1,342,342	1,728,457	2,865,825	4,751,608
	Kerosene	9,132	6,528	3,716	2,115	685	222
	LPG	256,563	278,388	318,125	363,534	474,723	619,919
Commercial and Institutional Buildings	Electricity	379,118	457,363	625,287	854,864	1,597,839	2,986,546
	LPG	37,189	64,356	160,522	400,388	2,491,009	15,497,791
Facilities	Electricity	139,873	153,801	180,164	211,045	289,594	397,379
	Diesel	6	10	19	38	149	590
Industry	Electricity	83,471	69,936	52,076	38,778	21,501	11,922
	Furnace Oil	542	209	43	9	0	0
	Petrol	1,027	558	202	73	10	1
	Diesel	47,175	65,061	117,638	212,702	695,375	2,273,354
	LPG	1,068	1,708	3,731	8,151	38,907	185,719
Agriculture Electricity	Electricity	609	663	765	883	1,175	1,565
Solid Waste & Waste Water Treatment	Solid Waste to Landfill	463,566	492,796	273,482	266,383	418,727	608,527
	Solid Waste to Compost	12,521	12,521	50,084	50,084	50,084	50,084
	Waste Water Treatment	157,003	127,536	90,608	94,567	124,629	159,624
Mobile (Transportation)	LPG	767	901	3,670	14,947	247,911	4,111,935
	Petrol	325,012	415,428	625,400	941,499	2,133,750	4,835,790
	Diesel	175,098	271,318	562,955	1,168,070	5,028,748	21,649,641
	Rail	7,625	8,243	9,384	10,684	13,849	17,951
	Aviation	41,637	49,576	66,312	88,698	158,693	283,925
Total		**3,034,759**	**3,519,377**	**4,486,523**	**6,455,967**	**16,653,184**	**58,444,093**

04

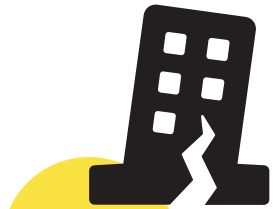
CLIMATE RISK AND VULNERABILITY ASSESSMENT



4.1 Nagpur Disaster Management and Response Plan

NMC, being a primary institution for providing necessary urban services, is also responsible for disaster management in the city. Nagpur faces hazards such as floods, drought, unseasonal rains and hailstorms. Major disasters such as flooding mostly occur in rural areas and some of the urban areas due to flooding of rivers flowing through the city. The city lacks robust sewerage and storm water drainage. However, as per the Disaster Management (DM) Act 2005, to strengthen the district and city's disaster management capacity, Nagpur has been selected as a regional headquarter and is responsible for managing the disasters faced by the city as well as surrounding cities/ villages i.e., Bhandara, Gondia, Wardha, Chandrapur and Gadchiroli. The responsibilities include the following:

1. Forming a Disaster Management Committee for each city headed by the Commissioner and comprised of core members such as Chief Fire Officer, Chief Engineer, Administrative Chief of search & rescue operations and Chief Medical Officers
2. Establishing a City Control Room to be aligned with state, district and police disaster control rooms
3. Forming well-trained groups for search and rescue operations
4. Preparing city/town-ward wise disaster management plans including information of city's vulnerable areas, identification of risks/hazards faced by the city/town, records of past events and the city/town's preparedness to manage these hazards in terms of infrastructure, technology and manpower
5. Keeping stock of essential instruments, kits, equipment etc.
6. Establishing robust communication and dissemination systems for public outreach
7. NMC has prepared a Disaster Management (DM) Plan, which includes Standard Operating Procedures (SOPs), a committee, 24*7 centralised and zone level control rooms for untimely disasters.



The Disaster Management plan provides details on objectives and methodology of plan development, Nagpur city's hazard vulnerability, hazard profile, potential hazards likely to occur in Nagpur, probability and seasonality of disasters, and institutional mechanism for disaster management.

4.1.1 Disaster Management in Nagpur

Nagpur has not experienced any severe natural calamities in recent times. However, to ensure the necessary response in times of a disaster, a mechanism is laid out in terms of quick response teams, quick assessment teams, disaster/hazard reporting procedures, checklists and handbooks. To handle disasters, emergency operation centres have been established. The Fire Department of NMC serves as a Disaster Management Cell for the city, headed by the Municipal Commissioner.

As per the DM Act 2005 legal framework, guidelines and mandates (Figure 30), NMC has recently published the DM Plan 2019-20. The plan provides details on objectives and methodology of plan development, Nagpur city's hazard vulnerability, hazard profile, potential hazards likely in Nagpur, probability and seasonality of disasters, institutional mechanism i.e. city disaster management committee and its functions, preparedness and mitigation measures and actions, response plans for different government authorities such as municipal commissioners, zone and ward offices, fire brigade control room SOPs, budget allocation, stakeholder analysis and important contact details (Table 23).

Figure 30: Legal framework of Disaster Management Act 2005

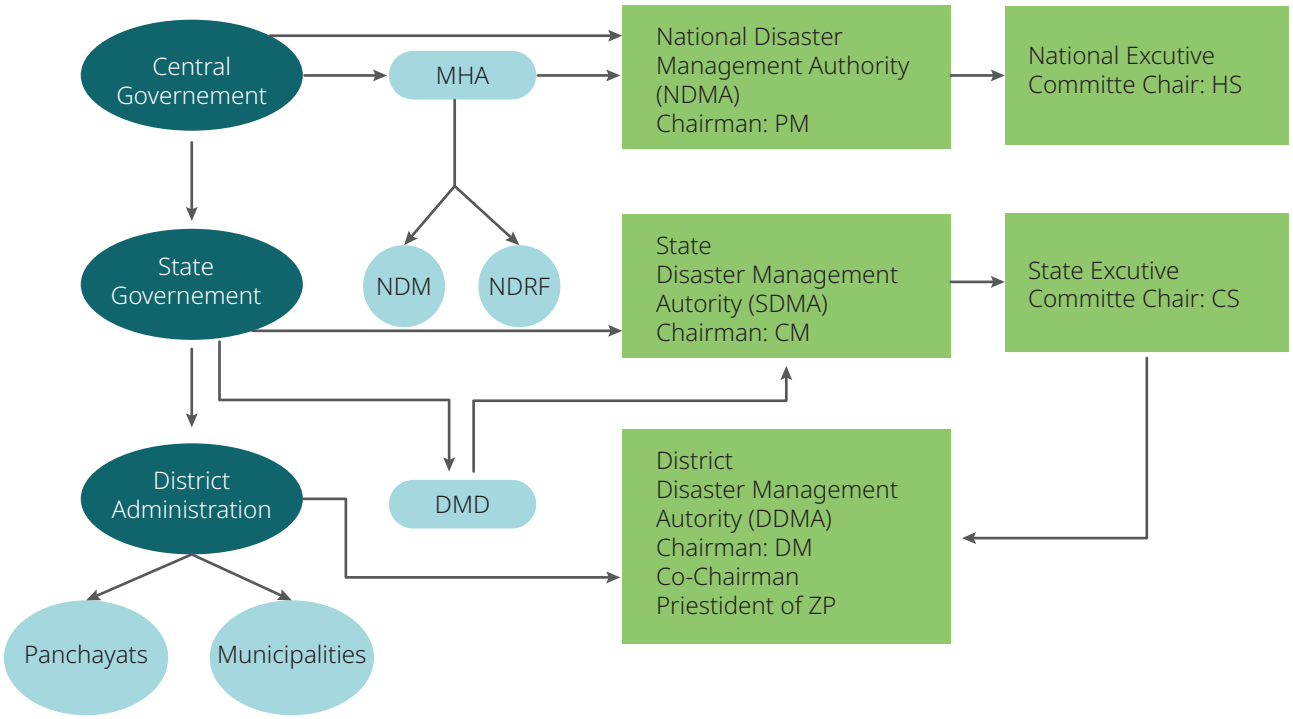


Table 23: Steps considered in preparing Nagpur's Disaster Management Plan

Sr No.	Activity	Nominated officers and institutions	Process
1	Existing setup review and analysis	Commissioner, fire officer, NMC department heads, zonal officers, local associations, NGOs, ward level workers	• Discussion and documentation of past disasters • Recording extent of severity and damages • Rescue and restoration process analysis and alteration if necessary
2	Situation analysis	Same as above	• Mapping the geography and topography of risk prone areas, ward-wise along with demographic details • Mapping the habitation in concerned areas • Mapping of natural resources • Listing all livelihoods and properties • Marking existing risk prone/safe infrastructure on the map
3	Hazard analysis	Same as above	• Identifying all possible hazards in the area based on past experience and available records • Identifying the most vulnerable areas with relation to threat to life, livelihoods and property

Sr No.	Activity	Nominated officers and institutions	Process
4	Vulnerability assessment	Same as above	• Mapping the location of vulnerable areas separately • Identifying the vulnerable people such as the elderly, the differently abled children and pregnant women, families living in thatched houses etc. • Identifying property or assets likely to be affected, such as cattle and other livestock, kachcha houses, weak structures etc. • Identifying weak points on embankments, over bridges, transformers, water tanks, mobile towers, partially/fully damaged houses/buildings/apartments, lowland areas, water logging places, fire danger zones • Marking the drainage system in the concerned area
5	Opportunity analysis	Same as above	• Identifying existing resources which may help reduce risks to life and property • Identifying high raised platforms, open land areas, open spaces, hydrant points, safe houses and hillocks for shelter and storage • Listing the existing shelters, if any • Identifying the elevated and up-lands which can act as natural barriers to protect livestock • Listing existing health and sanitation facilities • Identifying safe routes for evacuation • Identifying sources of funds to carry out preparedness activities

Source: Nagpur's Disaster Management Plan 2019-20

4.1.2 Identified Categories of Disasters by NMC

- Water and climate related: Flood, drought, hailstorm, heat and cold waves, cyclones, lightning etc.
- Geography related: Earthquakes, dam bursts etc.
- Chemical/industrial/nuclear accidents related
- Accident related: Stampede, road, rail, terrorism, electrical disasters, and fires, building collapse
- Biological: Epidemics, pest attacks etc.

The plan includes SOPs for each department with respect to what is to be done before, during and after the disaster hits the city as well as the activities prescribed for idle conditions. Responsibilities of disaster management cell, fire department, zone level control centres, departments such as medical, health, police, education, collector office, electricity office, public works etc. have been provided along with contact numbers.

Table 24 details climate linked risks, the respective urban services impacted and the city's interventions to tackle the issues. Table 25 provides locations of water logging areas in the city.

Figure 31: Flood disaster management functional chart

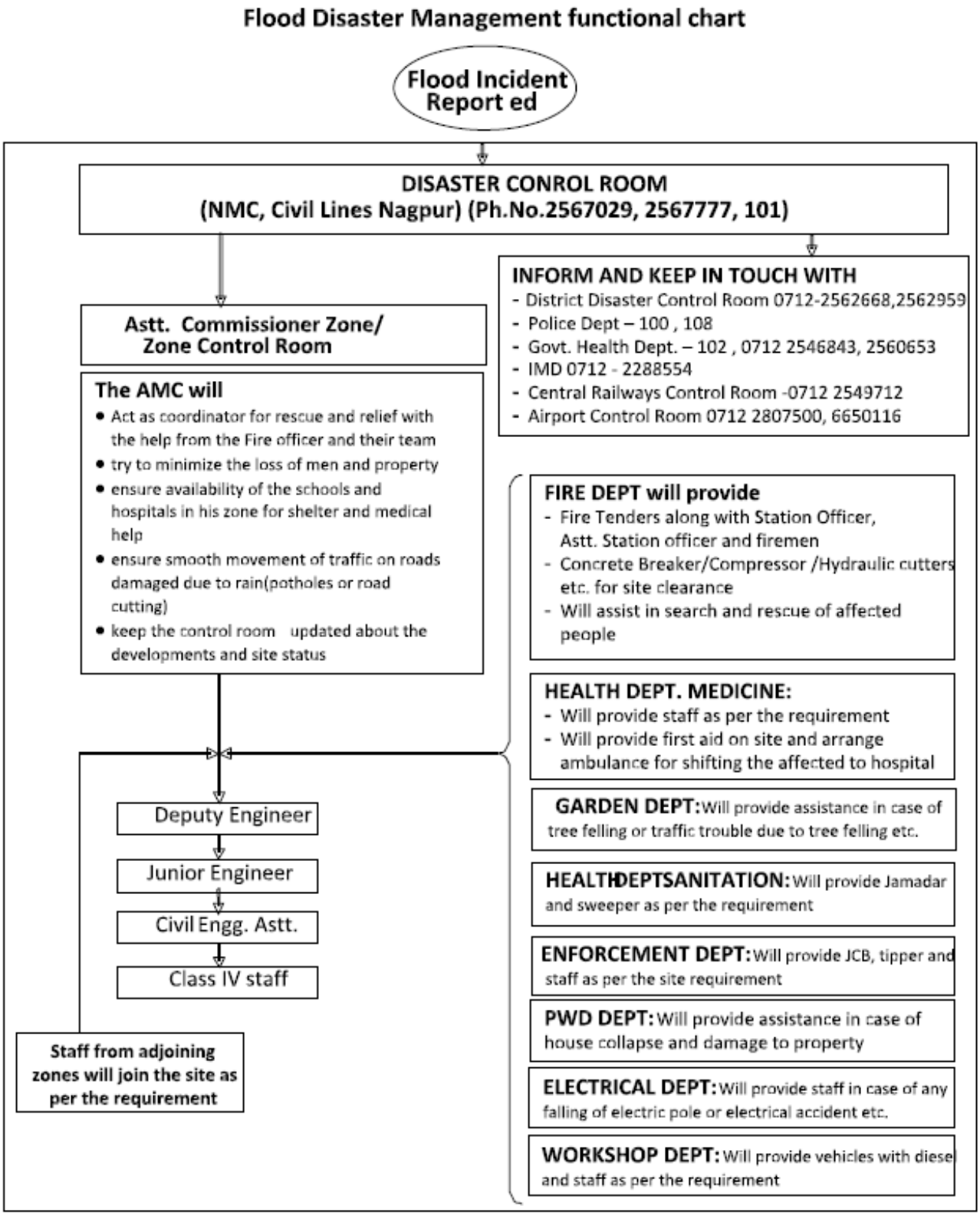


Table 24: Identified disaster risks in Nagpur's Disaster Management Plan

Disaster categories (Based on reports available with NMC)	List of the urban systems impacted (Based on reports available with NMC)	Areas and population (number and type) impacted (Based on discussions with NMC officials)	Interventions listed as per sector (Based on discussions with NMC officials and reports shared by them)	Issues identified (Based on discussions with NMC officials)	Probability of Occurrence (Rating)	Vulnerability (Rating)
Flood/ heat and cold wave/ drought/ climate change	Systems are identified in general, not disaster category wise: • Health • Public transport • Storm water drainage SOPs were prepared for all the above departments including fire brigade. Contact numbers of all associated agencies such as utility companies, water supply, police stations, irrigation etc. have been included along with recommendations for improving urban systems.	Number of families likely to be affected and areas for water logging, flooding etc. are identified disaster category wise Areas of submergence including slums have been marked on zonal maps with infrastructure (water sewerage, storm water, sanitation), nearby fire stations, hospitals, shelters such as schools and access roads etc.	Shelters identified in terms of schools, nearest hospitals along with contact numbers, information of no. of beds, boats etc. near low-lying areas along the major nullahs/rivers NMC role defined: such as cleaning of rivers/nullahs/drains, strengthening weak points/infrastructure, retaining walls before monsoon season SOPs for concerned departments and agencies such as medical, health, fire, energy utility, local government main & zonal control centres, etc. have been defined. For deployment of dewatering pumps & boats, tree displacement, utility wiring repairing/troubleshooting, etc.; zone-wise staff/class 4 officers are nominated for 3 shifts for the day reporting from control centres to tackle issues. Mitigation actions listed as Before, During & After the disaster occurs in the city. NMC prepares Heat Action Plan on yearly basis and undertakes several initiatives such as training, awareness programs along with interventions such as establishing shelters, water dispensers, etc. to prevent casualties due to Heat Waves in the city. Early warnings are displayed on screens and controlled 24*7 via centralised COC of the city established under Nagpur SCM. Under Nagpur SCM, city installed 10 air quality-monitoring stations at crucial junctions of the city. Citizens can access the information via mobile application. NMC launched Grievance Management System through which citizens can lodge complaint. Complaint is then routed to particular department and has verification system built in along with feedback. Grievance Management- Users (nmcnagpur.gov.in)	Irregular desilting of rivers/nullahs; Lack of efficient storm water drainage/sewerage system; Traffic, congested roads, encroachments, lack of awareness and negligence Improper River bank protection for encroachment & overflow. For heat waves, a greater number of water dispensers, shelters and capacity building for citizens.	Occasional (2)	Low (1)

Disaster categories (Based on reports available with NMC)	List of the urban systems impacted (Based on reports available with NMC)	Areas and population (number and type) impacted (Based on discussions with NMC officials)	Interventions listed as per sector (Based on discussions with NMC officials and reports shared by them)	Issues identified (Based on discussions with NMC officials)	Probability of Occurrence (Rating)	Vulnerability (Rating)
Drought			Nagpur as a city is not prone to drought due to 80% above water supply coverage, average precipitation and water bodies. This does not preclude the occurrence of droughts, but merely means that the impact of drought on water resource availability in the city would be limited.		Rare (1)	Low (1)
Food poisoning/ epidemic/ insects related			NMC health department is dedicated for epidemics and NMC has its own dispensaries, hospitals, referrals to speciality hospitals that can handle the tasks. NMC has 4553 beds in patient public hospital beds including Community Health Centres (CHCs) and 9744 private hospital beds. During COVID-19 pandemic the number has increased. NMC carry out awareness campaigns through social media, print media, radio, etc. NMC staff visit allocated areas of the city periodically to check in each household to check physical conditions such as water storage conditions & provide medications to prevent Dengue, etc. NMC health department monitors epidemics such as Dengue, Malaria, Cholera, Gastroenteritis, Infective Hepatitis, Encephalitis, Typhoid, Acute Diarrhoea, etc. During COVID-19 pandemic, NMC undertook several initiatives to contain virus under control which includes physical door to door health surveys, rapid testing, provided better quarantine centres, online portal to showcase city's status and launched portal which gives details of vacant oxygen, ICU, ventilators beds available in the city. NMC | COVID Beds (nsscdcl.org)	Record keeping of patients is difficult due to patient preference towards private hospitals which are mostly in city's core central and southern area. System is not in place to intimate NMC regarding patient history including address, contact details & disease related information.	Rare (1)	Low (1)

Table 25: List of water logging areas in Nagpur

Area Name	Area Name	Area Name
1. Ramdaspeth	2. Adarsh Nagar	3. Shanti Nagar
4. Kachipura Slum	5. Taj Nagar, Azad Nagar	6. Rani Durgawati Nagar, Kanji House
7. Behind Dharampeth College	8. Boudh Nagar	9. Punapur Area, Surya Nagar
10. Area near Telankhedi Lake	11. Noga Company	12. Ambedkar Statue Mankapur
13. Gavlipura, Dharampeth	14. Motibagh, Matatoli	15. Padole Hospital Square
16. Pandharabodi	17. Motibagh Bhosale Wadi	18. Navabharat press, Wardha road
19. Hazari Pahad, Borgaon	20. Wanjara	21. Narendra Nagar under Bridge
22. Gandhi Nagar, Gadga area	23. Wanjari	24. Pawanbhumi
25. Lokanchi Shala, Reshimbagh	26. Nari	27. Chunabhatti
28. Imamwada, Siraspeth	29. Takshasheela Nagar	30. Ujwal Nagar
31. Juni Shukrawari Slum	32. Fule Nagar	33. Empress Mill colony, Opp. Narendra Nagar fire stn
34. NMC School, Tulsibagh	35. Zingabai Takli	36. Jhansi Rani Square
37. Nandanwan Layout	38. Garib Nawaz Nagar	39. Manas Sqr, near Loha Pul
40. Bhuteshwar Nagar	41. Yashodhara Nagar	42. Gita Mandir, Subhash Road
43. Shivaji Nagar	44. Hamid Nagar	45. Jawahar Cement Road
46. Shivaji Nagar Old Lakadganj	47. Gulshana Nagar	48. Reshimbagh Sqr
49. Kumbhar Toil, Shastri Nagar	50. Santosh Nagar	51. Near Gitanjali Theatre
52. Padole Nagar	53. Balaji Nagar slum Badkas Sqr	54. Badkas Sqr
55. Hiwari Nagar	56. Sakkardara Lake Slum	57. Gaddigodam Sqr
58. Sanjay Nagar	59. Rani Bhosle Nagar slum	60. In front of Tirpude College, Tiger Ground
61. Chambhar Nala	62. Kamgar Nagar, Nullah	63. Behind Vidarbha school, Om Nagar
64. Panchsheel Nagar	65. Goa Colony, Gaddigodam	66. Sangam Restaurant, Medical Sqr.

4.1.3 Disaster Vulnerability and Impact: DM 2017-18

The disaster management plans for Nagpur identify the different activities to be undertaken to prepare for rescue and rehabilitation in the event of a disaster, both natural and man-made. However, it does not account for the potential changes in climate that affect the occurrence or frequency of climate related disasters such as floods and droughts that can in turn severely impact the city's resilience (Table 26). Subsequent sections try to identify some of the major climate risks to Nagpur and their impact on the city's urban systems.

NMC is implementing several urban systems improvement projects such as Nag River rejuvenation, STPs and coverage expansions, 24*7 metered water supply project and most importantly improving public health care services in terms of more hospitals with necessary medical equipment to handle critical situations considering the pandemic situation.

Table 26: Identified disasters in Nagpur's Disaster Management Plan

Sr No	Type of disaster	Potential impact	Areas to be affected
1	Lightning	Medium	Urban as well as rural areas such as Saoner, Mouda and Ramtek
2	Flood/ heavy rain	Medium	Low lying areas near the river course such as Vena and Chandrabhaga, Nag rivers and residential area in Bhiwapur, Butibori, Hudkeshwar, Jalakhera etc.
3	Drought	Medium	Rural area mainly Narkhed, Katol, Umred and Hingana as well as agricultural belts in the district

4.2 Past Hazards, Climate Events and NMC's Response

Nagpur witnessed extreme temperatures for 21 days, which is double the duration of a typical heat wave. The NRDC report also states that Nagpur has seen temperatures exceed 45°C

The main climate hazards faced by Nagpur are heat waves, floods, hailstorms and droughts (water scarcity), though their occurrence has been sporadic. However, with ongoing urban expansion, and loss of green spaces coupled with pollution, cases of heat wave have considerably gone up in Nagpur. As per estimates from the National Research and Defence Council (NRDC)[13], in 2013, Nagpur witnessed extreme temperatures for 21 days, which is double the duration of a typical heat wave. The NRDC report also states that Nagpur has seen temperatures exceed 45°C for seven consecutive summers. According to NMC estimates, in the last 10 years, 196 cases of sunstroke were recorded and 18 of these resulted in deaths due to heat-related complications.

Another major climate hazard faced by Nagpur is drought. The city has witnessed a long history of dry spells resulting in frequent events of droughts. An assessment by the Indian Meteorological Department (IMD) highlighted that Nagpur witnessed 12 incidents of droughts between 1901 and 1998[14]. However, the city is implementing several projects such as the 24*7 water supply project with new infrastructure, metered water supply with SCADA system to ensure equitable water supply across the city, reduction in leakages and thereby in NRW.

Further, as per a Central Research Institute for Dryland Agriculture (CRIDA) report analysing historical data on frequency of hailstorm events across India in the last 38 years (1972–2011), Nagpur district witnessed the highest hailstorm events (40)[15]. However, in Nagpur urban area, frequency of such events is very low.

Nagpur typically witnesses water stagnation and flooding during monsoon rains and has witnessed few flash floods in the last decade[16]. In just nine hours in 2018, Nagpur recorded a staggering 265 mm of rainfall resulting in widespread flooding, loss of lives and property damage. The record for highest 24 hrs rainfall is at 304 mm, recorded on 12 July, 1994. Under the SCM, the COC with citywide CCTV surveillance is capable of sending warnings to respective departments (disaster management cell) in events such as flash floods to ensure minimum economic loss or damage. Despite NMC undertaking regular storm water drainage cleaning to reduce flash floods, the city's overall drainage coverage remains poor and inadequate.

13 NRDC. 2021. City of Nagpur Leads Maharashtra with Plan to Protect Residents against Deadly Heat Waves. [online] Available at: <https://www.nrdc.org/experts/anjali-jaiswal/city-nagpur-leads-maharashtra-plan-protect-residents-against-deadly-heat>.

14 Metnet.imd.gov.in. 2021. [online] Available at: <http://metnet.imd.gov.in/mausamdocs/25341.pdf>.

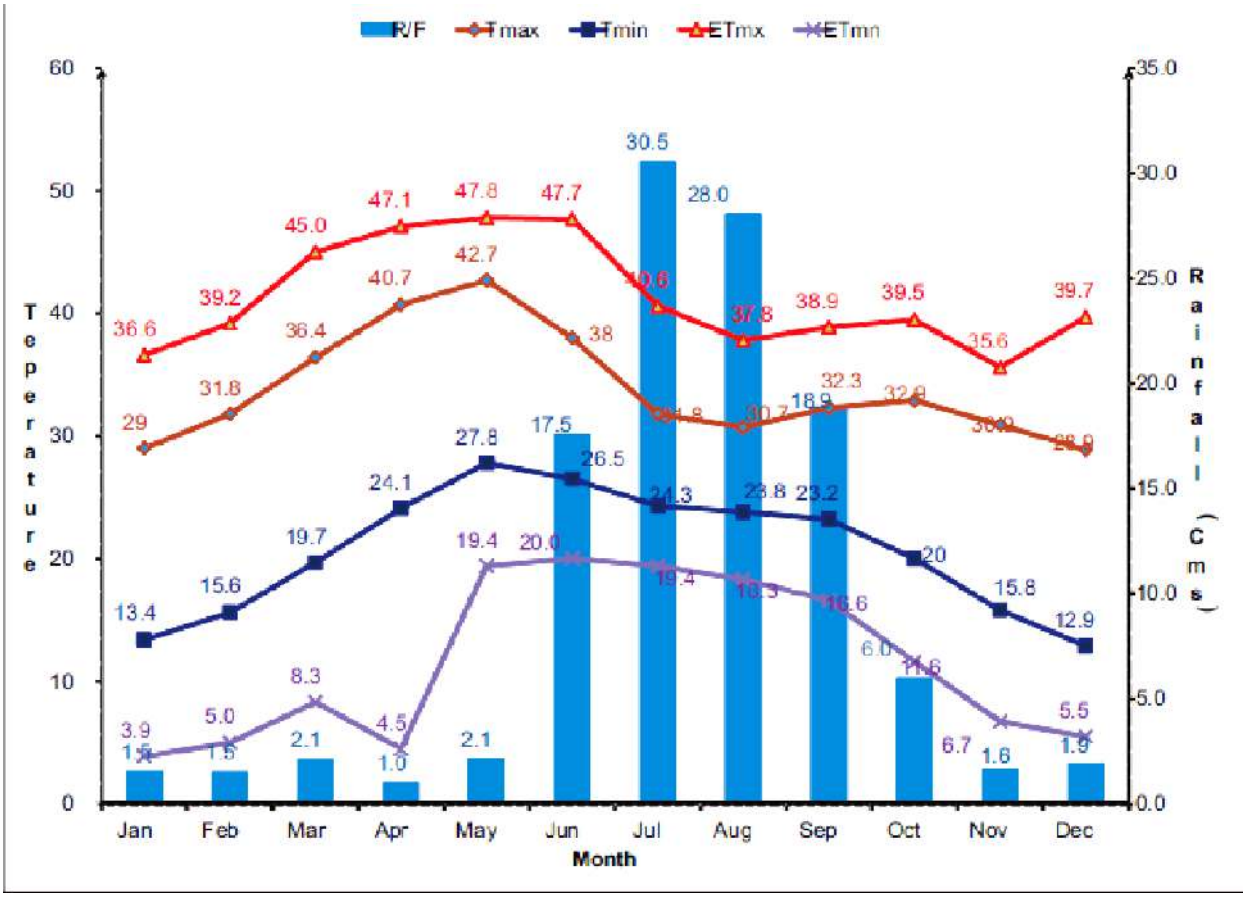
15 VUM Rao, R., 2021. Hailstorm Threat to Indian Agriculture : A Historial Perspective and Future Strategies. [online] Krishi.icar.gov.in. Available at: <http://krishi.icar.gov.in/jspui/handle/123456789/2591>.

16 Ansari, T., Katpatal, Y. and Vasudeo, A., 2016. Spatial evaluation of impacts of increase in impervious surface area on SCS-CN and runoff in Nagpur urban watersheds, India. Arabian Journal of Geosciences, 9(18).

4.3 Climate Scenario in the City

Nagpur has tropical savannah climate i.e. wet and dry climate conditions with pronounced dry conditions prevailing for most of the year. It experiences seasonal weather patterns and receives an annual average rainfall of about 1,100 mm between June and September, accounting for almost 90% of total rainfall. Summers are extremely hot in Nagpur, lasting from March to June, when temperature can go up to 48°C in May, the hottest month. Winter lasts from November to January, during which temperatures drop below 10.

Figure 32: Average annual temperature and precipitation pattern[17]



4.3.1 Past Climate Trends

In order to understand the climate vulnerabilities of Nagpur, time series data, primarily temperature and precipitation, obtained from the National Oceanic and Atmospheric Administration (NOAA) were analysed. The trend assessment of the annual average temperature data from 1981 to indicates an upward pattern. This observation corroborates the increasing instances of heat waves and a negative trend in very cold nights as observed by other studies[18]. On the contrary, a decreasing trend was observed for the annual average precipitation between 1989 and 2018 (Figure 34). A similar trend has been observed for Maharashtra by IMD, which conducted a long-term assessment of the precipitation data during 1951-2010 at the state level[19].

17 Indian Meteorological Department, Pune

18 Dhorde, A., Korade, M. and Dhorde, A., 2016. Spatial distribution of temperature trends and extremes over Maharashtra and Karnataka States of India. Theoretical and Applied Climatology, 130(1-2), pp.191-204.

19 Rathore, L., Jaswal, A. and Attri, S. (2013). State level climate change trends in India. IMD, Meteorological Monograph No. ESSO/IMD/EMRC/02/2013.

Figure 33: Average annual temperature trend[20]

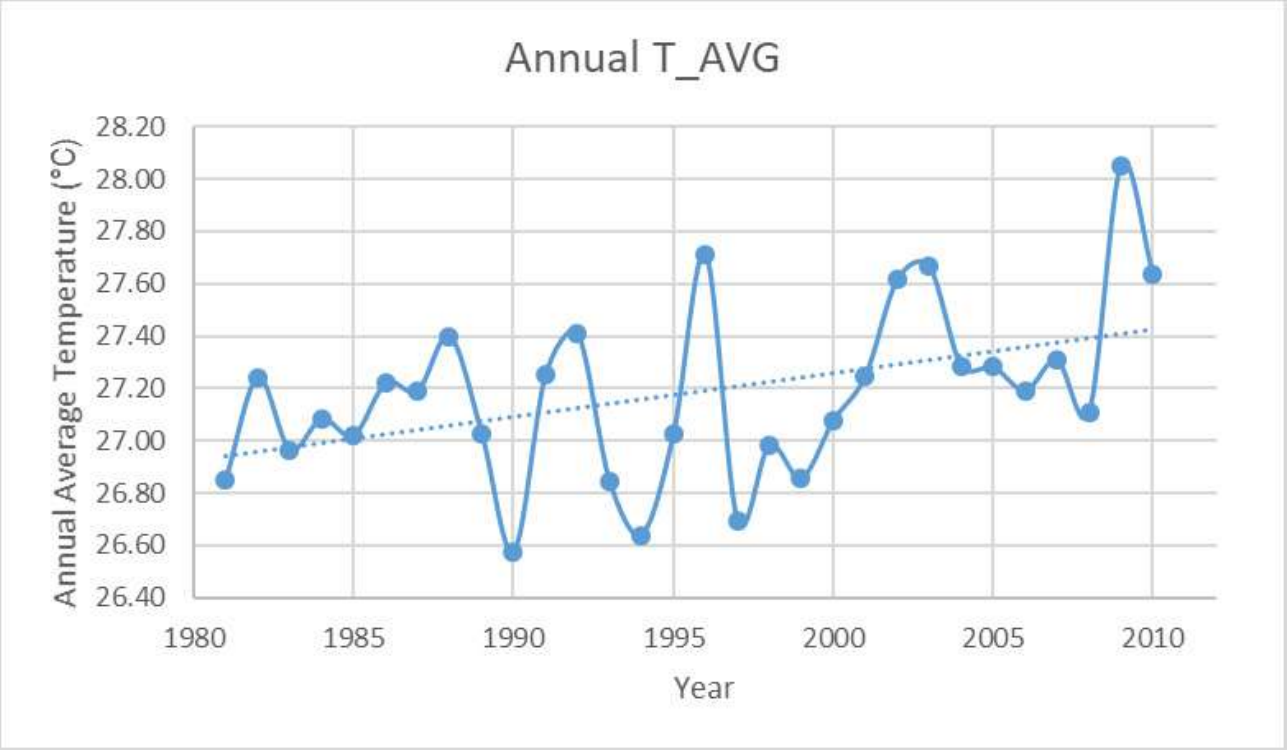
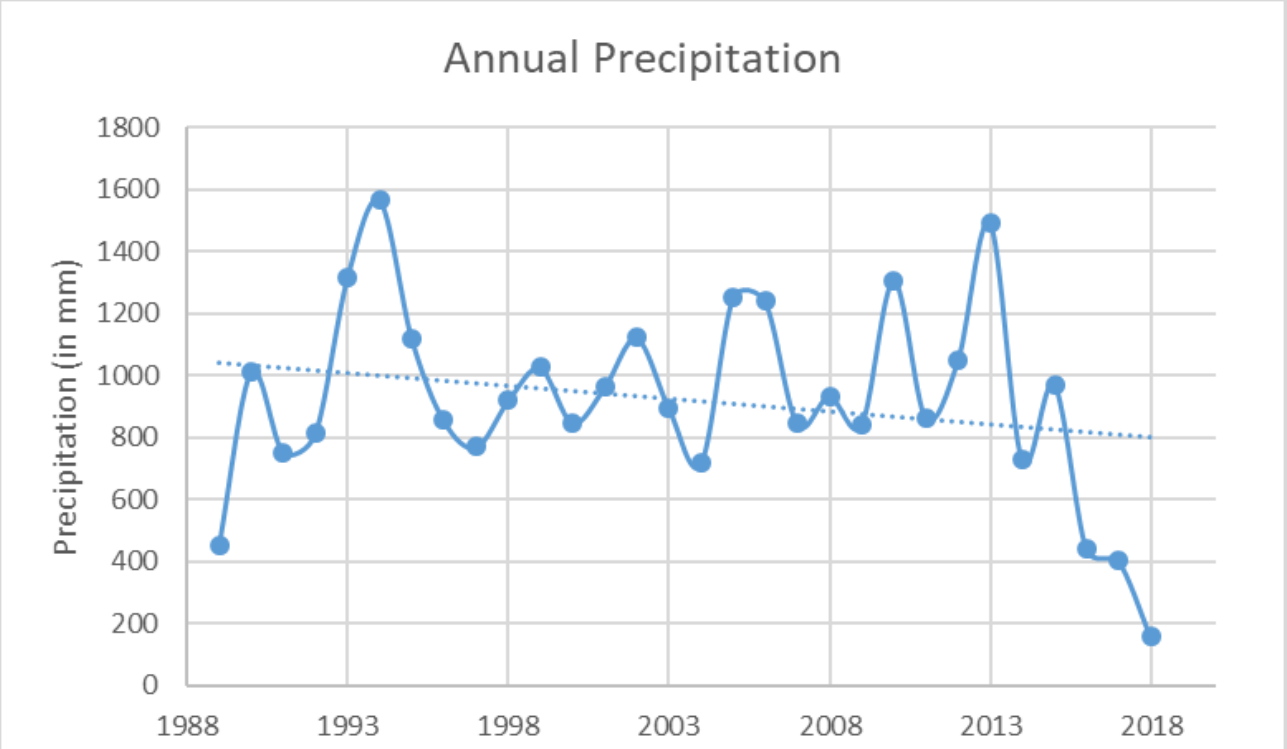


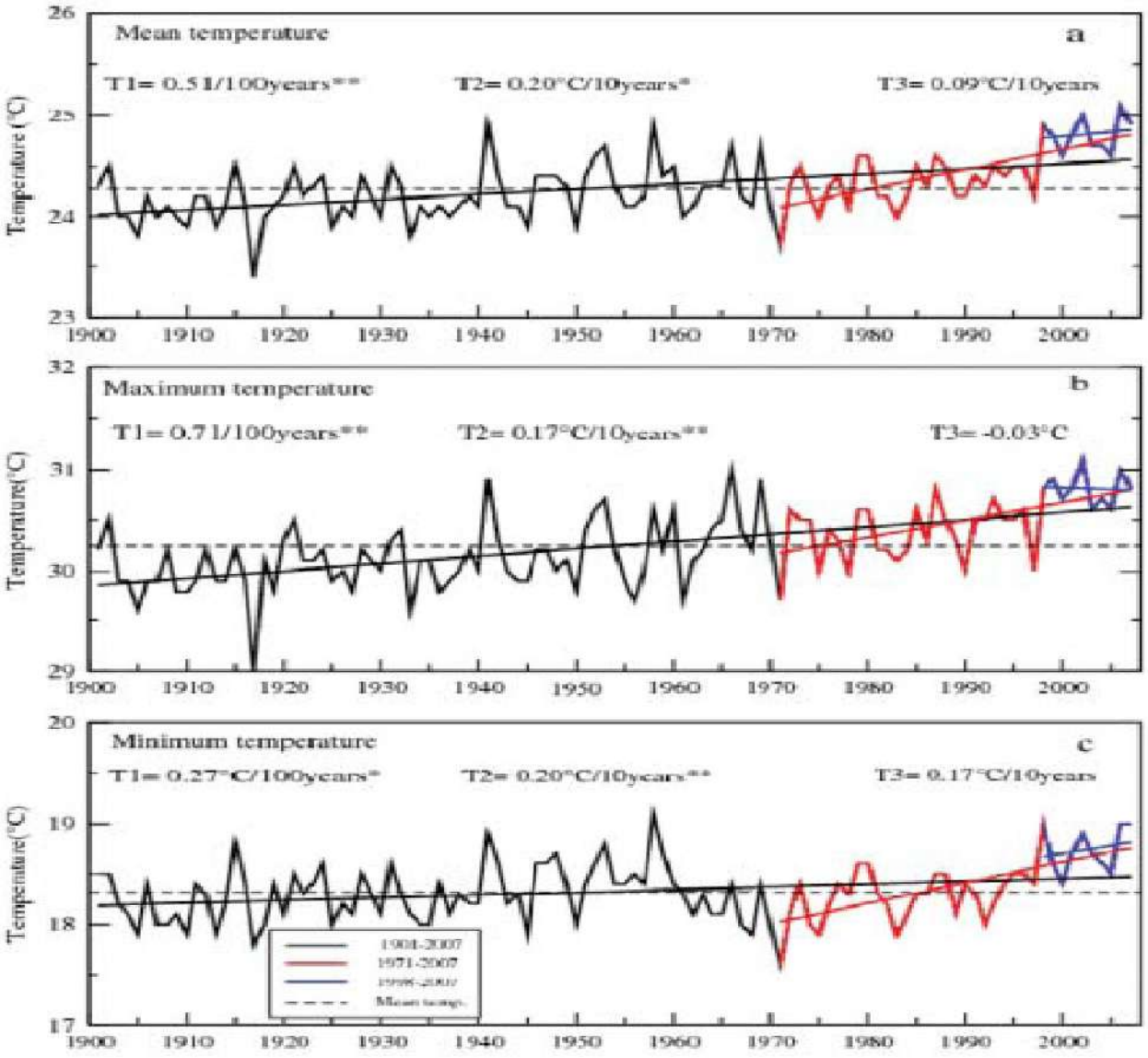
Figure 34: Average annual precipitation trend[21]



20 ICLEI South Asia assessment
21 ICLEI South Asia assessment

For assessing the state's climate trend, the Maharashtra State Adaption Action Plan on Climate Change[22] (MSAAPCC) refers to a study conducted by the Ministry of Environment and Forest, GoI published in the Indian Network on Climate Change Assessment[23] (INCCA) report. The report observes that mean temperatures all over India have shown a significant increase of 0.51°C during 1901–2007. Accelerated warming has been observed in the recent period of 1971–2007. Significant increase in temperatures has been observed during winter and post-monsoon seasons. Steeper increase in minimum temperatures has been observed compared to maximum temperatures (Figure 35).

Figure 35: All India annual mean, maximum and minimum temperature variations (1901- 2007)[24]



22 TERI. (2014). Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC). Project Report No. 2010GW01, The Energy and Resources Institute, New Delhi.

23 INCCA (2010) Climate change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s. New Delhi, India: Indian Network for Climate Change Assessment, Ministry of Environment and Forests, Government of India.

24 INCCA (2010) Climate change and India: A 4x4 assessment – A sectoral and regional analysis for 2030s. New Delhi, India: Indian Network for Climate Change Assessment, Ministry of Environment and Forests, Government of India.

4.4 Future Climate Projections

To appreciate climate vulnerability and suggest appropriate resilience strategies, understanding climate projections is imperative. However, there is no specific assessment for Nagpur looking at possible changes in temperature and precipitation patterns. Therefore, to understand the situation at the local level, available climate scenario data at the National and State level were referred.

One of the primary sources for ascertaining the climate projections is the MSAAPCC report. It employs the UK Met Office's 'Regional Climate Model' to provide high-resolution regional climate projections (25km x 25km) for the period 2021-2040 for Maharashtra. According to the MSAAPCC report, the percentage increase in rainfall in 2030s with respect to baseline years (1970-2000) shows that a few regions in Maharashtra will experience increase in rainfall, north-central Maharashtra more so than east (Vidharbha region), west and southern Maharashtra. The report also shows an increase in rainfall during monsoon in all regions with increase in Aurangabad and northern regions of Nashik division greater than in Konkan belt and Vidharbha region. The report does not discuss the region's projected annual rainfall (Figure 36).

Figure 36: Projected increase in Maharashtra precipitation in (a) 2030s (b) 2050s (c) 2070s relative to the baseline (in percentage)

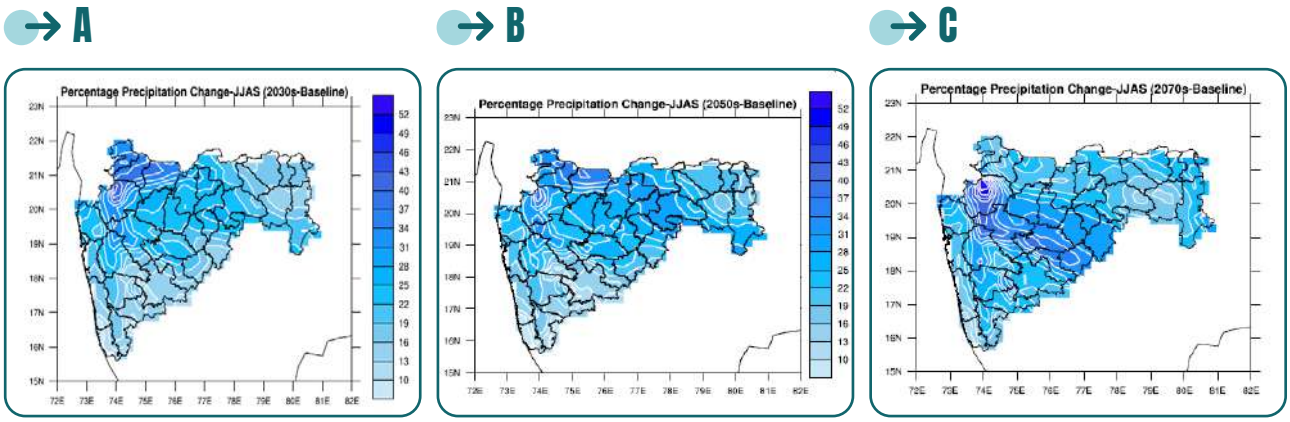
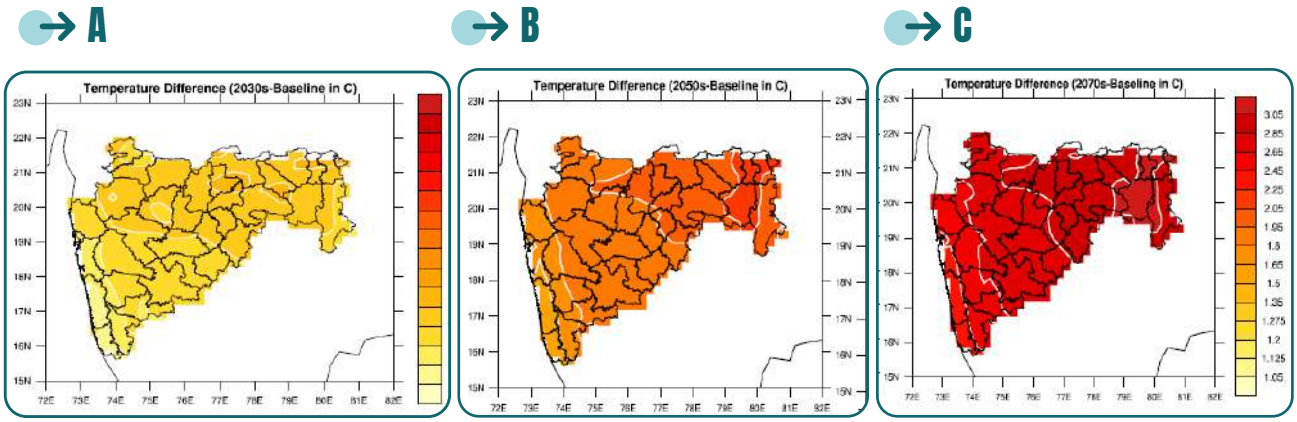


Figure 37: Projected increase in Maharashtra temperature in (a) 2030s (b) 2050s (c) 2070s relative to the baseline (in °C)[25]



25 TERI. (2014). Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC). Project Report No. 2010GW01, The Energy and Resources Institute, New Delhi.

The MSAAPCC report found an increase of 1.2°C to 1.5°C in temperatures in Vidharbha, Marathwada and Nasik regions; and 1°C to 1.2°C in Pune and Konkan regions. Based on the heat index (which combines relative humidity and air temperature) estimations, Nagpur division is expected to witness increased heat stress in the form of an increase in the number of dry days (5 to 6 days) in 2030s relative to baseline.

Table 27: Climate scenario summary statements

Changing climate conditions	Assessments	Climate scenario summary statements
Precipitation changes	Regional assessments (MSAAPC[26])	Nagpur is projected to receive more rainfall in absolute terms. For 2050s, the rainfall in monsoon shows an increase around 12.5-30% in the Nagpur. This pattern will continue in 2070s as well.
	City level assessment[27]	Future projections indicate a significant decrease in annual precipitation in Nagpur.
Temperature change	Regional Assessments (MSAAPC)	For 2050s, the annual mean temperature shows an increase of around 1.95 - 2.2°C in Nagpur region. This pattern is seen for 2070s as well but the overall increase in temperature is projected to be between 2.1 - 3°C for the entire state with highest increase (of about 2.8-3°C) projected over Vidarbha region.
	City level assessment[28]	Future projections indicate a significant increase in annual temperature in Nagpur.
Extreme events	Regional Assessments (MSAAPC[29])	The extreme rainfall index shows that the extreme rainfall (99th percentile) intensity increases in all regions, with larger amount of increase in Aurangabad and northern regions of Nashik division compared to Konkan belt and Vidharbha region.

City assessments are more relevant to Nagpur than state level regional assessment, as was evident from the discussion with city officials and other stakeholders. The climate risks likely to affect Nagpur are as under:

4.5 Risk Assessment

The risks associated with the fragilities of urban systems were evaluated through a risk assessment exercise conducted by ICLEI South Asia based on one-to-one discussion with the key officials of NMC. The fragile urban systems with the highest risks as per the assessment were investigated further. Table 28 shows the fragile urban systems, the criticality, the existing and anticipated problems caused by fragility and fragility statements.

26 TERI. (2014). Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC). Project Report No. 2010GW01, The Energy and Resources Institute, New Delhi.

27 Shravankumar, S.M. and Vasudeo, Dr.A.D. (2005). Climate Change and its Impact on Nagpur's Water Supply. International Journal of Engineering Research & Technology (IJERT), 4(10).

28 Shravankumar, S.M. and Vasudeo, Dr.A.D. (2005). Climate Change and its Impact on Nagpur's Water Supply. International Journal of Engineering Research & Technology (IJERT), 4(10).

29 TERI. (2014). Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC). Project Report No. 2010GW01, The Energy and Resources Institute, New Delhi.

Table 28: Critical urban systems and fragility statements

Sr. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement	Climate fragility statement
1	Water supply	City's rapid development & increase in migrant urban population has increased demand for limited and shared sources of water. Below average rainfall can affect equitable & round the year water supply in the city. NMC initiated 24*7 water supply in 2011 year with 68 identified command areas out of which 22 command areas have been covered under the project, remaining to be completed by 2022. Project funding was stalled for 3 years, slowing its progress. Zones such as Mangalwari, Nehru Nagar, Ashi Nagar, Lakadganj, Hanuman Nagar zones have more complaints regarding water supply and sewerage system as per the NMC's online grievance management portal.	**Availability of water:** Water allocation to Nagpur is quite high due to higher NRW in the system. Due to higher per capita per day supply, It affects overall consumption habits of the citizens and leads to uneven distribution throughout the city. **Dependency on water resources:** NMC depends on surface water resources namely Kanhan River & Pench (Navegao-Khairi) reservoir. Nagpur shares these resources with state of Madhya Pradesh. Drought situations faced in last few years along with state disputes on water allotment, Nagpur city faced water supply cuts and escalation in tariff charges by 5 %. **SCADA system with metering and NRW:** Though Nagpur city has implemented SCADA system with water metering at buildings, NRW is still 53%. Currently city supplies 648 MLD of water out of which only 308 MLD is billed. **Ground water:** NMC reports that the ground water extraction is negligible and only used for washing & other similar purposes. MPCB's report (2018) * on water quality of Nag River mentions its condition as 'Poor to Very Poor' category, mostly due to untreated inflow of sewage. Groundwater quality in city's Southern & Eastern part, mostly near to Bhandewadi dumping ground is deteriorated due to unscientific solid waste management at site. Despite of having mandatory RWH systems for new projects in Nagpur, working of the same after initial 1-2 years is a question. *Water Quality Status Report of Maharashtra State_2018-19 http://www.environmentclearance.nic.in/writereaddata/District/surveyreport/251220177QX3ML45DSRNagpur.pdf	Water Supply Department of NMC	Being in an arid zone with irregularity in rainfall, Nagpur faces problems like flash floods/droughts, nitrate contamination in ground water due to inadequate sewage treatment and disposal of solid waste in drains & open dumping, NRW losses, higher per capita consumption rate, old network and shared resources; hence city authority is reforming this service with various projects such as 24*7 water supply project with SCADA system thereby increasing accountability, accurate metering, overall system efficiency. Link for live SCADA system: Water Flow Details of All ESR-GSR-WTP Locations in Nagpur | OCW SCADA (orangecitywater.com)	Slow progress of 24*7 water supply project till date. Exposure of community to poor quality water and its irregular supply especially in summer season is a critical issue.

Sr. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement	Climate fragility statement
2	Sewage treatment	Contaminated rivers as well as local water bodies, Nag & Pili River, Ambazari & Futala lake, are the most affected areas due to insufficient treatment facilities. During monsoon, water logging situation arises at few places. Blocked drains due to solid waste and discharge sewage in storm water, affects health of citizens.	Nagpur generates 532 MLD wastewater, of which 345.3 MLD gets treated. Current STP capacity is not sufficient to treat sewage generated at city level, especially in monsoon season. Hence, few centralised & decentralised STPs have been planned under Nag River Pollution Abatement Project of total capacity 102 MLD and to be completed by the year 2024. For newly added area of Hudkeshwar Narsala in NMC jurisdiction, additional 20 MLD capacity plant is planned and funding proposal is submitted to state department. Higher per capita supply leads to dilution of the sewage generated and affects overall biological treatment/functioning of STPs with designed organic load. Untreated or partially treated sewage discharge increases pollution load in water bodies threatening aquatic life. Regular monitoring of the private STPs is required to check whether they are functioning properly or not. Reduced productivity of contaminated water bodies and land parcels. Under Individual Household Latrines (IHHL) scheme, approximately 13,000 households of below poverty line received funding assistance to construct toilets	Public Health Engineering Department of NMC	Insufficient sewage treatment capacity, higher rate of per capita consumption, insufficient collection system (64% sewerage network), functioning of private STPs and blockage of drains due to solid waste are the problems being faced by city and hence NMC has initiated Nag River pollution abatement project focusing on decentralization with total treatment capacity of 102 MLD	Insufficient sewage treatment capacity, blockages of sewer lines due to solid waste dumping is, as well as ground water contamination causing health problems among citizens.
3	Storm water management	City does not have proper storm water drain system; existing network is degraded and causes water logging during short duration high intensity rainfall and it worsens due to uncontrolled solid waste dumping in open drains thereby clogging the drains. Only 35-40% of city's roads are constructed with storm water drains of length approximately 1020 km considering primary, secondary and tertiary storm water drains. About 70 locations have been identified by the storm water management department facing water logging issue frequently. Water logging affects transportation facilities and breaks connectivity with other areas resulting in economic losses.	Climate change – High intensity short duration rainfall events Land use land cover plan of the city – more paved surface leads to less percolation and more run off generation. Solid waste dumping: Culverts, drains and nullahs at various places are blocked due to deposition of silt and solid waste. Siltation in drain: The problem of flooding exacerbated by siltation in roadside drain and nullah and clogging by disposal of solid waste by citizens. Siltation has reduced the carrying capacity of drain and disposal of solid waste has resulted in blocking of road culverts. As per the NMC grievance addressal system, inadequate nullah cleaning at few areas is observed. Inadequate inlet arrangement for roadside drains and connections from drain to nullah, obstruction of utilities, encroachment along Nullahs, etc. At most, of the places drains carry sewage thereby creating flooding/ overflows.	Public Health Engineering Department, Public Works Department, Disaster Management Cell of NMC	Changes in land use land cover pattern, increasing concretized surfaces, encroachments and developments on natural drains (nullahs), blockages due to solid waste, engineering problems of designing storm water drains, leads to water logging at few places which highlighted need of various projects undertaken by the NMC. NMC has prepared action plan for storm water drainage system for South Zone.	Inadequate and existing degraded drains mixed with sewer lines pose problems such as loss of aquatic life downstream, water pollution, foul smell, algae bloom at the time of overflow or water logging,

Sr. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement	Climate fragility statement
4	Solid waste management	City generates about 1100-1200 TPD having 100% household coverage of door-to-door collection system with GIS based vehicles, being managed by 2 agencies hired by NMC. Negligence of citizens in few places of dumping waste especially on the banks of nullahs and open drains cause blockages and reduce runoff potential of the stream. A partial sanitary landfill site constructed back in 2011 exists in the Bhandewadi area. NMC from technical support from NSSCDCL environment division team, has planned to execute 600 TPD of compost plant, 380 TPD of centralized MRF & RDF plant and 150 TPD of C&D waste treatment plant, tender documents of all the projects are ready and to be commissioned by 2022-23.	**Segregation at source:** Waste segregation is identified as the biggest issue in Nagpur, which impedes efficient waste treatment, even though segregating waste in 2 categories of dry and we waste is mandatory for citizens. **Waste Collection & Transportation:** There are no waste transfer stations in the city, waste NMC has prepared vehicle route maps for waste collection to monitor and improve the door-to-door collection system. Route Maps can be accessed here **Waste treatment:** Currently there is no major waste treatment plant in the city apart from 200 TPD composting. NMC undertook bio-mining projects at Bhandewadi dumping yard out of which one project to clear 1 Mn MT of waste is already started to reclaim land of 50 acres and other project will treat 0.6 Mn MT of waste and the recovered material will be disposed scientifically or supplied to the concerned industries of cement/glass/metal/etc. **Awareness:** It was observed that many citizens and slums are throwing their solid waste in open nullah, water bodies. Hence awareness about not to dump garbage in open areas and water bodies should be on priority. Scientific closure of the existing dumping site is also planned by NMC after reclaiming the bio mining of 0.6 Mn waste.	Solid Waste Management Department of NMC	Unsegregated Municipal Solid Waste (MSW) is collected and disposed in an open dumpsite, causing deleterious environmental and health impacts.	1. Increasing temperatures accelerate decomposition rates and create potentially hazardous conditions in open dumpsites by increasing the probability of landfill fires. 2. Disposal of untreated municipal solid waste results in direct methane emissions, contributing to global warming and impacting health of residents 3. Solid waste littered in streets is washed into drains and open sewer manholes, during periods of high intensity rainfall, blocking outflow and resulting in stagnation, leading to public health impacts.

Sr. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement	Climate fragility statement
5	Transportation	Avg. trip length in Nagpur is 7.6 km including walking. Nagpur is blessed with wide roads and good road network however lacks in optimum & efficient public transport and pedestrian friendly infrastructure. Yearly about 0.1 Mn private vehicles get registered 80% of which are 2-wheelers. As of now, about 1.8 Mn vehicles are registered causing traffic congestion in core areas of the city having narrow roads where all transport modes ply such as bus, freight along with unauthorized parking and encroachments. Citizens opt personal vehicles mostly 2-wheelers for commute eventually causing air pollution in the city. Under the strong political backing, Nagpur undertook several one-of-a-kind initiatives such as setting up EV charging stations, introducing fleet of Ethanol fuel-based buses. However, due to low response & debt, NMC had to shut bus fleet. Currently NMC has a fleet of 350 buses having average daily ridership of 1,48,002. Due to inadequate frequency and coverage of public transportation, auto-rickshaws on sharing basis is a preferred mode of transport, more than 26,000 rickshaws provide service in Nagpur with equal or less cost that of public transport.	Absence of Dedicated Lane for walking and cycling – NMC is working on pilot project under national government's Cycle for Change and Streets for People challenge in which dedicated bicycle track of 18 km will be developed and few vehicles free zones are identified. Air pollution – Unpaved roads and increasing automobiles are resulting in Particulate matter, SOx and NOx in the city, especially due to metro rail project work and traffic congestion caused. Encroachments on roads by informal settlements and street vendors lead to more congestion. Nagpur is witnessing increase in number of E-rickshaws, as of now 1350 ply on the roads out of which 870 were registered in last financial year.	Public Works Department, Roads and projects Department, Town Planning Department, Nagpur Municipal Transport, Western Railways, MMRDA, MSRTC, NHAI, IWAI	Nagpur has extreme weather pattern especially summers are harsh hence better transportation facilities with affordable, safe, pleasant and less time- consuming transport facilities are crucial.	During periods of water logging and increasing temperatures especially in May month, use of public transport is limited due to inadequate public transport services and limited last-mile connectivity however metro rail project has been commissioned in the city connecting major junctions and feeder system has been planned for last mile connectivity which includes 19 routes and covers 160 km.

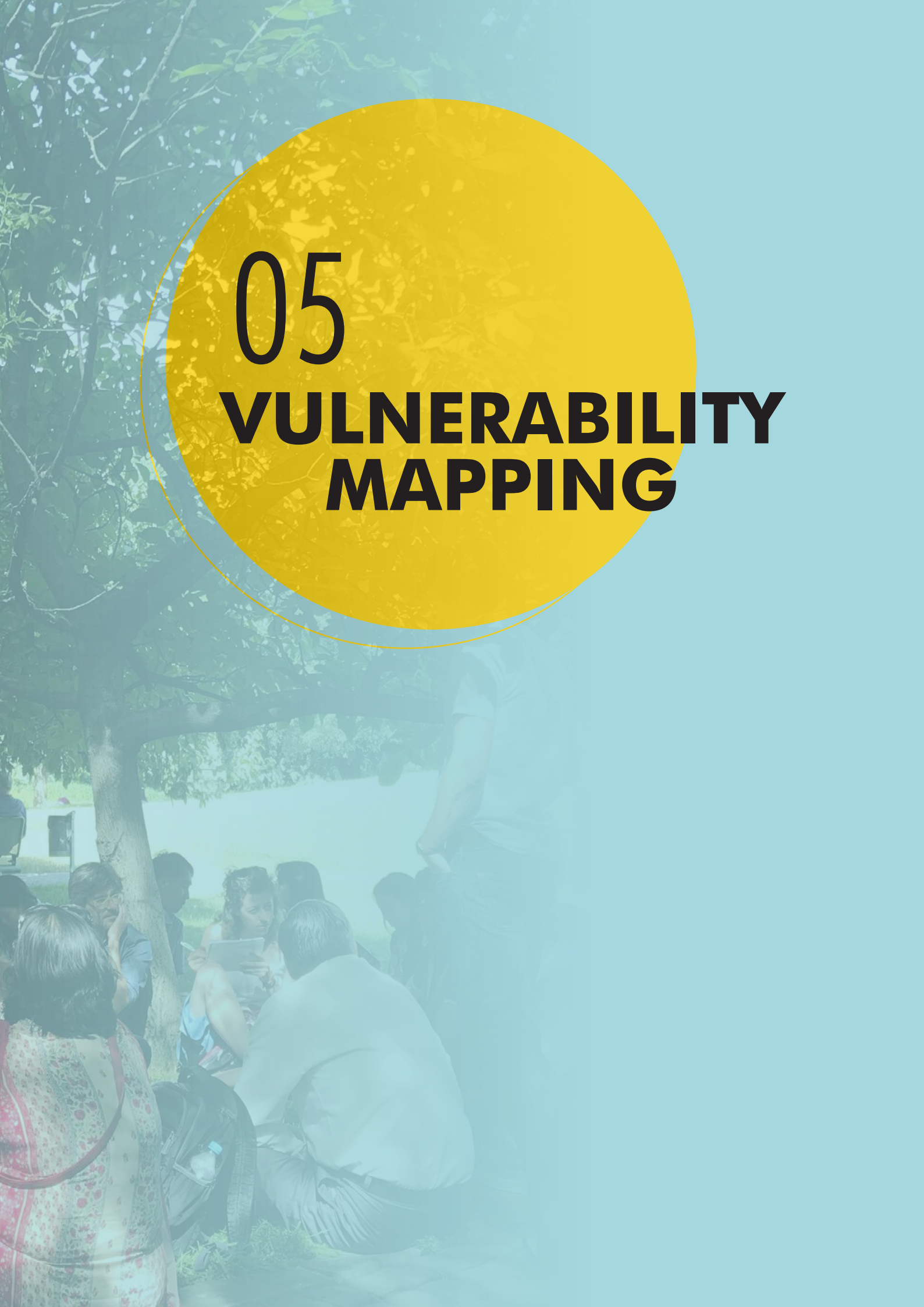
Sr. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement	Climate fragility statement
6	Health	Higher number of urban poor in slums and dilapidated buildings and inadequate & affordable public health facilities puts stress on health infrastructure. Nagpur experiences harsh climate conditions especially in Summer where temperature reaches at 46°C. NMC regularly works on Heat Action Plan for the city and undertakes necessary actions in the city including shelters, drinking water outlets, primary health care centres and alerts on radio, local TV channels and display screens set up across the city under SCM.	Seasonal influence on health issues e.g., during monsoon viral fever, malaria, gastro, during winter cough and cold, bronchitis, breathing problems and during summer skin itching, dehydration and heat stroke patients are common. Major concern is on Particulate matter due to development activities, street food (mainly due to use of coal) and vehicular pollution	Health Department of NMC, Health Department of Maharashtra State and Private hospitals	Dense population is prone to spread of epidemic and increasing air pollution require sufficient health care infrastructure developed by NMC and private entities. City's old area is very densely populated and has inadequate urban services such as water, wastewater, health.	NMC's public infrastructure is limited and ill equipped to handle the pandemic. However due to the urgency, city has been able to control the spread effectively. Private health care services are not available throughout the city and are not affordable to urban poor, which approximately is 25% of total urban population.
7	Biodiversity: Green spaces and water bodies	Nagpur is known for its Green cover however due to rapid urbanization, including metro rail projects, commercial & residential townships city's tree cover is reducing. A map has been prepared showing city's green cover under Urban LEDS II Project. Restoration and conservation of local ecosystem and development of additional green spaces will improve health of citizens. Under URBAN LEDS II project, NMC is preparing Local Biodiversity Strategy Action Plan (LBSAP) to mainstream urban biodiversity conservation in the city. Nagpur city has total 11 lakes but most of them are polluted due to uncontrolled sewage influx damaging ecosystems and aquatic life.	Lack of wastewater collection and treatment facility is increasing pollution load on water bodies Lack of awareness among local people – throwing solid waste in natural drains Encroachment on the banks of water bodies make it difficult to take any measures of restoration Restoration of aquatic ecosystem is also critical Survival of the planted trees and conservation of heritage trees must be considered. Encroachments on green spaces, nullahs for development projects is a major concern. NMC has undertaken lake restoration projects under which three lakes have been restored. Decentralised WTPs have been installed upstream to restrict pollution via neighbouring industrial clusters.	Public Works Department, Garden Department, Pollution Control Department, Town Planning Department, Disaster Management Cell of NMC, Forest Department.	Local biodiversity must be restored, conserved and enhanced to improve interaction of citizens to biodiversity with awareness as well as for healthy well-being of the residents.	Due to loss of green cover on regular basis and concretization, city is facing urban heat islanding effects, causing heat strokes and other related health issues. Cooling demand in buildings & vehicles also increase due to heat ingress.

These urban systems are further assessed in terms of the climate risks identified in the previous section. The risk score for each climate fragility statement is defined as a combination of the likelihood of an event to occur and the consequences faced if the event occurred (See Table 29).

Table 29: Risk Assessment for the Identified Fragile Urban Systems

S. No.	Urban systems	Climate fragility statement	Likelihood	Consequence	Risk score	Risk status
1	Water supply	High intensity & short duration rainfalls, rainfall irregularity and change in pattern will affect city's water supply.	4	3	12	Medium-High
		Increase in temperature will increase evapo-transpiration rate reducing available water quantity with degradation of quality and increasing water demand putting stress on ground water.	4	4	16	High
2	Sewage treatment	Mixing and overflows of sewage and storm water due to high intensity rainfall causes inefficient sewage treatment thereby polluting river streams, eventually affecting dependent farms.	4	2	8	Medium
		Increase in temperature causes septic conditions in open nullahs and drains thereby causing foul odour, toxic gas emissions eventually affecting wastewater treatment.	4	2	8	Medium
3	Storm water management	Dilapidated insufficient storm water drains get flooded due to high intensity rainfall causing water logging and backflow of contaminated water due to sewage mixing into residential/ commercial properties creates significant health risks and environmental pollution.	4	2	8	Medium
4	SWM	High intensity rainfall increases moisture content in waste making difficult to collect, transport and treat. Open storm water drains carry washed away solid waste causing pollution in fresh water streams such as Nag River.	4	4	16	High
		Higher temperature cause fires at open dumpsites causing toxic gas emissions and creating health risks to neighbourhood.	4	4	16	High

S. No.	Urban systems	Climate fragility statement	Likelihood	Consequence	Risk score	Risk status
5	Transportation	Apart from major road networks, narrow internal road lanes get waterlogged due to heavy rainfall affecting public & private transport movement resulting in traffic congestions, air & noise pollution and overall economic loss.	3	3	9	Medium
		Higher temperature demands high cooling in AC powered vehicles thereby increasing fuel consumption.	3	3	9	Medium
6	Health	High intensity rainfall and flooding conditions increase water borne diseases causing health risks to citizens.	3	3	9	Medium
		Nagpur faces extreme summer season (heat waves) which poses health risks to citizens.	4	3	12	Medium High
7	Biodiversity: Green spaces and water bodies	High intensity rainfall causes tree falling risking citizens in the areas. In addition, biodiversity is affected along with soil erosion.	3	3	9	Medium
		Biodiversity loss especially tree cover, bird & related species due to higher number of high temperature days. Nagpur is surrounded by major forests hosting wild life. Due to higher temperature, animals move to urban areas for food & water.	3	3	9	Medium



05 VULNERABILITY MAPPING

Based on the information received from various departments of NMC such as Public Health, Engineering, Fire, Traffic etc., vulnerability maps were prepared to understand the city's vulnerable hotspots. Vulnerability mapping is effective in identifying vulnerable areas impacted by fragile urban systems. Vulnerable hotspots are those affected due to multiple climate risks. Vulnerable population, in most cases slum areas, which make up almost 30% of Nagpur's population, are mapped.

- Major Slums Areas
- Green Cover
- Land Surface Temperature Area
- Traffic Congestion Areas
- Low Lying Areas

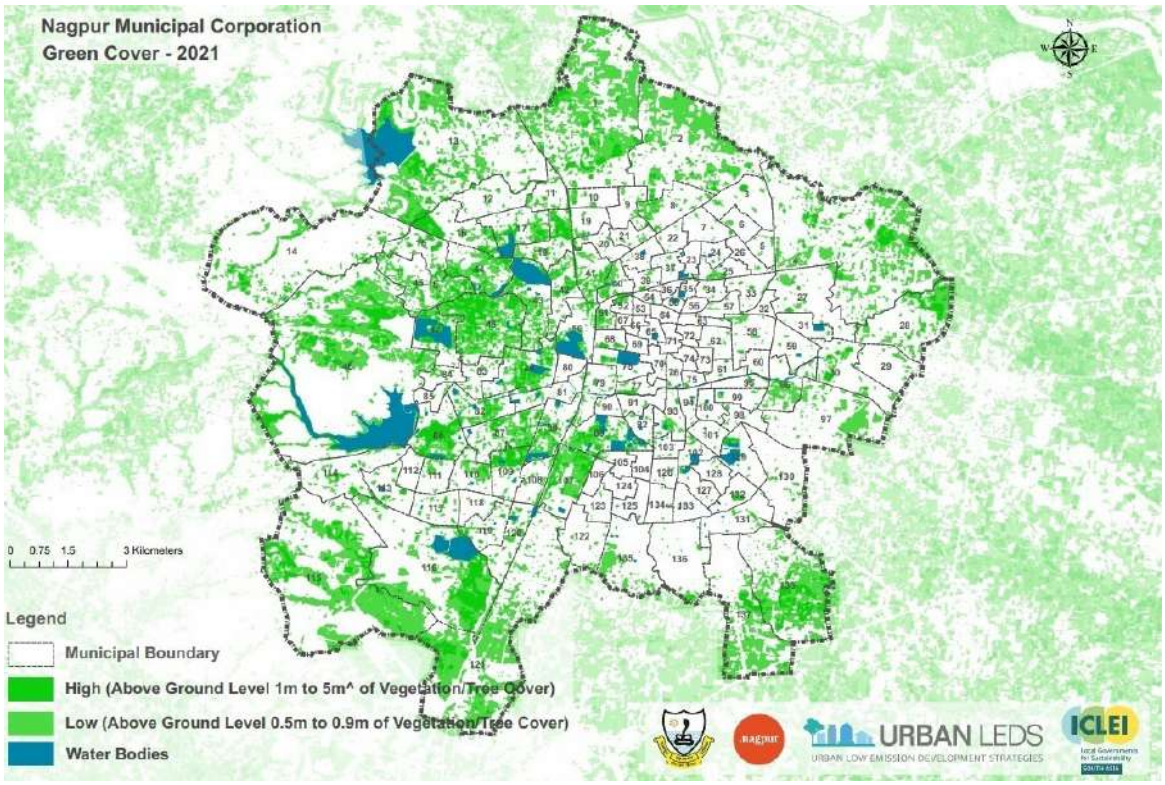
These maps were superimposed on one another to identify the areas (wards) most vulnerable to various climate risks and ranked as per the number of risks per ward. Maps were developed using satellite imagery and relevant GIS Tools.

Nagpur experiences harsh summers, temperature reaching up to 47°C. The city's green cover plays a crucial role in mitigating localised heat island effect

5.1 Green Cover and Land Surface Temperature Areas

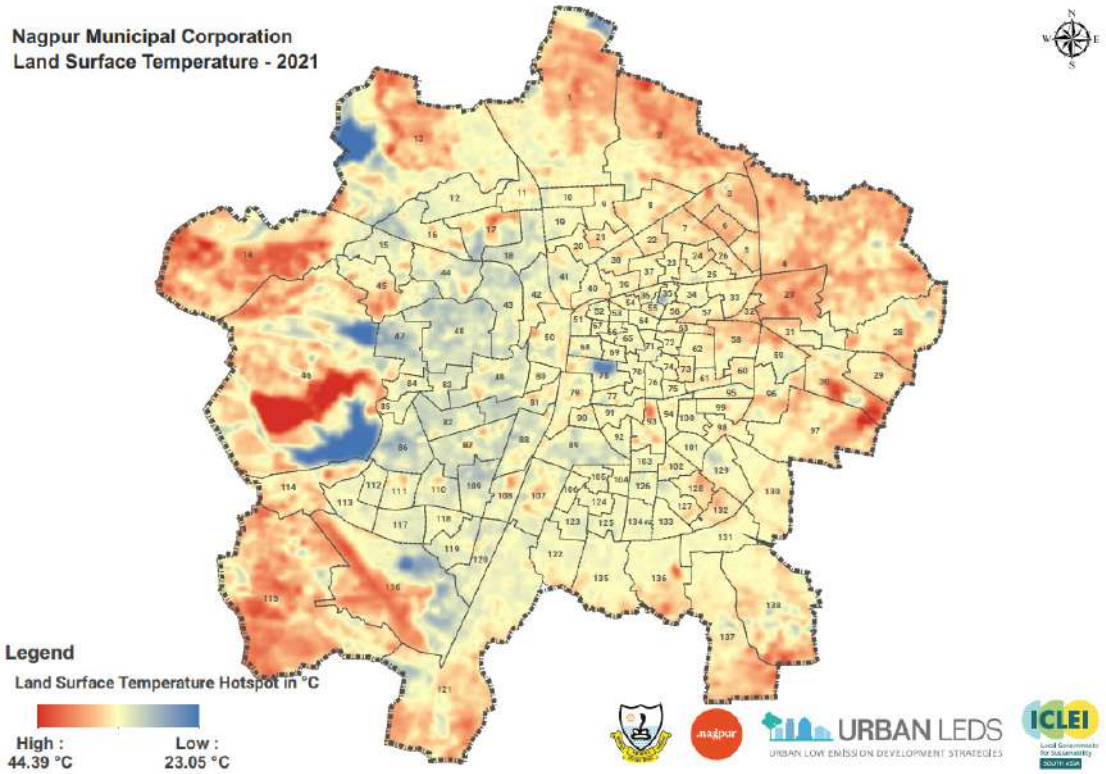
As discussed in earlier chapters, Nagpur experiences harsh summers, temperature reaching up to 47°C. The city's green cover plays a crucial role in mitigating localised heat island effect. The city's green cover is concentrated in central (north and south) and western part i.e., Ambazari Lake, Biodiversity Park, and Civil Lines area where most of the state and national institutional buildings are established. The eastern part of Nagpur's green cover is scarce and this is where most of the vulnerable population resides. The map shown in Figure 38 shows vegetation and tree cover areas colour coded based on their height above ground.

Figure 38: Nagpur green cover



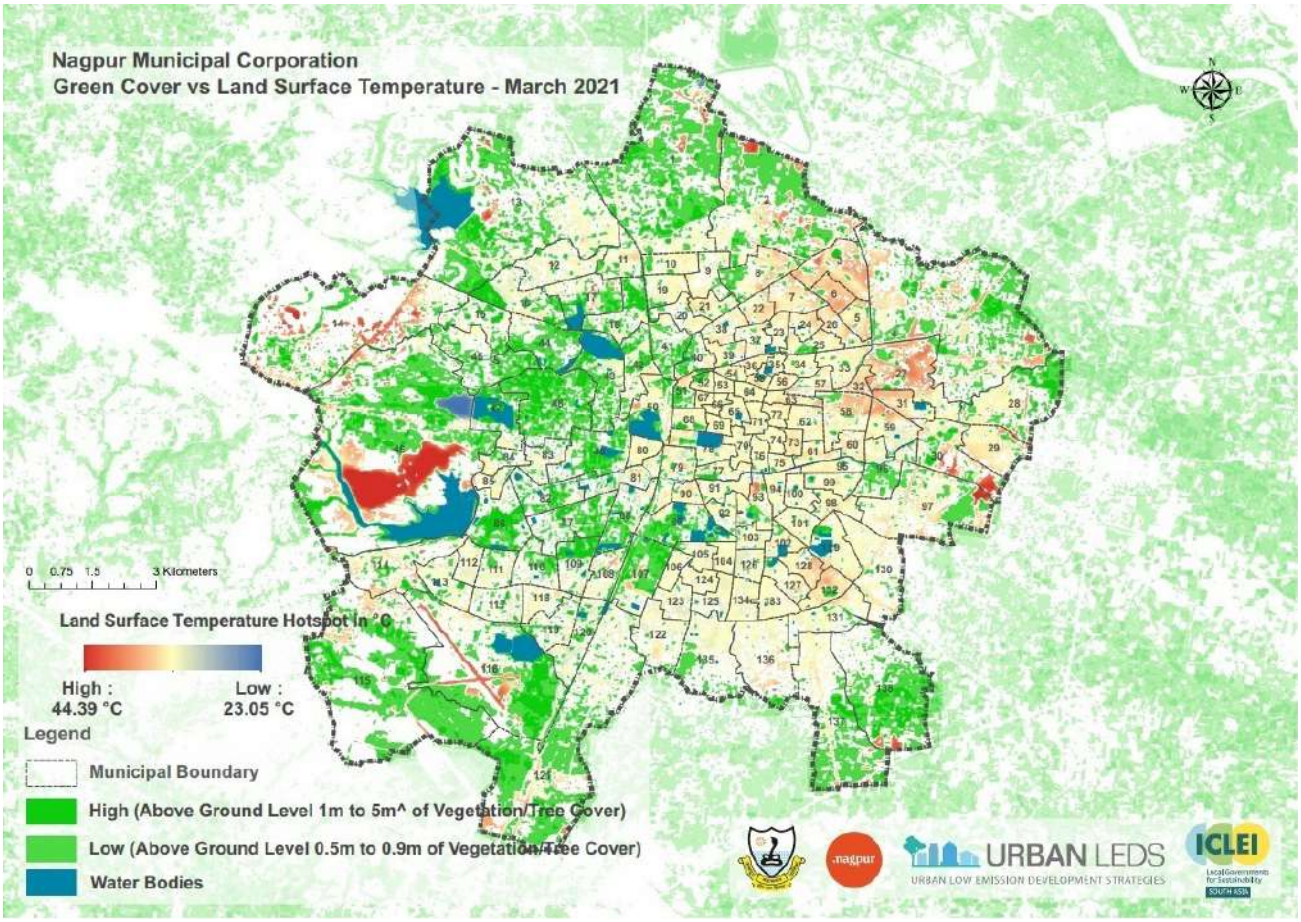
Land surface temperature area shown in Figure 39 clearly indicates that surface temperature in the eastern part of Nagpur is higher than in the western part due to the green cover and water bodies. High temperature near the western city boundary is due to low vegetation and seasonal variance. There is little tree cover in the central and eastern parts of Nagpur, evident from land use and land cover map, which shows higher, built-up area. Local authorities are taking initiatives for tree plantation using the Miyawaki Afforestation method. However, the efforts need to be scientific, considering vulnerable areas.

Figure 39: Nagpur land surface temperature



Superimposed maps of land surface temperature and green cover in Figure 40 show the potential areas for enhancing the city's green cover.

Figure 40: Map showing correlation between green cover and land surface temperature



5.2 Low lying (Waterlogging) and Traffic Congestion Areas

Information collected in consultation with disaster management cell shows that Nagpur faces several flash floods in low-lying areas, primarily due to the choked storm water drains in these areas. Several spots in Nagpur, including railway under bridges, slum areas without sewerage network and commercial establishments, face water logging which in turn causes health risks, economic loss and traffic congestion. Figure 41 shows the ward wise low-lying areas of Nagpur and Figure 42 shows traffic congestion areas. Wards identified in these maps are very closely spaced with high population density, and house the urban poor. NMC and the Public Works Department (PWD) have been working to improve road infrastructure and build several over bridges. However, this is a temporary solution, as the rate at which the vehicles registered in the city is rising, is continuously adding to traffic congestion.

Figure 41: Water logging/low lying areas in Nagpur

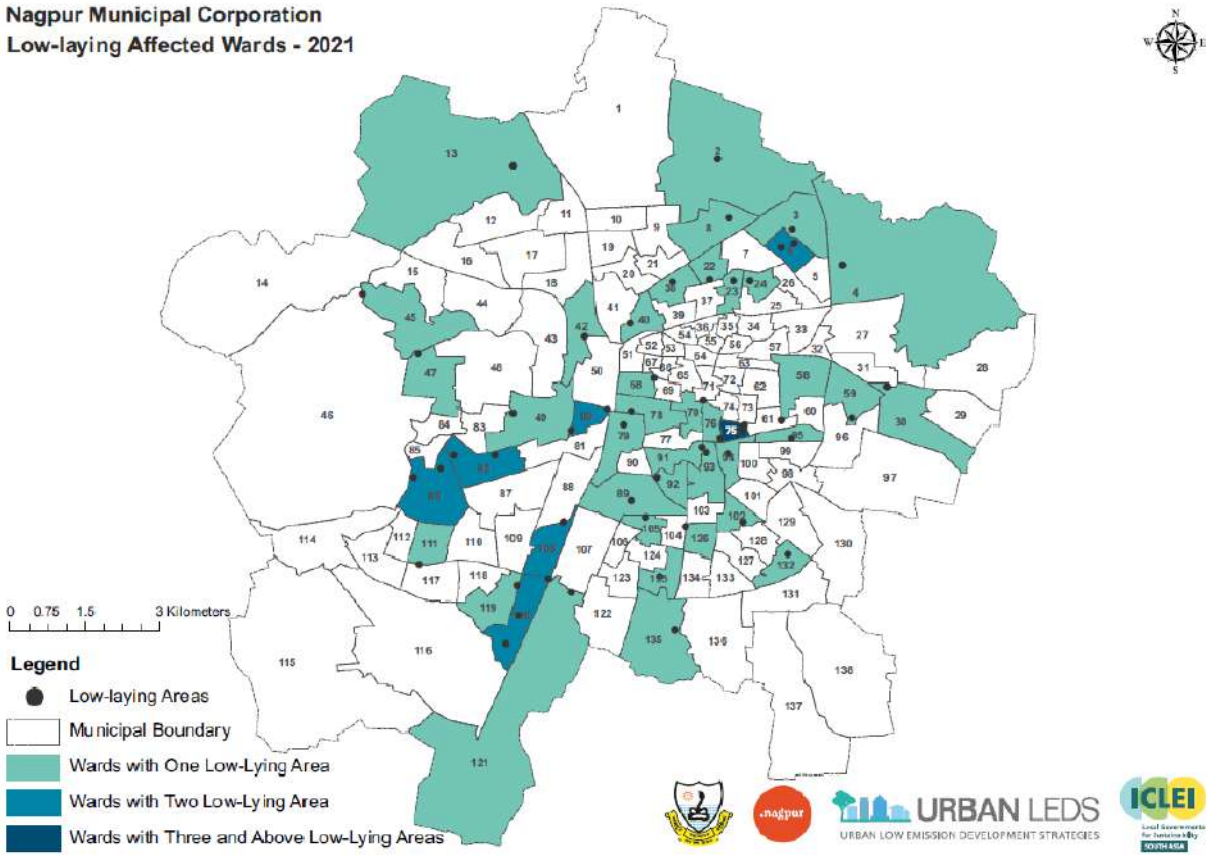
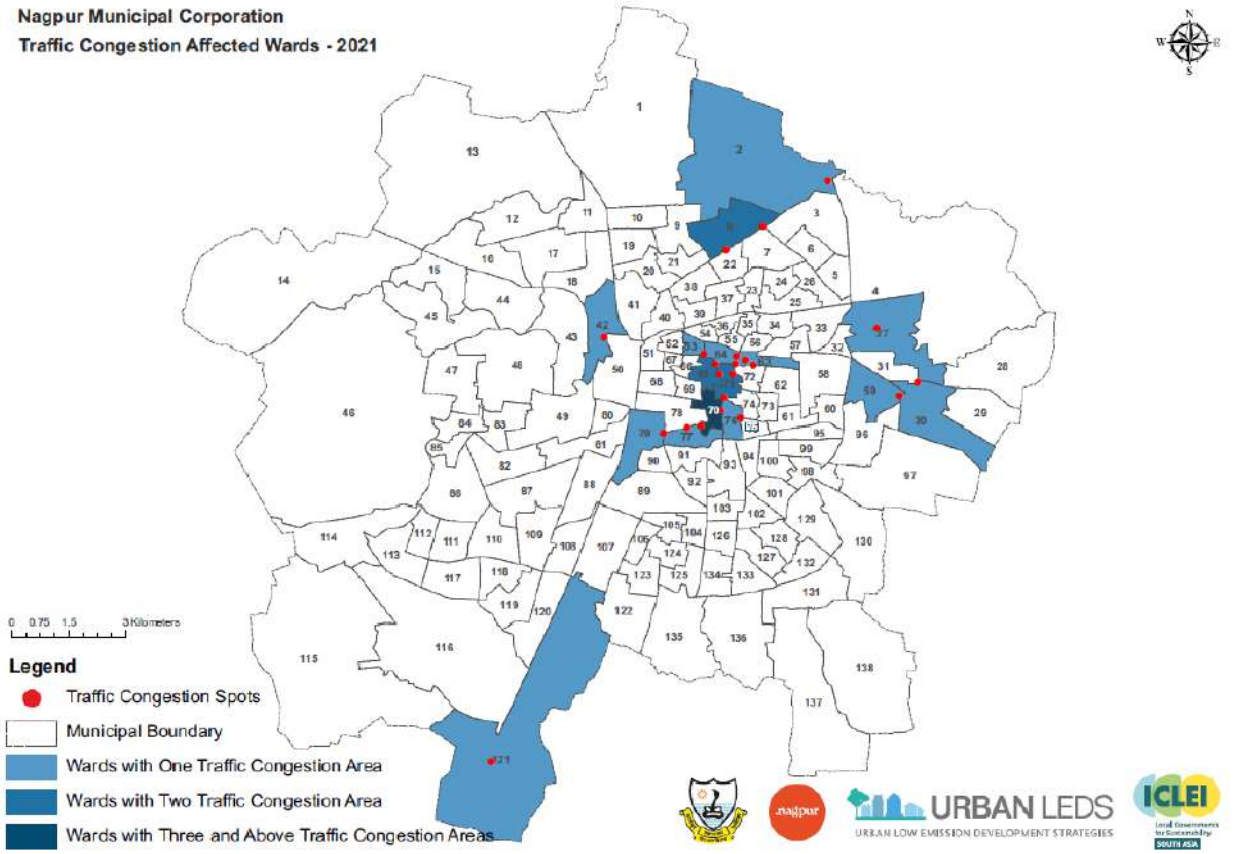


Figure 42: Traffic congestion points in Nagpur



5.3 Vulnerable Hotspots prone to Climate Risks

High intensity rainfall and high temperature are identified as the climate risks that Nagpur is prone to and the vulnerable areas i.e. the slums are the ones to get impacted first due to these risks. The identified areas are characterised by poor basic urban facilities/services such as inadequate health care services, unequal and inadequate water supply, dilapidated/negligible sewerage coverage, delayed door-to-door solid waste collection, inadequate transport facilities etc.

Nagpur is divided into 10 major zones for better administration. These 10 zones are further divided into 38 Prabhags, further divided into 138 wards. Vulnerability assessment was carried out at the ward level for better adaptation and mitigation of climate hazards in future. Four maps were prepared to evaluate vulnerability at ward level based on the data collected from different departments. Ward level information is either not readily available or not digitised. Maps were prepared based on identified climate risks and criteria.

Table 30: Criteria and basis of vulnerability mapping of Nagpur

S. No.	Climate issues	Basis of the mapping	Criterion of vulnerability and number of vulnerable wards
1	Precipitation – increase in rainfall (short duration and high intensity events)	Low lying and frequently water-logged areas in the city	Occurrence of such locations in a ward (Total wards 44)
2	Temperature – increase in mean maximum temperature	Summer season's surface temperature data from satellite imagery	For this criterion, particular threshold is not considered because the entire city experiences harsh summer season particularly in April and May. (Figure 39)
3	Most vulnerable population	Major slums in a ward	Occurrence of major slums in a ward (Total wards 27)
4	Vulnerability hotspots	Combined map of above 5 issues	Occurrence of 3 and more vulnerability issues in a ward (Highly vulnerable wards 8)

Table 31: Wards affected due to water logging/low lying areas

S. No.	Climate risks	Wards
1	Wards impacted by water logging issues	2,3,4,6,8,13,22,23,24,30,38,40,42,45,47,49,58,59,68,70,75,76,78,79,80,82,86,89,91,92,93,94,95,102,105,108,111,119,120,121,125,126, 132,135.

Figure 43: Wards with low-lying areas in Nagpur

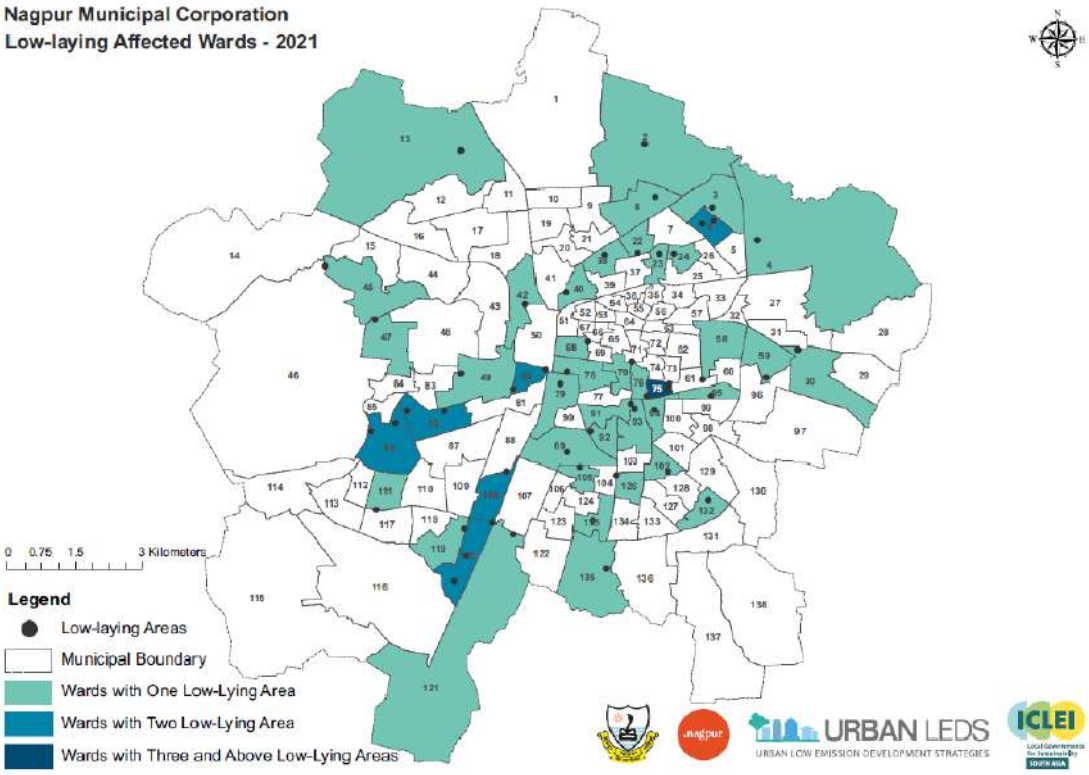


Table 32: Wards with major slums of Nagpur

S. No.	Climate risks	Wards with 5 or more slums
1	Vulnerable population (Major slums)	3, 4, 5, 14, 24, 25, 26, 27, 30, 40, 42, 43, 46, 54, 57, 78, 79, 81, 82, 85, 90, 106, 112, 115, 118, 122, 128

Figure 44: Location of major slum areas of Nagpur

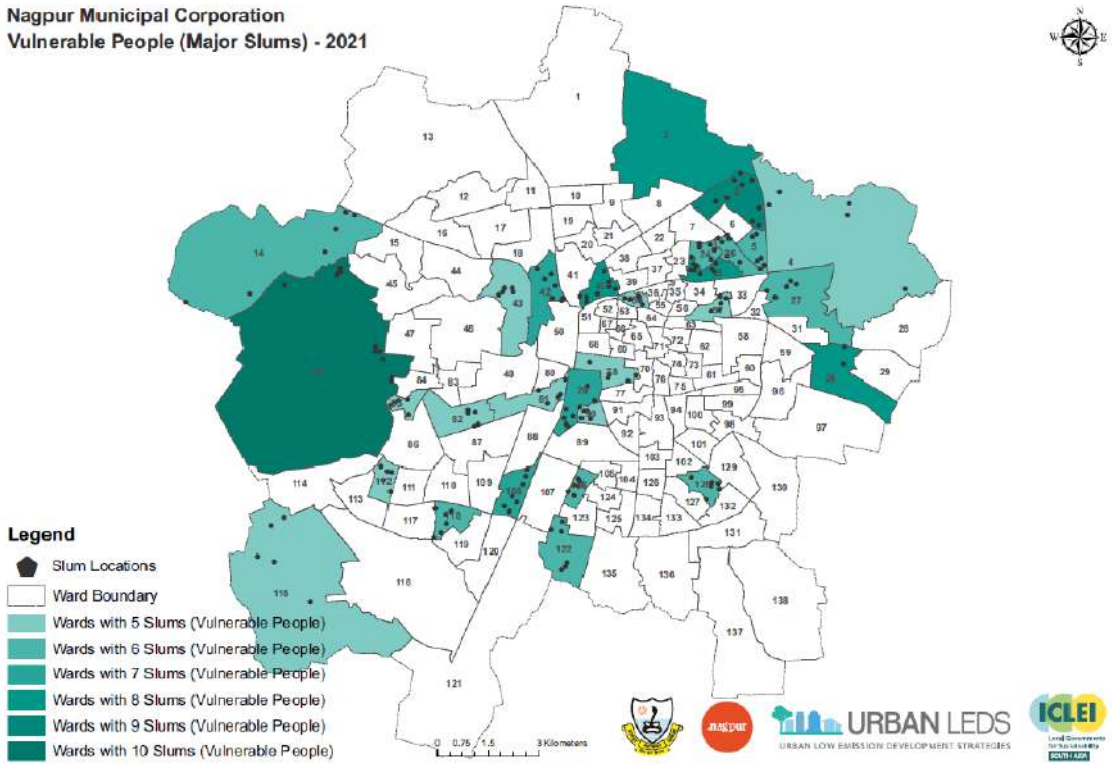
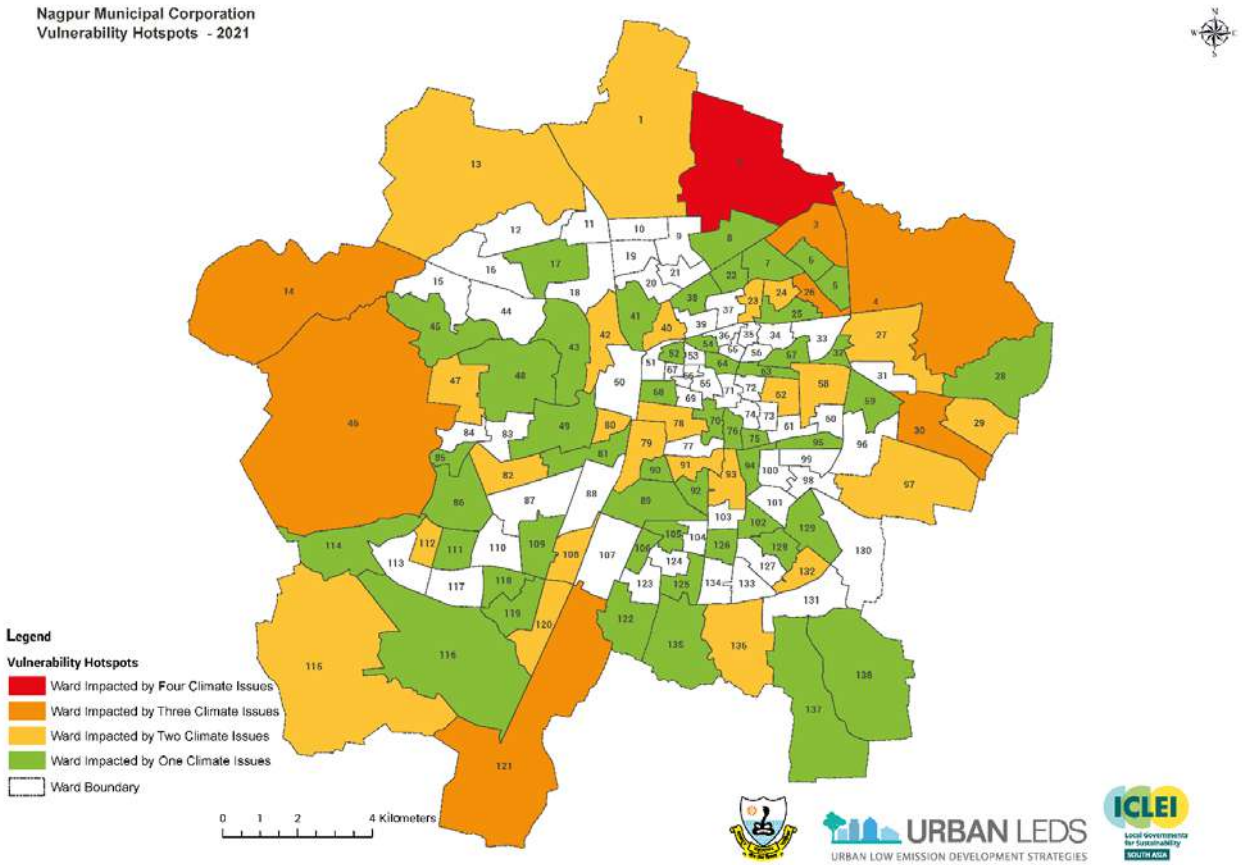


Table 33: Wards with 3 & 4 climate vulnerability risks/issues

S. No.	Climate risks	Wards with 5 or more slums
1	Wards with 3 vulnerability issues	3,4,14,26,30,46,121,
2	Wards with 4 or more vulnerability issues	2

Figure 45: Nagpur's vulnerable hotspots based on identified climate risks



5.4 Potential Strategies for Climate Risks

The vulnerability maps were prepared based on one-on-one consultations with city officials and available data. The maps may be improved further with data that are more accurate and considering several urban systems (e.g., current decade slum population, upcoming projects such as metro rail, new GoI missions for affordable housing, 24*7 water supply etc.). These maps are dynamic in nature and can be integrated into NMC's Online Grievance Addressal System. It will assist Nagpur in undertaking necessary actions and timely decisions. The city may undertake climate vulnerability assessments on short-term basis to enhance resilience to reduce the adverse effect of identified climate risks. Table 34 shows identified climate risks and potential strategies to mitigate them.

The city may undertake climate vulnerability assessments on short-term basis to enhance resilience to reduce the adverse effect of identified climate risks

Table 34: Climate risks and potential strategies

S. No.	Climate risks	Potential strategic/policy level interventions
1	Precipitation – increase in rainfall (short duration and high intensity events)	◆ Early warning system to be established at COC and alert systems for citizens ◆ In-depth urban services analysis (sewage, water, solid waste) and identification of necessary solutions including infrastructure and policy level interventions
2	Temperature – increase in mean maximum temperature	◆ Detailed Heat Action Plan to mitigate Urban Heat Island Effect and heat related health disorders, including other NMC departments such as town planning, traffic to identify innovative solutions such as urban farming, cool roofs, shaded walkways, adaptive traffic management system etc. ◆ Policy interventions such as amendments in DCRs for building approvals promoting green buildings, enhanced tree cover with monitoring mechanism
3	Traffic delays due to road congestion and air pollution	◆ Adhering to transport interventions identified in CMP promoting non-motorized, sustainable transport including public bicycle sharing, EV adoption in public transport, integrated multi-modal transport for last mile connectivity to discourage private vehicle transport ◆ Accurate and regular monitoring of air quality with higher number of Air Quality Monitoring Stations (AQMSs) across the city to improve air quality and overall livelihood
5	Most vulnerable population	◆ Improve living conditions of urban poor by notifying non-notified slums, affordable housing projects and better urban services and curb further slum settlement especially in vulnerable hotspots of the city ◆ Enhance healthcare services in vulnerable hotspots for urban poor
6	Vulnerability hotspots	◆ Project planning and implementation prioritizing vulnerable population to improve climate resilience ◆ Action plan to rehabilitate slum areas as 30% of urban population lives in slums

5.5 Adaptive Capacities of the Fragile Urban Systems

The municipal urban systems were analysed in connection with the identified climate risks. Their adaptive capacities were examined in terms of available technology, financial security and governance

NMC has an A Minus (A-) credit rating due to its stable financial profile with improved collection efficiency, major infrastructure projects generating revenues, the SCM, and a good experience with financial models such as PPP. However, the city's major urban renewal projects such as the 24*7 water supply project, the waste to energy project, old storm and sewerage infrastructure etc. are straining the city's vulnerable population therefore requiring urgent attention.

As a part of the vulnerability assessment, these urban systems were analysed in connection with the identified climate risks. Their adaptive capacities were examined in terms of available technology, financial security and governance. Table 35 provides qualitative analysis of all these urban systems based on Nagpur's current position.

Table 35: Adaptive capacities of the fragile urban systems

Sr. No.	Urban systems	Climate risks and related issues	Adaptive capacity			
			Technology	Finance	Governance	Overall
1	Water supply	Increase in precipitation Increase in mean maximum temperature Most vulnerable population	High	Medium	Medium	Medium-High
2	Sewage treatment	Increase in precipitation Increase in mean maximum temperature Most vulnerable population	High	Medium	Medium	Medium-High
3	Storm water management	Increase in precipitation Most vulnerable population	Medium	Medium	Medium	Medium
4	Solid waste management	Increase in precipitation Increase in mean maximum temperature Most vulnerable population	Medium	High	Medium	Medium High
5	Transportation	Increase in precipitation Increase in mean maximum temperature Traffic delays due to road congestion	Medium	Low	Medium	Medium Low
6	Health	Increase in precipitation Increase in mean maximum temperature Most vulnerable population	Medium	Low	Medium	Medium-Low
7	Biodiversity: Green spaces and water bodies	Increase in precipitation Increase in mean maximum temperature Most vulnerable population	Low	Low	Medium	Low

06

CLIMATE RESILIENCE INTERVENTIONS (2021-22 TO 2025-26)

Nagpur's CRCAP includes climate resilience interventions across the residential, commercial, institutional, industrial and municipal service sectors. Municipal services and facilities such as water supply, sewerage, storm water, SWM, transport, street lighting, municipal buildings, disaster management, biodiversity, pollution control and health are addressed in the Plan. The resilience interventions included in the CRCAP are informed by the baseline sectoral GHG emissions and identified climate vulnerabilities.

Identified sectoral interventions are prioritized based on their resilience capacity, which is assessed in terms of their propensity to increase the redundancy, flexibility and responsiveness of the relevant systems as well as their GHG emissions reduction potential. The interventions are then assessed for feasibility (technical, financial and political) and their impact (short, medium or long term). As far as possible, the prioritized interventions are linked to existing city plans and schemes so as to ensure that they are integrated, with little or no additional resources, into existing departmental programs or projects. They were discussed with Nagpur's Climate Core Committee.

The following Table summarises the selected climate resilience interventions that make up the Nagpur's CRCAP. Additional information on the interventions for each sector is provided in section 6.2. This section includes sector specific information, including energy consumption and GHG emissions for the baseline as well as BAU scenario, along with overall GHG emissions mitigation potential and possible energy savings from all interventions for the corresponding sector. The SDGs addressed by the proposed interventions for the sector are included to reflect overall contribution to sustainability.

For each of the interventions, the specific target location where the intervention should be sited (where relevant), scale of intervention, climate and other co-benefits, ballpark cost estimates, proposed implementation strategies, mode of implementation, entities that are primarily responsible for the implementation and various schemes and programmes that can support the intervention, are also indicated in section 6.2. In order to assess the bankability of the interventions, a detailed techno-commercial assessment is required to determine the ability of the NMC and NSSCDCL to access budgetary resources as well as repay loans and generate revenue.

CRCAP duration: 5 years (2021-22 to 2025-26)

Mitigation Target: The Climate Resilient City Action Plan proposes actions with an annual GHG emission mitigation potential of 20% by 2025-26 over the 2017-2018 baseline.

Adaptation Goal: Nagpur shall undertake participatory governance and strive to become an inclusive and climate resilient city, through provision of smart and sustainable urban services to all, with a focus on sustainable management of urban heat and enhancement of its biodiversity.

Municipal services and facilities such as water supply, sewerage, storm water, solid waste management, transport, street lighting, municipal buildings, disaster management, biodiversity, pollution control and health are addressed in the Plan

6.1 Summary of Key Strategies and Measures for Climate Resilience

Solid Waste Management (47%), Residential Sector (34%), and Commercial & Institutional Sector (9%) are the sectors expected to provide most of the GHG emission reduction benefits

The CRCAP for Nagpur city comprises of 40 actions (structural) delineated across 10 thematic areas/sectors that provide a pathway for Nagpur to enhance climate resilience and move towards a low carbon urban development pathway. These proposed interventions can deliver significant benefits in terms of reducing GHG emissions by lowering energy consumption, as well as reducing municipal expenditure on fuel and electricity.

These identified strategies will not only help reduce GHG emission and better manage local climate risks, but will also support the city in its Sustainable Development Goal (SDG) aspirations. Solid Waste Management (47%), Residential Sector (34%), and Commercial & Institutional Sector (9%) are expected to provide most of the GHG emission reduction benefits (see Figure 46).

While these 40 structural actions have direct GHG emission reduction impacts, the CRCAP also recommends additional 'enabling strategies and actions' that enable and inform design and implementation of interventions or provide necessary policy and planning support. Development of Green Building Policy based on pilot projects, Implementation of city-wide Rain Water Harvesting & Ground Water Recharge Plan and implementation of Local Biodiversity Strategy Action Plan are examples of enabling actions.

Following table provides a summary of the key strategies and interventions for enhancing climate resilience of Nagpur city. Figure 47 shows the GHG emission reduction scenario on implementation of the CRCAP and interventions therein as compared to the BAU emissions trajectory. Through implementation of ambitious but achievable actions proposed under the CRCAP, the city's GHG emission can be reduced by 20% by 2025-26, from the 2017-18 base year.

Table 36: Summary of Climate Resilient City Action Plan for Nagpur

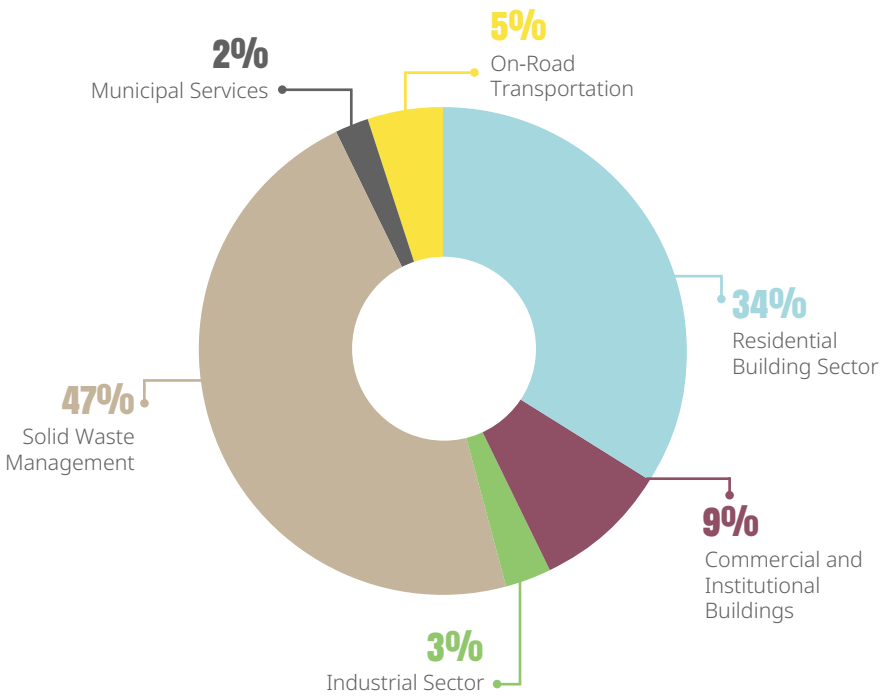
Sectors	Key Strategies	Mitigation Potential (tCO_2e)	Overall Climate Resilience Impact
Solid Waste	1 Waste to compost and RDF plant; promote decentralized bio-methanation 2 Scientific closure of existing landfill 3 Strengthen 3R implementation with IoT	286,968	Highest potential to reduce carbon emissions; PPP model will lower financial impact on ULB
Buildings Residential	1 Adopt existing Guidelines for Climate Responsive Homes in Nagpur 2 Scale-up rooftop solar and solar water heaters 3 Optimize energy efficiency of homes and apartments 4 Green Building measures in new affordable housing 5 Cool roof programme	2,08,700	Reduction of GHG emissions; Improved awareness among citizens regarding uptake of RE & EE
Commercial & institutional buildings	1 Expand benchmarking of energy consumption to additional commercial buildings 2 Map rooftop solar PV potential and scale-up implementation through demand aggregation 3 Assess potential for district cooling system 4 Adopt energy efficient star-rated equipment 5 Promote adoption of evaporative coolers	56,670	Reduction of GHG emissions; Improved building energy performance; Participation by Private sector and citizens; IEC activities
Industrial buildings	1 Map solar PV potential in large industries 2 At-scale installation of solar PV with energy storage 3 Adoption of energy efficient appliances	16,354	Reduction in GHG Emissions; Improved building energy performance; Participation by industrial associations
Transport	1 E-mobility in commercial passenger vehicles 2 E-mobility and switch to CNG in commercial and public bus fleets 3 Public bicycle sharing pilot 4 Feasibility study to establish solar PV based EV-bus or public charging stations Development of NMT infrastructure and zones	32,558	Reduction of GHG emissions; Improved air quality; Reduced traffic congestion; Improved public health
Street Lighting	1 Expansion of on-going LED street lighting retrofits	3,665	Reduced GHG emissions; Better visibility & safety

Sectors	Key Strategies	Mitigation Potential (tCO_2e)	Overall Climate Resilience Impact
Municipal buildings	1 Continue energy benchmarking and undertake energy efficiency retrofits for existing buildings 2 Design and construct all new public buildings as Green buildings 3 Net-metered rooftop solar PV systems	1,888	Reduced GHG emissions, visibility and awareness; Improved public building operations and monetary savings
Water	1 Implement city-wide rainwater harvesting and groundwater recharge plan 2 Reduction in NRW, water and energy audits 3 Solar PV systems at water supply facilities 4 Install automated Water ATMs	7,024	Equitable and clean water supply; Improved water supply system efficiency with reduced emissions
Sewerage and Storm water Drainage	1 Implement Nag River Pollution Abatement project; 2 Dual plumbing, greywater reuse in large residential, commercial and institutional properties 3 Decentralized wastewater treatment systems 4 Feacal sludge management Policy	549	Conservation of ecosystems – rivers; Reduction in methane emissions, contamination & health risks
	1 Strengthening the storm water coverage network and avoiding mixing of storm water & sewage 2 IoT based storm water grid; Hydro-geological studies 3 Sustainable urban drainage systems 4 Enhancing capacity and authority of Nuisance Detection Squad to prevent solid waste dumping in storm water drains	-	Improved storm water network, prevention of urban floods and water logging
Disaster management, biodiversity, pollution control and health	1 Implementation of Local Biodiversity Strategy Action Plan 2 Integration of Climate Risk and Vulnerability Assessment with Disaster Management Plan 3 Lake Rejuvenation Plan 4 Clean Air Action Plan	-	Improved conservation of existing ecosystems – water bodies and rivers; Improved urban air quality and health of citizens; Improved resilience against local climate risks

Total → 614,376

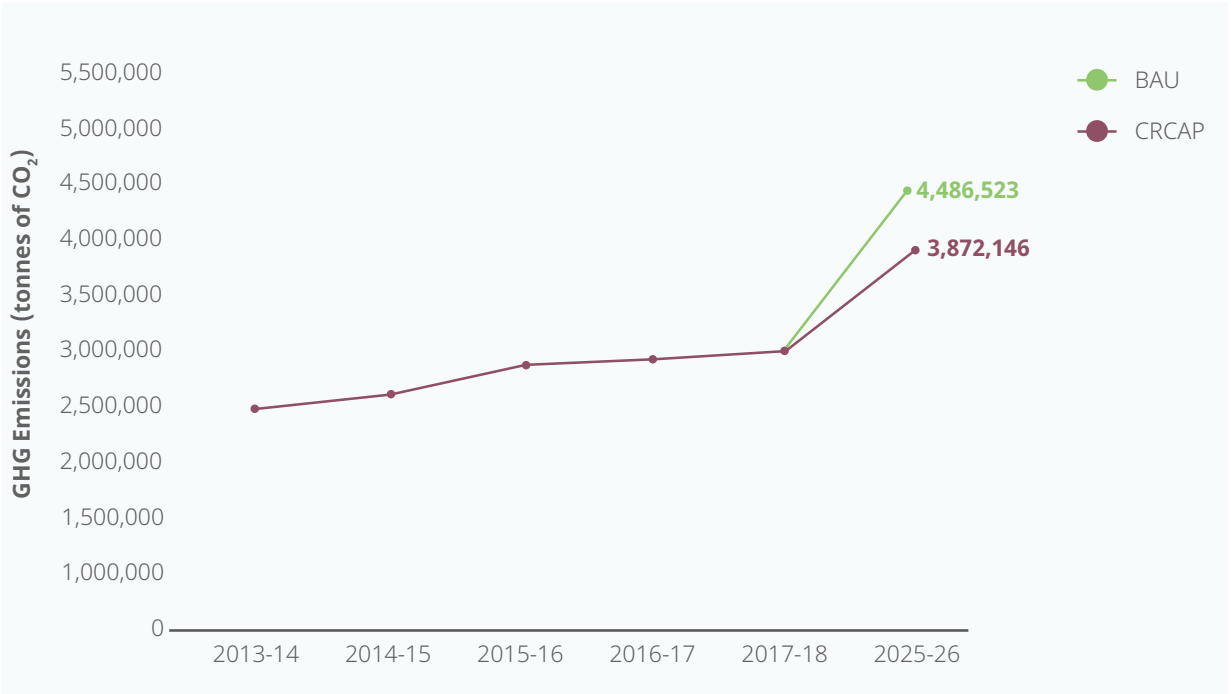
The following figures show the sector-wise GHG mitigation potential of the interventions and GHG emission reduction scenario post implementation of the CRCAP as compared to the BAU scenario.

Figure 46: Total annual mitigation potential of CRCAP (tCO_2e)



Note: Municipal services & facilities – includes water supply, wastewater and street lighting

Figure 47: Nagpur's GHG emissions projection scenario



6.2 SECTORAL CLIMATE RESILIENCE INTERVENTIONS FOR NAGPUR

6.2.1 Residential Buildings

2017-18
Energy consumption
8,108,294 GJ

2017-18
GHG emission
1,161,452 tCO_2e

Contributes to 2017-18
60% of city's electricity consumption

Baseline analysis and issues

- Highest electricity consumption across sectors
- Residential sector has the highest electricity consumption. Electricity consumption is rising at nearly 5% per year and expected to rise further in the future with growing population and temperature increase
- Higher rate of energy consumption in recent years and thereby higher potential for EE and RE solutions and benefits
- Lack of institutional framework to promote and adopt green buildings
- Need for effective implementation, financing mechanisms/schemes for wider adoption of EE and RE measures

Existing and Planned Measures by NMC

- NMC offers tax rebate of 10% to encourage residential building owners to adopt rooftop solar thermal and PV systems, along with RWH and waste composting
- City specific guidelines for energy efficient and climate responsive homes are in place to guide voluntary adoption by residents

Potential climate impacts and BAU scenario

- 2025-26 (projected): Energy consumption– 1,09,53,900 GJ
- 2025-26 (projected): GHG emissions – 16,64,182 tCO_2e
- 67% increase in electricity consumption from 2018-19 to 2025-26

Climate resilience potential of the sector

- 2025-26: Annual energy saving: 254 million kWh
- 2025-26: Annual GHG emissions reduction: 208,700 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 1,455,482 tCO_2e
- Clean energy supply with reduced dependency on conventional energy sources, improved self-sufficiency from decentralized RE generation, energy conservation without compromising thermal comfort
- Total cost of climate resilience interventions: INR 2,627 million

SDGs

GOAL 3: Good Health & Well-being

GOAL 7: Affordable & Clean Energy

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Note:

- Status of each intervention is defined as:
  a. Ongoing action: Already under implementation
  b. Planned action: Being considered and planned for
  c. New action: Not under planning or active implementation and proposed for the first time in the CRCAP
- Climate resilient potential of each intervention is defined as very high, high, medium or low considering the aspects of redundancy, flexibility, responsiveness, access to technology, implementation duration and GHG emissions reduction potential
- Duration of implementation is defined as:
  a. Short-term: within 2 years
  b. Mid-term: 2 to 4 years
  c. Long-term: 5 to 10 years

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
Adopt green building design in upcoming affordable housing scheme	• Pilot green building concept in new upcoming affordable housing scheme in Pardi area (Smart City pilot area) following Nagpur's Technical Guidelines for Climate Responsive Homes, 2020 • Launch city wide Green Building Policy with incentives in Floor Area Ratio (FAR) and/or property tax	• Lowers energy use and GHG emissions • Improves indoor thermal comfort, lower water & resource use	Not estimated	**Implementing Entities** – NMC, NSSCDCL, building developers & owners. **Implementation mode** – Budget allocated under Nagpur SCM	• Planned Action • Short-term
Implement a programme to promote adoption of Urban Cool Roofs - Promoting white roofs, and relevant measures	• Pilot implementation across 10 zones of the city in residential buildings with sizeable rooftop space • Launch city-wide policy based on pilot implementation to reduce Urban Heat Island Effect	• Contributes to heat mitigation, urban cooling • High resilience potential	Not estimated[30]	**Implementing Entities** – NMC, citizens, international funding agencies **Implementation mode -** NMC, NSSCDCL., Mandates/notification for Cool Roofs Programme, NMC's support through the municipal budget along with support from international technical agencies	• New Action • Short-term
Promote use of solar water heaters (SWH) in place of conventional geysers in households	• Scale – 100 LPD SWH per household for 34,500 properties (5% of households) • Target high- and middle-income households across the city to scale up SWH adoption	• 43.2 million kWh • 35,531 tCO_2e • Reduces grid dependency and increases self-sufficiency due to uninterrupted solar thermal energy available at source • High resilience potential	518	**Implementing Entities** –NMC, citizens, technology providers, MEDA **Implementation mode** –Investment by consumers, incentives by NMC and state nodal agencies, and mandates for large townships; NMC already offers rebates in property tax; Aggregation of multiple projects facilitated by NMC & NSSCDCL to reduce capital costs	• Ongoing Action • Mid-term
Promote and facilitate installation of rooftop solar PV with net-metering	• Scale – 1 to 2 kW systems in 5% of high-income and upper middle-income homes (22.8 MWp solar PV potential in 5 years) • 100 kWp solar PV installed at the affordable housing scheme • Target medium and high-income households across the city	• 34.35 million kWh • 28,264 tCO_2e • Reduces grid dependency, improves self-sufficiency from decentralized RE generation • High resilience potential	1,377	**Implementing Entities** – NMC, local DISCOM (MSEDCL), citizens, MEDA, Associations of local solar PV system providers **Implementation mode** –Net-metering Policy, 2015, investment by consumers, supported by MEDA, incentives from NMC (property tax); Aggregation of multiple projects facilitated by NMC & NSSCDCL to reduce capital costs	• New Action • Mid-term

30 will depend on program scope and activities envisaged

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
Adopt energy efficient lighting to replace conventional lighting	• Scale a) 30% incandescent/ CFL lamps phased-out and replaced with LED lamps b) 25% existing conventional tubes/CFLs replaced with LED tubes • Intervention suggested across all income groups as subsidized products are available	• 129 million kWh • 1,06,035 tCO_2e • Medium resilience potential	311	**Implementing Entities** – NMC, citizens, technology providers, MEDA, EESL **Implementation mode** – Purchase by consumers directly from market., through the Unnat Jyoti by Affordable LEDs for All (UJALA) scheme at subsidized rates	• New Action • Short-term
Adopt energy efficient ceiling fans to replace conventional fans	• Scale – Conventional ceiling fans replaced in 15% homes with super-efficient brushless type DC fans • Target: High and medium-income groups along with upcoming 2000 dwelling units in the affordable housing scheme	• 16 million kWh • 13,283 tCO_2e • delivers thermal comfort with lower energy use to address rising temperature risk • Medium resilience potential	421	**Implementing Entities** – NMC, citizens, technology providers, MEDA, EESL **Implementation mode** – Purchase by consumers directly from market., through the Unnat Jyoti by Affordable LEDs for All (UJALA) scheme at subsidized rates	• New Action • Short-term
Encourage use of energy efficient air conditioners and 2-stage evaporative coolers	• Scale –Energy efficient ACs in 15% of high-income and 5% in middle-income homes[31] • Potential for uptake of two stage evaporative coolers given Nagpur's hot climate • Target: High and middle-income groups across the city, especially in city's central & eastern part with lower green cover	• 7 million kWh • 5,702 tCO_2e • delivers thermal comfort with lower energy use to address rising temperature risk • Medium resilience potential	Not estimated[32]	**Implementing Entities** – NMC, citizens, technology providers, MEDA **Implementation mode** – Purchase by consumers, Programs/mechanisms from product suppliers to support exchange of inefficient stock for new efficient appliance	• New Action • Long-term
Encourage use of energy efficient refrigerators	• Scale –Energy efficient refrigerators in 10% of households	• 9.45 million kWh • 7,775 tCO_2e	Not estimated		• New Action • Medium Resilience Potential within a long-term period

31 Purchasing capacity and penetration predominant in high-income and upper mid-income groups
32 Cost is dependent on scale of the activity and other on-ground factors; hence not estimated here

6.2.2 Commercial and Institutional Buildings

2017-18
Energy consumption
22,46,701 GJ

2017-18
GHG emission
4,16,307 tCO_2e

Contributes to 2017-18
35% of city's electricity consumption

Baseline analysis and issues

- 2nd highest electricity consumption, with annual increase of nearly 5%. Electricity consumption is expected to rise further in the future with increase in commercial land use area and temperature increase
- Higher rate of energy consumption in recent years and thereby higher potential for adoption of EE and RE solutions and accrual of benefits
- Lack of institutional framework to promote energy conservation solutions across the sector and policy interventions such as Energy Conservation Building Codes and green buildings
- Need for effective implementation, financing mechanisms/schemes for wider adoption of EE and RE measures

Existing and Planned Measures by NMC

- NMC encourages commercial building owners to adopt rooftop solar thermal and PV systems along with mandatory RWH & waste compost by awarding 10% holding tax rebate

Potential climate impact and BAU scenario

- 2025-26 (projected): Energy consumption – 52,73,571 GJ
- 2025-26 (projected): GHG emissions – 7,85,808 tCO_2e
- 55% increase in electricity consumption from 2018-19 to 2025-26

Potential Climate Resilience impacts from identified interventions

- 2025-26: Annual energy saving: 69 million kWh
- 2025-26: Annual GHG emissions reduction: 56,670 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 729,138 tCO_2e
- Clean energy supply with reduced dependency on conventional energy sources, improved self-sufficiency from decentralized RE generation, energy conservation without compromising thermal comfort
- Total cost of climate resilience interventions: INR 2,018 million

SDGs

GOAL 7: Affordable & Clean Energy

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience interventions	Details of Intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
• **Expand energy benchmarking & undertake energy audits for energy performance improvement**	• NMC has initiated energy benchmarking and audits in commercial buildings through the BEA project. The benchmarking exercise can be expanded to a larger stock of commercial buildings to prioritize commercial properties for audits and retrofit measures.	• Reduced energy use and GHG emissions • High resilience potential	Not estimated[33]	**Implementing Entities** – NMC, NSSCDCL, building developers & owners, MSEDCL **Implementation mode** – NMC and NSSCDCL can issue a notification to promote reporting of energy use and audits by large buildings. Energy audits for prioritized buildings can be supported partly by municipal/ program budgets	• Planned • Short-term
• **Mapping of rooftop solar PV potential in large commercial buildings for demand aggregation**	• Undertake mapping of large rooftops across commercial and institutional buildings to identify potential for solar PV installation and to facilitate the same through demand aggregation	• Contributes to heat mitigation, reduced grid dependency due to decentralized RE generation and energy efficient cooling systems • High resilience potential	Not estimated[34]	**Implementing Entities** – NMC, NSSCDCL, technical institutions and agencies, local Solar PV association, CREDAI **Implementation mode -** NMC and NSSCDCL; support through the municipal/programs budgets	• New Action • Short-term
• **Technical assessment for District Cooling Systems for large commercial properties**	• Technical studies can be undertaken to identify district cooling potential in large commercial real estate projects with mixed-use development	• Reduced energy use and GHG emissions • Improved indoor thermal comfort, lower water & resource use	Not Estimated	**Implementing Entities** – NMC, NSSCDCL, technical specialists & technical support agencies, commercial entities, CREDAI **Implementation mode -** NMC, NSSCDCL to work closely with technical support agencies through international grants/ development funds	• New Action • High resilience potential within a mid-term period
• **Promote use of SWH in place of conventional geysers in hospitals and hotels** • **Establish long-term monitoring mechanism within the Town Planning Department to ensure functioning of all SWHs**	• Scale – 20% hot water demand in hospitals and hotels to be met through solar thermal systems (60,000 LPD SWH in total) • Target to promote the intervention across hotels of different categories and hospitals	• 0.8 million kWh • 617 tCO_2e • Reduced grid dependency and increased self-sufficiency due to uninterrupted solar thermal energy available at source • High resilience potential	9.0	**Implementing Entities** –NMC, business owners, hospitals, technology providers, MEDA, CREDAI-Nagpur **Implementation mode** –Investment by consumers; Mandates for large commercial properties and by type of use (hotels, hospitals); Rebates offered in property tax by NMC; Aggregation of multiple projects facilitated by NMC & NSSCDCL to reduce capital costs	• New Action • Mid-term

33 Cost dependent on scale of the activity; hence not estimated here
34 Cost dependent on the scale and activities; hence not estimated here

Resilience interventions	Details of Intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
• **Promote and facilitate installation of rooftop solar PV with net-metering**	• Scale – 10 kW solar PV each in 2,500 existing and upcoming commercial properties (25 MWp solar PV potential)	• 37.5 million kWh • 30,854 tCO_2e • Reduced grid dependency, improved self-sufficiency from decentralized RE generation • High resilience potential	1,750	**Implementing Entities** – NMC, local business owners and commercial entities, MSEDCL, , MEDA, Associations of local solar PV system providers, CREDAI **Implementation mode** –Net-metering Policy, 2015 with amendments; RESCO/ PPA mode with investment by third party; Supported by MEDA; Incentives from NMC (property tax); Aggregation of multiple projects facilitated by NMC & NSSCDCL to reduce capital costs	• New Action • Mid-term
• **Adopt energy efficient lighting to replace conventional lighting**	• Scale – a) 25% of incandescent/ CFL lamps phased-out and replaced with LED lamps b) 25 % of existing conventional tubes/ CFLs replaced with LED tube lights • Intervention suggested across all categories commercial properties as subsidized products are available	• 15 million kWh • 12,228 tCO_2e • Medium resilience potential	20	**Implementing Entities** – NMC, business owners and commercial entities, technology providers, MEDA, EESL, CREDAI **Implementation mode** – Purchase by consumers directly from market through the UJALA scheme at subsidized rates	• New Action • Short-term
• **Adopt energy efficient ceiling fans to replace conventional fans**	• Scale –Conventional ceiling fans replaced in 15% of commercial properties with super-efficient brushless type DC fans	• 6.4 million kWh • 5,278 tCO_2e • Delivers thermal comfort with lower energy use to address rising temperature risk • Medium resilience potential	151		• New Action • Mid-term
• **Encourage use of energy efficient air conditioners**	• Scale – Energy efficient Acs in 10% of commercial properties • Target: Large and mid-size commercial properties across the city, considering equipment lifespan and affordability • Can target properties located in the central & eastern part of the city	• 7.4 million kWh • 6,069 tCO_2e • Delivers thermal comfort with lower energy use to address rising temperature risk • Medium resilience potential	Not estimated	**Implementing Entities** – NMC, business owners and commercial entities, technology providers, MEDA, , CREDAI **Implementation mode** – Purchase by consumers; Programs/mechanisms from product suppliers to support exchange of inefficient stock for new efficient appliance	• New Action • Long-term

6.2.3 Industries

2017-18
Energy consumption
10,38,318 GJ

2017-18
GHG emission
1,33,282 tCO_2e

Contributes to 2017-18
5% of city's electricity consumption

Baseline analysis and issues

- Due to the subsidies & schemes provided by state & national government for Micro, Small & Medium Enterprises (MSME) sector, industries in Nagpur city are moving in industrial clusters outside the city boundary
- Electricity consumption not increasing as rapidly as other sectors due to declining presence of large industries in the city area
- Need for effective implementation, financing, monitoring and mechanisms/schemes for wider adoption of solid waste management, decentralized effluent treatment EE and RE measures for existing industries in the city

Potential climate impact and BAU scenario

- 2025-26 (projected): Energy consumption – 18,84,893 GJ
- 2025-26 (projected): GHG emissions – 1,73,689 tCO_2e
- 34% decrease in electricity consumption from 2018-19 to 2025-26

Potential climate resilience impacts from identified interventions

- 2025-26: Annual energy saving: 20 million kWh
- 2025-26: Annual GHG emissions reduction: 16,354 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 157,335 tCO_2e
- Clean energy supply with reduced dependency on conventional energy sources, improved self-sufficiency from decentralized RE generation, energy conservation without compromising thermal comfort
- Total cost of climate resilience interventions: INR 341 million

SDGs

GOAL 7: Affordable & Clean Energy

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
Mapping of rooftop solar PV potential in large industries	• Undertake mapping of large rooftops and areas to identify potential for solar PV installation and to target demand aggregation	• Contributes to heat mitigation, reduced grid dependency due to decentralized RE generation and energy efficient cooling systems • High resilience potential	Not estimated[35]	**Implementing Entities** – MIDC, local industries, MSME Association, NMC, MEDA, technical institutions and agencies **Implementation mode -** MIDC and local industry associations can initiate intervention with technical partners to help develop a demand aggregation program.	• New Action • Short-term
Install net-metered rooftop solar PV systems integrated with energy storage solutions[36]	• Scale – 10 kW each in 10% of existing and upcoming industrial properties • Large industries with high energy consumption to be targeted • Solar PV systems integrated with energy storage systems to reduce peak demand charges and reduced energy bills	• 8.5 million kWh • 7,016 tCO_2e • Reduces grid dependency, improved self-sufficiency from decentralized RE generation • High resilience potential	341	**Implementing Entities** – MIDC, local industries, MSME Association, NMC, MSEDCL, technology providers **Implementation mode** –Net-metering Policy, 2015; CAPEX investment by industries or PPA/RESCO mode with capital investment by third party for solar PV; Supported by MIDC, local industry associations and NMC; Aggregation of multiple projects facilitated by MIDC and industry associations, with support from NMC & NSSCDCL; MEDA/Industry associations can establish mandates and incentives.	• New Action • Mid-term
Adopt energy efficient star rated equipment	• Scale –5% of industries to replace lighting, fans, pumps and air conditioning systems with energy efficient ones	• 11 million kWh • 9,337 tCO_2e • Medium resilience potential	Not estimated	**Implementing Entities** – MIDC, local industries, MSME Association, NMC, MSEDCL, technology providers **Implementation mode –** Investment by industries; MIDC and industry associations can promote adoption and support aggregated procurement to lower capital costs.	• New Action • Mid-term

35 Cost is dependent on the scale and activities; hence not estimated here

36 Potential energy savings, GHG emissions reduction and costs are indicated for solar PV systems in this Table; inclusion of energy storage is recommended as a strategy.

6.2.4 Water Supply

2017-18
Energy consumption
98 million kWh

2017-18
GHG emission
80,361 tCO_2e

Contributes to 2017-18
57% of municipal electricity consumption

2017-18
665 MLD of water supply (production)

Baseline status

- More than 90% of the total population is served by piped water supply service.
- Water supply is dependent on intra-state surface reservoirs and restricted per capita supply allocation by state authority.
- High proportion of NRW
- Water scarcity in the non-monsoon months; Reduced groundwater recharge due to increasing impervious built-up area
- Water logging and flooding during high intensity rainfall and contamination of water supply, leading to health issues

Existing and Planned Measures by NMC

- 24*7 water supply project, funded under AMRUT scheme, underway and includes the following major activities"
- Establishment of WTP, installation of flow meters, repairing existing pipelines to reduce water leakages, water billing software, SCADA system
- Extension of water supply coverage area by extending pipeline network and connecting new household units; Reduce NRW within 15% as Central Public Health and Environmental Engineering Organisation (CPHEEO) norms
- Secure additional water resources and establish pumping stations considering future demand.

Potential climate impact and BAU scenario

- 2025-26 (projected): Electricity consumption – 92 million kWh[1]
- 2025-26 (projected): GHG emissions – 75,206 tCO_2e
- Climate Risk Status: **Medium-High |** Medium- High risk during high temperature and low rainfall months
- Water scarcity in the non-monsoon months
- Increase in temperature will increase evapo-transpiration rate reducing available water quantity with degradation of quality and increasing water demand putting stress on ground water.
- Exposure to contaminated ground water in non-network areas posing health risks

Potential climate resilience impacts from identified interventions

- 2025-26: Annual energy saving - 8.5 million kWh
- 2025-26: Annual GHG emissions reduction - 7,024 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 68,182 tCO_2e
- Freshwater conservation, improved groundwater recharge, better & equal water supply, enhanced water availability, quality and security, reduced risk of waterlogging, lower public health risks
- Total cost of climate resilience interventions: INR 5 million[2]

SDGs

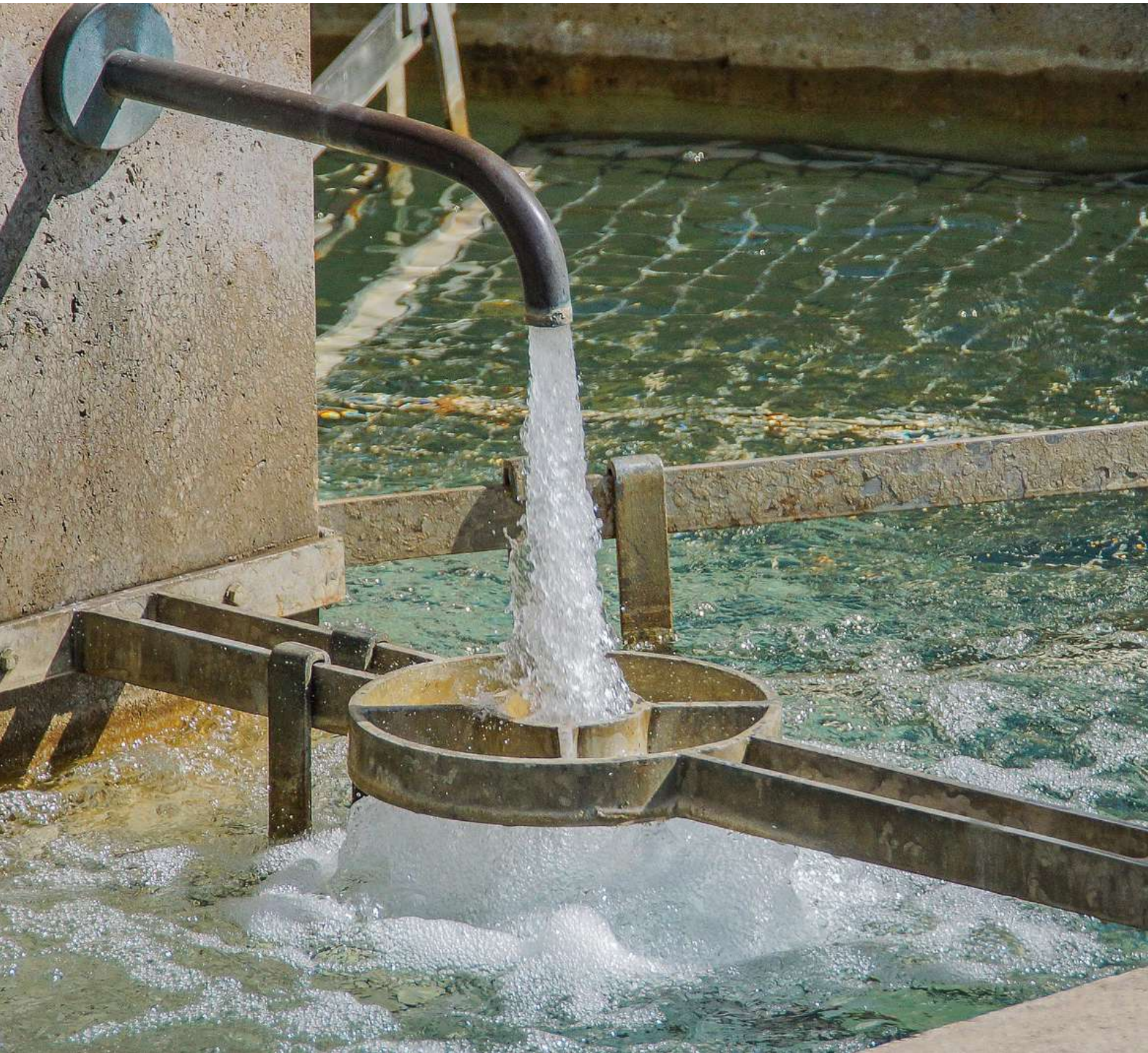
- GOAL 3: Good Health & Well-being
- GOAL 6: Clean Water & Sanitation
- GOAL 10: Reduced Inequality
- GOAL 11: Sustainable Cities & Communities
- GOAL 12: Responsible Consumption & Production
- GOAL 13: Climate Action
- GOAL 14: Life under Water

1 Reduced energy consumption due to reduction in NRW from 52% to 25% until 2025-16 from baseline
2 Represents costs for energy and water audits; Costs for NRW reduction and water reuse for secondary purpose are not estimated; hence not included here

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
Reduce physical water losses and NRW through water audits, leak detection, network improvement	• Scale – Reduce water losses to 22% through water audits, leak detection, upgradation of pipeline network, installation of SCADA system, water meters at property level and flow meters on distribution network. • Under the 24x7 water supply project, NMC intends to provide equitable water supply across the city as per the CPHEEO norms.	• 3.9 million kWh • 3,231 tCO_2e • Reduces energy consumption, water conservation and resource security, reduced water contamination and public health risks • High resilience potential	Estimation not possible[37]	**Implementing Entities** – NMC, OCW **Implementation mode** – Municipal budget; funds provided under AMRUT mission	• On-going Action • Mid-term
Reuse of water for gardening, avenue plantation and green cover	• Scale – 30% of city's green cover including parks and avenue plantation considered for reuse of water (0.87 million sq.m. area and water reuse of 52,000 kL per week) • Water will be sourced from nearby decentralized WTPs in the city and transported via tankers for watering.	• 0.62 million kWh • 509 tCO_2e • Freshwater conservation, reduced water treatment and pumping energy • Medium resilience potential	Not estimated[38]	**Implementing Entities** – NMC, local private sector, service providers **Implementation mode** – Municipal budget; private CSR funds	• New Action • Mid-term
Implementation of city-wide Ground Water Recharge Action Plan prepared under Urban-LEDS II project **Establish robust monitoring mechanism to evaluate existing and upcoming RWH systems**	• Implement RWH systems at all municipal buildings based on the citywide ground water recharge action plan and learnings from the pilot projects at two schools implemented under the Urban-LEDS II project. Undertake IoT based monitoring of groundwater levels and quality via COC. • Opportunities for RWH in central and eastern part of the city where ground water table is declining and shows good recharge potential. i.e., zone nos. 4, 18, 19, 22, 25, 26, 27, 28, 29 • RWH systems are made mandatory for all upcoming properties with area more than 300 sq. m.	• Lower freshwater consumption, improved groundwater recharge, increased self-sufficiency, reduced risk of frequent waterlogging[39] from high intensity rainfall • High resilience potential	Not estimated[40]	**Implementing Entities** – NMC, NSSCDCL, private sector/technology provider, technical experts, citizens & residential associations, public & educational institutions, commercial entities **Implementation mode** – Residents, building owners and institutions to invest; NMC offers property tax rebate for establishment of RWH systems; NMC's support funded through Municipal budget.	• New Action • Mid-term
Conduct energy audit to identify and implement EE measures	• Scale: Assuming atleast 5% reduction in energy consumption given that Nagpur is implementing the 24x7 water supply project • There is significant scope to improve EE in the water supply and distribution network and infrastructure.	• 4 million kWh • 3,285 tCO_2e	5	**Implementing Entities:** NMC, NIT, private sector, technology providers **Implementation mode:** NMC budget; GoI grants under AMRUT mission	• On-going Action • Short-Term

37 NMC's 24x7 water supply project has a budget of INR 3,878.6 million
38 Cost is dependent on the scale and type of reuse; hence not estimated here
39 Locations fall within the central & eastern part of the city as these areas are frequently affected by waterlogging and are suitable for ground water recharge
40 Dependent on the scale and timeline of implementation

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (Million INR)	Implementation entities and mode	Status and duration of implementation
Install automated water ATMs systems across the city, especially in the vulnerable areas for clean and safe water distribution.	• Establish permanent water ATMs in appropriate locations as part of the Heat Action Plan, to reduce the impact of heat waves and risk of heat strokes.	• Reduced health risks, improved potable water supply in vulnerable areas • High resilience potential	Not estimated	**Implementing Entities** – NMC, NSSCDCL, private sector (technology provider), citizens, **Implementation mode** – NMC's support funded through municipal budget; Local private sector and institutions to provide in-kind support and CSR funds	• New action • Short-term



6.2.5 Wastewater and Drainage

2017-18
GHG emission
157,003 tCO_2e

2017-18
532 MLD of waste water (estimated)

About
35% sewage is not treated.

Baseline status

- Over 80% households served by centralized waste water network, with 60-65% wastewater treated
- Rest of the households rely on septic tanks. Significant discharge of untreated wastewater from such septic tanks directly into local water bodies and rivers through storm and natural drains
- Open stormwater drains blocked frequently due to mixing of stormwater and sewage along with dumping of solid waste

Existing and Planned Measures by NMC

- By 2025-26, augmentation of wastewater treatment capacity by 157 MLD is planned through Nag River Pollution Abatement project and installation of various centralized & decentralized plants across the city.
- Plans to establish decentralized treatment systems of about 5,000 LPD capacity at 12 gardens located along Nag and Pili Rivers. Treated wastewater will be reused for watering of gardens.
- 130 MLD of treated wastewater is suppled for reuse at a thermal power plant located near the city. NMC plans to supply 200 MLD of treated wastewater additionally to the power plant.

Potential climate impact and BAU scenario

- 2025-26 (projected): GHG emissions – 90,608 tCO_2e
- Climate Risk Status: **Medium |** Medium risk during high temperature and low rainfall
- Infrastructural gaps (inadequate no. of STPs) and unsustainable practices (inadequate treatment and disposal in the open) are resulting in pollution of water bodies around the city.
- Disposal of sewage and solid waste into open storm water drains is contributing to the spread of unhygienic conditions leading to health impacts.

Potential climate resilience impact from identified interventions

- 2025-26: Annual energy saving – 0.67 kWh
- 2025-26: Annual GHG emissions reduction - 549 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 90,059 tCO_2e
- Improved surface and groundwater quality, enhanced sanitation, lower public health impacts, improved resilience to high intensity rainfall and waterlogging, revival of local biodiversity, ecosystem
- Total cost of climate resilience interventions: INR 5 million

SDGs

GOAL 3: Good Health & Well-being

GOAL 6: Clean Water & Sanitation

GOAL 10: Reduced Inequality

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

GOAL 14: Life under Water

1 Reduced GHG emissions due to increase in waste water treatment capacity by 2025-26 as per NMC's planned projects

2 Represents costs for energy and water audits; Costs for SCADA implementation and other interventions for this sector are not estimated; hence not included here

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Implementation of Nag River Pollution Abatement Project and additional STPs planned by NMC	• Establishment of 102 MLD STP under Nag River Pollution Abatement Project[41] • Additional 63.5 MLD STPs planned by NIT	• Reduces land, groundwater and surface water pollution, improved water resources quality, improved sanitation and reduced public health impacts • High resilience potential	-	**Implementing Entities:** NMC, NIT, private sector **Implementation mode:** PPP mode; Grants by GoI under AMRUT mission	Planned Action Long-term
Mandates for dual plumbing, on-site treatment and re-use of gray water	• Establish and enforce mandates, linked to building permission for large residential & commercial buildings for separation of gray and black water at site and reuse gray water for secondary purposes such as gardening, road cleaning, flushing • Promote on-site wastewater treatment at large properties through mandates	• Improves sanitation and reduced public health impacts; freshwater conservation; reduced pressure on centralized municipal water supply system • High resilience potential	Not estimated	**Implementing Entities:** NMC, NIT, residential associations, institutions, commercial entities, real estate developers and technology providers **Implementation mode:** NMC to issue notification to support pilot implementation; Investment by residential associations, commercial entities, institutions; NMC support and incentives through municipal budget	New Action Mid-term
Conduct energy audits to improve EE of pumping	• Undertake energy audits to identify efficiency improvements measures for equipment such as pumps	• 0.67 million kWh • 549 tCO_2e • High resilience potential	5[42]	**Implementing Entities:** NMC, NIT, private sector, technology providers **Implementation mode:** NMC budget, GoI grants under AMRUT mission.	New Action Mid-term
Prepare plan for fecal sludge management (FSM)	• Undertake technical assessment to prepare a city-scale plan for developing FSM system • The plan should address regulations to prevent untreated discharge, measures improve existing/establish new on-site sanitation systems (household and community/group-level), identify mechanisms for sludge transfer, establishment of treatment facilities and options for sludge end-use as fertilizer	• Reduces land, groundwater and surface water pollution; improves water resources quality, improved sanitation and reduced public health impacts • High resilience potential	Not estimated	**Implementing Entities** NMC, NIT, private sector, technology providers **Implementation mode** – NMC notification to support implementation; Funding through municipal budget; GoI funds through schemes such as AMRUT; Stakeholder consultations including public utilities, subject experts, beneficiaries etc.	New Action Mid-term
Pilot decentralized wastewater treatment systems (DeWATS) for households	• Scale –Undertake feasibility study for installing decentralized wastewater treatment solutions for cluster of households (independent houses) as well as in upcoming large residential townships and commercial areas • NMC to encourage adoption of anaerobic technology based DeWATS in large hospitals and public/institutional campuses	• Reduces water pollution and public health risk, improved flexibility and redundancy of wastewater treatment, biogas production for energy generation • High resilience potential	Not estimated	**Implementing Entities** –NMC, private sector/ technology providers, citizens, hospitals, public & educational institutions **Implementation mode** – Municipal budget; GoI funds; under AMRUT mission, international technical agencies & funds; part-investment by building owners & institutions	New Action Long-term

41 Budget of Nag River Pollution Abatement Project is INR 25,760 million

42 Cost of energy and water audit to identify improvement opportunities in the waste water collection and treatment infrastructure and system

6.2.6 Transport

2017-18

Energy consumption
70,36,350 GJ

2017-18

GHG emission
5,50,139 tCO_2e

Key transport modes share

- Two-wheeler **42.6%**
- Bus **15.6%**
- Auto rickshaw **19.8 %**
- Car **5.7%**
- Bicycle **6.4%**
- Walk **9.5%**

Baseline analysis and issues

- Metro-rail network in place, with total track length of 38.2 km for North-South and East-West corridors
- Absence of efficient public transport system and shared mobility to supplement the Metro rail and provide connectivity to all parts of the city; High dependency on private vehicles, and intermediate public transport modes (auto-rickshaws) for mobility
- Increasing private vehicle population
- Institutional setup and capacity needs to be strengthened to promote proliferation of electric mobility in the city.
- No dedicated infrastructure and policy for non-motorized vehicles; Unsafe conditions for non-motorized transport modes leading to traffic congestion

Existing and Planned Measures by NMC

- NMC has initiated conversion of public bus fleet from diesel-based fuel to CNG. 70+ out of 350 buses have been converted to CNG.
- Nagpur has around 100 E-taxis, along with charging stations, through a pilot project implemented in Nagpur by private mobility service company (OLA).
- Plans to procure 40+ electric buses through available grants and funding opportunities; Financially viable PPP based model to be prepared where NMC will provide per kilometre charge to private operator
- Pilot projects such as Streets for People, Nurturing Neighborhoods and Cycle for Change implemented to promote pedestrian friendly streets, cycling and safe public spaces
- DPR prepared for Public Bicycle Sharing system to be implemented in select areas of the city

Potential climate impact and BAU scenario

- 2025-26 (projected): Energy consumption – 1,66,26,762
- 2025-26 (projected): GHG emissions – 12,67,721 tCO_2e
- Climate Risk Status: **Medium** | Medium risk during high temperature and high intensity rainfall
- Frequent waterlogging during high intensity rainfall, due to inadequate & dilapidated storm water drains along the road infrastructure, causing traffic congestion and unsafe conditions for passengers; Resulting in higher air pollution and GHG emissions
- Due to increase in summer temperature, increased risk of heat strokes for two-wheeler riders and pedestrians

Climate resilience potential of the sector

- 2025-26: Annual energy saving - 12,350 kilolitres of diesel
- 2025-26: Annual GHG emissions reduction - 32,558 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 1,235,163 tCO_2e
- Reduced traffic congestion, improved air quality, lower public health risk, better mobility and accessibility; Higher mode share of electric mobility and public transport
- Total cost of climate resilience interventions: INR 3,622 million

SDGs

- GOAL 3: Good Health & Well-being
- GOAL 7: Affordable & Clean Energy
- GOAL 11: Sustainable Cities & Communities
- GOAL 12: Responsible Consumption & Production
- GOAL 13: Climate Action

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Adopt e-mobility and switch to cleaner fuel in commercial passenger vehicles	• Introduce CNG based commercial (non-public) buses in place of diesel-operated buses	• 4,739 kiloliters of diesel • 10,908 tCO_2e • Reduces air pollution and GHG emissions, improves public health • High resilience potential	613	**Implementing entities:** Private sector, technology providers in consultation with RTO, MSRTC and NMC transport department **Implementation mode:** Private sector investments; Financial incentives availed through FAME scheme.	• New Action • Mid- term
	• Adoption of 100 electric vehicles in fleet of taxis, commercial passenger cars	• 213 kiloliters of diesel • 1,043 tCO_2e • Reduces air pollution and GHG emissions, improves public health • High resilience potential	76.52		• On-going Action • Mid-term
Adopt E-mobility and switch to cleaner fuel in public bus fleet	• Introduce 100 electric buses in the municipal bus fleet under FAME II scheme. • NMC is procuring 40+ e-buses in 2022-23 • Install rooftop Solar PV systems for charging of e-buses	• 2433 kiloliters of diesel and 2.19 million kWh • 8,738 tCO_2e • Reduces air pollution and GHG emissions, improves public health • High resilience potential	2,852 (includes E-buses & solar PV costs)	**Implementing Entities:** NMC Transport Department, technology providers in consultation with RTO, MSRTC **Implementation mode:** NMC municipal budget, GoI grants under FAME II scheme, PPP mode implementation	• Planned Action • Long-term
	• Replace 100 diesel-based public buses with CNG buses	• 1,411 kiloliters of diesel • 3,286 tCO_2e • Reduces air pollution and GHG emissions, improves public health • High resilience potential	32.5		
Implement public bicycle sharing in identified pilot areas	• Implement public bicycle sharing project in three identified pilot zones/areas i.e. Laxminagar, Dharampeth and Mangalwari • Pilot intends to connect offices, academic institutions, shopping malls, public spaces, metro stations • Project to include cycling tracks, infrastructure, procurement and operation of cycles	• 3,554 kiloliters of petrol • 8,583 tCO_2e • Reduces air pollution and GHG emissions, improves public health • High resilience potential	47.7[43]	**Implementing Entities:** NMC and NSSCDCL Transport Department, technology providers in consultation with RTO, MSRTC **Implementation mode:** PPP mode; Supported by NMC municipal budget, GoI funds; Technical support from international agencies	• Planned Action • Mid-term

43 NMC Public bicycle sharing pilot project indicative cost

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Promote and develop non-motorized transit facilities	• Upscale pilot interventions implemented by NSSCDCL i.e. Streets for People, Cycle for Change and Nurturing Neighborhoods, across the city to create barrier-free and walkable public spaces and introduce facilities for bicycling to promote non-motorized transit. • NMT infrastructure can be improved in city core areas such as Dhantoli, Dharam Peth and Laxmi Nagar where traffic congestion is a challenge and shorter trip lengths are observed.	• Reduces traffic congestion, lower fuel consumption, improves local air quality and public health, improved pedestrian safety • High resilience potential	Not estimated[44]	**Implementing Entities** – NMC, Transport Department and NSSCDCL, technical experts/private sector **Implementation mode** – Technical & funding support from international technical agencies	• New action • Long-term

44 Dependent on program scale and activities; hence not estimated here

6.2.7 Municipal Solid Waste Management

2017-18	2017-18	2017-18	2017-18	2017-18
GHG emission $463,566\ tCO_2e$	GHG emission $12,521\ tCO_2e$	MSW generation 1100 TPD	Waste collection efficiency 100%	Waste composted 200 TPD

Baseline analysis and issues

- 100% door-to-door collection of MSW
- Centralized composting facility of 200 TPD
- Existing waste treatment and processing facilities are inadequate and need augmentation
- Open disposal of MSW at dumpsite situated at Bhandewadi, in an unscientific manner, leading to environmental and health risks; Absence of proper gas collection mechanism and processing at site
- Waste segregation at source is a major issue, inhibiting opportunities for waste treatment and processing; Need to strengthen awareness among low-income households and community
- Uncollected waste is dumped in open drains, open spaces, local ponds, canals and rivers. This blocks the drains and leads to water logging and flooding during monsoons.

Existing and Planned Measures by NMC

- Implementation of bio-remediation or bio-mining project to process legacy waste of around 1 million MT dumped at Bhandewadi, through a PPP model is ongoing
- Scientific closure of existing dumpsite is planned.
- Implementation of 600 TPD waste to compost, 380 TPD of Refuse Derived Fuel (RDF) plant; 150 TPD of Construction & Demolition (C&D) Waste treatment plant is planned. Tender for execution of C&D waste project has been published. Tenders for other projects are currently under preparation.
- Pilot projects for garden waste to compost planned in select gardens

Potential climate impact and BAU scenario

- 2025-26 (projected): GHG emissions from waste to landfill – 273,482 tCO_2e
- 2025-26 (projected): GHG emissions from waste to compost – 500,84 tCO_2e
- 41% decrease in GHG emissions from 2017-18 to 2025-26 due to planned actions by NMC
- Climate Risk Status: **High** | Medium High risk during high temperature and high rainfall
- Due to increased temperature, probability of fire-incidents at landfill increases; also accelerates waste decomposition; Due to heavy rainfall, moisture content in openly dumped waste increases making it difficult to treat; also increases ground water contamination, increasing septic conditions.
- Clogging of drains during high intensity rainfall due to waste dumped indiscriminately, resulting in water logging and related health impacts

Climate resilience potential of the sector

- 2025-26: Annual GHG emissions reduction: 286,968 tCO_2e
- Higher resource efficiency, lower air & land pollution and public health risks, reduced waste going to landfill, improved resilience from upcoming waste to compost, RDF and C&D treatment plants
- Total cost of climate resilience interventions: INR 1,500 million

SDGs

- GOAL 3: Good Health & Well-being
- GOAL 8: Decent Work & Economic Growth
- GOAL 11: Sustainable Cities & Communities
- GOAL 13: Climate Action
- GOAL 14: Life under Water
- GOAL 15: Life on Land

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Strengthen Implementation of 3R (Reuse, Reduce, Recycle) Strategy and scale up technology based measures for improved solid waste management	• Implement 3R practices at the city-scale to enable and support infrastructure planned for sustainable waste processing and management. • Conduct awareness generation activities, implement 100% segregated door-to-door waste collection, promote and establish systems to scale-up recycle, reduce and reuse practices. • Scale-up installations of IoT scanners at household level to monitor and optimize waste collection efficiency.	• Reduces GHG emissions from effective waste treatment and avoided disposal • Higher resource efficiency, lower local pollution and public health risks, improves resilience from decentralized systems • High resilience potential	Not estimated[45]	**Implementing Entities** – NMC, NSSCDCL, local NGOs, citizens **Implementation mode** –NMC can issue notification to support; Activity funded through municipal budget; GoI funds under Swachh Bharat Mission; support from international technical agencies & funds	Planned Action Short- term
Augment waste processing infrastructure and undertake scientific closure of landfill	• Scale - Addition of 600 TPD waste to compost capacity planned by NMC • NMC has planned to establish MRF & RDF plant of 380 TPD to process recyclables and dry waste. • NMC has planned to recycle C&D waste through 150 TPD C&D waste treatment plant. • Scientific closure of existing dumping ground in Bhandewadi area also planned	• 286,968 tCO_2e • Highest potential to reduce GHG emissions across other sectors; Higher resource efficiency, lower local pollution and public health risks, reduces waste going to disposal, alternate power source, improved climate resilience • High resilience potential	1,500[46]	**Implementing Entities** – NMC, local NGOs and private sector/technology providers **Implementation mode** –PPP mode through municipal budget; GoI funds under Swachh Bharat Mission; support from international technical agencies & funds.	Planned Action Mid- term period
Feasibility study to introduce decentralized bio-methanation facilities	• Undertake feasibility study to establish collection mechanism and bio-methanation plants at appropriate locations to process organic waste from vegetable markets, households & hotels, slaughterhouse to and generate biogas	• Higher resource efficiency, lower local pollution and public health risks, reduced waste going to disposal, alternate power source, improved climate resilience • High resilience potential		**Implementing Entities** – NMC, MSEDCL, local NGOs, subject matter experts, private sector/ technology providers **Implementation mode** –PPP mode through municipal budget; GoI funds; support from international technical agencies & funds	New action Mid- term
Enforce measures to minimize unscientific processing of plastic and electronic waste	• Establish and enhance capacity to curb unscientific use and handling plastic and electronic waste. • SWM department can coordinate with Nuisance Detection Squad for better enforcement.	• Reduces public health risks and local pollution due to unscientific treatment and disposal in open land or water bodies • Medium resilience potential	Not estimated[47]	**Implementing Entities** – NMC, local NGOs **Implementation mode** –Municipal budget; Swachh Bharat Mission funds	New action Short- term

45 Costs dependent on scale, type of activities and on-ground factors; hence not included here
46 Approximate cost estimate for the planned waste to compost facility
47 Costs dependent on on-ground factors; hence not estimated here

6.2.8 Street Lighting

2017-18
Energy consumption
54 million kWh

2017-18
GHG emission
441,59 tCO_2e

Baseline analysis and issues

- Highest electricity consumption in municipal services and buildings
- About 150,000 operational LED street lights
- Number of streetlights and corresponding energy consumption will increase due to expansion of city boundary and merging of planning authorities i.e. NMC and NIT.

Existing and Planned Measures by NMC

- Retrofit project underway to replace 136,000+ existing conventional street lights with LEDs through PPP mode
- Auto-dimming systems have been introduced for some of the street lights, which dims them by 40% during late night and early morning hours, leading to energy savings
- Additional LED Street lighting being installed in unserved areas

Potential climate impact and BAU scenario

- 2025-26: Annual energy saving - 4.45 million kWh
- 2025-26: Annual GHG emissions reduction - 3,665 tCO_2e

Potential climate resilience impact from identified interventions

- 2025-26: Net GHG emission after implementation of interventions: 56,307 tCO_2e
- Improved visibility; improved service quality, reliability and life of street lights
- Total cost of climate resilience interventions: INR 100 million

SDGs

GOAL 3: Good Health & Well-being

GOAL 7: Affordable & Clean Energy

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

GOAL 14: Life under Water

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Replacement of existing street lighting with LED energy efficient lights	• Scale- Replacement of remaining 19,038 conventional HPSV streetlights with LED lights to meet lighting standards as per the location	• 4.45 Million kWh • 3,365 tCO_2e • Reduces energy consumption, better visibility and security • High resilience potential	100	**Implementing entities** NMC, NIT, COC, PWD **Implementation mode** PPP model and through municipal budget	• Planned and Ongoing action • Short term

6.2.9 Municipal Buildings

2017-18
Energy consumption
2.51 million kWh

2017-18
GHG emission
2063 tCO_2e

Baseline analysis and issues

- Nagpur has been a model city under India's Solar Cities Programme.
- NMC has installed solar PV systems of about 300 kWp+ capacity on rooftops of own buildings.
- Some of these solar PV systems are non-functional due to physical damage and need upgradation to be connected with the local grid in line with the Net-Metering policy.
- Retrofits of conventional lights and ceiling fans to energy efficient ones have been undertaken in some of NMC's buildings.
- Energy consumption in municipal buildings is expected to increase with construction of additional buildings and revamping of old infrastructure including offices, clinics and schools, given the expansion of city's services.

Existing and Planned Measures by NMC

- NMC has undertaken a feasibility study to identify the potential of solar PV at its buildings and land parcels. Potential of 25-30 MWp has been identified and implementation is envisaged through RESCO mode in a phased manner. However, the progress of this activity has been slow.
- NMC has initiated energy benchmarking to improve energy performance for its zonal offices under the BEA project.

Potential climate impact and BAU scenario

- 2025-26 (projected): Electricity consumption – 5.09 million kWh
- 2025-26 (projected): GHG emissions – 4,192 tCO_2e
- Energy consumption to nearly double in 2025-26 from 2017-18 levels

Potential climate resilience impacts from identified interventions

- 2025-26: Annual energy saving - 2.3 Million kWh
- 2025-26: Annual GHG emissions reduction - 1,888 tCO_2e
- 2025-26: Net GHG emission after implementation of interventions: 2,304 tCO_2e
- Reduced grid dependency and GHG emissions due to decentralized RE systems and EE measures
- Total cost of climate resilience interventions: INR 121.5 million

SDGs

GOAL 7: Affordable & Clean Energy

GOAL 8: Decent Work & Economic Growth

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Continue energy benchmarking to implement energy retrofits in existing municipal buildings and implement green building measures for new municipal buildings.	• Scale-up and continue energy benchmarking and audits in all NMC owned buildings to identify retrofit measures. • NMC initiated energy benchmarking in 10 zonal offices and energy audits for prioritized offices through the BEA project • Adopt integration of green building concepts in design and construction of all new NMC buildings through a notification.	• 10-20% savings expected[48] • Reduces energy bills, lower GHG emissions; Better thermal comfort • Very high resilience potential	Not estimated[49]	**Implementing entities** NMC, NSSCDCL, NIT, PWD **Implementation mode** Municipal budget; Notification to be issued by NMC/ NSSCDCL emphasizing mandatory adoption of green building measures and energy efficient procurement for new buildings **Implementing entities** NMC, PWD **Implementation mode:** Municipal budget.	• New Action • Short term
Replacement of fluorescent tube lights & flat panel downlights with LED and adoption of super-efficient fans	Scale- a. Replacement of 1,000 conventional tube lights and flat panel lights in 10 zonal or administrative offices b. Replacement of 500 conventional ceiling fans in 10 zonal or administrative offices	• 0.14 million kWh • 113 tCO_2e • Medium resilience potential	2.0	**Implementing entities** NMC, PWD **Implementation mode** Municipal budget	• New Action • Short term
Replacement of old conventional ACs in all municipal buildings	• Target: Replacement of 500 old ACs with star rated ACs recommended by Bureau of Energy Efficiency (BEE) • Replacement of conventional evaporative coolers with 2-stage evaporative coolers to reduce water & energy consumption[50]	• 0.13 million kWh • 109 tCO_2e • Medium resilience potential	25	**Implementing entities** NMC, PWD **Implementation mode** Municipal budget	• New Action • Long-term
Installation of rooftop grid-tied solar PV systems in public buildings	• Scale - Installation of 1350 kWp of grid tied net-metered rooftop solar PV systems in various municipal buildings and facilities, using results of the solar feasibility study	• 2.03 million kWh • 1,666 tCO_2e • Reduces grid dependency due to decentralized RE generation; Reduces energy consumption and bills, better ventilation • High resilience potential	94.5	**Implementing entities** NMC, PWD and relevant stakeholder such as OCW water supply management company, transport department, technology providers **Implementation mode** RESCO/PPA mode, municipal budget	• Planned • Mid-term

48 Based on the benchmarking and audits undertaken for the zonal offices under the BEA project
49 Dependent on program scale and activities; hence not estimated here
50 Energy saving potential of replacement of ACs is estimated and 2-stage evaporative coolers are suggested as a strategy.

6.2.10 Disaster Management Urban Biodiversity, Air Quality, and Health

Baseline analysis and issues

- Disaster management plan and activities do not address climate change.
- Identification and mapping of vulnerable areas against climate risks such as heat waves and high intensity rainfall needed, along with identification of relevant climate adaptation strategies
- Poor maintenance of city's open-green spaces; Loss of tree cover due to on-going infrastructure projects causing air pollution and loss of biodiversity
- Water bodies and natural drains are highly polluted due to discharge of industrial effluents and untreated domestic sewage; Environmental degradation leading to negative impacts on biodiversity
- Low-lying areas are susceptible to water logging due to inadequacy & clogging of drainage network, and encroachments in and around natural drainage channels, ponds, canals.

Existing and Planned Measures by NMC

- NMC with the support of NSSCDCL has initiated monitoring climate impacts such as heat waves and high intensity rainfall. Appropriate actions such as sending of notifications/ alerts to departments, awareness activities for citizens have been initiated.
- NMC and NSSCDCL have piloted installation of 10 ambient air quality monitoring stations (AAQMS) to create an evidence base for decision-making and actions on urban planning.
- An LBSAP has been prepared supported by actions such as Tree Census, Natural Asset mapping and Tree labelling to conserve and enhance biodiversity and ecosystems.
- NMC has prepared Rejuvenation Plan for city's lakes. Work for rejuvenation is in progress at Naik Lake, Sonegao Lake etc.
- Decentralized effluent treatment plants are planned to be established near water bodies to address pollution from industrial effluent, with the technical guidance from Maharashtra Pollution Control Board.

Potential climate impact and BAU scenario

- Climate Risk Status: **Medium High** | Medium High risk during high temperature impacting city's biodiversity and ecosystems.
- Increased air pollutant concentration due to lower precipitation, and public health risk from heat waves

Climate resilience potential of the sector

- Ecology and biodiversity conservation, urban heat mitigation, cleaner air and water, urban flood mitigation

SDGs

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Implementation of LBSAP prepared under Urban LEDS II project	• Implement actions for biodiversity conservation and management as identified in the LBSAP. • Undertake tree census every 5 years to map the status and species to take informed actions such as preservation of heritage trees, plantation of native trees.	• Urban heat mitigation, ecology and biodiversity conservation • High resilience potential	Not estimated[51]	**Implementing Entities** – NMC, NSSCDCL, local NGOs, nurseries, private sector, citizens **Implementation mode** – Municipal budget; GoI funds	• Ongoing Action • Mid-term
• **Integration of Climate Risk and Vulnerability Assessment (CRVA) with Disaster Management Plan** • **Strengthen Heat Action Plan and Environmental Status report (ESR)**	• Integrate CRVA with Disaster Management Plan to establish linkage with climate change and integrate implementation of climate adaptation strategies • NMC prepares Heat Action Plan and Environmental Status Report annually. • Establish robust monitoring mechanism and critical review with respect to the city's development/growth to enhance these processes.	• Improves climate resiliency and public health • Reduces impacts of climate risks on livelihoods • High resilience potential	Not estimated	**Implementing Entities** – NMC- Disaster management Cell, NSSCDCL, local NGOs, private sector, citizens and academic institutions **Implementation mode** – Municipal budget; GoI funds; support from international technical agencies	• Planned Action • Mid-term period
Implementation of Clean Air Action Plan	• NMC to strengthen monitoring of air quality and undertake science-based decisions to curb rising air pollution levels due to on-going infrastructure development, concretization and loss of green cover	• Reduces air pollution, improved public health, biodiversity conservation • High resilience potential	Not estimated	**Implementing Entities** – NMC- Disaster management Cell, NSSCDCL, local NGOs, private sector, citizens **Implementation mode** – Municipal budget; GoI funds; support from international technical agencies & funds	• Planned Action • Mid-term

51 Will depend on the scale of implementation and timeline

Resilience interventions	Details of intervention	Climate benefits and co-benefits	Indicative cost (million INR)	Implementation entities and mode	Status and duration of implementation
Implementation of Nagpur Lakes Rejuvenation Plan	• Check encroachment and regulate illegal structures at lake boundaries. • Identify and map river stretches, wetlands and green belts to increase connectivity and act as potential corridors for biodiversity	• Urban heat mitigation, biodiversity conservation, environmental protection, improves surface water resources • High resilience potential	Not estimated[52]	**Implementing Entities** – NMC- Disaster management Cell, NSSCDCL, local NGOs, private sector, citizens **Implementation mode** – Municipal budget; GoI funds; support from international technical agencies & funds	• Planned Action • Mid-term
Promote nature-based solutions for flood control	• Demarcate catchments leading to flood prone areas and undertake native species plantations to regulate surface water runoff. • Reduce hardscapes and unnecessary concretization in public spaces by laying green pavements.	• Flood mitigation, improved groundwater recharge, ecology conservation, reduced public health risk • High resilience potential	Not estimated[53]	**Implementing Entities** – NMC- Disaster management Cell, Public Health Engineering Department, NSSCDCL, local NGOs, private sector, citizens **Implementation mode** – Municipal budget; GoI funds; support from international technical agencies & funds	• New Action • Long-term

52 Depends on scale of the implementation
53 Depends on scale of the implementation

07
WAY FORWARD

The CRCAP for NMC has been developed using the ClimateResilientCities methodology. Baseline GHG emissions in the city have been recorded through the HEAT+ tool following the GPC protocol, to identify the sectors mainly responsible for carbon emissions within the city, both at the municipal and community levels. The sectors responsible for majority of the emissions and therefore providing the maximum potential to reduce emissions include the solid waste and building sectors.

The plan considers two major impacts of climate change – increased temperature and increased precipitation with short duration and high intensity rainfall. The primary urban services, which will most severely be impacted by climate change, include water supply, sewerage management, SWM systems, energy and transportation. These fragile urban systems and their fragility have been identified. The methodology helped identify the broad climate risks to these fragile urban systems, the most vulnerable areas within the city and the most vulnerable actors that will be impacted by them.

On the basis of the vulnerable urban systems, areas, actors, and the GHG emissions information, resilience actions have been identified to help the city reduce carbon emissions and successfully adapt to potential climate impact in the future. **The CRCAP shows overall potential of GHG emissions mitigation at about 20% by 2025-26 compared to the baseline of 2017-18.** CRCAP also underlines the Nagpur's commitment to undertake participatory governance and strive to become an inclusive and climate resilient city, through provision of smart and sustainable urban services to all, with a focus on sustainable management of urban heat and enhancement of its biodiversity.

Nagpur is among the pioneering Indian cities to undertake climate actions locally. However, considering the rapid urban transformation, IEC and awareness generation activities are the need of the hour. A single window mechanism for citizens and a dedicated climate change cell within the municipal corporation is essential for implementing short medium and long-term low carbon interventions and policies proposed in the CRCAP. It will also help Nagpur to take informed decisions with better coordination and for effective monitoring of actions undertaken.

The CRCAP shows overall potential of GHG emissions mitigation at about 20% by 2025-26 compared to the baseline of 2017-18

Annexures

Annexure I: Climate Core Team and Stakeholder Committee

NAGPUR SMART AND SUSTAINABLE CITY DEVELOPMENT CORPORATION LIMITED
OFFICE OF THE CHIEF EXECUTIVE OFFICER

Smart City

nagpur

Shri Chhatrapati Shivaji Maharaj Administrative Building, Civil Lines, Nagpur-440001, Maharashtra, India.
Landline:+91 712-2567037 Mobile :+919967440222 E-mail : ceonsc.nmcngr@gov.in, ceonsscdcl@gmail.com website : www.nsscdcl.com

No: 3309 **NSSCDCL/2019** **Date: 08/03/2019**

To,

Mr. Emani Kumar
Deputy Secretary General, ICLEI &
Executive Director, ICLEI- South Asia,
New Delhi.

Subject: Regarding formation of Stakeholder Committee under the Urban Low Emission Development Strategies II (Urban LEDS II) project

Reference: ICLEI-SA Letter to NSSCDCL, dated 06.03.2019

Dear Mr. Kumar,

As per the reference letter above, regarding formation of Climate Core Committee and Stakeholder Committee under the project **'Accelerating Climate Action through the Promotion of Urban Low Emission Development Strategies (Urban LEDS II)'**, Nagpur Smart & Sustainable City Development Corporation Limited (NSSCDCL) has formed both the committees. Climate Core Committee will steer and monitor overall project activities whereas Stakeholder Committee will share its relevant expertise in the field to increase City's efforts towards low emission development activities and thereby will assist in achieving intended project objectives.

The composition of both the committees is attached herewith. The same will be revised as and when required based on the project activities and inputs from the committees.

With Regards

(Dr. Ramnath Sonawane)
Chief Executive Officer
NSSCDCL, Nagpur.

Encl.:

1. Climate Core Committee- Annexure I
2. Stakeholder Committee- Annexure II

Annexure I- Project: URBAN Low Emission Development Strategies II (Urban LEDS II)				
Core Climate Committee				
Sr. No.	Name	Organization	Designation	Contact Details
1	Smt. Nanda Jichkar	Nagpur Municipal Corporation (NMC)	Hon. Mayor	mayorofficenmc@gmail.com
2	Shri. Abhijit Bangar	Nagpur Municipal Corporation (NMC)	Hon. Commissioner	nmcnagpur@gmail.com
3	Dr. Ramnath Sonawane	Nagpur Smart & Sustainable City Development Corporation Limited (NSSCDCL)	Chief Executive Officer	ceonsscdcl@gmail.com
4	Shri. Devendra Mahajan	Environment Department, NSSCDCL.	General Manager	deven.mahajan@gmail.com
5	Shri. Rajesh Dufare	Pench Project Cell, NMC & Mobility Division, NSSCDCL	Dy. Engineer & General Manager	rjdufare@gmail.com

Dr. Manas Badge
PE, Environment Division
NSSCDCL

Mr. Devendra Mahajan
GM, Environment Division
NSSCDCL

Dr. Ramnath Sonawane
Chief Executive Officer
NSSCDCL

Annexure II- Project: URBAN Low Emission Development Strategies II (Urban LEDS II)				
Stakeholder Committee				
Sr. No.	Name	Designation	Department	Email-ID/Contact Number
1	Smt. Nanda Jichkar	Hon. Mayor	Nagpur municipal Corporation	mayorofficenmc@gmail.com
2	Shri. Pradeep Pohane	Hon. Chairman	Standing Committee, NMC	Ph: 0712-2567012
3	Shri. Abhijeet Bangar	Hon. Commissioner	Nagpur municipal Corporation	nmcnagpur@gmail.com
4	Dr. Ramnath Sonawane	Chief Executive Officer	Nagpur Smart & Sustainable City Development Corporation Limited (NSSCDCL)	ceonsscdcl@gmail.com
5	Shri.Nitin Kapadnis	Dy. Commissioner & CFO	Finance Department, NMC	nitingkapadnis@gmail.com
6	Smt. Divya Dhurde	Chairman	Biodiversity Committee, NMC	
7	Shri. Ulhas Debadwar	Chief Engineer	Public Work Department, NMC	Mo: 9890315040
8	Shri. Pramod Gawande	Asst. Director	Town Planning Department, NMC	Mo.: 7775064999
9	Shri. Naresh Borkar	Executive Engineer	Project Department, NMC	Mo: 9923750916
10	Shri. Sanjay Jaiswal	Executive Engineer	Electrical Department, NMC	Mo: 9823172908
11	Shri. Amol Chorpagar	Garden Superitendent	Garden Department, NMC	Mo: 9823391762 / 0712-2567032/145
12	Dr. Sunil Kamble	Health Officer	Health Department, NMC	Ph: 0712-2567009/127
13	Shri. Manoj Ganvir	Executive Engineer	Water Works Department, NMC	wwd.hw.nmc@gmail.com
14	Shri. Shivaji Jagtap	Transport Manager	Nagpur Mahanagar Parivahan Limited (NMPL) & Transport Department, NMC	transport.nmc@gmail.com
15	Shri. Mahesh Gupta	Additional General Manager	Maharashtra Metro Rail Corporation Limited (MMRCL)	mahesh.gupta@mahametro.org
16	Shri. Rajesh Dufare	Dy. Engineer	Pench Project Cell, NMC	rjdufare@gmail.com
17	Shri. Devendra Mahajan	General Manager	Environment Division, NSSCDCL	deven.mahajan@gmail.com
18	Shri Aasaram Bodhile	Executive Engineer	Traffic Department, NMC	Mo: 9823057996
19	Mr. Manish Wath	Chief Engineer (NAGPUR Urban)	Maharashtra State Electricity Distribution Company Limited (MSEDCL)	senagpuru@gmail.com, Mo: 07875760333
20	Shri. Rahul Wankhede	Regional Officer	Maharashtra Pollution Control Board (MPCB)	sronagpur1@mpcb.gov.in, Ph: 0712 - 2565308
21	Dr. Rakesh Kumar	Director	National Environmental Engineering Research Institute (NEERI), Nagpur	r_kumar@neeri.res.in, Mo.: 9820839821
22	Dr. P. V. Kathane	Dy. Director	Ground Water Survey & Development Agency, Nagpur	dydirhp.gsda@maharastra.gov.in
23	Dr. D. Venkateswaran	Scientist-D	Central Ground Water Board	rdncr-cgwb@nic.in
24	Dr. N.R. Ugemuge	Maharashtra State Biodiversity Board	Technical Assistant	ugemuge.botanist@gmail.com, 9823088702

Annexure II- Project: URBAN Low Emission Development Strategies II (Urban LEDS II)				
Stakeholder Committee				
Sr. No.	Name	Designation	Department	Email-ID/Contact Number
25	Dr. Siddharthavinayaka P. Kane	VICE-CHANCELL0R	Rashtrasant Tukadoji Maharaj,Nagpur University, Nagpur.	vc@nagpuruniversity.nic.in, Ph: 0712-2523045
26	Dr. Pramod M. Padole	Director	VNIT Institute, Nagpur	director@vnit.ac.in
27	Mr. Shripad Wadekar	Regional Transport Officer	Regional Traffic Office (RTO) Nagpur (URBAN)	mh31@mahatranscom.in
28	Shri. Sarang Mahajan	Regional Director (Nagpur)	Maharashtra Energy Development Agency (MEDA)	rdnagpur@mahaurja.com/ dgmnagpur@mahaurja.com
29	Mr. Rakesh L. Shrivastava	Chairman	The Institution of Engineers- Nagpur Chapter	rlshrivastava@gmail.com, Mo.: 9764996486
30	Mr. Ashok Mokha	Chairman -IGBC -Nagpur	Ashok Mokha Architects	Mo.: 9823078573
31	Mr. Amarkumar Badge	Regional Manager	Hindustan Petroleum Corporation Limited, (HPCL)	abbagde@hpcl.in, Mo: 9890398927
32	Mr. Manish Nandle	Regional Manager	Indian Oil Corporation Limited, (IOCL)	nandlem@indianoil.in, Mo: 9422804637
33	Mr. Sameer Dange	Regional Manager	Bharat Petroleum Corporation Limited, (BPCL)	dangesm@bharatpetroleum.in, Mo.:9752509914
34	Ms. Leena Budhe	Founder	Centre for Sustainable Development, Nagpur	Mo.: 9372391202
35	Mr. Kaustav Chatterjee	Founder	Green Vigil Foundation- Nagpur	greenvigilnetwork@gmail.com
36	Ms. Anusuya Kale	Founder	Swacha Association	Mo.: 9850489953
37	Mr. Aprup Adavatkar	Founder	Paryavaran Pratham- Nagpur	adawadkar@gmail.com
38	Dr. Anil Pimplapure	Central India Bird Academy (CIBA)	Director	anil.pimplapure@gmail.com, Mo: 9881713466
39	Dr. Manas Badge	Project Executive	Environment Division, NSSCDCL	badge_manas@yahoo.co.in
40	Dr. Parag Armal	Project Executive	Environment Division, NSSCDCL	armalparag@gmail.com

Manas Badge 7.3.19
Dr. Manas Badge
PE, Environment Division
NSSCDCL

07/03/2019
Mr. Devendra Mahajan
GM, Environment Division
NSSCDCL

Dr. Ramnath Sonawane
Chief Executive Officer
NSSCDCL

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Annexure II: Prioritized Resilience Interventions for Nagpur

The prioritization exercise uses five key criteria/characteristics described below:

- Redundancy: A resilient system can function and achieve results through multiple paths or nodes when one fails and when performance is critical. In contrast, a "single best solution" is not resilient because if this single option fails, the system collapses. Back-up systems, or decentralized nodes for service delivery in a linked network, are preferable.
- Flexibility and diversity: Essential systems should be able to work under a variety of conditions; they should not be rigid or designed only for one specific situation. Any system will fail if overloaded beyond its capacity, but it should be designed to fail under stress in a safe and predictable way, rather than suddenly and catastrophically.
- Re-organization and responsiveness: Under extreme conditions, systems should be able to respond and change to meet unexpected shocks. This requires flexible organizations and access to different kinds of resources (information, skills, equipment, knowledge and experience). It also means a high level of coordination and flexible organizational structures capable of adjusting to new conditions.;
- Access to information: Resilient systems have mechanisms to learn from and build on experience, so that past mistakes are not repeated and lessons from other cities can be integrated into planning. This requires procedures for monitoring and evaluating performance under stress, and requires multiple sources of knowledge and documentation (strengthening "corporate memory")
- Energy saving and GHG emission mitigation potential: Resilient systems have potential to reduce energy consumption and mitigate GHG emission, which may be integrated into their regular planning. This requires procedures for periodic monitoring and evaluating performance, which requires multiple sources of knowledge and documentation.

Residential Buildings

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Adopt Green Building Design in upcoming Affordable Housing Scheme	Yes	Yes	Yes	No	Yes	High
Implement a programme to promote adoption of Urban Cool Roofs - Promoting White Roofs, and relevant measures	Yes	Yes	Yes	No	Yes	High
Promote use of SWH in place of conventional geysers in households	Yes	Yes	Yes	Partial	Yes	High
Promote and facilitate installation of rooftop solar PV with net-metering	Yes	Yes	Yes	Partial	Yes	High
Adopt energy efficient lighting to replace conventional lighting	Yes	Yes	Yes	No	Yes	High
Adopt energy efficient ceiling fans to replace conventional fans	Yes	Yes	Yes	No	Yes	High
Encourage use of energy efficient air conditioners and 2 stage evaporative coolers	Yes	Yes	Yes	No	Yes	High
Encourage use of energy efficient refrigerators	Yes	Yes	Yes	No	Yes	High

Commercial and Institutional Buildings

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Expand Energy Benchmarking & undertake energy audits for energy performance improvement	Yes	Yes	Yes	Partial	Yes	High
Mapping of rooftop solar PV potential in large commercial buildings for demand aggregation	Yes	Yes	Yes	No	Yes	High
Technical assessment for District Cooling Systems for large commercial properties	Yes	Yes	Yes	No	Yes	High
Promote use of SWH in place of conventional geysers in hospitals and hotels. Establish long-term monitoring mechanism within Town-Planning Department to ensure functioning of all SWH	Yes	Yes	Yes	Partial	Yes	High
Promote and facilitate installation of rooftop solar PV with net-metering	Yes	Yes	Yes	Partial	Yes	High
Adopt energy efficient lighting to replace conventional lighting	Yes	Yes	Yes	Partial	Yes	High
Adopt energy efficient ceiling fans to replace conventional fans	Yes	Yes	Yes	No	Yes	High
Encourage use of energy efficient air conditioners	Yes	Yes	Yes	No	Yes	High

Industrial Buildings

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Mapping of rooftop solar PV potential in large industries	Yes	Yes	Yes	No	Yes	High
Install net-metered rooftop solar PV systems integrated with energy storage solutions.	Yes	Yes	Yes	Partial	Yes	High
Adopt energy efficient star rated equipment.	Yes	Yes	Yes	No	Yes	High

Water Supply

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Reduce physical water losses and non-revenue water through water audits, leak detection, network improvement.	Yes	No	Yes	Yes	Yes	High
Reuse of water for gardening, avenue plantation and green cover.	Yes	Yes	Yes	No	Yes	High
Implementation of city-wide Ground Water Recharge Action Plan prepared under Urban-LEDS II project Establish robust monitoring mechanism to evaluate existing and upcoming RWH systems	Yes	Yes	Yes	Partial	Yes	High
Conduct energy audit to identify and implement energy efficiency measures.	Yes	Yes	Yes	Partial	Yes	High
Install automated water ATMs systems across the city, especially in the vulnerable areas for clean and safe water distribution.	Yes	Yes	Yes	Partial	Yes	High

Waste water and Drainage

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Implementation of Nag River Pollution Abatement Project and additional STPs planned by NMC	Yes	Yes	Yes	Yes	Yes	Very High
Mandates for dual plumbing, on-site treatment and re-use of gray water	Yes	Yes	Yes	No	Yes	High
Conduct Energy audits to improve energy efficiency of pumping.	Yes	Yes	Yes	Partial	Yes	High
Prepare Plan for fecal sludge management (FSM).	Yes	Yes	Yes	No	Yes	High
Pilot decentralized wastewater treatment systems (DeWATS) for households.	Yes	Yes	Yes	No	Yes	High

Transport

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Adopt E-mobility and switch to cleaner fuel in commercial passenger vehicles.	Yes	Yes	Yes	No	Yes	High
Adopt E-mobility and switch to cleaner fuel in public bus fleet.	Yes	Yes	Yes	Yes	Yes	Very High
Implement public bicycle sharing in identified pilot areas.	Yes	Partial	Yes	No	Yes	Medium
Promote and develop non-motorized transit facilities.	Yes	Yes	Yes	No	Yes	High

Municipal Solid Waste Management

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Strengthen implementation of 3R (Reuse, Reduce, Recycle) Strategy and scale up technology-based measures for improved solid waste management	Yes	No	Yes	Yes	Yes	High
Augment waste processing infrastructure and undertake scientific closure of landfill	Yes	No	Yes	Yes	Yes	High
Feasibility study to introduce decentralized bio-methanation facilities	Yes	No	Yes	No	Yes	Medium
Enforce measures to minimize unscientific processing of plastic and electronic waste	Yes	No	Yes	No	Yes	Medium

Street Lighting

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Replacement of existing street lighting with LED energy efficient lights	Yes	Yes	Yes	Yes	Yes	Very High

Municipal Corporation Buildings

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Continue energy benchmarking to implement energy retrofits in existing municipal buildings and implement green building measures for new municipal buildings	Yes	Yes	Yes	No	Yes	High
Replacement of fluorescent tube lights & flat panel downlights with LED and adoption of super-efficient fans	Yes	Yes	Yes	Partial	Yes	High
Replacement of old conventional ACs in all municipal buildings	Yes	Yes	Yes	No	Yes	High
Installation of rooftop grid-tied solar PV systems in public buildings	Yes	Yes	Yes	No	Yes	High

Disaster Management Urban Biodiversity, Air Quality and Health

Resilience interventions	Redundancy	Flexibility	Responsiveness	Access to information	Energy saving and GHG emissions mitigation potential	Overall resilience score
Implementation LBSAP prepared under URBAN LEDS II project	Yes	Yes	Yes	Partial	Yes	High
Integration of Climate Risk and Vulnerability Assessment (CRVA) with Disaster Management Plan Strengthen Heat Action Plan and Environmental Status report (ESR).	Yes	Yes	Yes	Partial	Yes	High
Implementation of Clean Air Action Plan	Yes	Yes	Yes	Partial	Yes	High
Implementation of Nagpur Lakes Rejuvenation Plan	Yes	Yes	Yes	Partial	Yes	High
Promote nature-based solutions for flood control	Yes	Yes	Yes	No	Yes	High

Annexure III: Feasibility Assessment of the Climate Resilient Interventions

Residential Buildings

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Adopt green building design in upcoming affordable housing scheme	Medium	Medium	Medium	Mid-Term Period
Implement a programme to promote adoption of Urban Cool Roofs - Promoting white roofs, and relevant measures	Medium	Medium	Medium	Mid-Term Period
Promote use of solar water heaters (SWH) in place of conventional geysers in households	Medium	Medium	Low	Mid-Long-Term Period
Promote and facilitate installation of rooftop solar PV with net-metering	Medium	Medium	Low	Mid-Long-Term Period
Adopt energy efficient lighting to replace conventional lighting	Medium	Medium	High	Mid-Term Period
Adopt energy efficient ceiling fans to replace conventional fans	Medium	Medium	High	Mid- Term Period
Encourage use of energy efficient air conditioners and 2- stage evaporative coolers	Medium	Medium	Medium	Mid-Long-Term Period
Encourage use of energy efficient refrigerators	Medium	Medium	Medium	Mid- Term Period

Commercial and Institutional Buildings

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Expand energy benchmarking & undertake energy audits for energy performance improvement	High	Medium	Medium	Short-Term Period
Mapping of rooftop solar PV potential in large commercial buildings for demand aggregation	High	Medium	Medium	Medium- Term Period
Technical assessment for District Cooling Systems for large commercial properties	Low	Low	Medium	Medium-Long Term Period
Promote use of SWH in place of conventional geysers in hospitals and hotels. Establish long-term monitoring mechanism within the Town Planning Department to ensure functioning of all SWHs	High	High	Medium	Short-Term period
Promote and facilitate installation of rooftop solar PV with net-metering	Medium	Medium	Medium	Medium-Term Plan
Adopt energy efficient lighting to replace conventional lighting	High	Medium	High	Short-Term Plan
Adopt energy efficient ceiling fans to replace conventional fans				
Encourage use of energy efficient air conditioners	Medium	Low	Low	Medium-Long Term Plan

Industrial Buildings

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Mapping of rooftop solar PV potential in large industries	High	Medium	Medium	Medium-Term Plan
Install net-metered rooftop solar PV systems integrated with energy storage solutions	Medium	Medium	Medium	Medium-Term Plan
Adopt energy efficient star rated equipment	High	Medium	High	Short-Term Plan

Water Supply

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Reduce physical water losses and NRW through water audits, leak detection, network improvement	High	Medium	Medium	Medium-Long Term Plan
Reuse of water for gardening, avenue plantation and green cover	Medium	Medium	Medium	Medium-Term Plan
Implementation of city-wide Ground Water Recharge Action Plan prepared under Urban-LEDS II project. Establish robust monitoring mechanism to evaluate existing and upcoming RWH systems	High	Medium	Medium	Short-Term Plan
Conduct energy audit to identify and implement EE measures	High	Medium	Medium	Short-Term Plan
Install automated water ATMs systems across the city, especially in the vulnerable areas for clean and safe water distribution.	High	Medium	Medium	Short-Term Plan

Waste Water and Drainage

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Implementation of Nag River Pollution Abatement Project and additional STPs planned by NMC	High	Medium	High	Medium-Term Plan
Mandates for dual plumbing, on-site treatment, and re-use of gray water	Medium	Low	Low	Medium-Long Term Plan
Conduct energy audits to improve EE of pumping	Medium	Medium	Medium	Medium-Term Plan
Prepare plan for fecal sludge management (FSM)	Medium	Low	Low	Medium-Long Term Plan
Pilot decentralized wastewater treatment systems (DeWATS) for households	Medium	Low	Low	Medium-Long Term Plan

Transport

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Adopt e-mobility and switch to cleaner fuel in commercial passenger vehicles	Medium	Low	Medium	Medium-Long Term Plan
Adopt E-mobility and switch to cleaner fuel in public bus fleet	Medium	Medium	Medium	Medium-Long Term Plan
Implement public bicycle sharing in identified pilot areas	Medium	Medium	Low	Medium-Long Term Plan
Promote and develop non-motorized transit facilities	Medium	Low	Low	Medium-Long Term Plan

Municipal Solid Waste Management

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Strengthen Implementation of 3R (Reuse, Reduce, Recycle) Strategy and scale up technology based measures for improved solid waste management	Medium	Medium	Low	Medium-Long Term Plan
Augment waste processing infrastructure and undertake scientific closure of landfill	Medium	Medium	High	Medium-Term Plan
Feasibility study to introduce decentralized bio-methanation facilities	Medium	Medium	Low	Medium-Term Plan
Enforce measures to minimize unscientific processing of plastic and electronic waste	Medium	Medium	Low	Medium-Term Plan

Streetlights

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Replacement of existing street lighting with LED energy efficient lights.	High	High	Medium	Short-Term Period

Municipal Corporation Buildings

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Continue energy benchmarking to implement energy retrofits in existing municipal buildings and implement green building measures for new municipal buildings.	Medium	Medium	Medium	Medium Term Plan
Replacement of fluorescent tube lights & flat panel downlights with LED and adoption of super-efficient fans	High	Medium	High	Short-Term Plan
Replacement of old conventional ACs in all municipal buildings	High	Medium	Low	Medium Term Plan
Installation of rooftop grid-tied solar PV systems in public buildings	Medium	Low	Low	Medium Term Plan

Disaster Management Urban Biodiversity, Air Quality, and Health

Resilience Interventions	Feasibility of the intervention			Period of Impact
	Technical	Political	Financial	
Implementation of LBSAP prepared under URBAN LEDS II project	Medium	Medium	Medium	Medium-Term Plan
Integration of Climate Risk and Vulnerability Assessment (CRVA) with Disaster Management Plan Strengthen Heat Action Plan and Environmental Status report (ESR)	Medium	Low	Medium	Medium-Term Plan
Implementation of Clean Air Action Plan	Medium	Low	Medium	Medium-Term Plan
Implementation of Nagpur Lakes Rejuvenation Plan	Medium	Medium	Medium	Medium-Term Plan
Promote nature-based solutions for flood control	Medium	Medium	Low	Medium-Long-Term Plan