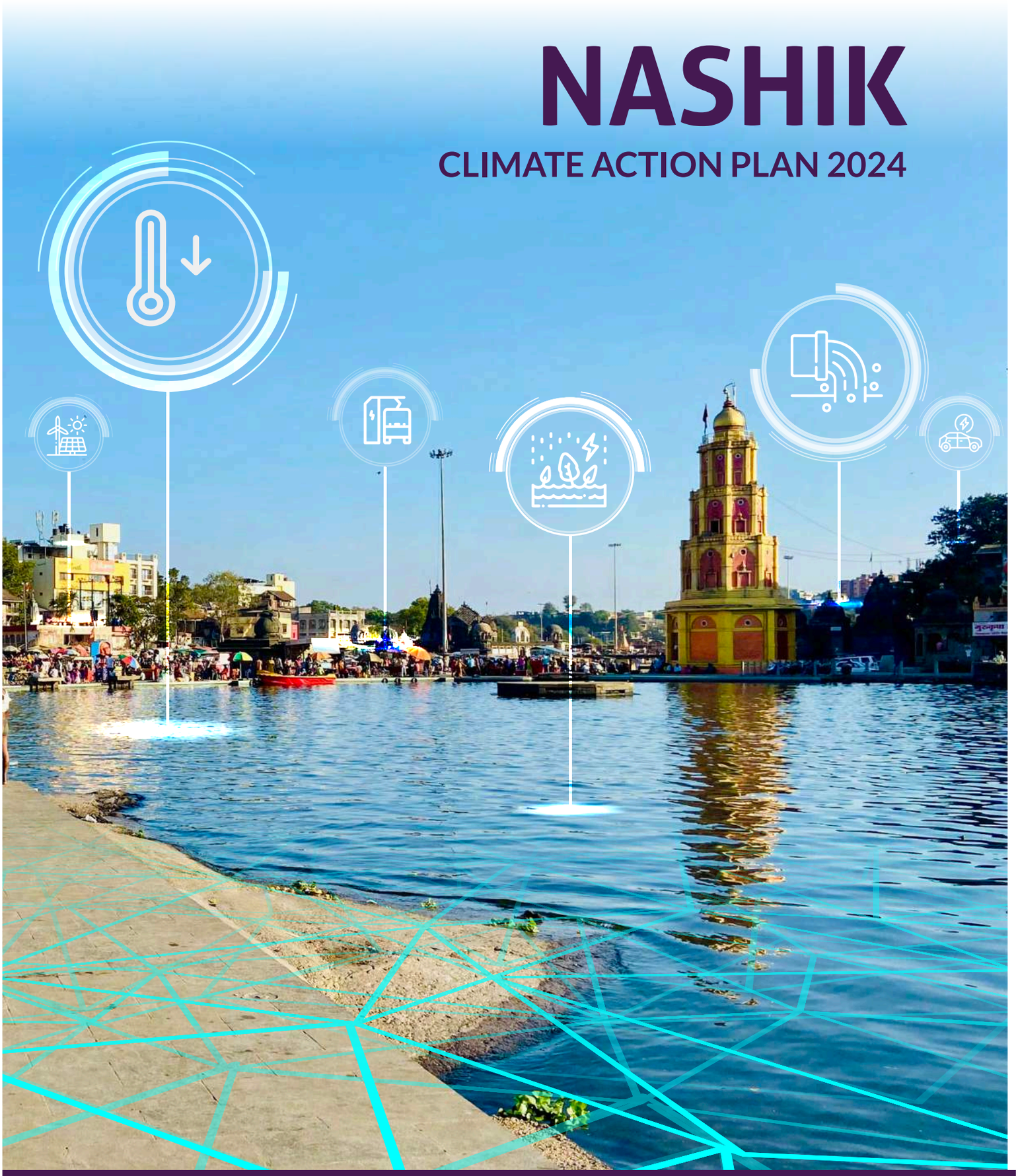
Government of Maharashtra
Environment and Climate Change Department

NASHIK

CLIMATE ACTION PLAN 2024



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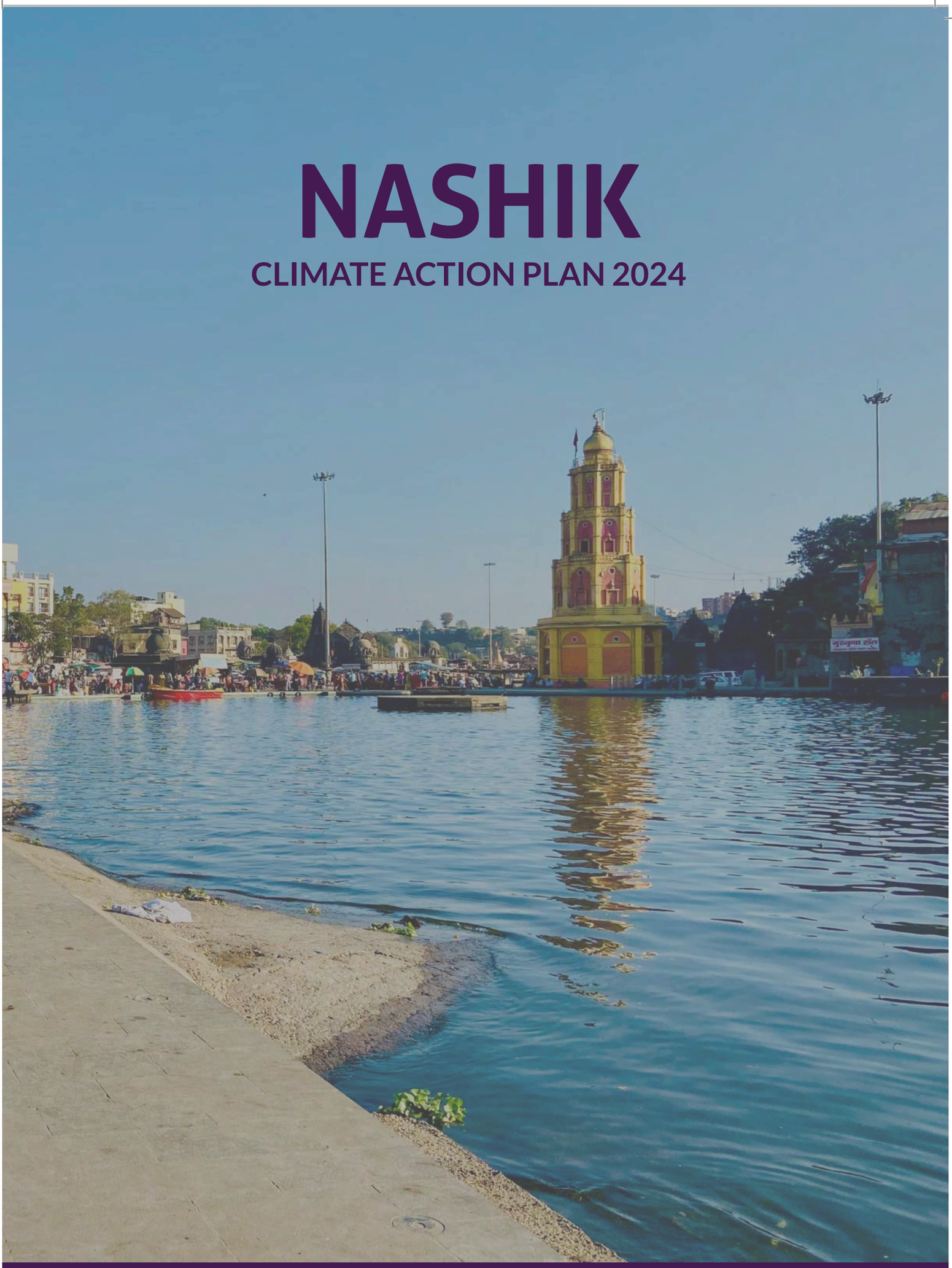

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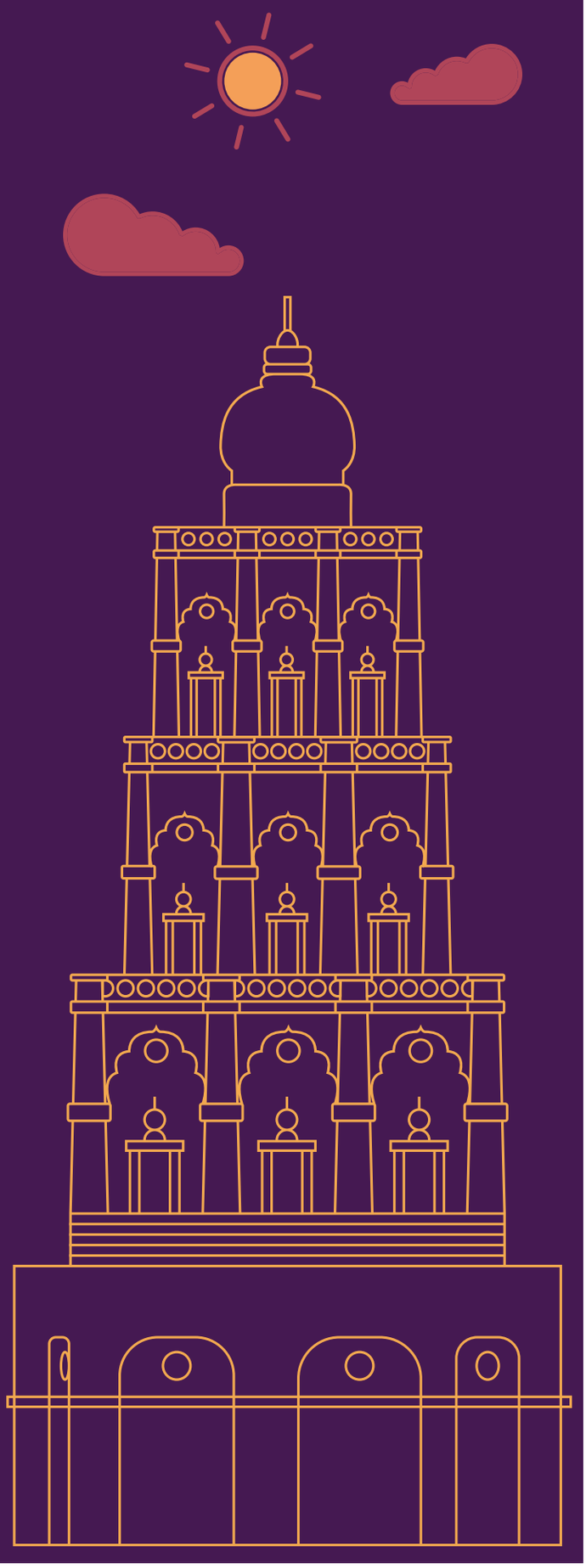

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ABBREVIATIONS

2W	Two-wheeler Vehicle
4W	Four-wheeler Vehicle
AMC	Assistant Municipal Commissioner
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BAU	Business as Usual
C&D	Construction and Demolition
CAAQMS	Continuous Ambient Air Quality Monitoring System
CAP	Climate Action Plan
CBO	Community Based Organisation
CDP	City Development Plan
CEAI	Central Electricity Authority of India
CIDCO	City and Industrial Development Corporation
CGWB	Central Ground Water Board
CIRIS	City Inventory Reporting and Information System
CMP	Comprehensive Mobility Plan
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2e	Carbon Dioxide Equivalent
CPCB	Central Pollution Control Board
CREDAI	Confederation of Real Estate Developers' Associations of India
CSCAF	Climate Smart Cities Assessment Framework
CSO	Civil Society Organization
CSR	Corporate Social Responsibility
CTTP	Comprehensive Traffic and Transportation Plan
CURB	Climate Action for Urban Sustainability
DCR	Development Control Regulations
DISCOM	Distribution Companies
DMC	Deputy Municipal Commissioner
DP	Development Plan
E&P	Existing and Planned

ECBC	Energy Conservation Building Code
EREs	Extreme Rainfall Events
ESR	Environmental Status Report
EV	Electric Vehicle
FAME	Faster Adoption and Manufacturing of Hybrid and Electric Vehicles
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GOI	Government of India
GPC	Global Protocol for Communities
GPS	Global Positioning System
GSDA	Groundwater Surveys and Development Agency
GSM	Global System for Mobile Communication
GW	Groundwater
GWRP	Groundwater Recharge Potential
ha	Hectare
HH	Households
HT	High Tension
IAS	Indian Administrative Services
ICLEI	International Council for Local Environmental Initiatives.
ICT	Information and Communications Technology
IEC	Information, Education and Communication
IGBC	Indian Green Building Council
IMD	Indian Meteorological Department
IPCC	Intergovernmental Panel on Climate Change
IPT	Intermediate Public Transport
ISWM	Integrated Solid Waste Management
km	Kilometre
kmph	Kilometre Per Hour
KPI	Key Performance Indicators
KW	Kilowatt
LPG	Liquefied Petroleum Gas
LST	Land Surface Temperature

LT	Low Tension
MAHAGENCO	Maharashtra State Electricity Distribution Company Ltd.
MC	Municipal Commissioner
MER	Monitoring, Evaluation, Reporting
MLD	Million Litres Per Day
MNGL	Maharashtra Natural Gas Limited
MODIS	Moderate Resolution Imaging Spectroradiometer
MoHUA	Ministry of Housing and Urban Affairs
MPCB	Maharashtra Pollution Control Board
MRF	Materials Recovery Facility
MSEDCL	Maharashtra State Electricity Distribution Company Limited
MSW	Municipal Solid Waste
MVA	Majhi Vasundhara Abhiyan
MW	Megawatt
MWh	Megawatt hour
NAAQ	National Ambient Air Quality
NAPCC	National Action Plan for Climate Change
NBS	Nature-based Solutions
NCAP	National Clean Air Programme
NCEI	National Centers for Environmental Information
NDC	Nationally Determined Contribution
NDVI	Normalized Difference Vegetation Index
NGO	Non-governmental Organization
NIMA	Nashik Industries and Manufacturers' Association
NIUA	National Institute of Urban Affairs
NMC	Nashik Municipal Corporation
NMPML	Nashik Mahanagar Parivahan Mahamandal Limited
NMSDCL	Nashik Smart City Development Corporation Limited
NMT	Non-motorized Transport
NOx	Nitrogen Oxides
NOAA	National Oceanic and Atmospheric Administration
NWMPL	Nashik Waste Management Private Limited

PM	Particulate Matter
PNG	Piped Natural Gas
PPP	Public-Private Partnership
PV	Photovoltaic
RCP	Representative Concentration Pathways
RDF	Refuse-derived Fuel
RE	Renewable Energy
RSPM	Respirable Suspended Particulate Matter
RTO	Regional Transport Office
RWH	Rainwater Harvesting
SCADA	Supervisory Control and Data Acquisition System
SDG	Sustainable Development Goals
SO_2	Sulphur Dioxide
SPM	Suspended Particulate Matter
STP	Sewage Treatment Plant
SWH	Solar Water Heaters
SWM	Solid Waste Management
TPD	Tonnes Per Day
UHI	Urban Heat Island
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
W2E	Waste to Energy
WAYU	Wind Augmentation and Purifying Units
WRI	World Resources Institute

PREFACE

SHRI PRAVIN DARADE, IAS

Principal Secretary,
Department of Environment and Climate Change,
Government of Maharashtra

It gives me an immense pleasure and a profound sense of accomplishment to acknowledge Nashik is leading the way forward in tackling the climate crisis by adopting the Nashik Climate Action Plan.

The increasing number of extreme weather events worldwide that directly affect our local communities has made it more urgent to address the climate crisis. During the COP26 summit in Glasgow, Hon. Prime Minister of India announced a target to achieve net-zero emissions by 2070. Hon. Prime Minister of India also introduced a new concept called "Lifestyle for the Environment (LiFE)" during the COP on 1st November 2021. This initiative encourages people to adopt mindful and deliberate practices to protect and preserve the environment rather than mindless and destructive consumption. The program is people-centric and aims to tackle climate change while also calling for global action.

Maharashtra is leading India's efforts to combat the imminent climate crisis by implementing policy reforms and encouraging climate action culture within society. The state has a history of pioneering initiatives such as the Sant Gadge Baba Gram Swacchata Abhiyan and Swachh Bharat Abhiyan and is now spearheading the Majhi Vasundhara Abhiyan in Urban Local Bodies and Panchayati Raj Institutions. While India is working towards achieving its Nationally Determined Contributions, Maharashtra's commitment to the cause sets an example for the nation.

Climate change requires tailored solutions that address the environmental concerns of our diverse urban landscapes. The Nashik Climate Action Plan is aligned with the Paris Agreement's goal of limiting global warming to 1.5°C. Additionally, formation of the Climate Action Cell at the state level inspires the city to establish its own city-level Climate Action Cell within the Nashik Municipal Corporation.

I personally congratulate the Nashik Municipal Corporation and WRI India, for their leadership in advancing the ambitious climate agenda for a 'Climate Forward Maharashtra'.

FOREWORD

SHRI ABHIJIT GHORPADE

Director, State Climate Action Cell, Department of Environment and Climate Change, Government of Maharashtra

Climate Change is the greatest challenge faced by man in this century. In the pursuit of a sustainable and resilient future, acting on climate change has never been more crucial. With its dynamic communities and diverse landscapes, Maharashtra stands at the centre stage of this global challenge.

I am proud to share that Nashik city is actively contributing to the effort of tackling the climate crisis by adopting its own Nashik Climate Action Plan. This plan adheres to a global standard, highlighting the significant role the city plays in addressing the pressing issue of climate change.

Maharashtra, the third most urbanized state in India, has around 45% of its population living in urban areas. As cities continue to grow and offer education, healthcare and job opportunities, they also present a unique challenge to climate adaptation and mitigation due to their diverse landscapes. Cities therefore, should not only be at the centre of climate change, but also at the forefront of climate action. In recent decades, the Government of Maharashtra has increased its focus on climate resilience to address the rising heatwaves, changing rainfall patterns, cyclones, and other extreme weather events.

Nashik has a unique opportunity to shape its future urban development while considering the impact of climate change. The newly created Nashik Climate Action Plan (CAP) is designed to align with important government schemes and policies, such as the National Clean-Air Action Plan (NCAP), the Swachh Bharat Mission, Majhi Vasundhara Abhiyan targets, and the Climate Smart Cities guidelines. The city should prioritise climate actions by utilizing funds from these schemes and missions.

The Government of Maharashtra aims to expedite localized measures to achieve the objectives of the Paris Agreement, which seeks to limit global warming to 1.5°C. The creation and release of the Nashik CAP mark a significant achievement for the city, encouraging other AMRUT cities to emulate its example and attain the ambitious target of achieving Net Zero emissions by 2050.

As the Director of the Maharashtra State Climate Action Cell, I extend my heartfelt gratitude and appreciation to the administrative leadership of the Nashik Municipal Corporation and WRI India's team for their unwavering commitment to combating climate change by implementing the ambitious climate action plan.

As the city of Nashik is working towards the goal of climate resilience, I urge all cities and towns in Maharashtra to tread the path towards a sustainable and resilient future for our urban communities and realize the dream of a 'Climate-Forward Maharashtra'.

PLEDGE

DR ASHOK N. KARANJKAR (IAS)

Municipal Commissioner, Nashik Municipal Corporation

I am filled with immense pride and gratitude to introduce a significant achievement in our pursuit of sustainability on behalf of the Nashik Municipal Corporation (NMC) - the Nashik Climate Action Plan (CAP). This milestone stands as a testament to the unyielding support of the Maharashtra State Department of Environment and Climate Change and the steadfast commitment of Nashik's residents. I also extend my sincere congratulations to the Deputy Municipal Commissioner (Environment and Godavari Cell), City Engineer, and all departments involved for their tireless efforts in shaping the Nashik CAP. We would also like to extend our gratitude to our knowledge partners, the World Resources Institute (WRI) India.

The Nashik CAP shines as a model of innovation, offering tailor-made solutions carefully designed to address Nashik's distinct climate vulnerabilities. It is crucial to underscore that this plan has been diligently formulated after extensive dialogues with stakeholders and key city departments. Our approach has been grounded in rigorous scientific analysis and attuned to the specific problems experienced by the citizens of Nashik.

Our journey commenced with a thorough assessment of the city's vulnerabilities, delving deeply into its climate-related challenges. Following this, a comprehensive Greenhouse Gas (GHG) inventory was created, pinpointing Nashik's pivotal sources and sinks of greenhouse gases. This inventory, in turn, provided invaluable guidance for devising strategies to reduce emissions across the city. The overarching aim of the Nashik CAP is to lead our city towards a net-zero future through an inclusive approach to urban development, centred on low-carbon practices. I earnestly call upon all Nashik residents to rally behind the NMC, supporting our efforts to implement the Nashik CAP with utmost effectiveness in the near future.

PLEDGE

SHRI VIJAYKUMAR MUNDE

Deputy Municipal Commissioner, Environment and Godavari Cell, Nashik Municipal Corporation

I want to express my gratitude to the visionary leadership of the Department of Environment and Climate Change of Maharashtra for their forward-looking perspective, without which the Nashik Climate Action Plan (CAP), a groundbreaking initiative, would not have come to fruition. It brings me immense joy to have led the Nashik Municipal Corporation's (NMC) team in shaping the Nashik CAP. My heartfelt thanks extend to all departments for their valuable contributions to this endeavour. Additionally, I am profoundly appreciative of our knowledge partners, the World Resources Institute India (WRI India), for their expert guidance and support in crafting the Nashik CAP.

Cities like Nashik, classified as Tier II, hold significant potential for sustainable growth, which is essential for the city's growth. Hence, the Nashik CAP stands as a crucial tool to ensure Nashik's urban development is resilient to climate impacts and centres around the needs of its citizens. The six key areas of focus outlined in the Nashik CAP align closely with India's commitments to the Sustainable Development Goals (SDGs). Through ongoing initiatives such as transitioning to electric buses, creating green and blue spaces, rejuvenating groundwater levels, and investing in renewable energy, we are actively putting these priorities into action.

I hold strong confidence that the Nashik CAP will greatly contribute to NMC's endeavours in tackling both the causes and effects of climate change.

MESSAGE

SHRI MADHAV PAI

CEO, WRI India

Tier II cities are crucial to India's growth, and the Nashik Climate Action Plan (CAP) is a pivotal tool in ensuring this growth is sustainable and resilient to climate impact; along with meeting the needs of the city's residents. The Plan's six key areas of action – energy and buildings, sustainable mobility, sustainable solid waste management, urban greening and heat mitigation, water resource management and air quality – are closely aligned with the Sustainable Development Goals (SDGs). The Plan is also in line with India's commitments to chart decarbonization pathways for the energy and transport sector.

Working with the Nashik Municipal Corporation's team in shaping the city's first every climate action plan brings me immense joy, and I extend my heartfelt thanks to all departments and agencies for their invaluable contributions. I also want to acknowledge Children's Investment Fund Foundation (CIFF) for their unwavering support towards climate-centric development which fosters positive change for children and other communities across India.

I am excited about the Nashik Climate Action Plan's transformative potential, not only for the city, but also for other Tier II cities that could take forward these learnings to create their own climate action plan. This is an opportunity for the city to build capacity across multiple sectors paving the way for sustainable, equitable and resilient development.

As we witness the plan unfold, WRI India looks forward to working with local authorities, communities, and other stakeholders to shape Nashik into becoming a more resilient city that fosters innovative thinking and sustainable practices.

MUMBAI NAKA CIRCLE
Photo credit- WRI India

ACKNOWLEDGEMENTS

WRI India prepared and compiled the Nashik Climate Action Plan under the leadership and direction of the Department of Environment and Climate Change, Government of Maharashtra, and Nashik Municipal Corporation (NMC).

We extend our heartfelt gratitude to the following individuals for their invaluable support and remarkable contributions to the Nashik Climate Action Plan (Nashik CAP).

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All maps in this report are intended as visualisations to communicate city-wide data analysis for information purposes only and are not to scale.

This report should be referred to as the 'Nashik Climate Action Plan, 2024'

Edited by Chandni Nair
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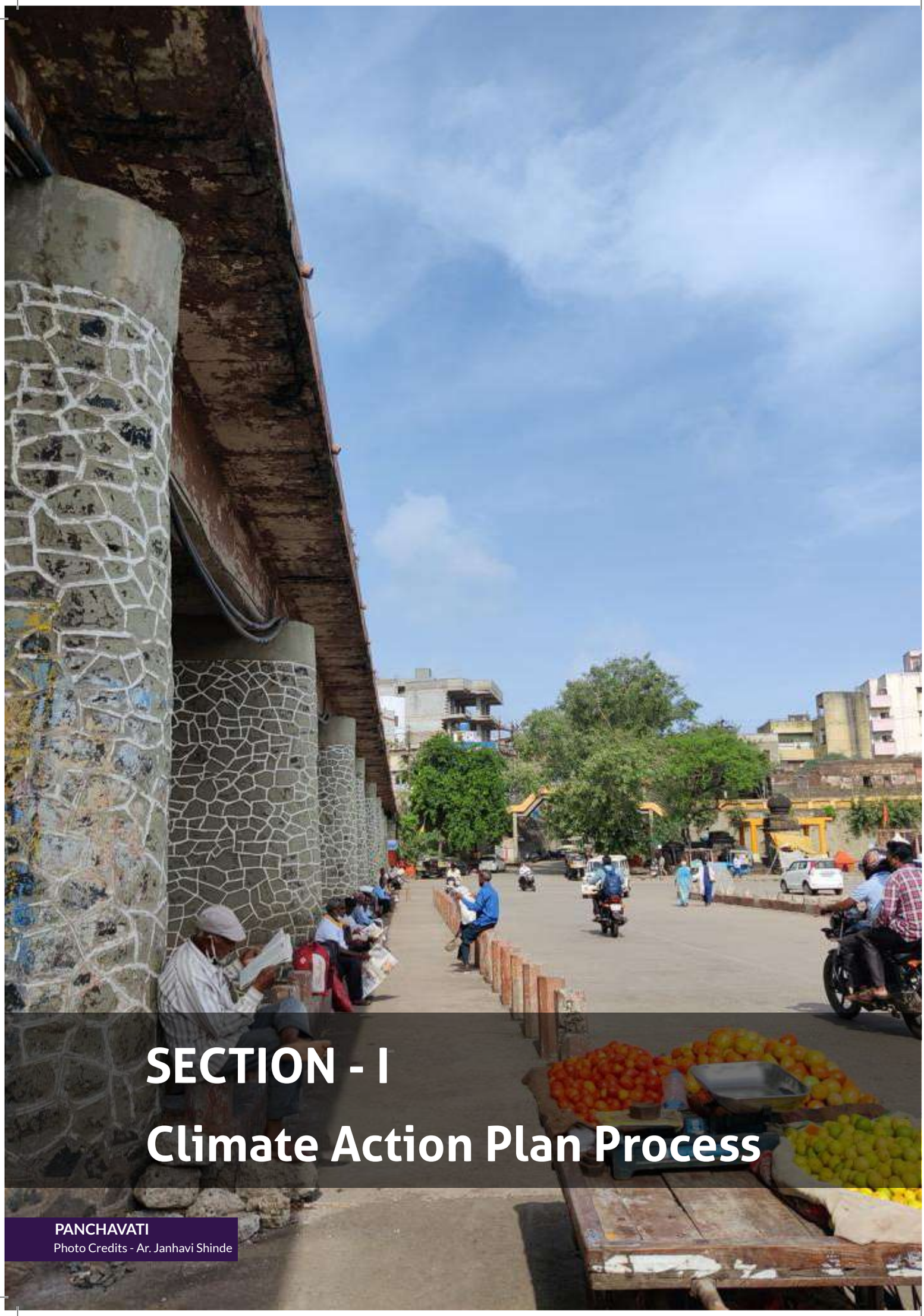
Cover page photo credit Ved Apte, WRI India



SECTION - I
Climate Action Plan Process

PANCHAVATI
Photo Credits - Ar. Janhavi Shinde

1. CLIMATE ACTION PLANNING – APPROACH AND METHODOLOGY

1.1. BACKGROUND

India accounts for nearly 6.5% of the global greenhouse gas emissions (GHGs), with almost half of the country's emissions having urban origins - industries, transport modes, buildings and waste[1]. This, coupled with rapid urbanisation and the depletion and degradation of natural resources, escalates the occurrence of more frequent and severe climate events. Indian cities are particularly vulnerable to water stress, prolonged hot (or cold) days, heat island effect, flash floods, urban water logging, droughts and deteriorating air quality.

At the national level, the Government of India has committed to addressing climate change impacts by implementing national-level policies down to the local level. Through large-scale urban infrastructure investment programmes led by the Ministry of Housing and Urban Affairs (MoHUA), many sub-missions and programmes with low-carbon development strategies have been financed to make cities sustainable.

Metros or large cities in the country have begun focussing on causes and impacts of climate change using the lens of adaptation and mitigation strategies. However, Tier II cities, i.e. those that have a million-plus population, have neither the capacity nor the capability to understand and focus on climate-related risks. Keeping this in mind, the Government of Maharashtra in collaboration with Children's Investment Fund Foundation (CIFF) and C40 Cities, selected three Tier II cities as project cities in Maharashtra, namely Solapur, Nashik, and Chhatrapati Sambhajinagar (Aurangabad), to the develop three Climate Action Plans (CAPs), one for each city.

World Resources Institute (WRI) India has been appointed to develop the CAPs for Solapur, Nashik and Chhatrapati Sambhajinagar (Aurangabad) cities and support in implementation. This will enable the local governments to integrate climate change actions with their urban development initiatives.

This report presents the Climate Action Plan for Nashik city in detail.

1.2. WHAT IS CLIMATE ACTION PLAN?

The World Bank's[2] latest Climate Change Action Plan 2021-2025 recognises city systems as one of the key generators of GHG emissions and facing significant adaptation challenges. Indian cities are continually dealing with the negative impacts of climate change (heat waves, floods, drought etc.), with piecemeal measures to tackle such extreme events. There is an urgent need for informed climate action planning that would integrate climate science with mitigation and adaptation strategies within the framework of development strategies.

The CAP would enable city stakeholders to use the relevant knowledge and frameworks to a) consolidate their actions under a comprehensive strategy b) understand the co-benefits of climate

action, and c) take a systemic approach to move from reactive to proactive climate action. The CAP is in alignment with the Climate Smart Cities Assessment Framework (CSCAF) with respect to the five sectors that the two frameworks have in common. While the CSCAF is a first step towards cities mainstreaming climate-centric measures, the CAP strengthens this through a comprehensive process that includes localised measures.

The CAP focuses on two key strategies:

Adaptation focuses on the impacts of climate change and sectoral sub-strategies and actions to enhance the capacities of the city and community to cope with climate change, and

Mitigation focuses on the causes of climate change i.e. assessing GHG emissions and its sectoral contribution to it, likely scenarios of future GHG emissions and sectoral sub-strategies and actions to reduce the emissions.

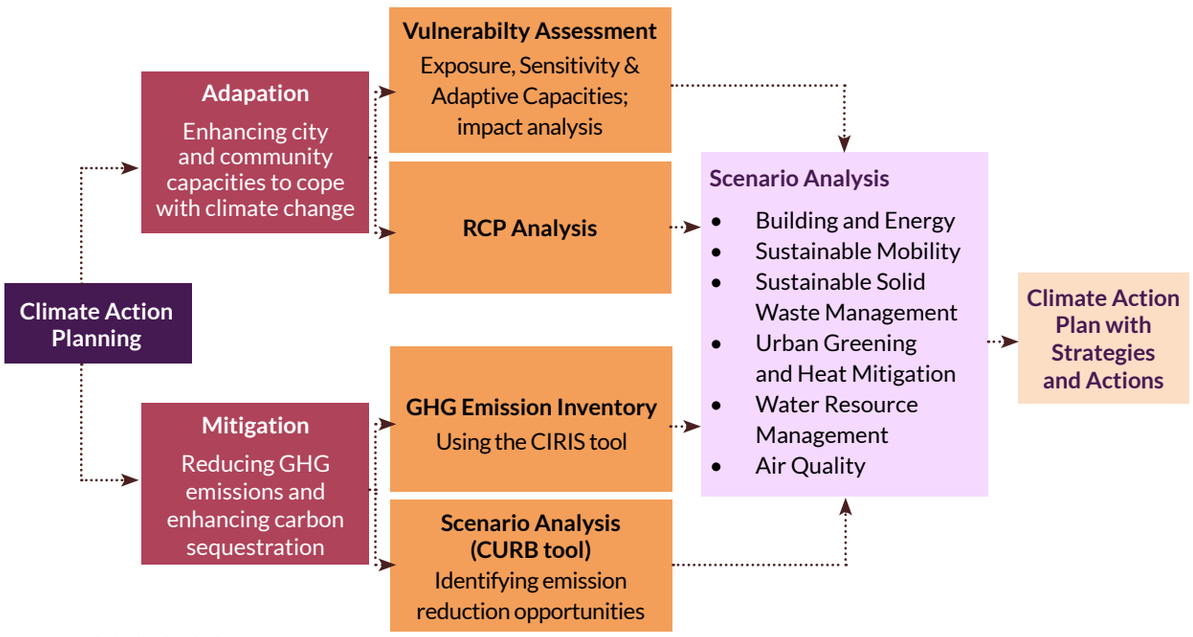
These strategies act as powerful tools for monitoring progress towards the climate goal as it allows cities to formulate evidence-based adaptation and mitigation goals and actions. Refer to Figure 1-1.

1.3. DEVELOPMENT OF CAP - APPROACH AND METHODOLOGY

1.3.1. CAP process in Nashik

The Nashik CAP process began in January 2022, with a kick-off meeting and the virtual signing of the Letter of Intent at an event chaired by the Hon'ble Commissioner and officials from various departments. Following which, an inclusive and consultative process was undertaken by WRI India to develop the CAP as detailed in the 12 steps below:

Figure 1-1: Climate Action Plan - tools and strategies



Source: *WRI India Analysis*

Project inception
Set up a core team, signed the Letter of Intent with Nashik Municipal Corporation, set the context, map stakeholders, and conduct initial discussions with city officials and parastatal agencies.

1

Baseline Assessment
Data collection, data validation, identification of data gaps, addressing gaps.

2

Stakeholder consultations
Data validation and mapping vulnerable areas, urban flooding, air pollution hotspots, etc.

3

Developing Climate Profile
Conducting Vulnerability Assessment (VA) and developing greenhouse gas (GHG) emissions inventory, identify climate risks, identify sectors.

4

Stakeholder consultations
Capacity building workshop on VA and GHG emissions inventory.

5

Scenario Analysis and RCP Analysis
Carried out future Scenario Analysis and RCP Analysis.

6

Stakeholder Consultations
Validate various assumptions under the Scenario Analysis.

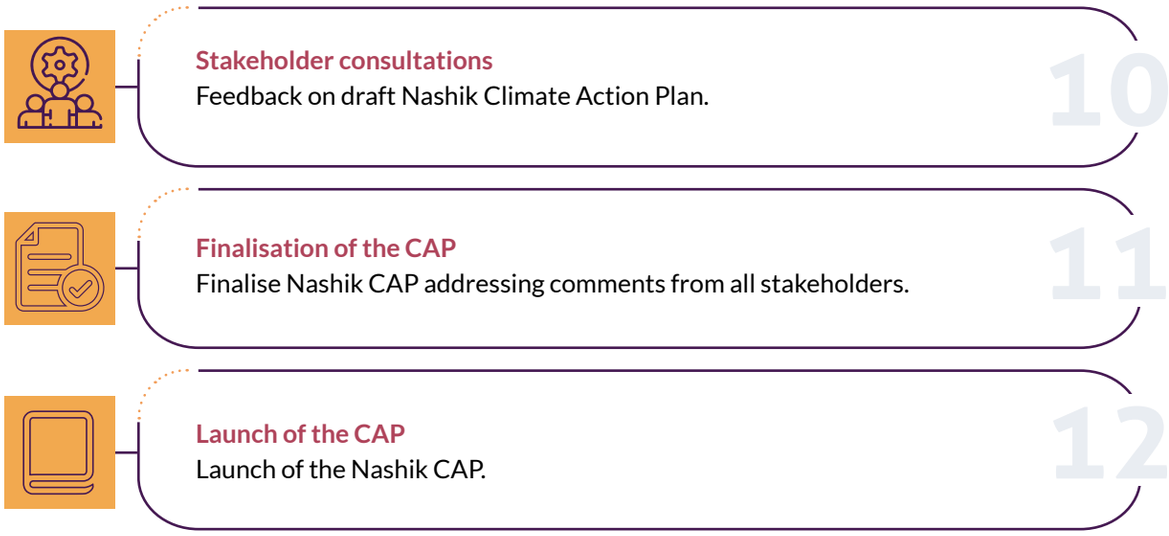
7

Sectoral analysis
Develop sectoral goals, strategies and actions, review with WRI India's sectoral experts.

8

Finalisation of draft CAP
Compilation of the VA, GHG Emissions Inventory, sectoral assessment, recommendations, and sectoral strategies; developing the structure of the Climate Action Cell, development of the Monitoring, Evaluation, and Reporting (MER) framework, acceleration of plans to projects and presentation of the draft Nashik Climate Action Plan.

9



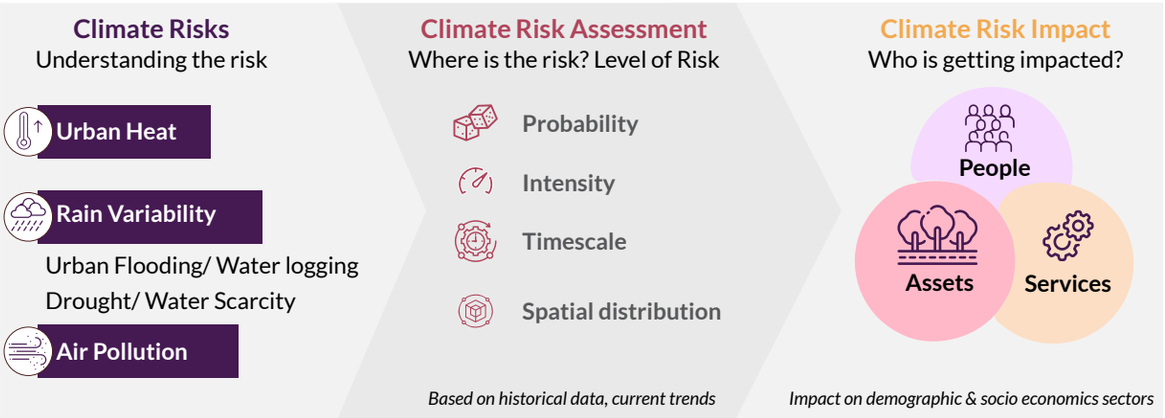
1.3.2. Vulnerability Assessment framework

WRI India's spatial VA framework is based on the Intergovernmental Panel on Climate Change (IPCC) approach (Exposure, Sensitivity and Adaptive Capacities) that helps cities assess differential vulnerabilities based on varied exposure to climate and disaster risks, pre-existing socio-economic sensitivities and access to essential services and amenities that are critical for rescue and recovery processes during extreme weather events. Geospatial vulnerability maps are created using a combination of climate risk data, remote sensing data, census data, and GIS-based data sourced from city authorities, which highlight differential vulnerabilities and adaptation needs of the city. Refer to Figure 1-2.

1.3.3. GHG emissions inventory and scenario analysis - framework

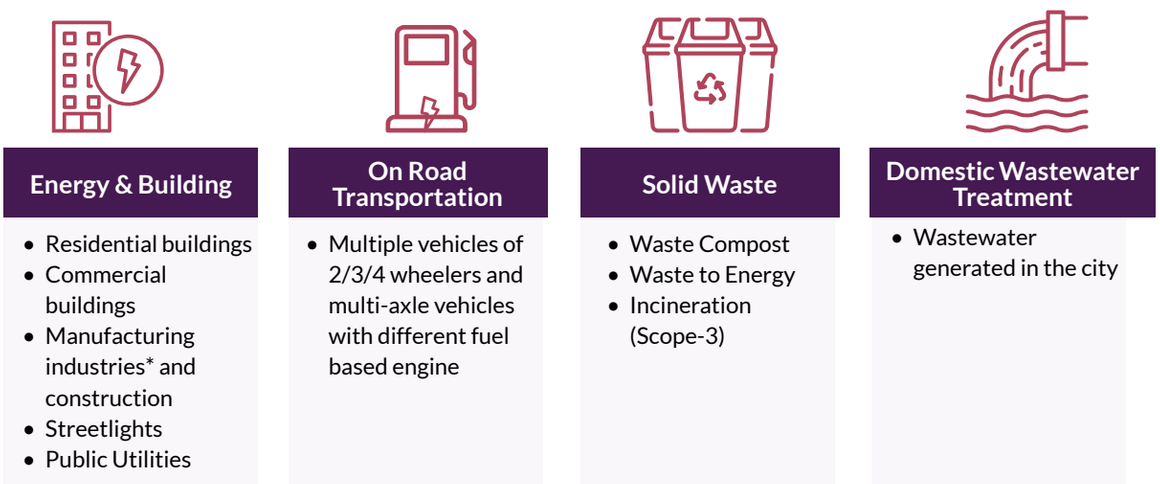
The GHG emissions inventory for Nashik is aligned with the Global Protocol for Communities (GPC) framework, a robust GHG accounting and reporting framework for cities prepared by WRI, C40 Cities Climate Leadership Group and ICLEI – Local Governments for Sustainability. It includes an analysis of three sectors: stationary energy, transport and waste (solid waste and wastewater) as seen in Figure 1-3. The inventory helps identify opportunities for emissions reduction.

Figure 1-2: Vulnerability Assessment Framework



Source: *WRI India Analysis*

Figure 1-3: Identified sectors in the Scope 1 of GHG Emission Inventory



Note: **industries outside municipal limits, coal consumption was not included due to difficulty in obtaining data*

Source: *CIRIS tool*

1.3.4. Key stakeholders

Nashik Municipal Corporation is the nodal agency that plans, implements, and regulates development in the city. There are several other agencies involved in developing the CAP that have shared relevant data. Table 1-1 presents a list of all agencies involved in the CAP development in Nashik city.

1.3.5 Aligning with global, national and sub-national planning goals

The Nashik CAP is aligned with the United Nations' Sustainable Development Goals (SDGs) and India's Nationally Determined Contributions (NDCs). To leverage policy and financial support, the CAP considers key elements from various national and sub-national schemes and missions. Refer to Figure 1-4.

- The six sectors of the Nashik CAP line up with the five sectors of the Climate Smart Cities Assessment Framework 2.0 developed by Climate Centre for Cities at NIUA that supports MoHUA's Smart Cities Mission.
- Nashik CAP has established linkages with Swachh Bharat Mission (Urban).
- Being a non-attainment city, the National Clean Air Program (NCAP) is applicable in Nashik city and measures are being taken accordingly.
- Funding for air pollution and waste management is available under XV Finance Commission, Government of India (GoI).
- At the sub-national level, the planning goals for Nashik CAP are aligned with Maharashtra's Majhi Vasundhara Abhiyan (MVA), which is a climate action policy approach where urban local bodies champion localised actions on the five elements of nature (Panchamahabhutas): Earth (Bhumi), air (Vayu), water (Jala), energy (Agni) and enhancement (Akash). The goals and actions proposed in the Nashik CAP are in line with the indicators prescribed in MVA toolkit.
- The MVA also comprises indicators that are in compliance with the Race to Zero of the United Nations Framework Convention on Climate Change (UNFCCC), a global campaign where local governments strengthen their contributions to the Paris Agreement to achieve net zero by 2050. Nashik city is a signatory in this campaign, and the Nashik CAP provides a robust roadmap to achieve this goal within the targeted timeframe.
- At the city level, the Nashik CAP is in alignment with AMRUT and Smart City Mission, which focus on infrastructure development for urban revival projects.

Table 1 -1: Key agencies and their roles

S.N	Name of the agency	Role/Sector
1	Nashik Municipal Corporation (NMC)	City administration managing - water supply, sanitation, solid waste management, roads and bridges, development plan, streetlights, etc.
2	Nashik Smart City Development Corporation Limited (NMSDCL)	Projects under smart city mission – area-based development and pan city initiatives
3	Regional Transport Office (RTO)	Vehicle registration
4	Oil companies	Sale of petrol, diesel and CNG
5	Maharashtra State Electricity Distribution Company Limited (MSEDCL)	Electricity distribution and supply
6	Maharashtra State Power Generation Company (MAHAGENCO)	Electricity generation
7	Groundwater Surveys and Development Agency (GSDA)	District ground water management

8	Traffic police	Traffic management
9	Indian Meteorological Department (IMD)	Rainfall and temperature data
10	MPCB	Control and regulation - Air, Water and land pollution
11	Forest Department	Social forestry program and greening measures
12	Disaster Management Authority	Preparation and response during disasters

Figure 1-4: National and Sub-national Schemes and Mission in India

1.4. CONSULTATIONS AND WORKSHOPS

The details of the city visits, meetings, consultations and workshops conducted by the WRI India team in Nashik city are presented in Table 1-2.

Figure 1-5: A Capacity Building Workshop at NMC

Source: *WRI India*

Table 1-2: List of meetings conducted

Date	Purpose	Key agencies consulted
8 Feb 2022	Kick off meeting	Commissioner, Public Health Engineering Dept (PHED), City Engineer, Fuel agency, Zonal representatives
9 – 11 Feb 2022	Data Collection & Stakeholders meetings	Meeting with SWM Department, Vetinary department, Gardens department, TATA power, Nashik smart city
20 Feb 2022	Data Collection & Stakeholders meetings	Meeting with MSEDCL, RTO, TPD
13-18 March 2022	Data Collection & Stakeholders meetings	Meetings and data collection from NMC internal departments, fuel agencies
10-12 May 2022	Meeting with Government stakeholders apprising them of CAP process and hotspot mapping Data collection and field visit	Data collection and validation, site visit PWD Dept., Water Supply Dept., Drainage Dept., Fire Dept., TPD
31 May- 2 Jun 2022	Validation of data collected with government stakeholders	Data validation and site visit Water Supply Dept., Drainage Dept., Transport Dept., CITILINC, TPD, IT Dept.
10 Aug 2022	Capacity Building Workshop on Vulnerability Assessment and GHG Emissions Inventory	Around 30 participants from NMC, Nashik Smart City Dev, Corp, Nashik Waste Management Pvt. Ltd., MSEDCL fuel agency etc.
9 Aug 2023	Presentation of draft Climate Action Plan	Approximately 20 participants from various departments of NMC and Nashik Smart City Dev Corp chaired by Hon'ble Municipal Commissioner of NMC.

LAKE, GANGAPUR BACKWATERS
Photo Credits - WRI India

2. NASHIK CITY PROFILE

2.1. BACKGROUND

2.1.1 Regional setting

Nashik is the fourth most populated city[3] in Maharashtra and the headquarters of the Nashik administrative division (comprising Nashik, Ahmednagar, Nandurbar, Dhule and Jalgaon districts)[4]. Situated 170 km from Mumbai and 210 km from Pune, its strategic location as part of the Mumbai-Pune-Nashik Golden Triangle makes Nashik suitable for development as a trade and tourist destination. The city is well connected by road and rail and is a hub for new commercial and industrial establishments.

2.1.2. History

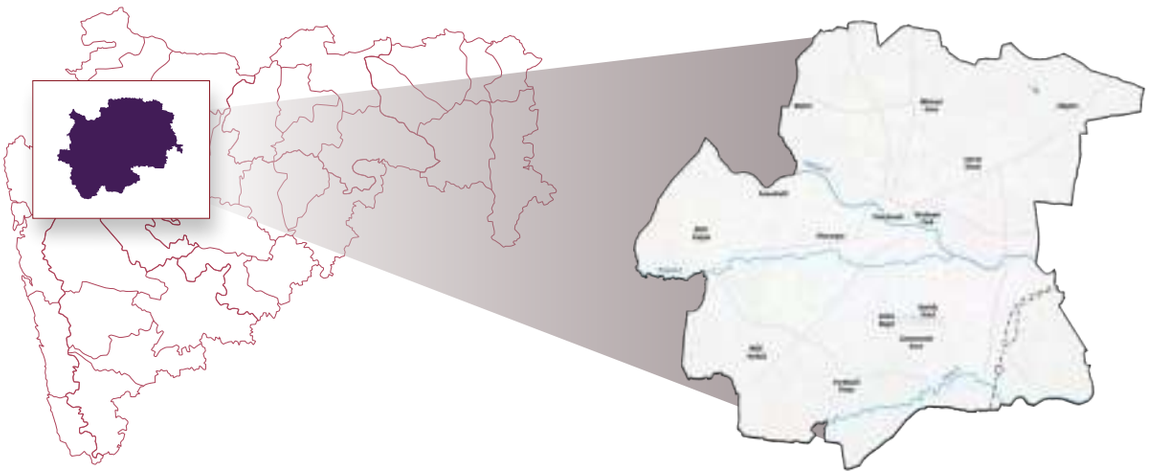
Nashik is known for its historical, social, religious and cultural significance. It is believed that its name has its origins in the epic Ramayana.[5] Another belief is that the city derives its name from the river Godavari that flows through the nine hills or Nav Shikhan. Historically, Nashik is an important place for Hindu culture as it is believed that Lord Ram resided in Panchavati in Nashik area. Nashik is also considered as the Kashi of western India, with the Kumbh Mela taking place every 12 years in the Panchavati (city central core area) and Tapovan (Ram Kund) areas.

2.1.3. Economy

The location, topography and climate of Nashik and its surrounding regions make it an important hub for trade, commerce and establishment of new industries. Nashik is known for its agro-produce due to the fertile agricultural land that exists in the periphery of the city. The agro-produce is exported to Mumbai, Pune and other cities in the vicinity. Nashik is also known as the wine capital of India as 80% of the wine consumed in the country is produced here[6].

Nashik has witnessed extensive industrial development in the past few decades. Major industries in the areas adjoining the city, such as Hindustan Aeronautics Ltd at Ozar, thermal power station at Eklahare and Sinnar Maharashtra

Figure 2-1 : Location map of Nashik



Source: www.d-maps.com; NMC, WRI India Analysis (2022)

Industrial Development Corporation (MIDC), have contributed to the trade and commerce within the city. Additionally, there has been growth in industrial activity at MIDC Satpur and MIDC Ambad, which were established in 1962 and 1980, respectively. There are about 6,990 small scale, 27 medium scale and 131 large scale industrial units registered here till date, which comprise sectors such as automobiles, engineering, electrical, electronics, stationary manufacturing, printing press components, metal arts, steel and wooden furniture, fiber and plastic moldings, pharmaceutical and medical equipment, data processing etc[7].

Nashik is also a spiritual tourist destination, with the Nashik-Trimbakeshwar Simhastha, a Hindu religious mela or fair, held every 12 years. It is one of the four fairs traditionally recognised as the Kumbha Mela and is also known as Nashik-Trimbak Kumbha Mela or Nashik Kumbha Mela. In 2015, the mela generated additional employment opportunities for more than 4.5 lakh people in sectors including airlines, airports, hotels, tour operators and medical and eco tourism[8]. Besides being an important religious event, the Kumbh Mela also contributes to the economy, employment and tourism in the city.

2.1.4. Geography

Nashik city is situated on the banks of the river Godavari on the western edge of the Deccan plateau, between 19° 55' and 20° 05' North Latitude and 73° 41' and 73° 54' East Longitude[9]. The city is geographically positioned at an elevation of 700 m[10] from the mean sea level and divided into two equal halves by the river Godavari, which originates from the Brahmagiri Mountain, Trimbakeshwar, about 24 km from Nashik, and flows through the central core of the city.

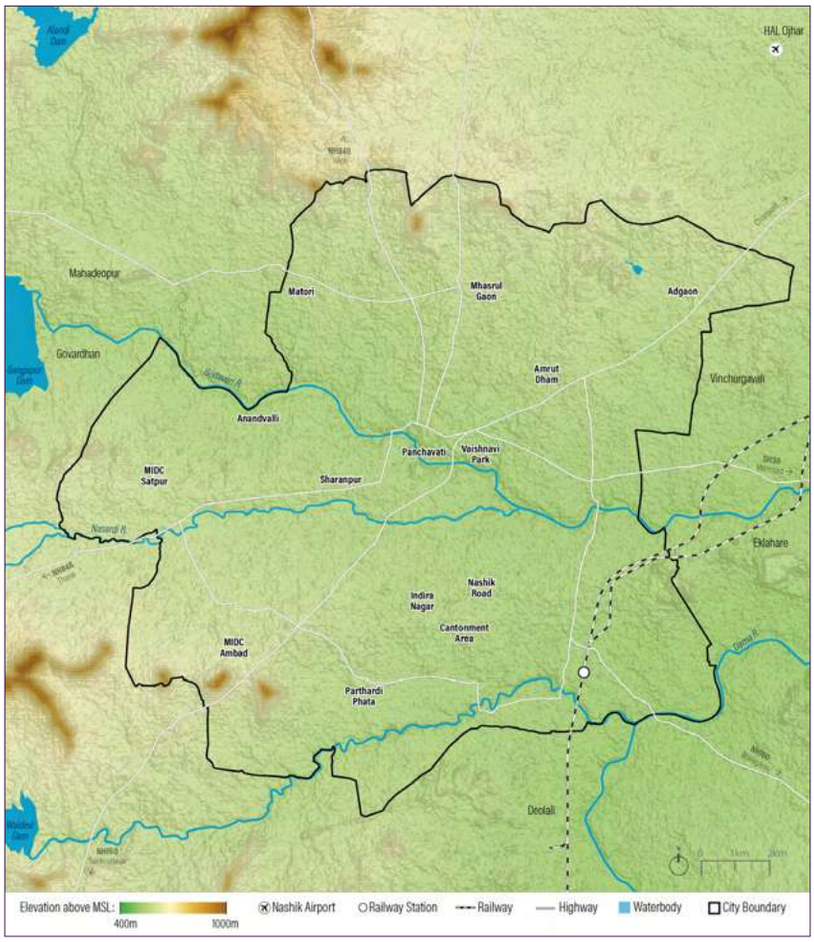
The Godavari is the main source of water for the city. The rivers Nasardi, a tributary of Godavari, and Waldevi also flow within the city boundaries, as seen in Figure 2-2. The agricultural fields all along the periphery of the city contribute to its economy. The city is surrounded by nine hills — Durga, Ganesh, Chitraghanta, Pandav, Dingarali, Mhasrul, Jog wada, Pathanpura and Konkani.

Table 2-1 : Growth in built-up area since 1990

Year	Growth in %
1990	10.72
2000	22.17
2015	42.53

Source: WRI India using World Settlement Footprint, ESA, 1985 – 2019

Figure 2-2 : Important geographical features in Nashik



Source: WRI India; NMC 2022

2.2 LAND USE AND DEVELOPMENT

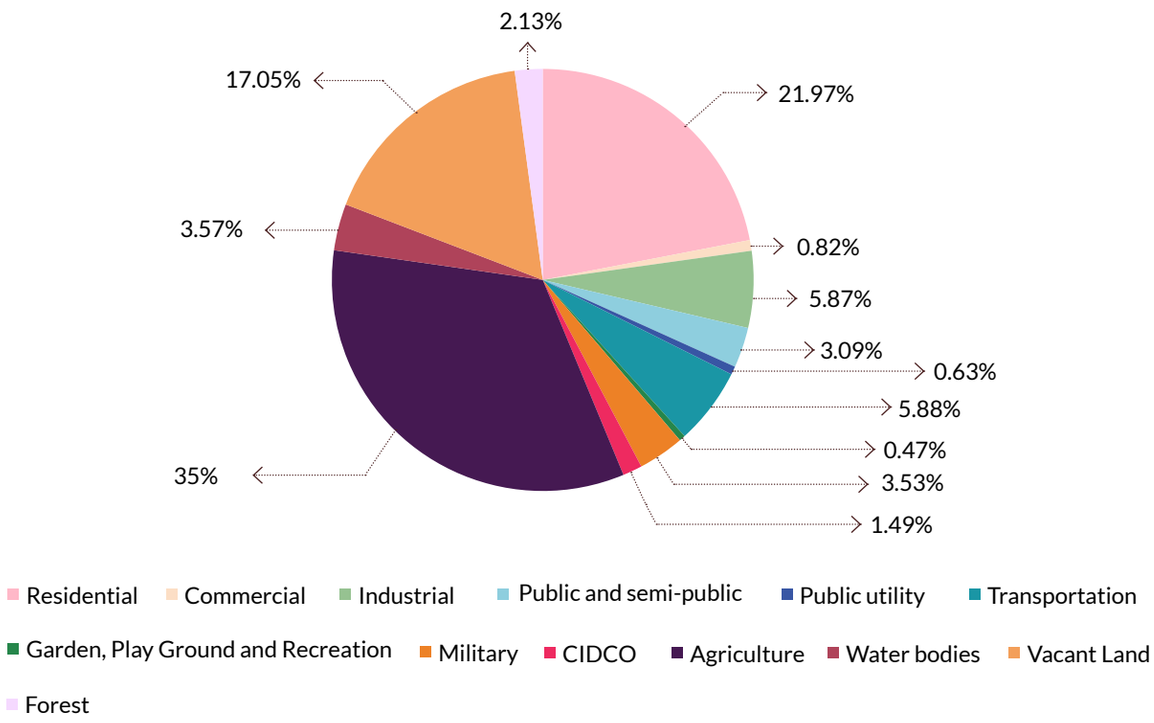
NMC was established in May 1864 and was accorded the 'A' Class Municipal Council status in 1874. The Nashik road Deolali Municipal Council was established in 1952 with Class 'B' status, followed by the development of the Satpur MIDC, which received independent status as 'C' Class Municipal Council. In 1982, the three Municipal Councils merged to form the NMC. The Municipal Corporation encompasses an area of 267.48 sq.km and includes 25 villages, in which Vihitgaon, Vadner and Pimpalgaon Khamb are only partly included.

Built-up Area: As seen in Figure 2-4, the city started developing from old Nashik, around the areas of Panchvati, Nashik Road and MIDC Satpur. Further development took place in a planned manner, to formulate contiguous areas of development. In the past decade, ribbon development has taken place along the major roads towards the periphery of the city.

Distribution of Land Use: The latest Development Plan for Nashik city is dated 2012. The total developed land area is approximately 43.75%, of which residential development accounts for 21.97 %. In the periphery of the city, 33.5% of the total area is used for agricultural activities, as seen in Figure 2-5. Figure 2-3 is a graphic representation of the land use in NMC as recorded in 2012.

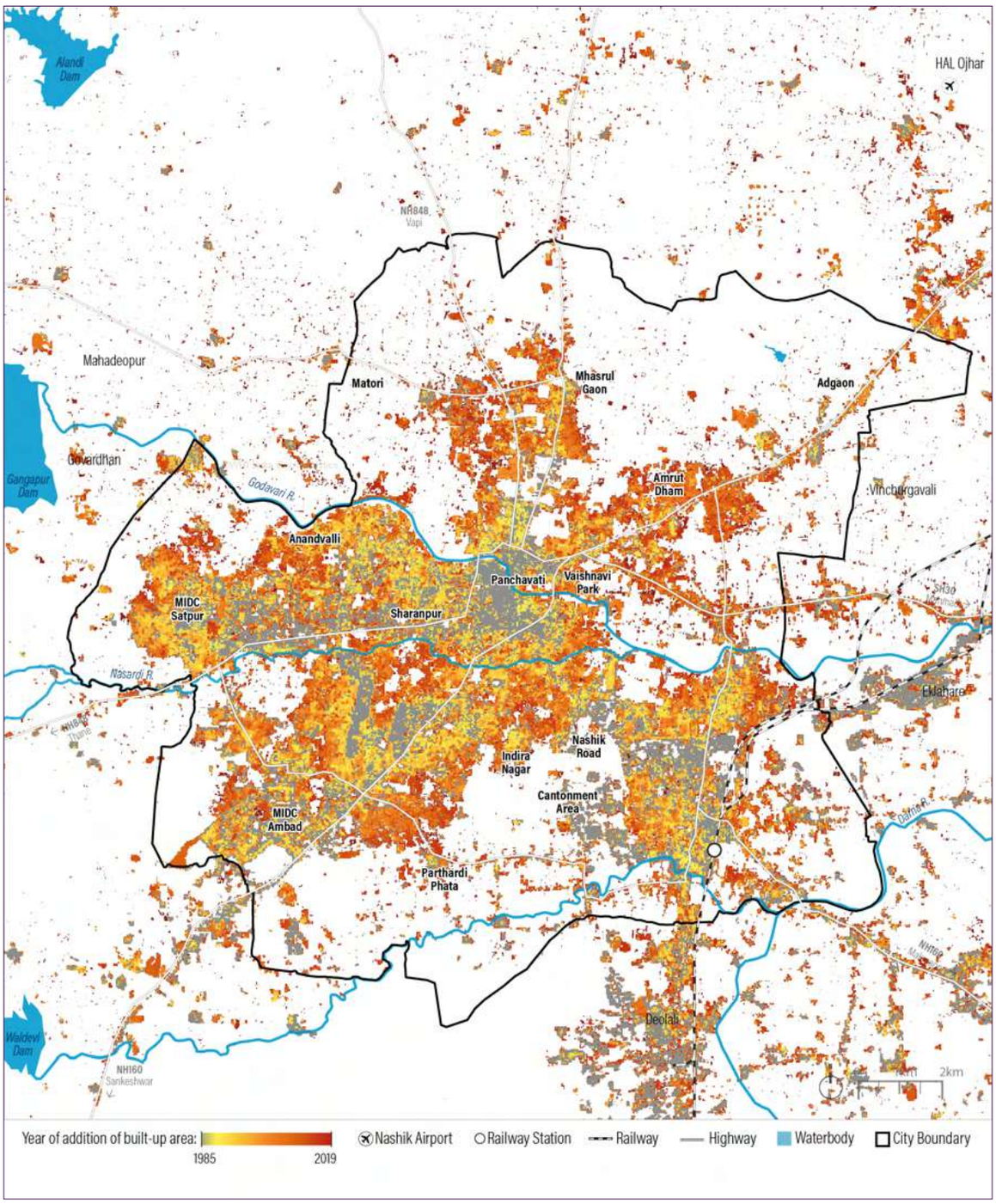
Housing condition: According to the Draft Development Plan of Nashik 2016-2036, approximately 16.6% of the housing stock is at least 40 years old. Most of the houses are concentrated in the old gaothan area of Nashik, Panchvati, Deolali and Satpur. In the year 2011, Nashik reported 131 slums, which have now increased to 344[11]. The slums are mainly concentrated in the core of the city, along railway tracks and the banks of rivers and drains.

Figure 2-3 : Existing land use distribution



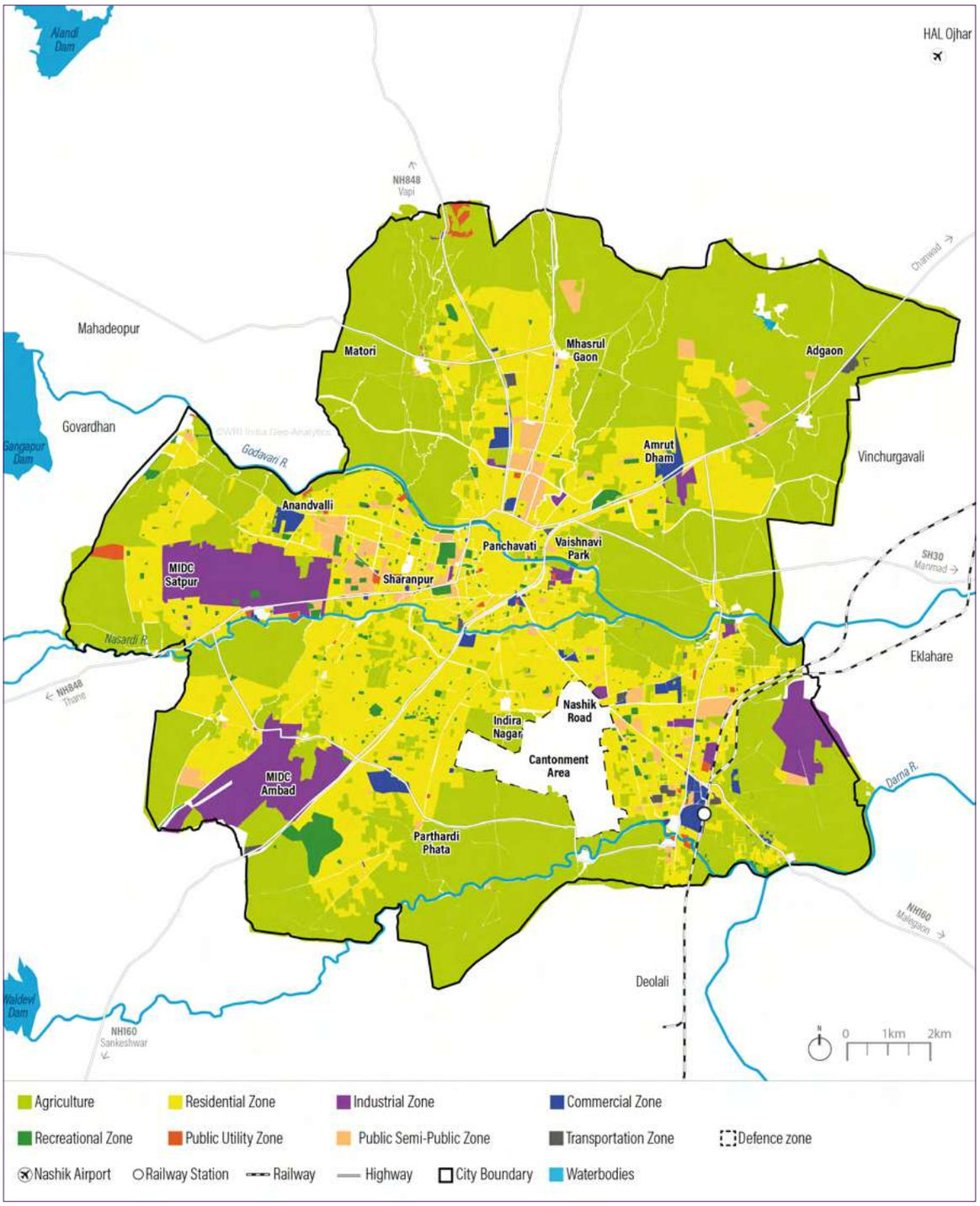
Source: Nashik Draft Revised Development Plan 2016-2036

Figure 2-4: Urban expansion of Nashik



Source: *WRI India; NMC 2022*

Figure 2-5: Study area: Nashik Municipal Corporation limits, 2022



Source: WRI India; NMC 2022

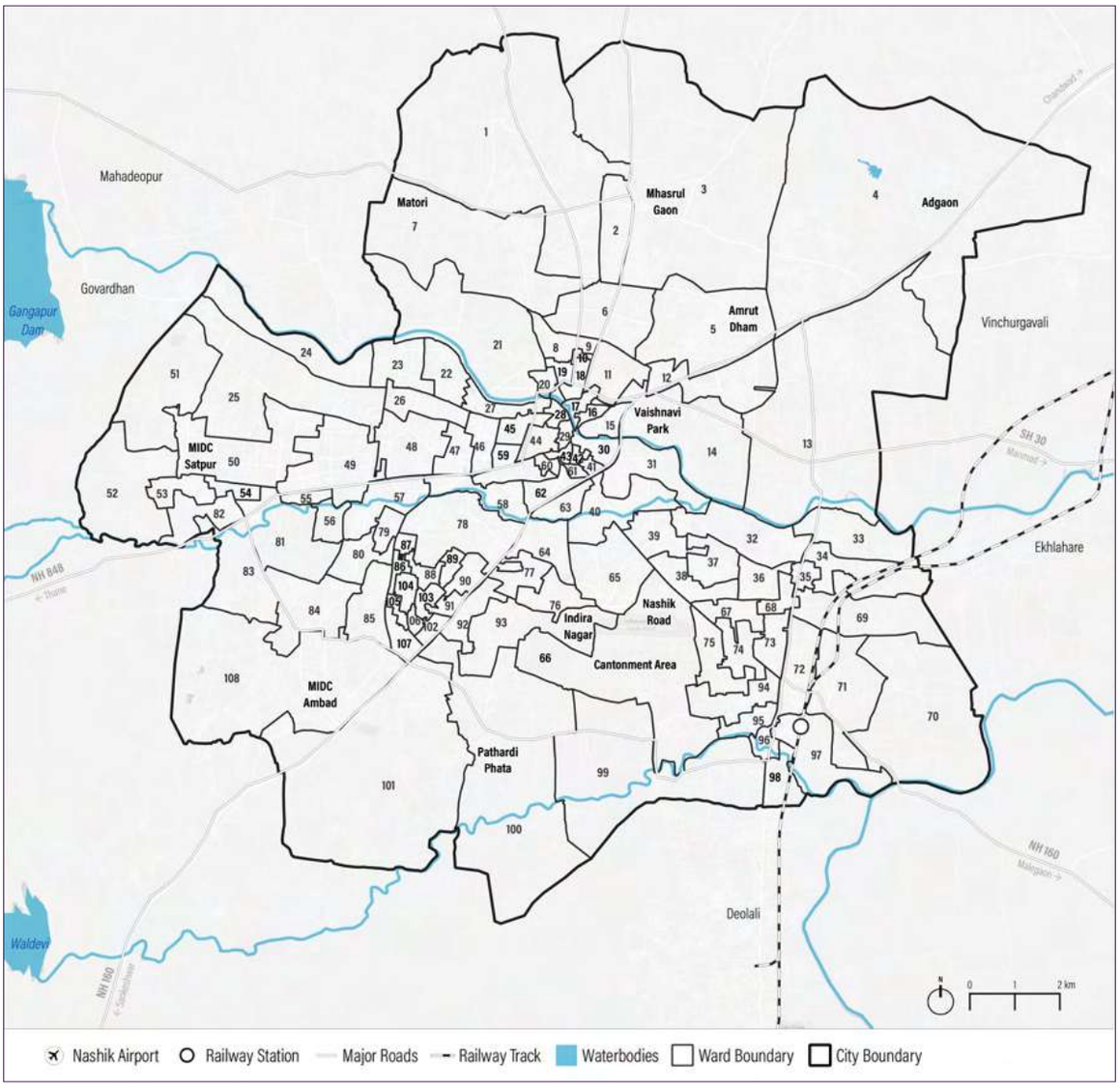
2.3. DEMOGRAPHY

2.3.1. Demographic growth in Nashik city

According to Census of India 2011, the NMC jurisdiction has a population of 14,86,053. The city is divided into 31 administrative wards, with 108 Census wards, as seen in Figure 2-6. The ward-wise population density is 56 persons/hectare on an average, with concentration in old Nashik and CIDCO areas.

Between 1981 and 2011, Nashik has witnessed a 57% increase in population growth owing to new industrial and trade establishments, as seen in Figure 2-4. The population growth from 1991 can be attributed to the establishment of government and educational institutions[12].

Figure 2-6 : 108-ward boundaries of Nashik



Source: WRI India; NMC 2022

Table 2-2 : Decadal growth in population (in %)

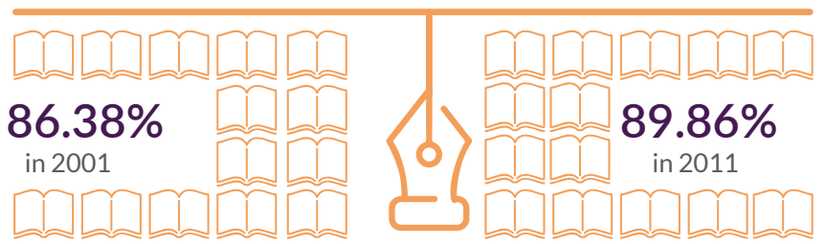
Year	Population	Decadal growth rate
1981	4,18,261	-
1991	6,56,925	57%
2001	10,77,236	64%
2011	14,86,053	38%

Source: Census 2011; Nashik Draft Revised Development Plan 2016-2036

No. of Households (HHs): The total number of households in the city has increased from 2.25 lakhs in Census of India 2001 to 3.36 lakhs in Census of India 2011.

Gender Profile: The trend in sex ratio of NMC shows that the average sex ratio (number of females per 1000 males) of the city has improved from 871 in 2001 to 899 in 2011. However, the sex ratio of NMC is lower than the sex ratio of Nashik district (931).

Effective Literacy: As per Census data, the literacy rate of Nashik increased from 86.38 % in 2001 to 89.85 % in 2011. The overall female literacy rate here is 85.92%

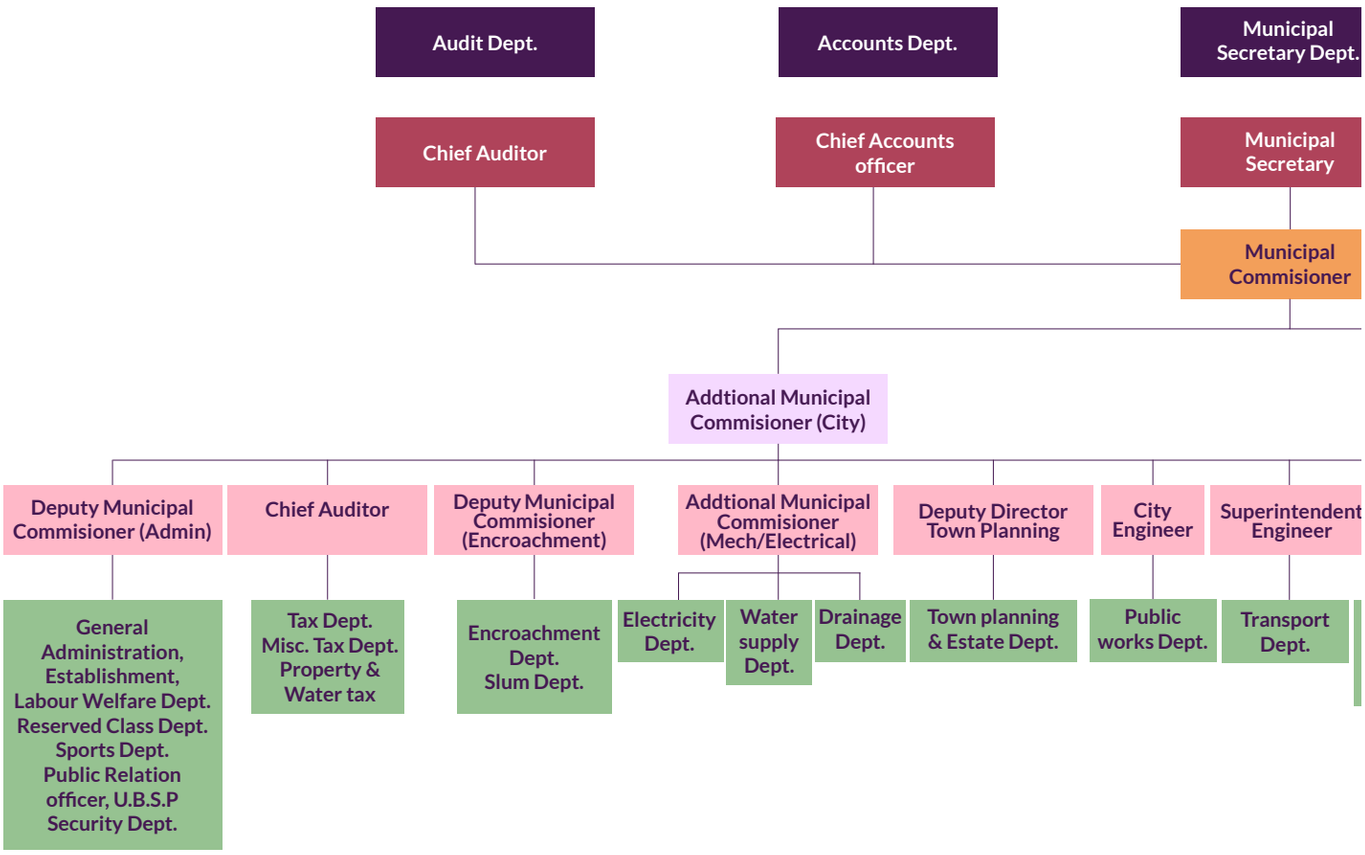


Social Composition: The SC-ST population is 21.67% of the total population as per Census of India 2011. Wards no. 9, 10, 25, 50, 55, 56, 108, 39, 67, 68, 69 and 98 have the highest share of SC/ST population

2.4. CITY MUNICIPAL CORPORATION AND ITS AUTHORITIES

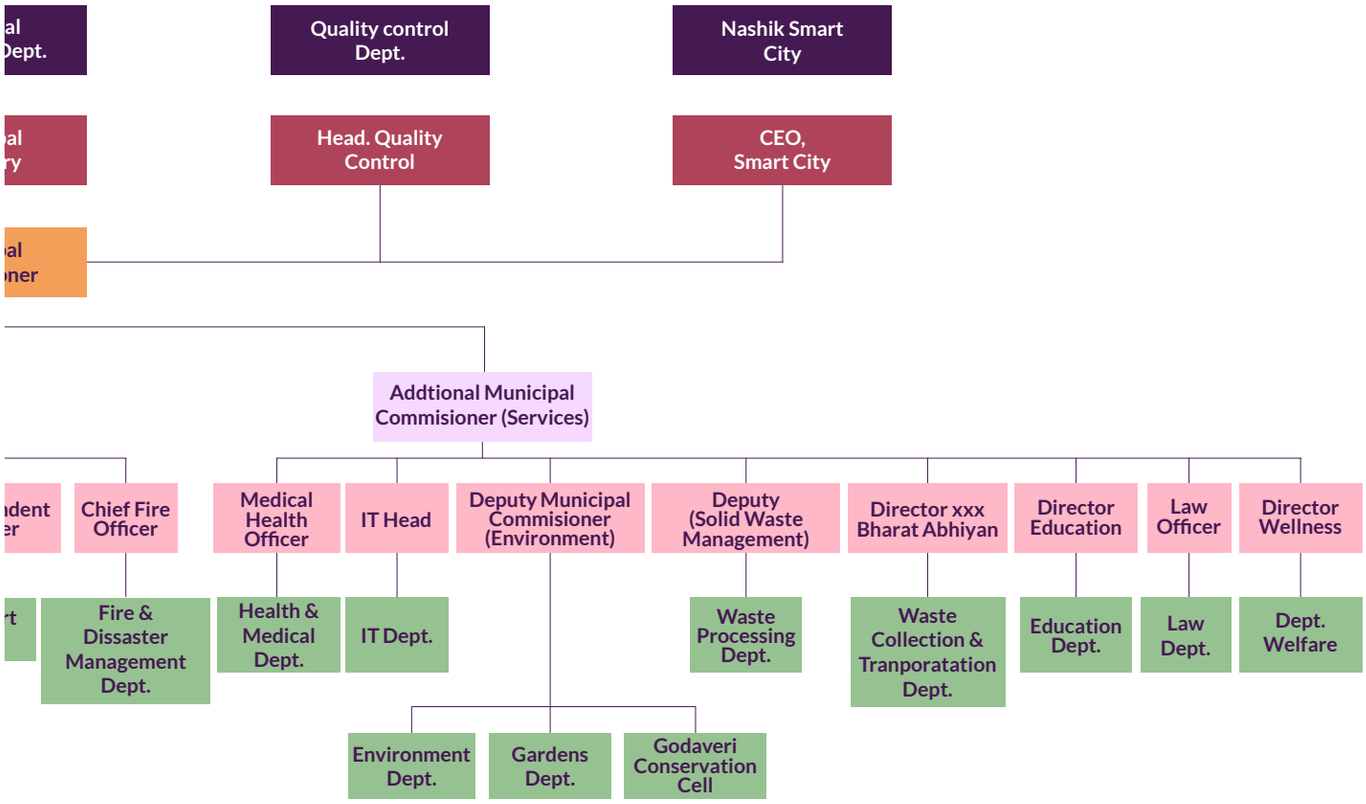
Currently, NMC incorporates the main administrative area and the 25 villages within its jurisdiction. For ease of civic administration, the city is divided into six wards — Nashik East, Nashik West, Panchvati, Satpur, CIDCO (New Nashik) and Nashik Road. NMC is headed by Hon'ble Municipal Commissioner and has several departments, such as Public Works, Water Supply and Town Planning,

Figure 2- 7 : Administrative Structure of Nashik Municipal Corporation



Source: NMC, 2023

as presented in Figure 2-7. These departments plan and provide basic infrastructure and services to the city. Other PSUs, SPVs and state-level agencies, such as MSEDCL, MPCB, Groundwater Surveys and Development Agency (GSDA), Nashik Municipal Smart City Development Corporation Limited (NMSCDCL), Nashik Waste Management Pvt. Ltd. (NWMPL) and Nashik Mahanagar Parivahan Mahamandal Limited (NMPML) to provide city appropriate services.



3. CLIMATE CONTEXT

3.1. CLIMATE OVERVIEW

3.1.1. Temperature and humidity

Based on an analysis of NCEI data (2006- 2021), since 2011, the hourly air temperature in summers (March-May) has ranged from 17°C to 40°C. Temperatures as high as 42.5°C was recorded in the summer of 2019. Winters in Nashik last from November to February, with the air temperature occasionally dropping as low as 6°C and rising to 35°C. According to IMD data (1970-2021)[13], on an average, July and August are the months with the maximum relative humidity (86-87%) and March and April the lowest (41-43%).

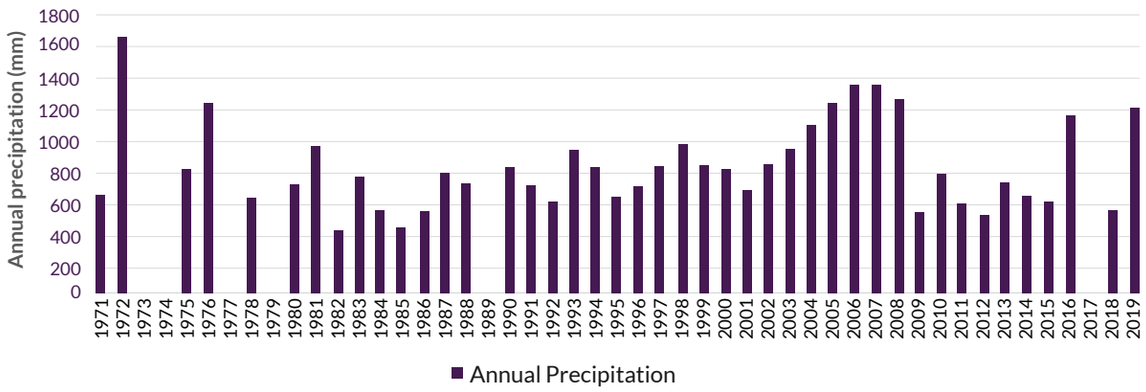
3.1.2. Rainfall analysis

On an average, Nashik receives 780 mm rainfall annually[14]. Based on IMD data, over the past five decades, the maximum amount of rainfall has been recorded during June- September, with average annual rainy days at 43 per year. The annual accumulated rainfall for the city between 1971 and 2019 is presented in Figure 3-1. There has been an annual increase of 0.012 mm/year, which is not very significant[15]. The years 2007, 2008 and 2016 were the deluge years for Nashik, when the areas around the Godavari witnessed major floods due to continuous rainfall lasting for as long as four days and the release of water from the Gangapur dam[16].

3.1.3. Wind speed and direction

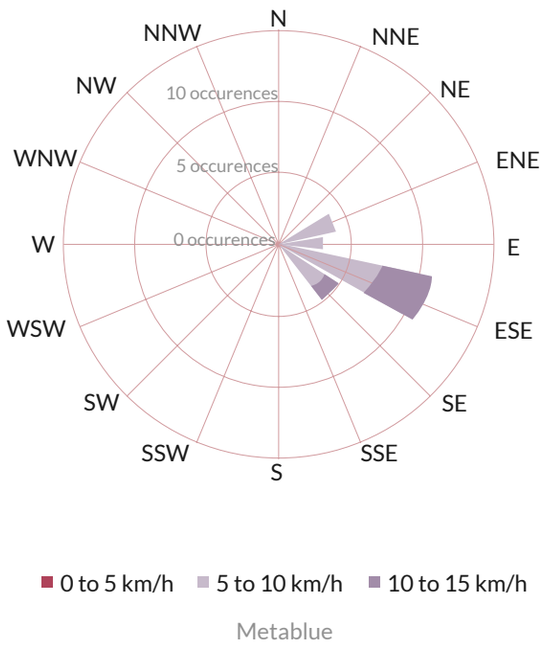
The study of wind rose based on an Environmental Status Report (ESR) report[17] indicates that the predominant winds are from the east and east of southeast directions, with dominant wind speed class of 10-15 km per hour as seen in Figure 3-2. High wind speeds are experienced during the monsoon months, leading to collapsing of trees and the associated losses.

Figure 3-1: Annual Precipitation at Nashik Station between 1971 & 2019



Source: WRI India using meteorological data from IMD, 2022

Figure 3-2: Wind Rose Diagram of Nashik



Source: Environmental Status Report 2020-2021, NMC

3.2. KEY CLIMATE RISKS

3.2.1. What is climate risk?

The climate risk context analysis is an attempt to understand risk exposure in the different geographical locations of Nashik city, using monitored weather data from sources such as IMD data, data from air quality stations, remote sensing techniques and data with various departments.

3.2.2. Key climate risks

The Climate Risk Index 2021[18] ranked India amongst the top 10 countries most affected and incurring maximum absolute losses of nearly $69 billion in 2019 from extreme weather events. Nearly 60% of India's land area is prone to earthquakes of moderate to very high intensity and 12% to flood and river erosion; 5,700 kilometres of coastline is prone to cyclones and tsunamis; 68% of cultivable land is vulnerable to drought; the hilly areas are at risk from landslides and avalanches; and 15% of landmass is susceptible to landslides[19].

The IPCC Fifth Assessment Report analyses climatic drivers and estimates potential future risks for Asia in the near term between 2030 and 2040 and in the long term between 2080 and 2100. As per this assessment, Asia is bound to face medium to very high risk of water shortage in arid areas and a decline in agricultural productivity in the near and long term, impacting food production and security, thus causing malnutrition. Coastal and marine systems are also projected to be under increasing stress, with rising sea levels, increased rates of coastal erosion, degradation of mangroves, salt marshes, saltwater intrusion and high sea surface temperatures. Increased riverine, coastal and urban flooding is projected with very low to medium risk in the near term and medium to very high risk in the long term, leading to widespread damage to livelihoods, infrastructure and increased flood-related deaths and injuries. Asia is also projected to face more frequent and intense heat waves and intensified heat island effects, resulting in very high risk of heat related mortalities in the long term, especially in vulnerable groups such as outdoor workers and residents of informal settlements. Consequently, Asia will witness exacerbated poverty, inequalities and new vulnerabilities with medium to very high risk.

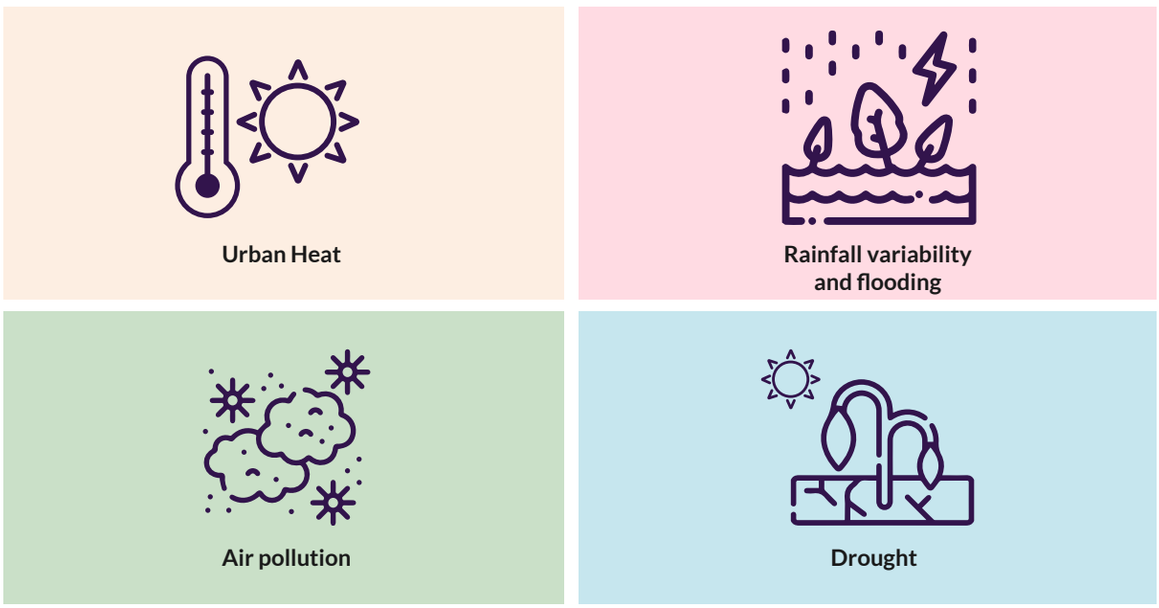
3.2.3. Key climate risks in Nashik

Nashik city faces four major climate challenges – heat risk, air pollution, rainfall variability

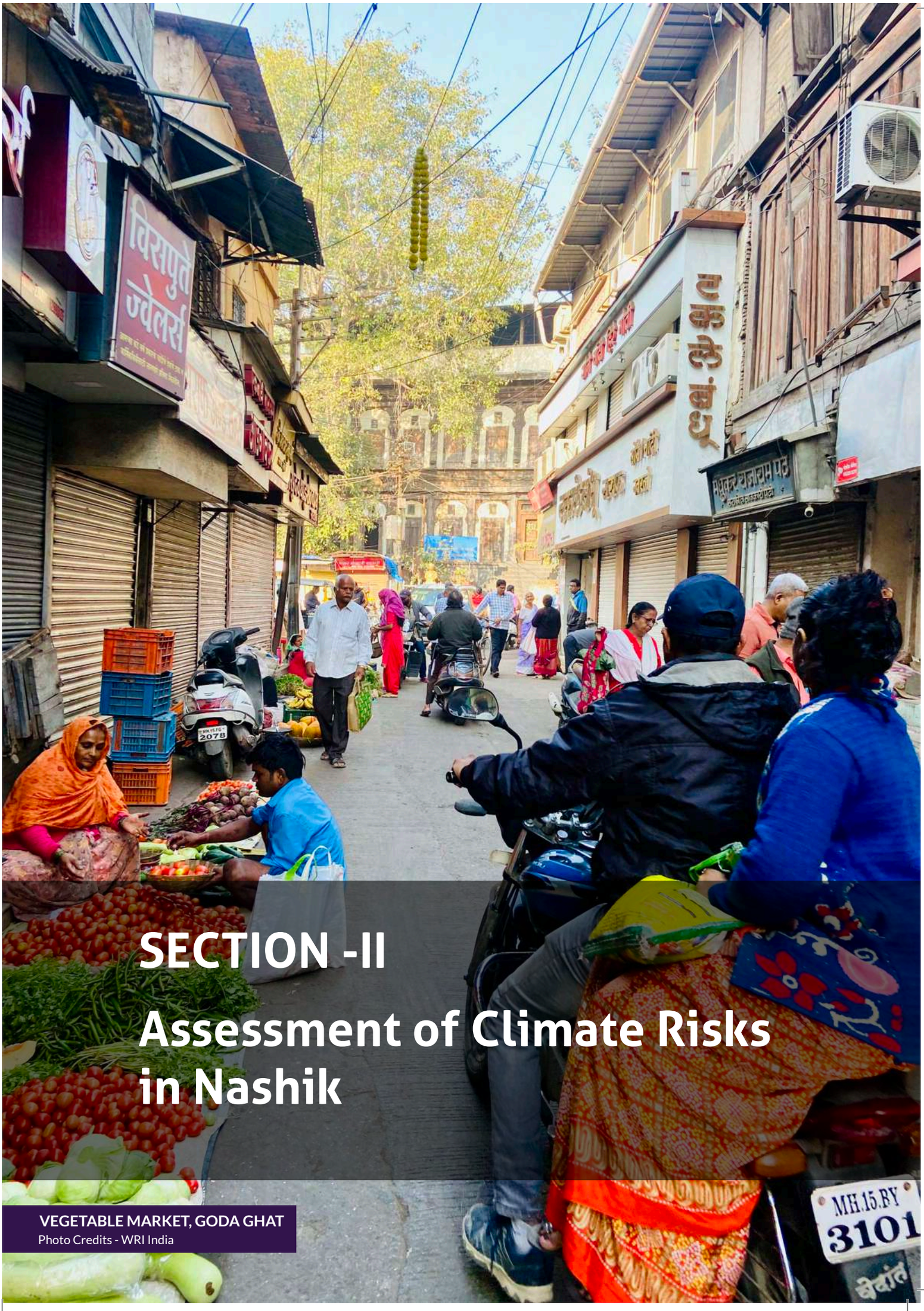
and water logging and groundwater depletion. Increase in temperatures in and around Nashik city is making the summer months (March–May) hotter, which has also been reported in the media[20]. Nashik is also experiencing an increase in rainfall during the pre-monsoon months February-May, as per a long-term trend analysis[21]. In the recent years, the city and surrounding regions have witnessed extreme rainfall events, leading to the release of water from the Gangapur dam, causing riverine flooding[22]. These increasing and extreme climatic conditions during the summer and monsoon months are increasing the risks associated with climate change in Nashik.

Disaster management is mostly addressed at the level of state, district and sub-division rather than city. The district management report categorises the following as disasters: floods, droughts, lightening, hailstorms, earthquakes, road accidents, rail accidents, fire accidents, crowd disasters, communal violence and industrial accidents. However, for the city in context with climate-induced disasters, this report focuses on heat, air pollution, rainfall variability and groundwater depletion. Although air pollution is an anthropogenic activity induced hazard, monitoring and reducing criteria air pollutants can significantly contribute to minimising short-lived climate pollutants (SLCPs), such as methane (CH4), tropospheric ozone, hydrofluorocarbons (HFCs) and black carbon, which curb global warming. These GHG emissions remain in the atmosphere for a brief duration but are more potent than carbon dioxide, leading to multiple challenges for human development and well-being.

Figure 3-3 : Key Climate Risks in Nashik



Source: WRI India Analysis



SECTION -II

Assessment of Climate Risks in Nashik

VEGETABLE MARKET, GODA GHAT
Photo Credits - WRI India

4. URBAN HEAT RISK

The assessment of urban heat risk has been done by analysing non-spatial and spatial parameters (Refer to Annexure 1-1).

Non-spatial parameters include air temperature using 2006-2021 data from National Centers for Environmental Information (NCEI) and night-time Land Surface Temperature (LST) from Moderate Resolution Imaging Spectroradiometer (MODIS). Annual variations of air temperature were analysed to demonstrate the overall trend of exposure to heat.

- Spatial analysis of heat risk uses LST data from Landsat mission, United States Geological Survey (USGS), that helps identify local areas that are more exposed to heat stress also known as Urban Heat Island (UHI) effect.

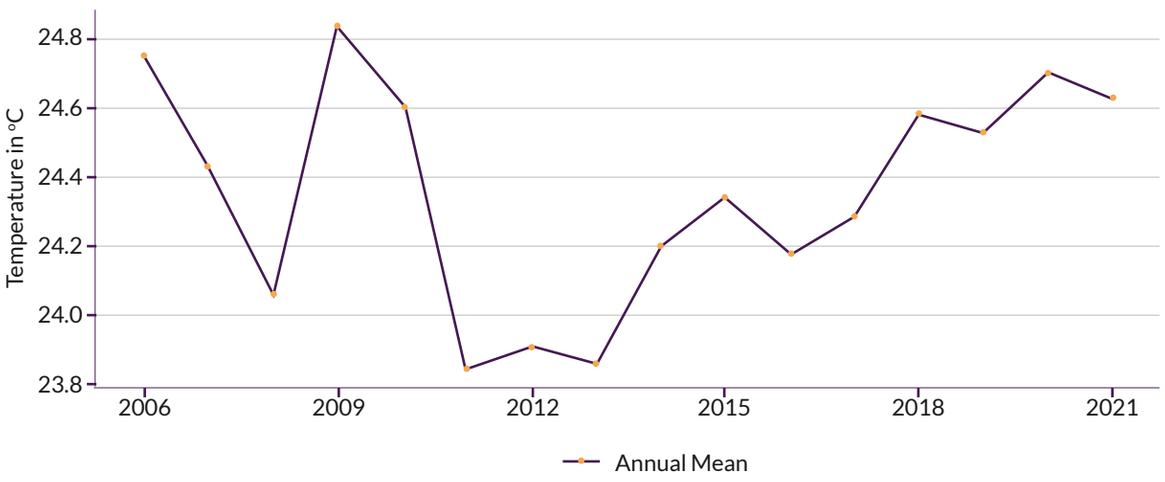
4.1 KEY FINDINGS

4.1.1 Temperature trend analysis

1. Annual air temperature trend

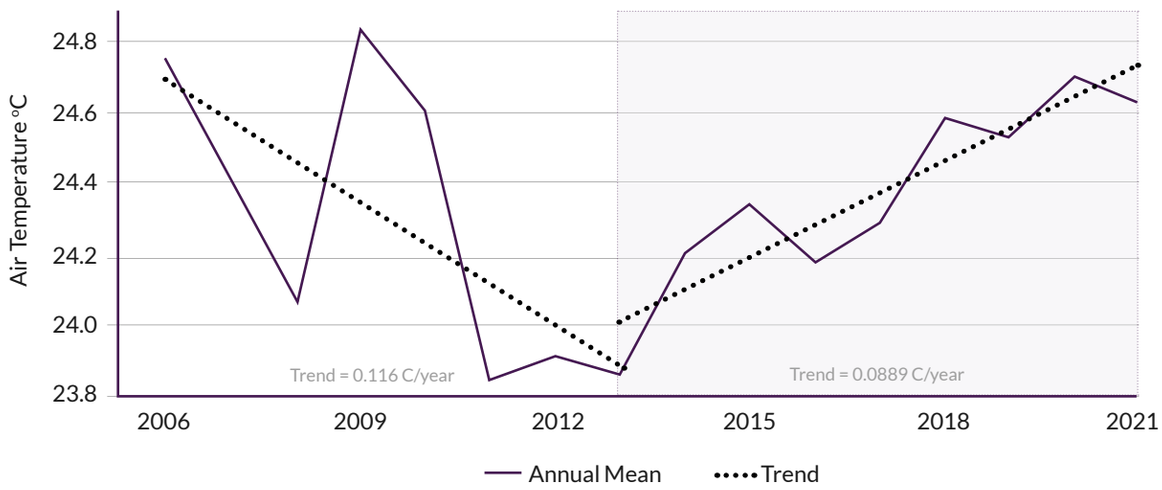
Annual mean temperatures were calculated for Nashik from the year 2006 to 2021. The data for this temporal analysis was sourced from NCEI. The annual average temperatures are observed to be rising continuously from 2013, as seen in Figure 4-1.

Figure 4-1: Annual average air temperature between 2006 to 2021



Source: WRI India Analysis 2022, NCEI 2006-2021

Figure 4-2: Change points in the annual average air temperature trend between 2006 & 2021



Source: WRI India Analysis 2022, NCEI 2006-2021

2. Change point detection

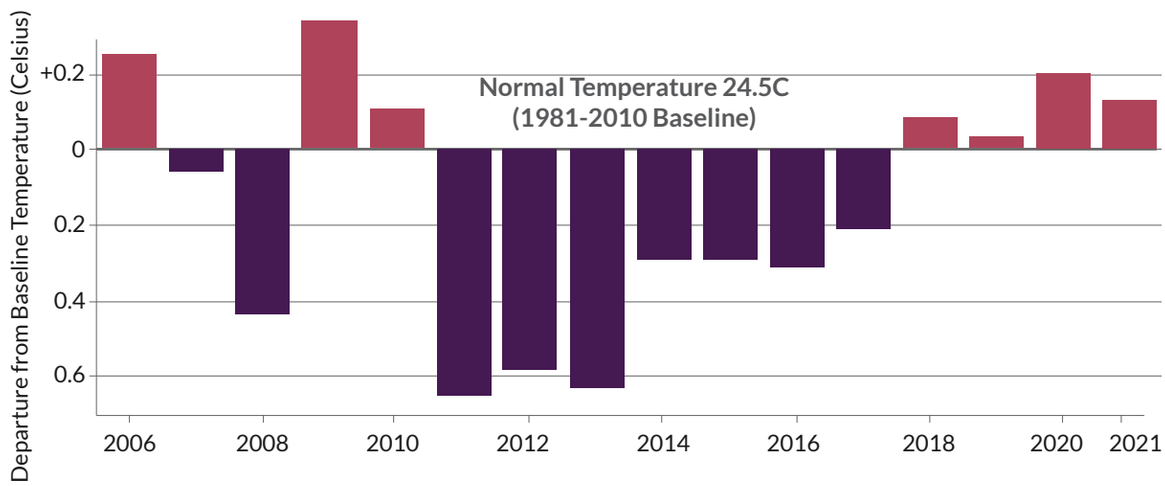
In addition to interpreting the annual average trend, it is insightful to study significant statistical shifts within the trend. The points in time at which the trend changes are referred to here as 'breakpoints'. Figure 4-2 shows the breakpoint that was identified using an established mathematical method. It divides the entire period into two sections, each with a different slope.

As explained above, since 2013, the annual average temperatures have been increasing rapidly, at the rate of 0.9°C per decade.

3. Annual air temperature deviations

Figure 4-3 shows annual air temperature deviations in Nashik from 2006 to 2021. The baseline temperature for the city, 24.5° C, was

Figure 4-3: Deviations of annual average air temperatures from the baseline temperature in Nashik between 2006 & 2021



Source: WRI India Analysis 2022, NCEI 2006-2021

calculated using IMD's definition. It is the average temperature of the period 1981- 2010. The anomalies were calculated by subtracting the baseline temperature from each year's annual average temperature.

In all, seven years are observed to have been warmer than the baseline average in this period, with every year since 2018 showing positive deviations from the baseline.

4.1.2 Extreme heat events

A heat wave is a period of high air temperature, which can be fatal for the human body based on the duration of exposure. Heat wave and extreme heat wave incidents in Nashik are analysed for the period 2006-2022 (data available until July 2022).

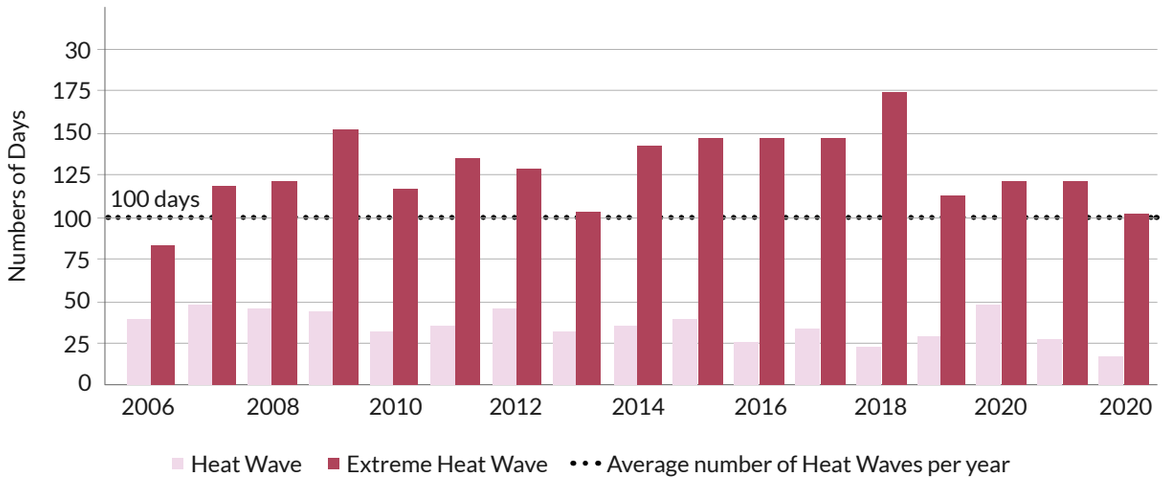
1. Heat waves

First, data was filtered for only those days where the maximum temperature was above 40°C as IMD requires plain areas to follow this threshold (a threshold of 30°C should be applied to areas in hilly regions). All days where the deviation from the daily long-term average air temperature was between 4.5°C and 6.4°C were classified as 'heat wave' while those where the deviation was more than 6.4°C were classified as 'extreme heat wave'. Figure 4-4 shows the number of heat waves and extreme heat waves in Nashik.

2. Heat index classification

Heat index classification considers both air temperature and relative humidity and, hence, provides an indication of the perceived temperature. As the moisture content in the air increases, the capacity of the human body to cool down decreases. The days were classified using the classification scheme of National Oceanic and Atmospheric Administration (NOAA). According to this scheme, temperatures in the 26° C- 32° C range are classified as 'Caution' and 32° C-39° C as 'Extreme Caution'. Table 4-1 lists the health hazards associated with the different heat index categories.

Figure 4-4: Number of days spent in Extreme Heatwave



Source: WRI India Analysis 2022, NCEI 2006-2022 (July)*

Since 2007, the city has recorded more than 100 days (denoted by the dashed line) of extreme heat wave days every year.

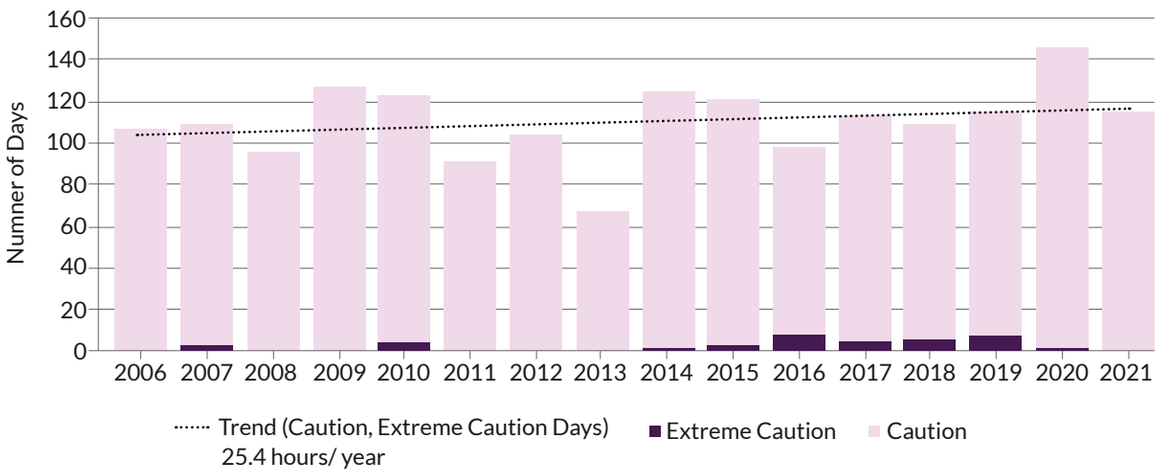
Table 4-1: Heat index classification of NOAA

Classification	Heat Index (°C)	Effect on the body
Caution	26–32	Fatigue possible with prolonged exposure and/or physical activity
Extreme Caution	32-39	Heat stroke, heat cramps or heat exhaustion possible with prolonged exposure and/or physical activity
Danger	39-51	Heat cramps or heat exhaustion likely, and heat stroke possible with prolonged exposure and/or physical activity
Extreme Danger	Above 51	Heat stroke highly likely

Source: WRI India Analysis

Every year, more than a day is getting added to the total number of both 'Caution' as well as 'Extreme Caution' days. The year 2016 had the maximum number of days in the 'Extreme Caution' category owing to the severe heat wave that swept across Nashik (as indicated in Figure 4-5).

Figure 4-5: Deviations of annual average air temperatures from the baseline temperature in Nashik between 2006 & 2021



Source: WRI India Analysis 2022, NCEI 2006-2021

4.1.3 Land surface temperature analysis

LST is the radiative skin temperature of the land derived from solar radiation (Khan et al., 2021). LST and air temperature are intrinsically distinct yet complementary as warm air rising from the Earth's surface influences the overall weather and felt temperature. The LST varies across natural and artificial landscapes and land uses. We have studied LST based on emissivity and radiative temperature sensed by satellite-based thermal sensors.

1. Night-time temperature trends from LST

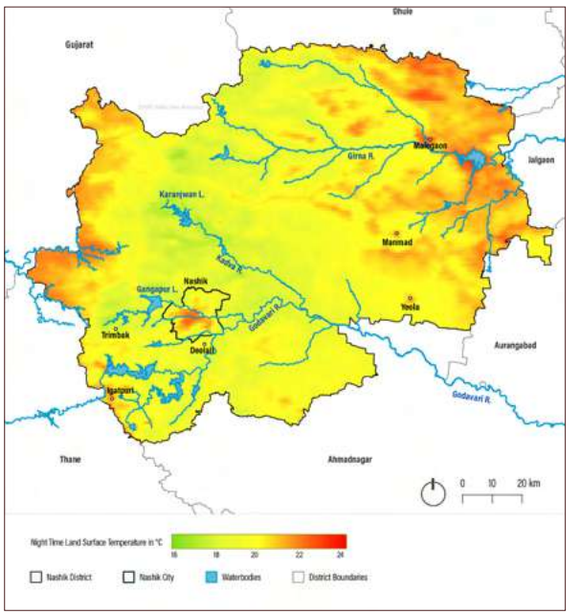
Urban built areas dissipate more heat at nighttime compared with the periphery. As a result, the human body does not get the opportunity to relieve itself from the day-long activity-based heat exhaustion. This phenomenon is largely known as Urban Heat Island (UHI) effect.

"A higher surface temperature is observed in the cities due to built-up impervious surfaces and high-rise buildings constructed through heavy use of metal as compared to surrounding rural landscapes characterized by forest–tree cover and pervious surfaces"[23].

The average night-time temperature was studied at the district level to understand the variation in night-time LST for rural, urban and other landcover. Using Moderate Resolution Imaging Spectroradiometer (MODIS) for the period 2019-2021, images were used to study this area.

- The urban areas such as Nashik city, Malegaon, Manmad, Yeola and Igatpuri have higher LST than the surrounding areas.
- The hilly areas towards the east and western edge of the district with less vegetation also appear hotter than the green areas.
- The night-time LST within the city core with dense built up is the highest within the district. This is due to the presence of paved surfaces, such as asphalt roads and concrete terraces, which are thermally conducive and lack vegetation cover. These surface store heat during the day, which is released slowly by night-time. Similar effects can also be seen in and around the smaller cities and towns of Igatpuri, Malegaon and Yeola within the district, which establish the relation between urban areas and night-time LST.

Figure 4-6: Land surface temperature in Nashik district from 2019 to 2021

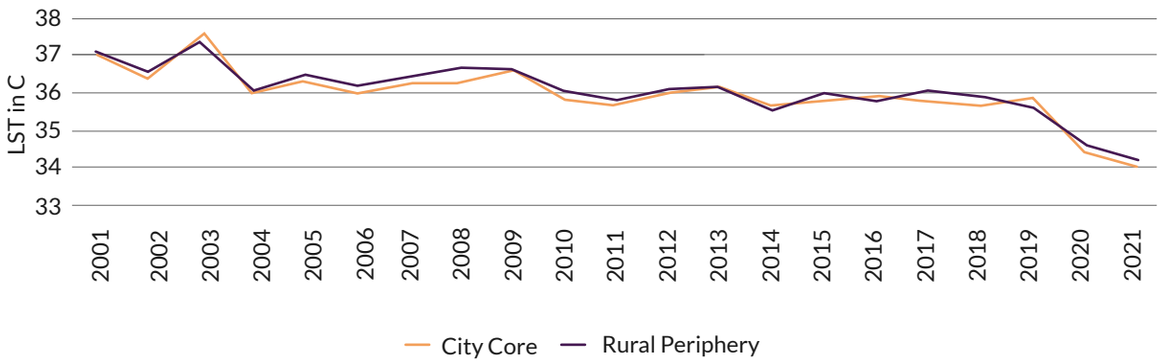


Source: *WRI India analysis; MODIS LST Product, 2019-2021*

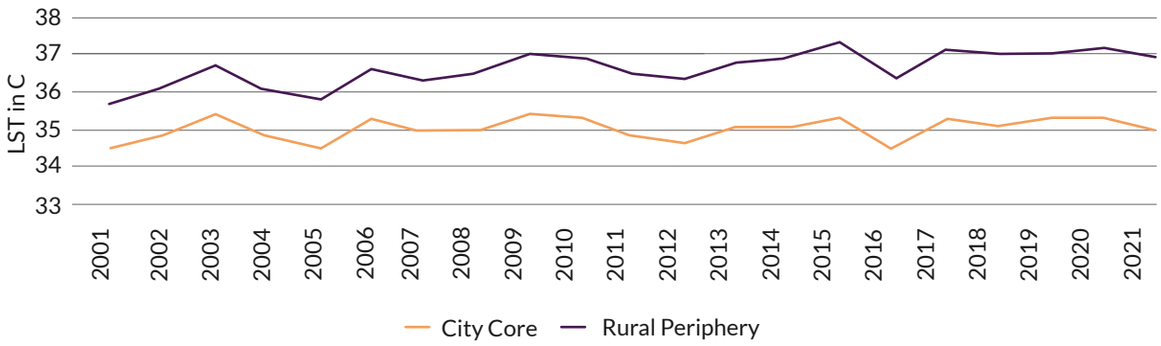
Figure 4-7 a) and b) shows the comparison between the yearly day-time and night-time temperatures of urban city core and surrounding areas within 25km buffer for time period 2001-2021.

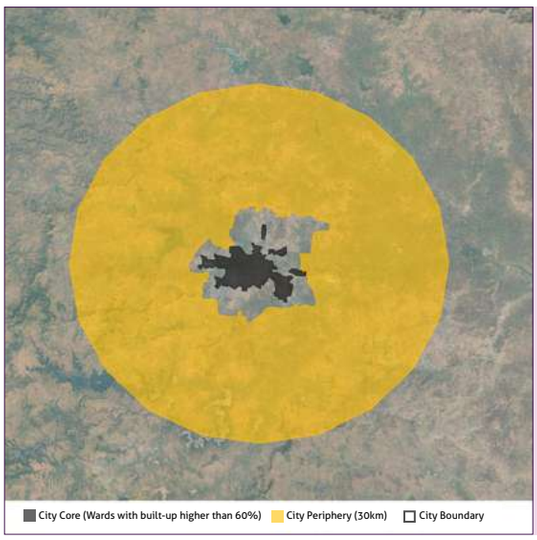
Figure 4-7: Comparing night-time and day-time LST outside Nashik city periphery

a. Comparison of day-time LST in the city core with the rural peripheries outside the corporation boundary



b. Comparing night-time LST in the city core with the rural peripheries outside the corporation boundary





The daytime LST for both city core and rural periphery are almost the same, but the night-time LST within the city core is higher by ~2 °C than the rural periphery.

Within the city corporation limits, the monthly average values were observed for the period 2001-2021. The trend shows an increase in night-time LST by 0.06°C/year.

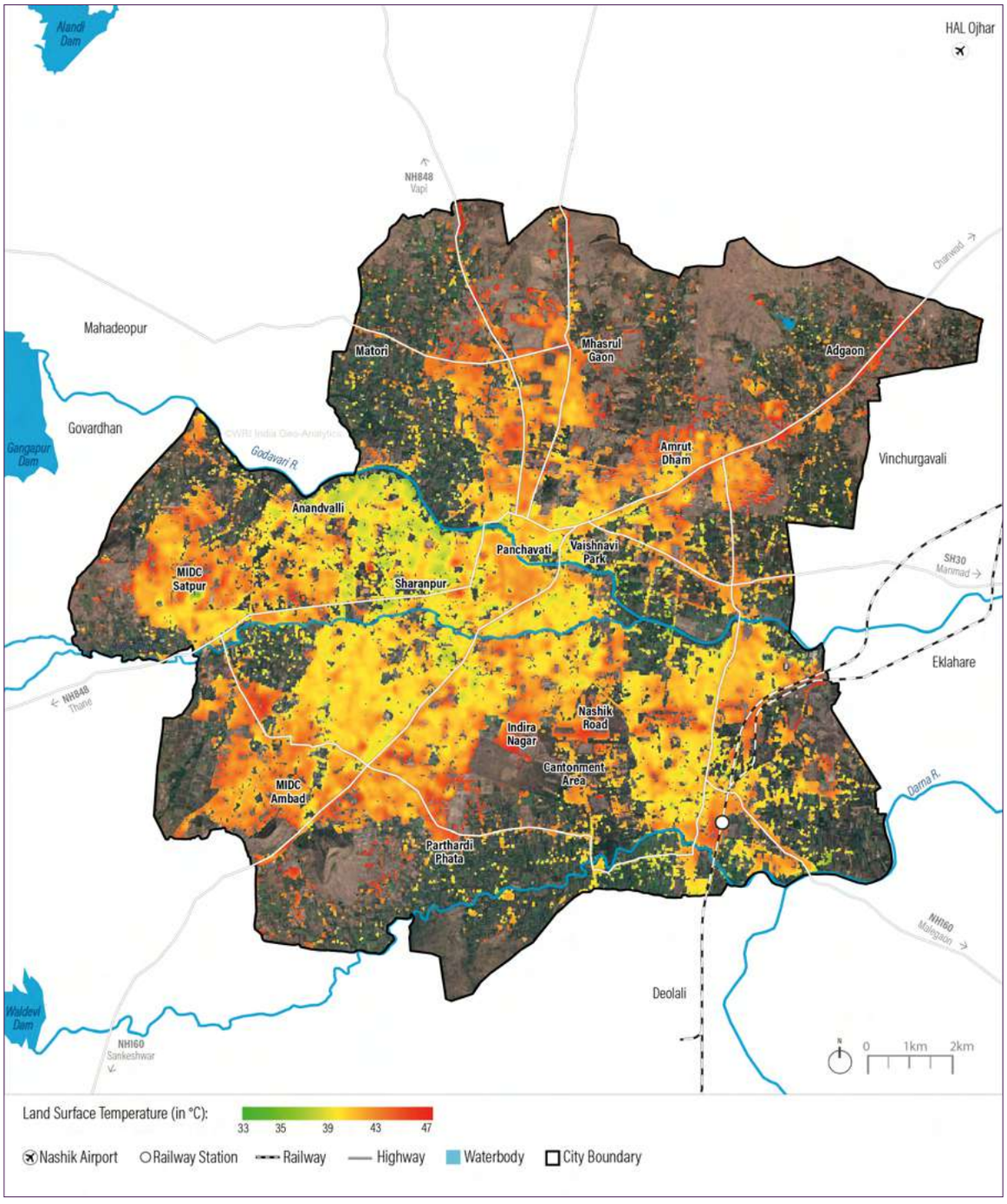
Refer to Annexure 1-2

2. LST hotspots

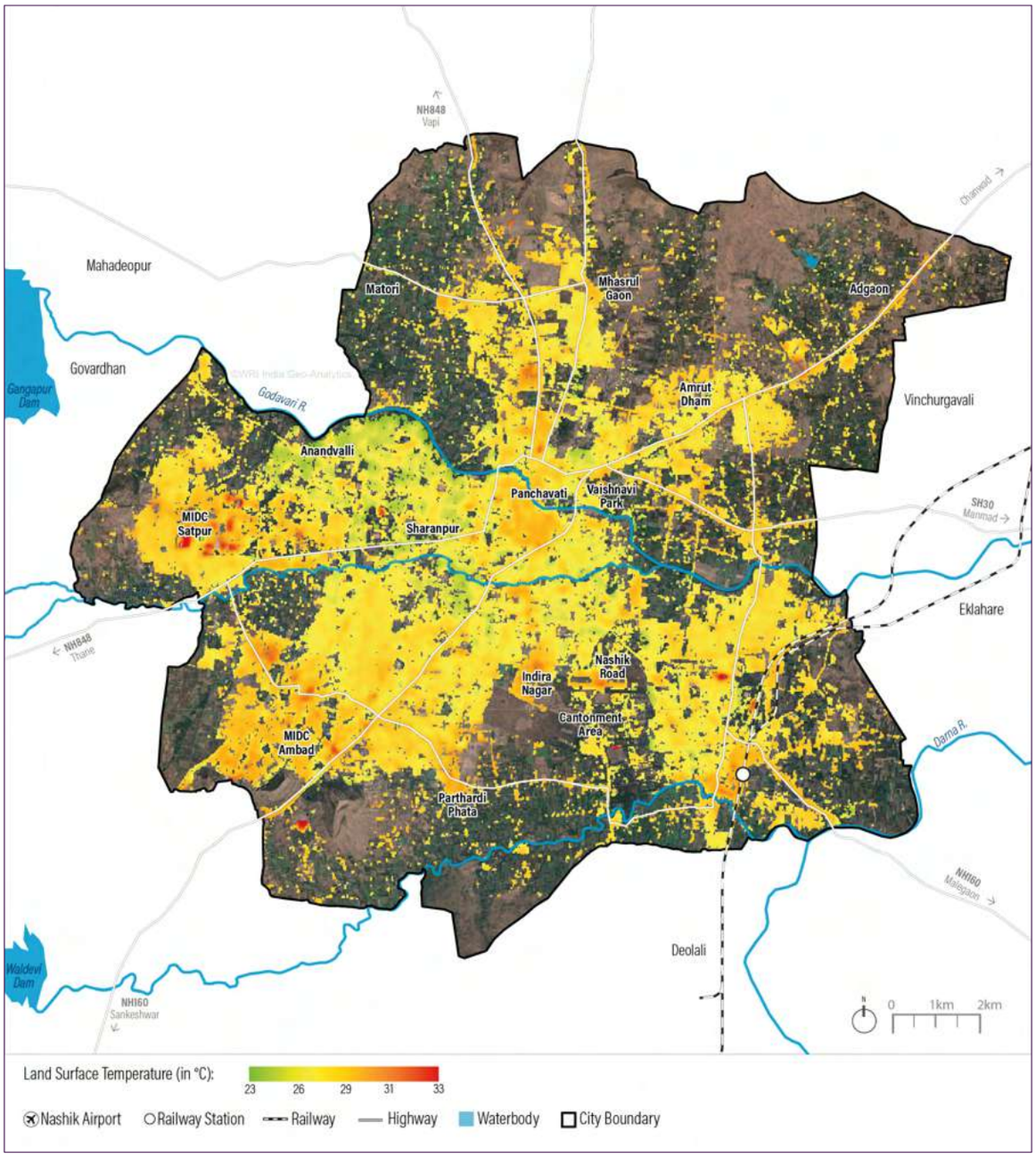
Within the urban core, paved surfaces, such as concrete and asphalt roads, concrete terraces and metal and asbestos roofs get heated and, creating hotspots. The hotspot analysis was done using Landsat 8 data using the day-time LST values. For Nashik, LST was derived for two-time durations, pre-monsoon (April and May, 2019-2021), and post-monsoon (October, November and December, 2019-2021), as shown in Figure 4-8.

Figure 4-8: Mean Land Surface Temperature for pre and post monsoon (2019-2021)

a) **Pre-monsoon**

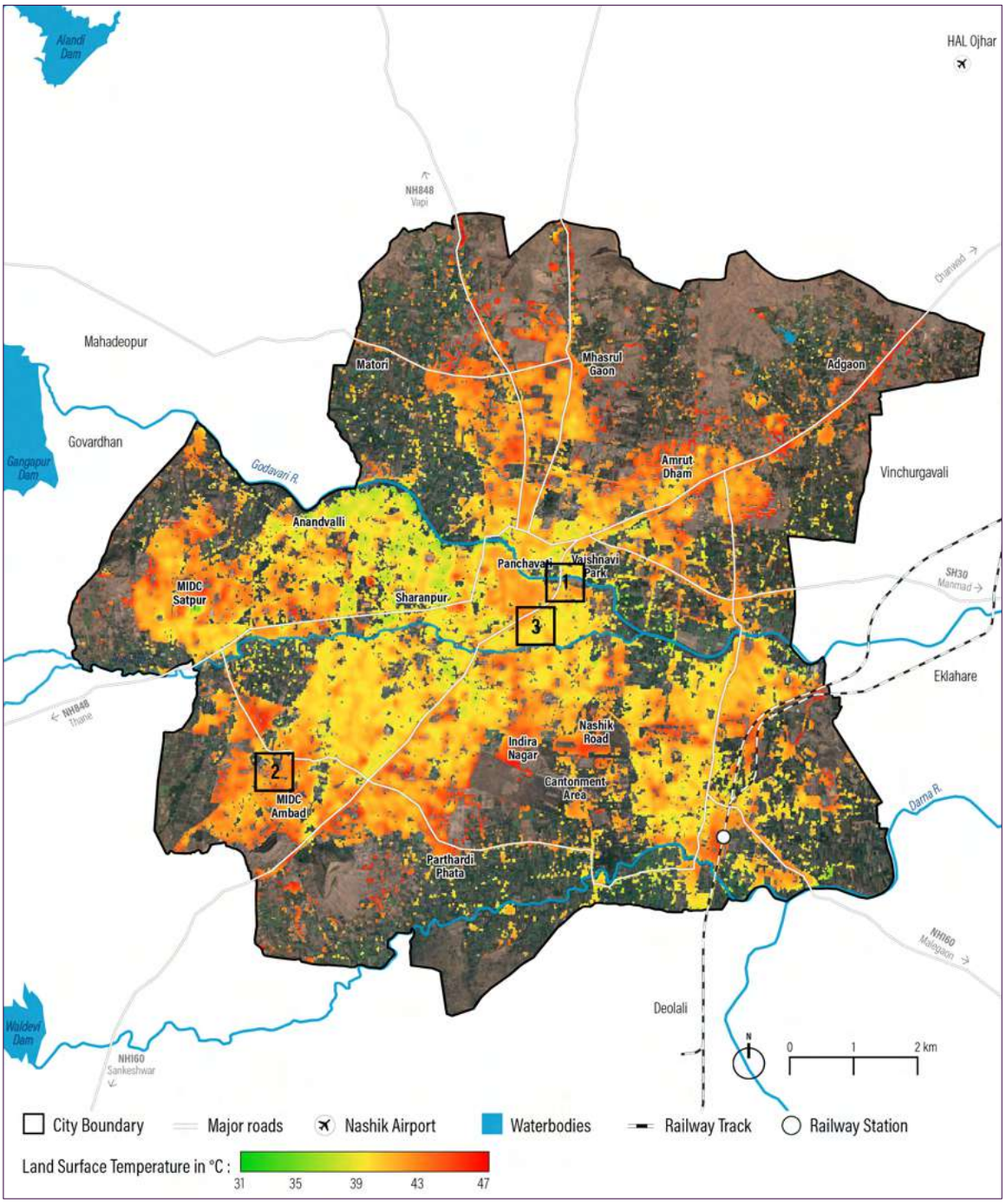


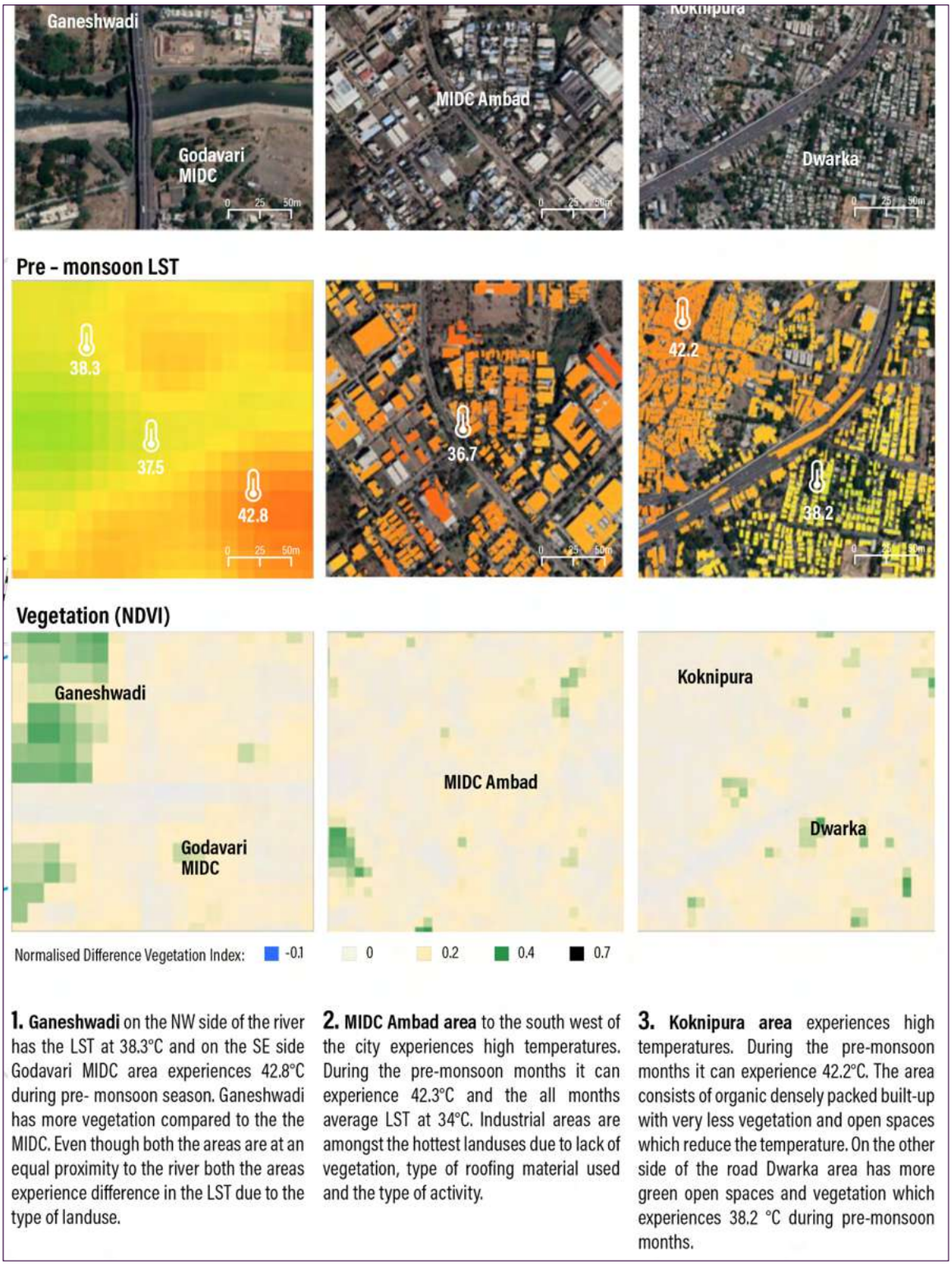
b) Post-monsoon



Source: WRI India analysis using Landsat 8, USGS, 2022; Left: Pre monsoon summer months (April & May), Right: Post monsoon winter months (October – December)

Figure 4-9: LST hotspots in the city





1. Ganeshwadi on the NW side of the river has the LST at 38.3°C and on the SE side Godavari MIDC area experiences 42.8°C during pre- monsoon season. Ganeshwadi has more vegetation compared to the the MIDC. Even though both the areas are at an equal proximity to the river both the areas experience difference in the LST due to the type of landuse.

2. MIDC Ambad area to the south west of the city experiences high temperatures. During the pre-monsoon months it can experience 42.3°C and the all months average LST at 34°C. Industrial areas are amongst the hottest landuses due to lack of vegetation, type of roofing material used and the type of activity.

3. Koknipura area experiences high temperatures. During the pre-monsoon months it can experience 42.2°C. The area consists of organic densely packed built-up with very less vegetation and open spaces which reduce the temperature. On the other side of the road Dwarka area has more green open spaces and vegetation which experiences 38.2 °C during pre-monsoon months.

Source: Landsat 8 (April and May) LST 2019 to 2021

For pre-monsoon months, the daytime LST within the city built-up areas ranges between 31°C and 47°C, and during the post-monsoon months, it ranges from 23°C to 33°C. Within both these durations the Panchvati area within the city core and MIDC areas in Satpur and Ambad are consistently hotter than the other areas within the city.

3. Correlation between LST and vegetation

Vegetation affects LST, and the two are inversely correlated i.e. areas with lesser vegetation tend to have higher LST. This correlation depends on the type of vegetation and its distribution and seasonality. Trees that are present as a part of the built-up fabric or trees along the roads or avenues have higher effect on the microclimate of the area as compared with isolated artificial plantations. Similarly, seasonal plants can help in reducing the LST for a limited period. Ornamental species may not reduce LST but end up burdening the water supply. Open grounds that lack grass or similar vegetation during summer months also act as heat hotspots. The graphs present a comparison between the ward-wise: % vegetation and average LST over two-time durations, pre and post monsoon. The months April and May are considered as pre monsoon and October, November and December as post monsoon.

Figure 4-10 : Comparison between ward wise mean LST and NDVI for pre monsoon months (April and May, 2019-2021)

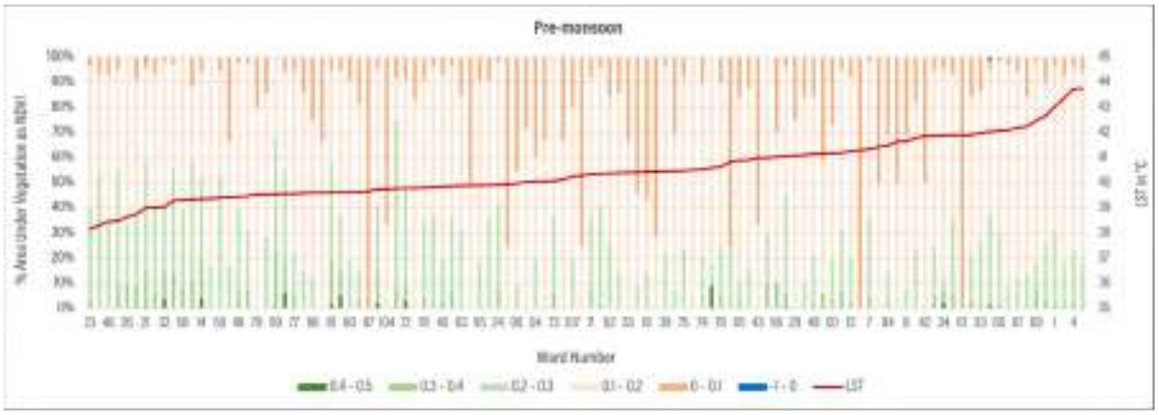
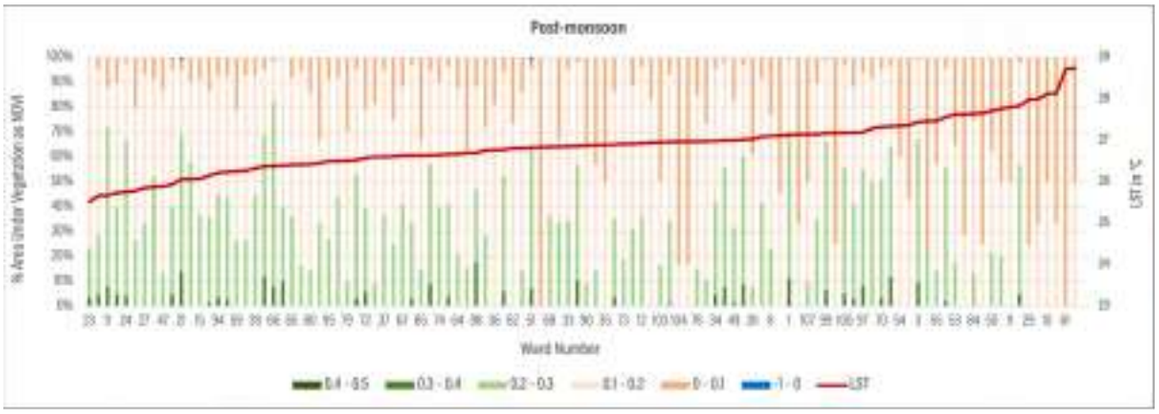


Figure 4-11 : Comparison between ward wise mean LST and NDVI for post monsoon months (Oct, Nov, Dec, 2019-2021)



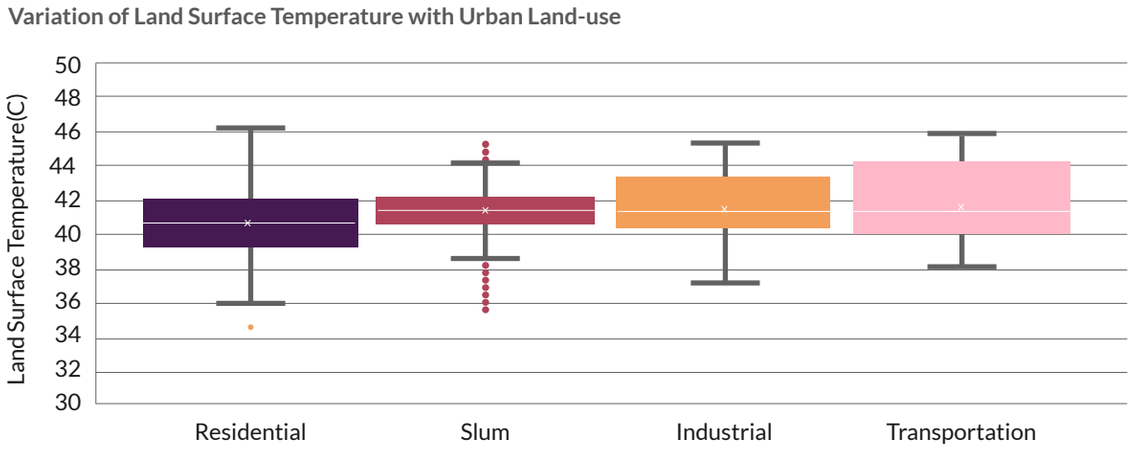
Source: WRI India analysis, Landsat 8 data between 2019 – 2021

The post-monsoon graph appears greener as the availability of water is higher during the months post southwest monsoon. Wards 22, 23 and 27 (Savarkar Nagar), which consist of many trees and vegetation as part of the built fabric, have lower LST in both the graphs. The pre-monsoon average surface temperature within these wards is between 38°C and 39°C. Wards 29 and 42 (Panchvati) are some of the wards that have very less vegetation. These wards experience approximately 41-42°C during the summers.

4. Correlation between LST and Land-use

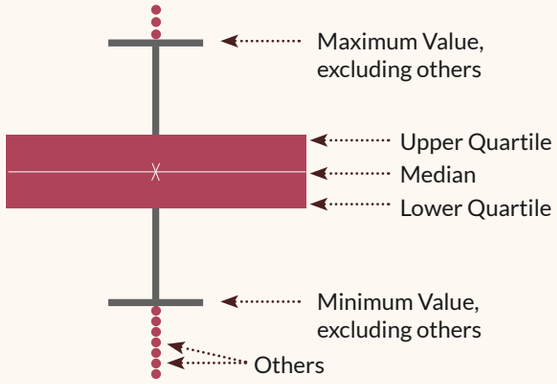
LST is affected by type of land-use and anthropogenic activity within an area. Residential areas with vegetation and open green spaces usually have lower LST than other urban land-uses. Industrial areas and areas with transport land-use appear to be the hottest, having activities that contribute higher emissions, as seen in Figure 4-9.

Figure 4-12: Variation of LST with landuse



The box-and-whisker plot or a box plot is an exploratiry graphic used to show the distribution of a dataset. The lines extending parallel from the boxes are know as the "whiskers", which are used to indicate variability outside the upper and lower quartiles. The dots inside the box on the whiskers are the data points including 'x' denoting the mean statistic of data.

In the current assessment, box plots are used to compare the LST of the various land-use features. Example on the right is a box plot for the slum features represented in Figure 4-12. The minimum and maximum LST values observed for the specified time-period are 38.49°C and 44.22°C. The lower and upper quartiles are recorded at 40.43°C and 42.08°C while the median value is 41.45°C. The mean value represented by an 'x' is observed to 41.38°C. Additionally, any values lying outside the range of minimum and maximum values are termed as outliers.



Source: WRI India 2022, Landsat 8, 2019-2021 (Pre-monsoon), Nashik Municipal Corporation

4.2 DISCUSSION AND CONCLUSIONS

The annual average air temperature in Nashik has been increasing from 1975 to 2021, at the rate of 0.1°C per decade. The number of extreme heat wave days experienced by the city is also on the rise. The years 2010, 2016 and 2019, on average, had 50 days of extreme heat wave. Moreover, the perceived temperature (heat index) analysis shows that the number of caution and extreme caution days are also increasing at the rate of almost one day per year. The UHI effect is evident within the high built-up density city core. An increase in night-time LST by 0.6°C per decade was observed within the city corporation boundaries from 2001 to 2021. Within the city, areas such as MIDC Ambad and those around Konkanipura appear as hotspots with less vegetation cover and high temperatures. Interventions in these areas could help lower temperatures.

CBS CHOWK, NASHIK
Photo Credits - WRI India

5. AIR POLLUTION RISK

The interactions between urban climate, air pollution and human health in cities need to be explored. Cities in developing nations such as India are facing high pressure due to air pollution and climate change. In India, studies on the combined effects of weather, climate variability, increased air pollution and health impacts are limited[24].

Climate plays a considerable role in spatial and temporal distribution of air pollutants. Greenhouse warming and ozone depletion in stratosphere are vital factors of climate change. Climate change can influence the air pollutant concentration and catalyse the formation of secondary pollutants. Also, the climatic conditions in addition to atmospheric parameters, topography and urban settlements influence the dispersion, accumulation and transformation of pollutants in the atmosphere. The dispersal of these air pollutants may cause respiratory disorders, such as emphysema and asthma, allergy problems and chronic bronchitis[25].

Besides, the nexus between urbanisation, climate change and air pollution is such that some of the atmospheric pollutants (aerosols) can enhance climate change because of their direct and indirect effects[26].

5.1 ASSESSMENT

Air pollution risk assessment includes temporal analysis using data from the Continuous Ambient Air Quality Monitoring Stations (CAAQMS) and manual stations established in the city and spatial analysis based on satellite imagery. Refer to Annexure 1-3.

- There are five Central and state monitoring stations in Nashik. The locations and details of pollutants monitored at these stations are presented in Table 5-1 and mapped in Figure 5 -1.
- The Indian Institute of Technology Bombay (IIT-B) and the National Environmental Engineering Research Institute (NEERI) conducted a source apportionment and emission inventory study in Nashik for MPCB.
- The city-specific air pollution micro action plan was created as a part of the NCAP programme, which included measures for mitigating the sources and strengthening air quality monitoring in the cities.

Air pollution monitoring includes studying the concentrations of physical and chemical compounds.

- Chemical compounds include gases such as sulphur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3) and carbon monoxide (CO), while the physical compounds include the dust particles PM_{10} and $PM_{2.5}$.
- For gaseous parameters, Nashik does not indicate non-attainment character. However, Respirable Suspended Particulate Matter (RSPM) levels were above the annual limit established by the Central Pollution Control Board (CPCB), which shows non-attainment.

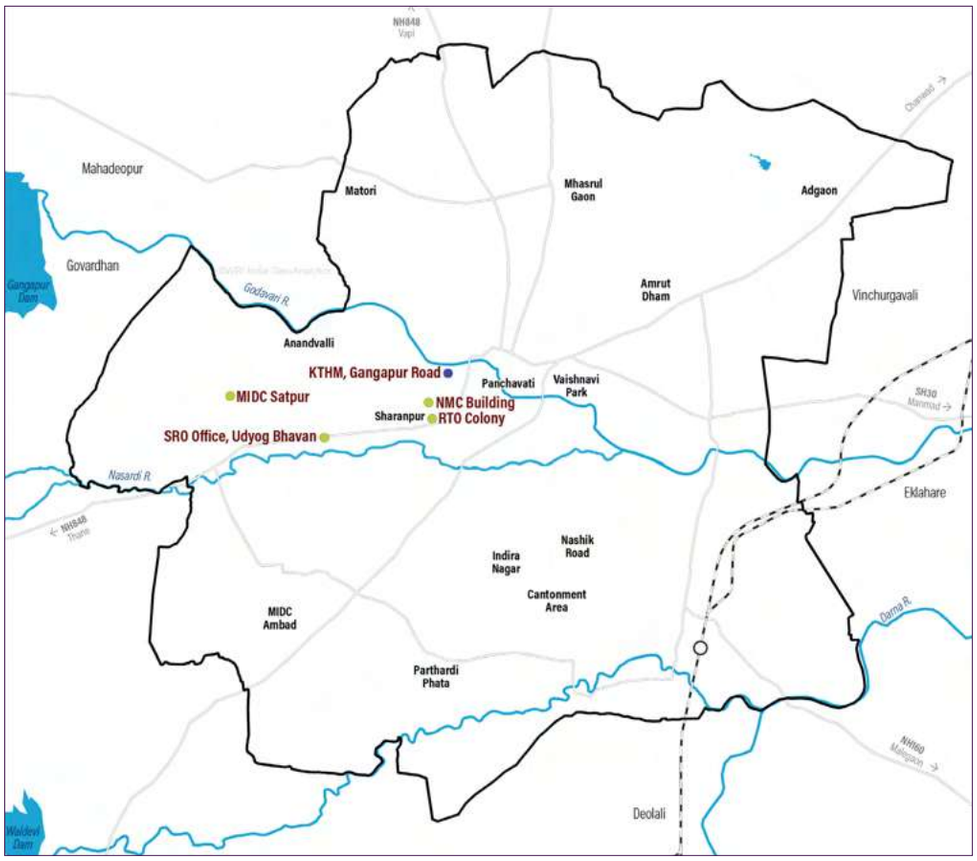
Table 5-1: Details of five air quality monitoring stations within Nashik City

Monitoring station name, area	Pollutants	Data Range	Monitoring Frequency
KTHM College, Shivaji Nagar off Gangapur road	SO_2, NO_2, PM_{10}, $PM_{2.5}$, CO, Ozone	11/08/2016 to 22/06/2022	Hourly
MIDC, Satpur	SO_2, NO_X, RSPM, SPM	01/01/2005 to 26/02/2022	Two days a week
Rajiv Gandhi Bhavan (NMC), Saharanpur road	SO_2, NO_X, RSPM, SPM	03/01/2005 to 28/02/2022	Two days a week
RTO Colony, Tilak wadi	SO_2, NO_X, RSPM, SPM	04/01/2005 to 25/02/2022	Two days a week
SRO Office, Udyog Bhawan, ITI Junction	SO_2, NO_X, RSPM, SPM	11/10/2004 to 28/02/2022	Six days a week

Note: RSPM is the same as PM_{10}

Source: CPCB, MPCB; http://cpcbenvis.nic.in/airpollution/finding.htm

Figure 5-1: Locations of air quality monitoring station in Nashik



Source: WRI India using CPCB, MPCB, NMC, 2022

5.2 KEY FINDINGS

The pollution levels for particulate matter and gases with respect to their individual permissible limits as per National Ambient Air Quality (NAAQ) standards prescribed by CPCB were analysed for the monitoring stations. In addition, the spatial analysis of the concentrations was carried out using satellite observations. The key findings of this analyses are presented in this section.

5.2.1 Air pollution concentrations

The temporal analysis of different air pollutant levels (annual averages) for Nashik city has been carried out for the period from 2004 to assess the city-wide and station-wise variations using data from the five manual stations: KTHM College, Satpur MIDC, Rajiv Gandhi Bhawan, RTO Colony and SRO Office. The landuse around these stations is mostly residential except for the Satpur MIDC station, which has some industrial activity around it. However, it should be noted that all these stations are concentrated in the west-central portion of the city.

Using the hourly data from the KTHM College CAAQMS station, hourly, weekly, monthly, seasonal, and annual scale analyses were carried out. However, for the same station and the remaining four stations, only annual averages were calculated using the limited data (1-2 data points per week) available on the MPCB website. These annual averages were compared with the NAAQ standards to determine when the concentrations were breaking above the threshold.

Spatial analysis includes the spread of each pollutant in the region of interest. It must be noted, however, that higher concentrations in a region, as seen in the spatial maps, do not indicate the presence of source(s) at that location as wind direction plays a key role in moving plumes of emissions to adjacent regions. Furthermore, the units of concentrations for all the pollutants in the sentinel data are different from those used in the temporal analysis, with no easy method of conversion between the two. Therefore, one should refrain from applying the NAAQ safety thresholds to the sentinel maps and utilise these maps to only understand the broader areas in the city where the concentrations of pollutants are relatively higher.

The maps presented in section below were created using data from the Sentinel satellite mission for all pollutants except $PM_{2.5}$ for which the data was provided by the Atmospheric Composition Analysis Group at the Washington University in St. Louis, USA. Also, note that the spatial data was not available for ozone and PM10/RSPM.

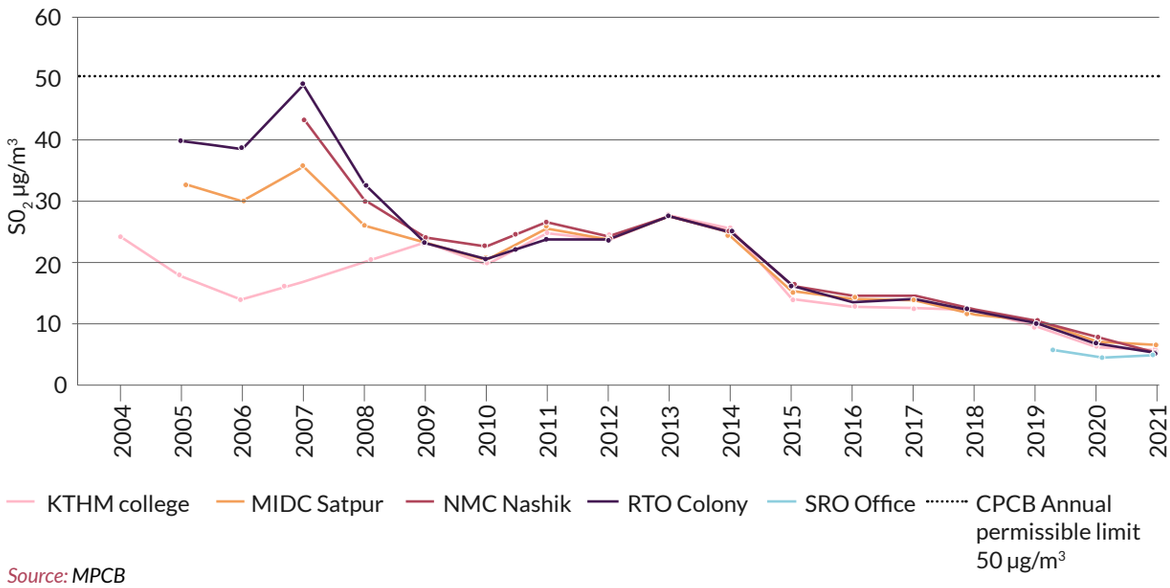
1. Analysis of concentration of Sulphur Dioxide

Annual average SO_2 concentrations are observed to be much lower than the stipulated regulatory limit (50 µg/m3), indicated by the black dashed line in Figure 5-2, since 2004. This indicates that SO_2 is not one of the major pollutants in Nashik.

The spatial data shows more variability as compared with the other pollutants, as seen in Figure 5-3. In 2019, the hotspot over Gulshan Nagar (near Indira Nagar) in the south-central part of the city is observed over a few bakeries and some smaller industries. The years 2020

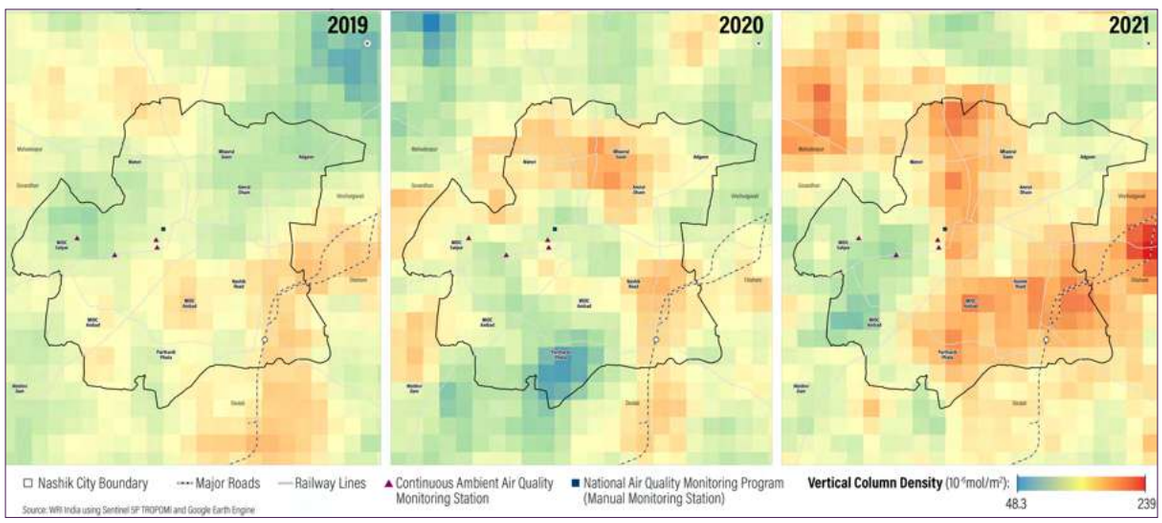
and 2021 show another prominent hotspot to the north, in Mhasrul, and correlates with the location of a metal manufacturing company. Lastly, all three years show high concentrations of SO_2 near the railway station to the southeast. Peak concentrations are also observed in 2021, near the Eklahare power plant outside the city limits.

Figure 5-2: Annual avg. concentrations of SO_2 - all manual AQMS (2004 to 2021)



Source: MPCB

Figure 5-3: Annual average concentrations of SO_2 in Nashik during 2019-2021



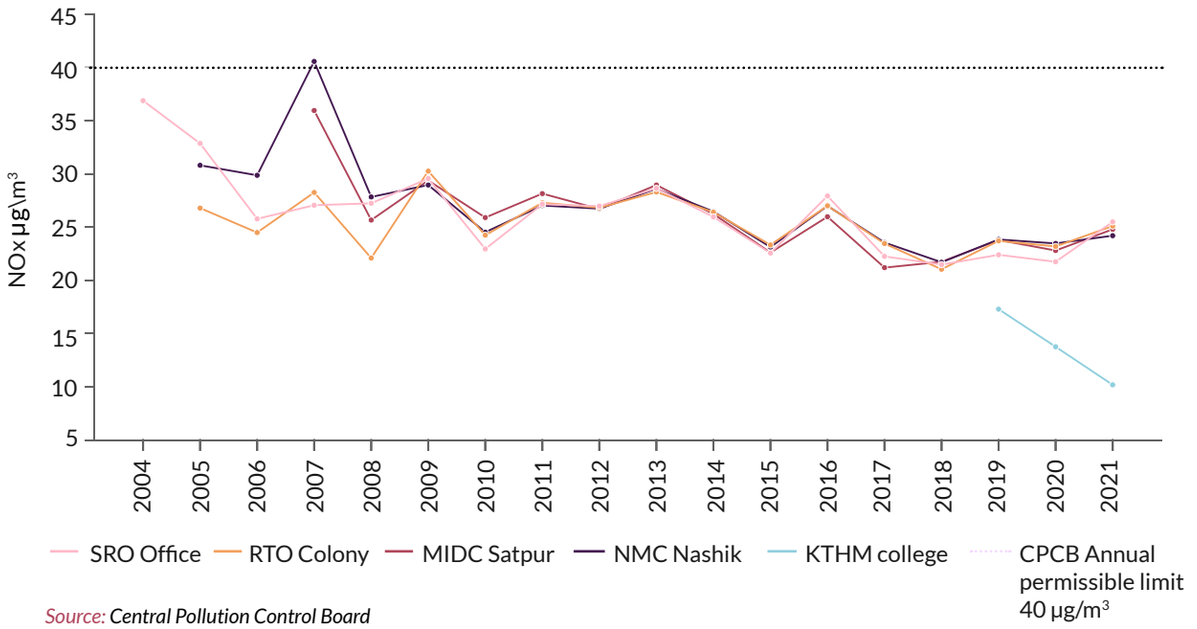
Source: WRI India using Sentinel data

The monthly average concentrations of SO_2 from 2019 to 2021 show a pattern consistent with the observations from the temporal analysis with high concentrations in the winter and low concentrations in the monsoon (Refer to Annex 2-4).

2. Analysis of concentration of nitrogen oxides

Figure 5-4 shows annual nitrogen oxide (NO_x) averages at the five manual stations. Similar to SO_2, these values are obeying the respective safety threshold of 40 µg/m^3 and, hence, indicate that NOx is not one of the major pollutants in the city.

Figure 5-4: Annual average concentrations of NOx across all manual air quality monitoring stations in Nashik during 2004-2021



Source: Central Pollution Control Board

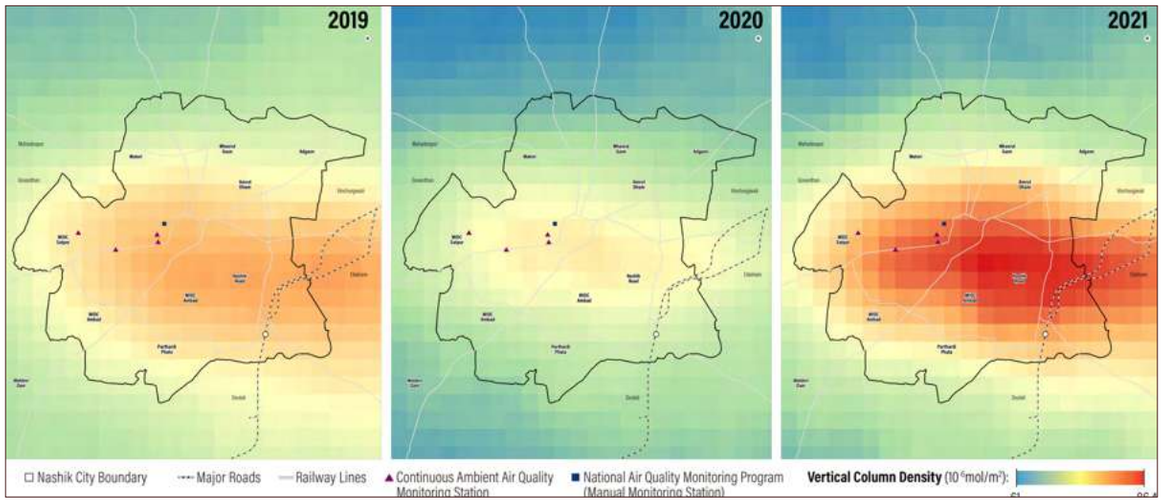
The analysis of hourly concentrations of NO_2 at the continuous monitoring station at the KTHM College shows seasonal variations. It shows the highest concentrations in January while the monsoon season in the middle of each year has the lowest concentrations (Refer to Annex 2-5).

Vehicular emissions are the most important source of NO_2. As such, the maps show relatively high concentrations in the middle of the city. The effects of COVID-19 lockdowns are quite apparent in these maps, with a significant reduction in the concentrations and the spatial spread of NO_2 in this region during 2020.

The monthly average concentrations of NO_2 from 2019 to 2021 in the city indicated higher values consistently over the city center. Moreover, the seasonal variations are similar to the other pollutants, with high concentrations in the winter and low concentrations in the monsoon months (Refer to Annex 2-6).

A total 428 days in this period have recorded concentrations peaking above the daily CPCB safety threshold, with a majority of these crossings taking place between November and April.

Figure 5-5: Annual average concentrations of NO_2 in Nashik during 2019-2021



Source: *WRI India using Sentinel data*

3. Analysis of concentration of Ozone

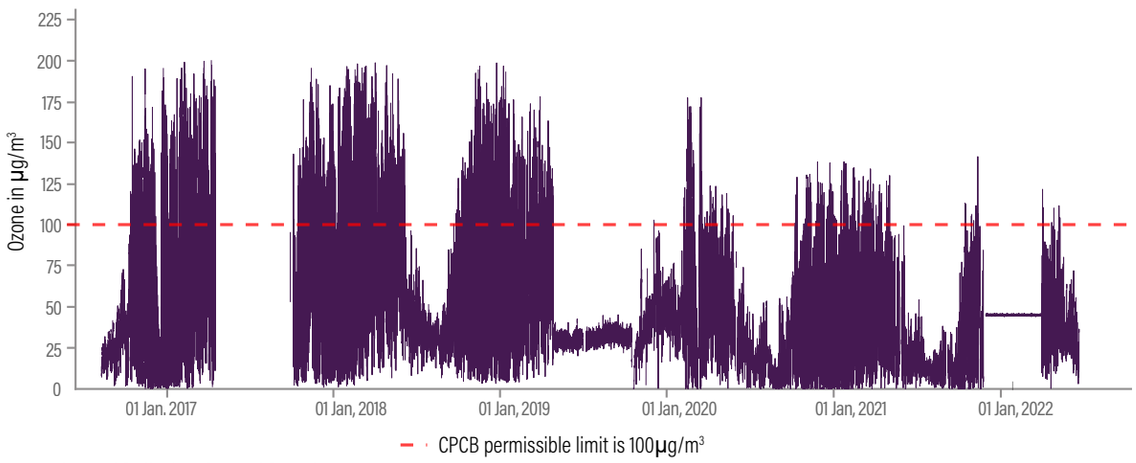
Figure 5-6 shows the measured hourly concentrations of O_3 at the KTHM College station. Similar to the other pollutants, winter months show higher concentrations (note the values around January for all the years).

Throughout this period, the daily CPCB threshold was crossed on 778 days, with a majority of the crossings taking place between November and May.

4. Analysis of concentration of Carbon Monoxide

Figure 5-7 shows the measured hourly concentrations of CO at the KTHM College station. The winter months typically show spikes in CO values whereas concentrations are the lowest during the monsoon season.The annual average concentration of CO indicates the hotspot is situated in the centre of the city and towards south-east, near the railway station (Refer to Annex 2-7). Uncharacteristically, the

Figure 5-6: Hourly O_3 concentrations at KTHM College AQMS (Aug 2016 - Jun 2022)



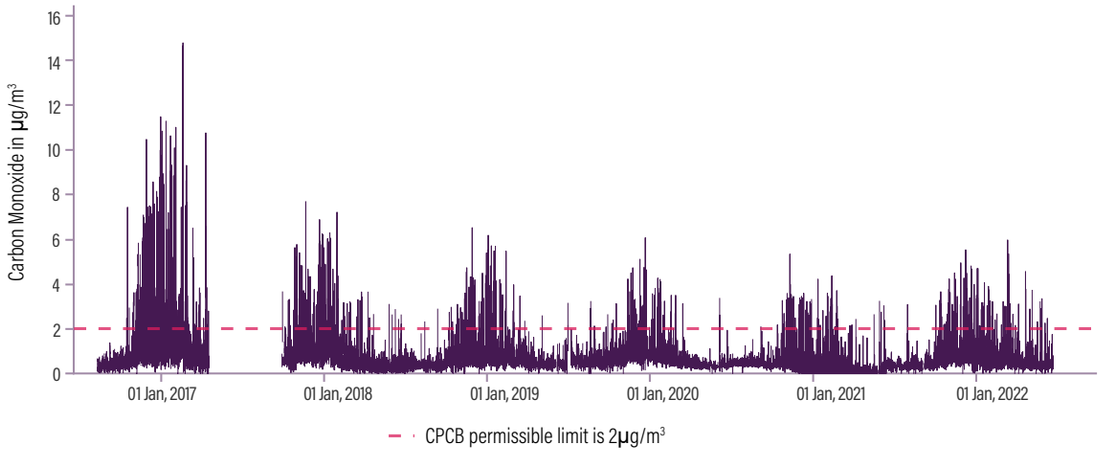
Source: *Central Pollution Control Board*

annual average CO concentrations appear to have increased during the COVID-19 lockdown. Stubble burning took place frequently during the summer of 2020 all across Maharashtra, which may explain these high annual average concentrations (Mohite & Sawant, 2022). Lastly, the lockdown may have pushed household dependency on diesel generator (DG) sets and the increased use of (polluting) cooking fuels could have added to the concentration levels. For the seasonal variations, refer to Annex 2-8.

5. Analysis of concentration of RSPM (PM_{10})

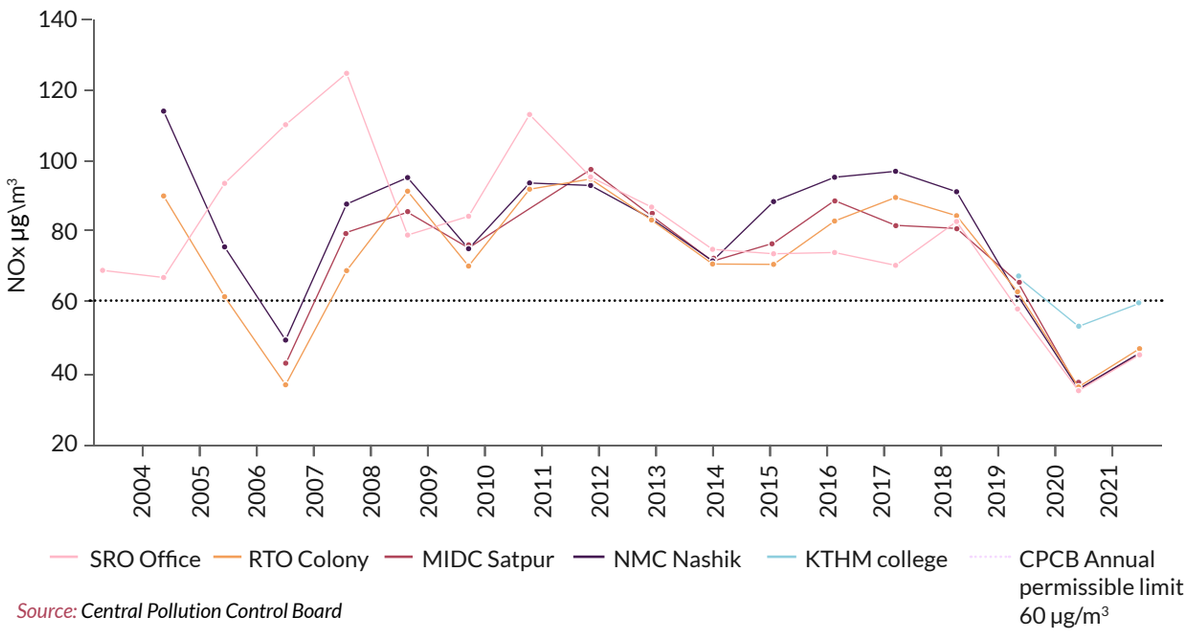
Figure 5-8 shows annual average concentrations of RSPM at the five manual stations. The markedly high values crossing the annual safety threshold of 60 µg/m^3 (black dashed line) are observed at all the stations, indicating non-attainment.

Figure 5-7: Hourly CO concentrations at the KTHM college air quality monitoring station between August 2016 and June 2022



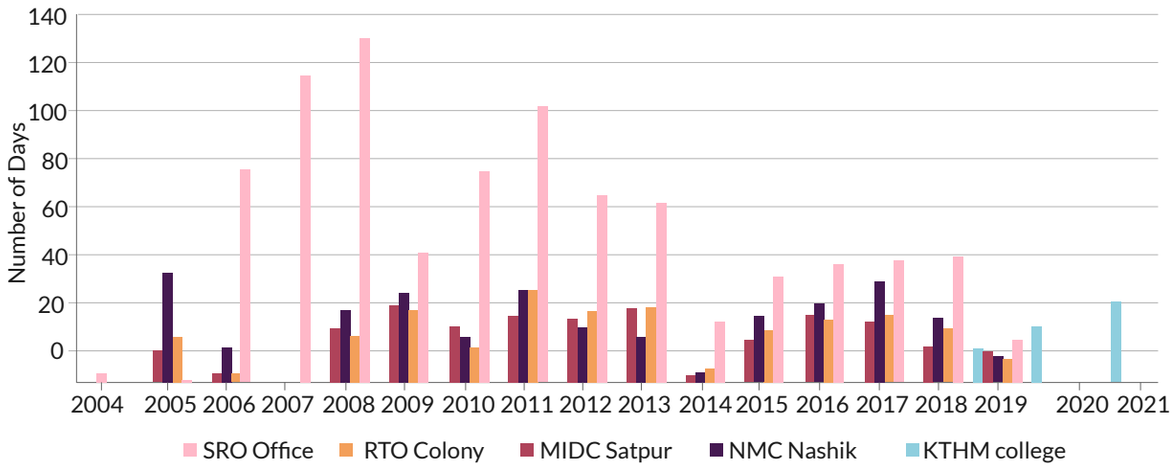
Source: *Central Pollution Control Board*

Figure 5-8: Annual average concentrations of RSPM/ PM10 across all the manual air quality monitoring stations in Nashik from 2004 to 2021



Source: *Central Pollution Control Board*

Figure 5-9: No. of days PM_{10} crossed threshold each year at all manual AQMSs (2004-2021)



Source: MPCB

The most common source of RSPM/PM_{10} emissions is suspended dust particles from road, construction sites etc., and, therefore, the phenomenon of non-attainment with respect to this pollutant is common across many Indian cities. Lastly, the sudden drop in values in 2020 at all the stations is most likely a clear effect of the COVID-19 lockdowns.

Figure 5-9 shows the number of days in each year that the CPCB daily threshold limit of 100 µg/m^3 was crossed at each of the five stations. Note that the stations at NMC, MIDC Satpur and RTO Colony are recording data points only twice a week and, hence, for these stations, the ideal number of data points per year should be around 105. However, SRO Office and KTHM College are reporting data points six and seven days a week, respectively.

Figure 5-9 shows that the station at SRO Office has the highest number of days when the RSPM threshold was crossed. This could be due to the heavy residential land-use in the vicinity of this station coupled with moderate to heavy traffic.

Similarly, the analysis of hourly concentrations of PM_{10} at the KTHM College station shows the numerous instances of concentrations breaking above the stipulated daily safety limit of 100 µg/m^3 (Refer to Annex 2-9).

When aggregated to the daily scale, the daily averages were above the threshold on 16% of the days. This amounts to a total of 1,018 days, with a majority of these crossings observed between November and May.

6. Analysis of concentration of Particulate Matter $PM_{2.5}$

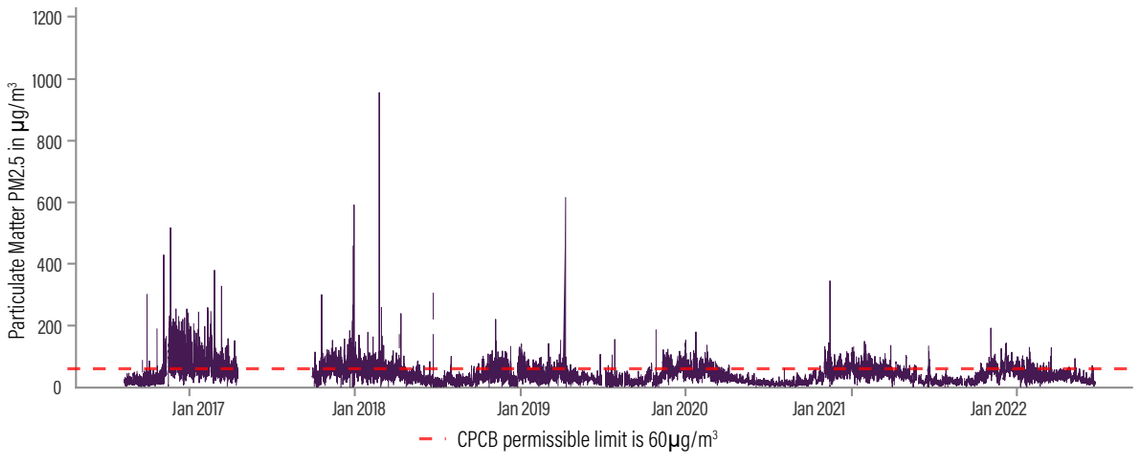
Particulate Matter 2.5 - fine fraction size up to 2.5 µm – contains airborne particles composed mainly of carbonaceous materials (organic and elemental), inorganic compounds (sulphate, nitrate and ammonium) and trace metal compounds (iron, aluminium, nickel, copper, zinc and lead) largely formed from combustion and vehicular emissions (CPCB, 2020). Due to the extremely small size, these are easily breathable and give rise to several health issues. Figure 5-10 shows the measured hourly concentrations of $PM_{2.5}$ at the KTHM

College station. Note the numerous instances of concentrations breaking well above the daily CPCB safety threshold (red dashed line). Also, the highest concentrations are observed in the winter season, around January each year.

A comparison of $PM_{2.5}$ for the years 2019 and 2020 shows that the number of days when $PM_{2.5}$ levels breached the annual limit was 141 in 2019 and 121 in 2020 (Refer to Annex 2-10). This decrease reflects the COVID-19 lockdown period in 2020. While the 2019 monsoons had numerous peaks, 2020 had a more conspicuous gap from April to October.

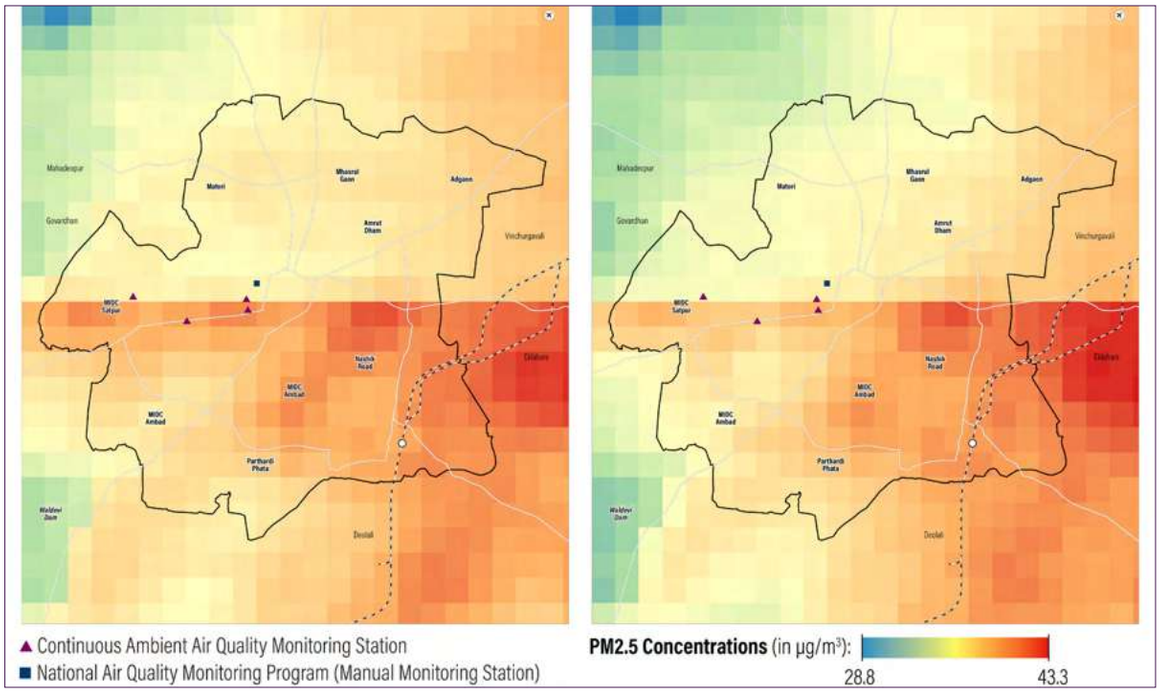
In Nashik, 18% of the daily average concentrations are above the daily threshold of 60 µg/m^3 in the duration considered (from August 2016 to June 2022). The total activity shutdown during the COVID-19 lockdown also led to a decrease in the concentrations in the middle of the year, between April and September (Refer to Annex 2-11). With regards to the spatial analysis, unlike other pollutants, $PM_{2.5}$ dataset is only available until December 2020, as shown in Figure 5-11. Also, note that the data shows some distortion, as seen from the horizontal line across the map. Nonetheless, the observed hotspots correlate well with relevant activities on the ground. The westernmost hotspot near the Satpur MIDC is located near a group of industries, while the one southeast of Vaishnavi Park is located above a few warehouses and construction sites, which could be responsible for the higher concentration of dust particles in this area. Lastly, the easternmost hotspot outside the city limits is located directly above the Eklahare power plant.

Figure 5-10: Hourly $PM_{2.5}$ concentrations at KTHM College AQMS (Aug 2016 - Jun 2022)



Source: *Central Pollution Control Board*

Figure 5-11: Annual average concentrations of $PM_{2.5}$ in Nashik during 2019-2020



Source: WRI India using Sentinel data

5.2.2 Source apportionment study – key findings

The source apportionment study carried out for the city of Nashik in 2017 by IIT-B and NEERI provides an emissions inventory to understand domestic and commercial activities, along with a spatial representation of the pollutant concentration caused by all sources.

1. Pollutant and sources

Contribution of PM arises from multiple sources, of which the significant numbers are: 12.55% from area sources of which 9.07% comes from building construction activity, 36.67% from point sources and 33.08% from unpaved road dust (Refer to Figure 5-12).

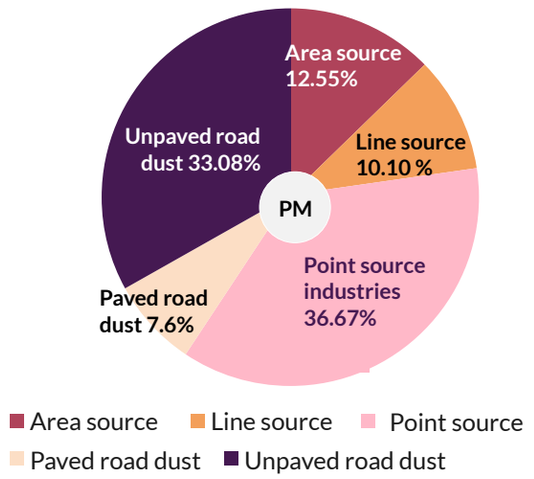
The emission load of PM is high due to burning of biomass, coal, and wood as sources of power in different industrial processes of Nashik region. The highest PM emission load was calculated from bagasse (48.1%), followed by coal (33.9%) and wood (17.4%). Increased building construction and development in the peripheral areas of the city contributes to emissions from area sources. Point sources (industries and allied activities) contribute 89% SO2, 96% CO and 60% HC. The main pollutant from line sources is NOx, contributing 71% of the emission, as seen in Figure 5-13.

As part of the The Source Apportionment Study, a hotspot map was developed, which is presented in Figure 5-14, it showcases the PM concentration due to all sources. The core city around Panchvati is a hotspot. Factors such as high density, large-scale commercial activity and concretisation along the river contribute to higher PM levels. Another area in the west of the city is demarcated as a

hotspot, where a concentration of brick kilns may be the reason for high PM concentration.

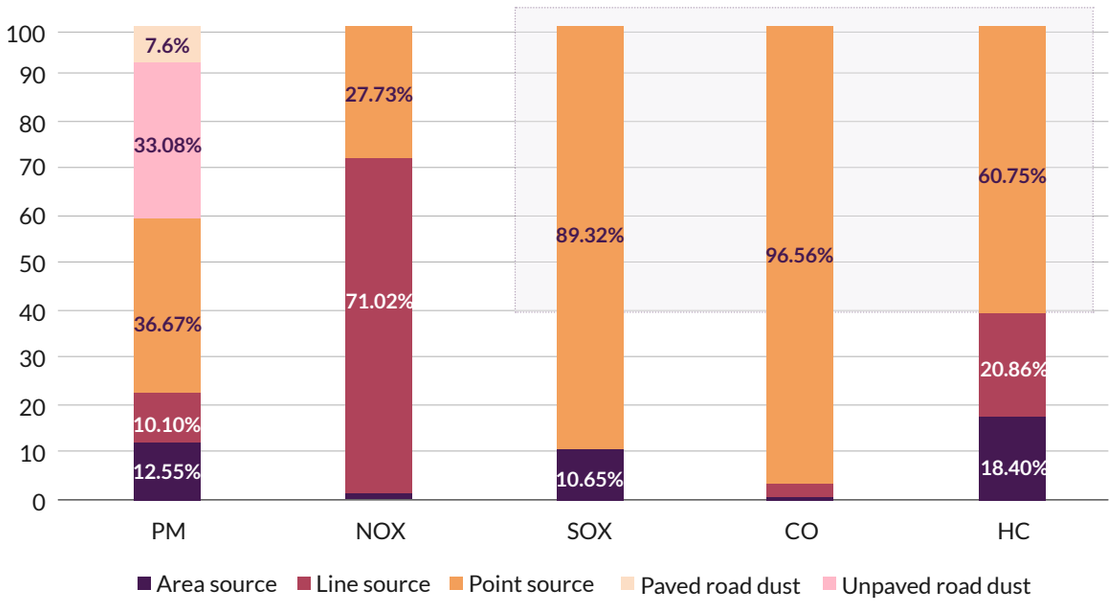
Similarly, hotspot mapping of NOx concentration due to all sources in Nashik in Figure 5-15 presents the core city as the primary contributor. This indicates that the vehicular movement may be the highest in the old city around Panchvati and acts as an area of intervention for vehicular and traffic management.

Figure 5-12: Primary sources of particulate matter in Nashik



Source: Source Apportionment Study, Maharashtra Pollution Control Board

Figure 5-13: Sources of pollution in Nashik City



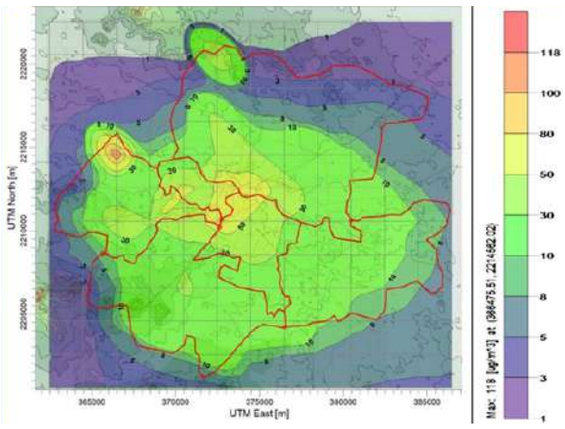
Source: Source Apportionment Study, Maharashtra Pollution Control Board

5.2.3 Indoor pollution analysis

$PM_{2.5}$ has numerous instances of concentrations breaking above the CPCB thresholds. Therefore, it is one of the major drivers for air pollution risk.

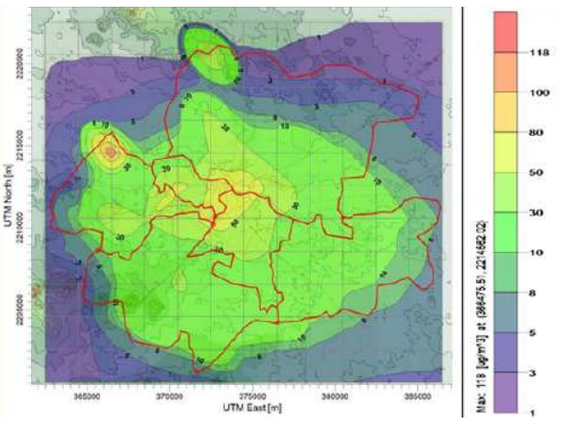
Indoor air pollution is often a forgotten aspect of air quality. However, various studies have shown that high concentrations of pollutants pervade Indian households. Of all the common domestic fuels, LPG, PNG, biogas and electricity

Figure 5-14: AERMOD predicted concentrations of PM due to all sources – Annual (Nashik city)



Source: Source Apportionment Study, 2017

Figure 5-15: AERMOD predicted concentrations of NOx due to all sources – Annual (Nashik city)



are considered as clean fuels while cow dung cakes, kerosene, coal/lignite/charcoal and firewood are considered as polluting fuels for which the exposure is computed using the $PM_{2.5}$ concentrations.

Figure 5-16 shows the concentration of $PM_{2.5}$ in the kitchen and living area, categorised according to the fuel type and based on the methodology adopted from Balakrishnan et al., 2013. The effect of the polluting fuels on the indoor concentration of $PM_{2.5}$ is clearly seen, with firewood and chips showing the highest $PM_{2.5}$ levels due to their usage followed by kerosene.

As per Census 2011 data, in Nashik, about 83% of the households are observed to be using clean cooking fuel (LPG/PNG, biogas, electricity) as the daily cooking fuel. However, the city is yet to achieve the benefits of the Pradhan Mantri Ujwala Yojana that targets 100% LPG prevalence.

Approximately 10% of the households are observed to be using kerosene as the daily polluting cooking fuel, with households in wards 56 (Salunkhe Nagar), 55 (Satpur Gaon/Swarbaba Nagar) and 108 (Chunchale) having the highest usage at 47%, 41% and 34%, respectively. Firewood is the next most used polluting cooking fuel, with 6% of the city households using it daily.

Figure 5-16: Daily avg. concentration of $PM_{2.5}$ in kitchen and living room for different types of fuels

Source: WRI India Analysis using Census 2011 data

Wards 60 (Ganjmal), 101 (near Pandav Leni Caves) and 98 (Bagul Nagar) have the highest consumption of firewood, at approximately 24%, 21% and 20%, respectively.

5.2.4 Health risk

Air pollution can lead to serious short-term and long-term impacts, both on human health as well as on the regional climate. In 2019, approximately four million people died from exposure to fine particulate outdoor air pollution, with the highest death rates occurring in East Asia and Central Europe. Exposure to $PM_{2.5}$ reduced average global life expectancy by approximately one year in 2019.[27]

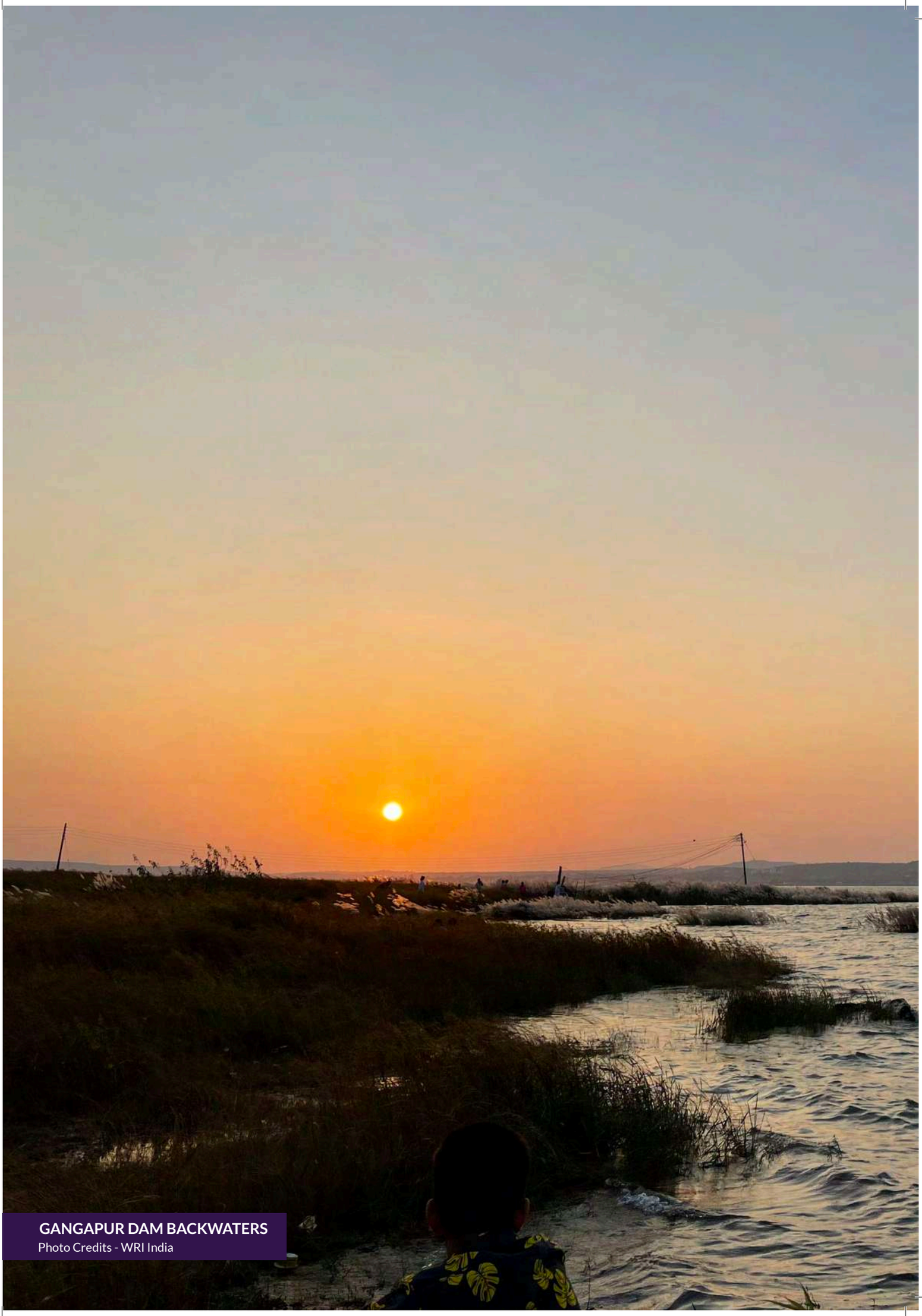
The deadliest illnesses linked to $PM_{2.5}$ air pollution are stroke, heart disease, lung disease, lower respiratory diseases (such as pneumonia) and cancer. High levels of fine particles also contribute to illnesses such as diabetes, can hinder cognitive development in children and cause mental health conditions.

The short-term health effects are well known and include various lung- and heart-related diseases, such as cough, difficulty in breathing and rapid buildup of calcium in the coronary artery leading to stroke and heart attack. Similarly, the short-term effects of declined air quality on the environment include increased apparent heat and pollution of waterbodies due to the dissolution of gaseous and physical particles. These conditions have impacts on humans inhabiting the environment.

5.3 DISCUSSION AND CONCLUSIONS

With increased population and urban expansion, the issue of air pollution has become critical in many Indian cities. As such, it is important to understand the key time periods as well as specific areas in the cities where pollution is the highest so that solutions can be implemented in the most efficient manner while ensuring economical use of resources.

In Nashik, $PM_{2.5}$ and PM_{10} are the pollutants that have crossed the CPCB safety thresholds at multiple stations in the city. Particulate matter is primarily sourced from industrial activities, road dust and construction sites. Temporal and spatial analyses show that the winter months have the worst air quality in terms of all the pollutants considered, owing to the environmental effects.



GANGAPUR DAM BACKWATERS
Photo Credits - WRI India

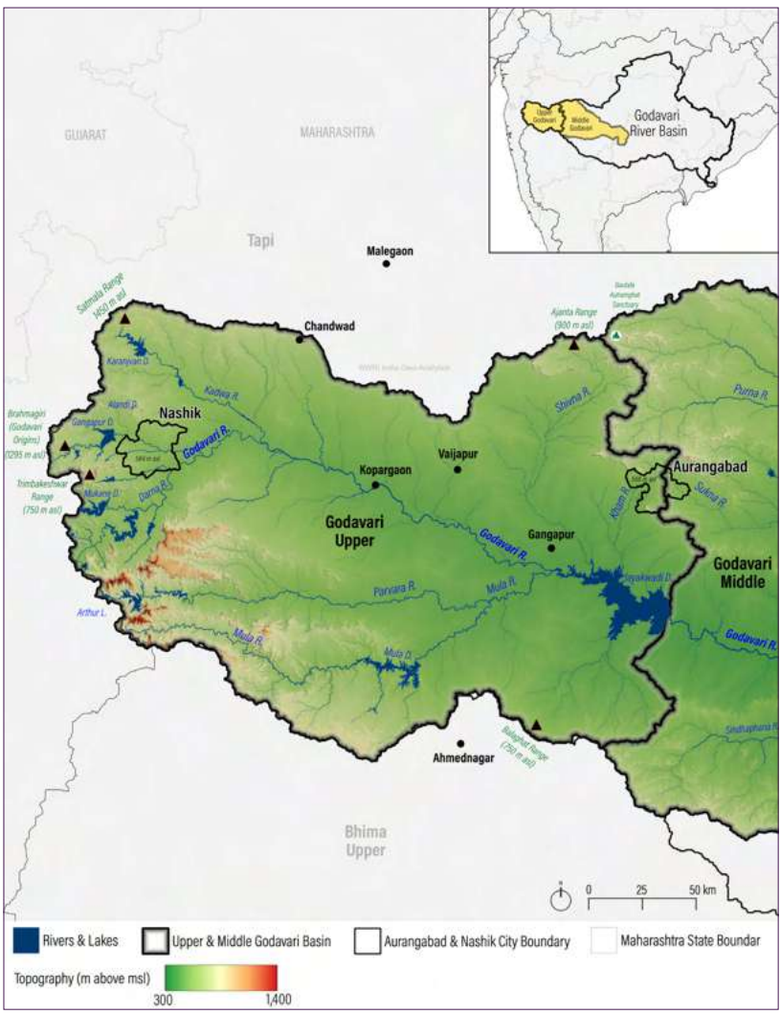
6. RAINFALL VARIABILITY AND WATER LOGGING

6.1 RAINFALL VARIABILITY

6.1.1 Regional setting

Nashik lies at an elevation of 584 m above sea level within the Upper Godavari sub-basin where the river finds its origin (~35 km west of the city). It fulfils its water demand from the various dams that lie to the west of the city and is mainly dependent on the Gangapur Dam. The main channel of the Godavari passes through the city, with many other first order streams that flow into the main channel from the north and the south. The city has an undulating to plain topography, with numerous hills that are dispersed across the city. To understand the risks of water availability for the city, analyses are carried out at a regional (sub-basin) scale. The dynamics of the surface and sub-surface water in the Upper Godavari basin along with the numerous dams directly impacts the water security of Nashik.

Figure 6-1: Regional setting of Nashik city located at the upstream reaches of the Godavari River in the Upper Godavari sub-basin



Source: WRI India using SRTM(USGS), CWC Streams, HydroBASINS level 4, HydroLAKES

6.1.2 Assessment

The assessment of rainfall variability is based on an analysis of two parameters: extreme rainfall events (EREs) and their impact on Nashik and the larger region. This analysis is carried out using rainfall data from IMD rain gauges in and around Nashik to assess the long-term variability of rainfall patterns, including intensity, duration and frequency (Refer to Annex 1-4). The city and adjoining region are dependent on water from the Gangapur Dam located ~15 km west of the city on the Godavari River. Data from three IMD stations within the NMC limits and four outside the city has been analysed. Data obtained from IMD is available at three stations within the city (at a daily resolution) and four other stations outside the city limits (at a monthly resolution).

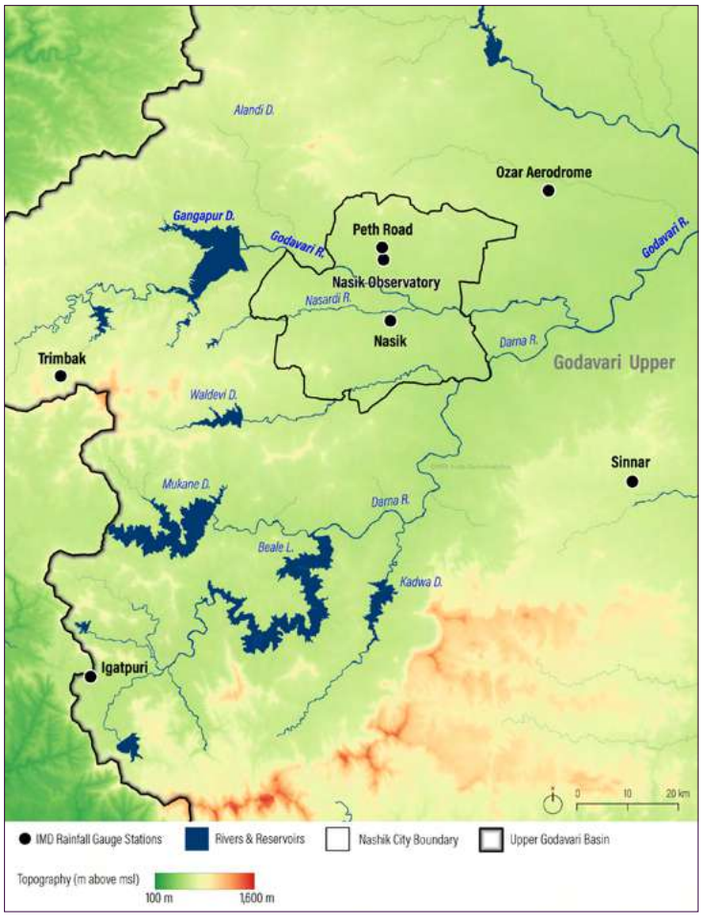
Climate trends are, in general, described as the average weather conditions of a particular place over a 30-year period. Therefore, the analysis is carried out using daily rainfall data from Nashik gauge station (50 years) located within the limits of the city boundary.

6.1.3 Key findings

1. Long-term rainfall trends

The mean annual rainfall in Nashik is approximately 780 mm, showing no significant trend. The average seasonal (accumulated)

Figure 6-2: Rainfall gauge network between Nashik and upper reaches of Godavari River



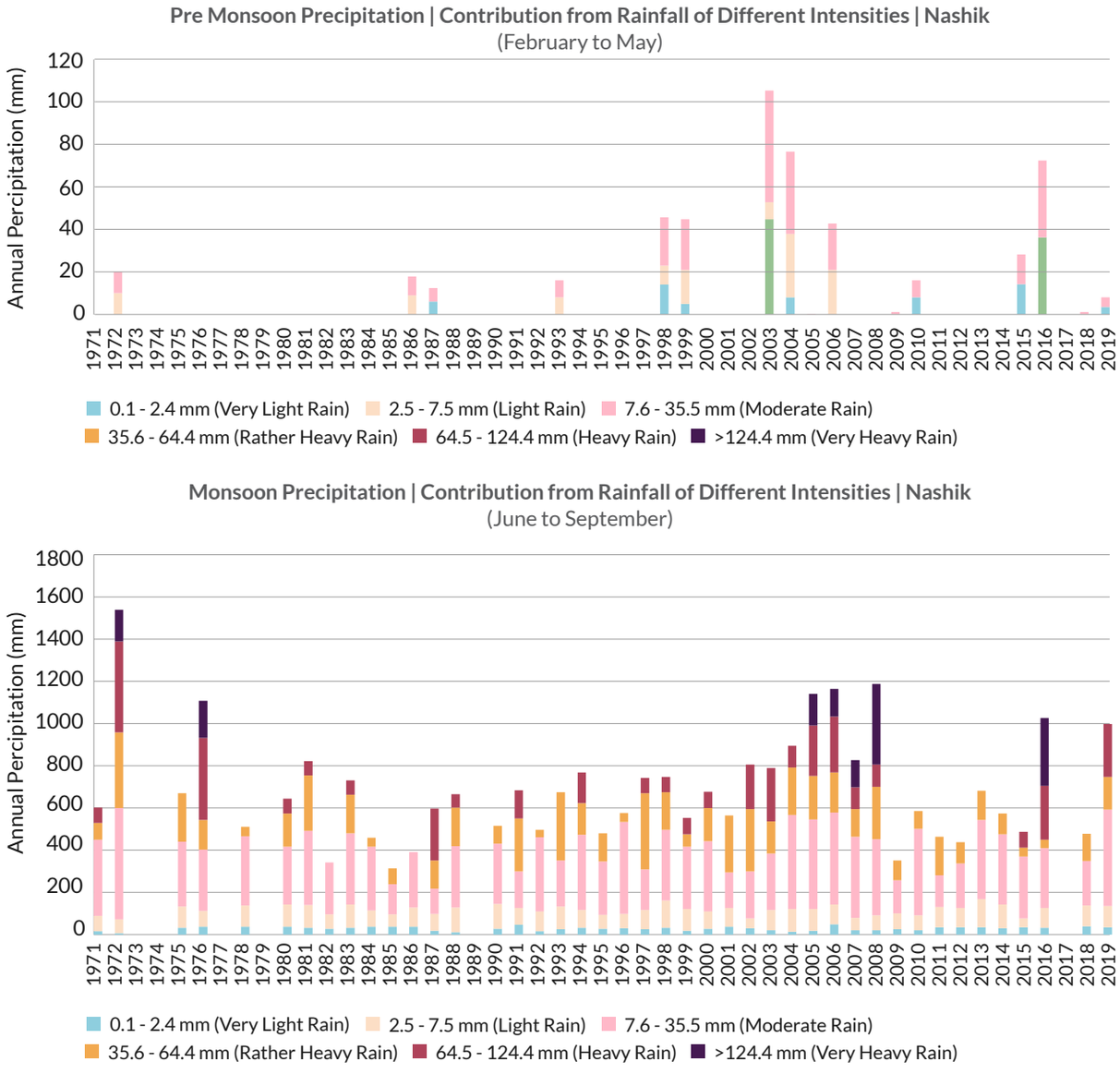
Source: WRI India using SRTM(USGS), CWC Streams, HydroBASINS level 4, HydroLAKES

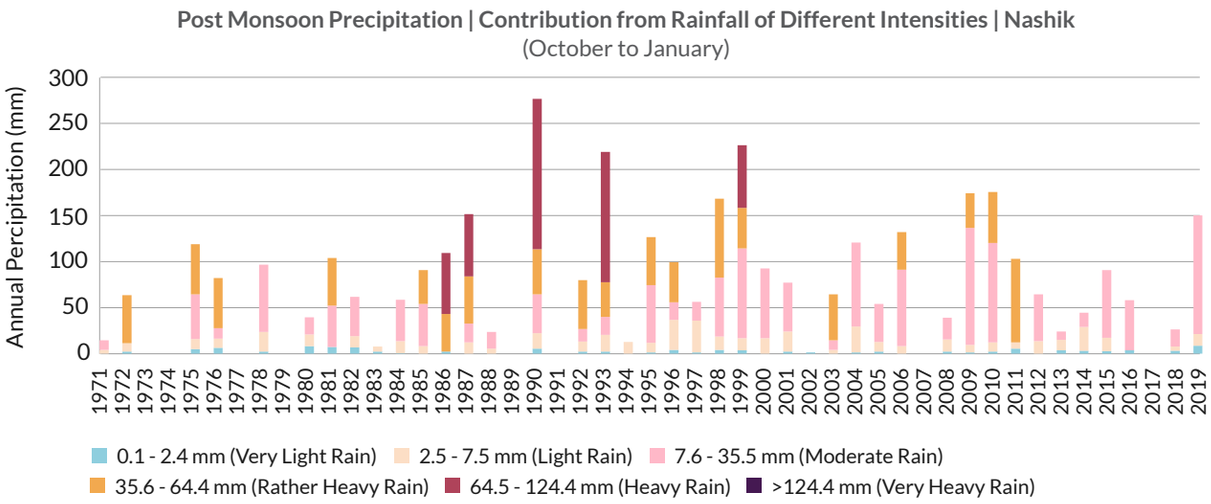
rainfall is ~10 mm pre monsoon, ~700 mm during monsoon and ~85 mm post-monsoon.

Nashik receives low intensity rainfall during the pre-monsoon months. There has been only one instance where the pre-monsoon accumulated rainfall was greater than 100 mm, refer to Figure 6-3. It does not rain more than 95% of the time. In the 5 decades of daily accumulated rainfall, during monsoon, there were 10 instances of Very Heavy to Extremely Heavy Rainfall and post monsoon, there were 7 instances of Heavy Rainfall (Refer to Annex 1-5). Pre-monsoon rainfall saw bouts of EREs during the first three decades. The contribution from these extreme events has increased in the last two decades. During monsoon, it does not rain 48%

The rainfall during the pre-monsoon season has a significant increasing trend of 0.24 mm/ year, while the monsoon and post-monsoon rainfall does not show any significant trend.

Figure 6-3: Seasonal accumulated rainfall with contribution from different Intensities at Nasik gauge station





of the time, low intensity rainfall events occur for another 48% of the time and EREs for the remaining 4% of the time.

2. Extreme Rainfall Events

The criteria used for classification of an ERE is based on the intensity of daily accumulated rainfall. Intensity is used to determine the probability of a single rainfall event that can overwhelm the drainage capability of hydraulic structures in a particular locality. IMD's classification scheme for 24-hour (daily) accumulated rainfall intensity is used to study ERE as follows — Very light, light, moderate, rather heavy, very heavy, and extremely heavy rainfall events.

- **Frequency and intensity of Extreme Rainfall Events**

  The ERE (rainfall more than 35 mm per day) in Nashik is usually of rather heavy intensity. There were 7 instances of Very Heavy and Extremely Heavy intensity events in the past 5 decades, of which 5 occurred in the past 20 years. There were only two extreme rainfall events o f Rather Heavy intensity, which have occurred during the pre-monsoon season. The frequency of rainfall is used synonymously with recurrence interval/return period. A frequency of 1% would correspond to an event with a 1 in 100 chance of being exceeded in any one year. A majority of the rainfall occurs during the monsoon months i.e. from June to September.

When it comes to understanding the dependency of the city on water resources and climate change, it is important to understand the spatial variation of rainfall in the watershed where the city is located. The rainfall patterns of the three IMD stations in Nashik were analysed to observe the inter-annual variation of different frequencies of EREs detailing the recurrence of different intensity rainfall events in the region. The city frequently receives rainfall of intensities varying from Rather Heavy to Extremely Heavy Rainfall. We see that the spatial variation in frequency for the three stations is similar, given that they all lie in proximity within the city limits (Refer to Annex 2-13).

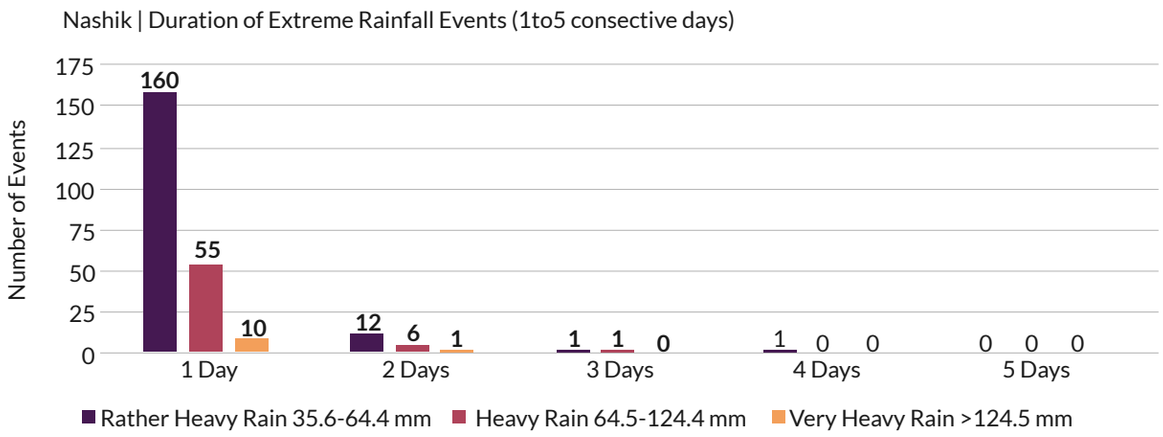
- **Duration of Extreme Rainfall Events**

  The analysis shows that the region receives rainfall lasting for either one or two days, with no occurrences where the rainfall continues for 3-5 days. Most EREs tend to last for 1-2 days, as seen in Figure 6-4. In the last five decades, the frequency of two different intensities were 1% of Rather Heavy rainfall, 0.35% of Heavy rainfall and 0.06% Very Heavy to Extremely Heavy rainfall.

The number of extreme events with frequencies of 1 – 9 % during monsoon in the last two decades has increased. The number of extreme events during post-monsoon (Oct-Jan) has decreased and has frequencies of 1 – 3% in the last two decades.

(Refer to Annex 2-12)

Figure 6-4: Duration of Extreme Rainfall Events based on Intensity and No. of Events (1970 – 2020)



Source: WRI India using meteorological data from IMD

6.2 WATER LOGGING/ URBAN FLOODING RISK

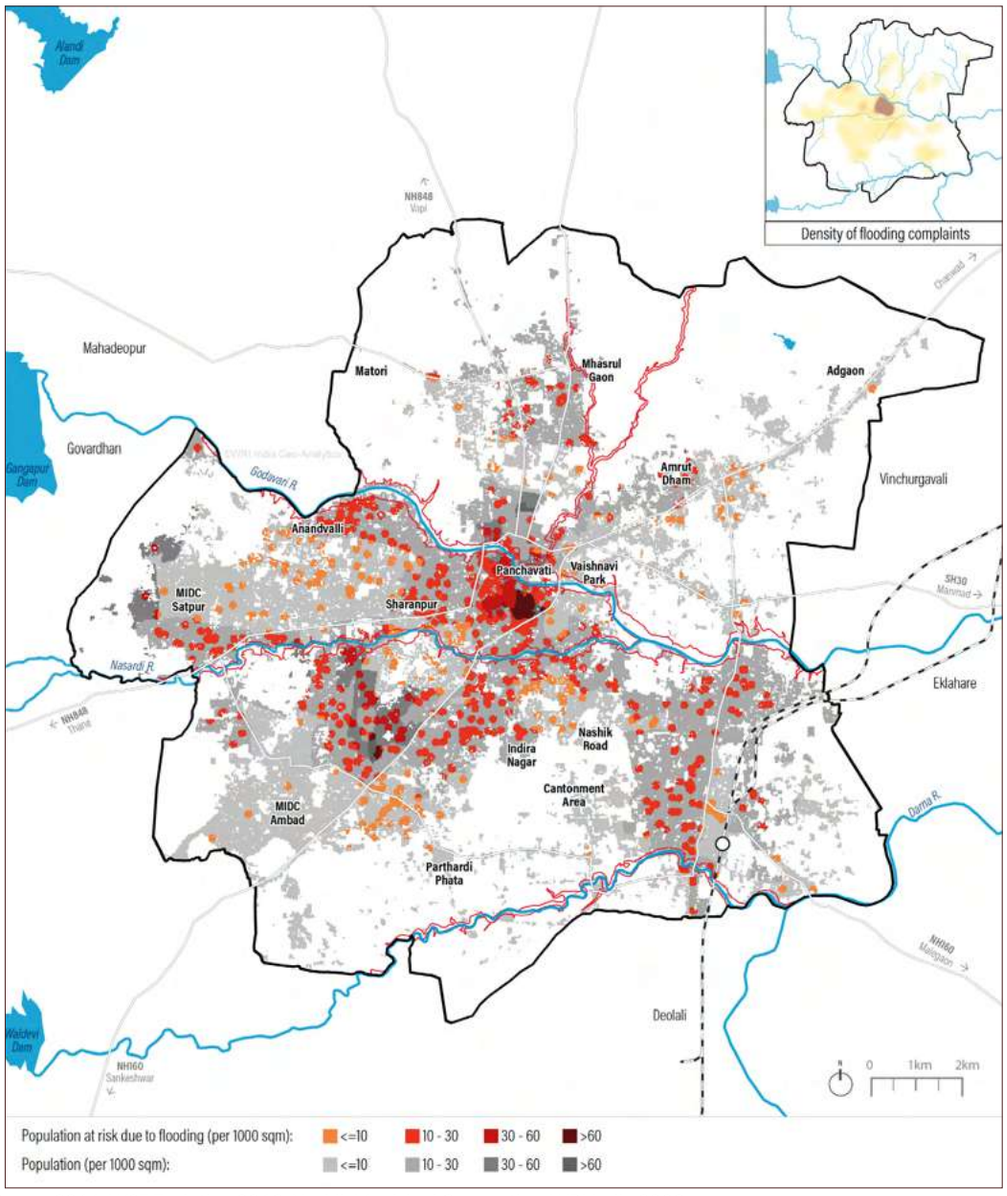
This parameter is used to spatialise the risk caused by flooding. Identifying differential impact would be facilitated by correlating flooding hotspots with population density, informal settlement locations and the degree of jobs and public transportation that would be affected. The Disaster Management Department, NMC, has compiled a list of places that have experienced recurrent flooding. Additionally, waterlogging/ flooding complaints data has been collated from the Maza Mahapur App and NMC's e-Connect App.. The effects of flooding on the population, informal settlements, jobs and public transportation have been assessed using a 100-meter buffer zone surrounding the affected areas.

6.2.1 Flooding hotspots and population affected

Based on the flooding data from NMC, it can be observed that the concentration of flooding hotspots is very dense within the central region of the city. This region has a dense built-up area as compared with the periphery of the city.

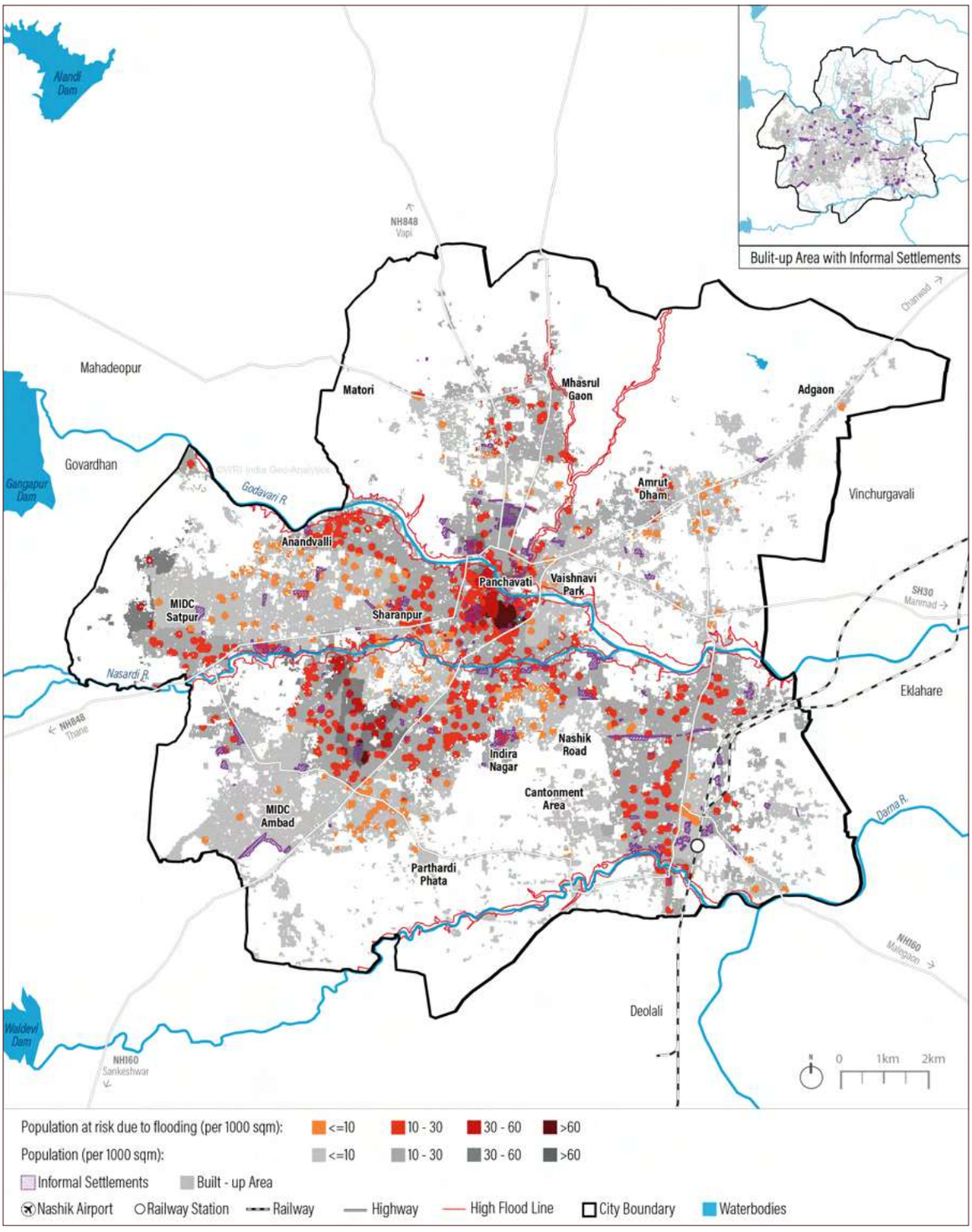
Overlaying the hotspots with the population density and subsequent intersection with the ward boundary helps in identifying vulnerable communities to streamline action on ground. Within NMC, 23% of the population is within a 100m buffer of these flooding hotspots (Refer Figure 6-5).

Figure 6-5: Population potentially at risk due to flooding



Source: Census 2011, WSF Evolution 2019, Nashik Municipal Corporation, WRI India 2022

Figure 6-6: Population (along with informal settlements) potentially at risk due to flooding



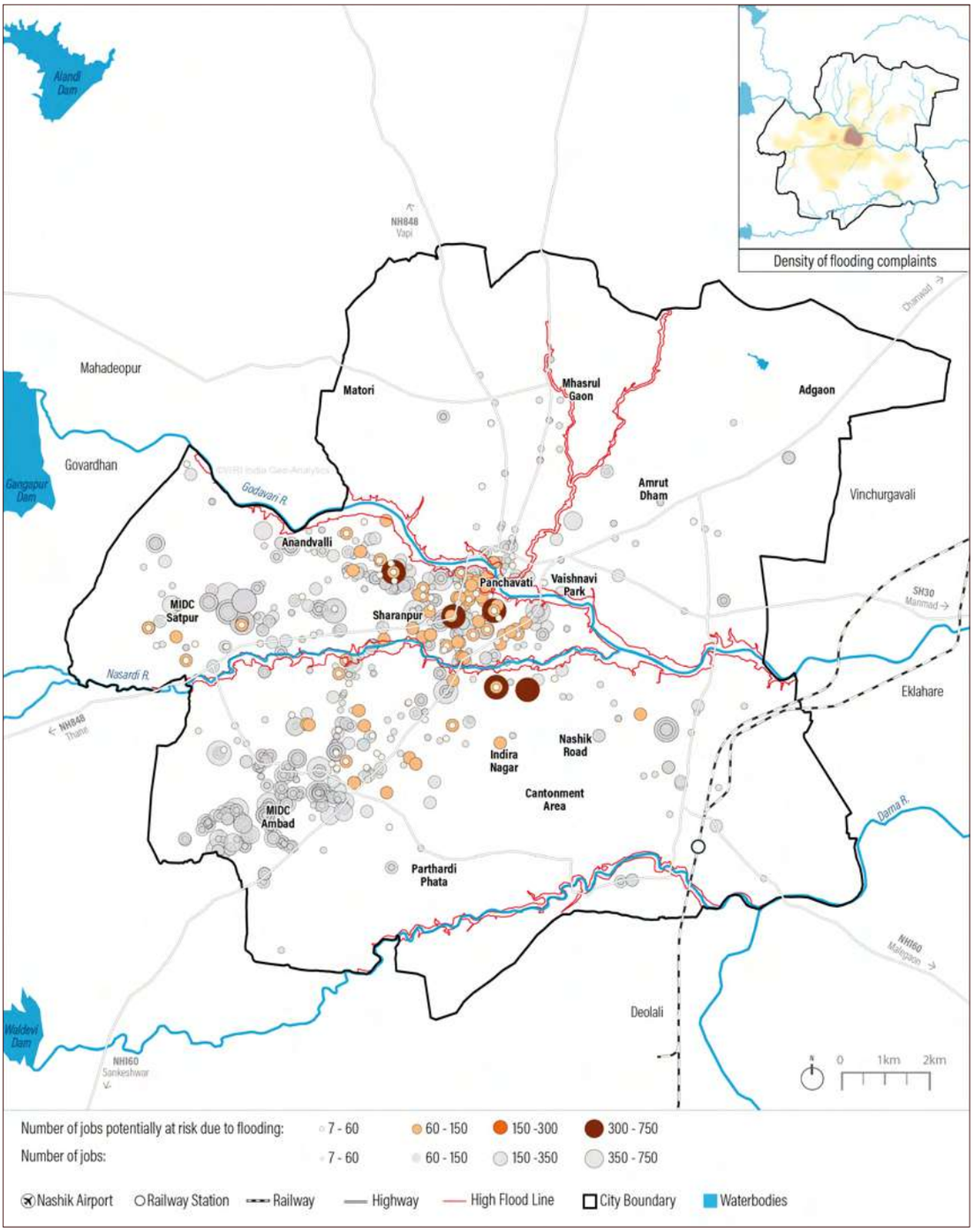
Source: Census 2011, WSF Evolution 2019, Nashik Municipal Corporation, WRI India 2022

6.2.2 Flooding hotspots and informal settlements

There are 172 locations of informal settlements identified by the NMC, where nearly 12.77% of the population dwells (as per Census 2011).

Of these, 73 locations are exposed to recurrent flooding i.e., 42% of the informal settlements are affected by floods (Refer to Figure 6-7).

Figure 6-7: No. of jobs potentially at risk due to flooding



Source: Directory of Establishments – 6th Economic Census 2015, NMC, WRI India (2022)

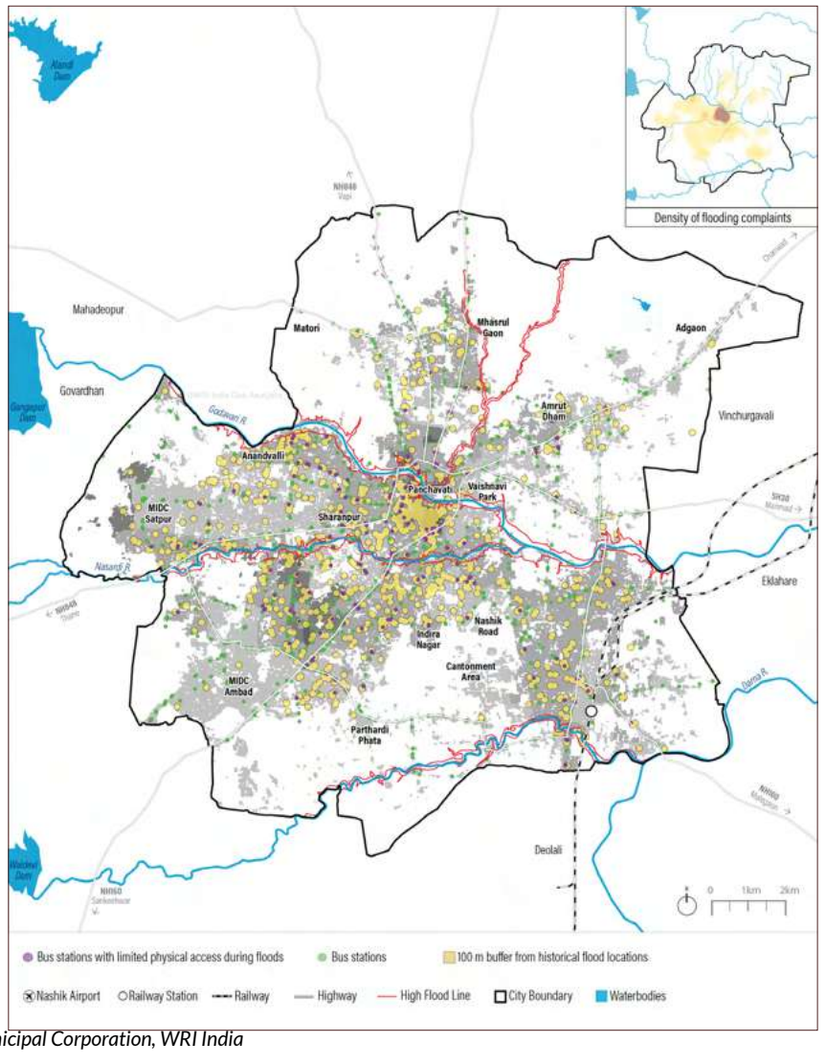
6.2.3 Effect of flooding on jobs

The 100m buffered flooding hotspots was overlayed with employment data obtained from Directory of Establishments. Recurrent flooding events limit the means to access business centres and impact daily wage/industrial jobs the most (UNICEF, 2021). Employment/jobs of 13% of the population is affected due to flooding. A majority of the jobs (>70%) that are affected by flooding are in 12 wards (18, 40 – 44, 52, 62, 79, 82, 88 and 93) (Refer to Figure 6-6).

6.2.4 Effect of flooding on public transport

The 100m buffered flooding hotspots was used along with the locations of bus stops within the city. Recurrent flooding events affects the accessibility to public transport, and this, in turn, affects the way the public moves around the city. Of the 108 wards present in the city, 20 wards are affected, where more than 50% of the population will have reduced access to public transport. The wards (60, 44, 28, 41, 62, 59, 23 and 61; in decreasing order of magnitude) that are affected the most are concentrated in the central and western parts of the city (Refer to Figure 6-8).

Figure 6-8: Public transport affected due to flooding



Source: Nashik Municipal Corporation, WRI India

PANCHAVATI
Photo Credits - Ar. Janhavi Shinde

7. DROUGHT RISK

A drought occurs when it rains less than usual in one place for a long time. When it does not rain for a long time, the amount of available water decreases. This means that there is less water in the soil, more water is drawn from the ground and less water flows through streams. As compared with other risks, it is harder to know when a drought will begin and end. Depending on how long sufficient water is unavailable, droughts take place in a particular order: meteorological drought, hydrological drought, agricultural drought followed by socioeconomic drought. Drought is a gradual process that occurs in stages that are characterised by changes in precipitation, soil moisture, stream flow and other indicators of water availability. Typically, the stages of drought are as follow:

- Meteorological drought: This is the initial stage of drought, characterised by a prolonged period of below-normal precipitation. This can lead to lower-than-normal stream flow and reservoir levels.
- Hydrological drought: This stage occurs when the lack of precipitation leads to lower-than-normal surface and groundwater levels. This can result in reduced availability of water for various uses, such as irrigation and drinking water.
- Agricultural drought: This stage occurs when the lack of water affects the growth and yield of crops. This can lead to reduced crop production and income for farmers.
- Socio-economic drought: This is the final stage of drought, characterised by the social and economic impacts of the previous stages. This can include food and water shortages, loss of livelihoods and increased poverty and migration.

It is important to note that the stages can occur in succession, one leading to the next, but also that not all droughts progress through all the stages. Additionally, the time frame for each stage can vary, depending on the severity of the drought and the climate of the region. Droughts can be long-term or short-term and irregular and unpredictable. So, it is important to be prepared to face them.

7.1 ASSESSMENT

The assessment of drought risk is based on analysing the probability of drought at a sub-basin scale. This analysis is carried out by using rainfall data from IMD gridded rainfall data. First, the percentage of each grid's annual deficit for each year is worked out. There are three classifications of meteorological drought: normal (25%), moderate (26–50%) and severe (>50%). The probability of drought is obtained by finding the frequency of drought that exceeds 25% during the duration of 70 years considered for the analysis (Refer to Annex 1-6).

7.1.1 Probability of Meteorological Drought

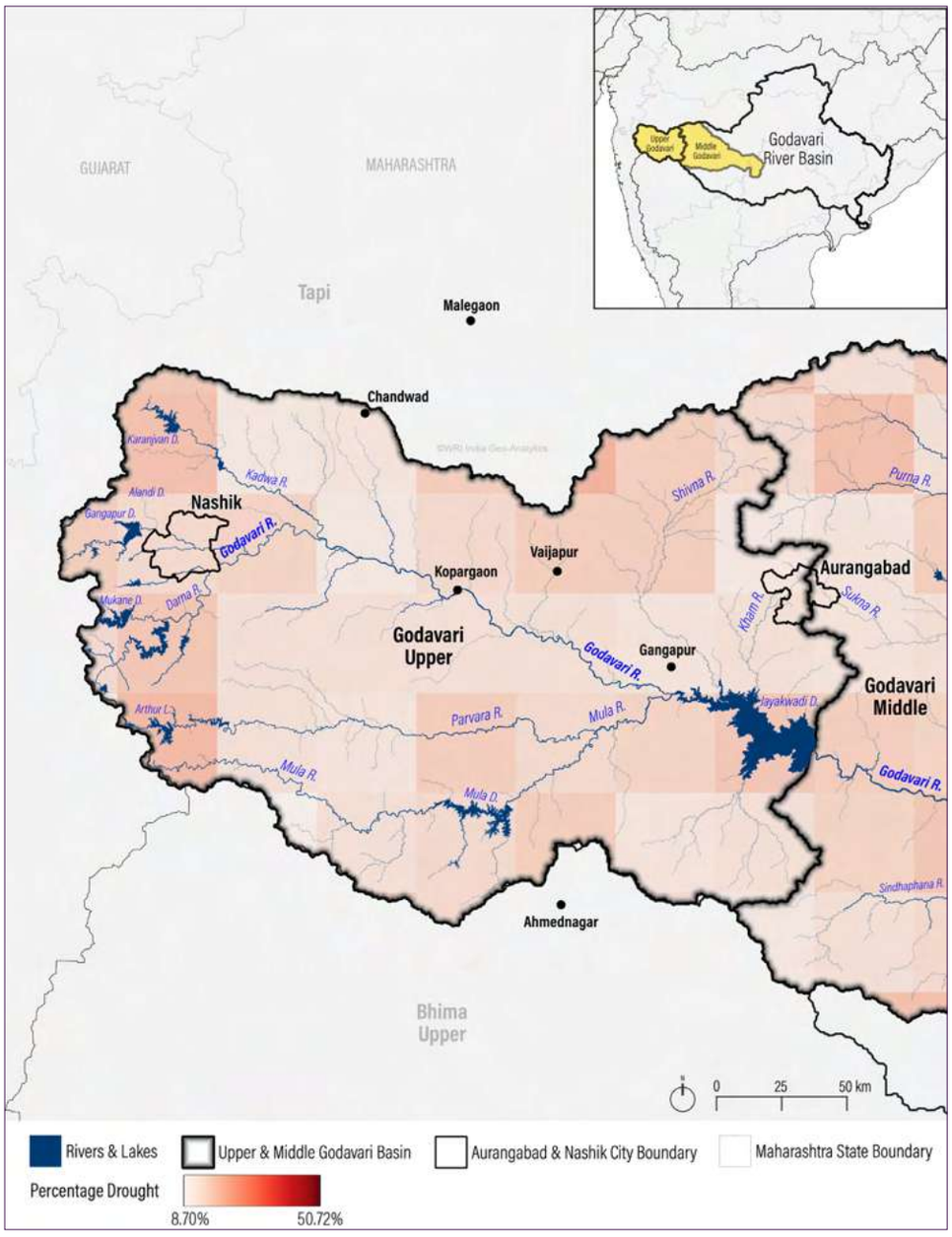
The probability (expressed as a percentage) of meteorological drought is calculated for each grid in the Upper Godavari sub-basin.

- For the catchment, the chance of drought is between 8% and 50%.
- Nashik is located ~15km downstream from where the Godavari River originates. The

city has four IMD grids across its extent. The probability of meteorological drought is obtained by calculating the mean of the values for the four grids, which is 16%.

- Since the probability of drought is less than 25%, the city falls within the 'normal' drought condition. The region lying in the head reaches of the Godavari, where it originates, has several reservoirs/dams that impound water and is significant for Nashik city's water security. Any water stress experienced in this region would exacerbate the risk to the city's water availability (Refer Figure 7-1).

Figure 7-1: Probability of Meteorological Drought using historical rainfall for the period 1951 - 2020

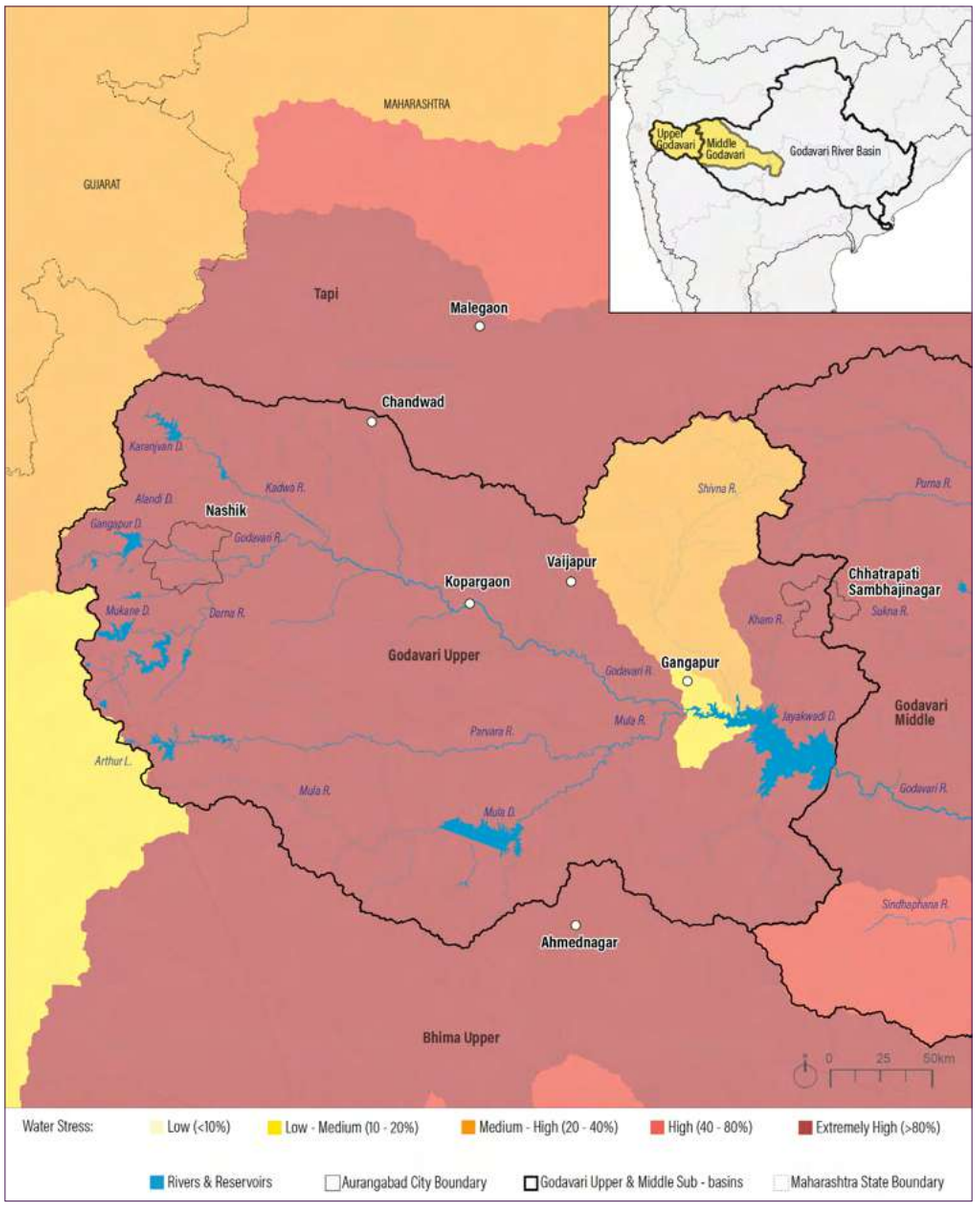


Source: WRI India using IMD Gridded Rainfall, SRTM Topography, CWC Streams, HydroBASINS and HydroLAKES

7.1.2 Water Stress

According to WRI Aqueduct, Nashik district has a high baseline water stress, which means that the district is already using or overusing a significant portion of its available water resources. Additionally, the city of Nashik has a high (40-80%) to extremely high (>80%) level of water stress, which indicates that the city is facing a significant amount of competition for its water resources from various sectors, such as agriculture, industry and households (Refer to Figure 7-2). This can lead to a shortage of water for various uses and may also cause conflicts between different users of the water.

Figure 7-2: Water stress

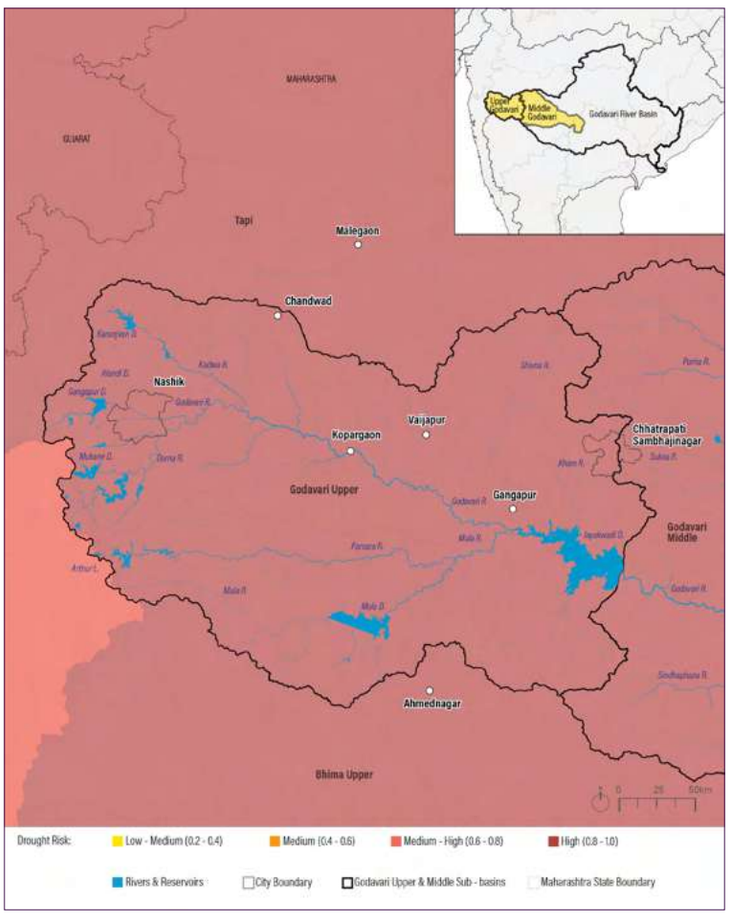


Source: WRI India using WRI Aqueduct

The state of Maharashtra is facing severe drought risk. The Upper-Godavari sub-basin, in which Nashik city is located, has a high (0.8 – 1.0) drought risk (Refer to Figure 7-3). Drought risk measures the locations where droughts are likely to occur, the population and assets exposed and the vulnerability of the population and assets to adverse effects. Higher values indicate a higher risk of drought (WRI Aqueduct, 2019). The reasons for this can be attributed to the decrease in rainfall and over-extraction of groundwater. Drought conditions can lead to crop failures and loss of livelihoods for farmers and water scarcity for drinking and other daily uses as well as exacerbate poverty and food insecurity in the region.

The over-extraction of groundwater from underground aquifers leads to land subsidence. When pumping is done at a rate faster than the rate of replenishment, the underground spaces that were once filled with water can collapse, causing the land above it to either sink or subside. This can lead to several problems, such as damage to buildings and infrastructure, flooding and changes in the local hydrology. It is important for the local government and other organisations to take steps to manage groundwater resources sustainably to prevent or mitigate land subsidence.

Figure 7-3: Drought risk



Source: *WRI India using WRI Aqueduct*

7.2 GROUNDWATER MANAGEMENT

7.2.1 Stage of Groundwater Development

The stage of groundwater development is the ratio of the annual groundwater draft to the net annual groundwater availability, expressed as a percentage. Simply put, it is the ratio of the actual groundwater extraction to the permitted groundwater extraction, as a percentage. The stage of groundwater development is categorised as safe (<70%), semi-critical (70-90%), critical (90-100%), and over-exploited (>100%). The stage of groundwater development was obtained from various reports from Central Ground water Board (CGWB). Several districts of Nashik exhibit a variation from semi-critical to safe (Refer to Annex 1-7 and Figure 7-4).

7.2.2 Groundwater Recharge Potential

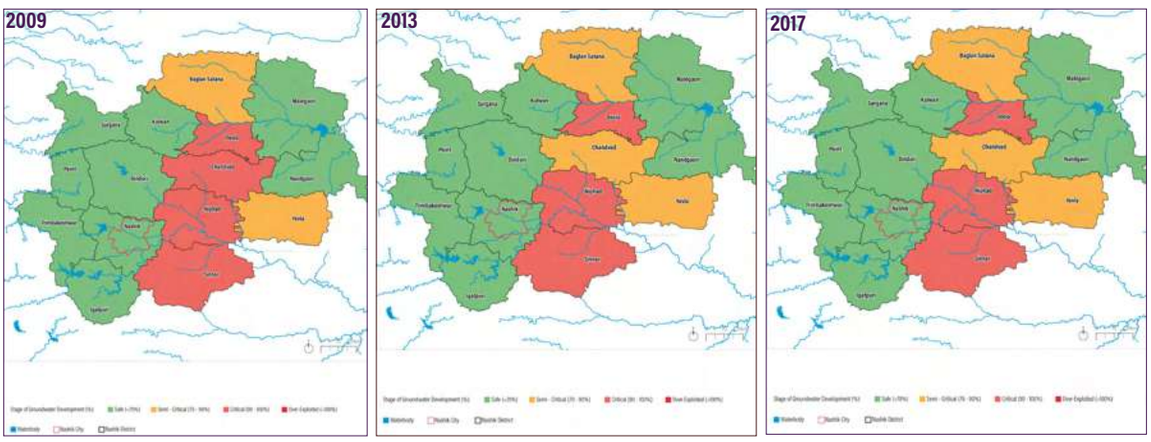
1. Assessment

One of the problems faced by Nashik is that it is water stressed. Most of the water resources available from the Gangapur Dam is utilised for domestic and irrigation purposes. Understanding the dynamics of surface water infiltration into the ground will aid in the identification of places facing imminent danger of decreased groundwater availability, which could then alter the quality of groundwater in aquifers. The groundwater recharge potential (GWRP) is estimated using three parameters – average annual rainfall (using IMD gridded daily rainfall), slope of the terrain (obtained from topography/DEM) and the conditions of the vegetation, soil and land-use (represented by NDVI). Depending on the rainfall, slope and NDVI classification, a weighted mean is used to calculate the GWRP on a scale of 0 to 5; 0 is no recharge, 1 is low recharge potential and 5 is high recharge potential. The GWRP for Nashik city was obtained for two years – 2000 and 2020. These two GWRP time periods were compared to find the percentage change in the recharge potential at each grid (resolution of 30m).

2. Groundwater Recharge Potential for years 2000 and 2020

The city exhibits a 'moderate' GWRP throughout its limits while the GWRP is 'good' around the

Figure 7-4: Stage of groundwater development for Nashik District



Source: WRI India and CGWB publication 2019

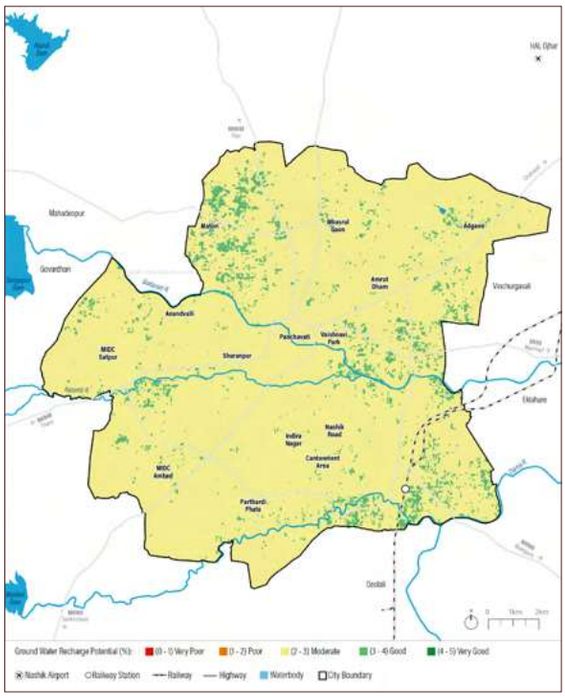
waterbodies as well as towards the west of the city along the Godavari River. The region to the south of the city has seen an increase (moderate to good) in GWRP in 2020 as compared with the year 2000 (Refer to Figure 7-5).

Table 7-1: Datasets used and its spatial and temporal details

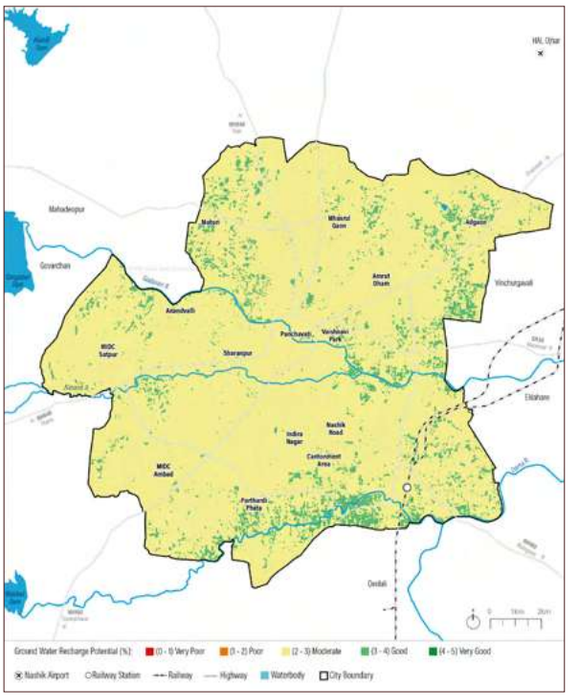
Dataset	Description	Resolution	Reference Period
Historical Rainfall	Long-term mean annual rainfall	0.25 degree	1951 - 2020
Vegetation	Mean NDVI for two-time stamps	30 m	1999 – 2000 & 2019 – 2020
Terrain slope	SRTM DEM	30 m	2014

Figure 7-5: GWRP for two time-periods, two decades apart

Ground Water Recharge Potential (2000)



Ground Water Recharge Potential (2020)



Source: WRI India and CGWB publication 2019

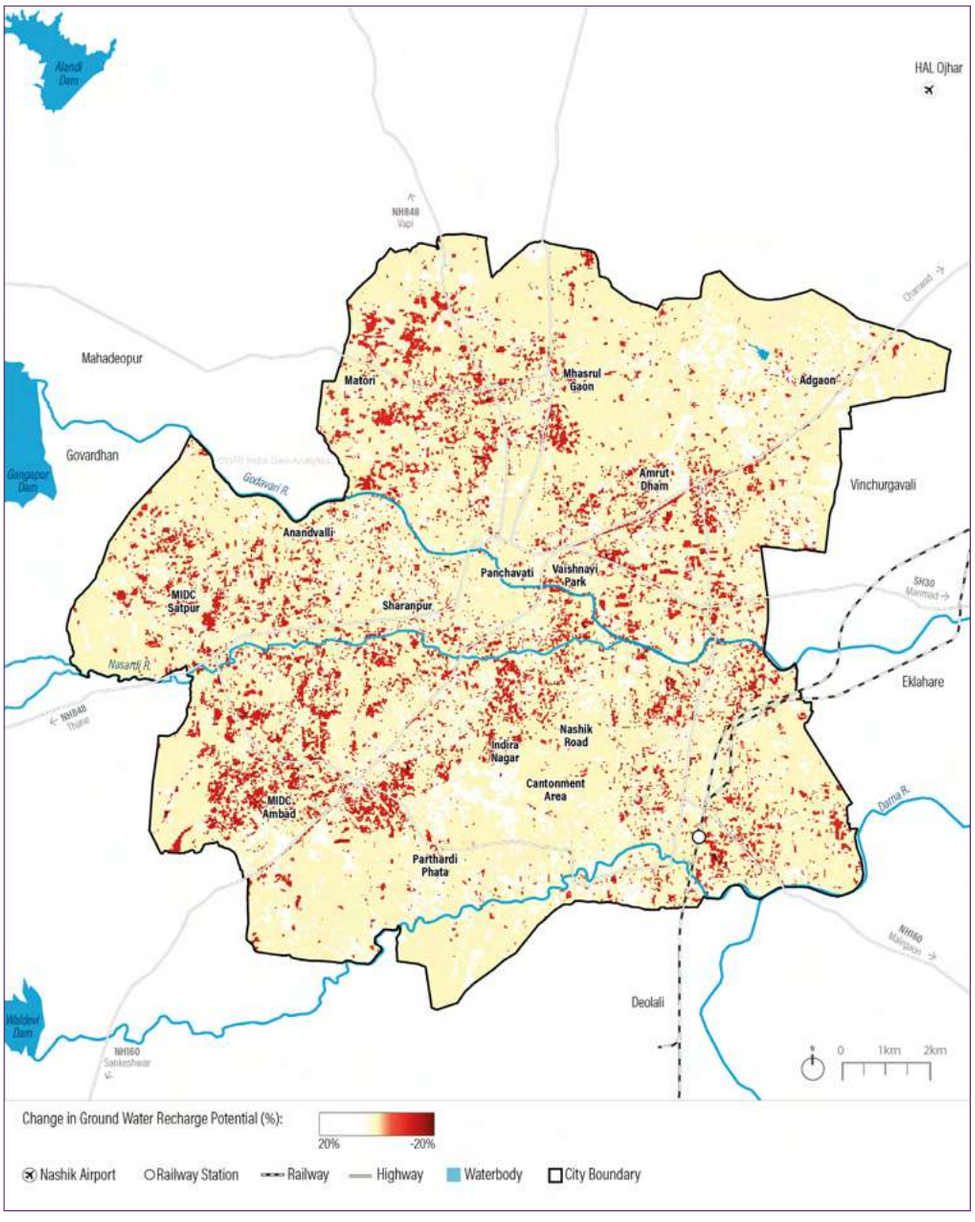
3. Change in Groundwater Recharge Potential

The change in GWRP is calculated as the ratio of the change between 2000 and 2020 to the conditions of the year 2000 and is expressed as a percentage. Figure 7-5 presents the areas that has a negative change in GWRP i.e. the excess water on the ground is no longer infiltrating into the GWT due to the impervious nature of the recently developed areas. The orange and red shades in Figure 7-6 are the regions

where new developments have taken place, causing the surface to become impervious and, therefore, decreasing the potential for surface water to infiltrate to the ground. These new developments could be anything from conversion of forested land to cropland, cropland to domestic settlements/industrial zones, extension of single-lane roads to multi-lane highway/expressway, etc.

These developments are scattered across the city, with least development towards the south and north-east regions of the city. The region to the west and south-west of the city has seen a growth in industrial activity over the past two decades, which has subsequently caused a reduction in GWRP.

Figure 7-6: Decrease in GWRP



Source: WRI India using IMD Gridded Rainfall, SRTM Topography, Landsat 7 NDVI

8. MULTI HAZARD ANALYSIS

Certain zones of the city are at the risk of more than one hazard. The concept of 'multi-hazard risk' refers to the overlap of urban neighbourhoods that are especially at danger from more than one climate-related threat. This analysis helps in identifying vulnerable zones where the city authorities can isolate at-risk populations/ industries on priority so that the necessary mitigation strategies (optimised to fit all the hazards) are deployed by the city authorities.

8.1 Context

The city of Nashik and surrounding hilly region are experiencing higher night-time LST along with an increasing trend of 0.6°C/ year. The central part of the city, which is densely populated with built-up, has a high concentration of flooding hotspots. The direct impact of urban flooding and LST may increase in the future. It is already impacting jobs, public transport and population living in the informal settlements exposed to recurrent flooding.

8.2 Methodology

The layers listed in Table 8-1 are overlaid for the multi-hazard analysis where the city's average LST is 32°C.

Table 8-1: Datasets used for multi hazard analysis

Layer	Source	Method Used
Land Surface Temperature	Landsat 8 (30m)	The pixels from the population layer falling in areas exposed to LST greater than 32°C are extracted.
Waterlogging	NMC eConnect App[28] Maza Mahapur App[29]	A buffer of 100m is considered from the identified hotspot.
Traffic congestion Hotspots	NMC, Environment Dept.	Mapping undertaken under NCAP

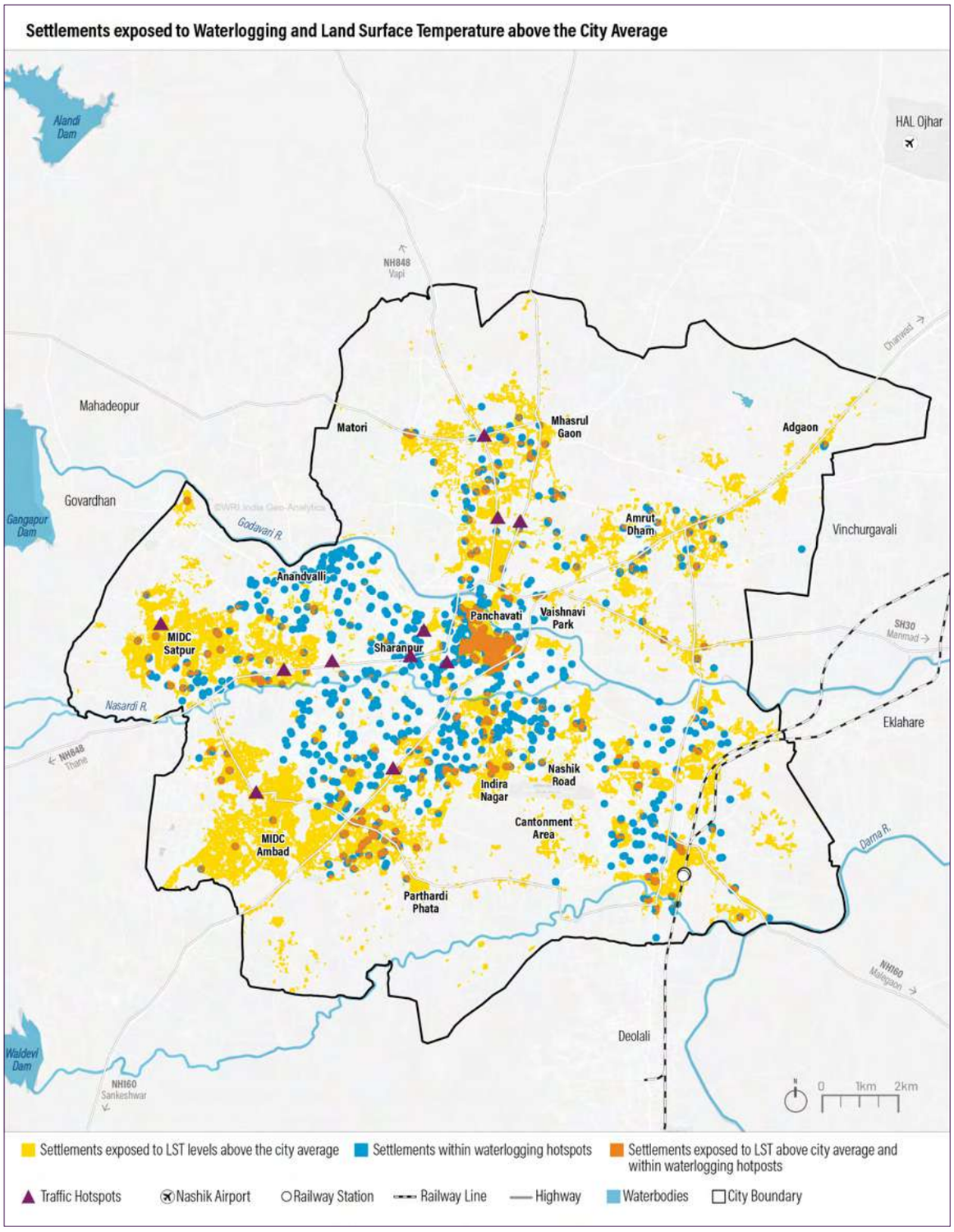
8.3 Key findings

The analysis shows that nearly 40% of Nashik's population is exposed to the LST above 32°C. A large chunk of this population lives in the western side of the city. Also, 23% of the population lives within the waterlogging hotspots spread across the city.

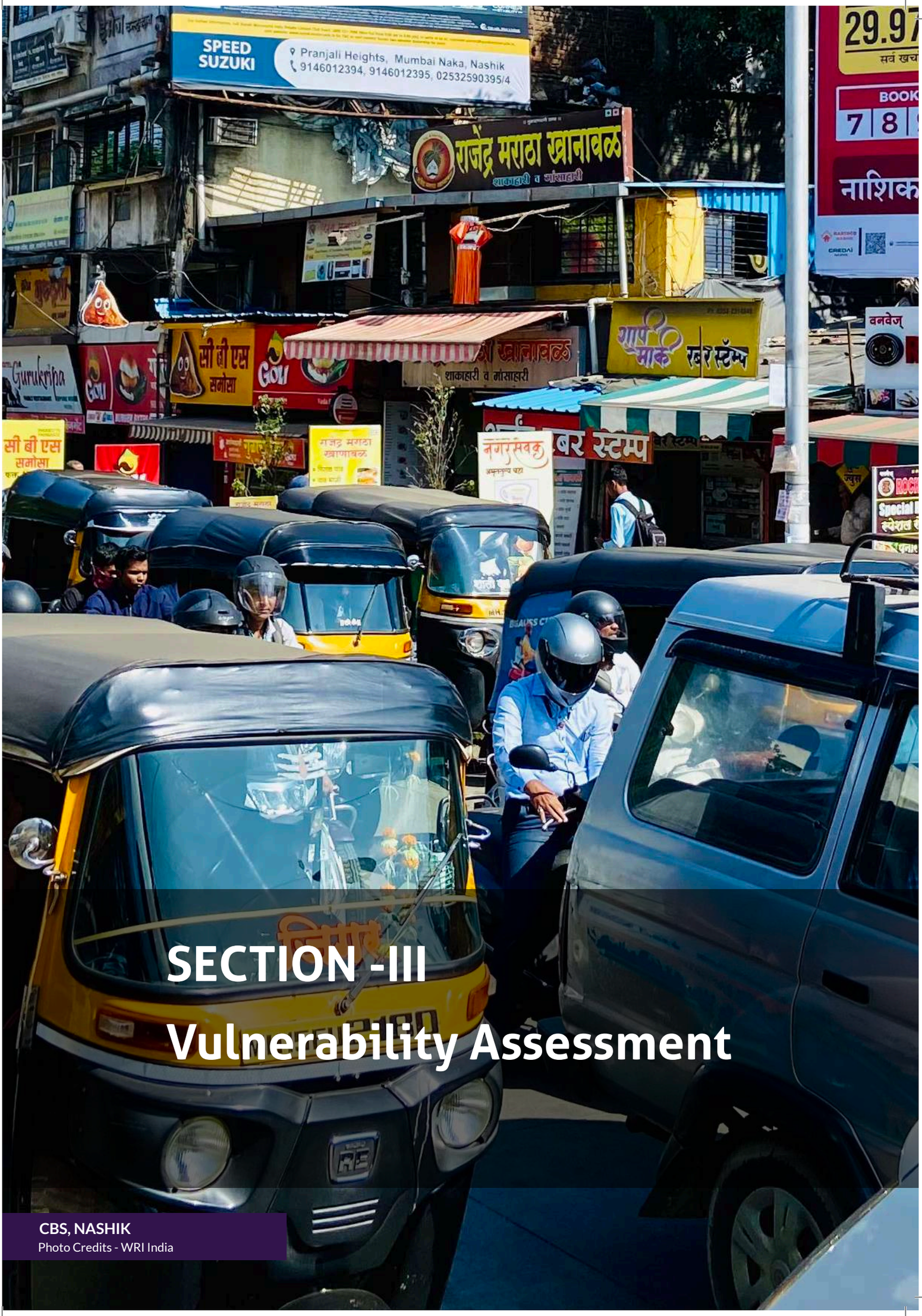
Approximately, 8.91% of population is exposed to both above average LST and waterlogging, mostly in the central part of the city. The predominant multi hazard risk prone areas are Koknipura, Doodh Sagar, Shivneri Chowk and Nashik main bus stop. A total of 42 schools and 18 hospitals lie in this region. Nearly 42.5% of slum area (mostly in Koknipura and Wadala Gaon) and 1.9% of industrial area (parts of MIDC Satpur and Ambad) are at risk of multi hazard.

EREs have been observed in the city, which could be one of the causes for urban flooding. Almost 13% of the population gets affected with flooding in different wards. These multi hazards are already affecting vulnerable populations of the city, and this trend may increase in the future. These areas require immediate attention, with measures implemented to combat heat and flood risk.

Figure 8-1: Multi hazard map for water logging and LST above city average and traffic hotspots



Source: *WRI India analysis*



SECTION -III
Vulnerability Assessment

CBS, NASHIK
Photo Credits - WRI India

9. VULNERABILITY ASSESSMENT – DEMOGRAPHIC CONTEXT

This section presents the analysis of demographic aspects using Census of India 2011 data. Although outdated, this is the only and most recent spatially available dataset that deeply captures socio-economic indicators. This analysis will help understand the potential effects of climate change on different socio-economic groups, the sensitivity of the population and its variation based on demographic diversity, such as age, sex and education, and how it manifests spatially in the city.

9.1 ASSESSMENT

The framework consists of a wide range of demographic characteristics indicators to represent complex socio-economic vulnerability dimensions in Nashik. Refer to annex 1-8. Using Census of India 2011 population series data, ward-level assessment (108 Census wards in the case of Nashik) and mapping were carried out to evaluate the dynamics of literacy, gender, and social composition in the city.

Table 9-1: Key findings - Demographic context

	Indicator	Vulnerability Analysis
	Literacy (Refer to Annex 1-8, 1-9)	Nashik's overall effective literacy rate is 89.85% (Annex 2-2). However, the effective female literacy rate is less than 85.92% (Annex 2-16). The areas near Fulenagar (ward no. 9) and Pokar Colony (ward no. 10) perform poorly, with an effective overall literacy rate at less than 78%, which might be caused by the high concentration of SC and ST population there (Annex 2-3). These areas, along with Salunkhe Nagar (ward no. 56), and Ambad Gaon near MIDC Ambad (ward no. 108), also perform poorly in terms of effective female literacy rate, which is less than 72%. In these two wards, the population having access to schools is less than 60% (Annex 2-14).
	Access to School (Refer to Annex 1-8, 1-9)	This includes all the public and private schools in the city. Approximately 82.6 % of the population has ease of access (within a 10-minute walkable distance) to schools. Areas such as Hanuman Nagar in the north and Ashtvinayak Nagar in the southeast lack ease of access (within 10-minute walkable distance) even with a higher population density of more than 60 persons per 1000 square metres (Annex 2-15). The cantonment area (Ward no. 66) is the most vulnerable, with only 9.26 % of the population having ease of access, followed by Satpute Mala and Mankar Mala (Ward no. 70) with only 22.29% of the population having ease of access to schools (within 10-minute walkable distance).
	Social Composition (Refer to Annex 1-8, 1-9)	Data shows that 21.67% of Nashik city's population belongs to the SC and ST communities. Fulenagar (ward no. 9) Pokar Colony (ward no. 10), and parts of Satpur Gaon and Swarbaba Nagar (wards no. 55), have more than 40% of the population belonging to SC and ST communities and, at the same time, have a higher population density of more than 28 persons per 1000 square metres (Annex 2-3). Effective literacy and female literacy rates are less than the city average in these wards.

10. VULNERABILITY ASSESSMENT: ACCESSIBILITY ANALYSIS

The overall demographic context provides a background to evaluate how vulnerabilities are experienced differentially across the city, depending on age, sex, and education. Even within a neighbourhood (having the exact geographical location) or a household, such differential experiences exist based on demographic parameters. Incorporating this in the vulnerability assessment will help identify areas requiring immediate action.

The vulnerability assessment investigates three critical socio-economic, physical environment, and infrastructural aspects to co-relate the city's spatial determinants to pertinent climate risks, such as air pollution, heat and waterlogging.

10.1 ASSESSMENT

The availability of various services, such as information (broadcast media and telephone), drinking water, sanitation, and electricity, at a household level using Census of India 2011 ward-level data and pedestrian access to services such as bus stops, schools, parks, and playgrounds in the city based on road network analysis have been evaluated for the accessibility indicators. Similarly, vehicular access to emergency infrastructural facilities, such as hospitals and fire stations, has been evaluated using their standard response times. This will help identify the specific areas that lack ease of access to these facilities and might be more vulnerable during disaster events.

For road network analysis, the Census of India 2011 population has been appropriated to the recent built-up pixels (gridded population) extracted from the World Settlement Footprint Evolution 2019 dataset and estimated to arrive at pixel-wise population density. It is then further divided into the population having access and lack of ease of access per 1000 square metres to a particular infrastructure. In the impact section, to understand and quantify the extent of climate risk – both spatially and numerically – an overlay analysis has been done, which superimposes spatial layers of areas with climate risks on the areas that have ease of access to different infrastructure, such as hospitals, fire station and schools. As per the findings from the Climate Risk Context Section, urban heat and urban flooding emerge as the most imminent threat to the residents of Nashik over other hazards. This gives a quantifiable, spatially located figure, either by the percentage of persons at risk or city or wards lacking access to facilities and at the risk of heat stress and waterlogging, thus enabling evidence-based mitigation and adaptation measures.

10.2 SOCIO-ECONOMIC ASPECTS

Socio-economic aspects include access to information and house ownership, which spatialise areas at risk of intensified climate disaster impact (Refer to Annexures 1-10, 1-11 and 1-12).

Table 10-1: Key findings - Socio-economic aspects

Indicator	Vulnerability Analysis
Access to information (Refer to Annex 1-10, 1-11)	Based on the Census 2011 analysis, Salunkhe Nagar (ward no. 56) has the lowest percentage of households owning landlines (1%) and households owning both mobiles and landlines (0.6%), where the city-wide average is 6.9% and 13.4%, respectively. Similarly, parts of Thakkar Nagar and Sharanpur (ward no. 46) have the lowest percentage of households owning mobiles (31%), which is much lesser than the city-wide average of 68.1% (Annex 2-16).Regarding access to broadcast media, Ambad Gaon near MIDC Ambad (ward no. 108) has the least percentage of households having access to television – (47.1%), while the average in Nashik is 83.2%. The lowest percentage of households owning radio/transistors is in parts of Satpur Gaon and Swarbaba Nagar (ward no. 55), with only 7.2%, whereas the citywide average is 31.1%. Lastly, Fulenagar (ward no. 9) has the least percentage of households having access to computers (0.7%) with Internet, while the average in Nashik is 10.2% (Annex 2-17).
Home Ownership (Refer to Annex 1-10, 1-12)	On average, 65.8 % of Nashik's population lives in 'own' houses i.e. houses owned by them. Parts of Gole Colony, Police Staff Colony (ward no. 45), Morwadi (ward no. 106) and Ambad Gaon near MIDC Ambad (ward no. 108) have less than 45% of households living in their own houses. Parts of Konknipura (ward no. 60), Fulenagar (ward no. 9) and Pokar Colony (ward no. 10), have the highest percentage of households, at more than 75%, living in 'own' houses with a higher population density (Annex 2-18). These areas tend to have higher concentrations of SC and ST population along with a higher percentage of area under slums.

10.3 PHYSICAL ENVIRONMENT ASPECTS

Poor living conditions, such as dilapidated housing conditions, temporary material for roofs and limited ease of access to public green spaces and other amenities, are reasons for mental stress and anxiety among many, especially those residing in potentially un-serviced areas and informal settlements in the city. The population residing in these areas becomes more vulnerable to climatic risks because of their inability to recover from extreme events quicker than others. This section discusses the physical-environmental aspects of housing conditions and access to public recreational spaces.

10.3.1 Assessment

Census of India 2011 house listing and housing data have been used for Census ward-level analysis to understand the percentage of households in each ward with predominant roofing material, presumably considered 'Temporary' as it has limited constructional durability, especially during extreme weather events. (Refer to Annex 1-13, 1-14)

Public recreational spaces, such as parks, gardens, playgrounds, or maidan, act as cushions during floods and as temperature-dampening resources at both neighbourhood and city levels. Proximity to such spaces reduces long-term exposure to higher air pollution levels and high surface temperatures. On the other hand, greener areas have more significant carbon sequestration potential and are needed for any climate-resilient city. (Refer to Annex 1-13, 1-16)

Table 10-2: Key findings - Physical environment aspects

Indicator	Vulnerability Analysis
House Condition (Refer to Annex 1-14, 1-15)	On average, 30.36% of Nashik's households live in houses with temporary roofing material. Parts of Satpur Gaon and Swarbaba Nagar (ward no. 55), Naikwadipura (ward no. 30) and parts of Konknipura (ward no. 60) have a high population density of more than 13 persons per 1000 square metres and also have more than 60% of households with temporary roofing material, making them more vulnerable (Annex 2-19) Parts of Konknipura (ward no. 60), with 18.72% of settlements being slums, have 77.1% of households living in houses with temporary roofing materials and also having 79.84% and 86.76% of population at risk due to heat and flooding, respectively.
Access to Public Recreational Spaces (Refer to Annex 1-16, 1-17)	While 71.9% of Nashik's population has access to public recreational spaces within the threshold values distance of 1 km within 10-minute walkable distance, 28.1% does not have access to any parks, gardens, playgrounds or maidans within the standard time. Higher density areas in and around MIDCs, around Mhasrul Gaon, Hanuman Nagar in the north and around Ashtvinayak Nagar in the southeast lack ease of access to such facilities (within 10-minute walkable distance) (Annex 2-20). Ajmeri Nagar and Mahalakshmi Nagar (ward no. 84), Satpute Mala and Mankar Mala (ward no. 70) and parts of Shramik Nagar (ward no 52) have no population with ease of access to recreational spaces within 10-minute walkable distance, making them more exposed to extreme events such as extreme heat stress. Of these, parts of Shramik Nagar (ward no. 52) are at most risk as 77.73% of the population here have limited ease of access to public recreational spaces and are also potentially at risk due to extreme heat (> 32°C). During a flood event, the population having access to public recreational spaces reduces, from 71.90% to 48.94%. Parts of Konknipura (wards no. 42, 60 and 61) and Doodh Bazar (ward no. 43) in the inner city lose complete access to public recreational spaces during a flood event.

10.4 INFRASTRUCTURE AND SERVICE ASPECTS

The infrastructure and service aspect section helps identify neighbourhoods that lack access to amenities / services at a household level (from Census of India 2011) and within a standard time or distance, which enhances the quality of living, thereby making a city more resilient. Physical access to essential services is potentially compromised during a disaster event. This section deals with access to indispensable infrastructure and how it is impacted during extreme heat and flooding events. (Refer to Annex 1-18)

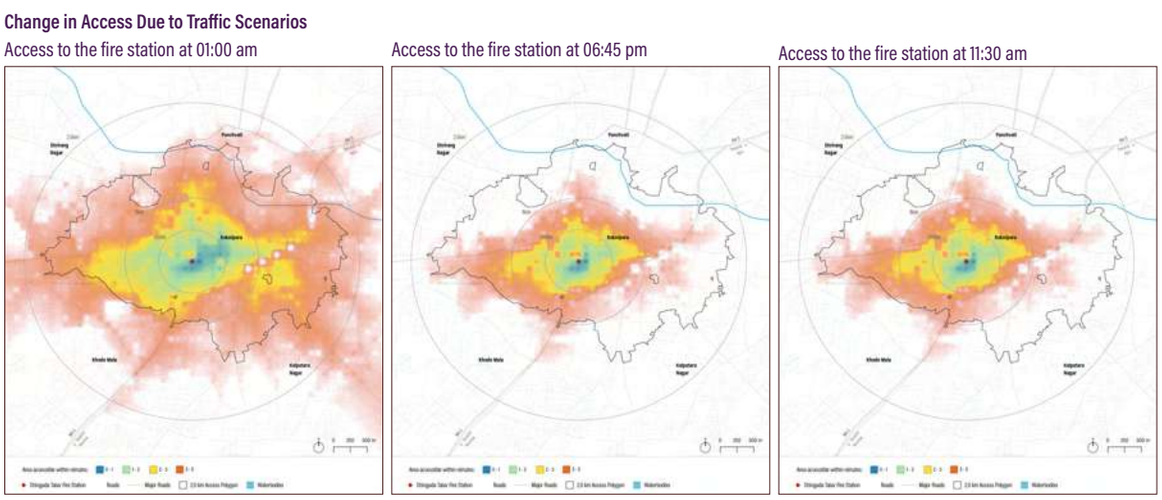
Table 10-3: Key findings - Key findings- Infrastructure and service aspects

	Indicator	Vulnerability Analysis
	**Access to Drinking Water**	Regarding drinking water sources, 4.57% of households in Nashik do not have the provision of treated drinking water (Annex 2-22). Parts of Adgaon, (ward no. 4), Doodh Bazar (ward no. 43), parts of Damodar Nagar, Buddha Vihar (ward no. 101) and Ambad Gaon near MIDC Ambad (ward no. 108) are the most vulnerable because more than 15% of households do not have access to any treated drinking water facility. An evaluation of the proximity of drinking water sources revealed that 13.28% of households do not have any drinking water source inside their premises (Annex 2-21). Fulenagar (ward no. 9), parts of Konknipura (ward no. 60) and Devlali Gaon (ward no. 96) have more than 30% of households with non-availability of drinking water within premises, along with a population density of 28 persons per 1000 square metres. With a higher population density, Doodh Bazar (ward no. 43) in the inner city has 20.1% and 27.6% of households without access to treated drinking water and without drinking water inside premises, respectively. This ward also has 100% of the population at risk due to heat events and 98.31% at flood risk. This area faces a higher health risk due to the contamination of drinking water during flood events, drying up of drinking water sources during extreme heat events, etc.
	**Access to Clean Cooking fuel** (Refer to Annex 1-21)	Overall, 17.19% of households do not have access to clean cooking fuel. The inner-city areas of Fulenagar (ward no. 9), Pokar Colony (ward no. 10) and parts of Konknipura (ward no. 60, 61) have more than 40% households having no access to clean cooking fuel. These areas are also having a higher population density and at least 25% of households with a household size of more than 6, making them more vulnerable to deteriorating indoor air condition (Annex 2-23).
	**Access to Sanitation** (Refer to Annex 1-22)	Assessing the proximity of latrines, it was found that 20.3% of households do not have latrines inside the premises (Annex 2-24). Regarding access to public toilets, approximately, 64.20% of informal settlement area is within 5-minute walkable distance of at least one public toilet on a typical day, while 35.80% of the area lacks ease of access to it (Annex 2-26). However, during flooding, the percentage of informal settlements accessible to public toilets (within a 5-minute walkable distance) reduces, from 64.20% to 38.37%. Approximately 23.15% of public toilets completely lose access, especially those near Panchavati, Naikwadi and Konknipura in the city centre, Devlali Gaon in the southeast, etc. The inner-city areas of Fulenagar (ward no. 9), Pokar Colony (ward no. 10), parts of Konknipura (ward no. 60) and parts of Satpur Gaon and Swarbaba Nagar (ward no. 55) have the maximum percentage of households (more than 60%) without latrines inside premises along with a higher population density of more than 28 persons per 1000 square metres. Most of this areas are slums. Approximately 40.12% of the total number of informal settlements in Nashik lack ease of access to any public toilet within 5-minute walkable distance, which are majorly concentrated in the periphery of the city (Annex 2-26). A total of 1.31% of households lack access to treated sewage disposal methods (Annex 2-25), while 9.85% of households dispose wastewater in an untreated manner (Annex 2-27).

		Matoshri Nagar (ward no. 38) and Bhim Nagar (ward no. 68) towards the south-eastern periphery have the maximum percentage (more than 10%) of households lacking access to treated sewage disposal methods. Parts of Samarth Nagar, Tarwala Nagar (ward no. 6), Shatari Nagar Godarej wadi (ward no. 69), Bridge Nagar (ward no. 71) and Ambad gaon near MIDC Ambad (ward no. 108) have more than 30% of households disposing their wastewater in an untreated manner along with a comparatively higher population density than other wards with a similar percentage of households with untreated wastewater disposal. Bhim Nagar (ward no. 68) towards the south-eastern periphery have 14.7%, 17% and 8% of its households without treated sewage disposal, wastewater disposal methods and without latrines inside premises, respectively. During floods, this area is vulnerable to severe consequences in terms of hygiene and sanitation, as an estimated 20.41% of the population here is likely to be affected as physical access to many of the services might be hampered.
	**Access to Electricity Grid** (Refer to Annex 1-23)	Overall, 3.15% of households do not have access to electricity as the main source of lighting. Areas of Samarth Nagar, Tarwala Nagar (ward no. 6), Fulenagar (ward no. 9), Salunkhe Nagar (ward no. 56) and parts of Suchita Nagar, Deepali Nagar, Bharat Nagar, Shri Ram Nagar (ward no. 64) have more than 10% of households without access to the electricity grid (Annex 2-28).
	**Access to Public Transit** (Refer to Annex 1-24, 1-25)	Around 74.69% of Nashik's population lives within 5-minute access of a bus stop in the city. Higher density areas in and around the inner city, such as Somvar Peth, Naikwadi Pura, MIDCs, Ashtvinayak Nagar and Muktidham Mandir in the south-eastern side lack ease of access (within 5-minute walkable distance) (Annex 2-29). During a flood event, Nashik's population having easy access to bus stops (5-minute walkable distance) reduces substantially, from 74.69% to 42.22%. Parts of Konknipura around Swami Vivekanand Chowk (ward no 42) in the city centre, having a population density of more than 28 persons per 1000 square metres, have the most minor ease of access to bus stops, with only 5.85% of the population having access within 5-minute walkable distance, which too is completely lost during a flood event (Refer Figure 6-8).
	**Access to Emergency Healthcare Services** (Refer to Annex 1-26, 1-27)	Approximately 96.82% of the population has easy access (within 8-minute response time) to hospitals. Most areas have easy access (within 8-minute response time), except Shatari Nagar near Nashik Central Jail in the southeast (Annex 2-30). Although parts of Pimpal Gaon Khamb and Kothule Mala (ward no. 99) in the extreme southern periphery of the city, with 68.25% of the population, have the most minor ease of access to emergency hospital services within 8-minute response time, it is Shatari Nagar (ward no. 69) that has the maximum percentage of population (22.53%) with limited ease of access to hospitals and is potentially at risk due to extreme heat (> 32°C). During floods, the serviceable population here is likely to reduce from 70.64% to 61.81%. Overall, during a flood event, Nashik's population having ease of access to hospitals (8-minute response time) reduces substantially, from 96.82% to 62.32%, and concerning slums, an overall reduction of serviceable settlements to 34.37%.
	**Access to Emergency Fire Services** (Refer to Annex 1-28, 1-29)	Approximately 49% of the population can access fire stations within five minutes. Nashik has six fire stations in each division of the city. Higher density areas in and around MIDCs (Satpur and Ambad), near Mhasrul Gaon in the north and Ashtvinayak Nagar and Shri Krishna Nagar in the southeast along the Godavari River remain beyond the 5-minute serviceable radius of the fire stations (Annex 2-31). Ashtvinayak Nagar (ward no. 35), parts of Narayan Bapu Nagar (ward no. 36), parts of Ashok Nagar, Jaswant Nagar (ward no. 53) and parts of Ashok Nagar, MHB Colony (ward no. 54) do not have ease of access to emergency fire services, with no population that can be accessed within 5-minute response time despite having higher population density (more than 13 persons in 1000 square metres). Approximately 19% of the wards do not have any ease of access.

	The level of access also varies temporally through the day based on traffic and road conditions. Based on a sample temporal analysis, the area that comes under the accessible radius of Shingara Talav Fire Station (Head Office), which can be reached within five minutes, reduces from 22 square km at 1.00 am to 9 square km at 11.30 am and 6.45 pm (Refer Figure 10-1). There is a 59% reduction in terms of service area in peak hours, which increases the potential risk. However, Ambad Gaon near MIDC Ambad (ward no. 108) in the periphery of the city has 79.79% of its population having limited ease of access to fire stations and are also potentially at risk due to extreme heat (> 32°C). In the case of a flood event, the percentage of Nashik's population serviced by the fire station drastically reduces, from 49.04% to 14.83%. For example, Fulenagar (ward no. 9) and Pokar Colony (ward no. 10), which have 100% of its population accessible by fire stations during a normal day, completely loses access during floods. Being predominantly slum locations (with more than 50% settlements being slum huts), the percentage of population in these areas also witness a reduction in serviceable settlements, from 56.70% to 16.23%.
Access to Relief Shelters (Refer to Annex 1-30, 1-31)	Only 50.2% of the population has access to relief shelters within 10-minute walking distance. These are majorly the municipal schools, which are currently used as relief shelters during climatic hazards such as flooding and can also be used in the future to house vulnerable population (houseless population, informal settlement population) during extreme heat events. Higher density areas in and around Veer Savarkar Nagar, Bhavik Nagar in the west, Mhasrul Gaon in the north, and Shree Ram Colony in the south and Nashik Road, Ashtvinayak Nagar in the southeast remains beyond 10-minute serviceable distance of these relief shelters. (Annex 2-32). Parts of Kala Nagar, Indira Nagar (ward no. 77) and parts of Sharanpur (ward no. 47) do not have ease of access to relief shelters with no population that can access within 10-minute walkable distance despite having a higher population density (more than 13 persons in 1000 square metres). In the event of a flood, Nashik's population with access to a flood shelter within 10-minute walking distance is potentially reduced, from 50.2% to 23.78%. Parts of Konknipura (ward no. 42) and Doodh Bazar (ward no. 43) with a higher population density, which had the maximum population (100%) having access to relief shelters, completely lose ease of access during a flood event. There is a reduction in the percentage of serviceable settlements too during floods, from 64.15% to 28.87%. During extreme heat events, 18.03% of the overall population of Nashik will remain beyond 10-minute walking distance of relief shelters.

Figure 10-1: Temporal analysis showing the change in serviced area under different traffic conditions during the day



Source: WRI India using Landsat 8, Nashik Municipal Corporation 2020, World Settlement Footprint 2019, Census 2011

11. VULNERABILITY ASSESSMENT - IMPACT ANALYSIS

11.1 IMPACT OF HEAT

Nashik city is surrounded by the Western Ghats. The annual average LST[30] for the built-up area within the city ranges between 28°C and 38°C. In summers, LST can rise up to 47°C during the daytime. Nashik has a built-up area ~45%, and these areas have LST hotspots that contribute to the vulnerability due to heat.

11.1.1 Impact of heat on the population

Nashik city has total population of 14,86,053 (Census of India 2011). The heat threshold LST for Nashik has been considered as 32°C. Approximately 40% of the city's population lives within the area with LST higher than 32°C. This population is at a higher risk due to heat.

Figure 11-1 shows the population density distribution within the area that has LST higher than 32°C. Areas such as Konkanipura and Panchavati are examples of high population density areas, with a population density of 60 or higher persons per 1000 square metres.

11.1.2 Impact of heat on livelihoods

To understand the employment opportunities available and the spatial distribution of these opportunities within Nashik city, the Directorate of Establishments (DoE) sample data from Economic Census 2015 was used[31]. Nashik has two MIDC areas within the city boundary, one in Satpur and another in Ambad towards the west and southwest, respectively. Commercial and industrial areas within heat risk can expose employees to the adverse effects of heat. In the establishments in the manufacturing or construction category, workers perform their duties in high temperatures usually inside metal and tin structures, which heat up during the daytime.

Approximately 56.6% of establishments belong to the manufacturing category, which has 71% of the job share within the high heat risk area. The manufacturing category consists of manufacturing and fabrication of mechanical parts that are used in various industries, such as automobile, pharmacy and construction.

11.1.3 Impact of heat in slums

Slum areas experience higher temperatures and are more susceptible to heat risk. Slums have densely packed built houses, and, often, materials such as metal or asbestos sheets are used for roofing. Usually, slums also have a fewer number of trees or other vegetation. These factors cause heat hotspots as a result of which the temperature in slums is usually higher than their surroundings. Slums usually have a high population density as well, which increases the impact of heat.

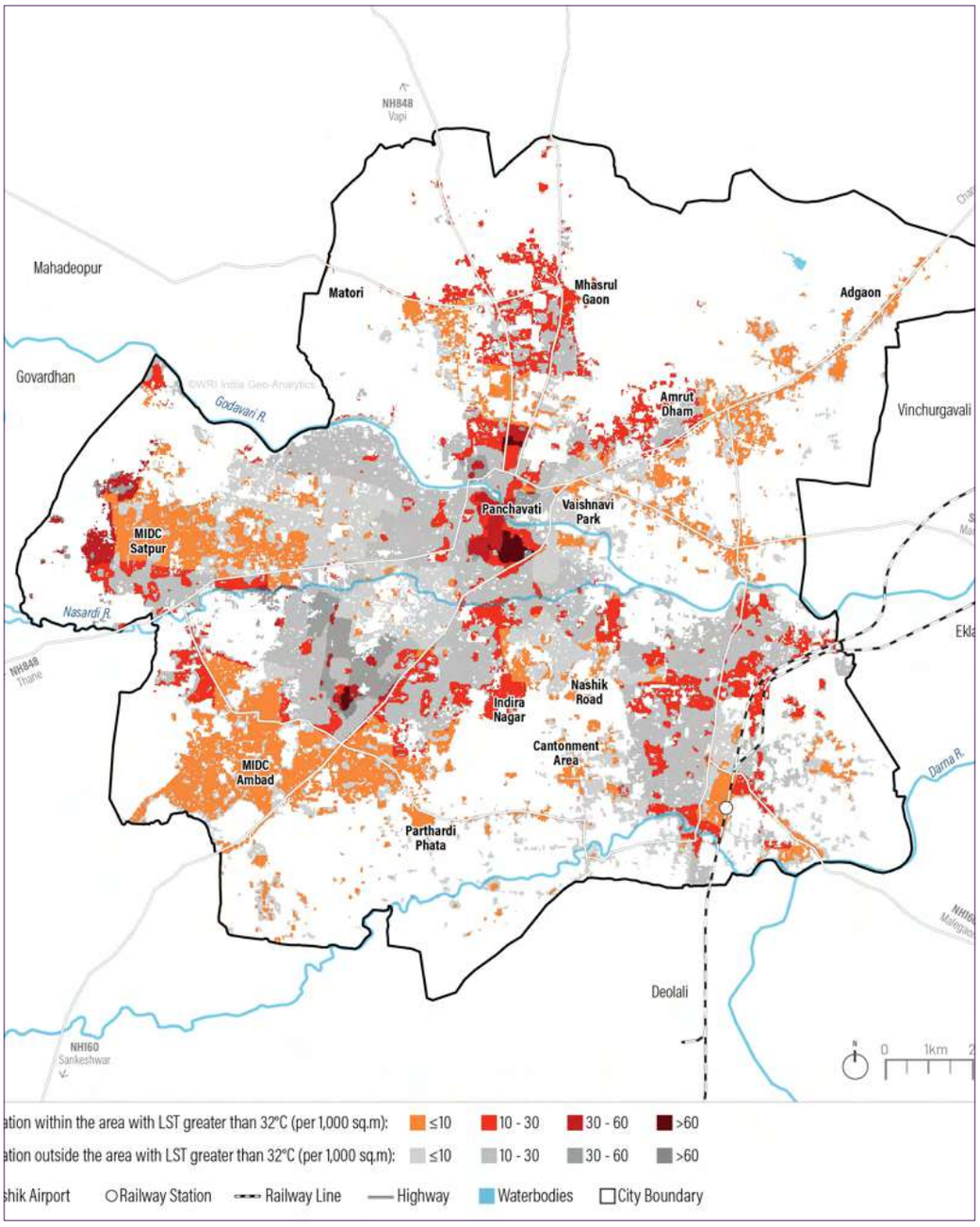
Nashik city has 170 slums marked spatially. These occupy a total area of 2.3 square km within the city. The slum population of the city is 1,89,721 (Census of India 2011).

- Out of the 170 slums, 44 appeared at a lower temperature as compared with

the surroundings. These have industrial, commercial or transport land uses around them, which have a higher LST than the slum area. Refer to Figure 11-3.

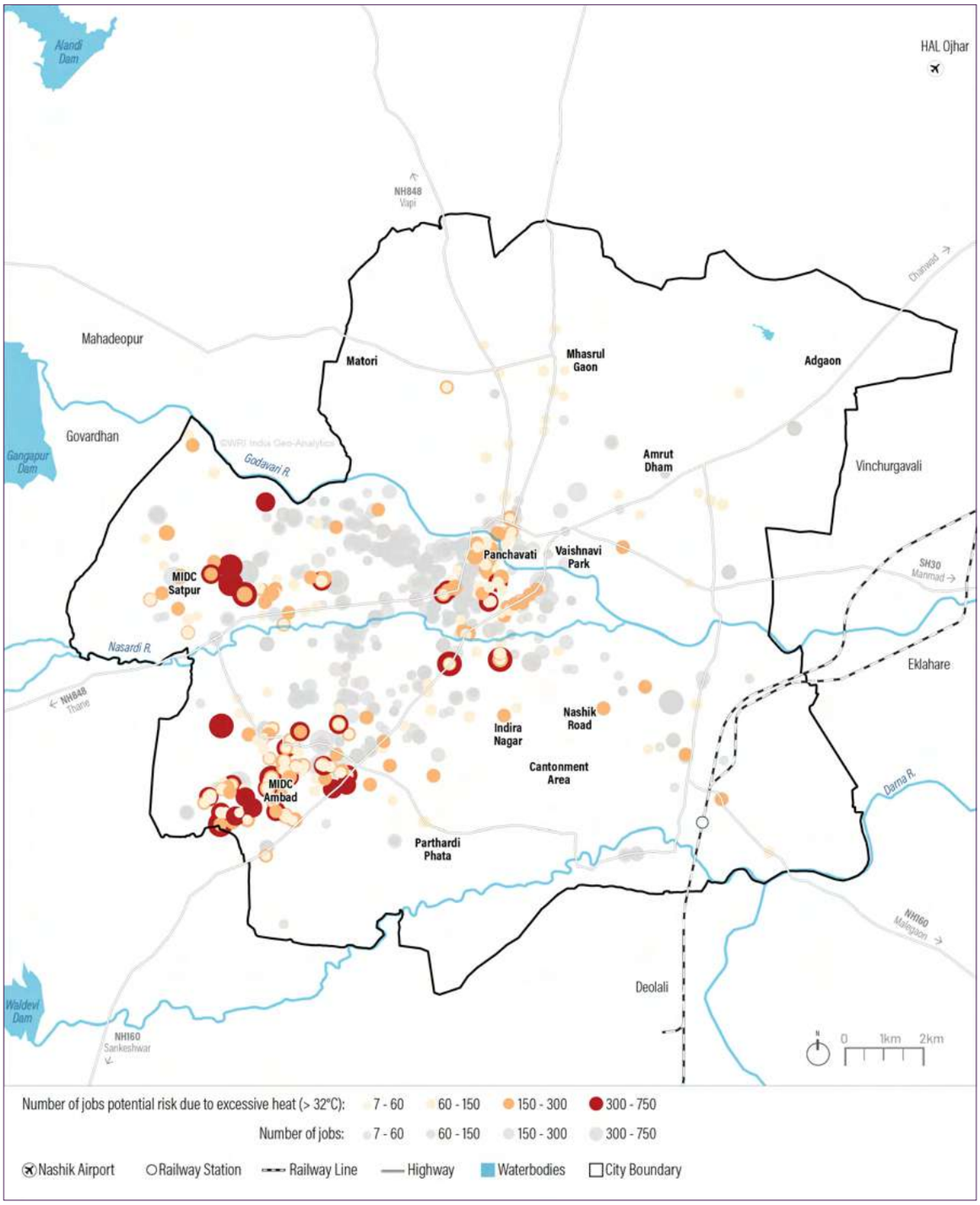
- Even if visually these slums appear at a lower LST than the immediate surroundings, these areas experience high temperatures as compared with the other residential areas.

Figure 11-1: Population at risk due to heat



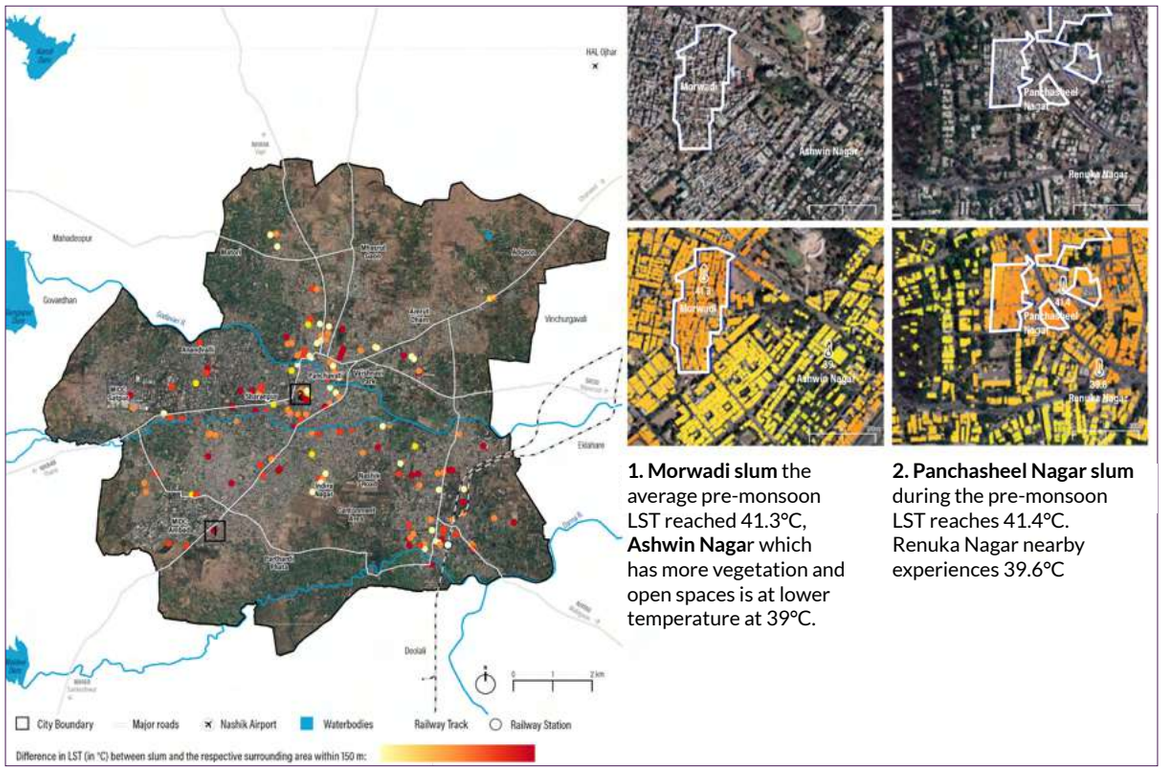
Source: WRI India,2022, WSF, Census 2011, Landsat 8 (2019-2021)

Figure 11-2: Jobs vulnerable to heat risk



Source: WRI India,2022, Economic Census 2015, Landsat 8 (2019-2021)

Figure 11-3: Slum areas with LST



1. Morwadi slum the average pre-monsoon LST reached 41.3°C, **Ashwin Nagar** which has more vegetation and open spaces is at lower temperature at 39°C.

2. Panchasheel Nagar slum during the pre-monsoon LST reaches 41.4°C. Renuka Nagar nearby experiences 39.6°C

Source: WRI India Analysis, NMC

Figure 11-4: Slums in industrial area

Source: WRI India Analysis, NMC

Wadar wadi slum is a small-sized slum area near MIDC Satpur. It has a lower LST than the surrounding areas since the surrounding areas are of industrial land use type. However, the pre-monsoon LST in this slum area can rise to 41°C.

11.2 IMPACT OF FLOODING ON SERVICES

Heavy rainfall and flooding hinder physical access to most essential services, thereby causing the city to come to a standstill. For example, with respect to the transport infrastructure in a city, flood events not only hamper operational costs, travel time and regularity of service but also compromise the safety of residents. Based on flood hotspot influence zone analysis,

- 32.47% of Nashik's population have lost the ease of access to public transit (in this case, bus stops), as physical access to such facility has been hindered due to flooding.
- Although 23.05% of Nashik's overall population is impacted due to flooding, the serviced population reduces, from 50.2% to 23.78%, as relief shelters (beyond 10-minute walkable distance) become non-accessible.
- Flooding also affects accessibility to public toilets, particularly in informal settlements, which may lead to sanitation issues as physical access gets restricted.
- 23.15% of public toilets fall in a completely flooded area. Hence, the settlement coverage of slums reduces, from 64.20% to 38.37%.

Table 11-1 shows the percentage of population that has access to various services on a normal day as compared with a day of a flood event and the un-serviced population also exposed to extreme heat.

Table 11-1: Summary of service indicators

	Indicator	Population having access on a normal day	Population having access on a flood event	Un-serviced Population also exposed to extreme heat
	Access to Public Transit	74.69%	42.22%	-
	Access to Emergency Healthcare Facility	96.82%	62.32%	1.16%
	Access to Emergency Fire Services	49.04%	14.83%	21.28%
	Access to Public Recreational Spaces	71.90%	48.94%	14.95%
	Access to All Schools	82.61%	43.45%	7.81%
	Access to Relief Shelters	50.20%	23.78%	18.03%
	Access to Public Toilets (with respect to slums)	64.20% (settlements)	38.37% (settlements)	-

SECTION -IV

Projected Risks and GHG – Emissions Scenario

GOLF CLUB JOGGING TRACK
Photo Credits - WRI India

12. PROJECTED CLIMATE SCENARIOS

There is a distinct difference between a projected trend and the observed variability; in climate sciences, these projections are in general fit for informing the long-term mitigation plans, while the temporally and spatially nuanced observed variability amongst the decadal, inter-annual and seasonal variations are of the biggest need for adaptation-savvy decisions. This chapter details the projected climate change scenarios[32], and their implications and observed variations in climate and environmental characteristics.

12.1 TAKEAWAYS FROM MSAAPC AND NASHIK GHG INVENTORY

The Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC) outlines sector-specific adaptation recommendations along with the associated departments to ensure a sustainable development pathway. The city would have to implement and enhance these recommendations in various sectors, such as agriculture, water resources, ecosystems, and health, to safeguard against any potential climate hazards. Enhancing the resilience of farming systems, groundwater recharge and water-use efficiency are a few suggestions that would help build a climate-resilient future for the city and, in turn, for the state.

12.2 SCOPE OF ANALYSIS

12.2.1. Analytical

The current assessment studies minimum and maximum temperatures as well as the precipitation changes for two climate scenarios – RCP 4.5 and RCP 6[33]– up to year 2100, with intervals of short term (years 2020-2050) and long term (years 2071-2100), to align with targeted strategies under National Action Plan on Climate Change (NAPCC). Each scenario plots a different emissions trajectory (called pathways) and the resultant cumulative CO_2 equivalent emissions' concentration by the year 2100. The goal of working with scenarios is not to predict the future but to better understand uncertainties and alternative futures, in order to consider how robust different decisions or options may be under a wide range of possible futures (IPCC, 2014).

12.2.2 Geographical

Nashik lies at an elevation of 584 metres above sea level within the Upper Godavari sub-basin, with the city surrounded by several hill ranges from the northwest to the southwest. The river Godavari finds its origins in these hills, 35 km west of the city. Given the undulating topography and dispersed hills circumventing the city, it fulfils its urban water needs from the Gangapur Dam that further relies on the various dams upstream (northwest and west) of the city. Being fed by various first order streams, the main channel of the river Godavari dissects the city, making it prone to riverine floods. To understand the risks of water availability or excessive water flows in the city in terms of both temperature and precipitation changes, RCP scenario-based projections are analysed at the regional (sub-basin) scale with the upstream to river and the city limits in focus.

12.3 ASSESSMENT

The assessment focuses on the projected changes for RCP 4.5 and 6. Precipitation, minimum air temperature and maximum air temperature (climatic parameters) variations with respect to the historical baseline for each of the three study domains and the entire study area collectively are computed as per the envisaged epochs – short term (2020-2050) and long term (2071-2100).

12.4 KEY FINDINGS

12.4.1 Minimum air temperature

Minimum air temperature is a concept associated with either night-time, early in the day or temperature during winters. It is a critical parameter for physical and psychological health of humans. A dramatic rise in minimum air temperature can also be deadly for plants and the overall functioning of the ecosystem. An increase in seasonal temperature post-monsoon affects the thermal comfort during winters and worsens the thermal endurance during summers. Rising minimum air temperature trends are directly proportional to energy demand, further fuel climate change woes if dependency on fossil-fuel consumption is not regulated.

For a tier-2 city like Nashik, with presence of rain and an agrarian economy driven by natural water

Table 12-1: RCP scenarios: methods and sources used for analysis

Climate Variables	Method used	Data Source
Minimum Temperature	For RCP 4.5: Temporal variations in minimum air temperature from the baseline (Magnitude of change based on 21 models)	NASA Earth Exchange Global Daily Downscaled Projections (NEX-GDDP) for RCP 4.5 CMIP5 daily data for RCP 6 ECMWF ERA5 daily data for historical baseline
	For RCP 6: Temporal variations in minimum air temperature from the baseline (Magnitude of change based on 13 models)	
Maximum Temperature	For RCP 4.5: Temporal variations in maximum air temperature from the baseline (Magnitude of change based on 21 models)	
	For RCP 6: Temporal variations in maximum air temperature from the baseline (Magnitude of change based on 13 models)	
Precipitation	For RCP 4.5: Temporal variations in precipitation from the baseline (Magnitude of change based on 21 models); including spatio-temporal variations' examples using selected GCMs.	
	For RCP 6: Temporal variations in precipitation from the baseline (Magnitude of change based on 13 models);	

Source: WRI India Analysis, 2022

flow-based irrigation, this can lead to a severe reduction in the yield. The city also has significant industrial areas, such as Satpur and Ambad. Rising temperatures can also lead to a hike in energy and a simultaneous soaring water demand. Both RCP 4.5 and RCP 6 simulations predominantly project an increasing minimum temperature trend across the study region. The scenario-wise details are as follows:

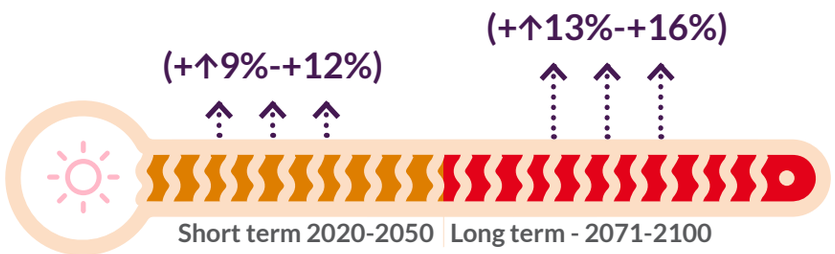
1. RCP 4.5

In the intermediate scenario, majority of the models project higher magnitude of increase in minimum air temperature than decrease. As per most of the models, by the year 2050, the minimum air temperature is observed to increase between +↑9% to +↑12% in the short-term between the upstream catchment area and NMC limits. Following the scenario for long-term epoch (2071-2100), energy and water demand may also grow as the temperature further is projected to rise with an increase of +↑13% to +↑16% from the baseline between upstream catchment and NMC limits.

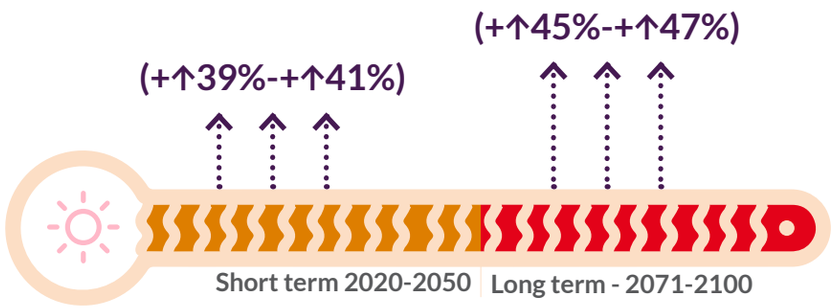
2. RCP 6

The upstream catchment and NMC area are projected to have a rise in minimum air temperature between +↑39% to +↑41% in the short-term epoch and +↑45% to +↑47% in the long-term epoch. Such increase in air temperature in these scenario could impact waterbodies in terms of water quality, quantity, and aquatic life.

Minimum Air Temperature- RCP 4.5



Minimum Air Temperature- RCP 6



12.4.2 Maximum air temperature

As per the baseline estimation, historically, Nashik's average maximum air temperature had stood around 30°C. This maximum temperature can be seen peaking in summer, starting March to June, and is applicable for the relatively active part of the day. Resonating with MSAAPC, for both RCP 4.5 and 6, most models project a high likelihood of a rise in temperature by 5°C (~+↑15%) to 9°C (+↑30%). As accounted for in the state action plan, this rise can lead to prolonged heat waves and augment the days conducive to malaria parasite development and transmission (TERI, 2014).

Changes in maximum air temperature can also affect the region's viticulture and other agricultural practices. The delicate chemistry of grapes and agricultural produce highly depends on the climatic conditions in which they are cultivated. Unbearable heat succession can temper the community-economy-environment nexus, pushing people to migrate from the hot environment and increasing socio-political, cultural, and financial vulnerabilities. In continuation of the impact of minimum air temperature rise, increasing maximum air temperature can also lead to frequent forest fires in the region, hamper air and water quality. The scenario-wise details are as follows:

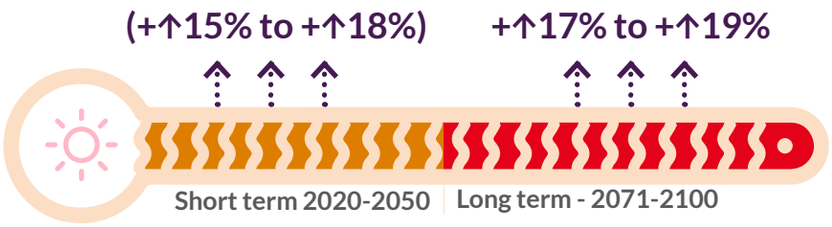
1. RCP 4.5

The maximum air temperature between the upstream catchment and NMC area is observed to be recording an increase of +↑15% to +↑18% in the short-term epoch and +↑17% to +↑19% in the long term epoch.

2. RCP 6

There is a small rise in maximum air temperature between the upstream catchment and NMC area of +↑22% to +↑23% in the short-term epoch and +↑29% to +↑30% in the long term epoch.

Maximum Air Temperature- RCP 4.5



Maximum Air Temperature- RCP 6

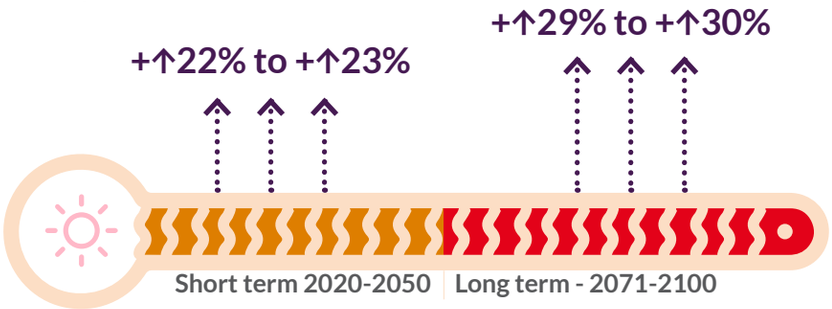


Table 12-2: Range of temporal variations observed in Minimum Air Temperature based on RCP 4.5 and 6 across study area and domains during 2020-2100

Study domain	Baseline Average (in °C)	Short-term (2020-2050)		Long-term (2071-2100)		81-year long period (2020-2100)		Projected Average		
		Max. Projected Decrease	Max. Projected Increase	Max. Projected Decrease	Max. Projected Increase	Max. Projected Decrease	Max. Projected Increase	Short-term	Long-term	81 year long period (2020-2100)
RCP 4.5										
Godavari Upper	19.6	7%	10%	4%	13%	7%	14%	0%	5%	3%
Upstream catchment	19.3	8%	9%	5%	13%	8%	13%	-1%	4%	2%
NMC	19	6%	12%	2%	16%	6%	16%	2%	7%	5%
RCP 6										
Godavari Upper	19.6	5%	29%	0%	35%	5%	35%	11%	19%	15%
Upstream catchment	19.3	0%	39%	0%	45%	0%	45%	18%	26%	22%
NMC	19	3%	41%	0%	47%	3%	47%	19%	27%	23%

Source: *WRI India Analysis 2022*

Table 12-3: Range of temporal variations observed in Maximum Air Temperature based on RCP 4.5 and 6 across study area and domains during 2020-2100

Study domain	Baseline Average (in °C)	Short-term (2020-2050)		Long-term (2071-2100)		81-year long period (2020-2100)		Projected Average		
		Max. Projected Decrease	Max. Projected Increase	Max. Projected Decrease	Max. Projected Increase	Max. Projected Decrease	Max. Projected Increase	Short-term	Long-term	81 year long period (2020-2100)
RCP 4.5										
Godavari Upper	30.8	0%	15%	0%	16%	2%	17%	8%	11%	10%
Upstream catchment	29.6	0%	15%	0%	17%	0%	17%	9%	12%	10%
NMC	29.4	0%	18%	0%	19%	5%	20%	11%	14%	13%
RCP 6										
Godavari Upper	30.8	7%	21%	6%	28%	7%	28%	3%	6%	5%
Upstream catchment	29.6	3%	22%	1%	29%	3%	29%	6%	10%	8%
NMC	29.4	3%	23%	1%	30%	3%	30%	7%	11%	9%

Source: *WRI India Analysis 2022*

12.5 PRECIPITATION

Rainfall, which is an increasingly important subject, continues to be a major regional and micro-climatic factor for the cities. Being vulnerable to rainfall extremes, cities witness floods and droughts and are at the intersection of various socio-economic vulnerabilities induced by rainfall variations. The temporal variations in precipitation (Refer to Table 14-4) have been consolidated and illustrated for the 81-year analysis period.

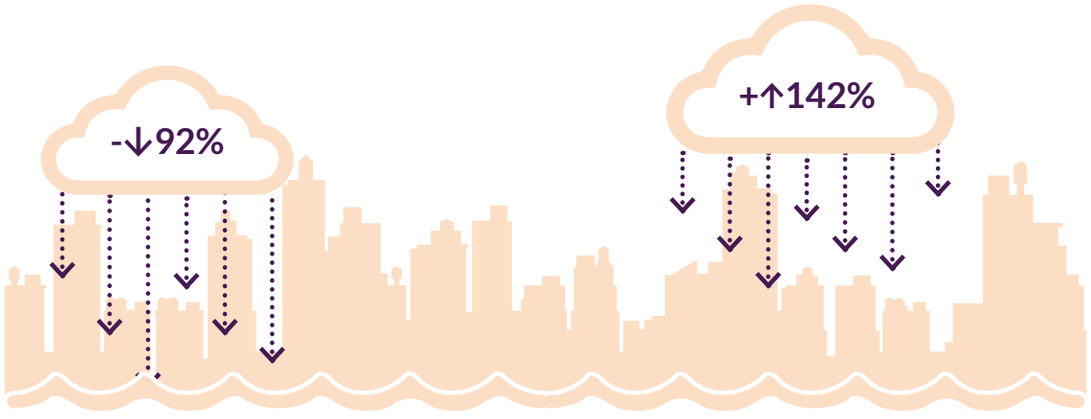
The spatial representation of four selected models, as per RCP 4.5, show the variations within the outputs of each model concerning the baseline for short-term and long-term epochs. Most of the models project the upstream region to record a rainfall deficit, as seen in the meteorological drought probability – 18.4% between 1951 and 2020 (as per Section 4.4.2, Chapter 4 of this document). Decreased rainfall could impact air quality, sanitation, hygiene, and nutrition. It could also cause long-term public health problems due to a shortage of drinking water, especially with heightening air temperature across the study area. Precipitation is a highly local phenomenon dependent on atmospheric and anthropogenic activities. The scenario-wise details are as follows:

1. RCP 4.5

Most models project the precipitation to be decreasing than increasing in both the studied epochs for upstream catchment. On an average, a decrease of ↓ 23% across the upstream catchment is projected for the study epoch. However, the change in precipitation fluctuates between -↓ 92% to + ↓ 142% for the upper catchment area across the study period indicating uncertainty with the projection models.

2. RCP 6

In this scenario, unlike RCP 4.5, there is no significant consensus among the models for the precipitation changes. Alternate flood and drought years are observed with around 100% of decrease and increased precipitation throughout the upstream region.



No significant precipitation changes in both short term and long term. Alternate flood and drought years are observed

Table 12-4: Range of temporal variations observed in Annual Accumulative Precipitation based on RCP 4.5 and 6 across study area and domains during 2020-2100

Study domain	Baseline Average (in °C	Short-term (2020-2050)		Long-term (2071-2100)		81-year long period (2020-2100)		Projected Average		
		Max. Projected Decrease	Max. Projected Increase	Max. Projected Decrease	Max. Projected Increase	Max. Projected Decrease	Max. Projected Increase	Short-term	Long-term	81 year long period (2020-2100)
RCP 4.5										
Godavari Upper	33884	87%	110%	76%	235%	87%	235%	-13%	-1%	-7%
Upstream catchment	4729	92%	95%	81%	142%	92%	142%	-27%	-18%	-23%
NMC	500	93%	103%	81%	170%	93%	170%	-21%	-10%	-16%
RCP 6										
Godavari Upper	33884	97%	163%	99%	171%	99%	178%	14%	21%	19%
Upstream catchment	4729	99%	111%	100%	120%	100%	120%	-21%	-15%	-18%
NMC	500	99%	142%	100%	153%	100%	153%	-8%	-1%	-4%

Source: *WRI India Analysis 2022*

12.6 CONCLUSION

In the RCP 4.5 scenario, most models have consensus regarding air temperature and precipitation, indicating proof of the rising air temperature and alternate drought and flood patterns in precipitation changes. This would impact the energy and water demands of the city, which could give rise to higher emissions in this scenario. Additionally, it could adversely impact crops sensitive to high night temperatures in the reproductive phase, such as grain growth in rice or tuberization in potatoes (TERI, 2014). The differences in the short-term and long-term precipitation changes in RCP 4.5 across the studied regions indicate erratic rainfall changes, as observed in the MSAAPC report.

RCP 6 also notes a rise in air temperature, which could lead to serious health hazards and extreme meteorological risks. RCP 6 does not provide high confidence results in precipitation, which could give rise to potential precipitation-related hazards, such as overwhelming the city's stormwater and medical and emergency infrastructure and resulting in persistent waterlogging and flooding issues in the case of a lack of commitment to preparedness. Moreover, the erratic nature observed in rainfall could impact the agricultural produce as excess rainfall gives rise to fungal diseases, weeds, and pests, worsening the food security in the region. To implement adaptation strategies, there is a need for more localised projections and monitoring station information across the city and in broader regions.

13. ASSESSMENT OF GHG EMISSIONS INVENTORY

13.1 WHAT ARE GREENHOUSE GASES?

Greenhouse gases (GHG) trap heat and contribute towards global warming. The main gases considered in this inventory include carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), CH_4 and N_2O emissions are converted into CO_2 equivalent (CO_2e) emissions by multiplying with their Global Warming Potential (GWP).

The GWP was developed to allow comparisons of the global warming impacts of different gases. Specifically, it measures the amount of energy that the emissions of 1 tonne of gas will absorb over a given period relative to 1 tonne of CO_2. The larger the GWP, the more a given gas warms the Earth compared to CO_2 over that time. This is called CO_2 equivalent or CO_2e. The standard duration usually considered for GWPs is 100 years. GWPs provide a common unit of measure, which allows analysts to add up emissions estimates of different gases (e.g., to compile a national GHG inventory), and allows policymakers to compare opportunities for emissions reduction across sectors and gases.

For example, CH_4 is estimated to have a GWP of 27-30 over 100 years[34]. CH_4 emitted today lasts about a decade on average, much less time than CO_2. However, CH_4 absorbs much more energy than CO_2. The net effect of the shorter lifetime and higher energy absorption is reflected in the GWP. The CH_4 GWP also accounts for some indirect effects, such as the fact that CH_4 is a precursor to ozone and that ozone is a GHG.

The GHG emissions inventory is developed based on the emission factors prescribed by the Global Protocol for Communities (GPC) and IPCC guidelines. The simple formula for calculating GHG emissions is given in Figure 13-1.

13.2 NEED FOR A GREENHOUSE GAS EMISSIONS INVENTORY AT CITY LEVEL

A citywide GHG emissions inventory forms a critical piece of any CAP and provides an overview of sector-wise GHG emissions in the city. This allows cities to build evidence-based mitigation actions and policies to form a CAP and can be a powerful tool for monitoring progress toward a target, such as keeping within the goals of the Paris Agreement and Nashik's Race to Zero commitment.

Figure 13-1: Illustrative formula for GHG Emissions assessment

GHG emissions =

Activity data x Emission Factor

A GHG emissions inventory helps the city to know the GHG emissions contribution of different sectors and activities, prioritise mitigation actions and monitor reductions. It also allows for direct funding towards high emitting sectors. Moreover, it helps cities meet reporting requirements, such as disclosing GHG emissions data through voluntary reporting platforms of the likes of Carbon Disclosure Projects (CDP), and meet funding criteria that require a baseline inventory. GHG emissions inventories also serve as a benchmarking tool for cross comparison between cities. It also allows for the aggregation of city-level inventories with national/state inventories to measure the contribution of city mitigation actions to state or national emissions reduction targets.

14. GHG EMISSIONS INVENTORY FOR NASHIK CITY

The GHG emissions inventory for Nashik includes an analysis of all the sectors/sources that emit GHGs into the atmosphere. The inventory was developed using the GPC framework and covers three sectors — stationary energy, transportation, solid waste management, and wastewater.

14.1 ASSUMPTIONS

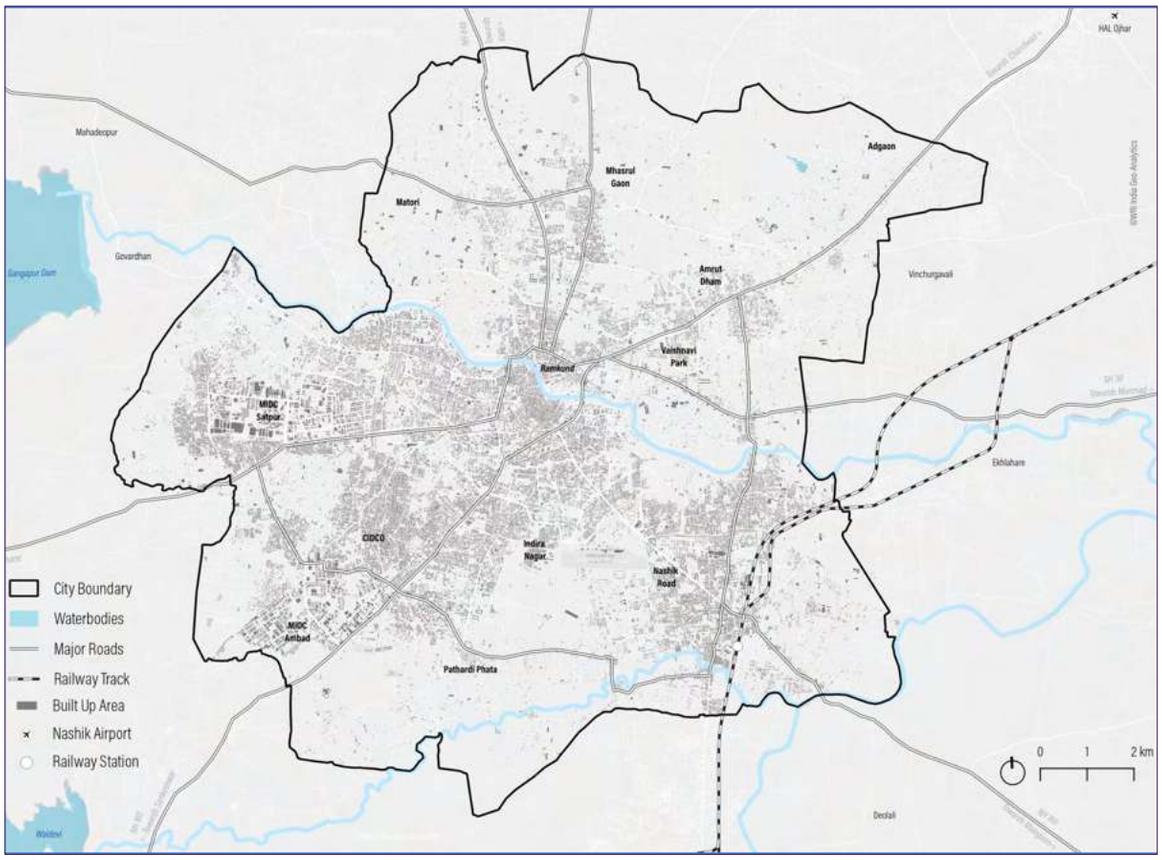
The GHG emissions inventory for Nashik is aligned with the GPC framework, a robust GHG accounting and reporting framework for cities prepared by the World Resources Institute, C40 Cities Climate Leadership Group, and ICLEI – Local Governments for Sustainability (ICLEI)[35]

- The year 2021 was taken as the base year for the inventory, and the inventory boundary was limited to NMC, which covers a land area of 267.48 km^2 and has a projected population of 20.13 lakh people as of 2021 (WRI India Analysis). The inventory includes emissions from the industrial clusters of Maharashtra Industrial Development Corporation (MIDC) located within NMC limits, namely Satpur MIDC and Ambad MIDC, as seen in Figure 14-1.
- The GHGs covered includes CO_2, CH_4 and N_2O. The inventory aligns with the BASIC inventory (Refer to Table 14-1) comprising emissions from stationary energy in boundary transportation and solid waste management and wastewater treatment in the city.
- Scope 1 emissions include emissions occurring due to activities within the city, while Scope 2 covers emissions from grid-supplied electricity. Scope 3 emissions include emissions occurring outside the city boundary due to activities happening within the boundary.

Table 14-1: BASIC inventory components under GPC

Emission sources and scopes included in BASIC inventory
• Scope 1 emissions from stationary energy sources (excluding energy production supplied to the grid, which shall be reported in the Scope 1 total) • Scope 1 emissions from transportation sources • Scope 1 emissions from waste sources (excluding emissions from imported waste, which shall be reported in Scope 1 total) • All Scope 2 emissions from stationary energy sources and transportation • Scope 3 emissions from treatment of exported waste

Figure 14-1: Map of Nashik city showing major landmarks and industries



Source: *WRI India Analysis; NMC 2022*

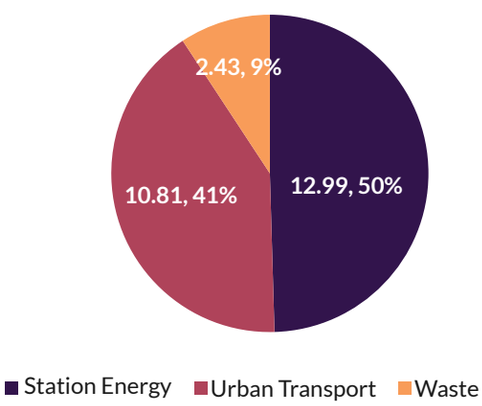
14.2 SUMMARY OF ESTIMATED GHG EMISSIONS IN NASHIK CITY

In 2021, the estimated GHG emissions in NMC area were 26.23 lakh tonnes of CO_2 equivalent (tCO_2e). This is approximately 1.3 tCO_2e per person (based on the estimated population of 20.13 lakh for the year 2021).

The highest contribution to the GHG emissions is from stationary energy sector (50%), followed by on-road transportation (41%) and waste sector (9%). The waste sector includes both wastewater and solid waste management sub-sectors. Refer to Figure 14-2.

Figure 14-2: GHG Emissions Inventory – Summary

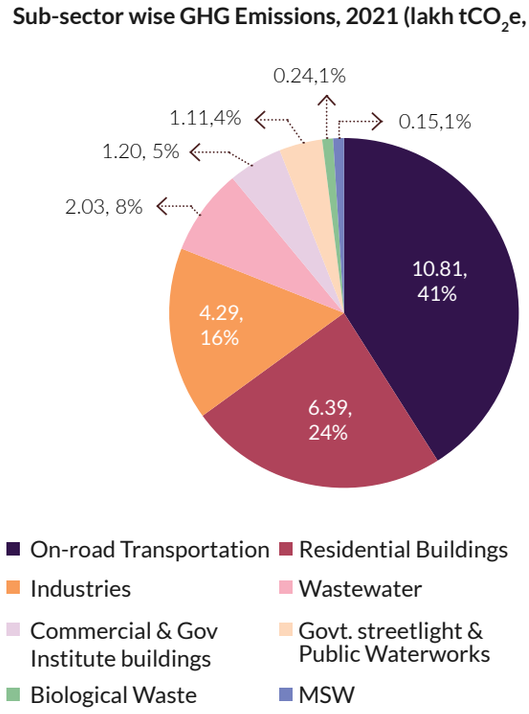
GHG Emissions Inventory, 2021 (lakh tCO_2e, %)



Source: *WRI India Analysis 2022*

The contributions by sub-sector are presented in Figure 14-3. The three major sub-sectors that contribute substantially to the GHG emissions are on-road transportation (41%), residential buildings (24%), industrial sector (16%) and wastewater (8%).

Figure 14-3: GHG emissions inventory – sub-sector wise break up



Source: WRI India Analysis, 2022

The estimated GHG emissions by sub-sector are covered in the following sections.

14.2.1 Stationary energy sector

1. Data availability

The stationary energy sector includes two segments — electricity and fuel (LPG) consumption by residential, commercial, and industrial sectors.

- Energy generation is undertaken by the state-run Maharashtra State Power Generation Company Ltd (MAHAGENCO). The electricity supply within Nashik city is managed by Maharashtra State Electricity Distribution Company Ltd. (MSEDCL), another state-run company. Tata Power Limited handles the electricity for streetlighting and lighting services in municipal utilities. The energy consumption by different user categories was collected and analysed. The data on electricity consumption for low tension (LT) and high tension (HT) categories was collected for various user categories, such as residential (LT), commercial (LT & HT), industrial (LT &HT), power looms (HT), public water works (HT), streetlights (LT), agriculture (LT), non-specified sources (HT & LT) and LT rooftop solar generation with consumer capacity.
- In the case of Maharashtra state, the energy is generated from different sources, such as coal- or gas-based thermal power plants and hydropower plants. This energy mix has coal-based power plants (60%) as a significant source of electricity generation, followed by renewable energy (23%), gas (8%), hydro (7.5%) and nuclear (1.5%)[36]. Therefore, a common GHG emission factor for electricity consumption is considered based on the energy mix, and this GHG emissions factor is provided by the Central Electricity Authority of India (CEAI) for the West zone. For 2021, the GHG emissions factor provided by CEAI is 0.79 t/MWh.
- In fuel consumption, data is available only on the use of LPG by residential, commercial, and industrial sectors. PNG within the city is very limited, and no data is available.

- A thermal power plant of National Thermal Power Corporation (NTPC) is located at Eklahare, but it falls outside NMC limits and is not considered for the analysis.
- The field visits and consultations in the city indicate that firewood and coal are also used in the residential, commercial, and industrial sectors. However, due to the non-availability of data, the contribution of these fuels to GHG emissions could not be ascertained.

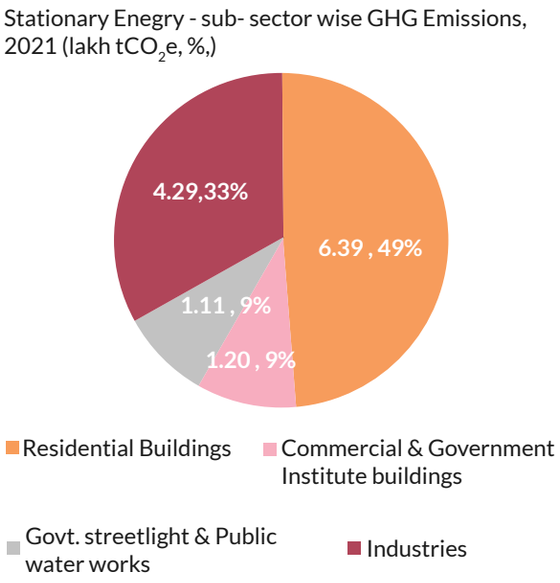
14.2.2 Sub-sectoral analysis- stationary energy sector

This stationary energy sector contributes around 50% (12.99 lakh tCO_2e) of the total GHG emissions of Nashik city. The electricity sub-sector contributes 98%, followed by 1.5% LPG and 0.5% wood/wood waste.

In terms of sub-sectors within the stationary energy sector:

- Residential buildings are responsible for 6.39 lakh tonnes of CO_2e, 49% of stationary energy's GHG contribution. Commercial and government institutional establishments account for 1.20 lakh tCO_2e, 9% of stationary energy's GHG contribution. The industries account for 4.29 lakh tCO_2e, 33% of stationary energy's GHG contribution. Refer Figure 14-4.
- As shown in Figure 14-4, the emissions from industries are from HT & LT connections of the manufacturing industry.
- Scope 2 emissions are higher because only 48,980 KW of RE is grid-connected, which translates to 0.03% dependency on RE in the energy mix. Approximately 80% of the total solar generation is also from residential and institutional buildings, as very few industrial premises depend on renewable energy for heating. Fuel wood is used in the city's confectionaries and other bakeries, and around 25 wood-operated crematoria are under NMC jurisdiction.

Figure 14-4: GHG emissions from stationary energy – sub-sectoral contribution



Source: WRI India Analysis, 2022 (percentages are rounded off)

The estimated GHG emissions from fuel (LPG) usage in residential, commercial, and industrial sectors is 2.53 lakh tCO_2e, 19.5% of the stationary energy emissions. The residential sector has a significant share of 98% in LPG consumption, possibly due to a lack of complete data from the commercial and industrial sectors. Only partial data is available on coal consumption in the residential sector.

14.2.3 Transportation sector

1. Data availability

Nashik city has only an on-road transportation system and no intra-city railway, metro, or water transport system.

- The transport sector emissions are estimated using the fuel sales method, based on the fuel data received from the fuel companies on sales of auto LPG, auto CNG, petrol and diesel from the petrol pumps located within Nashik city.
- Currently, the city has an 81% dependency on petrol and diesel fuels. The CNG sales data has been collected from one MNGL petrol pump, the only distributor in the city. At the time of data collection, the supply of PNG had only reached a very few upcoming high-rise residential establishments and, hence, is not considered in the study.
- Data on the number of vehicles registered with the Regional Transport Office (RTO) by fuel type from 2010-2021 was also considered to assess the current fuel mix in the vehicle fleet and understand the trends in vehicle usage in the city by fuel type.

14.2.4 Sub-sectoral analysis- transportation sector

In 2021, the transport sector's contribution to GHG emissions is 10.81 lakh tCO_2e, which is around 41% of the total GHG emissions for the city. The high vehicle registration rate of 14.59 lakh vehicles, which is fossil-fuel heavy, till February 2022 is another prime factor for the high emissions reported from this sector. Currently, there is also a limited public transit system within the city as there are only 250 CITILINC (intra-city bus service-subsidiary of NMC) buses operational, with a daily average public ridership of 52,000 passengers, of which 26,000 are female. As the airport is located outside NMC boundary, emissions from flights have not been considered.

14.2.5 Waste management sector

1. Data availability

City-level data on solid waste management and wastewater treatment was analysed. The key data points referred are given below:

A. Municipal Solid Waste

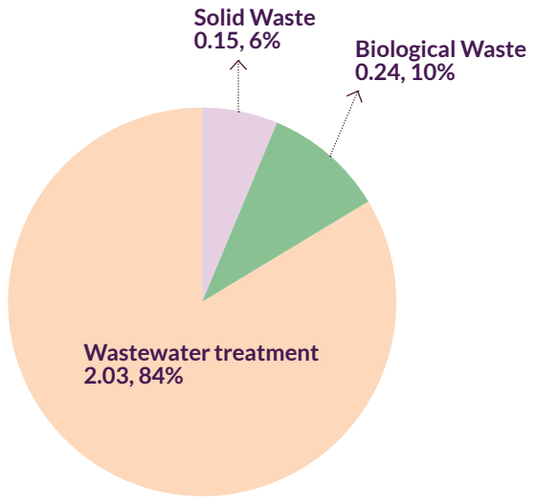
- In 2021, around 635 tonnes per day of solid waste was generated, of which around 61% is organic waste and 32% is non-organic waste (paper, wood, textile, plastic, inert, C&D waste). The remaining 7% waste comprises metal waste (1.33%) and hazardous waste (0.012%), which are not processed at the ISWM facility, and 5% of other waste. In terms of overall waste composition, nearly 51.2% is food waste, 10% is garden waste and other plant debris, textile waste is 15% and plastic waste is 7.2%, Construction and demolition waste is 5%, paper is 2.5%, and the remaining 8.3% is other wood waste, inert, metal and hazardous and other industrial material waste.
- About 49% of the waste is recycled, 11 % is composted, refuse derived fuel (RDF) recovers 22%, and 18% is dumped in landfills. All this falls within Scope 1 as waste incineration, or RDF is done inside the plant and not transported to another facility outside the boundary.

- The city undertakes organic waste treatment through waste-to-energy and compost treatment. Regulation of waste segregation in the city is improper, and the segregation is done at the plant by a system called trammelling or size separation of all mixed waste in the unloading pit by trammel lines. Waste is segregated based on particle size. About 120 TPD is disposed of at landfills. Although the landfill is scientifically managed, it has only 85% of gas collection efficiency. The residue or recovered waste compost or RDF is sold to the manufacturing industries for usage as boiler feed and to wineries. It is understood from the consultations during the data collection process that biogas is not captured as there is an issue of flaring and plant efficiency and capacity but is in the pipeline.

B. Wastewater treatment

- In 2021, the estimated wastewater generation in Nashik city was at a total of around 337 MLD and the combined capacity of 10 sewage treatment plants (STPs) was 360.5 MLD as of February 2022. An installation of Pimpalgaon Khamb STP is in the pipeline, with a capacity of 32 MLD. However, the sewerage network coverage is only 80%. Therefore, only around 67.4 MLD of wastewater is treated, and the remaining is discharged without treatment.
- Methane is captured during the wastewater treatment process only from September 2021. However, due to low-quality output, it is flared, and only about 4,500 units are captured and used in plant energy generation.

Figure 14-5: GHG emissions from Waste – sub-sectoral contribution



Source: WRI India Analysis, 2022

14.2.6 Sub-sectoral analysis- waste management sector

Waste contributes to GHG emissions of around 2.43 lakh tCO_2e, which is nearly 9% of the total GHG emissions. The wastewater sector contributes 84% (2.03 lakh tCO_2e) of the waste sector-related GHG emissions. The GHG emissions from municipal solid waste (MSW) are primarily due to CH_4 emissions, N_2O emissions during the biological process, and CO_2 emissions due to the incineration process of dry waste.

In the case of wastewater treatment processes, primary emissions are from CH_4, and the CO_2 is generated due to the flaring of the CH_4.

15. GHG EMISSIONS - SCENARIO ANALYSIS

15.1 APPROACH AND METHODOLOGY

15.1.1 Objective

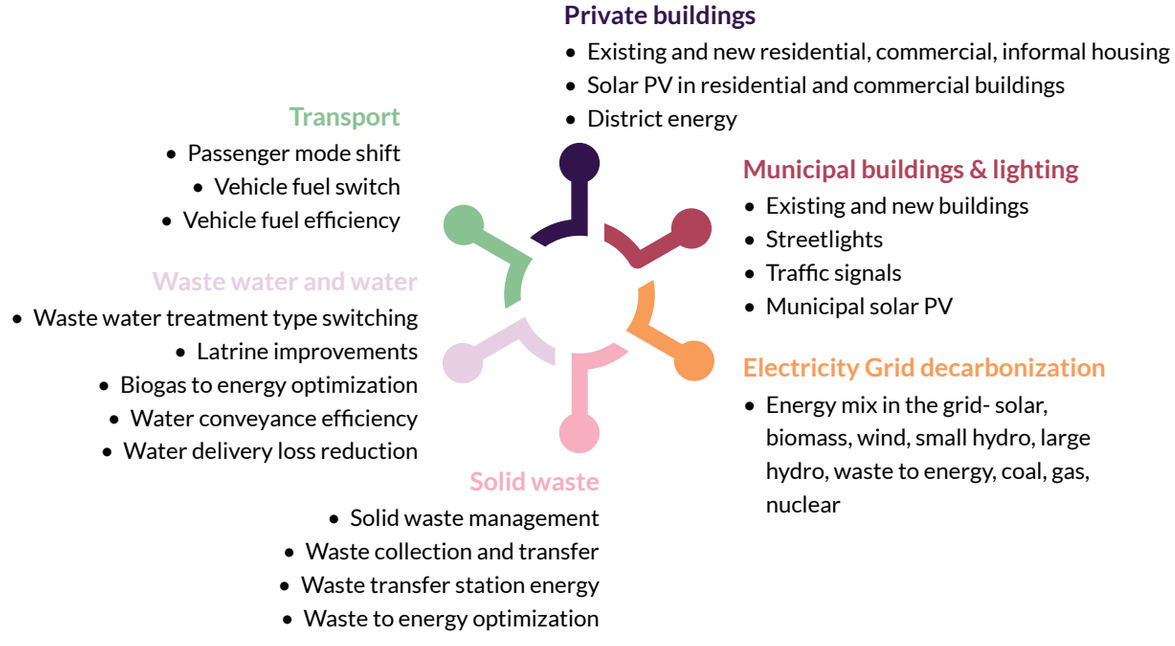
The objective of the scenario modelling exercise is to establish an evidence base on which the city can set emissions reduction targets for energy, transport, and waste sectors in line with a fair-share 1.5-degree scenario and identify the strategies to achieve them. These scenarios would be used to structure the climate action planning analysis, document the city's current strategies, identify new strategies that Nashik can plan on implementing in the near and medium terms and assess barriers in implementation. These strategies would help the city mitigate the growing climate risks and help understand the project financing needs for the city to set achievable targets. This exercise also aligns with the Maharashtra state's Race to Zero Campaign, of which Nashik city is a part.

15.1.2 Tools, approach & methodology

The scenario modelling for Nashik city has been developed using the Climate Action for Urban Sustainability (CURB) tool. The CURB is an interactive Excel-based tool designed by the World Bank in partnership with C40 Cities Climate Leadership Group, Global Covenant of Mayors, and AECOM Consulting. It helps cities develop emissions reduction targets for key sectors, assess investments required and prioritise low-carbon interventions based on cost, payback period, feasibility and impact on energy consumption and emissions reduction.

CURB allows cities to plan across six sectors in an integrated way: private buildings, municipal buildings, public lighting, electricity generation, solid waste, transportation and water and wastewater (Refer Figure 15-1).

Figure 15-1: Scenario analysis through CURB tool - sectors and sub-sectors



Source: Author's infographic based on the CURB user guide, World Bank

CURB is being used by cities globally to compare the cost, energy, and climate impact of different technological and policy solutions to direct investments, develop robust climate action plans, set informed targets and acquire project financing. It is a free, open-access tool, driven by city-specific data cost of water, fuels, and electricity and city baseline information for each sector.

As per the tool, there are three main scenarios that have been developed:

Business as usual
to represent development as per usual with no actions being taken to become sustainable

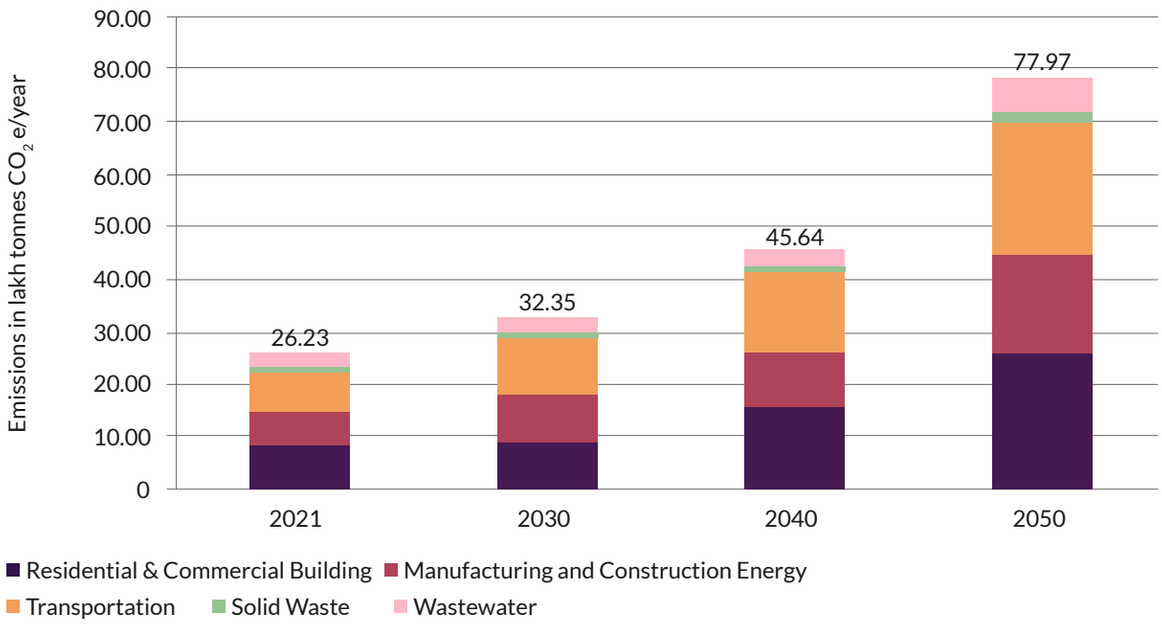
Existing & planned
to represent development considering plans and policies that have been envisioned for the city

Ambitious
to represent development where ambitious targets have been set for the city to see sustainable growth

For the modelling study, 2021 has been accounted for as the base year. The future interim target years are 2030, 2040 and 2050.

The targets and outputs modelled using the CURB align with the RCP 2.6 scenario and the Paris goals of 1.5-degree reduction. Whereas in a few cases, it also considers RCP 4.5, an intermediate scenario, emissions in RCP 4.5 peak around 2040 and then decline. As per IPCC, RCP 4.5 is a moderate scenario in which emissions peak around 2040 and then decline. RCP 8.5 is the highest baseline emissions scenario in which emissions continue to rise throughout the twenty-first century. This could be correlated to the current BAU scenario if no action is taken. Each scenario has a specific set of policy levers that provide relatively high GHG emission mitigation opportunities.

Figure 15-2: Business-as-usual scenario: GHG emissions projection



Source: *WRI India analysis using CURB tool*

15.2 SCENARIO ANALYSIS

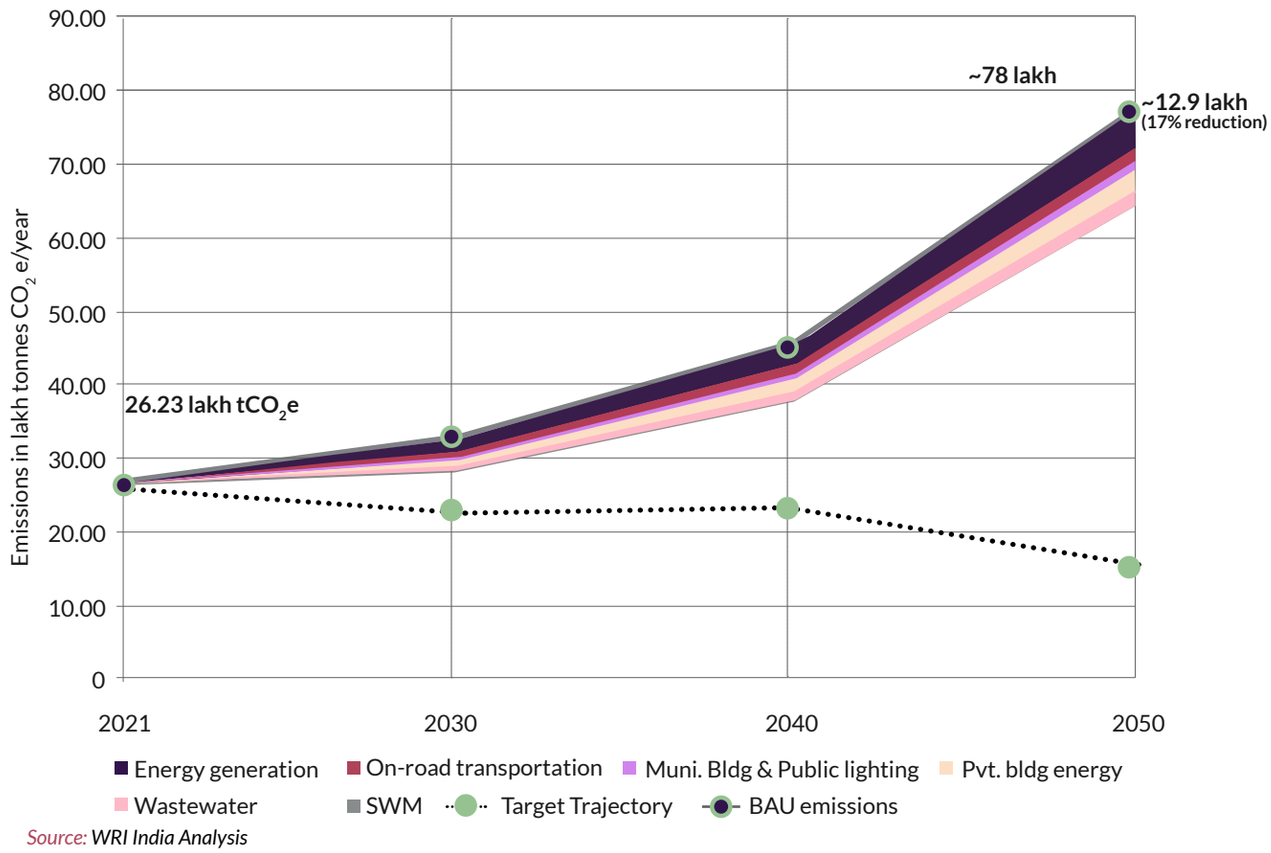
15.2.1 Scenario-1: Business-as-usual scenario

The GHG emissions in 2021 account for 26.23 lakh tonnes of CO_2 equivalent (tCO_2e) estimated, based on the GPC 4th Assessment Report. Under the BAU scenario, if no action is taken to mitigate climate change, the overall GHG emissions of the city are likely to increase nearly three times between 2021 and 2050, reaching 77.97 lakh tonnes of tCO_2e.

15.2.2 Scenario-2: Existing and Planned Scenario

The E&P scenario uses data from existing and planned city, regional and national actions, policies, and programmes to demonstrate the emissions reduction trajectory for the city regarding the current ambition level. It considers current and planned development strategies with indirect co-benefits of emissions reductions. Examples include nationally determined contributions (NDC), the Maharashtra Power System Master Plan, Net Metering Guidelines, Energy Efficiency and Conservation Policy, National Action Plan for Climate Change (NAPCC), Maharashtra Electric Vehicle Policy 2021, Development Plan (2016), Comprehensive Traffic and Transportation Plan (2017), which cover actions to subsidise photovoltaic solar installations, solar rooftops, electric vehicle policy etc. All these were factored as input data in the E&P scenario.

Figure 15-3: Existing & Planned scenario



Source: *WRI India Analysis*

As shown in the graph below, given all the above sectoral input data, in the E&P scenario, Nashik can achieve a 17% emission reduction by 2050 as compared to the baseline GHG emissions. This is due to the ongoing initiatives in the transport and municipal buildings sector. However, this is sizeably low, owing to an already low emission profile and BAU scenario.

The GHG emissions reduction target for 2050 is 80% of the estimated emissions, i.e., 80% of 78 lakh tCO_2e, which is 62.4 lakh tCO_2e. Suppose the actions proposed as per the Ambitious scenario are implemented by 2050. In that case, the GHG emissions will be reduced by 56.8 lakh tCO_2e, approximately a 91% reduction compared to the target of 62.4 lakh tCO_2e reduction by 2050. Thus, there will be residual emissions of 5.6 lakh tCO_2e, 9% of the emissions reduction target.

15.2.3 Scenario-3: Ambitious scenario

Targets in the ambitious scenario has the potential to achieve approximately 72.8% emission reduction by 2050 as compared with BAU emissions of 78 lakh tCO_2e in 2050.

The residual emissions can be linked to a lack of technological advancement and R&D needed to mitigate further emissions from the sectors. There is also a need to create more carbon sinks.

As indicated, in the Ambitious scenario, the emissions amount to 21.2 lakh tCO_2e as compared with ~ 78 lakh tCO_2e in the BAU scenario.

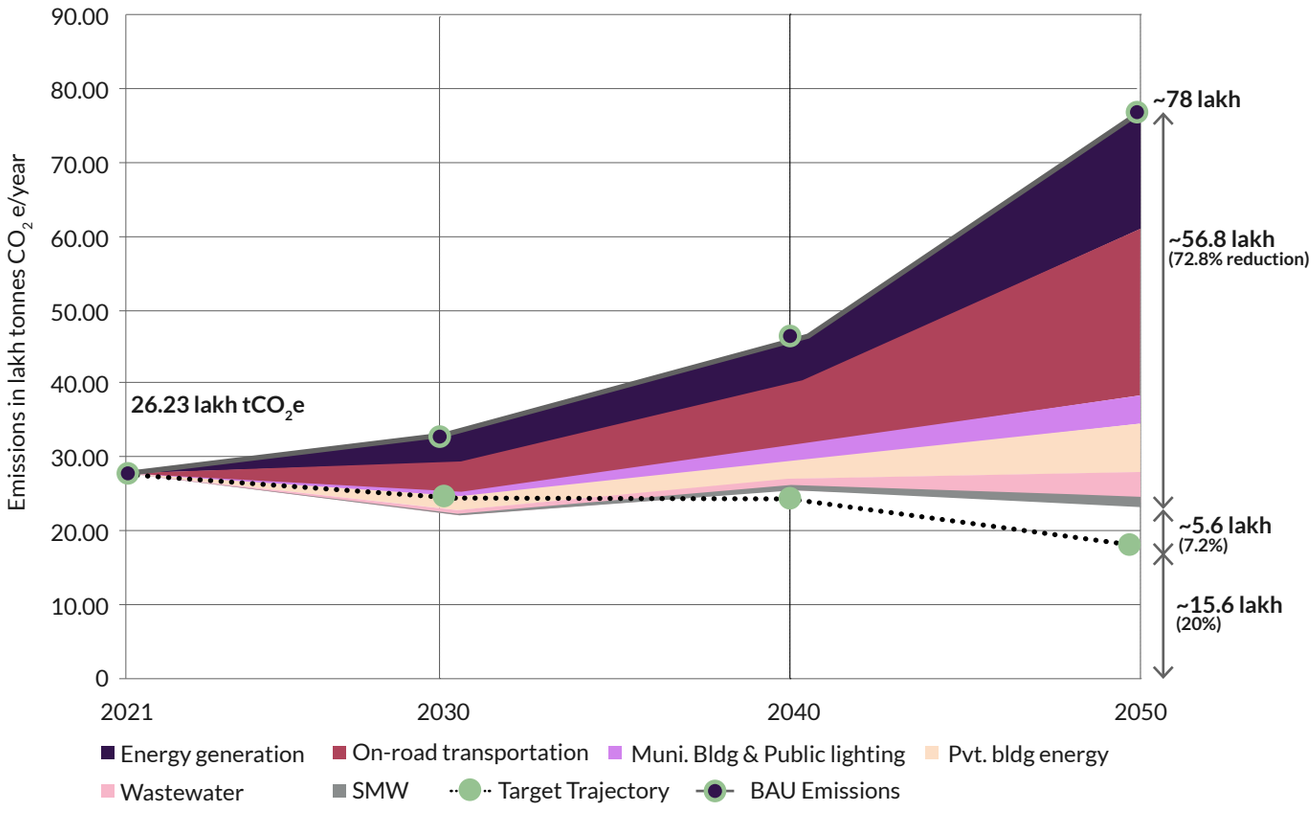
- In the Ambitious scenario, given further aggressive policy scenario setting, we can expect deeper decarbonisation of the grid beyond 2040 because of India's high rate of renewable energy deployment and global pressure to retire coal power plants.
- Interventions such as fuel efficiency improvements in internal combustion engine (ICE) vehicles, vehicle electrification, increased use of alternative fuels and restraining travel demand could limit or even reverse the growth trend of CO_2 emissions from the transport sector.
- Any significant impact in peaking and subsequent reversal of the emissions trend would only be possible if aggressive vehicle electrification and continued efficiency improvements in ICE vehicles till 2050. Thus, the need for more decisive action to decarbonise the road transport sector is clear as efforts under the high Ambition scenarios fail to achieve carbon neutrality by mid-century.
- The effective implementation of policies could help decrease 45–50% of cumulative CO_2 emissions between 2021 and 2050 using additional decarbonisation efforts, such as mode shift and deeper grid decarbonisation.
- Residual emissions can be further reduced if the city sets a higher renewable energy target. This is a state responsibility, and the city can contribute to a certain extent by adopting rooftop solar, solarising utilities and buildings and adopting energy efficiency measures. Further research would be required to gauge the reduction of all long-term residual emissions.

Limitations of the modelling analysis:

- No model is 100% correct about scenario prediction, as some degree of approximation is always required while making simulations for plausible pathways.

- Having the outputs in terms of impacts on GHG emissions, pollutants, jobs, GDP, etc., would depend on several considerations, such as structural modifications in the city, lifestyle changes, projection of energy demand and travel demand, over the time horizon. Long-term projections of these parameters generally induce uncertainties within the model.

Figure 15-4: Ambitious Scenario - GHG emissions reduction

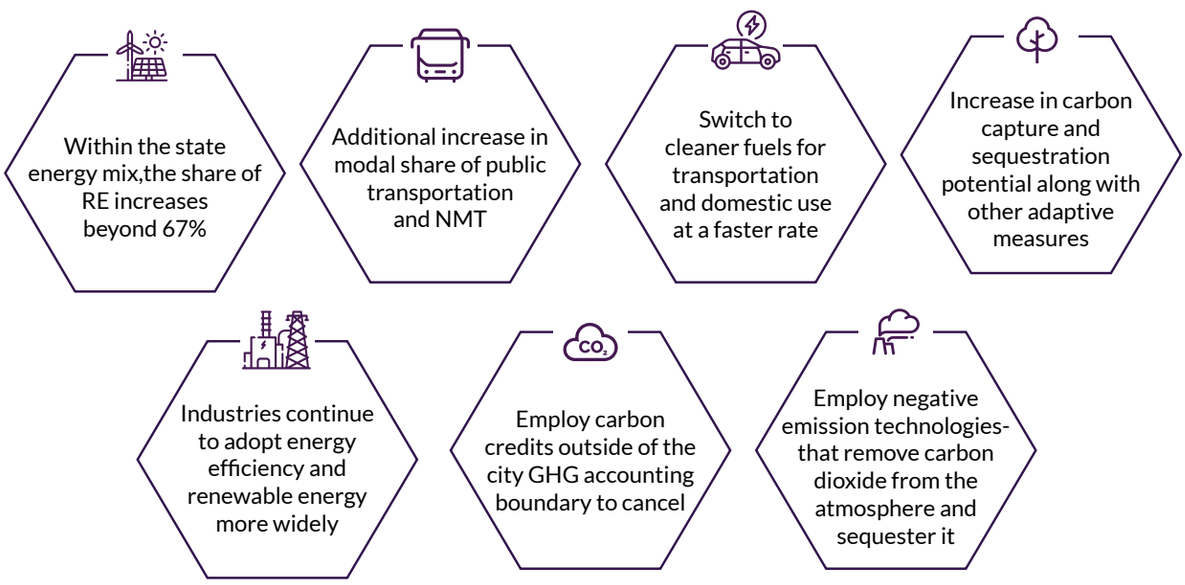


Source: *WRI India analysis*

15.3 NET ZERO BY 2050

Based on the city's institutional and financial capacity, along with constraints in political will, Nashik will still have some residual emissions by the year 2050. However, the projected emission reduction target aligns with the Government of India's 2070 net zero emission reduction target. To reach a net zero by 2050, the Government of Maharashtra and NMC must take additional vital measures, as presented in Figure 15-5.

Figure 15-5: Measures to achieve extended scenario



SECTION -V:
Priority Sectors- Assumptions and Targets

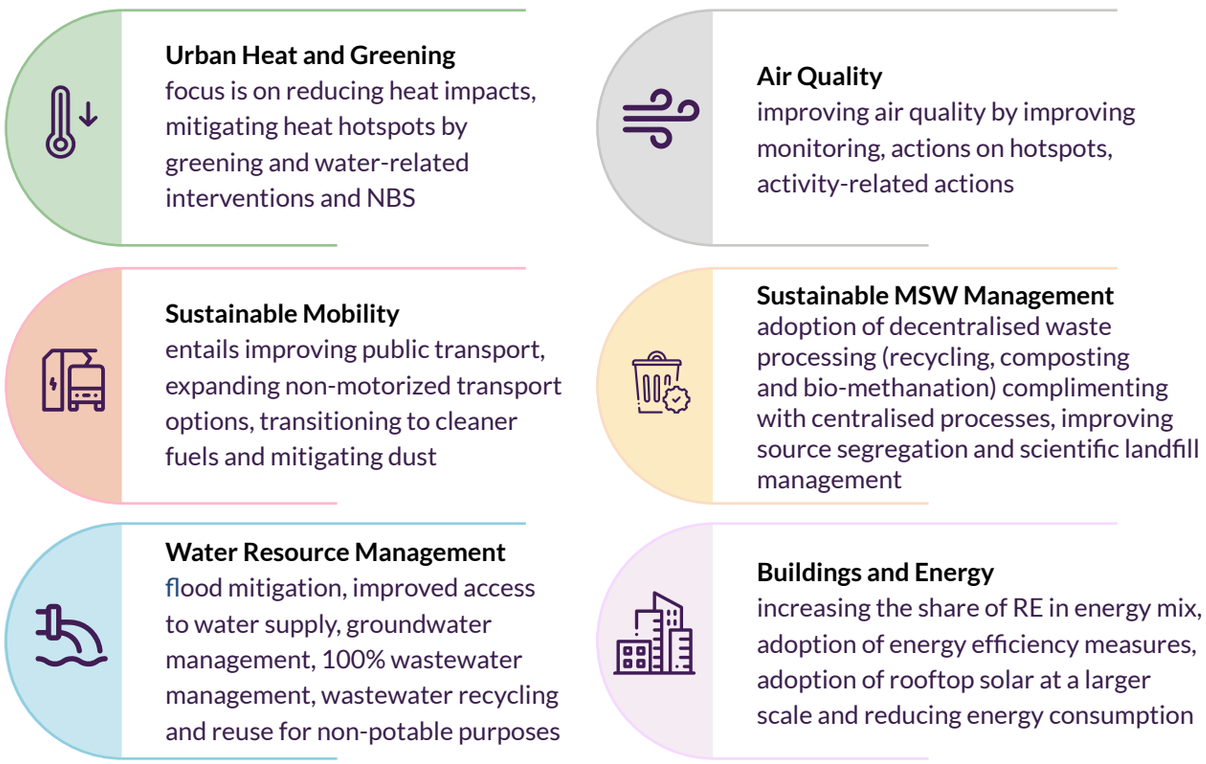
KALARAM TEMPLE
Photo Credits - WRI India

16. PRIORITY SECTOR IDENTIFICATION

16.1 KEY PRIORITY SECTORS

Based on the VA, the GHG inventory, and stakeholder consultations, six priority areas have been identified for the implementation of strategies for adaptation and mitigation. These include energy and buildings, urban mobility, municipal waste management, urban greening and heat mitigation, water resource management, and air quality. In order to develop assumptions and targets under the Ambitious scenario, various stakeholders were consulted and secondary research conducted. The stakeholders included NMC departments of water supply, public works, environment, solid waste management, and planning, as well as parastatal agencies namely MSEDCL, fuel companies, and community organisations.

Figure 16-1: Key priority sectors



While creating the Ambitious scenario, the priorities, ongoing projects, and realistic targets for the city are taken into consideration. However, the city does not have the authority to carry certain reforms and actions.

The energy sector is the most significant contributor to emissions in Nashik city. Since electricity supply to the NMC area is from a state utility, therefore, requires interventions and reforms at the state level to improve the energy mix. The targets for the transport sector prioritise the reduction of private mode shares and increase of mass transit usage. However, it is essential to note that despite these efforts, personal vehicles will continue to be a mode of transport in the city owing to the state of public transportation, citizens' preference for private modes, and the limited reduction of dependency on personal vehicles.

Similarly, source segregation of waste and cleaner fuels for waste transportation is critical for sustainable waste management. Various cities have implemented source segregation, which has been challenging due to multiple reasons such as the challenges in changing behaviours change, sustaining awareness, and penalising. The transition to cleaner fuels for waste vehicles also depends on the auto market and technology innovations. The wastewater sector also chalks out Ambitious scenario targets that depend on investments made in the existing processes, which would enhance efficiency and yield improved results.

A summary of the Ambitious targets proposed for Nashik City using the scenario modelling is presented in Table 16-1.

Table 16-1: Summary of sectoral targets for ambitious scenario

Target	2030	2040	2050
Energy: Private Residential buildings and energy			
Energy-efficient lighting in existing residential buildings	50%	75%	90%
Energy-efficient cooling in existing residential buildings	45%	70%	100%
Energy-efficient water heating in existing residential buildings	50%	60%	85%
Energy-efficient lighting in new residential buildings	45%	75%	100%
Residential PV on-grid connected electricity	30%	70%	85%
Energy: Private Commercial buildings and energy			
Energy-efficient lighting in existing commercial buildings	30%	80%	100%
Energy-efficient cooling in existing commercial buildings	40%	75%	90%
Energy-efficient water heating in existing commercial buildings	25%	60%	90%
Commercial PV on-grid connected electricity	40%	60%	80%

	Energy: Municipal buildings, public street lighting and Traffic lights			
	Energy-efficient lighting in existing municipal buildings	40%	65%	100%
	Energy-efficient cooling in existing municipal buildings	40%	80%	100%
	Public streetlight LED retrofit	50%	90%	100%
	LED traffic signals	60%	80%	100%
	Electricity decarbonization sector			
	Solar PV	10%	15%	25%
	Total by renewables	39%	50%	67%
	Coal	61%	50%	33%
	**Sustainable Mobility**			
	Mode share for public transport	20%	30%	40%
	Mode share of NMT and walking	22%	24%	25%
	4 & 2 wheelers in modal split	36%	26%	17%
	Share of auto in modal split	22%	20%	18%
	Electrification of vehicles			
	Electrification of passenger automobiles (Three-wheeler auto)	25%	50%	70%
	Share of electrification of light-duty freight	15%	40%	60%
	Share of electrification of buses	10%	20%	50%
	Fuel switch of all on-road transport (CNG, electric etc.)			
	2W	35%	65%	100%
	3W	30%	50%	100%
	4W	10%	25%	50%
	LDV	30%	60%	100%
	HDV	10%	25%	45%
	Bus Standard	20%	40%	70%
	**Sustainable MSW Management**			
	Share of organic waste composted	60%	90%	100%
	Share of CNG SWM transport vehicles	10%	30%	70%
	Share of recycling – Paper waste	18%	50%	85%
	Share of recycling – Plastic waste	35%	70%	100%
	Waste–energy optimisation	25%	50%	80%

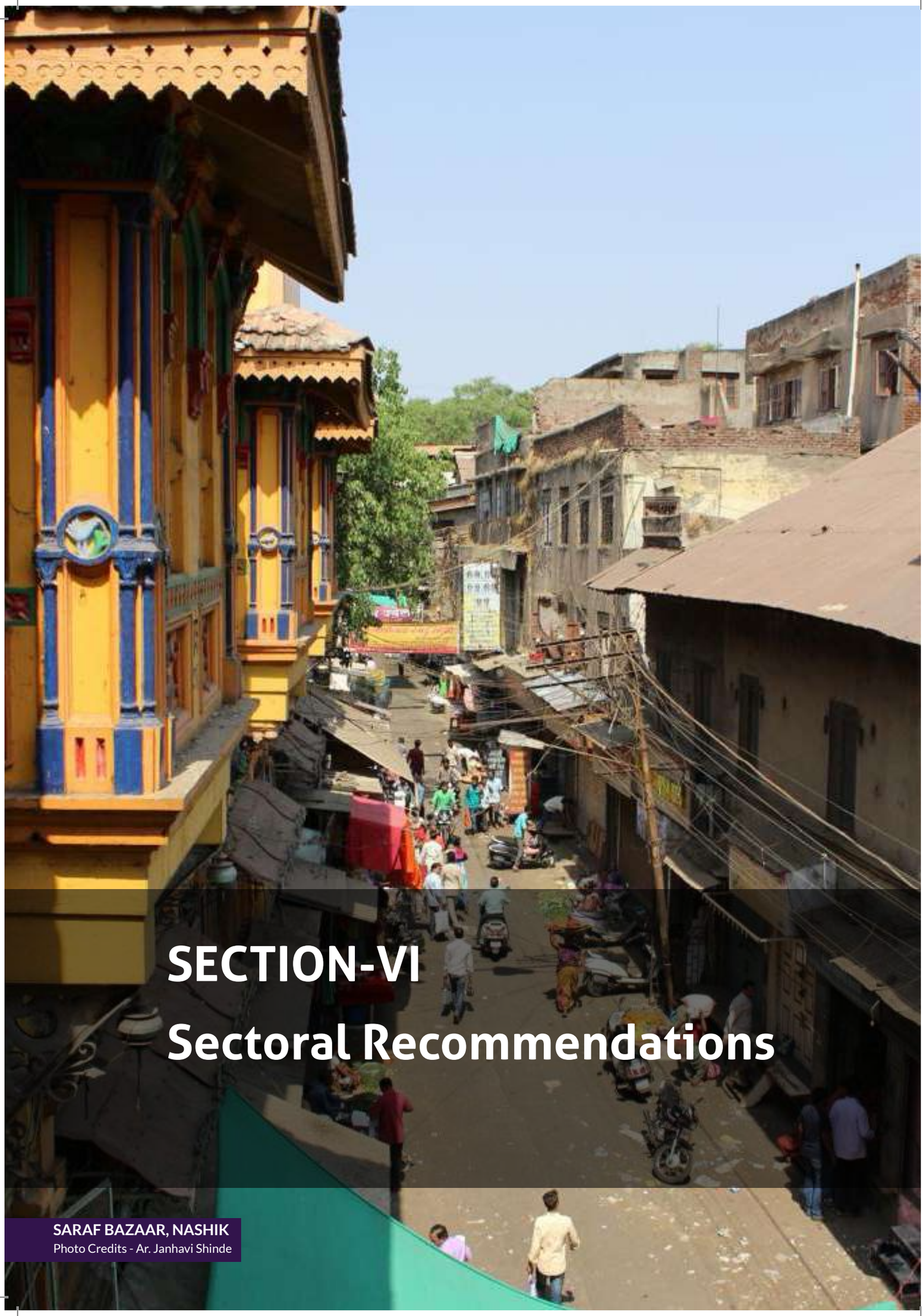
Wastewater sector			
Improved centralised treatment	20%	65%	95%
Improved decentralised treatment	5%	20%	30%
Wastewater to biogas optimisation	5%	20%	30%
Water			
Share of pumps with improved efficiency	15%	30%	50%
Share of NRW	40%	20%	10%

Source: WRI India Analysis, 2022

While these targets align with the sectoral departments of NMC to ensure the efficient implementation of the Nashik CAP, there is immense scope to converge across sectors, catalyse collaborations across Departments, and reap the co-benefits of holistic solutions.

The Nashik CAP envisions promoting low-carbon, green, and inclusive development in Nashik city while building resilience for systems, people, nature, and businesses aligned with achieving a net-zero emissions pathway for a 'Climate Forward Maharashtra'.

Recognising the need to take steps across the six identified sectors on priority, the Nashik CAP presents detailed analyses and elaborates on target setting and actions in the chapters that follow



SECTION-VI
Sectoral Recommendations

SARAF BAZAAR, NASHIK
Photo Credits - Ar. Janhavi Shinde

17. RECOMMENDATIONS- BUILDING & ENERGY

17.1 SECTORAL OVERVIEW

The assessment of the stationary energy sector in Nashik City comprises two segments: electricity and fuel (LPG) consumption.

17.1.1 Buildings

The buildings and construction sector plays a key role in accelerating the transition towards a low-carbon, resilient and sustainable future in India. As one of the highly energy-intensive sectors in the country, it contributes greatly to overall GHG emissions as compared with other end-use sectors.

Energy consumption and carbon emissions in the built environment are largely born out of the use of electricity and building materials. The emissions associated with the energy use in a building are termed operational emissions. The ones associated with building material production, construction of a building and renovation, repair and demolition at the end of life are termed embodied emissions[37]. In this CAP, the operational emissions are considered for the analysis i.e. the electricity consumption by different user categories.

The electricity supply within Nashik City is managed by the state-run Maharashtra State Electricity Distribution Company Ltd. (MSEDCL). The electricity for street lighting and lighting services in municipal utilities is entrusted to Tata Power Limited by NMC on a PPP basis. The energy generation is handled by Maharashtra State Power Generation Co. Ltd (MAHAGENCO), another state-run company, along with other private generating companies such as Tata Power with whom the MSEDCL has power purchase agreements.

In the case of Maharashtra state, energy is generated from different sources, such as coal- or gas-based thermal power plants and hydropower plants. The major source of electricity is coal (60%), followed by renewable energy (23%), gas (8%), hydro (7.5%) and nuclear (1.5%)[38]. Therefore, one of the decarbonisation strategies under this building and energy sector is to improve the energy mix to be based on cleaner fuel, where the state government plays a bigger role than the NMC. The NMC can contribute by sensitising citizens and other users to demand management and promotion of renewable energy, such as rooftop solar in all types of institutes and residential buildings, and adoption of energy

Figure 17-1: Stage of energy consumption and carbon emissions in buildings

Source: *https://aeee.in/tackling-embodied-carbon-from-indias-building-sector/*

efficiency improvement measures. Under the CAP, the energy consumption by different user categories within the NMC area was collected and analysed.

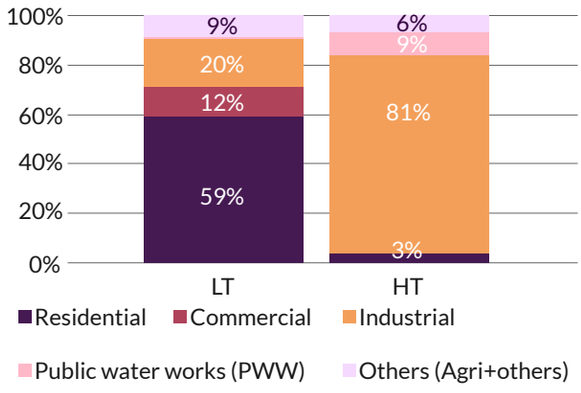
Refer to figure 17-2 for the consumer category-wise electricity connections within NMC.
Under the LT category, 59% of connections are residential, 20% industrial and 12% commercial.

Under the HT category, most of the connections i.e. around 81% of the connections are industrial, followed by 9% under the public water works category.

The percentage of solar energy generation at the buildings level to the total electricity consumption from the different user categories is low. For instance, under the LT category, the solar energy generation from the residential sector is 0.09% of total energy consumption from that sector, and for the commercial sector, it is 0.42%. Similarly, under the HT category, the commercial sector is 0.72% and the industrial sector is 0.16%.

17.1.2 Energy - Fuel (LPG) usage

Figure 17-2: Electricity consumption, year 2020-21



Source: MSEDCL, Tata Power

In fuel consumption, the data is available only on the use of LPG by the residential, commercial and industrial sectors. PNG lines are in the process of being installed for major residential areas in the city but are not present for the year 2021. During field visits and consultations in the city, it was observed that firewood and coal are also used in the residential, commercial and industrial sectors, but due to the unavailability of data, the contribution of these fuels to GHG emissions could not be estimated.

The thermal power plant in Eklahare is operated by MAHAGENCO, but it is situated outside NMC limits and, hence, not considered for the GHG emissions analysis.

17.2 ONGOING INITIATIVES

1. To make a shift towards renewable energy, NMC is installing solar PV in municipal buildings , WTPs and STPs.
2. At the building level, to promote energy efficiency, NMC offers a 5% rebate on property tax if any of the five facilities — rainwater harvesting, EV charging stations, recycling of wastewater, solar water heaters and solar power panels — are set up in the financial year 2023-24.
3. Revamping the entire street lighting system by installing smart LED streetlights with functional features such as remote dimming control, remote on-off options, timer and GSM presentation under Nashik Smart City is in the tender phase. Additionally, a pilot smart road in ABD Area is under execution, which will include smart street lighting.

17.3 KEY GAPS AND CHALLENGES

Some key gaps and opportunities in this sector are as follow:

- Insufficient data is available on the use of coal and other fossil fuels in industries, commercial and residential areas.
- According to Census of India 2011, 30% of Nashik's households live in houses with temporary roofing material, and more than half of these are a part of informal settlements. This reduces the opportunity to install solar PV to shift towards renewable energy.

17.4 RECOMMENDATIONS

17.4.1 Approach

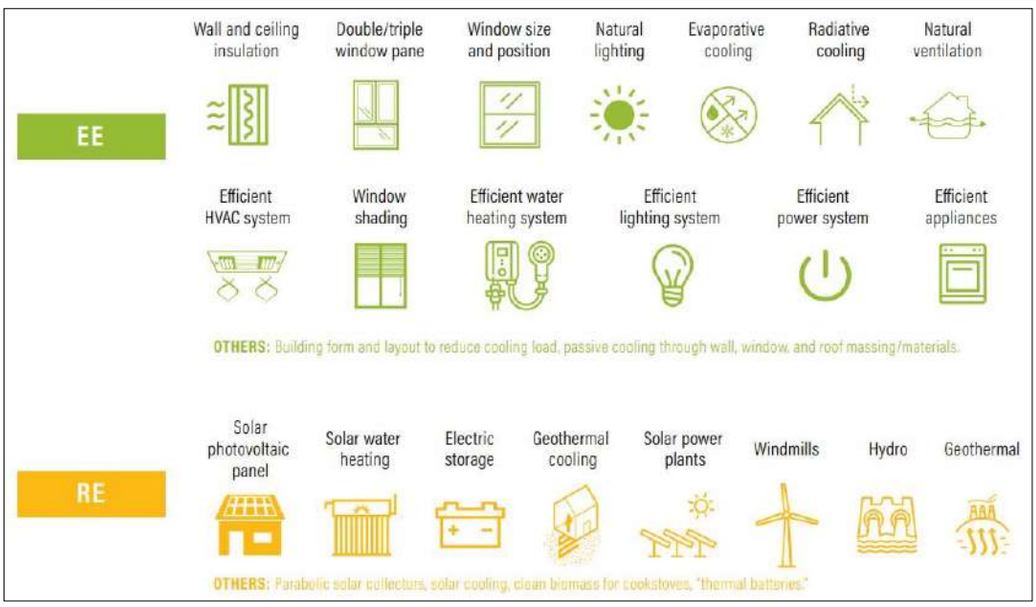
- Grid decarbonisation, with focus on solar power
- Energy efficiency and conservation in buildings (residential, municipal and commercial)
- Low carbon transition in industries
- Fuel switch in residential and commercial buildings

17.4.2 Strategies and actions

The key strategies are as follow:

- **Strategy B&E-1:** Promote grid decarbonisation by shifting to 40% energy from solar by 2040 and 60% by 2050.
- **Strategy B&E-2:** Adopt measures to increase energy efficiency and conservation in all residential, commercial and institutional buildings; and municipal utilities to achieve 85% increased energy efficiency by 2040.
- **Strategy B&E-3:** Facilitate planning and implementation of low carbon transition in industrial clusters within the NMC area.
- **Strategy B&E-4:** Switch to cleaner fuels for all domestic and commercial purposes by 2040.

Figure 17-3: Illustrative measures to achieve energy efficiency and shift towards renewable energy at building level



Source: *WRI India Analysis*

Table 17-1: Strategy B&E-1: Promote grid decarbonisation by shifting to 40% energy from solar by 2040 and 60% by 2050

Actions	Stakeholders & finance	Monitoring & Output Indicators
Prepare a Solar Master Plan, which includes the following actions: • Carry out baseline surveys to identify the potential for solar PVs. • Introduce subsidies and incentives to encourage solar uptake at the society and institute levels. • Mandate 100% solar water heating in public, private and institutional buildings. • Explore and promote different business models to increase the uptake of solar PVs at the decentralised level. • Undertake the 'cool roof' initiative in low-income communities / vulnerable households through subsidies / technical assistance. • Explore models of powering the proposed metro rail project and public charging infrastructure through renewables. **Timeframe: 2024-26**	Electricity Dept, DISCOMs, Private aggregators, ALMs, citizen groups, Transport Dept., Electricity Dept., Town planning dept. **Finance:** NMC budget, XV FC funds	**Output:** City Solar Master Plan, no. of households that have been retrofitted to demonstrate cool roofs; no. of residential, commercial and commercial units that have installed SWH **Outcome:** % increase in solar PVs, and SWHs at the unit level; % decrease in energy to cool HHs and reduce heat stress
Take the following actions to shift to RE in municipal buildings: • Ensure 100% electricity from RE. • Install occupancy sensors in all municipal buildings to reduce energy costs. • Install solar PVs at the ISWM facility to reduce energy costs. • Install solar PV at bus depots, parking lots, municipal schools etc. • Target to convert all the 150 traffic signals to street lights to LED signals by 2030, as currently only 5 are energy efficient. **Timeframe: 2024-26**	NMC **Finance:** NMC budget, XV FC funds	**Output:** No. of municipal buildings running on RE **Outcome:** % increase in RE as a source of electricity
Set up an Energy Conservation Cell within NMC's Climate Change Cell (proposed) in coordination with MSEDCL. • Facilitate city-level RE and EE buildings implementation following coordination with relevant stakeholders. • Ensure that correct benchmarking data is requested, analysed centrally and that businesses report year-on-year. • Develop a local energy supply plan to define the optimally diversified energy supply portfolio to achieve a 50% RE mix by 2030. To do so, introduce RE procurement policy for public buildings and RE transition programme for alternative options in informal and low-to-middle income communities. • Fast-track approval for green buildings. • Conduct programmes and awareness campaigns, and take up demonstration pilots to encourage the shift towards RE in all building categories. **Timeframe: 2024-26**	Electricity Dept, TP dept.NMC, NGOs, Industries, Hotel associations, RWAs, Market Traders Associations, ward officials, Advanced Locality Management Groups (ALMs) etc. **Finance:** XV FC fund, CSR, NMC budget	**Output:** Setting up of Energy Cell No. of awareness programmes/ campaigns initiated in a year No. of LED streetlights **Outcome:** % increase in RE as a source of electricity % of emissions reduced from stationary energy, increase in RE and EE % reduction in emissions from stationary energy

Table 17-2: Strategy B&E-2: Adopt measures to increase energy efficiency and conservation in all residential, commercial and institutional buildings; and municipal utilities to achieve 85% increased energy efficiency by 2040

Actions	Stakeholders & finance	Monitoring & Output Indicators
Conduct surveys to assess the current penetration of energy-efficient appliances, such as cookers, chillers, refrigerators and LEDs, in residential and commercial buildings. **Timeframe: 2024-28**	Electricity Dept **Finance:** NMC budget, XV FC	**Output:** Data on the penetration of energy-efficient appliances **Outcome:** % reduction in emissions from stationary energy
Conduct sensitisation programmes/ workshops for developers, TPD by IGBC on how to increase energy efficiency of buildings. **Timeframe: Starting 2024; can be conducted annual/biannually**	NMC, IGBC, Research organisations, RWAs **Finance:** NMC budget, XV FC	**Output:** No. of awareness programs/ campaigns initiated in a year **Outcome:** % reduction in emissions from stationary energy
Mandate the life cycle assessment (LCA) in all new buildings and implement a passive architectural design strategy in all upcoming buildings. This needs to be verified and validated during the building's approval phase. An energy score could be linked to the more energy-efficient component in the building, which could be rewarded by tax rebates for a period of years. **Timeframe: 2024-26**	NMC, TPD, Energy Cell **Finance:** NMC budget, XV FC	**Output:** Determination of annual electricity saving potential, Determination of lifecycle cost saving **Outcome:** % reduction in emissions from stationary energy
Increase uptake of energy-efficient cooling systems (4-star AC, refrigerators and fan) by conducting audits to understand the potential and provide incentives. **Timeframe: 2024-26**	NMC, TPD, Energy Cell **Finance:** NMC budget, XV FC fund	**Output:** Database of building typologies **Outcome:** % increase in the energy efficiency of buildings
Develop a thermal comfort index mapping for different typologies of buildings under the various wards in the city to understand the relation of buildings to their urban heat island effect. **Timeframe: 2024-26**	TPD **Finance:** NMC budget, XV FC	**Output:** No. of buildings with BEMS **Outcome:** % increase in the energy efficiency of buildings
Mandate the installation of Building energy monitoring systems (BEMS) and building energy control systems in all new buildings. **Timeframe: 2024 onwards for all new buildings**	TPD **Financing:** NMC budget, XV FC fund	**Output:** No. of buildings with BEMS **Outcome:** % increase in the energy efficiency of buildings

Table 17-3: Strategy B&E-3: Facilitate planning and implementation of low carbon transition in industrial clusters within the NMC area

Actions	Stakeholders & finance	Monitoring & Output Indicators
NMC to facilitate planning and implementation of a roadmap for transition to a low-carbon development with the help of industry associations and MIDCs with the following objectives: • Enhance their resource efficiency, Perform, Achieve and Trade (PAT) /Non-PAT compliance to be mandated. • Promote and support the owners of MSMEs to install net-metering and rooftop solar in the MSME cluster in Nashik. • Phasing down of fossil fuel-based boilers with vineyard residues, incentivise solar power for the breweries and wineries in Nashik. • Provide incentives such as subsidies or tax exemptions or energy wheeling agreements to reduce the capital costs for setting up RE-based power plants. **Timeframe: 2023-27**	NIMA, NMC, Private industries, MIDC **Finance:** NIMA, industry owners, MIDC	**Output:** % of industries set SBTIs, % of industries approved for PAT, % of industries with reduced electricity bills and cost savings; % of industries installed net-metring systems, solar PVs; % of wineries/breweries running of RE; uptake of RE-based power plant **Outcome:** % increase in energy efficiency enhancement in industries; % increase in energy efficiency in industries

Table 17-4: Strategy B&E-4: Switch to cleaner fuels for all domestic and commercial purposes

Actions	Stakeholders & finance	Monitoring & Output Indicators
Promote, facilitate, and incentivise by • Upscaling the distribution of Piped Natural Gas (PNG) in all residential areas, hotels, and institutional complexes within the city through the provision of ease of access to laying of pipelines, plots for storage facilities for a decentralised system etc. • Incentivise the PNG infrastructure, especially within slum areas so that slums dwellers can get access to PNG at affordable rates • Conversion of all local bakeries and small-scale breweries in the city from traditional fuels to clean fuels like PNG	• NMC, MNGL, NMC, NEMA, Wineries associations, breweries operators Finance: MNGL, users, Winery/Bakery owners	**Output:** No. of HH that have adopted PNG, Bakeries and breweries that have shifted to clean fuels **Outcome:** % decrease in indoor air pollution, energy consumption per capita/HH, % increase in energy efficiency in industries

CITILINC CNG BUS
Photo Credits - WRI India

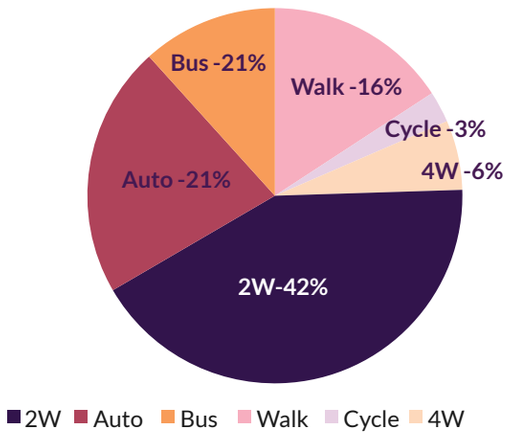
18.SUSTAINABLE MOBILITY

18.1 SECTORAL OVERVIEW

Nashik city has an on-road transportation system. However, there is no intra-city railway, water transport system or metro in the city yet. The modal split of Nashik in 2016, as per the Comprehensive Traffic and Transportation Plan of Nashik (2017), is presented in Figure 18-1. Approximately 48% of the population depend on private vehicles for their commute i.e. they have at least one car or two-wheeler available.

The transport sector emissions are estimated using the fuel sales method based on the fuel data received from fuel companies on sales of auto LPG, auto CNG, petrol and diesel from the petrol pumps located within Nashik city. According to data from March 2022, the city has the following number of vehicles registered under different fuel types — 78.3% petrol, 18.3% diesel, 0.55% CNG, 1.8% LPG and 1.05% others such as electricity. The CNG sales data has been collected from one MNGL fuelling station, which is the only distributor in the city.

Figure 18-1: Modal split in Nashik

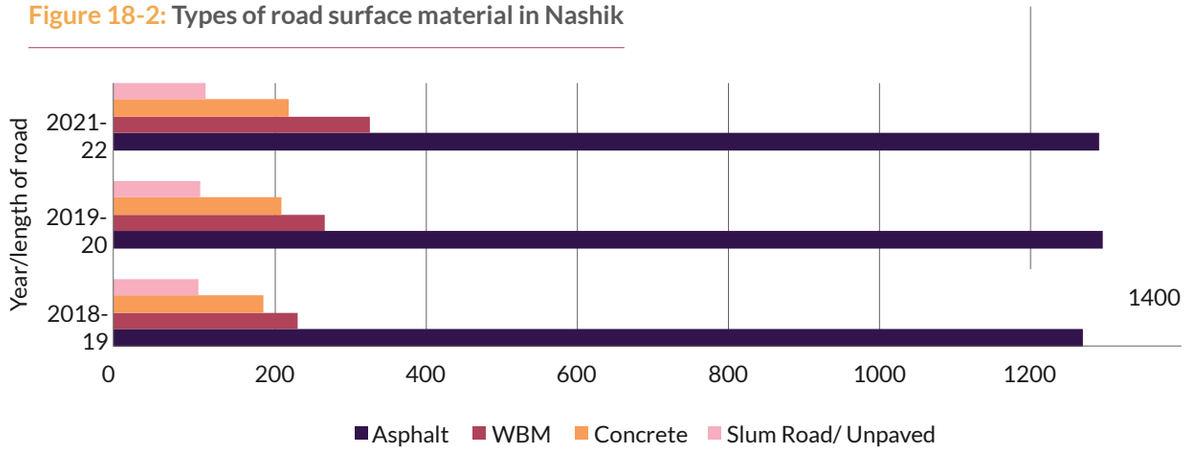


Source: *Comprehensive Traffic and Transportation Plan, 2017*

In Nashik city, the area under roads for year 2021-22 is about 2,033 km, which is an increase of 160 km from year 2018-19. The roads have been divided based on the surface material, such as asphalt, concrete, WBM or unpaved/slum roads , as seen in Figure 18-2.

According to the Air Pollution - Source Apportionment Study for Nashik, Particulate Matter (PM) emissions from paved road dust and unpaved road dust is 7.6% and 33%, respectively, which is the second largest contributor of PM emissions in Nashik city.

Figure 18-2: Types of road surface material in Nashik



Source: *WRI India Analysis*

18.1.1 Public transport

The public bus service in Nashik is operated by Nashik Mahanagar Parivahan Mahamandal Ltd. (NMPML) since 2019, which is an SPV of NMC. It is operated under the brand name CITILINC. Currently, there are only 250 buses (200 CNG and 50 diesel) operational in the city, with a daily average public ridership of 36,000 passengers, of which almost half are female passengers. The city has 2,862 bus stops spread across the city, with a route length of 10,600 km.

Around 74.69% of Nashik's population lives within 5 minutes access of a bus stop. Higher density areas in and around the inner city, such as Somvar Peth, Naikwadi Pura, MIDCs, Ashtvinayak Nagar and Muktidham Mandir in the south-eastern side lack ease of access (within 5-minute walkable distance), as seen in Figure 18-3. The entire network is controlled by an Intelligent Transit Management System (ITMS) within the SPV, which is an automated real-time monitoring system with 30-second intervals. The system captures feeder routes, bus stations, authorised/unauthorised stoppage, crew dispatch, number of trips per day (both scheduled and operated), driver-related details each day route-wise, revenue generated per day, grievance redressal data etc.

According to the Service Level Benchmarks prescribed by MoHUA , Nashik has currently 250 buses, or 12 buses per lakh population, based on Nashik's estimated population of 20.13 lakh in 2021. Based on the MoHUA norm, the requirement for buses for Nashik's 2031 population of 27.24 lakh is 1,090 buses.

Nashik city also has a neo metro planned, with a network of 32 km stretch from Gangapur to Nashik Road railway station and another route between Gangapur and Mumbai Naka.

18.1.2 Intermediate public transport

As on March 2022, there were around 19,000 autos in Nashik, of which over 11,000 run on LPG or petrol. Based on the EV convergence report submitted by NMC in 2022, around 10,000 autos are to be converted to electric autos. NMC need to bear 50% of the cost of INR 35,000 to retrofit rickshaws into electric ones, and the remaining amount will have to be borne by the vehicle owner.

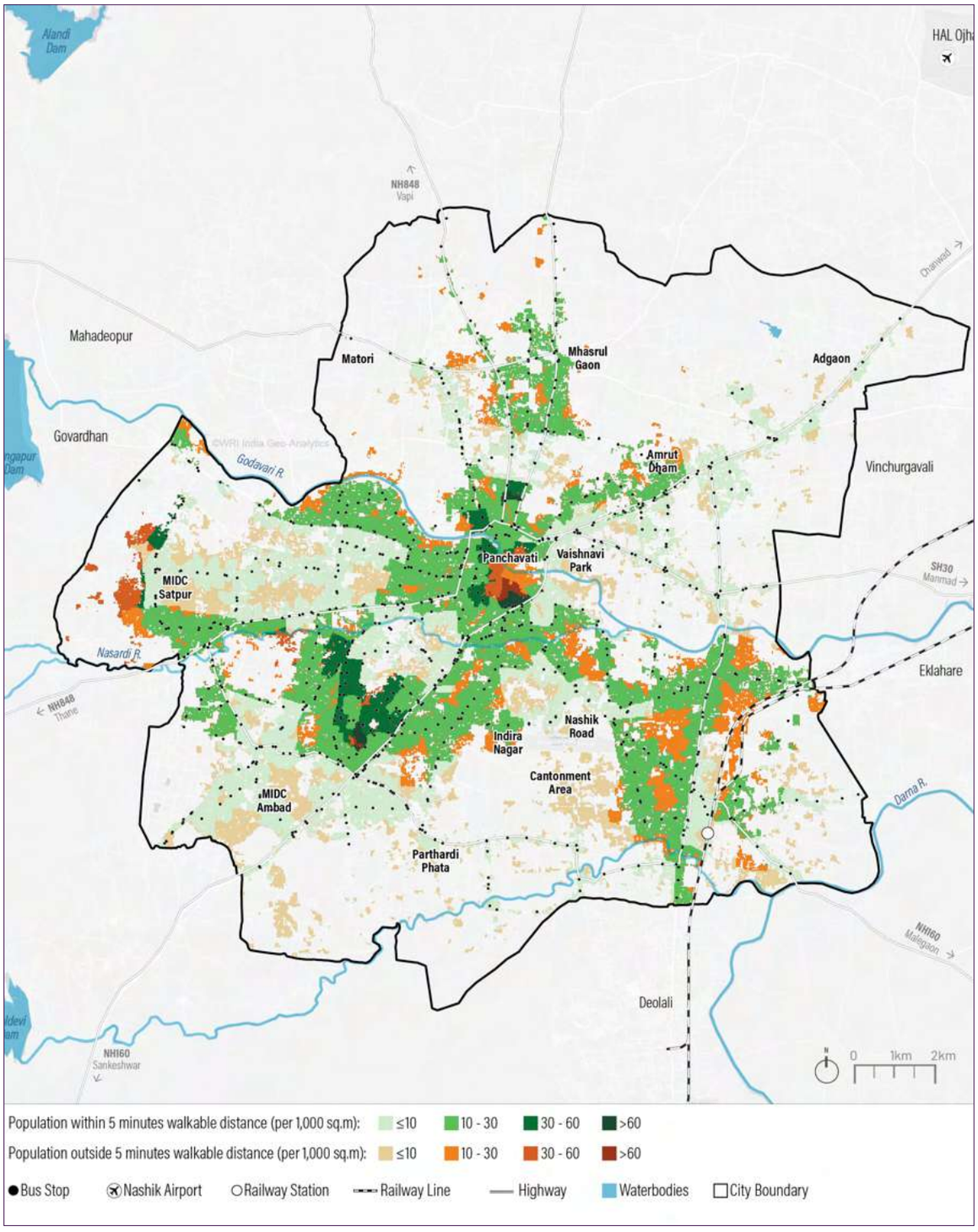
As of 2022, there were 65 passenger e-autos and 45 goods e-autos registered with the RTO.

18.1.3 Private transport

Based on the modal split, 6% of the population use four-wheelers (4W) and 42% use two-wheelers (2W). On average, the registered 2W and 4W have increased by 18% and 12%, respectively, between 2010 and 2020. Approximately 99% of 2W run on petrol, 42% of motor cars are fuelled by petrol and 47% by diesel. Of private tourist cabs, 77% run on diesel. Taxi services, such as Uber and Ola, operate in Nashik, and a new electric cab service called Go Green Cab was launched in the city in November 2021.

Nashik city does not have a parking policy currently, although the Comprehensive Traffic and Transportation Plan (CTTP) lists parking strategies for on-street and off-street parking through short-term and long-term measures.

Figure 18-3: Percentage of population living within 500m of a bus stop (2022)



Source: *WRI India Analysis*

18.1.4 Non-motorised transport

Nashik has 66 km of footpath and 6.4 km of cycle track, as of 2020. There are no existing NMT policy or street design guidelines to plan roads better for pedestrians or cycle users. A public bike sharing project under Nashik Smart City was implemented in the city, with a provision of 1,000 bikes at 100 docking stations. However, this had low uptake due to a poor app system, inadequate infrastructure on the road and a poorly designed network of bikes and docking stations.

18.1.5 Urban freight

Freight transport is primarily diesel-based, which has grown by 13% between 2010 and 2020. A truck terminal at Adgaon is undergoing improvement, and the adjoining area is being developed as parking lot for public buses. There are no proposals to convert freight vehicles to run on electricity in the pipeline. According to the Source Apportionment Study, there is a need to frame a legislation for the retro-fitment of new engine/Emission Control Devices/Diesel Particulate Filter (DPF) /Diesel Oxidation Catalyst (DOC), particularly to heavy duty vehicles, that could help in major reduction of particulate matter. There is also a state government notification to restrict the number of heavy good vehicles passing through the city. Hence, there is a need to plan by-passes and ring roads outside the city area to allow for movement without entering the city.

18.1.6 EV infrastructure

To increase the uptake of electric vehicles, NMC has undertaken multiple initiatives to develop EV infrastructure in the city.

To promote the sale of EVs on a PPP basis , INR 120 crores have been allocated under the Fifteenth Finance Commission funds for the EV component for Nashik, in which 28 of 106 locations have already been identified to set up charging stations. Additionally, the Tapovan bus depot is planned to be retrofitted to have EV infrastructure to be taken up with these funds. As of September 2022, there were 5,805 electric vehicles registered with RTO.

18.2 ONGOING INITIATIVES

The Nashik Municipal Corporation (NMC) submitted its electric vehicle (EV) proposal for approval to the state government in May 2022. As part of XVFC and NCAP funds, NMC will receive around Rs 130 crore during 2022-2027 for EV promotion and adoption:

- 50 E-buses sanctioned under FAME 2: Rs. 50 Cr
- Electric work at Tapovan depot: Rs. 35 Cr
- Retrofitting of 10000 diesel autos: Rs. 35 Cr.
- E-GHANTAGADIS: RS. 10 CR.

- As per the Maharashtra State EV policy,2021, Nashik has a city-wide target of setting up 100 public and semi-public charging stations by 2025. NMC plans to set up electric vehicle charging stations in 106 locations that it identified earlier. The charging station

locations for 28 feasible pilot locations have been identified and submitted for EoI. This is expected to be completed in 2023 under the Fifteenth Finance Commission.

- NMC funds have been allocated for the preparation of DPR for Nimani bus depot, Dwarka bus depot and Nashik Road bus terminus which is currently in progress.
- 33.82 km of road widening through NMC funds is in progress.
- Parking: RfP for the development of two multi-level car parking on a PPP basis is in process.
- The Environment department has identified 11 traffic congestion hotspots as part of an exercise under NCAP which will lead to priority junction redesign based on the context.
- DPR for Nashik neo-metro has been submitted for approval after which it will move to the implementation stage.

18.3 KEY GAPS AND CHALLENGES

The following are some key gaps and opportunities in this sector.

- High emissions from the transport sector which requires a shift towards cleaner fuel across all modes of transport.
- Existing ITMS system that has the scope to expand and collect real-time data across all modes of transport- NMC can have primary data based on which transport planning can be undertaken.
- Poor NMT network
- Neo-metro being planned for the city gives an opportunity for integrated land-use and transport planning along the metro corridors.
- Push for the uptake of EVs in the city.

18.4 RECOMMENDATIONS

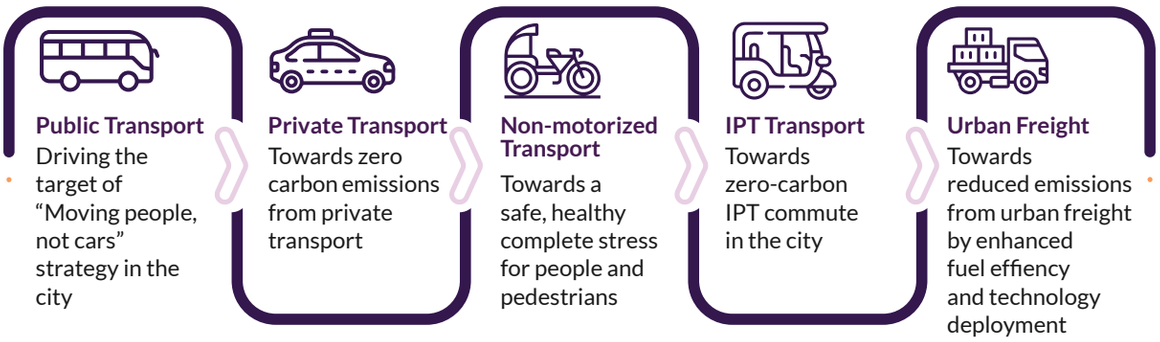
18.4.1 Approach

To a smarter commute in Nashik with a shift in behavioural change and smarter people with a choice of transition towards clean public transportation, equipped with low-carbon infrastructure for a sustainable low-carbon transit shift in the passenger and urban freight sector by 2050. Overall target: 25% GHG emissions reduction by 2030, 50% by 2040, and 70% by 2050.

18.4.2 Sectoral strategies and actions

Below are the key sectoral strategies for the transport sector. These include augmenting public transport and enhancing its modal share, strengthening infrastructure, and supporting policy environment for non-motorized transport to create people-friendly complete, and safer streets, healthy communities, promoting clean vehicles and fuel shift efficiencies uptake in all private and public modes by adopting technology and laying adequate clean infrastructure, and moving towards low-carbon freight systems in the city.

Figure 18-4: Urban Transport – Key strategies



Key Strategies are as follows -

- **Strategy SM-1:** Increase mode share of public transport (bus and future neo-metro) from 12% to 25% by 2035 and shift to cleaner fuels in public transportation.
- **Strategy SM -2:** Increase NMT trips (walking and cycling) from 19% to 23% by developing safe, healthy complete streets for pedestrians and cyclists by 2035
- **Strategy SM -3:** Move towards low-carbon local IPT commute in the city by 2035
- **Strategy SM -4:** Shift towards clean private transportation through the promotion of e-mobility and an efficient parking management system
- **Strategy SM -5:** Shift towards clean urban freight and minimise traffic congestion in the city due to freight movement.

Table 18-1: Strategy SM-1: Increase mode share of public transport (bus and future neo-metro) from 12% to 25% by 2035 & and shift to cleaner fuels in public transportation.

Actions	Stakeholders & finance	Monitoring & Output Indicators
Increase bus fleet from 250 to 1,100 by 2031, and increase accessibility to bus stops from 74% to 100% with the following actions: • Increase the fleet of buses, from 250 to 1,100, by 2031 to achieve 40 buses per lakh population, and ensure that all new buses are either CNG or electric. • Increase the bus transit network coverage within the city by procurement of mini-buses or local feeders for inter-city connectivity. • Carry out route rationalisation based on demand, passenger load, passenger trips and opinions based on surveying bus drivers, conductors and passengers. • Increase accessibility to bus stops, from 74% to 100%, by increasing the number of bus stops in areas with low accessibility identified through the vulnerability assessment, such as Somvar Peth, Naikwadi Pura, MIDCs, Ashtvinayak Nagar and Muktidham Mandir areas. • Ensure last-mile connectivity to increase uptake of public buses by developing accessible footpaths and cycle tracks around bus stops, especially the areas near Ambad and Satpur MIDCs, college road etc. • Implement passenger information systems (PIS) in all bus stops to provide real-time bus arrival information. **Timeframe: 2023**	NMC Transport Dept., CITILINC, NGOs, Civil society groups, Research organisations, State GoM **Finance:** XVFC fund, NMC budget, Multilateral agencies, CSR	**Output:** No. of buses operational, No. of bus stops built in areas having low accessibility, No. of new routes planned to ply buses, No. of new cycle tracks and footpaths developed around bus stops, No. of bus stops that have installed PIS **Outcome:** % increase in ridership, % increase in buses against the norm, % increase in accessibility to bus stops
Introduce schemes/policies that will increase uptake for public transport: • Increase the female public bus ridership by announcing female-centric policy schemes – such as incentivised transport for all women, special ladies' buses during peak time, as implemented in Pune (Tejaswini buses) etc. • Encourage educational institutions and other large-scale private institutions to have their own bus facilities to reduce dependency on private transport. • Conduct programmes and awareness campaigns to create a shift towards public transport from private transport and encourage walking and cycling. **Timeframe: 2024**	NMC Transport Dept., CITILINC, Institutions (public and private), Industries, NGOs, Civil society groups **Finance:** XV FC grant, NMC budget, CSR	**Output:** No. of female riders using public transport, No. of awareness programs/ campaigns initiated in a year,No. of organisations/ institutes having their own bus facilities **Outcome:** % increase in public transport mode share;
Shift to cleaner fuels in public transport: In the short term (2025), replace the existing 50 diesel buses with CNG or electric buses • Ongoing/ planned procurement of 50 e-buses will help improve the service levels. Further, prepare a detailed plan for the deployment of more e-buses such that at least, 25% of the total fleet is electric by 2031. • Shift CNG buses to run on bio-CNG produced at the integrated solid waste management facility. • Develop a roadmap for exploring the transition to solar-powered buses.	NMC Transport Dept., CITILINC, SWM Dept. **Finance:** XV FC grant, NMC budget, CSR	**Output:** No. of e-buses in the total bus fleet, No. of e-vehicles in government organisations, No. of buses running on alternative fuels such as bio-CNG/ solar **Outcome:** % increase in e-vehicles (public + private), % decrease in emissions from the transport sector

Actions	Stakeholders & finance	Monitoring & Output Indicators
Prepare Transit-Oriented Plan (ToD) for the upcoming neo-metro corridor to ensure integrated land use and transport planning along with last-mile connectivity such as auto and feeder bus services to ensure seamless travel **Timeframe: 2030**	NMC Transport Dept., CITILINC **Finance:** The state budget, NMC budget	**Output:** TOD plan prepared for neo-metro **Outcome:** % increase in metro ridership

Table 18-2: **Strategy SM-2: Increase NMT trips (walking and cycling) from 19% to 23% by developing safe, healthy complete streets for pedestrians and cyclists by 2035**

Actions	Stakeholders & finance	Monitoring & Output Indicators
Develop an NMT policy for the city, which will help identify area-based interventions to increase walking and cycling in the city. **Timeframe: 2023-25**	NMC Transport Dept., CITILINC Financing: NMC budget, XVFC fund	**Output:** NMT Policy **Outcome:** % increase in NMT trips
Increase coverage of footpath to reach basic service level benchmark by: • Adopting street design guidelines to improve footpath design, traffic junctions, street lighting and street sections to include walking and cycling infrastructure. • Taking up junction improvement at identified traffic congestion hotspots as a priority to tackle traffic and air pollution issues. • Enhancing the existing integrated command and control (ICCC) system to monitor lighting and function of CCTV cameras along identified streets/pedestrian paths. **Timeframe: 2027**	NMC Transport Dept., CITILINC **Finance:** NMC budget, XVFC fund	**Output:** No. of street sections improved based on street design guidelines; No. of junctions improved; Continuous monitoring of street lighting and CCTV cameras along identified streets **Outcome:** % increase in NMT trips
Encourage cycling as a recreational activity by: • Developing a dedicated cycling infrastructure, leading to the outskirts of the city limits where leisure cycling is practised • Reviving public bike sharing (PBS) system in which docking stations are strategically planned (bus stops, metro stations, institutions) and the PBS app is smoothly functioning to encourage more users. **Timeframe: 2027**	NMC Transport Dept., CITILINC **Finance:** NMC budget, XVFC fund, PPP	**Output:** No. of street sections with cycling tracks, Well-functioning PBS application **Outcome:** % increase in cycling as an activity in the city

Table 18-3: **Strategy SM-3: Move towards low-carbon local IPT commute in the city by 2035**

Actions	Stakeholders & finance	Monitoring & Output Indicators
Transition to CNG-based and electric autos by 2033 through a financial contribution by NMC and auto owner for retrofitting the auto	NMC Transport Dept., Auto owners **Finance:** NMC budget, XVFC fund, auto owners	**Output:** No. of autos converted to e-autos **Outcome:** % decrease in emissions from the transport sector

Table 18-4: Strategy SM-4: Shift towards clean private transportation through the promotion of e-mobility and an efficient parking management system

Actions	Stakeholders & finance	Monitoring & Output Indicators
Ensure reduced emissions from private transportation by: • Institutionalisation of an EV committee / EV cell within the NMC on adopting the city EV policy to mainstream the EV infrastructure in the city and for implementation of the city EV plan. • Developing incentives for the purchase of e-2W and e-4W and allotting dedicated parking slots. • Setting up the proposed 106 charging stations by 2026 - at present 28 locations have been identified as pilot projects for EV charging stations. • Setting up EV charging infrastructure at all government buildings and public institutions to ensure ease of access to EV facilities. • Phasing out old BS IV and V standard cars in the city by rebates or incentives and announcing a city-wide sensitisation campaign. • Ensuring all vehicles have updated PUC certificates. **Timeframe: 2025**	NMC Transport Dept., RTO, **Finance:** NMC budget, XVFC fund	**Output:** Institutionalisation of EV cell, Incentives created to increase uptake of EV, No. of old BS-IV, BS-V vehicles phased out No. of vehicles that have updated PUC certificate **Outcome:** % decrease in emissions from the transport sector
Provide efficient and organised parking management system through - • Preparation of a parking policy that identifies on-street and off-street parking locations and development fiscal measures, such as the price of parking to manage parking demand; for example, Pune has developed a comprehensive parking policy. • Identification of smart parking solutions and their implementation through a PPP contract for select on-street and off-street areas that include smart sensor-based parking solutions, app-based tracking, online payment etc. • Preparation of a tariff policy (as part of the parking policy) that includes higher parking charges in the core city of Nashik to discourage the use of private vehicles in crowded areas. • Ensure dedicated parking lots of electric vehicles at important locations **Timeframe: 2027**	NMC Transport Dept., RTO **Finance:** NMC budget, XVFC fund	**Output:** Parking policy, areas that have been covered with on-street and off-street parking in the parking policy **Outcome:** No. of streets that have pay and park; % increase in areas that have parking management policies in place

Table 18-5: Strategy SM-5: Shift towards clean urban freight and minimise traffic congestion in the city due to freight movement

Actions	Stakeholders & finance	Monitoring & Output Indicators
Reduce emissions from urban freight through a series of actions: • As Nashik is an industrial city with continuous freight movement, develop a dedicated freight policy, which focuses on planning the regional infrastructure and movement of vehicles within the city in a sustainable manner. • Enforce the time restrictions for the movement of freight within the city. • Encourage electric Light Duty Vehicles (LDVs) within urban municipal limits for all inter-city freight transport. • Develop a truck terminus near MIDC areas for better management of truck traffic. **Timeframe: 2027**	NMC Transport Dept., RTO, Industry owners **Finance:** NMC budget, XVFC fund	**Output:** Freight policy, No of e-LDVs for inter-city freight movement **Outcome:** % decrease in emissions from the transport sector

RAMKUND Ramkund
Photo Credits - WRI India

19. SUSTAINABLE SOLID WASTE MANAGEMENT

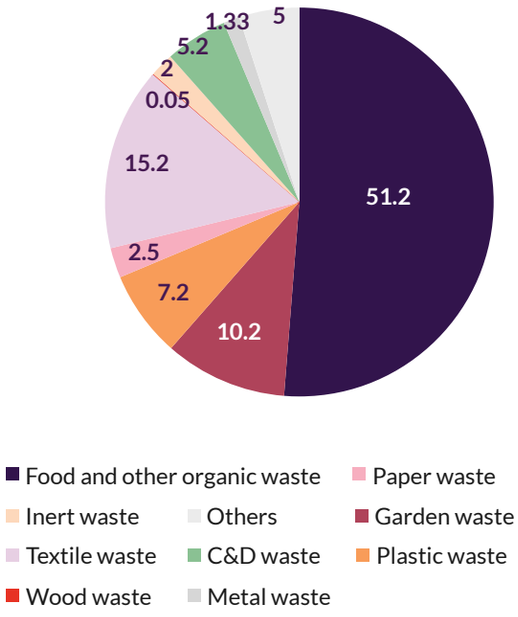
19.1 CURRENT STATUS

In 2021, around 635 TPD municipal solid waste (MSW) was generated in Nashik city. The estimated MSW generation for the year 2031 is 1628 TPD.

The share of organic waste (food waste and garden waste) was around 61% and that of non-organic waste (paper, wood, textile, plastic, inert, C&D waste) was approximately 32%. The remaining 7% waste comprises metal waste (1.33%) and hazardous waste (0.012%), which are not processed at the ISWM facility, and 5% of other waste. The Solid Waste Management (SWM) Department in NMC has two verticals: Collection and Transportation and Processing.

While all day-to-day activities have been outsourced to private players on contract, the overall monitoring is managed by NMC officials. The processing of waste has been outsourced to Nashik Waste Management Pvt. Ltd. (NWMPL) a special purpose vehicle (SPV) formed in 2016-17 for the treatment and management of solid waste at a processing site at Pathardi village, Nashik.

Figure 19-1: Composition of municipal solid waste generated in Nashik



Source: SWM Dept, NMC

Of the waste generated, 71 TPD is recovered as compost and 142 TPD as refuse derived fuel (RDF). This falls in Scope 1 of GHG emissions assessment as the waste is processed within the plant and not transported to a facility outside the boundary. Other than metal waste and hazardous waste, all other MSW is processed at the Integrated Solid Waste Management Facility (ISWMF) managed by NWMPL. MSW is managed using the process presented in Figure 19-2.

Figure 19-2: Process of waste management in Nashik

Source: SWM Dept, NMC

19.1.1 Collection

For the year 2023, NMC has outsourced the door-to-door collection of MSW to four private contractors that collect waste based on their designated zones. While NMC owns the waste pickup vehicles called ghantagadi, the contractor provides the diesel, the driver and the waste-picking staff. According to the weight of the waste collected, the contractor is paid a tipping fee of INR 1,500 per tonne basis the contract.

MSW is partially segregated at source and transported to the ISWM facility through the vehicles (ghantagadi) as mixed waste.

Techeco eWaste Management LLP, a private agency located in the outskirts of Nashik city processes the e-waste generated in Nashik city. For the ease of collecting e-waste, the agency has proposed to NMC a plan of having six e-waste collection centres (one per zone), which are still in the pipeline.

The sweeping of streets is primarily managed by NMC. Workers have been employed to maintain the cleanliness of roads and streets in four zones of the city, while the two remaining zones and Ganga Ghaat area are handled by a private contractor, Watergrace Pvt. Ltd.

19.1.2 Transportation

The waste pick-up vehicles or ghantagadi have a separator installed, which segregates organic and non-organic wastes. A total of 398 municipal corporation waste collection vehicles of various sizes, which run on diesel, collect waste across all six zones. The vehicles are installed with GPS tracking that follows a designated route, which is monitored at the ISWM facility.

19.1.3 Segregation

The MSW is transported to the unloading area at the ISWM facility, where the waste is passed through trommel machines that segregate the waste based on size. In the pre-sorting unit, large objects are sorted manually and the rest are fed into the mechanised sorting trommel machines. Waste with particle size above 100 mm is passed on to RDF and below 100 mm to the composting yard.

Additionally, 65 ragpickers (4 male and 61 female) have been employed on the site to further segregate the waste. To include ragpickers in the formal workforce, the local government has issued identity cards to them and provided them with medical insurance, which ensures their safety and work security. The provision of creche, toilet block, resting area, personal protective gear and equipment too are provided at the facility by NWMPL.

19.1.4 Processing

Waste is processed based on the type:

Organic waste	**Dripping wet waste** i.e. waste from temples and bulk weight generators is processed in the W2E plant that involves leachate treatment as well as in the biogas plant from which biogas is produced. **Nashik waste-to-energy plant (bio-methanation) supported by GIZ:** NMC has set up the Waste to Energy Project through the co-processing of septage (faecal sludge) with organic solid waste and is generating energy to create a sustainable business model. The plant is set up with a capital cost of INR 8.02 crore, with an 85% grant from GIZ and a 15% contribution by a private player on Design – Finance - Build – Own – Operate – Transfer (DFBOOT) basis. NMC has provided 6,000 square metres of land and will contribute INR 5 lakh per annum for the O&M of the plant. On a daily basis, 10 to 15 tons of food and vegetable waste from approximately 500 restaurants and 10 to 20 tons of septage from 400 community toilets are collected by trucks and delivered to the plant. Approximately 2,500 m_3 biogas and, subsequently, 3,300 kWh of electricity is produced per day. **Compost plant:** The material below 100 mm undergo microbial culture in which Windrows (heaps) are formed every week mixed using excavators. Around 40 MT of compost is produced over a 45-day cycle as per Fertilizer Control Order (FCO) norms. The compost is supplied to fertilizer companies such as RCF and Zuari who in turn sell it under their respective brands. Additionally, the compost is tested for quality by a third party and the Fertilizer Control Lab (FCL), Nashik, to be certified as HARIT Maha city compost. **At the decentralised level,** many households and societies practise the composting of organic waste. However, data is not available in terms of the number of households practising this and the quantity of waste processed in this manner.
Inorganic waste (plastic remains, paper, textile, wood, organic waste above 100 mm in size)	Waste is sent to the RDF plant for shredding where fluff is produced. This is then sold to industries for use in boilers as a clean source of fuel. **Plastic waste:** Non-recyclable plastic is sent to the plastic pyrolysis plant, which converts it into oil that is sold to industries.

	**E-waste**	This is collected and processed by an e-waste plant with a capacity of 50TPD. However, the amount of e-waste received is 70TPD. Most of this waste comes from technology companies, such as Xiaomi, LG and Samsung. E-waste such as laptops are refurbished and resold at 30% cost of MRP.
	**Inert waste (stone, grit)**	This is sent into the landfill where it helps in layering of the landfill site.
	**C&D waste:**	C&D waste is either sent into the landfill for layering or used to fill low-lying areas.
	**Other (dead animal carcass):**	It is sent to the incineration plant that is fuelled by fluff or oil from a plastic pyrolysis plant.
	**Bio-medical/ domestic hazardous waste**	This waste is sent to the bio-medical waste processing plant at Kathda, Nashik.
	**Landfill**	The legacy waste has been bio-mined and capping of the old landfill is almost complete. A new landfill of over 1 hectare has been constructed at the ISWM facility in which the leachate produced (600-1000 cubic metre) is now being treated and the water is used for irrigation purpose in the non-monsoon season. Pipelines for the same are being laid in the land reclaimed from the landfill.

Table 19-1: Responsibility matrix for management of solid waste in Nashik

Sr. No.	Role	Agency responsible
1	Waste collection	4 private contractors as on 2023
2	Street cleaning	NMC- 4 zones Watergrace Pvt. Ltd.- 2 zones, Ganga Ghaat area
3	Waste transportation (except vehicles which are owned by NMC)	4 private contractors as on 2023
4	Waste segregation	NWMPL/ Rag pickers
5	Waste processing	NWMPL
6	E-waste processing	Techeco Waste Management LLP
7	Bio-medical/domestic hazardous waste	Watergrace Pvt. Ltd

Source: NMC, WRI India Analysis

Table 19-2: Processes to manage different types of waste

Type	Process	Location	Capacity	Product/day
Organic waste	Leachate plant+ biomethanation	ISWM facility, NWMPL	30 TPD	2500 m3 biogas/3300 kWh electricity
Garden waste	Briquette making machine		30 TPD	Biomass briquettes
Mixed organic waste (below 100mm)	Compost plant		60-70 TPD	40 MT (45 day cycle)
Plastic waste	Plastic pyrolysis plant		4 TPD [24]	Sludge/black carbon and oil
Non-organic waste	RDF plant		150 TPD[25]	142.2 TPD Fluff
Inert waste	Landfill		Over 1 Ha	-
C&D waste	Landfill		Over 1 ha	-
Dead animal carcass	Incinerator		250 kg/hour	-
E-waste	E-waste recycling plant	Dhakambe village, Nashik district	50 TPD	Some electronic goods refurbished and re-sold
Bio-medical/ hazardous waste	Bio-medical waste processing plant	Off Nashik freeway, Dwarka	7.2 TPD [26]	-

Source: WRI India Analysis

19.2 ONGOING INITIATIVES

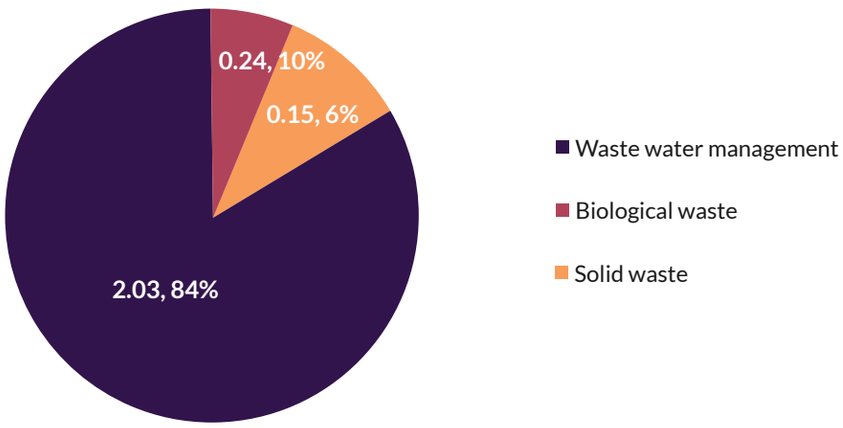
- As a result of the reforms that have taken place in Nashik Industries and Manufacturers' Association (NIMA), the potential for reduction and management of Industrial waste will be possible, as the waste by industries is currently managed by individual manufacturing plants in both MIDC areas.
- A C&D waste management facility with a capacity of 50 TPD has been proposed.
- The installation of three electric crematoria have been listed in the initiatives under XVFC.
- Six mechanical sweeping machines are to be procured under XVFC.
- A previously functioning landfill of over 5 hectares in the area has been bio-mined, and capping of the landfill is almost complete, at 95%. The land recovered from the old landfill is being laid with water irrigation pipelines to transport water from the treated leachate.
- The installation of solar panels at the ISWM facility is in the pipeline.
- The development of a rainwater harvesting pond of 5,00,000 litres capacity at the ISWM facility is ongoing.

19.3 KEY GAPS AND CHALLENGES

The following are some key gaps and opportunities in this sector:

- There is limited segregation of waste at the source and a lack of enforcement.
- The character of mixed waste results in a low resource efficiency of the plant, making it inefficient for waste to energy production.
- Aerobic digestion of waste is not taking place.

Figure 19-3: GHG emissions from the waste sector – sub-sectoral contribution



Source: WRI India Analysis

- As per the SWM collection data, currently, all 398 NMC waste collection vehicles run on diesel.

19.4 RECOMMENDATIONS

19.4.1 Approach

- Reduce the waste going into landfill, from the current 120 TPD to zero by 2035.
- Promote source segregation (50% by 2030, 100% by 2040) and focus on decentralised waste management to improve recycling and recovery efficiency.

19.4.2 Sectoral strategies and actions

The key strategies are as follow:

- **Strategy SWM-1:** Promote waste segregation at the source (50% by 2030, 100% by 2050) to improve recycling and recovery efficiency and focus on decentralised waste management that will complement the existing centralised process of waste management and reduce the waste going to landfill from 120 TPD to zero by 2035.
- **Strategy SWM-2:** Improve waste collection, and ensure clean transportation of waste for end-to-end disposal.
- **Strategy SWM-3:** Ensure the processing of maximum waste reaching the ISWM facility, with minimum waste being sent into the landfill.

Table 19-3: Strategy SWM-1: Promote waste segregation at the source (50% by 2030, 100% by 2050) to improve recycling and recovery efficiency, and focus on decentralised waste management that will complement the existing centralised process of waste management and reduce the waste going into landfill from 120 TPD to zero by 2035.

Action description	Stakeholders & Financing	Monitoring Indicators
Promote waste segregation at the source to improve the existing output of processing, recycling and reuse of waste and increase focus on a decentralised level that will complement the existing centralised process of waste management- • Bulk Waste Generators of waste such as hotels, vegetable markets, parks/ gardens, housing societies, and educational, and government institutions should be mandated to manage their waste at their end by setting up composting and bio-methanation plants within their premises and sending dry waste to the centralised/ decentralised MRF facility. Wherever there are land constraints for these bulk generators, the organic waste can be sent to the existing/ upscaled waste to energy plant and dry waste to the MRF facility on a user-charge basis. • Install MRFs at the area/ward level to encourage more opportunities for material recovery and bring more rag pickers into the formal workforce and ensure a sustainable source of income for them. • The well segregated waste gives scope for the existing bio-methanation plant to upscale from 30 TPD to 100 TPD through the co-processing of septage (faecal sludge) with organic solid waste and generating energy to create a sustainable business model preferably in PPP mode. **Timeframe: 2030**	NMC, NWMPL, NGOs, Industries, Hotel associations, etc. **Finance:** Swacch Bharat, XVFC fund, CSR, NMC budget	**Output:** No. of BWG that manage waste on site, No. of MRFs installed to segregate and recover waste **Outcome:** % increase in waste segregation at source
Conduct programs and awareness campaigns and take up demonstration pilots to encourage the segregation of waste at the source and promote decentralised processing such as bio-methanation and composting etc. • This may be done by making waste-related data (such as daily collection, segregation, recycling of waste, location of community collection/ recycling centers/vendors etc.) publicly available thereby increasing accountability. • Use of various media like radio, print, and social platforms for creating awareness and dissemination of information, put recorded messages and slogans on waste collection vehicles to increase awareness on segregation and decentralised treatment of waste. • Provide two coloured bins for the segregation of wet waste and dry waste. • Encourage citizen-led challenges such as 'zero waste wards/ societies' to promote participation from citizens and RWAs by rewarding such groups with a token of appreciation and monetary benefits. **Timeframe: 2023-25**	NMC, NWMPL, NGOs, Industries, Hotel associations, RWAs, Market Traders Associations, ward officials, Advanced Locality Management Groups (ALMs) etc. **Finance:** Swacch Bharat, XVFC fund, CSR, NMC budget	**Output:** Creation of public dashboard with all data related to SWM No. of awareness programs/ campaigns initiated in a year **Outcome:** % increase in waste segregation at source

Promote waste segregation and processing at source by the involvement of the private sector through CSR, PPP, and promotion of entrepreneurship models such as - • Develop buy-back schemes for plastic and paper waste and install separate bins for organic and recyclable waste, and PET bottle reverse vending machines at tourist areas such as Ram Kund, Pandavleni caves, railway stations, and bus stops to encourage segregation of waste. • Encourage entrepreneurs working in solid waste management to work with housing societies, institutions etc. to adopt service charge-based waste management e.g., in the case of Pune, the Institute of Natural Organic Agriculture (INORA) identified and trained young local entrepreneurs to take up society-level waste management projects. NMC can tie up with INORA to provide such training to the local youth. **Timeframe: 2024-26**	NMC, NGOs, Industries, Hotel associations, RWAs, Market Traders Associations, Advanced Locality Management Groups (ALMs) etc. **Finance:** CSR, NMC budget	**Output:** Create programs to train entrepreneurs to work in SWM sector Create schemes/install infrastructure to ensure segregation of waste at public places **Outcome:** % increase in waste segregation at public places and at residential and institutional level % increase in entrepreneurs working in SWM sector % increase in public places that have been installed with bins and pet bottle vending machines

Table 19-4: **Strategy SWM-2: Improve waste collection, and ensure clean transportation of waste for end-to-end disposal**

Action description	Stakeholders & Financing	Monitoring Indicators
Ensure smart waste collection that covers the entire city: • Conduct training programmes for door-to-door waste collectors on type of waste and method of segregation to ensure maximum segregation of waste before it reaches the ISWM facility. • Ensure waste is collected from all areas, especially areas of low income communities, on a daily basis to ensure there is no malpractice of waste disposal. • Install RFID tags on all community bins to ensure all waste has been collected and have all waste collection points geo-located that may be monitored from the existing Command & Control Centre at the ISWM facility **Timeframe: 2024-26**	NMC, NGOs, NWMPL, Waste collection and transportation agencies, Industries, Hotel associations, RWAs, residents from low income communities, etc. **Financing:** NWMPL, CSR, NMC funds	**Output:** No of waste workers trained, Command and Control Centre monitoring all areas for waste collection **Outcome:** % of city from which municipal solid waste is regularly collected % increase in segregated waste reaching the ISWM facility
Conversion of all waste collection vehicles (ghantagadi) from diesel run to CNG/electric run **Timeframe: 2024-28**	SWM Dept (collection and transportation), Transport Dept. **Financing:** NMC funds, NCAP funds, PPP, XVFC fund	**Output:** No of waste collection vehicles shifted from diesel to CNG/electricity **Outcome:** Reduction in NOx concentration
Develop e-waste collection centres in each zone of the city to ensure safe collection and processing of e-waste **Timeframe: 2024-26**	SWM Dept (collection and transportation), organisations collecting e-waste **Financing:** NMC funds, CSR	**Output:** Set up of e-waste collection centres **Outcome:** Increase in e-waste collected and processed

Table 19-5: Strategy SWM-3: Ensure processing of maximum waste that reaches the ISWM facility with minimum waste being sent into the landfill

Action description	Stakeholders & Financing	Monitoring Indicators
Develop a strategy to strengthen extended producer responsibility (EPR), making the manufacturer responsible for the products. **Timeframe: 2024-28**	NMC, Industries **Financing:** NMC fund, Swachh Bharat fund	**Output:** City-level mandate/ strategy to strengthen EPR **Outcome:** % of e-waste or plastic waste recycled, number of green enterprises/jobs created
Make economic wealth and social benefit out of temple waste: Formalise SHGs with women-led groups as a mechanism to increase women-led employment and better management of floral and temple waste recycled to leaf plates, woven baskets etc. at the Tapovan Ram Kund and Trimbakeshwar temple sites. **Timeframe: 2024-26**	SWM Dept, NGOs, Temple associations, Women SHGs **Financing:** NMC fund, Swachh Bharat fund, CSR	**Output:** Recycling of temple waste **Outcome:** % of waste recycled, no. of new green jobs created and individuals participating in green skills training
Develop biodegradable waste processing units in each ward, based on land and resource availability, with market creation and subsidies for compost. NMC has already proposed 1 decentralised compost plant for INR 2 crores **Timeframe: 2024-28**	SWM Dept, Market Traders Association, Rag pickers **Financing:** NMC fund, Swachh Bharat fund, NCAP funds	**Output:** No. of ward-level waste management units for recycling, composting etc. **Outcome:** % increase of city's organic wet waste that is composted/recovered % of population with waste processing units accessible within 500m of home
Strengthen the existing ISWM facility for efficiency of the waste processing system. • Install solar roof at ISWM facility to make the processing units function on solar, thus making it sustainable. • Install bio-gas digester to increase the efficiency of producing compost, from 75 % to 90%. • Ensure gas capture while developing the new scientific landfill. • Set up a biochar processing plant to convert garden waste to biochar. • Explore the feasibility of setting up a separate bio-CNG plant that may supply CITILINC buses CNG at discounted rates. Around 200 TPD of wet waste from decentralised wet waste collection plant may be utilised. • Upscale the existing bio-methanation plant, from 30 TPD to 100 TPD, through the co-processing of septage (faecal sludge) with organic solid waste, and generate energy to create a sustainable business model, preferably in PPP mode. **Timeframe: 2024-28**	NMC, NWMPL, Nashik Smart City, DISCOMs, MAHAGENCO, CITILINC **Financing:** Smart City funds, NMC funds, NCAP funds, XVFC funds,	**Output:** Functioning of ISWM facility on solar power, installation of bio-gas digester, gas capture mechanism at landfill, biochar processing plant, bio-CNG plant, upgradation of bio-methanation plant **Outcome:** % increase in efficiency of the ISWM facility

GODAVARI RIVER
Photo Credits - Ar. Janhavi Shinde

20. URBAN GREENING AND HEAT MITIGATION

20.1 SECTORAL OVERVIEW

The Urban and Regional Development Plans Formulation and Implementation (URDPFI) guidelines categorise open spaces into three, namely recreational space, organised green and other common open spaces (such as vacant lands/ open spaces including flood plains and forest cover in plain areas). So, as per the URDPFI guidelines, the norm for open spaces, including these three categories, is 10-12 square metres per person.

Nashik has open spaces in the form of parks, gardens, playgrounds, plantations and recreational areas comprising 8.8 square km within the city[39]. As per URDPFI guidelines, the norm for open spaces is 10-12 sq square metres per person while Nashik has only 5.92 square metres per person as open space. According to the Gardens Department of NMC, the green area (gardens and plantations) comprises 1.47 square km[40] of the city area, which amounts to 1 square metres per person green space.

The need for such open spaces comes from the role it plays in the microclimate at the neighbourhood and city levels as well as their role in reducing the impact of floods by acting as sponge infrastructure. The proximity to such spaces reduces long-term exposure to both higher air pollution levels and high surface temperatures. On the other hand, greener areas have greater carbon sequestration potential and are needed for any climate-resilient city.

20.1.1 Tree Census and carbon sequestration potential

The Tree Census conducted by NMC in 2016-17 reveals that the city of Nashik has 257 species of trees, of which 70% are indigenous/ native and 30% are of exotic origin. Although the species are varying, the percentage of individual tree count that belongs to native species is only 34% in comparison with 66% of the exotic species. The exotic species are primarily Giripushpa (Gliricidia sepium) (45%) and Subabhul (Leucaena leucocephala) (13%), which are located majorly on the hillocks/ peaks and open spaces surrounding Nashik city. Almost 60% of the city's vegetation is contributed by these two exotic species, which is an alarming situation for the city. This calls for better management of the city's native biodiversity.

According to the Tree Census, a total of 47,95,387 trees were counted, which covers an area of 4.8 square km. To calculate the carbon sequestration potential, the entire canopy area is considered as 'Trees Outside Forest' since the number/area of trees within protected areas such as biodiversity parks is not known. Based on the available data, the carbon removed amounts to 4,924.5 tonnes of CO_2/year[41]. This number becomes critical when the next Tree Census is conducted and a comparison between the change in tree cover may be observed.

20.1.2 Urban heat and NDVI

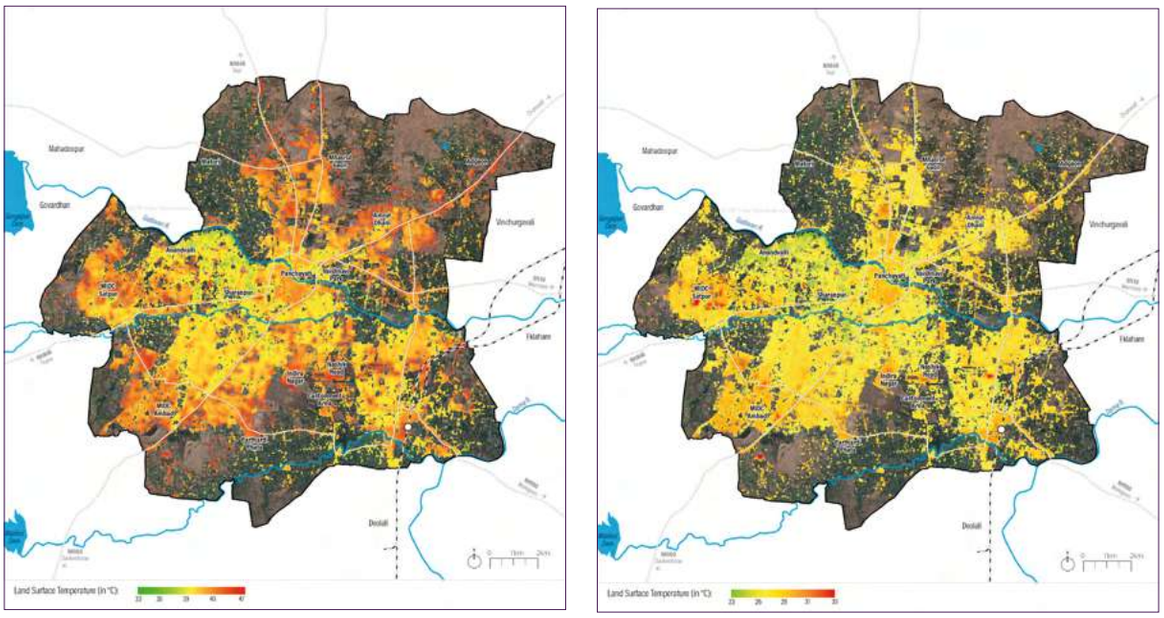
Urban heat and its correlation to vegetation and greening in the city is assessed using Land Surface Temperature (LST) data from the Landsat mission, United States Geological Survey (USGS), which helps identify local areas that are more exposed

to heat stress. Heat stress is one of the causes leading to the Urban Heat Island (UHI) effect. The UHI effect occurs when urban built areas dissipate more heat during the night as compared with the peripheral blue and green areas, which result in the human body not receiving the opportunity to relieve itself from the day-long activity-based heat exhaustion. Within the city boundary, during the daytime, certain areas get more heated than the surroundings due to the lack of vegetation, low heat absorbing building material used for development, type of land use and built density. Paved surfaces such as concrete or asphalt roads, concrete terraces, metal roofs and asbestos roofs get heated, thus creating these hotspots. For Nashik, LST was derived for two-time durations, pre-monsoon (April and May 2019-2021) and post-monsoon (October, November, and December 2019-2021), as shown in Figure 20-1.

During the pre-monsoon months, the daytime LST within the city built-up areas ranges between 31°C and 47°C, and during the post-monsoon months, it ranges from 23°C to 33°C. During both durations, the Panchvati area within the city core and MIDC areas in Satpur and Ambad are consistently hotter than the other areas.

Vegetation is one of the factors affecting LST and has an inverse correlation with LST. The areas with less vegetation tend to have a higher LST. This correlation depends on the type of vegetation, its distribution and seasonality. Trees that are present as a part of the built-up fabric or trees along the roads and avenues have a higher effect on the microclimate of the area as compared with isolated artificial plantations. Similarly, seasonal plants can help reduce the LST for a limited period. Ornamental species can even end up burdening the water supply. Open grounds that lack grass or

Figure 20-1: Mean Land Surface Temperature for pre and post-monsoon (2019-2021)



Source: WRI India analysis using Landsat 8, USGS, 2022; Left: Pre monsoon summer months (April & May), Right: Post monsoon winter months (October – December)

similar vegetation during summer months also act as heat hotspots.

The post-monsoon visual (Figure 20-3) appears greener as the availability of water is higher during the months post-southwest monsoon. Wards 22, 23 and 27 (Savarkar Nagar), which have many trees and vegetation as part of the built fabric, have a lower LST in both graphs. The pre-monsoon average surface temperature in these wards is between 38°C and 39°C. Wards 29 and 42 (Panchvati) are some of the wards that have very less vegetation. These wards experience approximately 41-42°C during the summers.

Figure 20-2 : Comparison between ward wise mean LST and NDVI for pre monsoon months (April and May, 2019-2021)

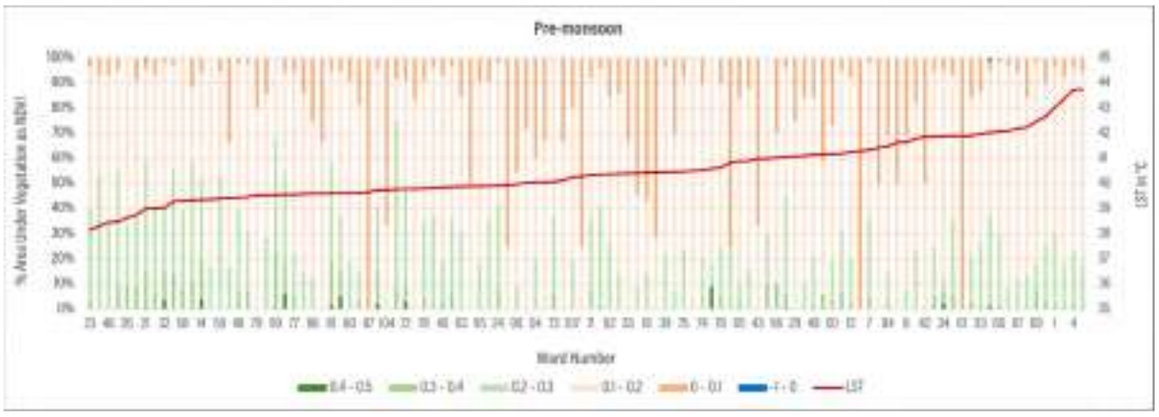
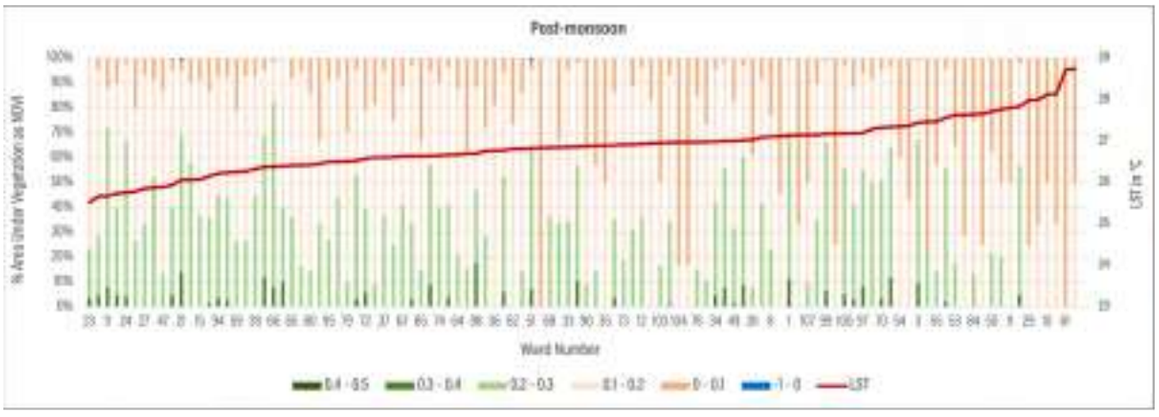


Figure 20-3: Comparison between ward wise mean LST and NDVI for post monsoon months (Oct, Nov, Dec, 2019-2021)



Source: WRI India analysis, Landsat 8 data between 2019 – 2021

20.1.3 Land Surface Temperature and land use

On comparing the average LST of different land uses, it is observed that the type of land use and anthropogenic activity affect the temperature within an area, as seen in Figure 20-4. Residential areas with vegetation and open green spaces usually have a lower LST than other urban land use classes. Industrial areas and areas with transport land use appear hottest amongst the urban land use classes due to the type of activity and increase in emissions.

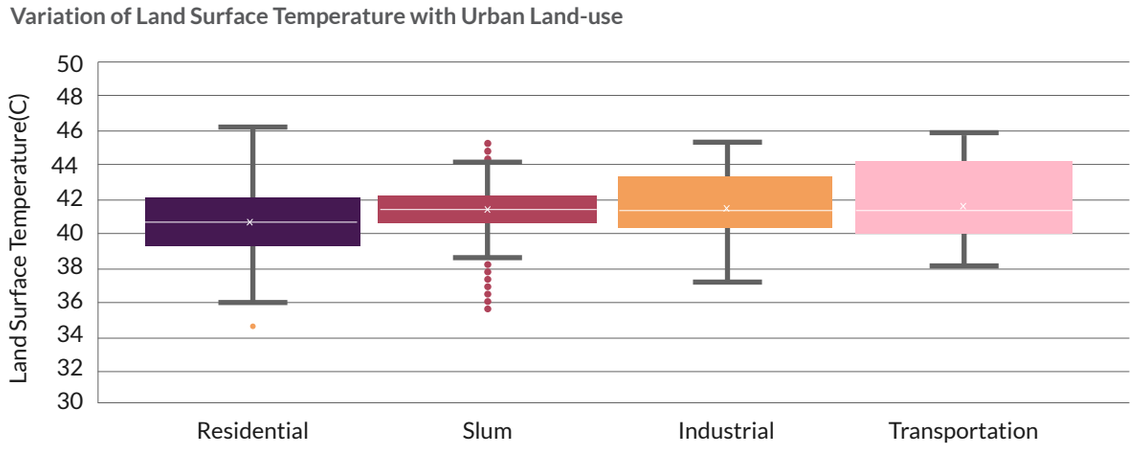
20.1.4 Access to green spaces

As seen in Figure 20-5, 71.9% of Nashik's population has access to public recreational spaces within the threshold values distance of 1 km within 10-minute walkable distance and 28.1% does not have access to any parks, gardens, playgrounds or maidan within the standard time. Higher density areas in and around MIDCs, Mhasrul Gaon, Hanuman Nagar in the north and around Ashtvinayak Nagar in the southeast lack ease of access to such facilities (within 10-minute walkable distance). No population in Ajmeri Nagar and Mahalakshmi Nagar (ward no. 84), Satpute Mala and Mankar Mala (ward no. 70) and parts of Shramik Nagar (ward no. 52) have ease of access to recreational spaces within 10-minute walkable distance, making them more exposed to extreme events such as extreme heat stress.

Of these, parts of Shramik Nagar (ward no. 52) are at the most risk as 77.73% of the population here has limited ease of access to public recreational spaces and, at the same time, are potentially at risk due to extreme heat (> 32°C).

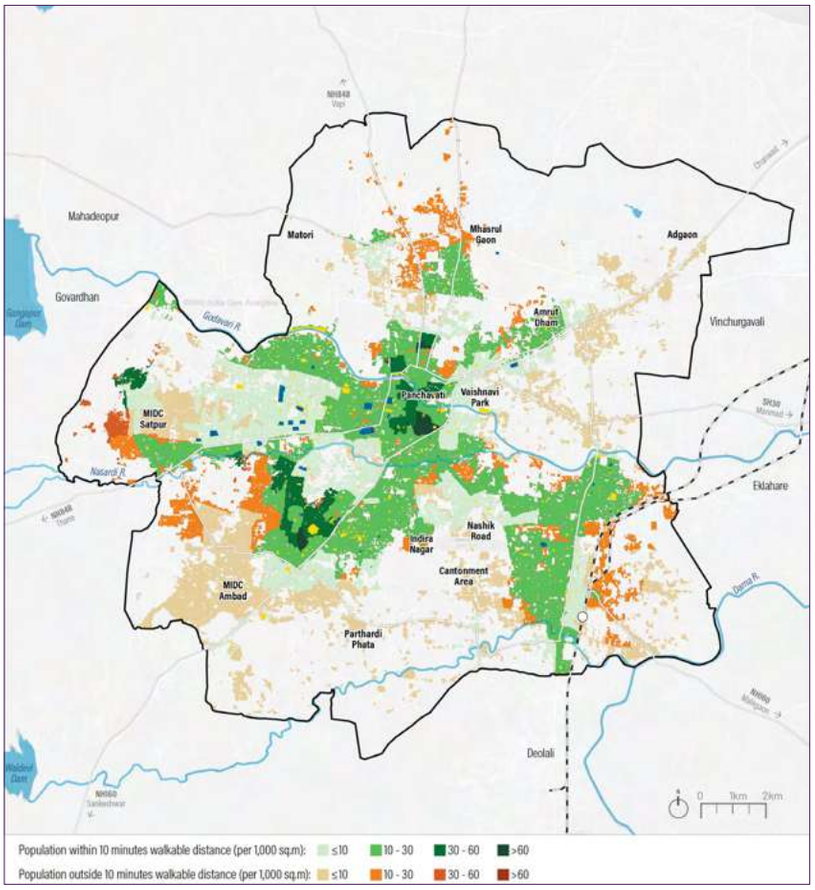
During a flood event, the population having access to public recreational spaces reduces, from 71.90% to 48.94%. Parts of Konknipura (wards no. 42, 60 and 61) and Doodh Bazar (ward no. 43) in the inner city loses complete access to public recreational spaces during a flood event.

Figure 20-4: Variation of LST with landuse



Source: WRI India 2022, Landsat 8, 2019-2021 (Pre-monsoon), Nashik Municipal Corporation

Figure 20-5: Access to Public Recreational Spaces



Source: WRI India using Census 2011, World Settlement Footprint 2019, Existing Land Use NMC 2021

20.2 ONGOING INITIATIVES

Under the National Clean Air Programme (NCAP) 2019, Nashik is one of the 131 cities deemed as a non-attainment city and mandated to prepare a Micro Action Plan to reduce air pollution. Several greening strategies have been listed, which will help reach the targets for ambient air quality. Many of the strategies listed in the Micro Action Plan are either in progress or yet to be initiated.

- Under the Godavari Riverfront Development project, a plantation along the river, canals and nallahs is in progress, and it is to be funded by Nashik Smart City.
- A total of 49 traffic islands/dividers are to be developed as green buffers, of which 7 have been completed through CSR funding and 8 are in progress.
- Urban greening with vertical gardens is to be taken up under NCAP.

Additionally, NMC has conducted extensive plantation drives in which over 69,000 trees were planted in 2021[42] as part of the state government's' Mission Plantation, which began in 2016 to increase Maharashtra's green cover to 33%. Under the AMRUT scheme, the city has developed Amrutvan in Tauli Phata, which is one of the largest gardens in the city.

Other than these initiatives, a Detailed Project Report is being prepared for the Namami Godavari project in which riverfront beautification will be an important aspect.

20.3 KEY ISSUES/OPPORTUNITIES

Based on the analysis of the Tree Census and Vulnerability Assessment, the following issues and opportunities emerge in the Greening sector for Nashik:

- **Develop a robust database of open spaces, and create ward-level plans to increase the per capita open space:** Since the city lacks a common database of all open spaces (playgrounds, parks, gardens, plantations etc.), there is a need to create an accessible database based on which the city can plan its development strategy for open spaces. As the city is currently undertaking a GIS mapping of all its existing infrastructure, the database can identify open spaces based on varying typologies to help identify the existing open spaces and areas that need new open spaces.
- **Increase the number of and accessibility to green spaces in the city:** The low per capita green spaces makes the areas more prone to heat risk and leads to a lack of access to spaces for evacuation, rescue and recovery
- **River as a recreational space:** With the ongoing plan to rejuvenate River Godavari, there is an opportunity to create public green spaces along the river, which will increase the area under greens in the city as well as act as sponge infrastructure in case of flooding.
- **Develop new green spaces:** Due to the lack of green spaces, new greening initiatives may be adopted at ward, layout, institutional and society levels to increase the green cover.
- **Need to focus on plantation of native species:** With the increase in exotic species, there is a need to increase and protect native species through plantation drives as well as increase awareness.
- **Address the increasing heat risk in the city:** The LST analysis of the city suggests that the city needs a comprehensive Heat Action Plan, with a focus on greening.

20.4 RECOMMENDATIONS

20.4.1 Approach

- Increase open spaces and their accessibility within developed/ built-up areas.
- Increase the green spaces and their accessibility within the city.
- Reduce heating effect through greening measures, and increase heat resilience.

20.4.2 Sectoral strategies and actions

The key strategies are as follow:

- **Strategy UG-1:** Increase the per capita open space by 50% from 5.92 square metres to 9 square metres, and increase accessibility to open spaces from 72% to 100% by 2035
- **Strategy UG-2:** Increase the per capita green spaces in the city from 1 square metre to 2 square metres by 2035
- **Strategy UG-3:** Create a comprehensive capacity building and awareness programme to enhance the green assets.
- **Strategy UG-4:** Develop a comprehensive Heat Action Plan for Nashik City.

20.5 STRATEGIES AND ACTIONS

Table 20-1: Strategy UG-1: Strategy UG-1: Increase the per capita open space by 50% from 5.92 square metres to 9 square metres, and increase accessibility to open spaces from 72% to 100% by 2035

Action description	Stakeholders and Financing	Monitoring Indicators
Priority Action: **Develop a robust database of open spaces and create ward-level plans to increase the per capita open space by 50%, from 5.92 square metres to 9 square metres and increase accessibility to open spaces from 72% to 100% by 2035** • Create a database of the existing and newly developing open spaces in the city (playgrounds, gardens, parks, plantations, recreational spaces etc.) and make the data publicly accessible • Developing on the database, create ward-level open space (including greening) plans in wards that have low per capita open spaces and/or low access to existing open spaces and identify areas that may be developed as open spaces; 28% population does not have access to any parks, gardens, playgrounds, or maidans within the standard time. For example, higher density areas in and around MIDCs, around Mhasrul Gaon, Hanuman Nagar in the north and around Ashtvinayak Nagar in the southeast lack ease of access to such facilities (within 10-minute walkable distance). Vulnerable neighbourhoods, such as low-income communities and areas identified as heat hotspots may also be prioritised. • Each ward-level plan shall consider the provision of a tanker facility for transport and supply of recycled water (good for the human touch) from STPs for watering the recreational areas and green spaces, thus reducing the use of fresh / treated water. **Example:** The methodology of database creation based on crowdsourcing data, such as in Kochi, has created an application that collects data based on crowdsourcing with features such as reporting obstacles on the street including fallen trees, garbage dumps, potholes etc. **Timeline: 2024-27**	Garden Dept, IT Dept., Nashik Smart City, Ward officials, Gardens Dept, Resident Welfare Associations (RWA) **Financing:** NMC budget, Nashik Smart City fund, XVFC fund, AMRUT fund	**Output:** City-level dashboard/application, No. of wards which create ward-level greening plans **Outcome:** % of population having access/ downloaded the database % Increase in per capita open space % Increase in access to open spaces

Table 20-2: Strategy UG-2: Increase per capita green spaces in the city, from 1 square metre to 2 square metres.

Action description	Stakeholders and Funding	Monitoring Indicators
Develop green corridors along major rivers – Godavari (19 km) and Nasardi (7 km) —along with the streams meeting these as major green corridors through a series of interventions. • Identify different stretches along the water bodies (such as Ramwadi bridge to Holkar bridge, Holkar bridge to Gadge Maharaj bridge, Gadge Maharaj bridge to Talkuteshwar bridge) and apply greening interventions to protect and enhance the existing open, green spaces. • Create a plan that maps all the blue-green assets of the city, such as rivers and nallahs and parks, gardens and recreational areas, and integrate these by creating a city-wide network plan, making the assets accessible through walking and/ or cycling. This will create new access points to blue-green assets of the city and give access to the 28% population that does not have access to any parks, gardens, playgrounds and maidans within the standard time. For example, higher density areas in and around MIDCs, around Mhasrul Gaon, Hanuman Nagar in the north and around Ashtvinayak Nagar in the southeast lack ease of access to such facilities (within 10-minute walkable distance). • Provide nature-based solution (NBS), with a focus on greening (such as developing bioswales, rain gardens) at (i) flooding hotspots, such as Panchvati and CIDCO area identified along the water bodies and (ii) multi-hazard areas, such as Panchvati and MIDC Satpur. • Undertake plantations programmes that shift from monoculture of exotic species to polyculture of native species across the city. • The Miyawaki method can be adopted to increase the green cover in community gardens/ biodiversity parks. **Example:** The city of Medellin in Colombia transformed 18 roads and 12 waterways into Green Corridors, reducing the urban heat island effect by 2°C since 2018. **Timeline: 2026**	Environment Dept., Garden Dept, Godavari Conservation Cell of NMC **Financing:** NMC budget, Nashik Smart City fund, XVFC fund, AMRUT fund, CSR	**Output:** Development of new green spaces Plantation of native species **Outcome:** % increase in green spaces along the river and in the city % increase of native species

Increase the green cover at society, layout, road infrastructure and institutional levels by adopting measures such as the following: • Develop new green spaces in community places, schools and housing societies to increase the per capita green spaces available. • Incentivise the integration of green roofs, green walls and community gardens with the Development Control Regulations (DCRs) during the development or redevelopment of buildings. • Encourage industrial areas, such as Satpur and Ambad MIDCs, to increase the green cover to mitigate heat risk, making the environment suitable to work. • Undertake plantations programmes that shift from monoculture of exotic species to polyculture of native species. • Develop green corridors along roads. **Timeline: 2026**	TPD, Environnent Dept., Garden Dept., NIMA- Industry owners Asso., CBOs,NGOs, ALMs (Advanced Locality Management Groups) **Financing:** NMC budget, Nashik Smart City fund, XVFC fund, AMRUT fund, CSR, NIMA-Industry owners Association.	**Output:** New green areas across the city, revision in DCRs to incentivise greening initiatives, new green spaces in industrial areas **Outcome:** % increase in green assets at the building level, % increase in per capita green spaces, % increase of green spaces in industrial areas and reduction in temperature; % of new plantation as per the native species, captured through Tree Census.
• Enhance the existing Biodiversity Park at Tauli Phata to demonstrate actions such as the promotion of native species and creating blue infrastructure to capture rainwater and recharge the groundwater. This area will help in carbon sequestration, reduction of air pollution, and urban heat impact. • This may be done by formulated at a city level by formulating a Biodiversity committee and maintaining a biodiversity register to map and maintain the city's ecological assets. **Example:** Coimbatore is building Climate Resilient Bio Parks that demonstrate practices in landscape architecture, environmental design, blue-green infrastructure design, social infrastructures, and ecological upgrading. **Timeline: 2026**	Garden Dept, Water Dept., Environment Dept. **Financing:** NMC budget, Smart city fund, AMRUT fund	**Output:** No. of biodiversity parks developed by adopting scientific greening methods and NBS **Outcome:** % increase in per capita green space under biodiversity parks, % increase of areas adopting NBS

Table 20-3: Strategy UG-3: Create a comprehensive capacity building and awareness programme to enhance the green assets

Action description	Stakeholders and Funding	Monitoring Indicators
Enhance the existing NMC app on which citizens can report the felling of trees to expand its service, and allow the reporting of the status of all existing green, open spaces in the city. **Timeline: 2026**	Gardens Dept, IT Dept, Nashik Smart City **Financing:** NMC budget, CSR	**Output:** Enhanced application **Outcome:** % decrease in felling of trees
Develop awareness campaigns and capacity building programmes to be conducted regularly for various stakeholders on greening initiatives and its benefits **Timeline: 2026**	Gardens Dept, Ward councillors, CBOs, NGOs, ALMs, educational institutes **Financing:** NMC budget, CSR	**Output:**Total no. of outreach programmes planned and undertaken in a year **Outcome:** % area/ population covered by awareness and outreach programmes

Table 20-4: Strategy UG-4: Develop a comprehensive heat action plan for Nashik City

Action description	Stakeholders and Funding	Monitoring Indicators
Prepare a comprehensive heat action plan for the city based on the NDMA guidelines, with a focus on the following: • Establish an Early Warning System and Inter-Agency Coordination. • Develop capacity building/training programmes for health care professionals at the local level to recognise and respond to heat-related illnesses, particularly during extreme heat events. These training programmes should focus on medical officers, paramedical staff and community health staff so that they can effectively prevent and manage heat-related medical issues to reduce mortality and morbidity. • Public awareness and community outreach: Disseminate public awareness messages on how to protect against the extreme heat-wave through print, electronic and social media and Information, Education and Communication (IEC) materials such as pamphlets, posters and advertisements and Television Commercials (TVCs) on Dos and Don'ts and treatment measures for heat-related illnesses, reducing heat exposure and promoting adaptive measures. • Collaboration with non-government organisations (NGOs) and the civil society: Collaborate with NGOs and civil society organizations (CSOs) to improve bus stands, build temporary shelters, wherever necessary, improve water delivery systems in public areas and undertake other innovative measures to tackle heatwave conditions. **Timeline: 2026**	Environment Dept, Garden Dept **Financing:** NMC budget, XVFC fund, AMRUT fund	**Output:** Citywide heat action plan **Outcome:** % of area/ population covered under the heat action plan and awareness/ outreach programmes

PANCHAVATI, NEAR RAMKUND
Photo Credits - Ar. Janhavi Shinde

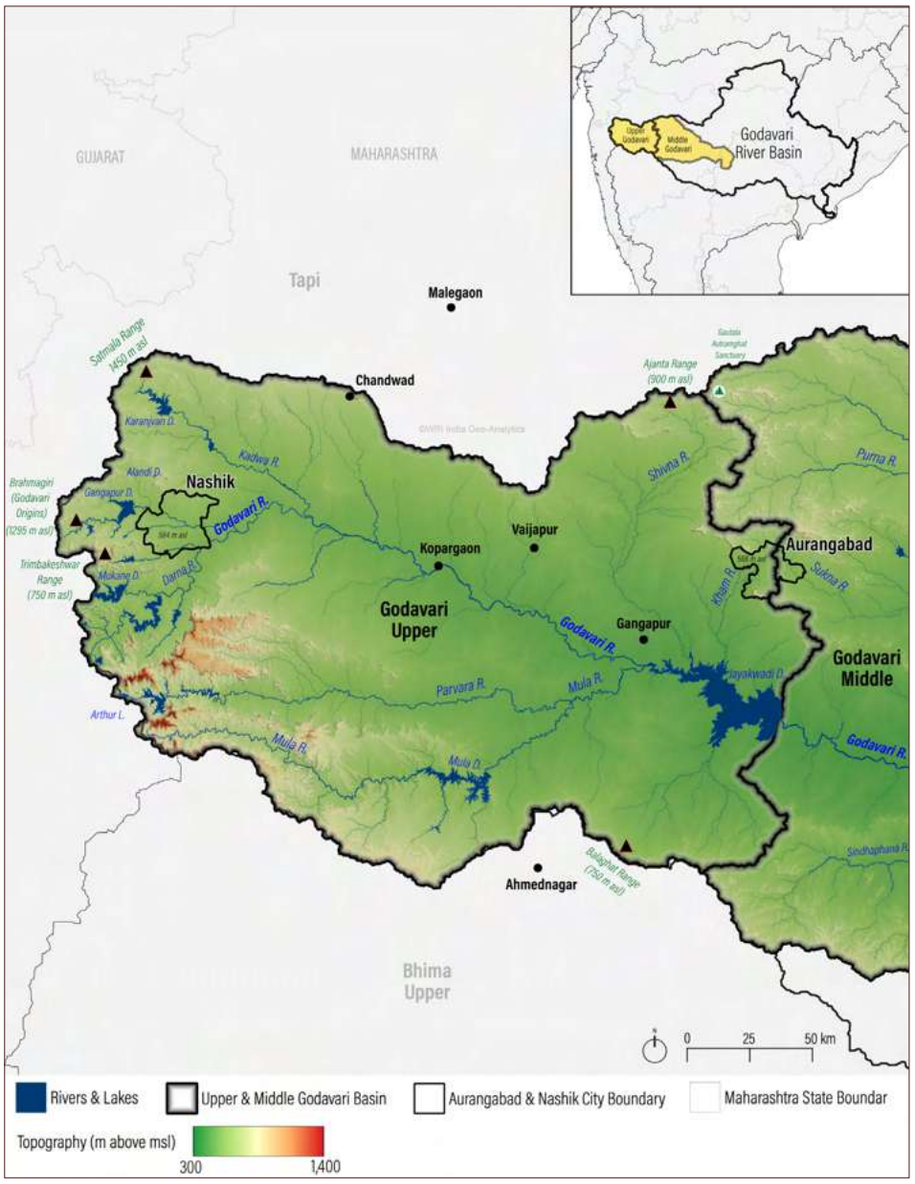
21. WATER RESOURCE MANAGEMENT

21.1 CITY WATER SUPPLY SYSTEM

21.1.1 Sectoral overview

Nashik City receives ~500 million litres per day (MLD) of water from three sources – Gangapur Dam on the Godavari river (~375 MLD), Mukane Dam (~122 MLD) and the Darna river (20 MLD)[43]. There is a separate water allocation for MIDC industrial areas and thermal power plant at Eklahare. There are a total of 6 water treatment plants (WTPs) with a total treatment capacity of 472.5 MLD[44].

Figure 21-1: Location of water sources from Nashik city



Source: *WRI India Analysis*

Table 21-1: Water demand and supply scenario in Nashik city

Indicator / Year	2011	2021	2031	2041
Population (lakhs projected) – as per Water Audit 2018	14.86	21.88	28.75	38.80
Daily water demand (MLD) as per PWD	337[48]	539	721	1,096
Current water supplied (MLD)	391[49]	520	520	520
Gap, MLD (estimated)	-	19	201	576

Source: Nashik Water Audit 2018, PWD, ESR 2020-21, NMC

21.1.2 Water demand and supply

The estimated water demand of Nashik City for the year 2021 was 539 MLD[45], and the projected demand is 721 MLD for the year 2031 and 1,096 MLD[46] for the year 2041. NMC had lifted around 483 MLD in 2019-20 and around 516.7 MLD in 2020-21[47]. The estimated water supplied was 520 MLD in 2021, and the billed quantity was 207.19 MLD in 2019-20 and 216.61 MLD in 2020-21. As per Water Audit Report 2018, non-revenue water (NRW) is more than 41% on average. In the current situation, NMC supplies water at a frequency of 1.5-3 hours per day. To understand the water demand and supply scenario, data is sourced from different documents, which call for a need to consolidate the available data.

21.2 ONGOING INITIATIVES

- Nashik city targets 100% water meter-connected connections by 2040. The city is working on replacing all old pipeline distribution systems to reduce leakage.

- The Nashik Municipal Smart City Development Corporation Ltd (NMSCDCL) has issued a Request for Proposals (RfP) to the Ministry and issued a work order to install 12,000 supervisory control and data acquisition (SCADA) water meters for commercial consumers in the city.

- The Smart City Corporation will also construct two WTPs at the Bara Bungalow and Panchavati locations, with a total capacity of 90 MLD.

21.3 KEY GAPS AND CHALLENGES

The key gaps are as follow:

- 100% metering has been reported by NMC, but of those connections, only about 30% of meters are functional, as per the Nashik water audit report.
- In the absence of functional meters, there is no reliable data on actual NRW levels, although it was found to be more than 41% in 2018, as per the city water audit report 2018.

21.4 GROUNDWATER MANAGEMENT

21.4.1 Sectoral overview[50]

No information is available on the groundwater situation and aquifers within the NMC area. Hence, the groundwater assessment is carried out based on a 2014 report on Groundwater

Information of Nashik District published by the Nagpur Division of the Central Groundwater Board.

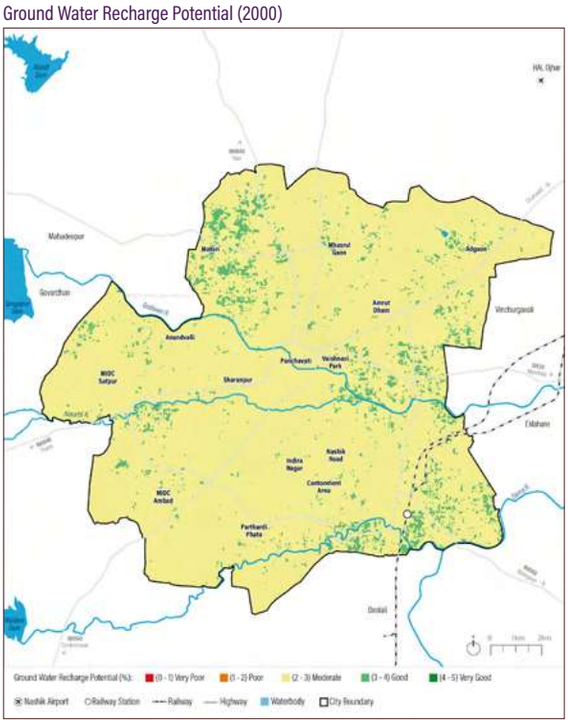
The district forms a part of the Western Ghats and the Deccan Plateau. Physiographically, Nashik district has a varied topography. The southern part of the district falls in the Godavari basin and is drained by the Godavari River and its tributaries. Nashik city is situated along the Godavari river.

Basaltic lava flows occupy about 90% of the area of the district. The groundwater in Deccan Trap Basalt occurs mostly in the upper weathered and fractured parts down to a depth of 20-25 metres. At places, potential zones are encountered at deeper levels in the form of fractures and inter-flow zones. The upper weathered and fractured parts form a phreatic aquifer, and groundwater occurs under water table (unconfined) conditions. At deeper levels, the groundwater occurs under semi-confined to confined conditions. The yield of dug wells tapping the upper phreatic aquifer down to the depth of 12 to 15 metres bgl ranges between 45 and 90 m3/day, depending upon the local hydrogeological conditions. Borewells drilled down to 70 metres depth, tapping weathered and vesicular basalt, are found to yield 18-68 m3/day. The discharge of Piezometers ranges from 0.14 to 1.73, as seen from CGWB data. The several talukas of Nashik exhibit a variation from semi-critical to safe. Based on the stages of groundwater development from various CGWB reports, overall, it has increased from 49% to 59% in the district, with Deola and Sinnar in the 'critical' stage, being most dependent on groundwater.

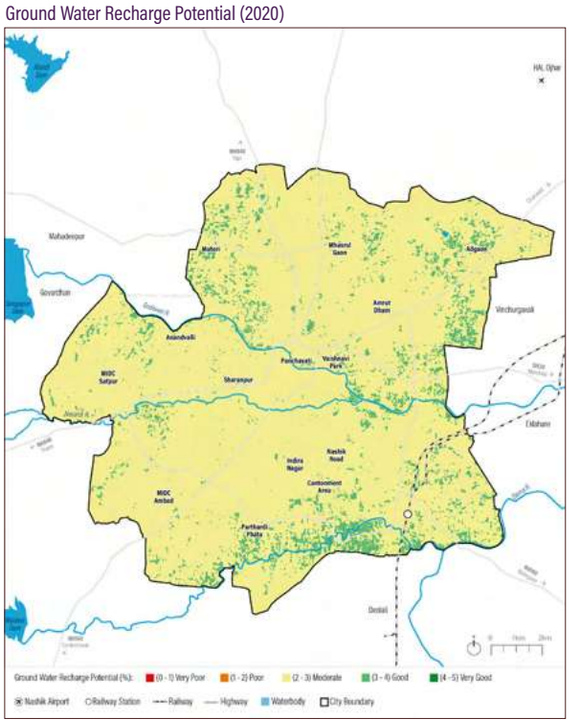
The groundwater recharge potential (GWRP) within the NMC area is estimated using three parameters – average annual rainfall (using IMD gridded daily rainfall), the slope of the terrain (obtained from topography/DEM) and the conditions of the vegetation, soil and land use (represented by NDVI). The GWRP for Nashik city was obtained for two years – 2000 and 2020. These two GWRP time periods were compared to find the percentage change in the recharge potential at each grid (resolution of 30m). The city exhibits a 'moderate' GWRP throughout its limits while the recharge potential is 'good' around the waterbodies as well as towards the west of the city along the Godavari river. The region to the south of the city has seen an increase (moderate to good) in GWRP in 2020 as compared with that in the year 2000, as seen in Figure 21-2.

Figure 21-2: GWRP within NMC area for two timestamps, two decades apart

Ground Water Recharge Potential (2000)



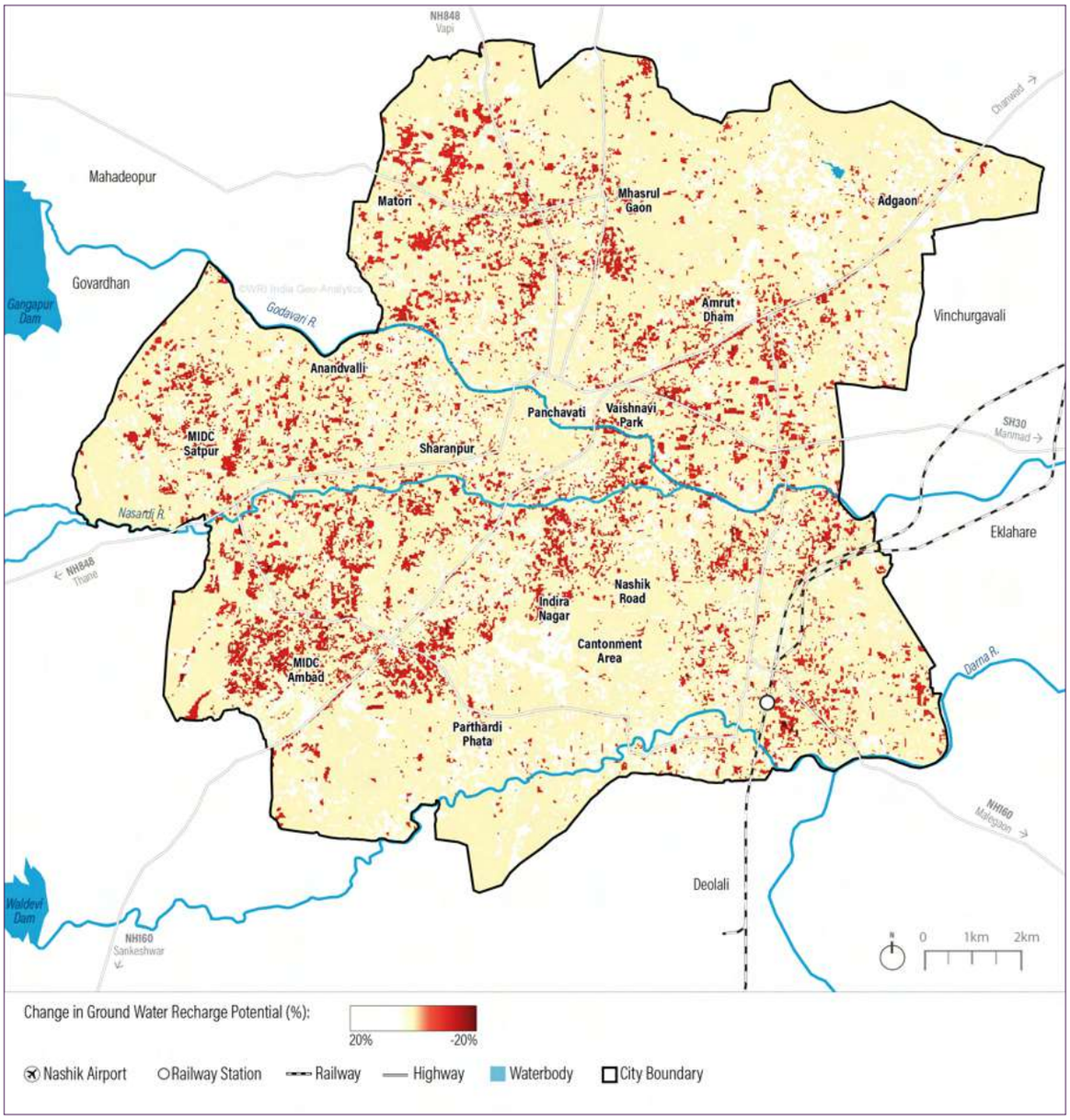
Ground Water Recharge Potential (2020)



Source: WRI India using IMD Gridded Rainfall, SRTM Topography, Landsat 7 NDVI

On calculating the change in GWRP between 2000 and 2020, it is observed that the west and south-west regions of the city have seen a decrease in the GWRP due to various reasons, such as lack of surface water availability, increased industrial and commercial activity, as seen in Figure 21-3.

Figure 21-3: Areas showing a Decrease in Groundwater Recharge Potential



Source: *WRI India Analysis*

21.5 ONGOING INITIATIVES

There are no ongoing initiatives related to groundwater development within the NMC area.

21.6 KEY GAPS / CHALLENGES

The key challenges are as follow:

- Observatory wells are located only at the district level and not within the city limits.
- Data on city-level aquifer maps and groundwater levels and annual groundwater extraction is not available.
- Data on private borewells and yield of public borewells and tubewells is not available

21.7 URBAN FLOODING

21.7.1 Sectoral overview

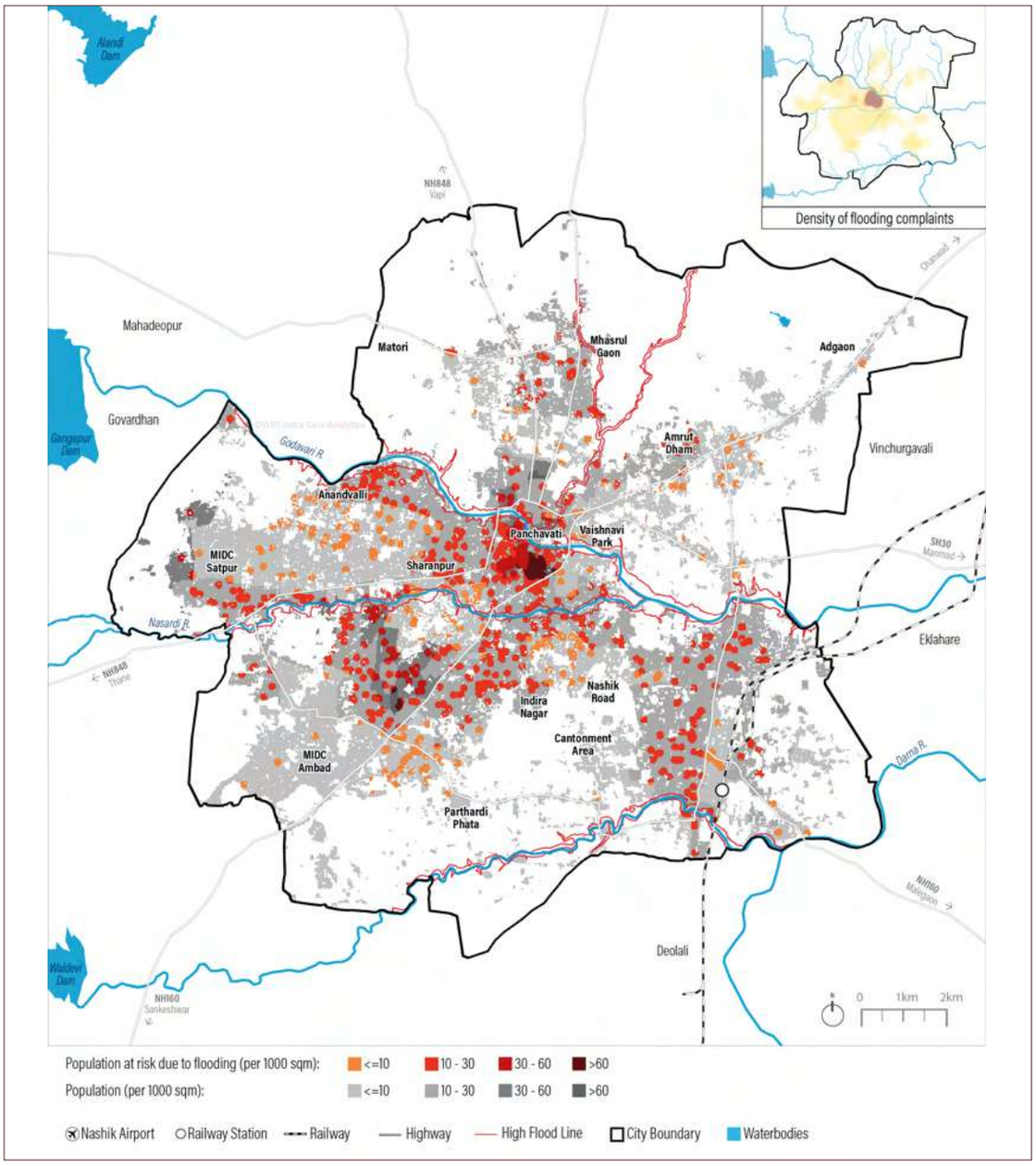
The Godavari river originates from Bramhagiri mountains at Trimbakeshwar and flows through Nashik city. The Gangapur Dam is situated on the Godavari river, 10 km upstream of Nashik city. The Godavari has an 18 km stretch within the NMC area and is joined by its tributaries Nasardi and Darna, which have a combined length of 11 km within or adjacent to NMC limits[51].

On an average, Nashik receives 780 mm rainfall annually[52]. As per the Disaster Management Plan of Nashik City (2020), the flooding of the Godavari river and its tributaries happens 2-3 times a year. As per a 2017-18 survey, during heavy rainfall, water is discharged from Gangapur and its upstream dams, which creates a flood-like situation within Nashik city, affecting 21 settlements within NMC. NMC has also identified around 40 low-lying areas that are vulnerable to flooding. During a year, NMC receives on average 2,000 complaints of flooding through its NMC E-connect and Mazha Mahapur grievance apps.

The city lacks a comprehensive stormwater drainage system[53]. The old city is in a low-lying area where the ground slopes are steep, especially near the Godavari and its tributaries. Roadside stormwater drains have a network of only 12.21 km[54]. Although NMC has a constructed pucca lining along the natural drains, unplanned development activities have caused the blocking of the waterways.

Based on flooding data from NMC, it can be observed that the concentration of flooding hotspots is very dense within the central region of the city. This region has a densely built-up area as compared with the periphery of the city. A relatively higher concentration of flooding hotspots is observed in old Nashik areas of Panchvati and other areas, such as CIDCO, based on waterlogging/ flooding complaints data from the Maza Mahapur App and NMC's e-Connect App, as seen in Figure 21-4.

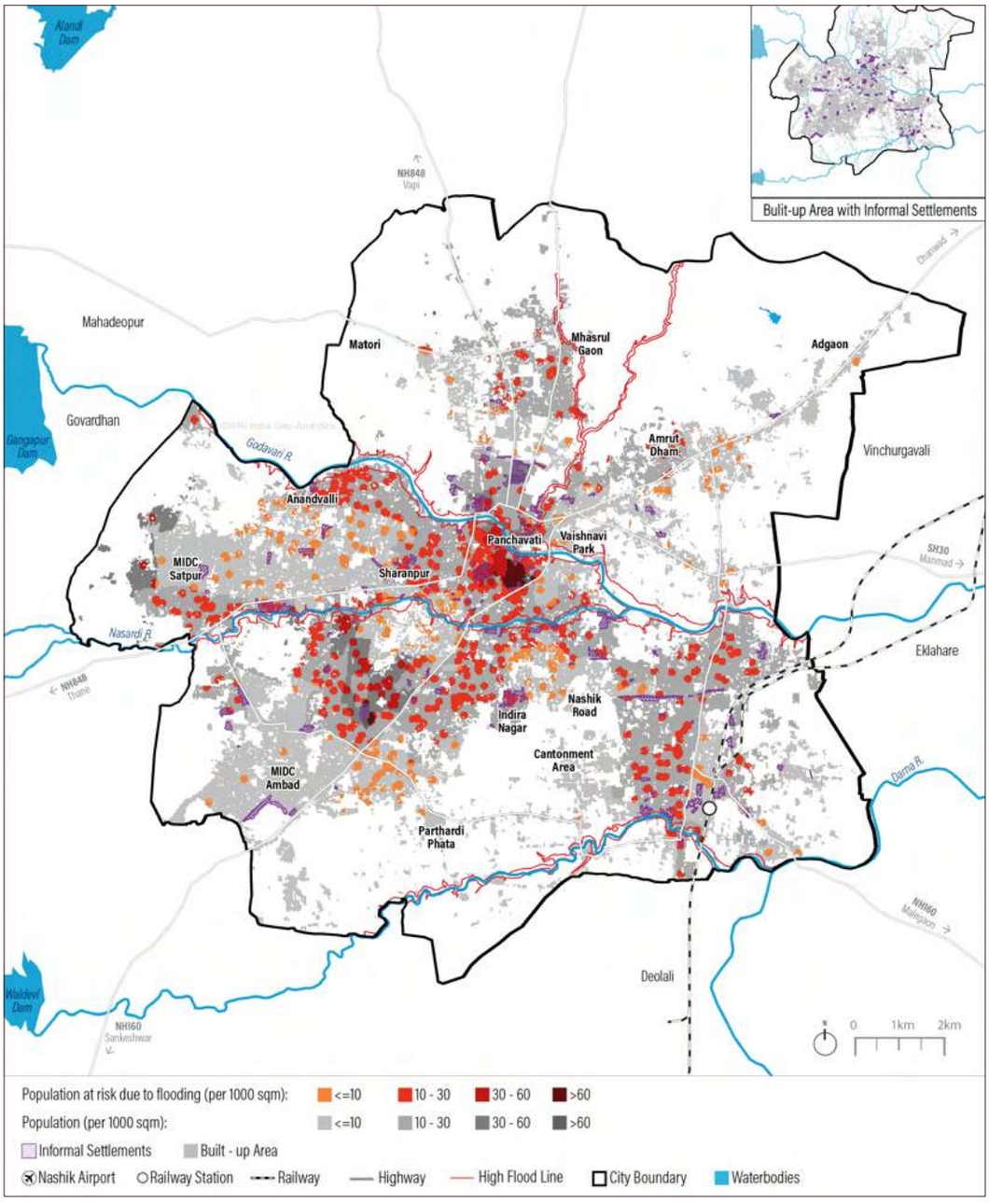
Figure 21-4: Population potentially at risk due to flooding



Source: *WRI India Analysis*

On overlaying the complaints data with the population density and subsequent intersection with the ward boundary, it is observed that 23% of the population is within a 100m buffer of the flooding hotspots in the city. Of the 172 informal settlements, 73 are exposed to recurrent flooding, i.e., 42% of informal settlements are affected by floods, as seen in Figure 21-5.

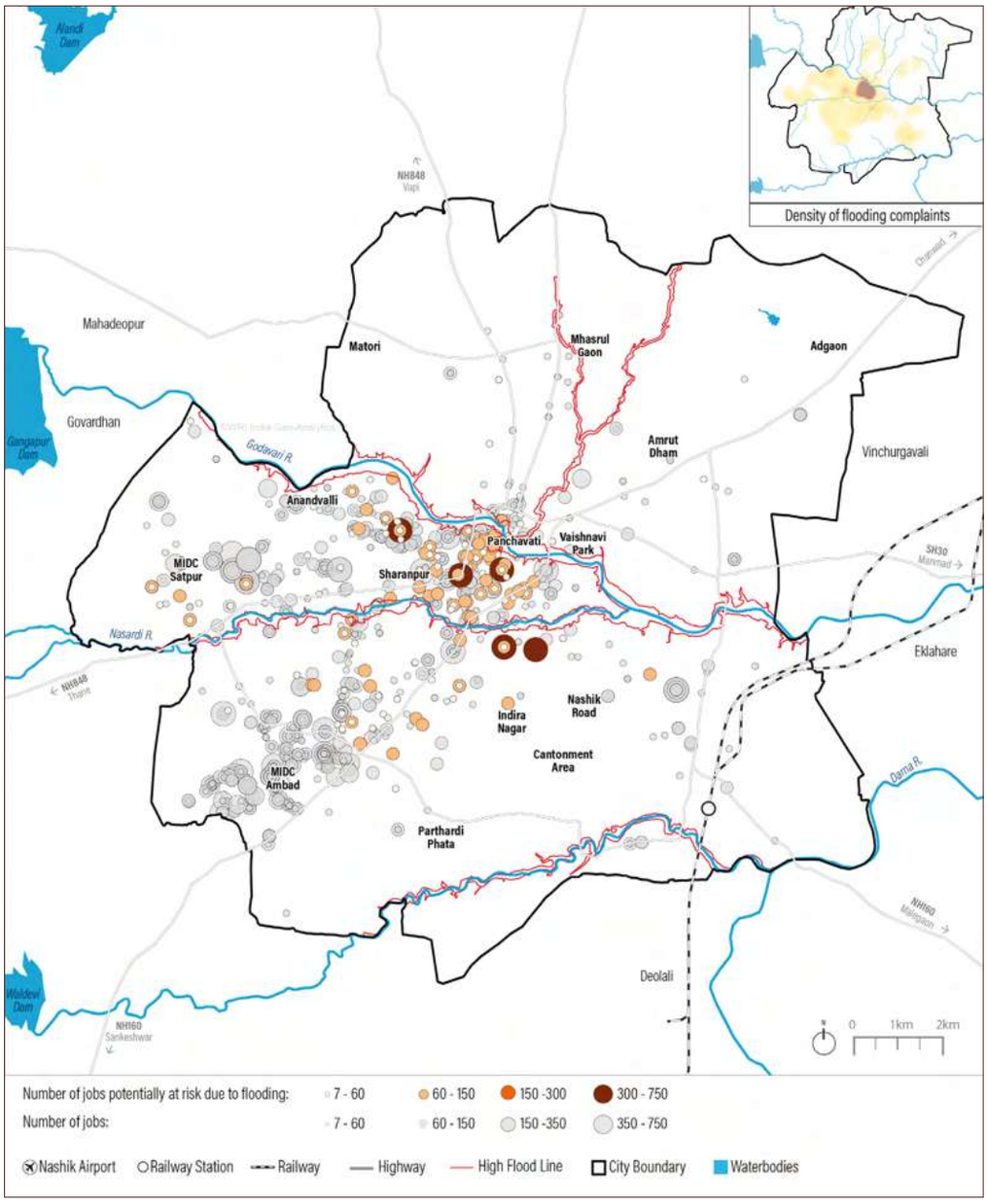
Figure 21-5: : Population along with Informal Settlements Potentially at Risk due to Flooding



Source: Census 2011, WSF Evolution 2019, Nashik Municipal Corporation, WRI India 2022

The 100m buffered flooding hotspots were overlayed with employment data obtained from Directory of Establishments. Recurrent flooding events limit the means to access business centres, impacting the daily wage/industrial jobs the most (UNICEF, 2021). Approximately 13% of the population's employment/jobs are affected due to flooding. Most of the jobs (>70%) that are affected by flooding are in 12 wards (18, 40 – 44, 52, 62, 79, 82, 88 and 93)

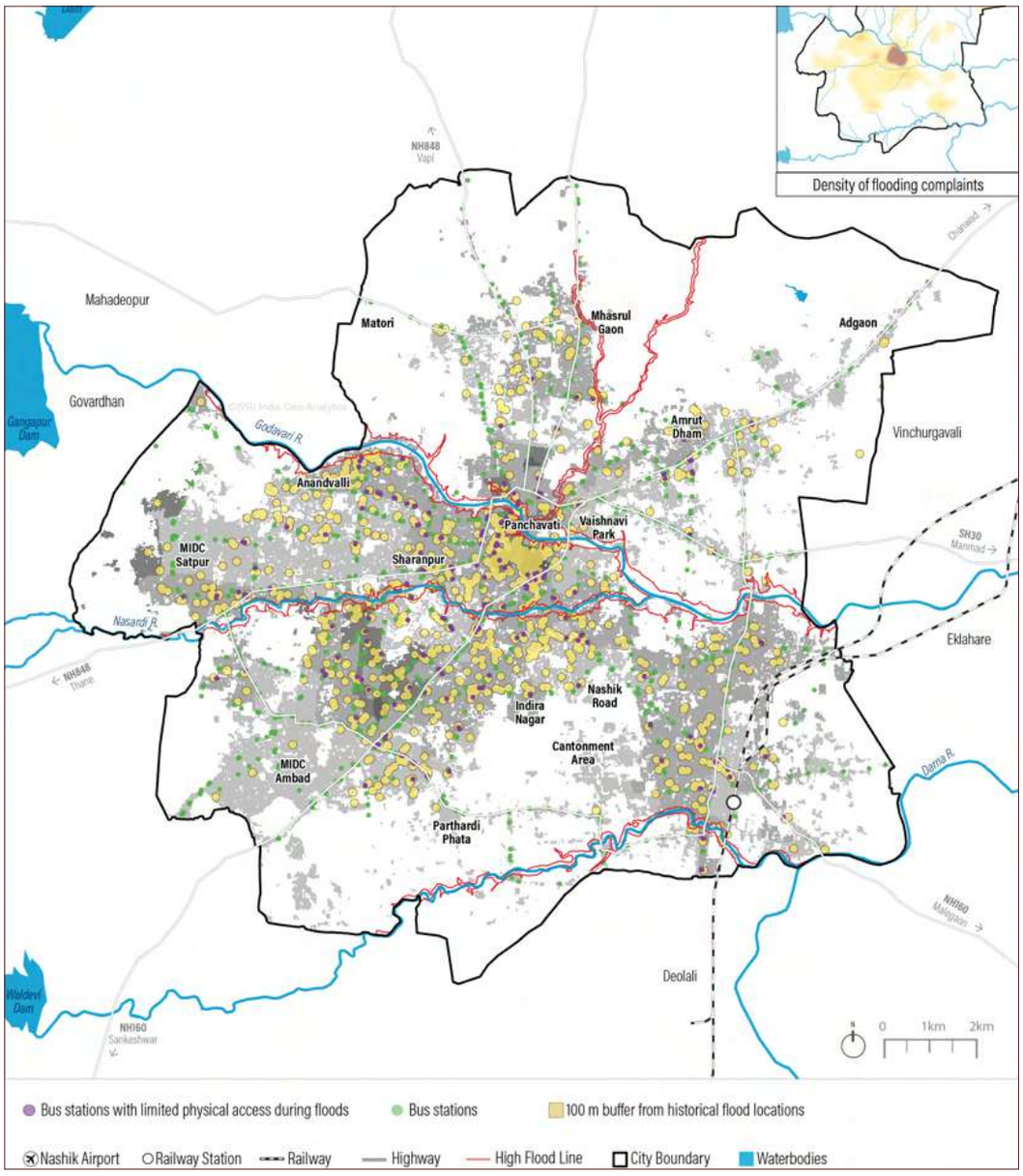
Figure 21-6: Jobs Potentially at Risk due to Flooding



Source: WRI India Analysis

Access to public infrastructure, such as bus stops, is compromised when there is excess rainfall that causes flooding. These affected locations would cause a hindrance to the daily commute of the population that is being serviced with the help of public buses. There are a total of 2,862 bus stops in the city, of which 633 are located within the 100 m buffered flooding zones. That is, nearly 22% of the public transport system is affected due flooding, as shown in Figure 21-7.

Figure 21-7: Public transport affected due to flooding



Source: *WRI India Analysis*

21.8 WASTEWATER GENERATION AND TREATMENT INFRASTRUCTURE

Nashik has 10 Sewage Treatment Plants (STPs) with a total capacity of 360.5 MLD (2021). As per the documents submitted by NMC to Swachh Survekshan 2022, the monthly average quantity of sewage received at STPs was of 337.2 MLD in November 2021 and 336.5 MLD in December 2021. That implies an average utilisation of ~93%. In 2031, there is a gap of 216 MLD in the treatment capacity of STPs, which is expected to be partially addressed through the ongoing/ planned initiatives that are presented in the next section.

21.8.1 Ongoing initiatives

The key ongoing initiatives are as follows:

- The eleventh upcoming STP at Pimpalgoan Khamb (11th STP), which is in the test and trial phase, is expected to be launched by 2023 with a capacity of 32 MLD.
- Under the Fifteenth Finance Commission grant, INR 20 crores has been allocated to the NMC for setting up the twelfth STP / additional infrastructure for recycling treated wastewater at the existing STP in Gangapur STP with a capacity of 18 MLD.
- Under AMRUT, NMC has budgeted for increasing the capacity of Gangapur STP by revamping with the latest advanced technologies.
- NMC has an INR. 410-crore proposal to upgrade a total of four old sewage treatment plants.
- A 1550-km sewer network has been completed. A 210-km sewer network work is ongoing with 40% work completed, and it is expected to be complete by March 2022, as informed by an NMC representative

21.8.2 Key gaps/ challenges

The key challenges are as follow:

- The current sewerage coverage is reported as 100%. However, maintenance and quality checks are not regularly conducted, leading to a lack of functional networks in several areas.
- By 2031, the treatment capacity needs to be augmented by at least 216 MLD.
- A major concern for the NMC is that the Biological Oxygen Demand (BOD) and Total Suspended Solids (TSS) levels of the treated sewage at its old STPs are in the 20-25 range. As per the environmental norms, this needs to be reduced to less than 10.
- The reported BOD levels at the STPs, particularly at Tapovan and Chehedi STPs, show significant variation, with very low BOD levels noticed for extended periods of time.
- Currently, there are 4 STPs that operate using the Activated Sludge Process (AS) Up

Table 21-2 : Wastewater generation and treatment in Nashik city

Indicator / Year	2011	2021	2031	2041
Population (lakhs projected) – as per Water Audit 2018	14.86	21.88	28.75	38.80
Daily water demand (MLD) as per PWD	337	539	721	1,096
Current water supplied (MLD)	391	520	520	520
Gap, MLD (estimated)	-	19	201	576

Source: CDP, 2012, Sewage Department, NMC

Flow Anaerobic Sludge Blanket (UASB), and the existing Sequential Batch Reactor (SBR) treatment system is not functional.

- As per SWM data, the city has 57,789 residential households and commercial establishments with septic tanks. There are only 79 community toilets in the city.
- In the New Nashik Zone area, several households have soak pits as well. In many places, the septic tanks of public toilet complexes are not properly maintained. For example, near the Ramkund area bridge, the septic tanks directly drain into a river or water body, which even lead to groundwater contamination.
- NMC has six vehicles to de-sludge septic tanks from the six zones of Nashik city. Of these, only four are in working condition. Therefore, there is a need for additional vacuum suction vehicles on priority.
- There is a need to explore options for wastewater recycling and reuse for non-potable purposes, such as gardens and horticulture, construction activities, industrial processes and toilet flushing.

21.8.3 Wastewater recycling and reuse potential

- The existing sewage treatment capacity is 360.5 MLD, and the utilisation is 337 MLD (i.e. 93 %). The treated wastewater is discharged into a nalla (stream) near STPs. There is a need for recycling wastewater and reusing it for non-potable purposes as an alternative to freshwater supply.
- The thermal power plant located at Eklahare, about 16 km from the centre of Nashik city, has a capacity of 990 MW and is a potential bulk buyer of recycled water. The plant requires large quantities of water and is dependent on the Gangapur Dam as a source of freshwater supply.
- There is an opportunity to supply treated wastewater from the 42 MLD capacity STP in Chehedi to these power plants. NMC can work out the reasonable selling price of secondary treated water to at least recover the O&M cost of the STPs, which is approximately INR 79 lakhs per annum for both plants for 2020-21 (translates to INR 0.51/kl)[55]. It will help in the reuse of around 42 MLD of wastewater and diverting an equal quantity of fresh water, which was otherwise used for the thermal power plant's process water.

Other key potential demand centres for wastewater recycling and reuse are as follow:

- There are 493 gardens of various sizes in Nashik city, including the Nehru Garden developed under the AMRUT scheme[56]. These gardens span an approximate area of 298 acres[57]. The secondary treated water from STP or recycled water with further treatment can be used for watering these gardens. Thus, it will help in conserving freshwater sources.
- In the case of multi-storeyed construction and gated communities, internal dual piping for toilet flushing must be made mandatory. It must also be mandated for high-end users, such as hotels, malls and industries.
- Such building communities and groups of housing implementing dual piping must also ensure on-site treatment of wastewater to the water reuse standards of the nation or as per

national/ international best practices.

- The supply of treated wastewater to non-potable users, such as process water for textile industries, horticulture, gardens and toilet flushing at public toilet complexes, bus stands and railway stations, must be explored.
- NMC may provide incentives on the quantity of wastewater treated and reused, for which separate metering may be necessary.
- Incentives may be provided to customers (in water tariff, property tax etc.) for the recycling and reuse of treated wastewater.
- Make the Godavari river clean, and reduce flooding.
- Reduce water losses, and increase water supply coverage and system efficiency.
- Effective groundwater management must be put in place through mapping, conservation and management.
- Recycle and reuse domestic wastewater for non-potable purposes.
- Treat the entire wastewater through a combination of a centralised and decentralised wastewater management system.

21.9 APPROACH

The broad thematic focus areas are indicated here for this sector/ broad subsector:

21.9.1 Sectoral priority

The overall vision for the sector for Nashik city with action tracks are presented in Table 21-3.

Table 21-3: **Sub-sectors and priority actions for the Water sector**

Sub-sector		Strategy
River and Urban Flooding Management	Strategy UF 1	Make the Godavari river clean and pollution-free, and conserve the river.
	Strategy UF 2	Provide NBS to absorb flood, and create a buffer.
	Strategy UF 3	Set up an end-to-end Early Warning System to monitor and forecast extreme precipitation events.
	Strategy UF 4	Strengthen the weather monitoring network.
Water supply system management	Strategy-WS1	Extend the formal piped water network to improve water access/ address intermittent water service.
	Strategy-WS2	Focus on NRW management by setting up a NRW Cell and adopting technological and smart interventions.
	Strategy-WS3	Adopt various approaches to reach the target audiences, and achieve the overall communication objectives, behaviour change and awareness.
Groundwater management	Strategy-GW1	Map the aquifers within NMC areas, and implement measures for aquifer rejuvenation and management.
	Strategy-GW2	Promote rainwater harvesting.
Wastewater Management	Strategy-WW1	Achieve 85% enhanced resource efficiency by 2040.
Wastewater recycling and reuse	Strategy-WR1	Explore opportunities for wastewater recycling, and supply it to the Eklahare thermal power plant for their processes.
	Strategy-WR2	Explore opportunities for wastewater recycling and reuse for non-potable purposes.

Table 21-4: **Strategy UF-1:** Make the Godavari River clean and pollution free; conserve the river

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Reduce the pollution in the Godavari by ensuring that all the wastewater outfalls in the river are intercepted and solid waste is not disposed of in the river or its tributaries. Map the entire river stretch, carry out hydraulic modelling and simulation modelling and suggest measures to improve the existing wastewater and drainage system. **Timeframe: 2024-26**	**Lead:** NMC and Irrigation Dept. **Supporting:** District Collectorate, NGOs, Citizen groups **Financing:** Namami Goda Project, NMC budget, State, and Central Govt. schemes	**Output:** % increase in sewerage coverage, % of water quality samples adhering to norms **Outcome:** Reduction in pollution of the river, reduction in the occurrence of eutrophication of river

Table 21-5: **Strategy UF 2:** Provide Nature-based solutions to absorb flood and create a buffer

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Under Namami Goda Master Plan, identify 3-4 types of stretches of the Godavari river, -such as rural, semi-urban and urban. Accordingly, provide measures to control floods by providing NBS at varying degrees at these stretches. The blue-green solutions can be provided in the rural and semi-urban stretch, whereas the NBS can be implemented as per feasibility in the urban stretch. The intent is to collect, treat and store stormwater — catchment on roads, pedestrian walkways, bicycle paths, waterbodies, open fields, urban plazas and building features; treatment through constructed wetlands, sedimentation basins, and sponge features such as vegetated swales, rain gardens, bio-retention swales and basins; and conveyance and storage through water bodies and waterways. **Timeframe: 2024-25**	**Lead:** NMC and Irrigation Dept. **Supporting:** District collectorate, NGOs, Citizen groups **Financing:** Namami Goda Project, NMC budget, State, and central govt. schemes	**Output:** No. of stretches developed with NBS **Outcome:** Reduction in the number of flooding instances

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Key flooding hotspots have been identified as part of the Vulnerability Assessment. Probe those areas further to identify key reasons, such as topography, imperious surfaces and encroachment, and provide relevant measures to reduce flooding / water logging. Also, update the disaster management plan to incorporate the analysis and findings of the vulnerability assessment. **Timeframe: 2024-25**	**Lead:** NMC **Supporting:** Irrigation Dept., District Collectorate, NGOs, Citizen groups **Financing:** Namami Goda Project, NMC budget, State, and Central Govt. schemes	**Output:** Reduction in the number of flooding hotpots **Outcome:** Reduction in flooding impact on lives and assets
Priority action: Link blue-green infrastructure with urban planning Blue-Green Infrastructure (BGI) is an integrated planning approach with water and vegetation as a tool to meet flood resilience in cities. It is an internationally accepted approach that explores the perquisites of integrating urban green spaces and waterways in a natural manner, through strategies such as pre-zoning sponge areas and inventorying pre-existing natural features beyond the administrative needs of the city-specific development plan. In Nashik city, provision of 20% of land along the Godavari river and its tributaries with sponge features (for absorbing and utilising up to 70% rainfall) by 2030, and increase to about 80% of land by 2040. **Timeframe: 1 year**	**Lead:** NMC **Supporting:** Irrigation Dept., District Collectorate, NGOs, Citizen groups **Financing:** Namami Goda Project, NMC budget, State, and Central Govt. schemes	**Output:** No. of stretches developed as BGI projects **Outcome:** Reduction in the number of flooding instances

Table 21-6: **Strategy UF 3: Set up an end-to-end Early Warning System to monitor and forecast extreme precipitation events**

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Set up an end-to-end Early Warning System to monitor and forecast extreme precipitation events in the Godavari basin. Also, develop an institutional coordination mechanism for urban flood resilience and new rules for improved reservoir operation and systems.State-of-the-art automatic water level recorders must be installed throughout the drainage network of the watershed, which may extend beyond the administrative boundary of the NMC. For example, Surat city has developed an early warning system for flooding of the Tapi river. **Timeframe: 2024-26**	**Lead:** NMC and Irrigation Dept. **Supporting:** District Collectorate, NGOs, Citizen groups **Financing:** NMC budget, State, and Central Govt. schemes	**Output:** Implementation of early warning system **Outcome:** % of incidences reported, reduction in response time during disasters

Table 21-7: Strategy UF 4: Strengthen the weather monitoring network by installing new Automatic Weather Stations (AWS)

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: To have more granular information on rainfall and temperature, install the required number of Automatic Weather Stations (AWS) as currently there is only one IMD station within NMC limits. This will be immensely useful for much improved early warning, resulting in better response and management of urban flooding. Such rainfall data will also enable the robust designing of urban drainage infrastructure in the future. In the United Kingdom, the recommended rain gauge density for urban areas is 1 automatic rain gauge (ARG) per 4 square km. while in Malaysia, it is 1 ARG per square km. To improve the response and determine the spatial and temporal variation of rainfall in real time, a network of six weather stations with tipping bucket rain gauges has been set up in the city by the Disaster Management Cell of MCGM as per recommendations from the National Centre for Coastal Research after the deluge of 2005. These weather stations have been programmed to give rainfall intensity in real time (every 15 minutes) to the emergency control room at MCGM headquarters through the Internet. The average rain gauge density is 1 per 16 km^2 and inter-station distances range from 0.68 km to 4.56 km[58]. **Timeframe: 2024-26**	**Lead:** NMC **Supporting:** Universities/ institutions, Garden Dept., CREDAI, NGOs etc. **Finnacing:** NMC budget, Corporate Social Responsibility (CSR), institutional funding wherever there is reuse potential within institutional premises	**Output:** No. of monitoring stations installed; no. of stations operational throughout the year **Outcome:** Use of data for regular updation, analysis and decision making

Table 21-8: Strategy WS 1: Extend the formal piped water network to improve water access/ address intermittent water service

Action description	Stakeholders & Financing	Indicators
Priority action: Extend the piped network to the uncovered areas, and increase treatment capacity and network to address the demand-supply gap by 2030 and onwards. **Timeframe: 2024-26**	**Lead:** NMC **Supporting:** NGOs, citizen groups **Financing:** NMC budget, State / Central schemes	**Output:** % increase in water supply coverage, increase in treatment capacity, increase in service levels,percentage of monthly income spent on the water,no. of water supply interruptions per household per day/week/month/year **Outcome:** MLD of water saved, increase in revenue from water charges

Table 21-9: Strategy WS 2: Focus on NRW management by setting up an NRW Cell and adopting technological and smart interventions

Action description	Stakeholders & Financing	Indicators
Priority Action: NMC must set up an NRW Cell with the mandate to plan, develop, implement and monitor an action plan to obtain reliable estimates from NRW and for the reduction of NRW from the current 41% to 15%, conduct periodic water audits and undertake leakage mapping and repairs in a phased manner. **Timelines: 2024-25**	**Lead:** NMC **Supporting:** NGOs, citizen groups, private vendors **Financing:** NMC budget, State / Central schemes	**Output:** An NRW cell can be formed with the following main objectives to achieve the targeted benchmark of NRW (% reduction) and to ensure streamlined implementation: • Increase in efficiency in transmission and distribution network • Financial recovery • Periodic water audits (every 3 years) to assess progress
Priority Action: Use Information and Communication Technology (ICT) such as Internet of Things (IoT) enabled smart metering, bulk metering and consumer metering to effectively measure, monitor and control the flow; and integrate citizen grievance and feedback with the existing mobile app; and integrate the above components to the Command-and-Control Center (CCC) or through a dashboard to effectively monitor the system. **Case examples:** Pimpri Chinchwad city established a SCADA system for bulk water supply and sewerage systems in 2010. **Timelines: 2024-26**	**Lead:** NMC **Supporting:** Pvt. Operators, NGOs, citizen groups **Financing:** NMC budget, State / Central schemes	**Output:** Increase in service levels **Outcome:** Reduction in grievances, increase in revenue from water charges

Table 21-10: Strategy WS 3: Adopt various approaches to reach the target audiences, and achieve the overall communication objectives, behaviour change and awareness

Action description	Stakeholders & Financing	Indicators
Priority Action: Adopt the following approaches (strategies) to reach the target audiences, and achieve the overall communication objectives. Implement internal communication activities to address staff concerns in NMC, public participation mechanisms that serve as information-sharing to engage opinion leaders and implementation partners, a multi-media information campaign to increase knowledge on the objectives and benefits of the reform to motivate key stakeholders to adopt positive Water Supply and Sewerage Services and Water Resource Management practices. **Timelines: 2024 onwards**	**Lead:** NMC **Supporting:** NGOs, citizen groups **Financing:** NMC budget, State/ Central schemes	**Output:** No. of initiatives/ campaigns each year **Outcome:** No. of citizens covered; the estimated amount of water saved

Table 21-11: Strategy GW 1: Map and monitor the aquifers within NMC areas, and implement measures for aquifer rejuvenation and management

Action description	Stakeholders & Financing	Indicators
Priority action: Map, monitor and protect the aquifers by identifying the recharge and discharge zones and updating the Development Control Rules (DCR) to allow controlled development in recharge zones with measures for water percolation. **Timeframe: 2024-25**	**Lead:** NMC and GSDA Supporting: NGOs, Geological Dept of Nashik University, Institutions **Financing:** NMC budget, Corporate Social Responsibility (CSR), Institutional funding wherever the recharge zone is within institutional premises	Output: % of city's area mapped, % of recharge area to be protected, a protected area in Ha. Outcome: MLD of groundwater recharge
Priority action: Identify low-lying areas, lakes and flood plains, and reserve them for storing rainwater for better environmental conditions and improving groundwater recharge. **Time frame: 2024**	**Lead:** NMC **Supporting:** NGOs, GSDA, Institutes, Citizen groups, **Financing:** NMC budget, Corporate Social Responsibility (CSR)	Output: % of city's area mapped, % of the area to be protected, a protected area in Ha.
Priority action: Identify potential sites for artificial ground recharge structures, delineate them and take up pilot projects in the government / institutional premises. **Time frame: 2024**	**Lead:** NMC **Supporting:** NGOs, GSDA, Citizen groups, Institutes, **Financing:** NMC budget, Corporate Social Responsibility (CSR)	Output: no. of sites developed Outcome: quantity of groundwater recharge achieved.

Table 21-12: **Strategy GW 2:** Promoting rainwater harvesting

Action description	Stakeholders & Financing	Indicators
Priority action: Improve rainwater harvesting (RWH) infrastructure at two levels – • Identify, map and monitor existing RWH structures within the NMC area • Make RWH mandatory in institutional areas and large residential societies / bungalows. • Identify low-lying areas, lakes and flood plains, areas with high recharge potential and enough percolation capacity (i.e. sufficiently low water table depth) and reserve them for storing rainwater for better environmental conditions and improving groundwater recharge. NMC shall identify and reserve 2-5% of the development area for water bodies, either natural or constructed. **Timeframe: 2024-25**	**Lead:** NMC and GSDA **Supporting:** NGOs, Geological Dept of Nashik University, Institutions **Financing:** NMC budget, Corporate Social Responsibility (CSR), Institutional funding wherever the recharge zone is within institutional premises	Output: quantum of water consumption avoided from the organized water supply system. Outcome: A system of groundwater table monitoring wells may be developed at the ward level, to be used for assessing the efficiency of RWH measures and warnings against excessive exploitation of groundwater.

Table 21-13: **Strategy WW 1:** Achieving 85% enhanced resource efficiency by 2040

Action description	Stakeholders & Financing	Monitoring Indicators
Priority Action: Upgrading one STP at Pimpalgaon, which has a UASB reactor – moving bed biofilm reactor (MBBR) for mainstream wastewater treatment to UASB reactor - Down-flow Hanging Sponge (DHS) system for an enhanced 15% efficiency in biogas capture **Timeframe: 2024-25**	**Lead:** SWM Mechanical and Sewerage Dept, NMC **Supporting:** Maharashtra Pollution Control Board, NWMPL, RWAs, Ward-level or taluka authorities, CSOs/NGOs **Financing:** Swachh Bharat Mission – Urban City-level SWM Plan CSR Majhi Vasundhara	**Output:** Number of assets retrofitted, volume of wastewater reused **Outcome:** % of wastewater released into the water body; level of dissolved oxygen (DO), phosphorous, nitrates, nitrites, and faecal matter; level of sedimentation in freshwater and marine water bodies; percentage of households connected to the sewerage system

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Install two localised Faecal Sludge Treatment Plants (FSTPs), and upgrade to at all urban node points. **Timeframe: 2024-28**	**Lead:** SWM mechanical and Sewerage Dept, NMC **Supporting:** Maharashtra Pollution Control Board, NWMPL, RWAs, Ward-level or taluka authorities, CSOs/NGOs **Financing:** Swachh Bharat Mission – Urban City-level, SWM Plan, CSR, Majhi Vasundhara	**Output:** Number of assets retrofitted; volume of wastewater re-used **Outcome:** Level of dissolved oxygen (DO), phosphorous, nitrates, nitrites, faecal matter; level of sedimentation in water bodies
Priority Action: Implement nature-based and hybrid sewage treatment solutions, phase-wise, at outfalls of sewage zones, to include 100% of the sewage generated. **Timeframe: 2030**	**Lead:** SWM Mechanical and Sewerage Dept, NMC **Supporting:** Maharashtra Pollution Control Board, NWMPL, RWAs, Ward-level or taluka authorities, CSOs/NGOs **Financing:** Access funds under National Adaptation Fund for Climate Change, international banks including World Bank, Asian Development Bank	**Output:** Water quality standards of the marine outfalls sample **Outcome:** Level of DO, phosphorous, nitrates, nitrites, faecal matter; level of sedimentation in freshwater and marine water bodies

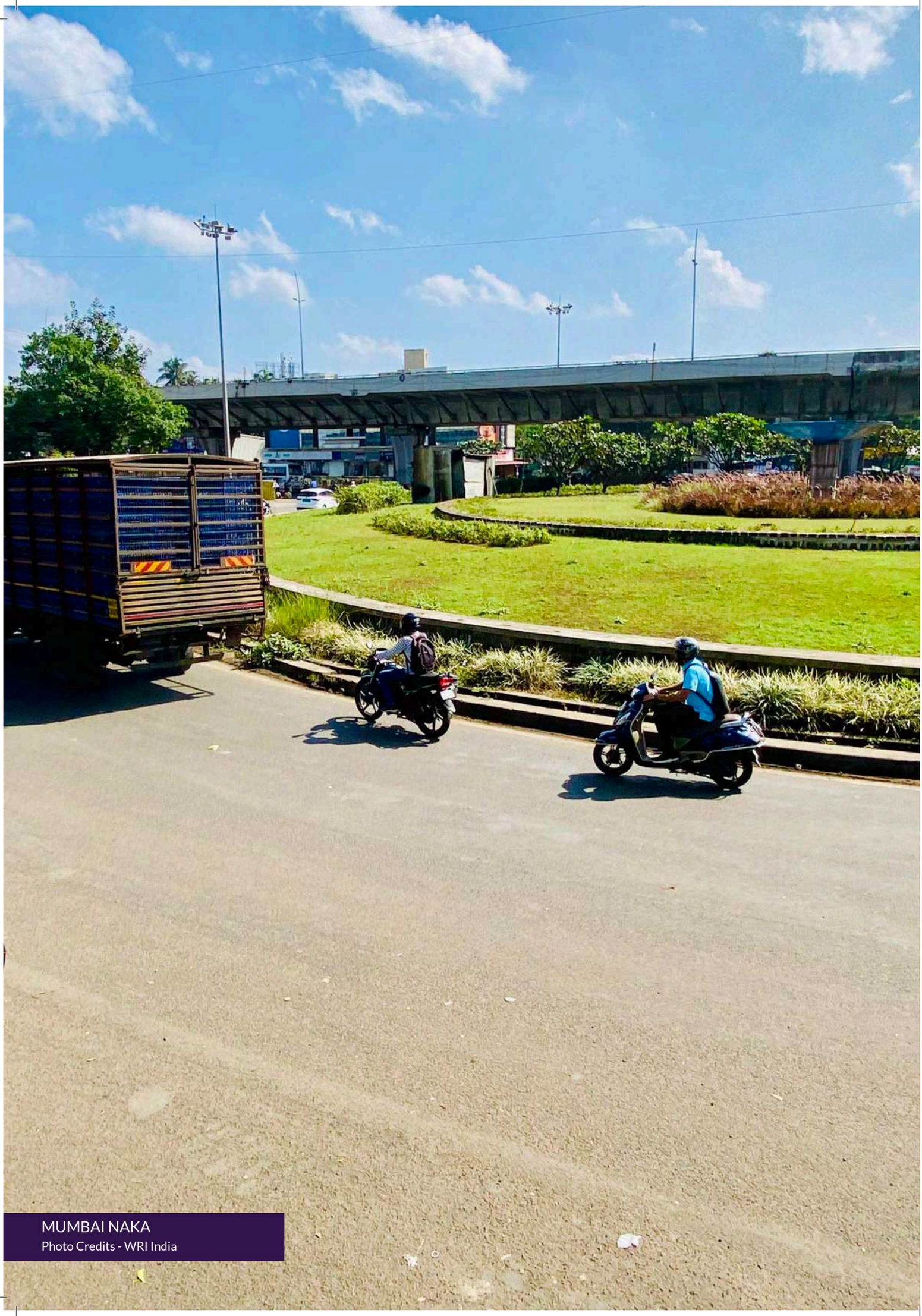
Table 21-14: **Strategy WR1: Explore opportunities for wastewater recycling, and supply it to NTPC plant at Eklahare for their processes**

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Supply treated wastewater from 2 STPs at Chehedi, of an average of 21 MLD capacity, to the NTPC thermal power plant at Eklahare to further treat it and reuse it for their processes. The NTPC thermal power plant has developed a 990-MW coal-based thermal power plant at Eklahare, about 16 km from Nashik city. The plant needs around 110 MLD of water and is dependent on the Gangapur Dam as a source of freshwater supply.	**Lead:** NMC, NTPC **Supporting:** Industries Dept. and Urban Development Dept. of the State Government of Maharashtra **Financing:** Public Private Partnership (PPP), NTPC, NMC budget, XV FC grant	**Output:** Quantity of wastewater recycled, quantity of wastewater reused, net revenue to NMC from the sale of water **Outcome:** % of potable water that was to be supplied to industries as process water saved, additional revenue to NMC

Action description	Stakeholders & Financing	Monitoring Indicators
NMC can work out a reasonable selling price of recycled/ secondary treated water to at least recover the O&M cost of the STPs, which is approximately INR 79 lakh per annum for both plants for 2020-21 (translates to INR 0.51/ kl) It will help reuse around 42 MLD of wastewater and divert an equal quantity of fresh water. **Timeframe: 2024-26**		

Table 21-15: Strategy WR2: Explore various options for domestic wastewater recycling and reuse for non-potable purposes

Action description	Stakeholders & Financing	Monitoring Indicators
Priority action: Explore various options for recycling domestic wastewater and reuse for non-potable purposes, such as gardens (119 gardens, including those developed under the AMRUT scheme and covering an approximate area of 298 acres), institutional/ industrial consumers, other non-potable users, such as process water for textile industries, horticulture and toilet flushing at public toilet complexes, bus stands and railway stations. **Timeframe: 2024-26**	**Lead:** NMC **Supporting:** Universities/ institutions, Garden Dept., CREDAI, NGOs etc. **Financing:** NMC budget, Corporate Social Responsibility (CSR), institutional funding wherever there is reuse potential within institutional premises	**Output:** Quantity of wastewater recycled, quantity of wastewater reused, net revenue to NMC from the sale of water **Outcome:** % of potable water that was to be supplied to various usages saved



MUMBAI NAKA
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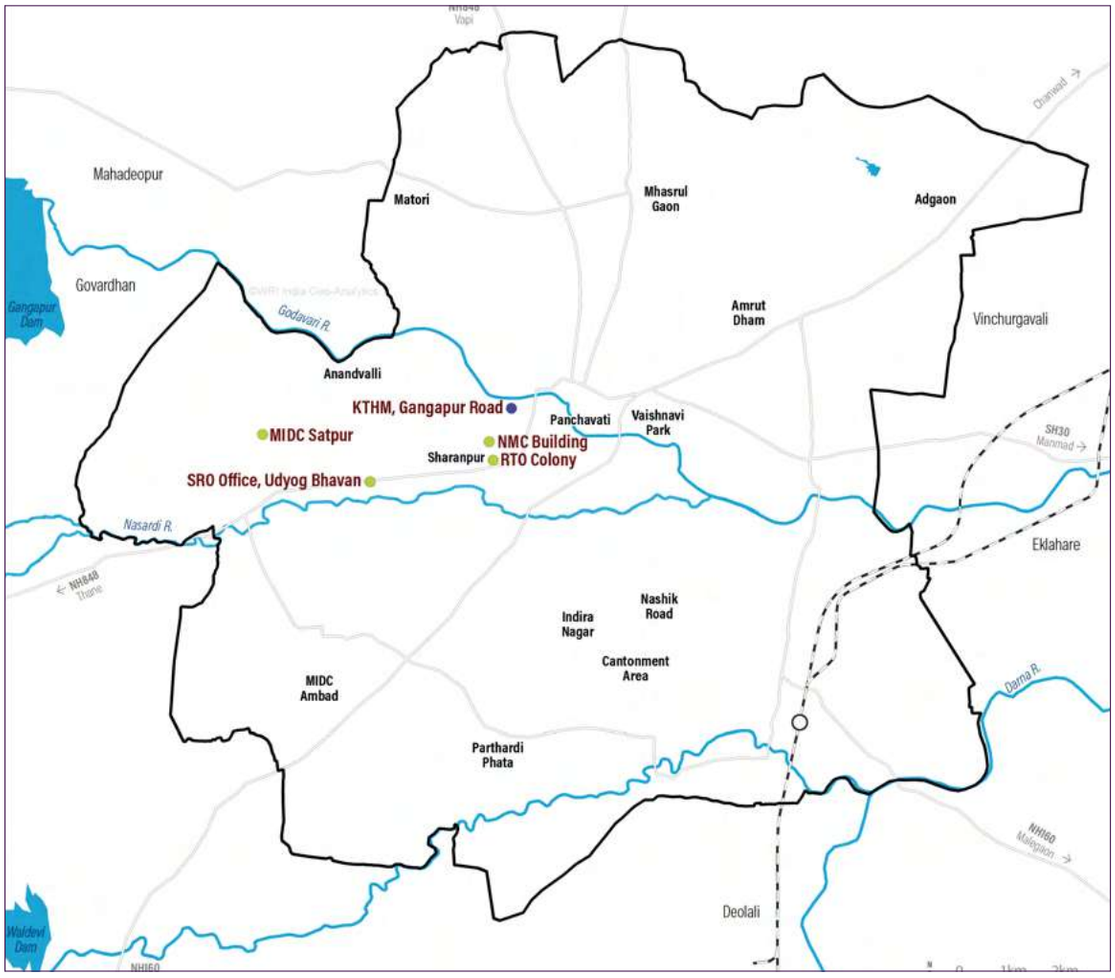
22. AIR QUALITY

22.1 SECTORAL OVERVIEW

The air quality in Nashik is assessed using data from the Continuous Air Quality Monitoring Stations (CAAQMS) and manual stations established in the city, and the spatial analysis is based on satellite imagery. The five Centre- and state-led air quality monitoring stations (AQMS) are concentrated in the centre and west of the city, as seen in Figure 22-1. Of the five AQMS, only KTHM at Gangapur Road is a continuous monitoring station, where data is collected on an hourly basis. The remaining four AQMS collect data on a bi-weekly basis. The five AQMS capture the levels of the following particles and gases; SO_2, NOx, $PM_{2.5}$, PM_{10}, CO and ozone.

Among those captured, $PM_{2.5}$ and PM_{10} cross the daily and annual permissible limits whereas NOx, CO, and tropospheric ozone cross the daily permissible limits during the winter months.

Figure 22-1: Location of Air Quality Monitoring Stations in Nashik



Source: *WRI India using CPCB, MPCB, NMC, 2022*

22.2 ONGOING INITIATIVES

Under the National Clean Air Programme (NCAP) launched in 2019, Nashik was one among the 131 cities to be accorded the status of a non-attainment city and mandated to prepare a Micro Action Plan to reduce air pollution. This plan categorises strategies across sectors, such as road and construction, vehicles, industries, waste burning, capacity building and public outreach, which will help attain the targets for ambient air quality. Many of the strategies listed in the Micro Action Plan are either in progress or yet to be initiated.

Some of the direct air quality-related actions, which are in progress, are listed below:

- Through GoI funding, two CAAQMSs have been proposed, for which funds have been released but installation has been delayed.
- MPCB has funded the setting up of an AQM Cell but it has not been formulated.
- An Emergency Response System, including Graded Response Action Plan, has been prepared by MPCB and is yet to be approved.
- Black topping of unpaved roads in a phased manner is in progress, with funds from the NMC budget.
- The procurement of four mechanical sweepers is in progress, and funds are to be obtained under a Fifteenth Finance Commission grant.
- Water fountains are to be installed at major traffic intersections through NCAP funding.
- The installation of Wind Augmentation Purifying Unit (WAYU) at 10 major traffic junctions is in progress.
- A facility for segregation and recycling of C&D waste is in process of being established, with funding from a Fifteenth Finance Commission grant.
- Three electric crematoria are planned under the Fifteenth Finance Commission grant.

In addition to the Micro Action Plan, a Source Apportionment study on the city of Nashik was conducted in 2017 by Indian Institute of Technology Bombay (IIT-B) and the National Environmental Engineering Research Institute (NEERI). As part of the study, an emissions inventory was developed to understand the sources and causes of the net play of various pollutant concentrations from different source types — point (industrial activities), line (vehicular emission) or area (domestic and commercial activities), along with a spatial representation of the pollutant concentration due to all sources.

22.3 KEY ISSUES AND CHALLENGES

Nashik was one of the 131 cities that received the non-attainment status, which meant that it did not meet the ambient air quality standards as prescribed by Central Pollution Control Board (CPCB) Although there has been an emphasis on particulate matter ($PM_{2.5}$ and PM_{10}) as a critical pollutant, other pollutants such as NOx, CO and ozone show high concentrations in Nashik. According to the Source Apportionment study, the following sources contribute to the air pollution in the city:

- Area source: Building construction and road dust (50% of PM concentration)
- Line source: Vehicular emissions (71% of NOx concentration)
- Point source: Industrial activity (89% SOx, 60% HC, 96% CO)

Nashik is reported to have over 2,000 real estate projects approved between September 2021 and September 2022[59] , and these are primarily concentrated on the outskirts of the city [60]. According to the Source Apportionment study, both C&D waste and road dust contribute to 50% of PM concentration. This rapid expansion in construction and allied activities can be attributed to the increased PM levels in the city.

The transport sector is also a major contributor to high NO_2 concentrations due to increased dependency on private motor vehicles. The use of 2W and 4W is estimated to have grown by 18% and 12%, respectively, over the past 10 years (from 2010 to 2020). This, along with limited public transport and NMT facilities, makes it essential for the transport sector to adopt air pollution mitigation strategies.

The growing industrial activity in Nashik is also a source of multiple pollutants. Industries depend on fuel sources such as bagasse, coal and wood, which contribute to high PM, SOx and CO levels.

A shift towards cleaner fuels and an in-situ switch towards advanced and sustainable technology are critical to curbing industrial pollution in the city. Additionally, the proximity to the Eklahare thermal power plant (15km from Nashik) may also be a contributor to the air pollution hotspots towards the east of the city.

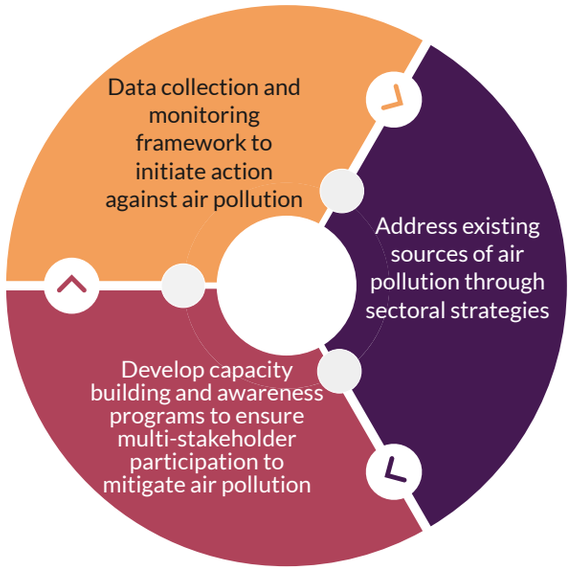
22.4 RECOMMENDATIONS

22.4.1 Approach

An assessment of air quality is data-intensive and requires both long term-temporal data as well as well-distributed spatial data. Based on the assessment of existing data, vulnerability assessment and ongoing initiatives, a three-pronged approach is adopted that comprises the strategies to address air pollution risk comprehensively.

- The first key component of the evaluation of air quality is to have a robust data collection process and monitoring system.
- Secondly, the Source Apportionment study presents the major sectors that contribute to air pollution in the city. Based on these sources of pollution, priority sectoral strategies are listed to mitigate existing air pollution risks.
- Finally, a citywide capacity building and awareness programme can be undertaken, in which multiple stakeholders take measures towards mitigating air pollution risk.

Figure 22-2: Three-pronged approach to address air pollution risk



22.4.2 Strategies and actions

Air pollution and transport are linked to each other. A list of actions related to the transport sector is already covered comprehensively in the section on transport sector strategies. A list of these strategies is given below:

- Public transport - Driving the target of 'Moving people; not cars'; strategy in the city by increasing the transit network, improving infrastructure and shifting towards e-buses and cleaner fuels
- Private transport - Towards zero carbon emissions from private transport by incentivising EV and developing associated infrastructure.
- NMT- Towards safe, healthy and complete streets for people and pedestrians by promoting walking and cycling
- IPT transport - Towards zero-carbon local IPT commute in the city by promoting a shift towards e-rickshaw
- Urban freight - Towards reduced emissions from urban freight by enhanced fuel efficiency and technology deployment

Apart from the above transport related strategies, there are other sectors that are major contributors to air pollution and are covered as follows:

Table 22-1: Strategy AP-1: Strengthen the air quality monitoring system, and create a supporting institutional mechanism

Action Description	Stakeholders & Financing	Monitoring Indicators
Install new AQ monitoring stations so as to spatially cover the entire city, including key pollution hotspots such as industrial area and traffic junctions area, to get city-wide coverage as per CPCB norms (based on population). Case: The area to the southeast, near the railway station, that is in close proximity to the Ekhlahare thermal power plant emerges as a pollution hotspot with no monitoring station in the vicinity. **Timeframe: 2024-26**	MPCB, NMC **Financing:** CPCB, MPCB, NMC under XVFC fund	**Output:** No. of AQMS installed (manual and continuous) **Outcome:** Area of city/ population being monitored that are affected by exposure to air pollutants
Install background AQ monitoring stations (outside NMC boundary) to capture the information on background ambient air quality so as to compare it with the air quality concentrations within various parts of the city. **Timeframe: 2030**	NMC, MPCB **Financing:** CPCB, MPCB, NMC under XVFC fund	**Output:** No. of AQMS installed (manual and continuous) **Outcome:** Benchmark to compare average exposure to air pollutants and set city-level benchmarks accordingly
Set up an Air Quality Monitoring Committee (AQMC) within NMC to oversee the air pollution mitigation work, including the expansion of the AQMS network, creation of an AQ monitoring portal, review and updation of emission inventory periodically, carry out further studies and implementation actions related to air pollution abatement. **Timeframe: 2026**	NMC, Environment Dept., MPCB **Financing:** Aligned to NCAP, MPCB, XV FC grant	**Output:** Functioning AQMC **Outcome:** Monitor overall AQ in the city
Conduct ward-wise / citywide health impact studies to identify the population that is exposed to air pollution risk. **Timeframe: 2026**	**Lead:** AQMC, Health Dept. **Support:** Ward Councillor/Mayor, NGO, CSO, Research Organisations, Hospitals, Nashik Health University, KTHM **Financing:** NMC budget, CSR	**Output:**Identify population vulnerable to health risks and types of recurring health issues from each ward **Outcome:** Appropriate health related interventions may be planned at ward level

Table 22-2: Strategy AP-2: Create a comprehensive capacity building and awareness programme to keep a check on air quality

Action Description	Stakeholders & Financing	Monitoring Indicators
Use ICT-based system to enhance the NMC app for grievance redressal towards burning of municipal waste, C&D dust in addition to water logging issues; set up electronic display boards at critical locations to disseminate information and enhance awareness among citizens. Case: The Flood Free Kochi app not only collects data on water logging/flooding based on crowd sourcing but also has added features such as reporting obstacles on the street, such as fallen trees, garbage dumps and potholes. **Timeframe: 2026**	Environment Dept., Nashik Smart City **Financing:** Nashik Smart City	**Output:** No. of electronic display boards installed **Outcome:** % of area/ population covered by electronic display boards based on which health precautions may be taken
Develop awareness campaigns and capacity building programmes to be conducted regularly amongst various stakeholders on air quality related information, and release health advisories as required. **Timeframe: Starting 2024, campaigns can be annual/biannual**	**Lead:** Ward councillor, Health Dept., AQMC **Support:** NMC Environment Dept, Ward councillors/Mayor, Research Organisations, Health institutions, Students, residents of low-income communities, RWA, CSOs, NGOs, Universities, artists, etc. **Financing:** NMC budget, CSR	**Output:** Total no. of outreach programmes that have been planned and undertaken in a year **Outcome:** % area/ population covered by awareness and outreach programmes

Table 22-3: Strategy AP-3: Adopt measures to reduce C&D waste and road dust to reduce their contribution to PM concentration by 50% by 2030

Action Description	Stakeholders & Financing	Monitoring Indicators
Prepare C&D waste and dust management plan as per CPCB guidelines, and set up of C&D waste processing facility (50 TPD) on PPP basis Case: Delhi Master Plan 2041 has proposed the preparation of a Dust Management Plan based on which local bodies can monitor the development site regularly. The real estate sector may refer to the Handbook of Clean Construction Practices, 2020 to manage pollution from construction activities. Pune had developed a C&D waste management facility of 250 TPD capacity on PPP mode. **Timeframe: 2026**	NMC, TPD, SWM Dept., local builders association (CREDAI local chapter) **Financing:** NMC budget- SWM Dept., XVFC fund, CSR	**Output:** Citywide plan, no. of new construction projects that have prepared dust mitigation plans **Outcome:** % reduction in PM due to reduction in C&D waste and dust
Adopt road dust control techniques such as: • Black topping of unpaved roads/ unpaved roads to be coated with high albedo material (C&D waste can be used for the same). • Adopt mechanical sweeping machines for ease of cleaning major roads. • Regularly water primary roads/roads with high traffic volume. • Install water fountains at traffic junctions to mitigate road dust. **Timeframe: 2026**	NMC Transport Dept. **Financing:** XVFC fund, NMC budget	**Output:** No. of initiatives such as black topping of roads, mechanical sweeping machines procured, watering of roads/ junctions taken up **Outcome:** % reduction in road dust

Table 22-4: Strategy AP-4: Adopt measures to reduce vehicular pollution contribution to NOx concentration by 50% by 2030

Action Description	Stakeholders & Financing	Monitoring Indicators
Revise the 2014 Comprehensive Mobility Plan (CMP) and focus on key mobility strategies, including impact of proposed neo-metro rail. **Timeframe: 2026**	Transport Dept. **Financing:** NMC budget	**Output:** Integrated mobility plan with comprehensive strategies across all modes of transport **Outcome:** Reduction in NOx concentration
Adopt the concept of congestion pricing in the core city of Nashik, with alternative arrangement in public transport (except for e-vehicles). This will reduce the vehicular congestion and parking demand during peak hours. **Timeframe: 2040**	**Lead:** Transport Dept. **Support:** Resident welfare association, market traders association, CITILINC	**Output:** Implementation of congestion pricing in the core city **Outcome:** Decongestion of core city, better planning of public transport
Identify and update the list of vehicular pollution hotspots, and provide area-specific solutions, such as junction improvement, road section redesign. Cases: CBS junction, Gangapur road junction, Mumbai Naka **Timeframe: Starting 2023; can be a continuous process**	Transport Dept. **Financing:** Nashik Smart City fund, NMC budget, CSR fund	**Output:** Identify vehicular pollution hotspots and develop street design guidelines **Outcome:** Shift from private vehicles to public transport and non-motorised transport
Monitor vehicular pollution by: • Increasing PUC centres for efficient functioning and monitoring of emissions through vehicles • Enforcing the scrapping of old vehicles • Framing a legislation for retrofitting of particulate filters in heavy duty vehicles **Timeframe: 2035**	RTO, Transport Dept. Traffic Police, Government of Maharashtra, freight operators **Financing:** State grants to RTO	**Output:** No. of PUC centres established an operational, no. of old vehicles scrapped, increase in low carbon freight **Outcome:** % reduction in PM and NOx concentration, % reduction in number of old vehicles

Table 22-5: Strategy AP-5: Strategy AP-5: Adopt measures to reduce pollution caused by industrial units by 50% by 2030

Action Description	Stakeholders & Financing	Monitoring Indicators
Ensure representation of all scale and types of industries within Nashik Industries and Manufactures Association (NIMA) **Timeframe: 2026**	LEAD: INDUSTRY OWNERS/ ASSOCIATIONS; **SUPPORT:** NMC **FINANCING:** INDUSTRY OWNERS	**OUTPUT:** ACTIVE NIMA WITH INCREASE PARTICIPATION FROM DIFFERENT INDUSTRIES **OUTCOME:** INCREASE IN ACTIVITIES AND INITIATIVES TAKEN UP BY NIMA TO REDUCE POLLUTION FROM INDUSTRIES

Develop an action plan with a mitigation strategy for the existing industrial units to reduce pollution by increasing process efficiency, and conduct third party audits to report non-compliance of industrial units based on the Gujarat model Case: The Gujarat model of making environmental auditors more independent improved the accuracy of pollution audit reports and led industrial plants in Gujarat to reduce their emissions. **Timeframe: 2026**	MPCB, NIMA, Industry owners, Research organisations **Financing:** MPCB, Industry owners	**Output:** No. of industrial units that have conducted third party audits **Outcome:** Accurate audits leading to pollution reduction from industries
Industrial units must install water spraying system on internal roads and ensure the washing of tyres **Timeframe: 2026**	NIMA, Industry owners	**Output:** No. of industrial units that have installed water spraying system on internal roads **Outcome:** Reduced road dust due to vehicles moving in and out of industrial areas
Provide guidance for brick kiln industries on the use of alternate clean fuel, such as gas or biomass, instead of coal, adopt energy efficiency improvement measures, shift to the zig-zag technology and adopt production of porous and hollow bricks that would offer both energy and raw material efficiency. **Timeframe: 2030**	MPCB, Brick kiln owners, NIMA, Research organisation	**Output:** No. of brick kilns that have adopted new techniques **Outcome:** % reduction in pollutant concentration from brick kilns

Table 22-6: **Strategy AP-6: Shift to cleaner fuels in domestic, industrial and commercial activities**

Action Description	Stakeholders & Financing	Monitoring Indicators
Inventorisation of fuel consumption patterns in industries, slum, non-slum areas hotels, dhabas and bakeries. Incentivise and enforce the phasing out of fossil fuel dependency, and shift towards cleaner fuels, such as LPG, PNG, and electricity. **Timeframe: 2030**	NIMA, Supply agencies,	**Output:** No. of industrial units, HH (slum & non slum), hotels, dhabas, bakeries that have shifted to cleaner fuels, such as LPG, PNG, RE; no. of units using LPG or PNG as primary source of fuel. **Outcome:** Reduced pollution from industries, hotels, dhabas, bakeries, % increase of LPG uptake in all HHs, especially low income, vulnerable communities
Adopt green cremation techniques, such as open pyre type crematoria (CSIR-NEERI case study), electric and/or PNG crematoria, and use APC equipment for existing crematoria **Timeframe: 2026**	NMC, SWM Dept. **Financing:** 15th finance commission fund	**Output:** No. of crematoria having shifted towards greener techniques **Outcome:** % change measured in pollutants concentration in areas around crematoria

23. INCLUSIVITY & CO-BENEFITS IN CLIMATE ACTION PLANNING

23.1 ENSURING INCLUSIVITY AND EQUITY IN THE CAP PROCESS

Achieving the goals of the Paris Agreement requires a collective, sustained long-term effort and more inclusive climate action. The process of formulating the Climate Action Plan (CAP) for Nashik is in line with the Mumbai Climate Action Plan and C40 Cities' Climate Action Planning Framework. However, besides formulating the GHG inventory for cities and setting targeted actions for 2050, the inclusivity and equity considerations in Nashik CAP were made by adopting the inclusive planning guidance of C40 Cities and WRI.

The roadmap to inclusive CAP aligns with the city's existing needs to address climate action in the form of stakeholders' consultations and workshops for capacity building as well as to validate the actions and net zero targets by 2050. Under the needs assessment and through an extensive Vulnerability Assessment, communities and areas that are prone to higher risk have been identified. Interactions with NGOs, civil society groups and ground truthing were carried out to understand the challenges in the adoption of climate-sensitive strategies.

Inclusive Climate Action Planning (ICAP) facilitates local governments to access climate-related risks and identify actions that are consistent with the country's climate goals. Inclusivity can be achieved by engaging relevant stakeholders in the policy-making process.

Inclusivity can be thought of in terms of processes, policies and impacts. In terms of process, primary consultations were held with the NGOs, civil society stakeholders, government and parastatal agencies and those working in the environment space on various initiatives such as greening, transport, water, etc.

In terms of policy considerations, relevant documents under NCAP, city's Source Apportionment study, Development Plan, etc were referred. Nashik CAP aligns with national programmes and polices, such as the NCAP, Swachh Bharat Mission and CSCAF, through the five sectoral actions targets identified within them. Moreover, the actions and pilot projects are aligned with the municipal budget, Fifteenth Finance Commission and NCAP budget. The participation by Nashik city in Majhi Vasundhara Abhiyan (MVA) ensures that local bodies take up environment-related actions, incorporating the five elements i.e. Earth, air, water, energy and enhancement. The impact analysis considers an assessment of risks by identifying the hotspots attributed to LST, flooding or waterlogging and air pollution and overlaying them with the most vulnerable population in the city. The impacts of climate change, especially extreme weather events, are felt disproportionately by the poor and the marginalised. The assessment of impacts is done from a multihazard lens. In the case of

Nashik, we look at heat hotspots, flooding and water logging hotspots and traffic congestion hotspots. The resultant 8.91% of Nashik's population is vulnerable to both above-average LST as well as flooding, a majority of which resides in the central part of the city. Risk assessment has taken into account the city's historic trends and current situation, based on available scientific evidence from 2005 till date. Basis the historical trend, the major climatic risks are that of heat risk, rainfall variability, flooding/water logging and ground water depletion.

Inclusive CAP can advance the development outcomes in cities in domains related to the environment, health and wellbeing, education and skills, economic prosperity, essential public services, civil society and governance and institutions. These aspects are mainly referred to in terms of action tracks. For instance, health and wellbeing is addressed through increased monitoring and evaluation of air pollution monitoring stations in the city. Education and skillset development are to be addressed through actions in the waste sector, which also employs women staff for waste segregation and management activities. Similarly, the usage of unclean fuels for domestic is tracked through indoor air quality analysis. The river Godavari is as an important physical, socio-economic and religious feature of Nashik and it contributes to the city. Actions on development along the river are presented keeping in mind the role it plays for the city's growth. With respect to economic prosperity in the city, with increased share and access to public transport and NMT infrastructure. the overall expenditure towards transport will increase, leading to an increased share of women participating in the workforce.

CAP requires input from a diverse network of groups with an interest in or influence on climate action. An inclusive, collaborative process for climate action planning is as important as the CAP itself as it builds widespread community and political support, fosters credibility and strengthens the resulting plan.

23.2 CO-BENEFITS IN CLIMATE ACTION PLANNING

The Fifth Assessment Report of the IPCC defines co-benefits as being "the positive effects that a policy or measure aimed at one objective might have on other objectives thereby increasing the total benefits for society or the environment. Co-benefits are often subject to uncertainty and depend on local circumstances and implementation practices, among other factors. Co-benefits are also referred to as ancillary benefits" [61]

Climate action planning have added co-benefits in addition to climate risk mitigation and adaptation outcomes. It has wider social, economic and public health related co-benefits that impact the people and environment.

Mitigation

Co-benefits of climate change mitigation are the benefits related to mitigation measures which reduce GHG emissions or enhance carbon sinks.

Climate change mitigation policies can lead to lower emissions of co-emitted air pollutants. For instance by shifting away from fossil fuel

combustion the reduction of methane can bring benefits in terms of limiting global temperature increase as well as improving air quality which in turn benefit the health and economic well-being of the people.

Adaptation

There are some synergies or co-benefits between adaptation and mitigation, one of which is the inclusive benefits of public transport system. It has implications both in terms of reduction of GHG emissions as well as increase resilience in case of disasters. Reduced air pollution from transport improves health. It also improves resilience in terms of accessibility to the public transport network and opportunities for employability as a social and economic benefit. Active lifestyles and increased exposure to urban green spaces provides both physical and psychological benefits.

The social, economic and health related co-benefits are outlined below:

Social- Some actions emphasise on equity and inclusivity with a focus on vulnerable areas and communities. This has been addressed through prioritisation of action in hazard prone areas, strengthening information dissemination and increased awareness campaigns. Focus on vulnerable groups such as women, children, elderly and urban poor is also ensued.

Economic- Employment through green jobs, financial incentives to switch to sustainable practices, savings on public expenditure such as lowered travel cost with public transport or switching to cleaner appliances, and opportunities for vulnerable groups such as women are some of the economical benefits through climate action planning.

Public health- The overall mental and physical health and well-being is addressed through increased access to green spaces and protected biodiversity, cleaner air and safety of citizens with reduced exposure to climate risks amongst other measures

Figure 23-1: Illustration of the co-benefits under increase in green spaces

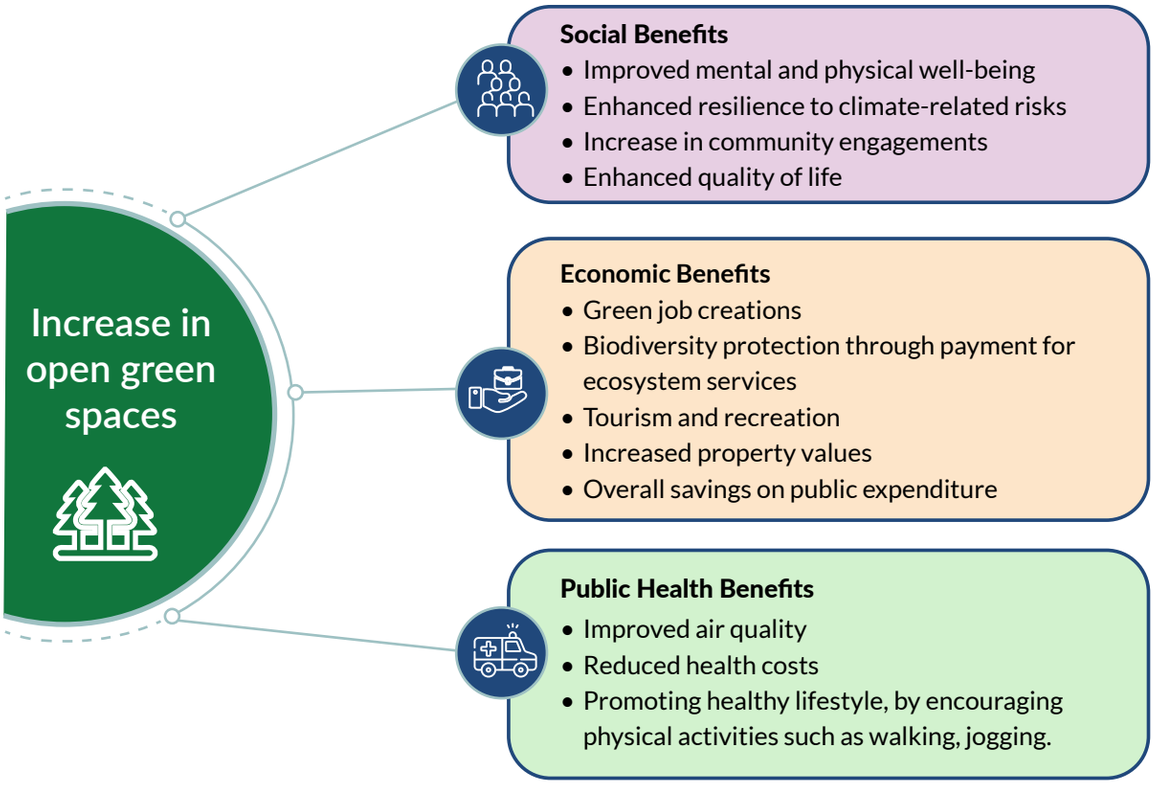
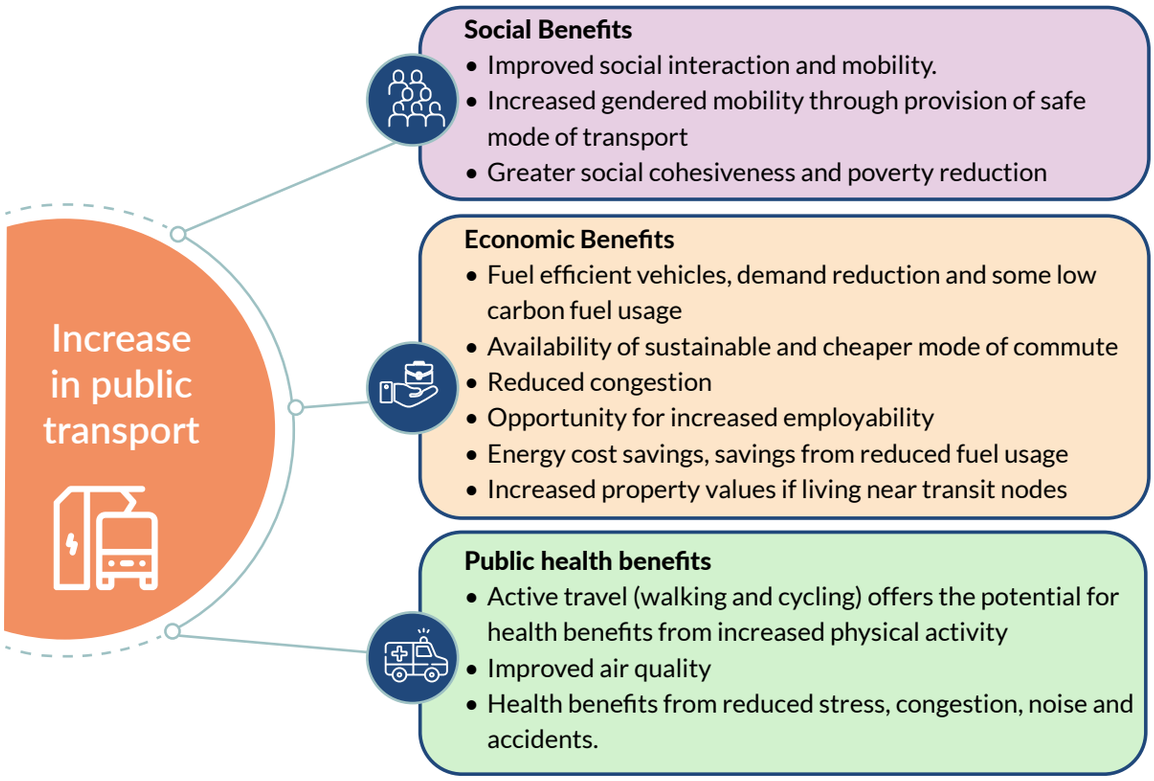


Figure 23-2: Illustration of the co-benefits under increase in public transport mode share



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24. GOVERNANCE & INSTITUTIONAL STRUCTURES

24.1 ORGANISATIONAL STRUCTURE

24.1.1 Organisational structure of Nashik Municipal Corporation

Nashik Municipal Corporation was established in May 1864. The governing structure of NMC consists of political (elected) and administrative wings. The political wing is an elected body of councillors headed by the City Mayor. The Municipal Commissioner heads the administrative wing and is responsible for strategic decisions, operational planning, and management of the Corporation.

24.1.2 Agencies that support Nashik city administration

Nashik city is primarily administered by NMC which is responsible for basic infrastructure and service provision. Additonally, there are parastatal agencies that come outside the purview of NMC and provide services, technical data and support to the city, as required. Table 24.1 presents a list of the agencies and sectors/services that they support.

Table 24-1: Various agencies that support Nashik city administration

Organisation	Sector/Role	Nashik CAP Sector
Nashik Municipal Corporation (NMC)	City administration managing - water supply, sanitation, solid waste management, roads and bridges, development plan, streetlights, etc.	Air Quality, Buildings & Energy, Greening & Biodiversity, Transport, Solid Waste Management, Water, Urban Heat
Nashik Municipal Smart City Development Corporation Limited (NMSDCL)	Projects under Smart City Mission – area-based development and pan city initiatives	Air Quality, Buildings & Energy, Greening & Biodiversity, Transport, Solid Waste Management, Water, Urban Heat
Regional Transport Office (RTO)	Vehicle registration	Transport
Oil companies	Sale of petrol, diesel and CNG	Buildings & Energy
Maharashtra State Electricity Distribution Company Limited (MSEDCL)	Electricity distribution and supply	Buildings & Energy
Maharashtra State Power Generation Company (MAHAGENCO)	Electricity generation	Buildings & Energy
Groundwater Survey & Development Agency (GSDA)	District ground water management	Water
Traffic police	Traffic management	Transport
Indian Meteorological Department (IMD)	Rainfall and temperature data	Air Quality, Urban Heat
Maharashtra Pollution Control Board (MPCB)	Control and regulation - Air, Water and land pollution	Solid Waste Management, Air Quality

Source: WRI India Analysis

24.1.3 NMC - Institutional barriers

- NMC oversees the provision of infrastructure and services such as water supply, sanitation, storm water drainage, solid waste management, public transportation, open spaces and public health. Environmental concerns in policy, strategy and plans are managed across multiple departments, with no concentrated or holistic effort institutionally towards the larger impact on climate.
- Currently, the Environment Department is focussed on projects under the NCAP and XVFC funds, which may be multi-sectoral. The department in its current functioning has limited expertise to advise cross-sectoral projects across departments on environmental and climate change aspects due to a lack of institutional and financial capacity.
- The Environment Department currently does not have adequate budget allocation for administrative and project related works, and its institutional capacity also needs to be built to oversee various functions related to environment management within NMC area.
- There is a need for a separate department to take ownership for interdepartmental/ interagency coordination for the implementation of strategies and actions, data collection, validation and monitoring of Nashik CAP.

24.1.4 Proposals – institutional arrangement - environment and climate change

Currently, the Environment Department is headed by the Deputy Municipal Commissioner Environment who is the nodal coordinating agency for the Nashik CAP. In line with the changes made by the Government of Maharashtra, at the state level, the newly named Department of Environment and Climate Change addresses the issues pertaining to environment as well as accelerates climate action in the state. Similarly, the Department of Environment at NMC is proposed to be expanded, strengthened and renamed as the Department of Environment and Climate Change (ECC).

The overall institutional structure for the ECC Department at NMC is as follows:

As the Department of ECC provides advisory support for all environment related projects as well as projects pertaining to gardens and river Godavari, it is important to create a climate action cell that will facilitate and support the implementation of the Nashik CAP. This Environment and Climate Action Cell (ECAC) would play a critical role in data management and research, coordination with other interdepartmental and parastatal agencies and providing support in the projects and programmes pertaining to the environment, as well as in the monitoring of outcomes and outputs of the Nashik CAP. The ECAC will be divided into three verticals, as shown in Figure 24-2. The ECAC has three verticals based on function:

- Advisory role in projects and programmes: Advisory role on environmental aspects during implementation of various national, subnational and externally funded projects / programmes, advice on climate-related budget, schemes and grants.
- Research, data and Monitoring Evaluation & Reporting (MER): Collect and analyse data related to climate change, monitor, reporting and implementation of CAP etc. implementation of CAP etc.
- Biodiversity committee: Conserve and protect the biodiversity of the city and restore biodiversity that is in derelict condition.

Figure 24-1: Changes proposed in the Environment Department, NMC

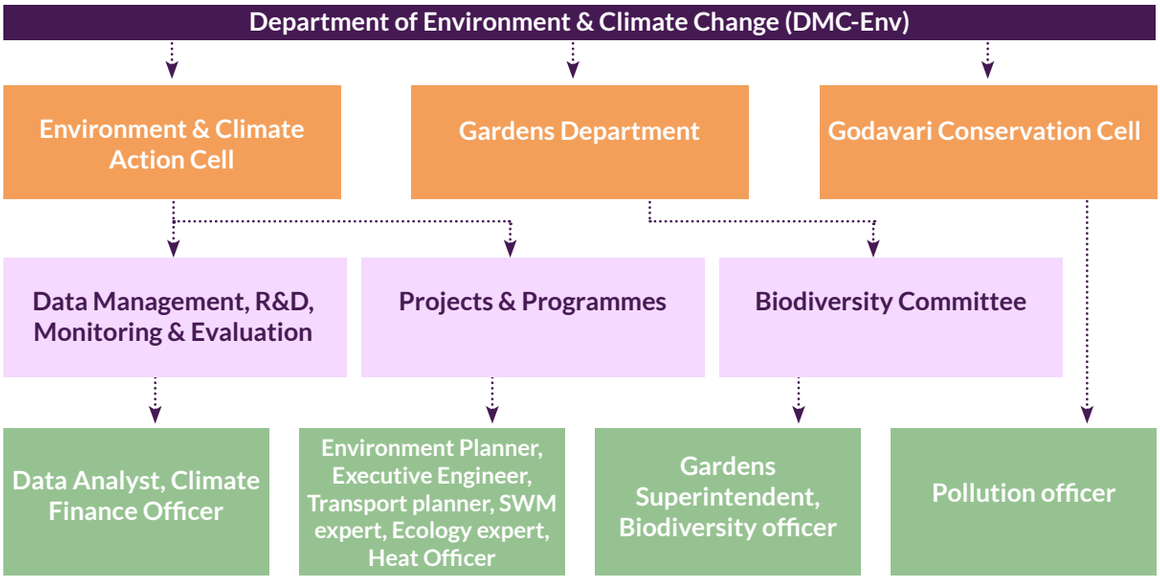


Table 24-2: Roles of new verticals in Department of Environment & Climate Change

Data Management, R&D, Monitoring and Evaluation	Projects & Programs	Biodiversity cell
Create data repository	Prepare plans and policies ensuring climate resilience for existing and new projects	Prepare People's Biodiversity Register (PBR) in consultation with citizen groups
Develop guidelines for projects aligned with climate goals	Integrate existing and new projects with on-going programs such as SBM, AMRUT, NCAP, MVA	Eco-restoration of the local biodiversity
Update GHG inventory and VA every 3 years and update Nashik CAP every 5 years	Inter-departmental coordination to mainstream climate action for all projects	Conserve and protect biodiversity in the city
Monitor outputs and outcomes of Nashik CAP	Build technical and institutional capacity to execute projects	Biodiversity Education and Awareness building.
Report progress of the Nashik CAP every year	Create committees/cells such as Air Quality Committee, EV cell for the implementation of these projects/programs	

Source: WRI India Analysis

25. FINANCING ARRANGEMENTS

25.1 NMC – SECTOR-WISE BUDGET ALLOCATION

The NMC budget has two major heads - revenue and capital. The share of revenue income in the overall income ranges from 62% in the financial Year 2020-21 i.e. FY21 to 99% in FY23. Thus, the revenue expenditure and capital works are largely funded through the revenue income of NMC.

25.1.1 Revenue and capital accounts

1. Revenue account

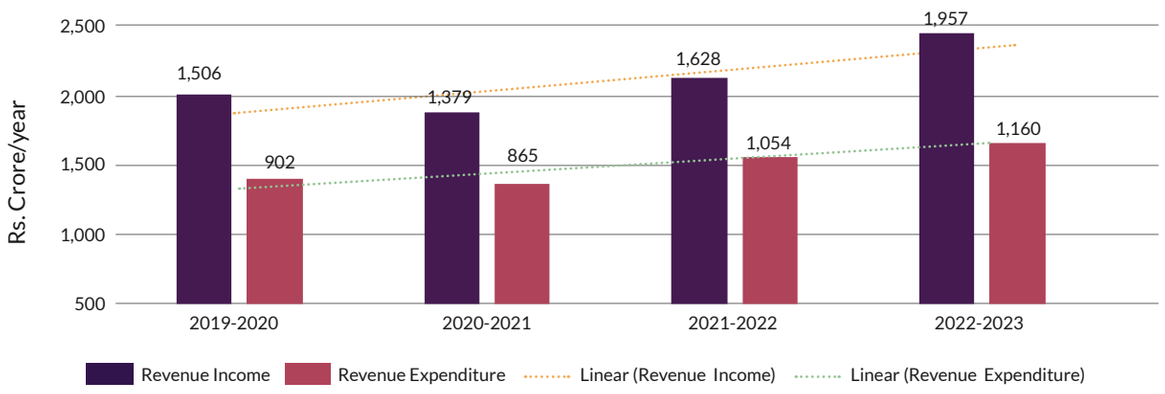
The trend of revenue income and expenditure during FY20-FY23 is shown in Figure 25-1.

During this period, the revenue income grew at a compounded annual growth rate (CAGR) of 9.1% whereas the revenue expenditure is growing at a slightly lower CAGR of 8.8%. The account is revenue surplus during all these years.

2. Capital account

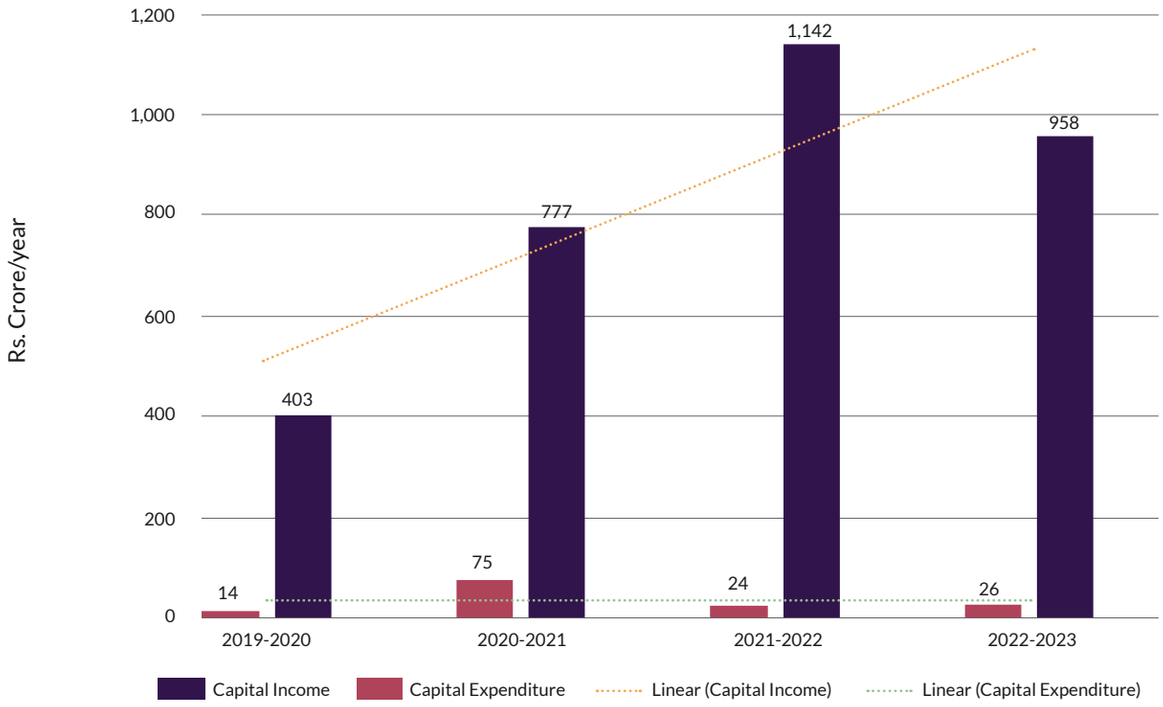
During FY20-FY23, the capital expenditure grew at a CAGR of 33.4% whereas during FY21-FY23, it grew at a CAGR of 11%. In both cases, this growth is more than the revenue income growth. It highlights that NMC needs to plan for improving its income and, at the same time, manage the capital expenditure in a judicious manner. It should also leverage its balance sheet so that it can fund more capital works based on existing income streams.

Figure 25-1: NMC: Revenue income and expenditure growth trends



Source: *WRI India Analysis*

Figure 25-2: NMC: Capital income and expenditure growth trends

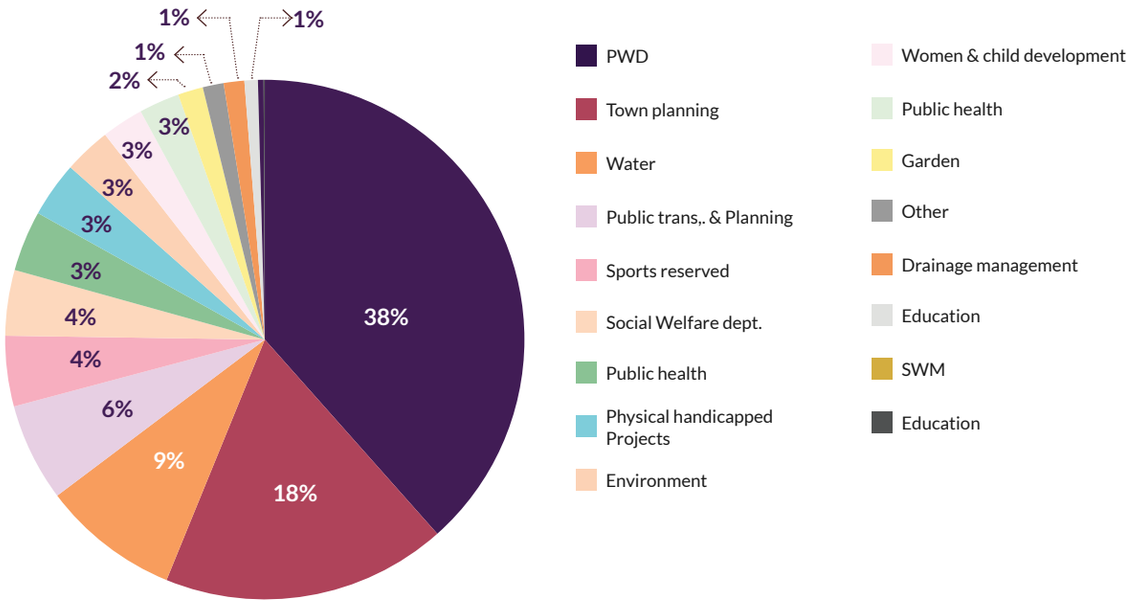


Source: WRI India Analysis

25.1.2 Department-wise revenue and capital expenditure

The department/sector-wise capital expenditure assessment was done for FY23 in Figure 25-3:

Figure 25-3: Department/ Sector wise Capital expenditure for FY23



Source: WRI India Analysis

The key observations are as follow:

- The total estimated capital expenditure for FY23 is INR 958.13 crore.
- The major share is that of Public Works Dept (PWD) i.e. 38%, and within that Road has a 57% share.
- Town Planning Dept has an 18% share, which is for the acquisition of land.
- Capital Works for Water and Wastewater constitute 9% and 6% share, respectively, followed by Public Transport and Planning at 4%.
- Around INR 39 crore (~4%) is spent on sports, including provision for new grounds, stadiums, gyms, jogging tracks etc.
- Around INR 25 crore (~ 3%) is allocated for Environment and INR 12.5 crore (~ 1%) for Garden.

25.2 FINANCING AND INSTITUTIONAL ARRANGEMENT

Currently, the NMC implements the capital project through the revenue surplus and scheme grants and manages and maintains the assets through revenue expenditure. The major capital works are taken up through the revenue income as capital income is less.

INR 37.5 crore is allocated for environment and gardens, and portions of other funds such as INR 39 crores allocated for new grounds, stadiums, gyms, jogging tracks etc. can be used for urban greening.

In 2020-21, the XVFC funds allocated INR 82 crore to Nashik, of which INR 41 crore is to be spent on air quality and the remaining INR 41 crore on solid waste management and sanitation. It is expected that NMC will receive around INR 82 crore per annum between 2021 and 2025 i.e. a total of INR 410 crore in a period of five years. This is an important source of funding that is linked to areas related to climate action and focussing on waste management and air pollution.

Furthermore, there is a need for reclassification, reallocation and fresh allocation of the budget for climate actions, both for adaption and mitigation.

A few case examples are given below:

- In 2022-23, the budget allocated for the Road Department is INR 209 crores. There is a scope to look at some of the priority actions proposed under CAP, such as traffic hotspot mitigation, junction improvement and provision of rainwater recharge structures along the major roads. These actions can be adopted in road development works, and some of the budget from Road Dept can be reallocated to these initiatives.
- Similarly, funding for waste management is available under Swacch Bharat Mission and the XVFC fund. So, there is scope for convergence and prioritisation of the funds allocated for mainstreaming climate actions.
- Thus, there is a need to relook at the budget of NMC and identify areas of convergence, reclassification and prioritisation. Based on this, a dedicated climate budget can prepared so that the city can take climate actions on priority.

In terms of project structures and business model, NMC can explore various ways of developing and implementing projects.

25.3 NEED FOR CLIMATE BUDGET

Given the need for reclassification, reallocation and fresh allocation of a part of the budget for climate actions, a climate budget is essential for Nashik to ensure that there are dedicated financial resources available to implement the CAP. It is also important to leverage such a budget as a governance tool to overcome the institutional barriers identified in the city's existing governance structure.

Although the budget will be anchored within NMC and activities that are directly under NMC's control will be prioritised, the ECAC and climate budget will ensure that the department within NMC or parastatal agencies assumes the responsibility to implement climate actions that lie within their control in order to ensure better coordinated outcomes. Through this engagement, the city will prepare a climate budget for FY 2022-23 with sector-specific emission ceilings, in alignment with the plan. The status of climate efforts and achievements will be tracked on a quarterly basis and reported annually. As part of the budget process, climate measures will be proposed, implemented, monitored and reported regularly as per the Monitoring, Evaluation and Reporting (MER) process laid out in Chapter 26.

25.4 PILOT PROJECTS

While developing the draft of Nashik CAP, a list of pilot projects have been identified and discussed with NMC. The objective of taking up pilot projects is to demonstrate to NMC the process of implementation of the climate action strategies identified under the CAP. A list of such pilots is given in Table 25-1. WRI India will provide technical support to NMC on a few pilot projects from this list.

Table 25-1: Pilot projects identified under Nashik CAP

Project	Brief description
Godavari River Management	Mainstream climate actions by providing inputs to the Godavari River DPR covering the following aspects: • Sharing analysis on flooding/ water logging hotspots • Natural ways of flood management – suggest areas where flood water can be diverted to the nearby open spaces, and to areas where there is potential for groundwater recharge • Suggest nature-nased solutions (NBS) at certain feasible stretches - NBS for the management of buffer zone and flooding (linking NBS with Godavari DPR) • Multi-hazard risk areas: a list of these areas and suggested actions for these areas can be provided as inputs to the Godavari River DPR for the adaptation component

Project	Brief description
Support in EV Adoption - EV transition & channelise EV component of XVFC	• Support in identifying projects/ components under XVFC funds • Support in document review / sharing case studies on the adoption of EVs in Indian cities » For e.g., sharing the experience of e–bus procurement in Pune and other cities, the business model adopted etc. » For e.g., EV auto rikshaw subsidy model of Pune, where PMC provides a subsidy of INR 22,000 / e-auto • Support in analysing potential areas of public charging infrastructure and business models for the same • Support in setting up and operationalising an EV Cell similar to Mumbai and Pune
Ground Water – RWH, Recharge structures within gardens and other places	• Utilise the insights gathered from the Vulnerability Assessment (VA), identify groundwater recharge potential areas • Identify 5-6 large gardens with good groundwater availability • Develop a recharge structure as per the GSDA norms - recharge shaft, borewell, dug-well recharge etc. • RWH in municipal buildings, schools and hospitals etc.
Urban heat hotspot mitigation	• Select one heat hotspot area, such as Panchvati, MIDC Ambad, MIDC Satpur • Carry out activity mapping • Work further on the analysis done under CAP • Implement interventions such as greening, groundwater management, energy conservation, waste management and cool roofs in informal settlements. • Monitor with CAAQMS and environmental sensors (by Smart City) • Support in carrying out a pre-feasibility study to preserve Amrutvan biodiversity zone to increase the carbon sequestration potential
Traffic hotspot mitigation	• Select traffic hotspot areas as identified under NCAP, such as Peth road, market yard signal, Panchavati • Carry out mobility mapping and work further on the analysis to be done as per CAP • Implement interventions such as traffic junction/area improvement, stormwater management, greening and EV charging • Monitor and track pollution levels with monitoring stations/ environmental sensors

Rooftop solar on NMC buildings and utilities	• Map the existing adoption of solar roof-top in government buildings in Nashik • Identify business models to adopt solar rooftops • Install rooftop solar on » Municipal buildings - NMC buildings, schools, hospitals, bus stops, NMC parking lots » Integrated SWM facility, WTP, STPs
Mainstreaming climate actions in Nashik DP	• Utilise the insights gathered from the Vulnerability Assessment (VA), integrate these findings into the city's Development Plan • Specifically, incorporate the accessibility analysis to inform planning strategies for the establishment of gardens, playgrounds, fire stations and mobility infrastructure such as bus stops • Flooding/waterlogging and heat hotspots – • Provide greening spaces, buffer zones etc. • Waterlogging hotspots – provision in DP for stilt construction, more open areas for water passage and percolation, mandatory use of paver blocks and other filter media etc. • Groundwater recharge potential – preserve some of the areas around water bodies and greener areas to allow water percolation
Mapping of blue-green corridors (suggested during consultations)	• Map all the gardens, green spaces, open spaces along with the nallas, river and water bodies • Based on the above mapping, identify if there are any existing blue-green corridors • Identify gaps in the existing corridors or propose new corridors connecting missing links
Climate Change Department	• Restructuring of Environment Department into Environment and Climate Change Department

Source: WRI India Analysis

26. TRACKING PROGRESS

It is important to have a continuous Monitoring, Evaluation and Reporting (MER) structure in place to track the progress of the implementation of Nashik CAP. MER allows for actions to be tracked, evaluated and reported in an organised manner to promote accountability in implementation and make improvements based on the learnings. Monitoring is essential for tracking the progress of actions through continuous and systematic data collection. Evaluation is important for assessing the impact of actions, while reporting enable transparency and data-driven accountability amongst various stakeholders.

26.1 MONITORING

The Environment and Climate Action Cell (ECAC) within the Environment and Climate Change Department would play a critical role in data management and research, coordinate with other interdepartmental and parastatal agencies and support the projects and programmes that pertain to the environment, as well as monitor the outcomes and outputs of the Nashik CAP.

- A Monitoring, Evaluation and Reporting (MER) cell in ECCC is to be formed.
- There has to be an update of the GHG inventory and the climate risk assessment every three years.
- Once in five years, it will monitor the progress of Nashik CAP against the targets set in the plan, report on a list of key performance indicators, communicate progress against indicators, and develop a system to reflect on learnings against the key objectives and principles of the Nashik CAP.

26.1.1 Key performance indicators

To track progress, key performance indicators (KPIs) have been identified across various sectors, which relate to the outcome indicators for each of the six priority action areas.

1. Water management

Table 26-1: Water Management - Key Performance Indicators for key strategies/ priority actions

SN	Key strategies/ priority actions	Key Performance Indicators
1	Flood management	• No. of incidences of flooding, population affected • No. of flood hotspots mitigated • Improvements in flood-prone areas especially in low-income settlements
2	Groundwater management	• No. of rainwater harvesting, groundwater recharge structures and the estimated quantity of water conserve
3	Access to water supply	• Improvement in access to water supply
4	Wastewater recycling and energy generation	• Quantity of wastewater recycled and reused for non-potable purposes • Gas captured at the STPs

2. Sustainable mobility

Table 26-2: Sustainable Mobility- Key Performance Indicators for key strategies/ priority actions

SN	Key strategies/ priority actions	Key Performance Indicators
1	Public transport	• % change in mode share • Increase in no. of buses per lakh population • Increase in public transport trips per capita per annum (disaggregated by gender and income level), • % increase in share of CNG or electric buses in the fleet • % of population within 500m-walk of public transportation option (e.g., bus, neo metro)
2	e- mobility	• No. of charging stations at public places set up and managed by government and private sector • No. of vehicles taken benefits of subsidy for e-mobility under state and central schemes/ programs
3	Non-motorised transport	• % change in mode share • Km of walking and cycling infrastructure
4	Cleaner fuels	• % of CNG or electric vehicles in the city, decreasing total annual fuel consumption from transport
5	Sustainable freight	• % of low-carbon road freight • Percentage of monthly income spent on transportation / delivery costs

3. Municipal solid waste management

Table 26-3: Municipal Solid Waste Management- Key Performance Indicators for key strategies/ priority actions

SN	Key strategies/ priority actions	Key Performance Indicators
1	Decentralised waste management	• % of total waste treated at ward or zone level • Compost generated in TPD, biogas generated in kg / day • % increase in no. of HHs with decentralised system • Waste recycled through MRF facilities
2	Source segregation	• % of segregated at source
3	Scientific disposal	• % of legacy waste processed • Gas capture
4	Livelihood	• No. of green jobs created, • No. of woman employees / workers

4. Air quality

Table 26-4: Air Quality- Key Performance Indicators for key strategies/ priority actions

SN	Key strategies/ priority actions	Key Performance Indicators
1	Air quality improvement	• Daily concentrations of gaseous pollutants, and $PM_{2.5}$ and PM10 • No. of good air quality days
2	$PM_{2.5}$ and PM_{10} targets	• $PM_{2.5}$ and PM_{10} targets achieved as per the NCAP

5. Building & Energy

Table 26-5: Building & Energy - Sector wise Key

SN	Key strategies/ priority actions	Key Performance Indicators
1	Renewable Energy generation and use at NMC buildings and utilities	• Increase in Renewable Energy (in % and MW) at NMC buildings and utilities
2	Adoption of cleaner fuels in residential, commercial, and industrial users	• Transition of HHs or users from coal/ fossil fuel to LPG/ PNG/ biogas • Transition of HHs or users from LPG/ PNG to electric / solar • Transition of HHs or users from low- income or vulnerable sections of the society from coal/ fossil fuel to LPG/ PNG/ solar/ biogas
3	Green Buildings	• No. of ECBC compliant buildings
4	Renewable Energy share in energy mix at state level	• Increase in share of Renewable Energy (in %) in energy mix at state level • Increase in localised energy generation (solar, wind etc.) via Renewable Energy (in % or MW) sources

6. Air quality

Table 26-6: Greening and open spaces- Key Performance Indicators for key strategies/ priority actions

SN	Key strategies/ priority actions	Key Performance Indicators
1	Green cover and open spaces	• Increase in per capita green cover and open spaces • Increase in accessibility to green cover and open spaces
2	Urban Heat	• No. of heat hotspots identified and mitigated • Change in LST across wards, slums etc.

26.2 DATA MANAGEMENT

During the process of developing the Nashik Climate Action Plan, various data gaps came to light, which challenged the extent of correctness and representation of several recent sectoral challenges. Socio-economic data and demographic differences at ward level were extracted from Census of India 2011, knowing that conditions would have changed over the past decade. Sector-specific data was accessed from government reports. For example, travel behaviour and modal splits data was referenced from the Comprehensive Traffic and Transportation Plan for Nashik prepared in 2017, as modal splits data for the base year 2021 onwards was not available.

Monitored data used for the risk assessment – air temperature, air pollution, and rainfall variability – was irregular or available intermittently for some stations, restricting the correctness of models and the ability to estimate the projected risks that can influence accurate climate resilient infrastructure projects. In the case of air pollution, sentinel data was not able to give accurate location of the source of pollution, nor the threshold of

concentrations due to variation in units used to calculate it, leaving the city to depend on data from CAAQMS, which should capture all data related to pollutants and be reliable. If holisitic and reliable data is made available, NMC can integrate monitored data into planning and decision making. The C40 Cities climate data management framework (C40 Knowledge Hub, 2019) can be a starting point to evaluate the data maturity of the city and effectively monitor progress.

26.3 EVALUATION

A comprehensive evaluation of the status of current actions within the CAP will be conducted once in five years. The proposed evaluation and reporting template are presented in Table 26-7.

The evaluation process would be conducted by the Research, Data and MER cell in the newly formed 'Department of Environment and Climate Change. This cell would be supported by the Head of Departments, Chief Engineer, Garden Superintendent, Executive Engineers of internal departments of the NMC, project managers under Smart city, and officers from various parastatal agencies such as GSDA, MSEDCL, and IMD.

The evaluation process will adopt a participatory approach, engaging external stakeholders and vulnerable communities affected by it, including civil society organizations (CSOs), NGOs, and research agencies. This collaborative effort aims to enhance the effectiveness of the Nashik CAP in improving the lives of vulnerable communities and promoting inclusivity. Through this process, the city will evaluate the inclusiveness of actions and the fair distribution of impacts. The outcomes of the evaluation will be openly published and shared with various stakeholders, ensuring transparency and enabling participatory review. Additionally, these evaluation results, coupled with the updated climate risk assessment and GHG inventory, can be utilised to revise the baselines, targets, and trajectories outlined in the CAP, facilitating accelerated action.

Strategy SM-1: Increase the mode share of public transport (bus and future neo metro) from 12% to 25% by 2035 and shift to cleaner fuels in public transportation.

Priority Action: Increase bus fleet from 250 to 1,100 by 2031 and increase accessibility to bus stops from 74% to 100% by 2035.

26.4 REPORTING

The Research, Data and MER cell under the newly formed ECAC would be responsible for monitoring

Table 26-7: Sample of goal-wise evaluation of goals and targets

Output indicator	Target (year)	Current progress (year)	Source
No. of buses operational	1,100 (2031)	250 (2022)	Data from CITILINC
Increased accessibility to bus stops from 74% to 100% as a result of increase in the number of bus stops in areas with low accessibility	100% (2035)	74% (2022)	Data from CITILINC and Road Department of NMC

the progress of the CAP. The ECAC, will ensure that GHG inventory as well as the climate risk assessment is updated every three years to understand the city- and sector-wide impacts of CAP implementation.

Every year, the Research, Data and MER Cell will prepare the Nashik CAP progress report, evaluating three levels of indicators – 1) at an aggregate city level, 2) as per KPIs and 3) as per outcome indicators listed across every action in the sectoral action plans.

The list of indicators proposed for aggregate city-level progress assessment are presented below. These can be revised and updated as per the Department's decisions. Additionally the Research, Data and MER cell will also prepare an updated CAP every five years to ensure the city meets its intended target for 2050.

Table 26-8: Proposed indicators for aggregate city-level progress assessment.

Sr No.	Indicator
1.	Total GHG emissions reduced – aggregate reduction across all sectoral actions mentioned in the CAP, resulting in emission reduction
2.	Total lives saved in vulnerable communities – estimated lives saved in risk-prone areas where adaptation actions are implemented
3.	Improved access to amenities, utilities, and services across all the communities in the city
4.	Overall community health improved – qualitative assessment of improved health in vulnerable/exposed communities
5.	Total green jobs created – aggregated green jobs created across all actions in the Nashik CAP

**This is an indicative list to help the Department in drafting a detailed MER framework that builds on the outcome indicators and KPIs and helps communicate climate action impacts to a wide range of city stakeholders*

Table 26-9: Sustainable Mobility- illustrative table of Key Performance Indicators for key strategies/ priority actions

SN	Key strategies/ priority actions	Key Performance Indicators
1	Public transport	• % change in mode share • Increase in no. of buses per lakh population • Increase in public transport trips per capita per annum (disaggregated by gender and income level), • % increase in share of CNG or electric buses in the fleet • % of population within 500m-walk of public transportation option (e.g., bus, neo metro)
2	e- mobility	• No. of charging stations at public places set up and managed by government and private sector • No. of vehicles taken benefits of subsidy for e-mobility under state and central schemes/ programs
3	Non-motorised transport	• % change in mode share • Km of walking and cycling infrastructure
4	Cleaner fuels	• % of CNG or electric vehicles in the city, decreasing total annual fuel consumption from transport
5	Sustainable freight	• % of low-carbon road freight • Percentage of monthly income spent on transportation / delivery costs

GODAGHAT
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27. CONCLUSION

Climate-resilient development policies and plans need to aim to keep global warming below 1.5 as well as adapt to current and future impacts of climate change while also considering how countries can continue to improve wellbeing and ensure equity around the world. The decision-making process is very critical, for once we have hit 1.5°C, some impacts of climate change will become irreversible, particularly in some sensitive ecosystems. This considerably limits the options for adaptation and human development.

Technical solutions alone cannot solve the challenge of climate change. Instead, it requires integrated efforts on the part of the entire society as well as world. The Indian state of Maharashtra is committed to achieving net zero by 2050, with Mumbai leading the way towards achieving a reduction of GHG targets through the strategies and actions within Mumbai Climate Action Plan (MCAP). The Nashik CAP serves as a roadmap of NMC's commitment to combat climate change and to increase the climate resilience of the city.

Nashik CAP aligns with the policies and plans developed at the national, state, regional and city levels. The CSCAF, NCAP, Development Plan 2017, etc. have provided a strong base for planning the current and future strategies related to climate action in the city. Moreover, the institutional structures and financing mechanisms in Nashik's CAP are aligned to work towards policy reforms and regulatory amendments to mainstream climate actions with NMC's planning ethos.

Climate-resilient development emerges from explicitly bringing together actions to adapt to climate change, with actions to reduce GHG emissions, in order to advance sustainable development. The consultative processes conducted for identifying climate and environmental risks, presenting the findings from the GHG Inventory and the sectoral actions and strategies included participation from leadership within NMC and various departments, external stakeholders, parastatal agencies and sectoral experts. However, the most important stakeholders are the residents of the city and their willingness to act at a personal, household or community level to help achieve the city's net zero targets, thus promoting sustainable development.

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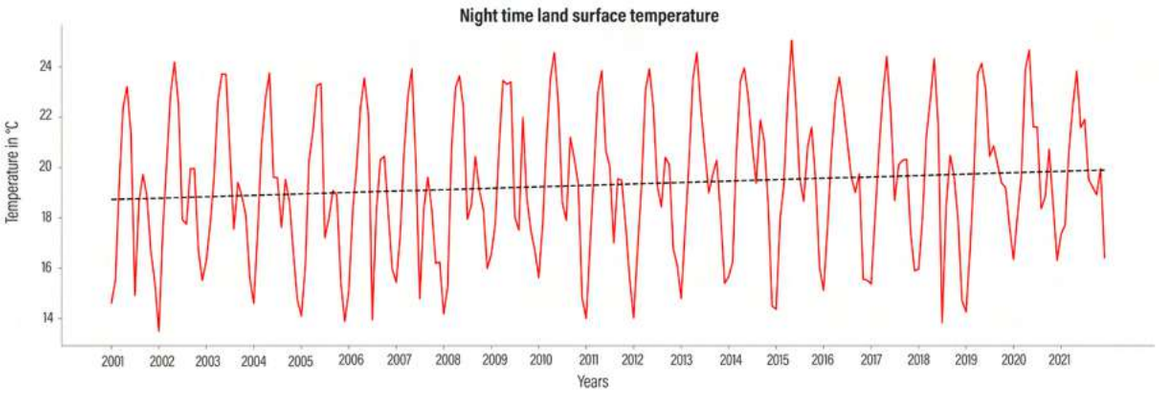
1. Annexure 1: VA Process Methodology

Annexure 1-1: Urban Heat Risk- Assessment parameters and attributes

Parameter	Methodology	Data Source
Annual air temperature trend analysis and deviations	Annual air temperature trend, change-point detection, Annual air temperature anomalies	NCEI, 2006-2021
Extreme heat events	Heatwaves and Heat index classification	NCEI, 2006-2022* (up to July*)
Land surface temperature	Night-time temperature trends from LST Average land surface temperature, seasonal variations, LST hotspots, area under vegetation, types of landuse.	MODIS LST Product, 2001-2021 Landsat 8, 2019-2021; Census 2011

Source: *WRI India analysis*

Annexure 1-2: Monthly mean night-time land surface temperature trend between 2001 & 2021



Source: *WRI India analysis; MODIS Night time LST Product, 2001-2022*

Annexure 1-3: Air pollution – key parameters

Parameter	Vulnerability	Methodology	Data Source
Concentration of gases	Positive relation	Time-series showing the annual mean	CPCB, MPCB
Concentration of physical pollutants	Positive relation	Time-series showing the annual mean	CPCB, MPCB
Percentage of sector-wise contribution of various sources		Base year of study 2017	Source Apportionment study
Indoor air pollution	Positive relation	Bar chart showing PM2.5 concentrat -ions in the kitchen and living area for most common cooking fuels	Census 2011

Source: *WRI India analysis*

Annexure 1-4: Rainfall Variability- Assessment Parameters and Attributes

Parameter	Vulnerability	Method Used	Data Source
Long-term Rainfall trend	Positive Relation	50-year time series to measure the annual mean precipitation	Indian Meteorological Department
Extreme Rainfall Events	Positive Relation	50-year time series to measure the frequency, intensity, & duration of Extreme Rainfall Events (ERE)	Indian Meteorological Department

Source: WRI India analysis

Annexure 1-5: Duration of Extreme Rainfall Events between 1970 and 2020, Nashik Observatory

Category/Duration	1 Day	2 Days	3 Days	4 Days	5 Days
Rather Heavy (35.6-64.4 mm)	160	12	1	1	0
Heavy (64.5- 124.4 mm)	55	6	1	0	0
Very Heavy & Extremely Heavy (>124.5 mm)	10	1	0	0	0

Source: WRI India using meteorological data from IMD

Annexure 1-6: Drought Risk-Assessment Parameters and Attributes

Parameter	Vulnerability	Method Used	Data Source
Probability of Drought	Positive Relation	70-year (1951 – 2020) time series to measure the probability of meteorological drought	Indian Meteorological Department
Water Stress	Positive Relation	Global data layer clipped to sub-basin boundary and symbolised using the same classes as used in the original global dataset	WRI AQUEDUCT
Stage of Groundwater Development	Positive Relation	The stage of groundwater development was obtained from various reports published in the past decade	Central Ground Water Board
Groundwater Recharge Potential	Negative Relation	Weighted average of average annual rainfall, slope of the topography and NDVI is used as an indicator of GWRP	Indian Meteorological Department, Shuttle Radar Topography Mission, Landsat 7

Source: WRI India analysis

Annexure 1-7: Evolution of Stage of Groundwater Development in Nashik District

Year	2009	2013	2020
Administrative Unit	**Stage of Groundwater Development**		
Baglan Satana	65.79	82.09	83.63
Chandwad	89.17	91.09	81.55
Deola	95.51	98.8	94.98
Dindori	43.13	55.68	58.96
Igatpuri	9.73	19.32	24.91
Kalwan	62.76	67.9	63.63
Malegaon	59.8	65.44	61.52
Nandgaon	45.66	54.85	58.75
Nashik	38.8	59.65	43.74
Niphad	83.96	99.98	97.39
Peth	3.6	4.83	5.22
Sinnar	98.72	98.75	99.93
Surgana	7.12	11.24	12.23
Trimbakeshwar	8.03	9.34	11.26
Yevla	66.38	76.36	79.02
District Total	49.33	59.68	58.45

Source: CGWB report, 2019

Annexure 1-8: Indicators based on demographic context

Indicator	Description	
Literacy	Definition	Literacy indicator includes overall effective1 literates, effective female literates, and access to educational institutes, such as schools, for preliminary education.
	Rationale for Selection	Literacy is important for raising awareness regarding climatic hazards, and building resilience and capacities for preparedness for response activities during a disaster event. Higher levels of literacy (with the assumption that ease of access to schools offer an opportunity for the improved status of enrolments) lead to improved adaptive capacities by enhancing the opportunity to access stable jobs, thereby increasing socio-economic stability and reducing vulnerability to climatic hazards. Disaster responsiveness, knowledge of saving mechanisms, etc. are observed to be better in educated individuals and families.
Gender Profile	Definition	Gender profile is understood using the indicator of sex ratio.
	Rationale for Selection	Disproportionate impact on women and girls with increased care-giving tasks after the disaster and unequal access to resources and services play a crucial role for women in disaster response.

Indicator	Description	
Social Composition	Definition	The percentage of Scheduled Castes (SC) and Scheduled Tribes (ST) population is estimated to understand the extent of social vulnerability based on caste.
	Rationale for Selection	Caste also serves as an equity indicator to identify underserviced neighbourhoods. SC and ST populations potentially have higher exposure, higher sensitivity and lower adaptive capacity.

[1]*According to Census definition of 'Effective' literacy, only population above 6 years of age is considered for this analysis. Chapter 6, "State of Literacy", Pg 99, Provisional Population Totals, Paper 1 of 2011 India Series.*

Annexure 1-9: Demographic Context — Assessment parameters and attributes

Indicator	Parameter	Methods Used	Data Source
Literacy	Effective Literacy Rate	(Total literate population above 6 years of age /Total population above 6 years of age) *100	Ward-level: Census 2011 - Primary Census Abstract
	Effective Female Literacy Rate	(Total female literate population above 6 years of age /Total female population above 6 years of age) *100	
	Access to Schools	Population coverage computed within 10-minute walking distance using service area polygons around school locations	National Informatics Centre (NIC) 2018, Census 2011, Education Department S MC 2019
Gender Profile	Sex Ratio	(Total female population)/ (Total male population) *1000	Ward-level: Census 2011 - Primary Census Abstract
Social Composition	Percentage of Scheduled Caste (SC) and Scheduled Tribe (ST) population	(Total SC population + Total ST population) / (Total Population) *100	Ward-level: Census 2011 - Primary Census Abstract

Annexure 1-10: Indicators relative to socio-economic aspects

Indicator	Description	
Access to Information	Definition	This indicator is measured as a function of ownership of a phone (landline, mobile or both), computer with Internet, television and/or radio/transistor. Access to these assets indicates access to related information/ news/ broadcasting, significantly reducing vulnerability.
	Vulnerability to Climate- Induced Hazards	Ownership of information and telecommunication devices offers the opportunity to access regular live news updates, broadcast warning alerts, evacuation instructions as well as preparedness information in the event of a disaster. Information access enables awareness and better adaptive capacity, reducing vulnerability to disasters and slow onset events. Communication with a higher percentage of the population before and during such events can help authorities and communities be better prepared, efficiently manage evacuation plans, and effectively carry out rescue operations.

Indicator	Description	
House Ownership	Definition	Home ownership is understood based on Census data that indicates households that own the house they live in.
	Vulnerability to Climate- Induced Hazards	Home ownership increases one's willingness to invest in improvements to increase safety (against increasing climate risks like heat and extreme rainfall events) and resilience of property and associated assets. In case of other associated losses like job loss, income loss due to health impacts, and asset losses (like vehicles or electronics), having a safe living space to come back to is critical to retain a sense of social security and decreased vulnerability.

Annexure 1-11: Access to Information — Assessment parameters and attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Households owning Radio/Transistor	Negative	Percentage of households having each of the specified assets	Ward level: Census 2011 – HH 14 table - Availability of Assets
Households Owning Computers with Internet			
Households Owning TV			
Households Owning Landline, Mobile and Both			

Annexure 1-12: House Ownership — Assessment parameters and attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
House Ownership	Negative	Percentage of households having ownership of the property they reside in	Ward Level: Census 2011 HH14 table– Ownership Status

Annexure 1-13: Indicators reflective of Physical Environment Aspects

Physical Environment Aspects		
House Condition	Definition	Roof is the prime built envelope of the house with the highest area being exposed. House condition has been assumed here as a function of the roofing material used for its construction. Based on Census categories, households with roofing material that can be termed as 'temporary' with limited constructional durability are considered as vulnerable.
	Vulnerability to Climate Induced Hazards	Houses with temporary roofing materials are potentially at greater risk during extreme weather conditions, such as heavy rainfall, flooding, or extreme heat, due to their limited constructional durability.

Physical Environment Aspects		
Access to public recreational spaces	Definition	Recreational spaces include parks, gardens, playgrounds, and maidans affiliated with the government, freely accessible by the public, and non-ticketed.
	Vulnerability to Climate Induced Hazards	Open spaces provide much needed space for play, active health, and mental relief.
		These spaces act as drainage areas during heavy rainfall events, reducing the risk of urban flooding. Green areas also play a pivotal role in reducing effects of urban heat. During disasters, these areas can also provide spaces for evacuation, rescue, and recovery.
		Populations with limited access to public recreational spaces are at greater risk and more vulnerable. During slow onset events such as extreme summers, properly shaded open spaces offer weaker and more exposed section of the society including those living in slums, with necessary respite from extreme indoor heat stress.

Annexure 1-14: House Condition — Assessment parameters and attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Households with Temporary Roofing Material	Positive	Percentage of households having temporary roofing material- includes Grass/ Thatch/ Bamboo/ Wood/Mud etc., Plastic/ Polythene, Stone/ Slate, and Galvanized Iron /Metal/ Asbestos sheets. etc.	Ward Level: Census 2011 HH14 table – Material of Roof

Annexure 1-15: House Condition — Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Heat Risk*	Positive	Area with > 32°C LST overlaid to ward areas	Ward Level: Census 2011 HH14 table –Material of Roof
Urban Flood Risk**	Positive	100 m buffer zone overlaid on wards with highest share of 'temporary' roof households	Census 2011, Nashik Municipal Corporation

**Urban heat risk is assumed for areas with LST >32°C. This has been calculated by taking mode of average annual temperature from cloud free thermal band images from Landsat 8 within 2019 -2021*
***Using a buffer of 100m from the flood hotspots.*

Annexure 1-16: Access to Public Recreational Spaces — Assessment parameters and attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Access to Public Recreational Spaces	Negative	Proximity is used to evaluate access to these public recreational spaces. It includes include publicly accessible and non-ticketed parks, gardens, institutional playgrounds, and maidans. Ped-shed of 10 minutes walkable distance was considered for parks, institutional playgrounds or maidans.	Existing Land Use (2021) from Nashik Municipal Corporation, World Settlement Footprint 2019, Census 2011

Annexure 1-17: Access to Public Recreational Spaces — Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Heat Risk*	Positive	Area with >32°C LST overlaid to gridded population density with limited access to public recreational spaces (unserviced population)	Landsat 8, Nashik Municipal Corporation, World Settlement Footprint 2019, Census 2011
Urban Flood Risk**	Positive	A 100 m buffer zone overlaid to gridded population density, having access to public recreational spaces	Landsat 8, Nashik Municipal Corporation, World Settlement Footprint 2019, Census 2011

**Urban heat risk is assumed for areas with LST >32°C. This has been calculated by taking mode of average annual temperature from cloud free thermal band images from Landsat 8 within 2019 -2021*
***Using a buffer of 100m from the flood hotspots.*

Annexure 1-18: Indicators relative to Infrastructure and Service Aspect

Indicator	Description	
Access to Drinking Water	Definition	Access to drinking water is calculated as a function of the source of drinking water and its proximity. It is shown by illustrating wards that lack access to drinking water sources within premises and treated drinking water facilities.
	Vulnerability to Climate Induced Hazards	Sources are considered as a proxy for the quality of water and the proximity of that source, whether near or away from premises, are vulnerable to climate risks, such as flooding, water logging, pollution etc.
		During or after a disaster, households dependent on alternate water sources (which do not have a drinking water source within their premises), such as tankers or community taps, are vulnerable since physical access via roads may be impacted.
		On extreme heat-like situations, households with limited access to piped water are vulnerable to health impacts. During water stress in the city, these households do not receive tanker water or other sources, or procurement is very expensive, thereby restricting access to many.
		Lack of ease of access to reliable and potable water is important for public health as contaminated drinking water might cause health hazards and vulnerabilities increase during climate-induced disasters.

Indicator	Description	
Access to Sanitation	Definition	Access to sanitation infrastructure is evaluated as a function of the proximity of latrine availability, sewage, wastewater disposal methods, and access to public toilets (with respect to slums). It is represented by illustrating wards that lack access to latrine availability within premises, treated sewage disposal, wastewater disposal methods, and serviceable/ unserviceable slum area of public toilets.
	Vulnerability to Climate Induced Hazards	Households without latrines located inside premises are dependent on public toilets, exposing them to health risks and ease-of-use issues, especially for women, children, and special needs population. These challenges increase manifold during extreme events when physical access is hindered.
		Unsanitary methods of sewage and wastewater disposal can pose serious health hazards, pollute surface and groundwater, escalate air pollution, and deteriorate living conditions during climate induced hazards, such as flooding.
		Usually, informal settlements are congested, with a higher population living in small built areas. They mostly belong to economically weaker sections and, at times, cannot afford to have latrines within their premises. Hence, public toilets function as sanitation facilities for them. However, during extreme events, such as that of flood or heat, physical access to such services gets restricted, making them more vulnerable.
Access to Clean Cooking Fuel	Definition	Access to clean cooking fuel is defined by the use of non-polluting fuels, which includes LPG/PNG, electricity, and biogas. It is represented by illustrating wards that lack access to these non-polluting fuels.
	Vulnerability to Climate-Induced Hazards	Several low-income households continue to rely on firewood, kerosene, and other fuel for cooking purposes. The use of such polluting cooking fuels increases harmful exposure and worsens indoor living conditions.
		Current trends of deteriorating air quality along with indoor air pollution increase health risks, making the population more vulnerable. Those living in smaller homes with kitchens not separated from living quarters are most at risk.
		Households dependent on wood for cooking either have to travel far or depend on the limited local natural resources available. Thus, those responsible for collecting fuelwood are more exposed to outdoor climate events.
Access to electricity grid	Definition	Access to clean cooking fuel is defined by the use of non-polluting fuels, which includes LPG/PNG, electricity, and biogas. It is represented by illustrating wards that lack access to these non-polluting fuels.
	Vulnerability to Climate-Induced Hazards	Lack of access to electricity, which is the main source of lighting, increases the risks of illegal connections. It cannot ensure stability and, therefore, the ability to resume connectivity after disasters once the grid is restored. It decreases the adaptive capacity of households.
Access to public transit	Definition	Access to public transit (in this case, bus stops) is measured by evaluating pedestrian access to them within 5 minutes.
	Vulnerability to Climate-Induced Hazards	Access to public transit (in this case, bus stops) enables access to jobs and resources, which can help improve household incomes. Women and children also have access to these networks, allowing them to opt for better jobs and education opportunities, thereby increasing adaptive capacity and reduction in vulnerability.
		During flood events, waterlogged streets hinder physical access to bus stops, disrupting regular access to mobility networks, opportunities, and basic amenities and impacting livelihoods.
		Population dependent on bus stops to access jobs and for personal needs are deeply impacted due to loss of working hours, reduced productivity, loss of income, and inability to access basic needs or health and emergency services.
		Vulnerability of poor households and end users further escalates during such events.

Indicator	Description	
Access to emergency health care facility	Definition	All public and private hospitals with emergency in-patient facilities are considered. Access is defined as vehicular access within 8-10 minutes response time from a hospital.
	Vulnerability to Climate-Induced Hazards	Having access to urban health facilities remains a basic essential service. Access to medical care is important for improving living standards and becomes even more critical during disaster events. Better access improves adaptive capacity by enabling timely medical assistance.
		Vulnerability of the population with limited access increases further during heat waves, flooding, or landslides, which may lead to higher mortalities or long-term health risks.
Access to emergency fire Services	Definition	Access to emergency fire services is defined as the response time (5-7 minutes response time) taken by emergency personnel to reach the incident location.
	Vulnerability to Climate Induced Hazards	Prompt emergency services with adequate coverage across the city increases adaptive capacity and ensures timely emergency response to vulnerable areas.
		Residents of high-density, informal settlements are most at risk during fire emergencies (since the risk of spread is highest due to high densities) and for rescue operations during a flood or other disasters.
Access to Relief Shelters	Definition	Proximity and easy pedestrian access to relief shelters is necessary during flood events for timely evacuation. 10 minutes walkable distance has been identified as optimal for a person to access a relief shelter, especially during heavy rains and flooding events.
	Vulnerability to Climate-Induced Hazards	In flood-prone cities such as Nashik, access to relief shelters is crucial to ensure safety of lives, effective evacuation, and emergency response services. Better access to them increases adaptive capacity, enabling effective response measures.
		Unserviced populations who live away from flood shelters or those whose usual access gets compromised are more vulnerable during flood events due to restricted road access. People living in temporary structures, such as in dense informal settlements, are more vulnerable as there is a danger of the structure collapsing, giving lesser time to evacuate.

Annexure 1-19: Access to Drinking Water – Assessment Parameters and Attributes - Lack of Access to Drinking Water

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Lack of access to treated drinking water	Positive	Percentage of households without access to treated drinking water- – including households with drinking water sources from untreated tap water, covered wells, uncovered wells, handpump, tube well/ borewell, springs, river/canal, tanks/ponds/ lakes and other sources	Ward Level: Census 2011 – Main source of drinking water and location of drinking water source[1]
Limited ease of access to drinking water		Percentage of households without drinking water inside premises- including households with latrines near and away from premises	

Annexure 1-20: Access to Drinking Water – Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Heat Risk*	Positive	Area with > 32°C LST overlaid to ward areas	Landsat 8, Nashik Municipal Corporation, Census 2011
Urban Flood Risk**	Positive	100 m buffer zone overlaid to ward areas	Census 2011, Nashik Municipal Corporation

**Urban heat risk is assumed for areas with LST >32°C. This has been calculated by taking mode of average annual temperature from cloud free thermal band images from Landsat 8 within 2019 -2021*
***Using a buffer of 100m from the flood hotspots.*

Annexure 1-21: Access to Clean Cooking Fuel – Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Lack of access to clean cooking fuel	Positive	Percentage of households without access to clean cooking fuel- includes households using firewood, crop residue, cow dung cake, coal/lignite/ charcoal, kerosene, others as their fuel for cooking.	Ward Level: Census 2011 – Type of fuel used for Cooking

Annexure 1-22 :Access to Sanitation – Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Limited ease of access to latrine	Positive	Percentage of households without latrine inside premises	Ward Level: Census 2011 – Number of households having latrine outside premises, Flush/pour latrine, Pit latrine, Night soil disposed into open drain, Service latrine[1]
Lack of access to treated sewage disposal methods		Percentage of households without access to treated sewage disposal methods- including households with Flush/pour flush latrines connected to systems other than septic and piped water sewer system, pit latrine without slab/ open pit, service latrine with night soil disposed into open drain, service latrine with night soil removed by humans and service latrine with night soil serviced by animals.	
Lack of access to treated waste-water disposal methods		Percentage of households without access to treated wastewater disposal methods — outlets connected to open drainage or no drainage	

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Access to Public toilets (with respect to slums)	Negative	Slum area coverage within 5 minutes walking service area polygons around public toilet locations	Nashik Municipal Corporation
Vulnerability to Climate Induced Hazard			
Urban Flood Risk*	Positive	100 m buffer zone overlaid to ward areas	Census 2011, Nashik Municipal Corporation

**Using a buffer of 100m from the flood hotspots.*

Annexure 1-23 :Access to Electricity Grid – Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Lack of Access to Electricity Grid	Positive	Percentage of households without access to electricity as main source of lighting — includes households using kerosene, other oil, any other as their main source of lighting and households with no lighting	Ward Level: Census 2011 – Main Source of Lighting

Annexure 1-24: Access to Public Transit (Access to Bus Stops) – Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Access to Bus Stops	Negative	Population coverage within 10 minutes walking service area polygons around bus stop locations[2]	Nashik Municipal Corporation, Nashik CITILINC 2021, World Settlement Footprint 2019, Census 2011

[2] Access to public recreational spaces is mapped using service area polygons that are for analyzing access within 1 km. It has been considered based on pedestrian accessibility standards within 10 minutes walkable distance (Bernard van Leer Foundation, 2018).

Annexure 1-25: Access to Public Transit - Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Flood Risk*	Positive	100 m buffer zone overlaid to gridded population density with access to bus stops	Census 2011, Nashik Municipal Corporation, CITILINC 2021, World Settlement Footprint 2019

**Using a buffer of 100m from the flood hotspots.*

Annexure 1-26: Access to Emergency Healthcare services- Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Access to Hospitals (in patient facility)	Negative	Population coverage within 8 minutes drivetime service area polygons around hospital locations	Nashik Municipal Corporation 2021, World Settlement Footprint 2019, Census 2011

Annexure 1-27: Access to Emergency Healthcare services- Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Heat Risk*	Positive	Area with >32°C LST overlaid to gridded population density with limited access to hospitals (unserviced population)	Landsat 8, Nashik Municipal Corporation 2020, World Settlement Footprint 2019, Census 2011
Urban Flood Risk**	Positive	100 m buffer zone overlaid to gridded population density with access to hospitals	Census 2011, Nashik Municipal Corporation 2021, World Settlement Footprint 2019

**Urban heat risk is assumed for areas with LST >32°C. This has been calculated by taking mode of average annual temperature from cloud free thermal band images from Landsat 8 within 2019 -2021*
***Using a buffer of 100m from the flood hotspots.*

Annexure 1-28: Access to Emergency Fire Services – Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Access to Fire Stations	Negative	Population coverage within 5 min drivetime service area polygons around fire station locations	Nashik Municipal Corporation 2020, World Settlement Footprint 2019, Census 2011, Google API

Annexure 1-29: Access to Emergency Fire Services – Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Heat Risk*	Positive	Area with >33°C LST overlaid to gridded population density with limited access to fire stations (unserviced population)	Landsat 8, Nashik Municipal Corporation 2020, World Settlement Footprint 2019, Census 2011
Urban Flood Risk**	Positive	100 m buffer zone overlaid to gridded population density with access to fire stations	Census 2011, Nashik Municipal Corporation 2020, World Settlement Footprint 2019

**Urban heat risk is assumed for areas with LST >32°C. This has been calculated by taking mode of average annual temperature from cloud free thermal band images from Landsat 8 within 2019 -2021*
***Using a buffer of 100m from the flood hotspots.*

Annexure 1-30: Access to Relief Shelters – Assessment Parameters and Attributes

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Access to Relief Shelters	Negative	Population coverage within 10-minute walkable service area polygons around relief shelter locations	Nashik Municipal Corporation 2021, World Settlement Footprint 2019, Census 2011

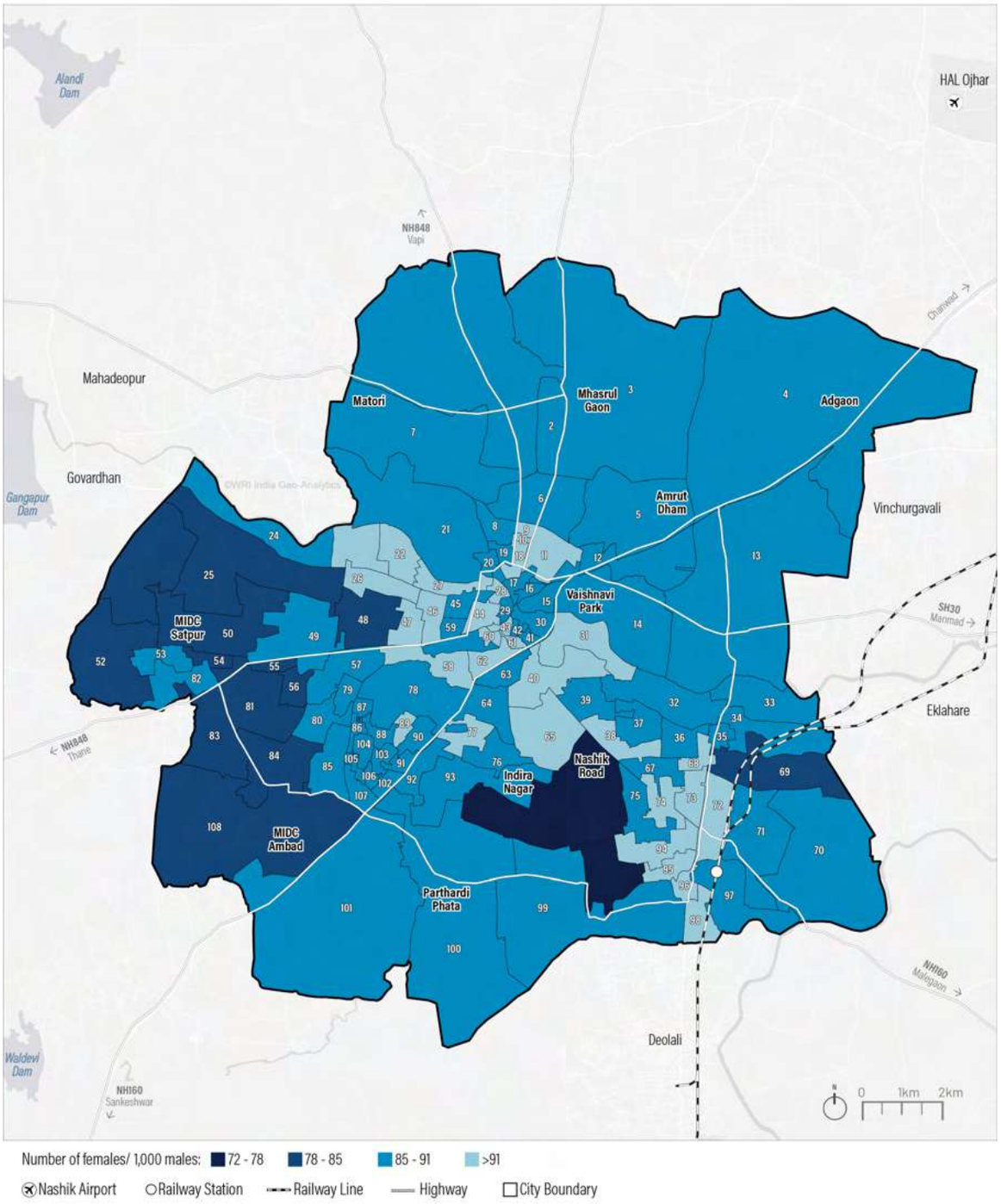
Annexure 1-31: Access to Relief Shelters – Vulnerability to Climate Induced Hazard

Parameter Mapped	Relationship to Vulnerability	Methods Used	Data Source
Urban Heat Risk*	Positive	Area with >32°C LST overlaid to gridded population density with limited access to relief shelters (un-serviced population)	Nashik Municipal Corporation 2021, World Settlement Footprint 2019, Census 2011
Urban Flood Risk**	Positive	100 m buffer zone overlaid to gridded population density with access to relief shelters	Census 2011, Nashik Municipal Corporation 2021, World Settlement Footprint 2019

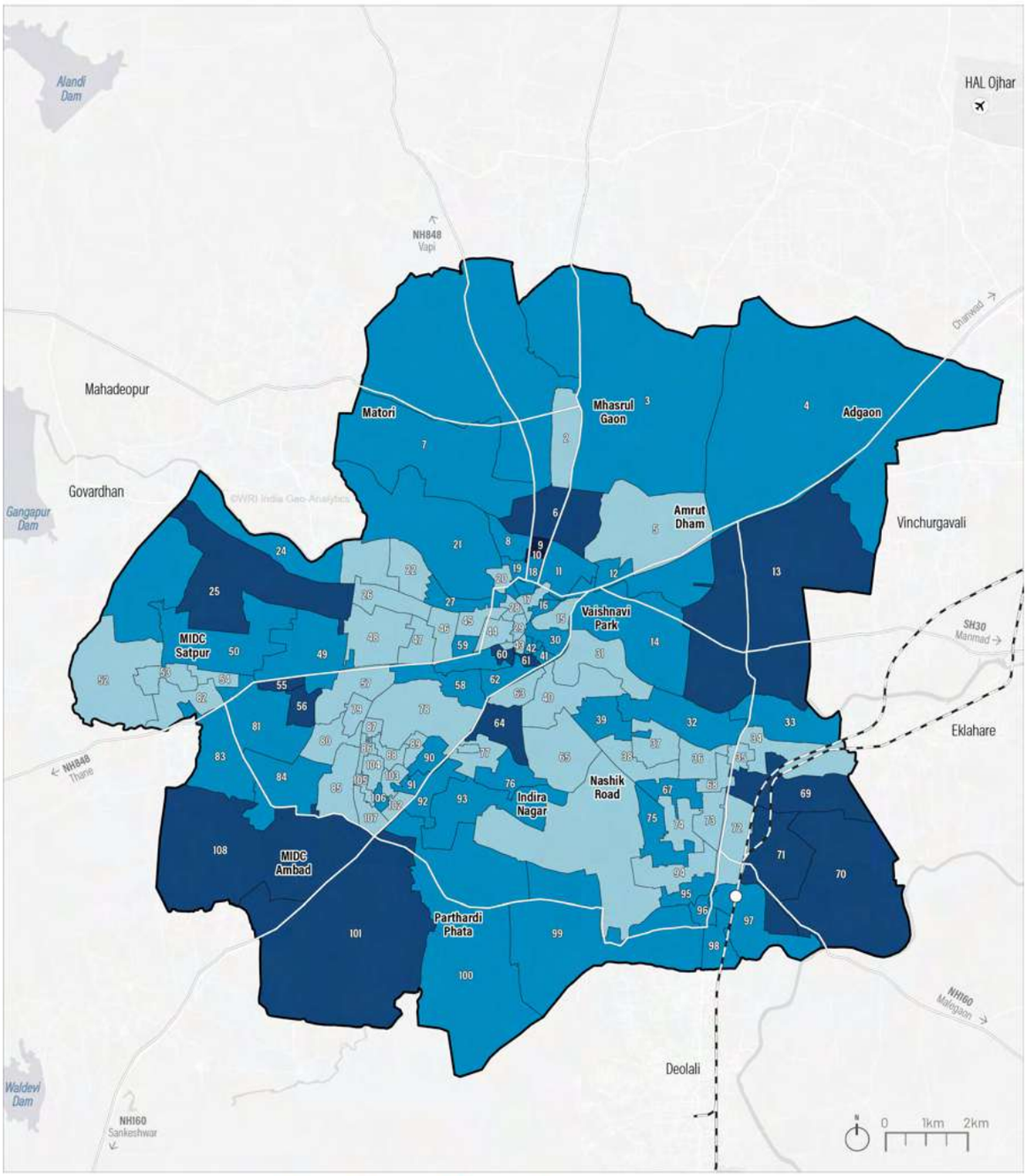
**Urban heat risk is assumed for areas with LST >32°C. This has been calculated by taking mode of average annual temperature from cloud free thermal band images from Landsat 8 within 2019 -2021*
***Using a buffer of 100m from the flood hotspots.*

2. Annexure 2: Maps & Figures

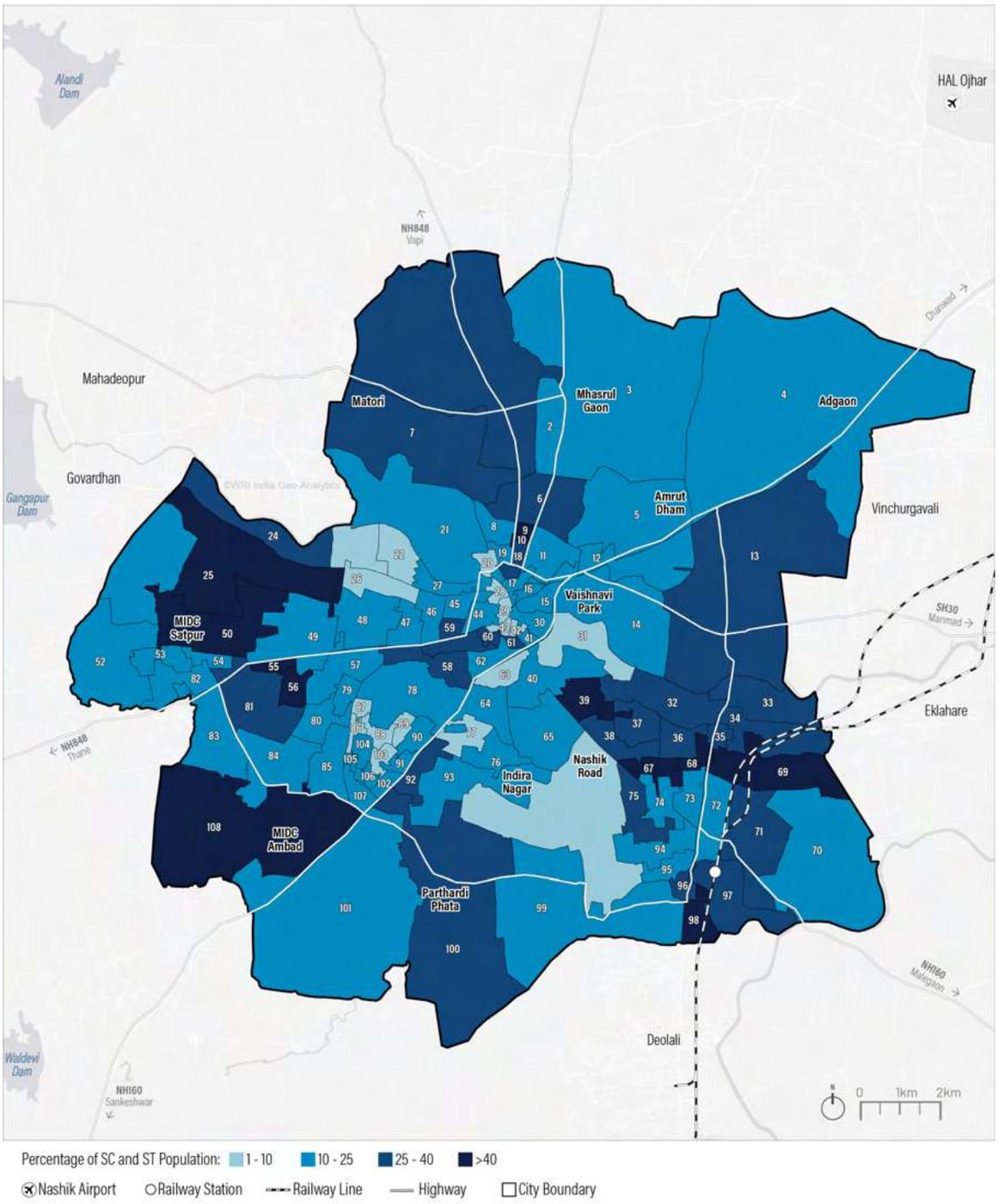
Annexure 2-1: Gender Profile



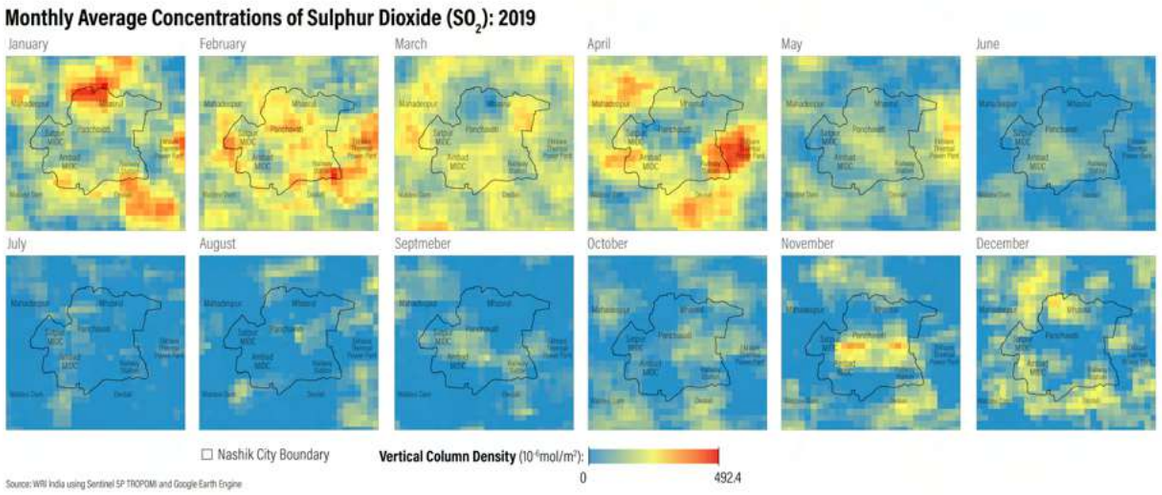
Annexure 2-2: Effective Literacy Rate

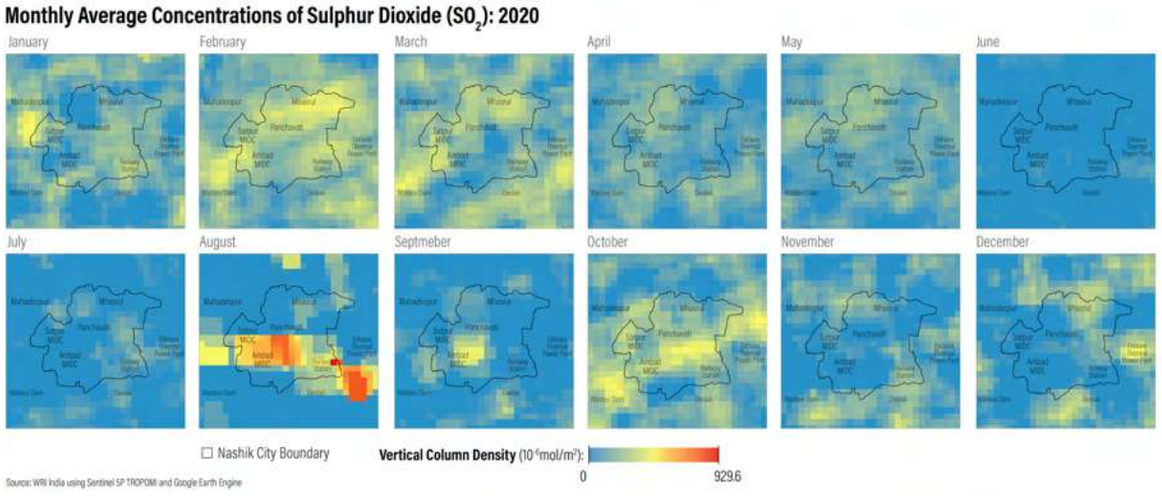


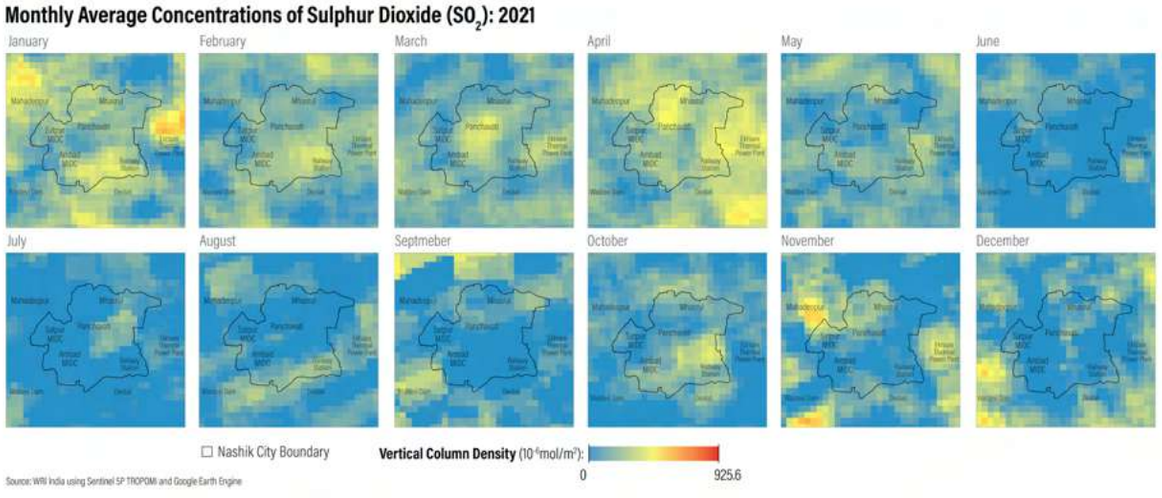
Annexure 2-3: Social Composition



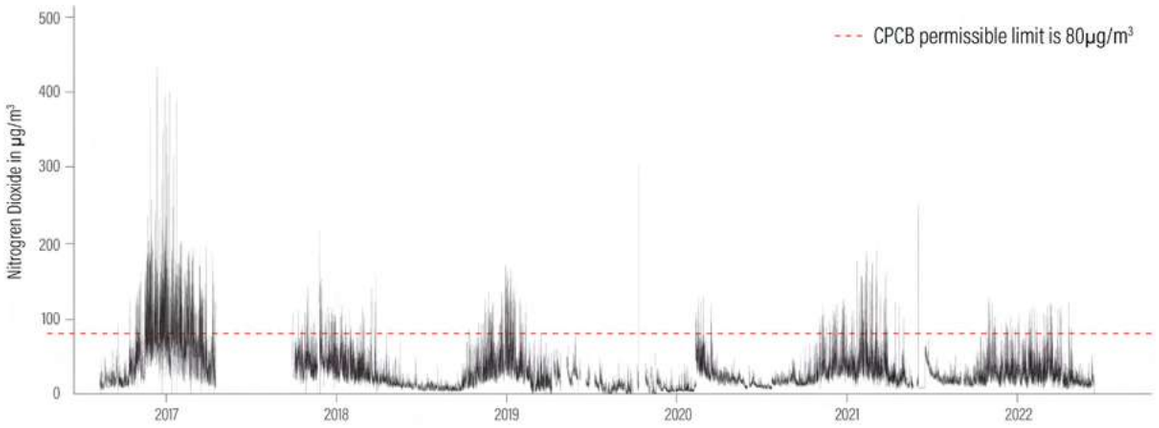
Annexure 2-4: Monthly average concentrations of SO2 in Nashik from 2019-2021





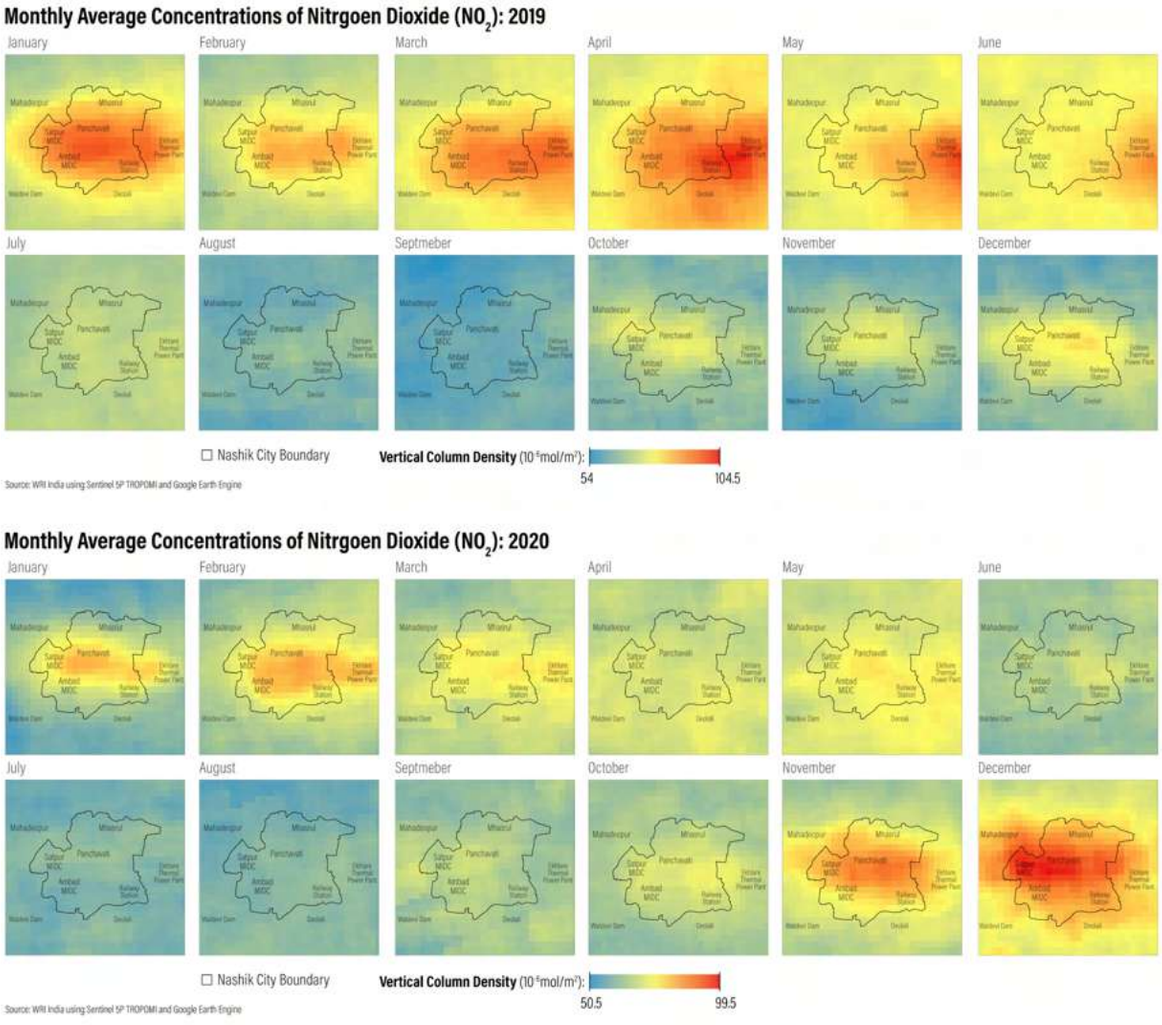


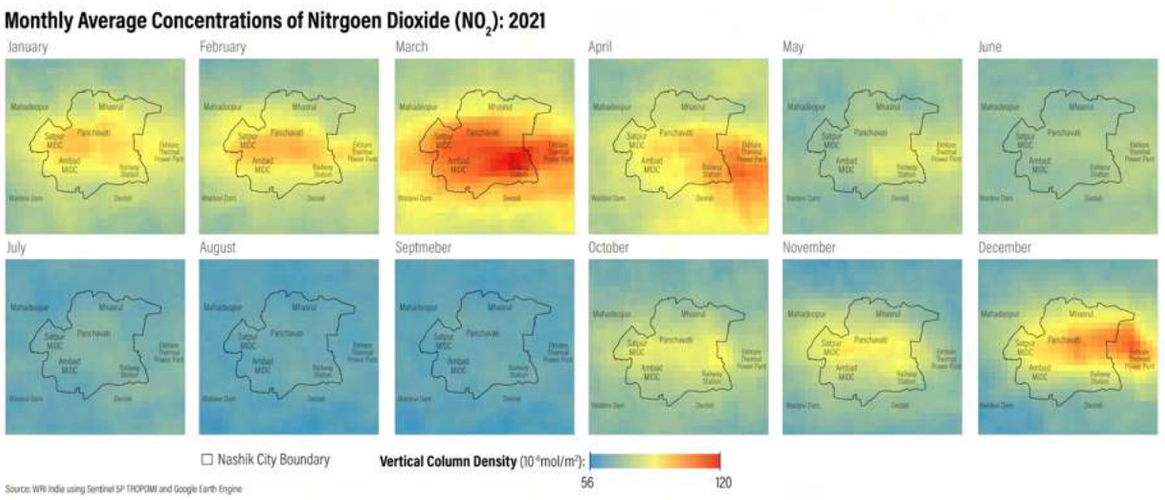
Annexure 2-5: Hourly Nitrogen Dioxide (NO2) concentrations at the KTHM College air quality monitoring station between August 2016 and June 2022



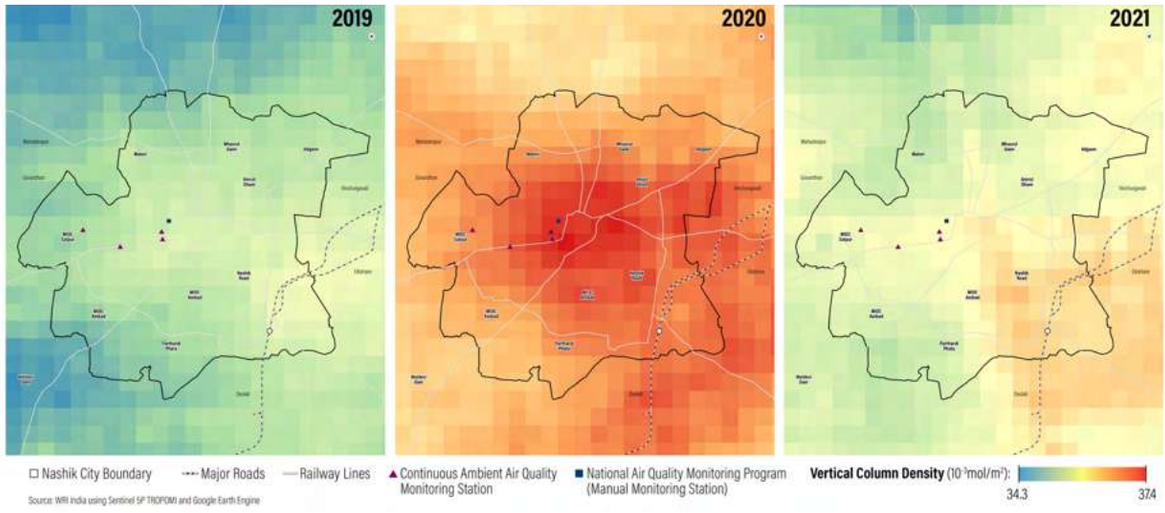
Source: CPCB

Annexure 2-6: Monthly average concentrations of Nitrogen Dioxide (NO2) in Nashik from 2019 to 2021

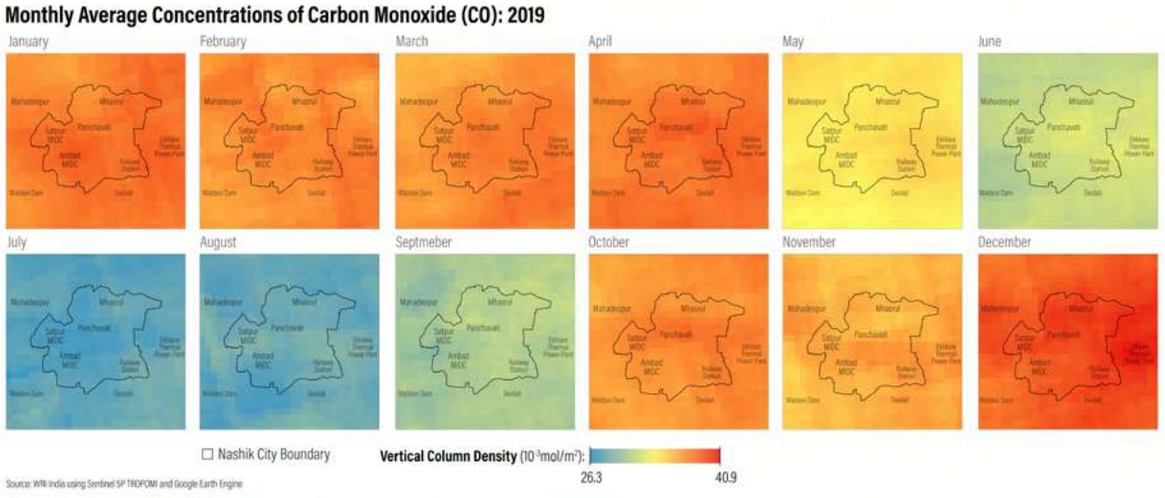


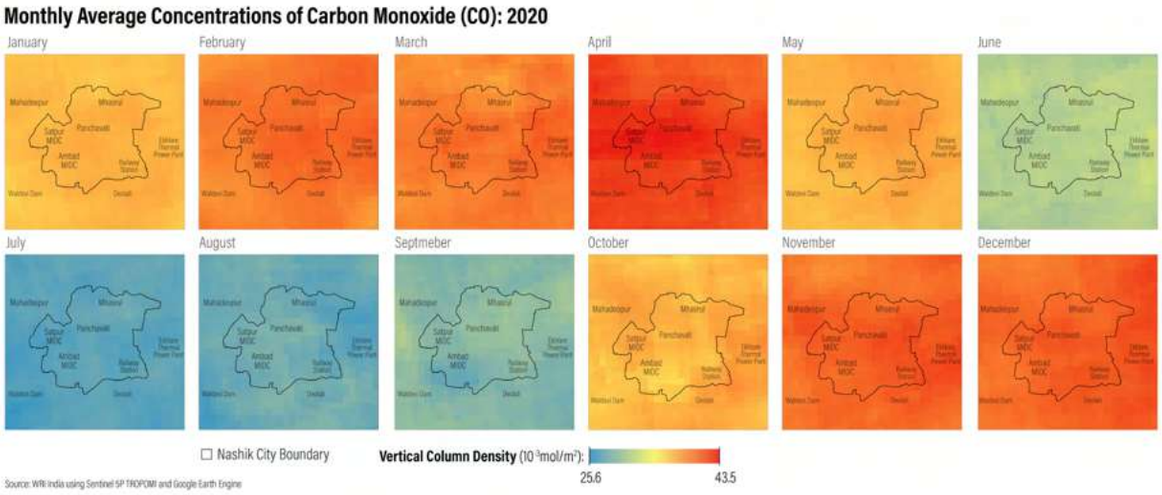


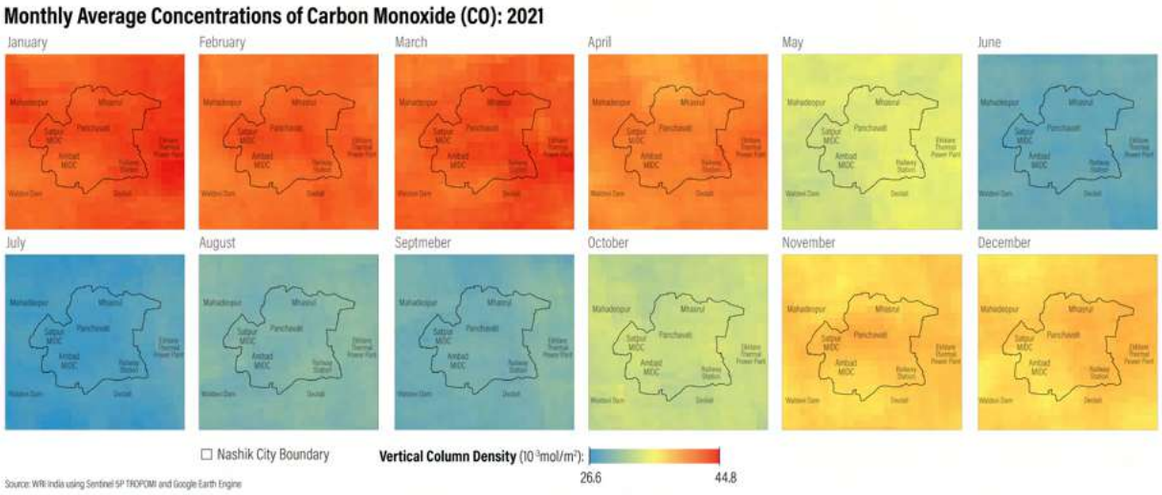
Annexure 2-7: Annual average concentrations of Carbon Monoxide (CO) in Nashik from 2019-2021



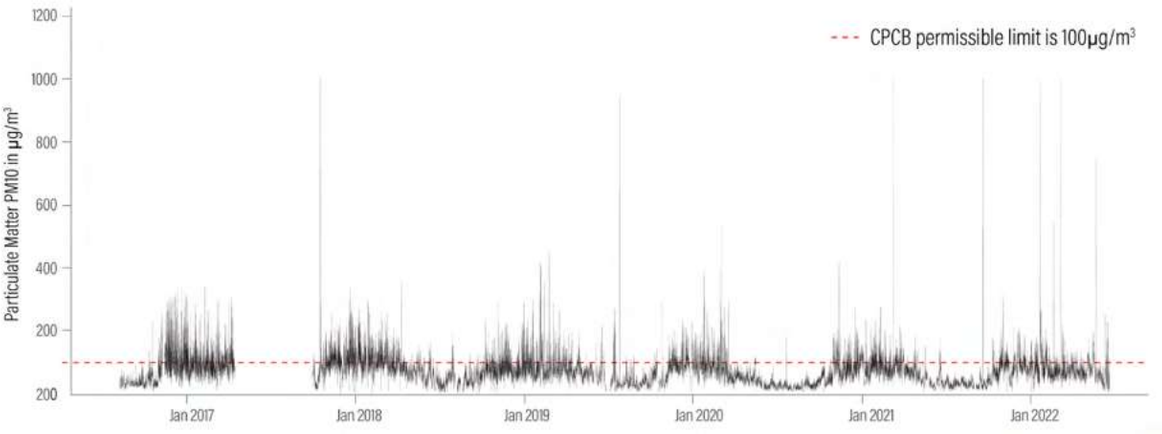
Annexure 2-8: Monthly average concentration of Carbon Monoxide in Nashik from 2019-2021





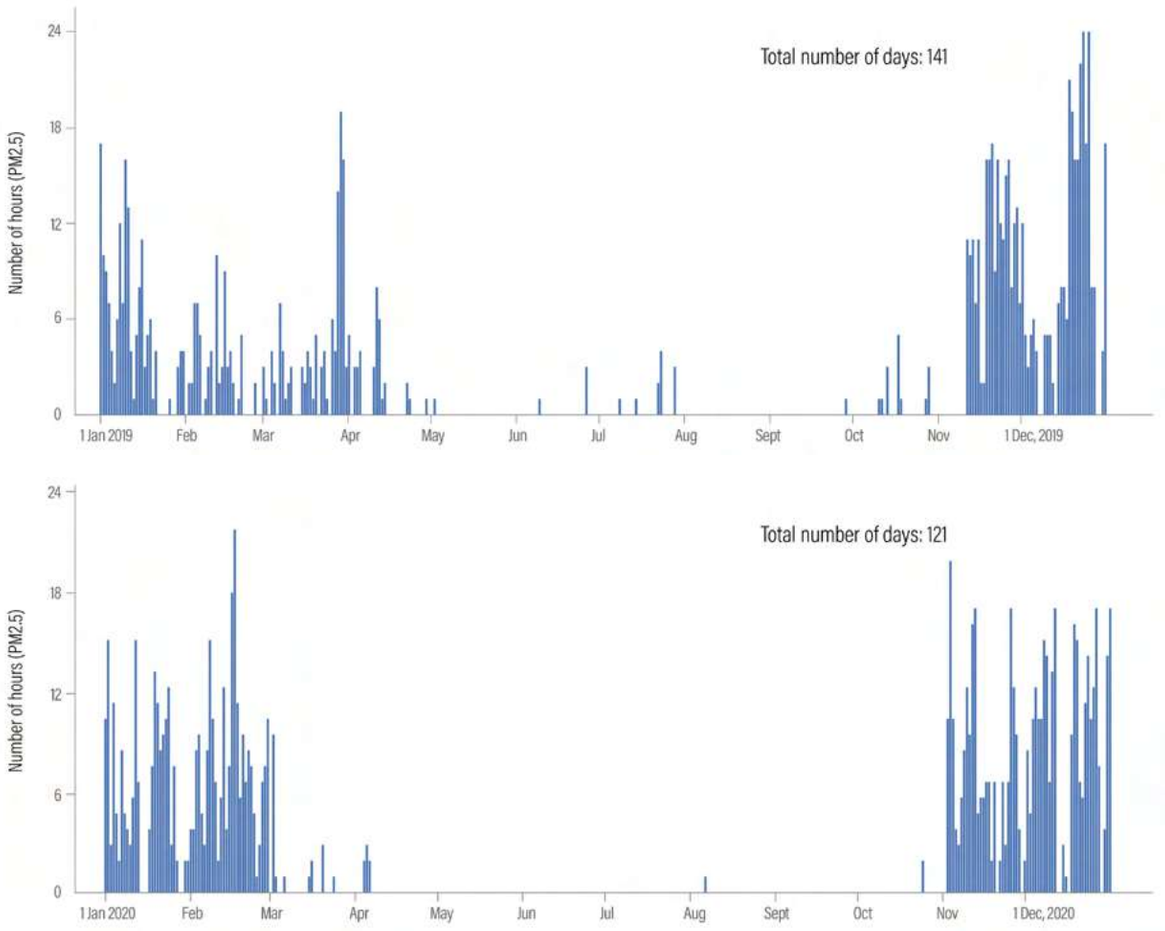


Annexure 2-9: Hourly PM10 concentrations at the KTHM College air quality monitoring station between August 2016 and June 2022



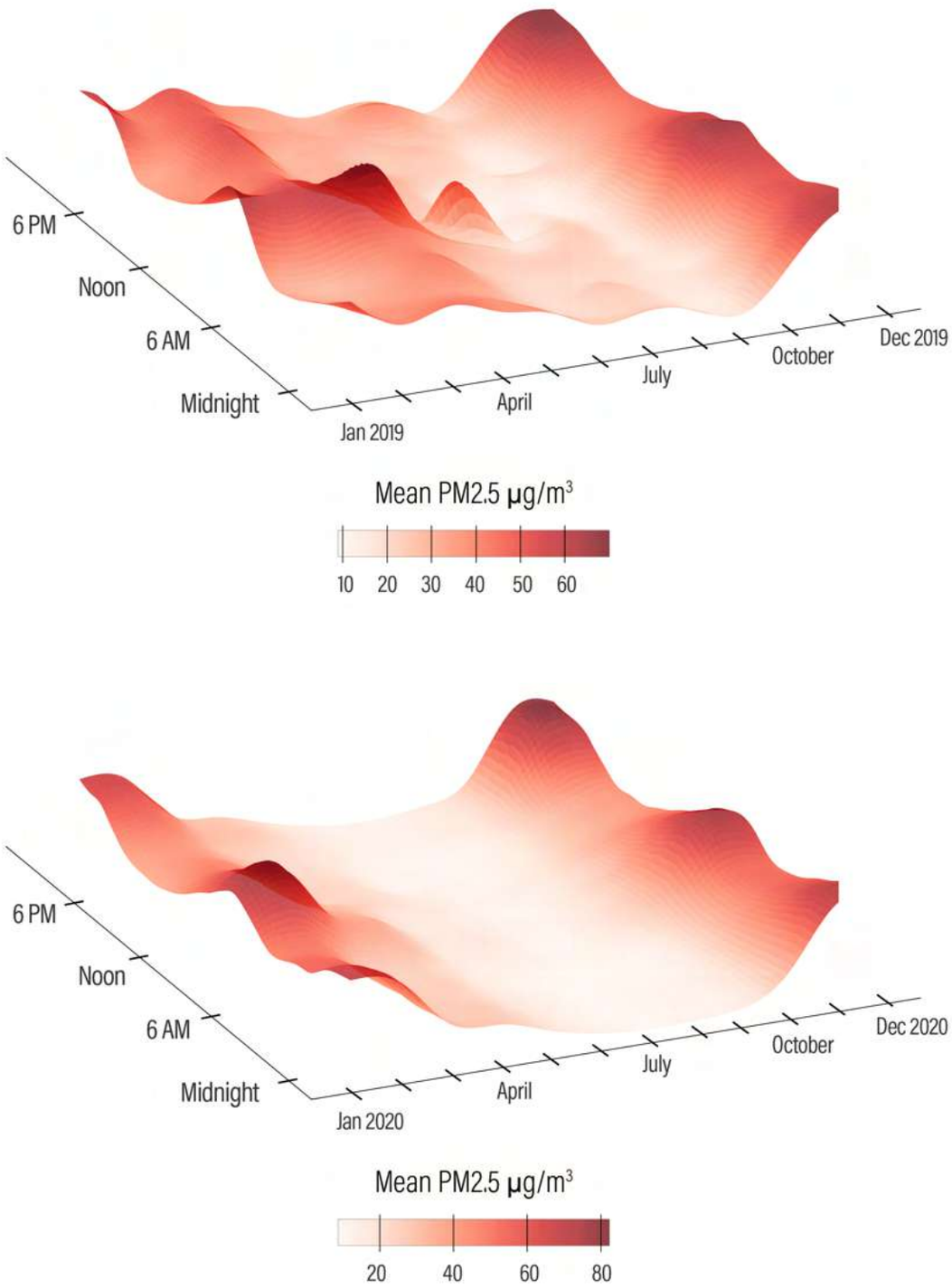
Source: ?

Annexure 2-10: CPCB threshold crossings of PM2.5 in Nashik 2019 (top) and 2020 (bottom)



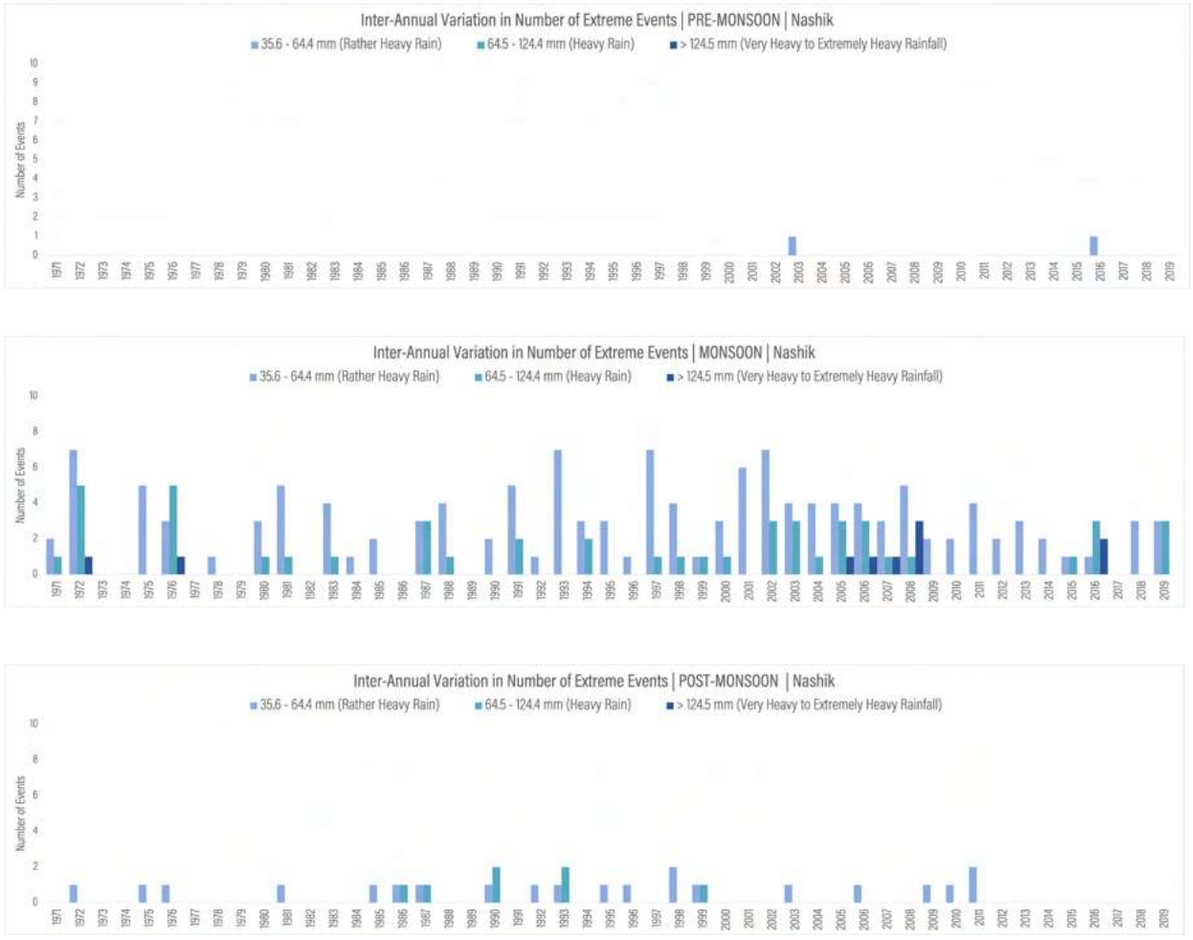
Source: *WRI India analysis using CPCB data*

Annexure 2-11: Timeseries of monthly-hourly average concentration of PM2.5 in 2019 (top) and 2020 (bottom)



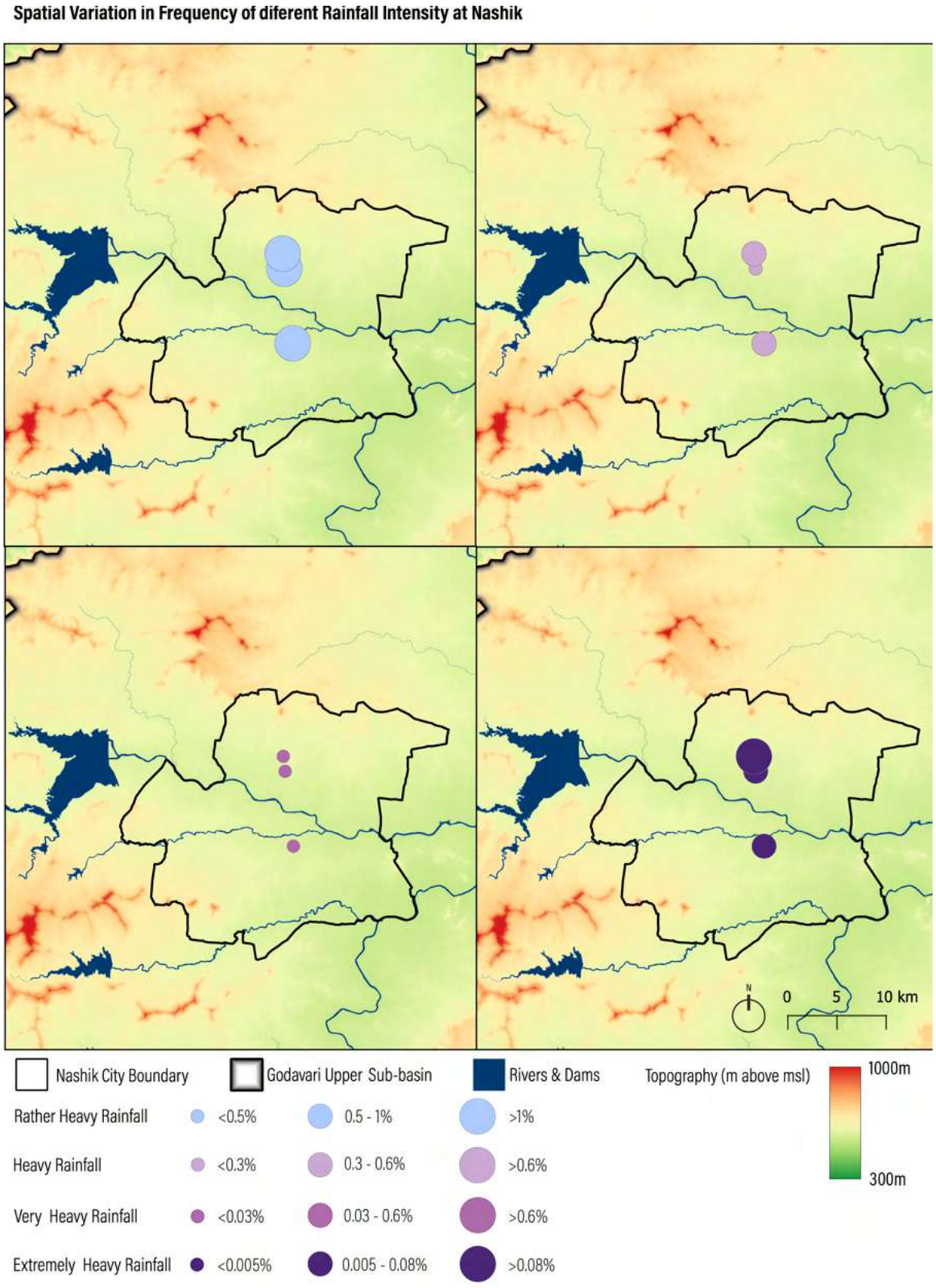
Source: WRI India analysis using CPCB data, 2022

Annexure 2-12: Interannual Variation in Number of Extreme Rainfall Events at Nashik gauge station in Nashik

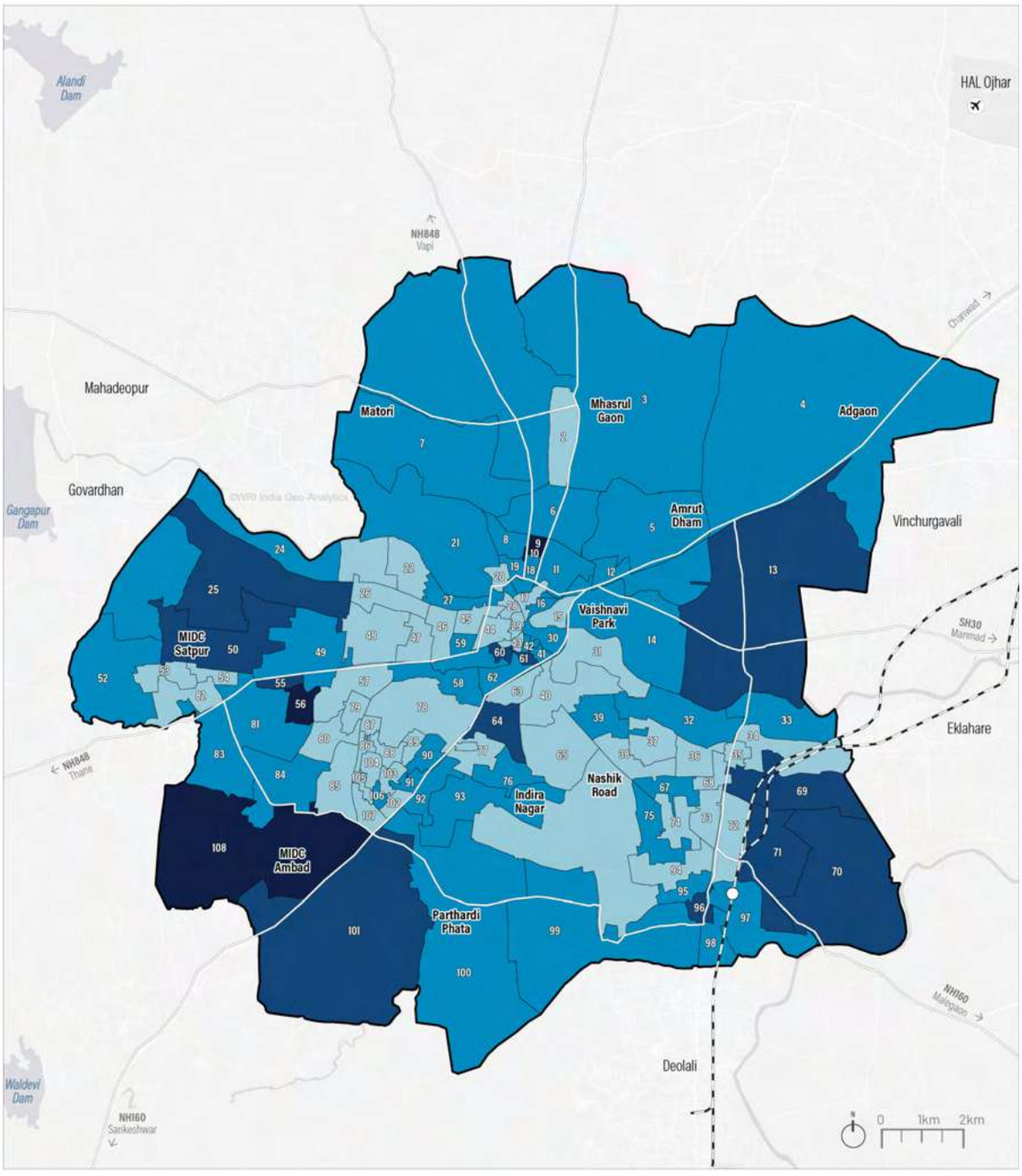


Source: *WRI India using meteorological data from IMD*

Annexure 2-13: Interannual Variation in Number of Extreme Rainfall Events at Nashik gauge station in Nashik

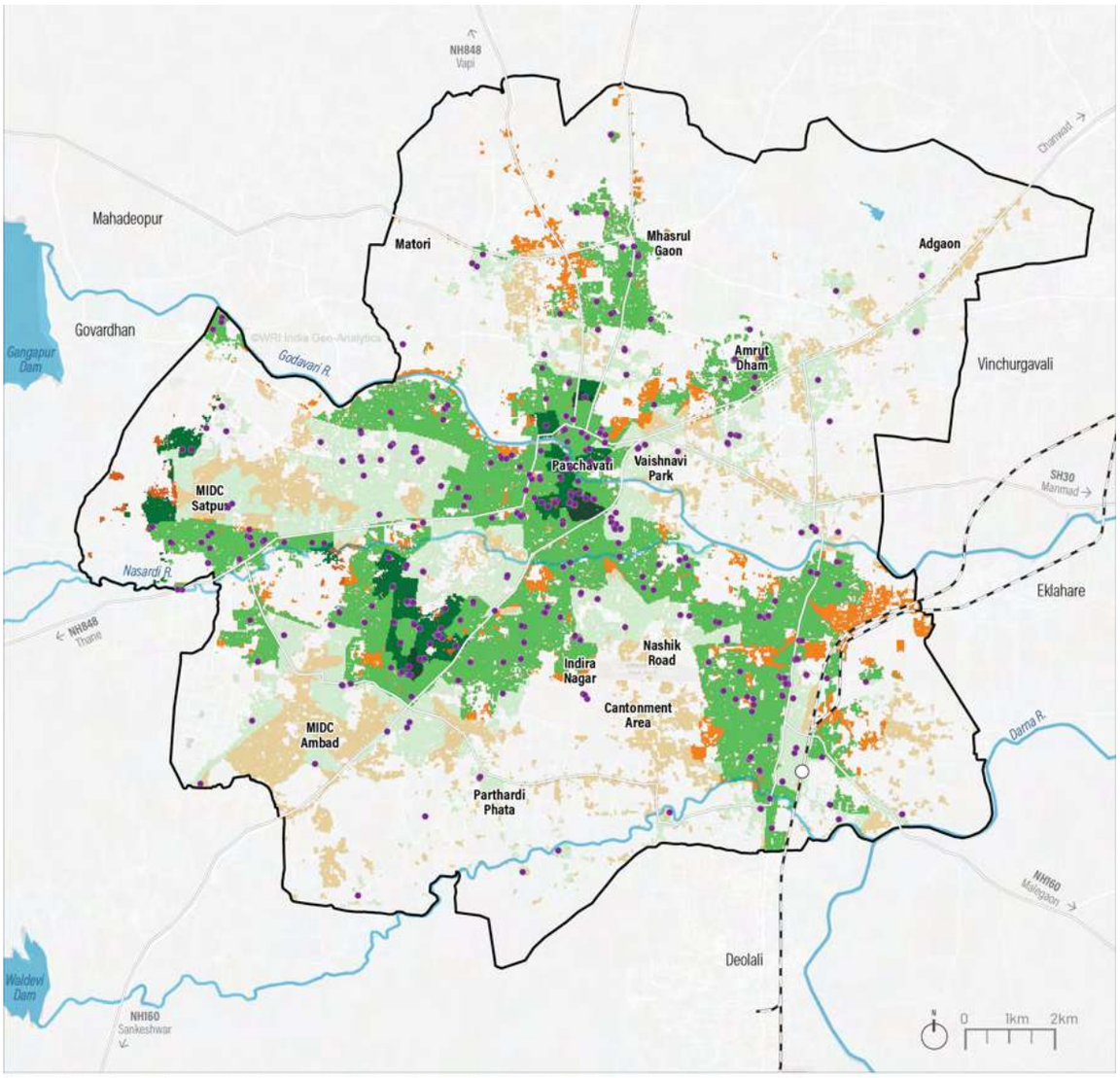


Annexure 2-14: Effective female literacy rate



Source: Census 2011; WRI India 2022

Annexure 2-15: Access to All Schools



Population within 10 minutes walkable distance (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

Population outside 10 minutes walkable distance (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

School | Nashik Airport | Railway Station | Railway Line | Highway | Waterbodies | City Boundary

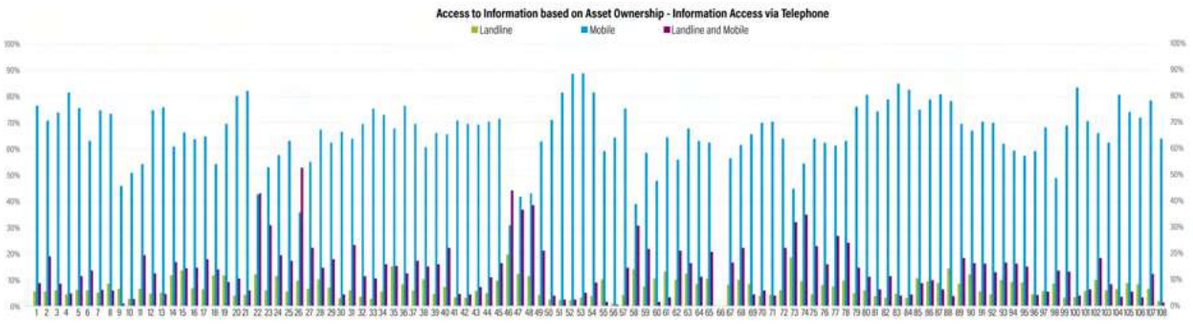
Source: Census 2011, World Settlement Footprint Evolution; NMC; NIC 2018; WRI India 2022

Note: Average distance covered in 10 minutes in Indian condition is 800 - 1,000 meters for an adult (Benvard van Leer Foundation, 2018)

Caveat: *Accessibility analysis is limited to physical provision and proximity evaluation. Enrolment, teacher-student ratio, drop-out etc. are not included. Schools having primary, secondary education facility (having 10th standard) are considered here.*
Junior Colleges (with only 11th and 12th standards) are excluded.

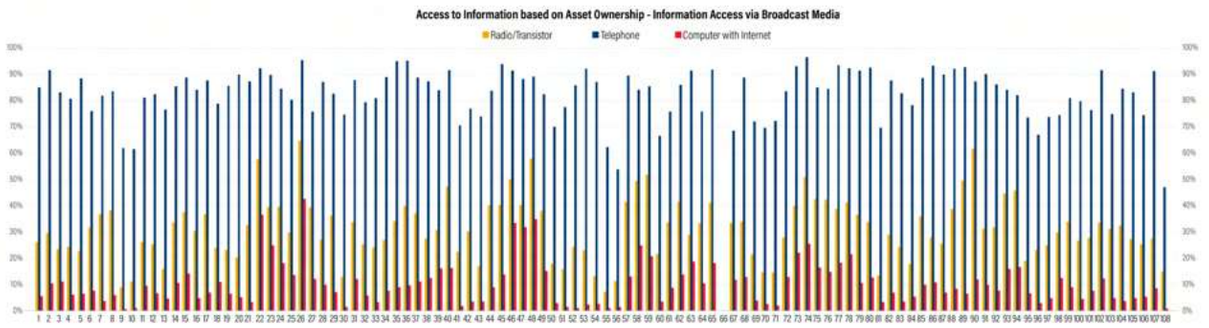
Assumption: *Access to schools is mapped using service area polygons that are created for the schools for analyzing access within 1 km. It has been considered based on pedestrian accessibility standards within 10 minutes walkable distance (Bernard van Leer Foundation, 2018).*

Annexure 2-16: Access to Information based on asset ownership- information Access via Telephone



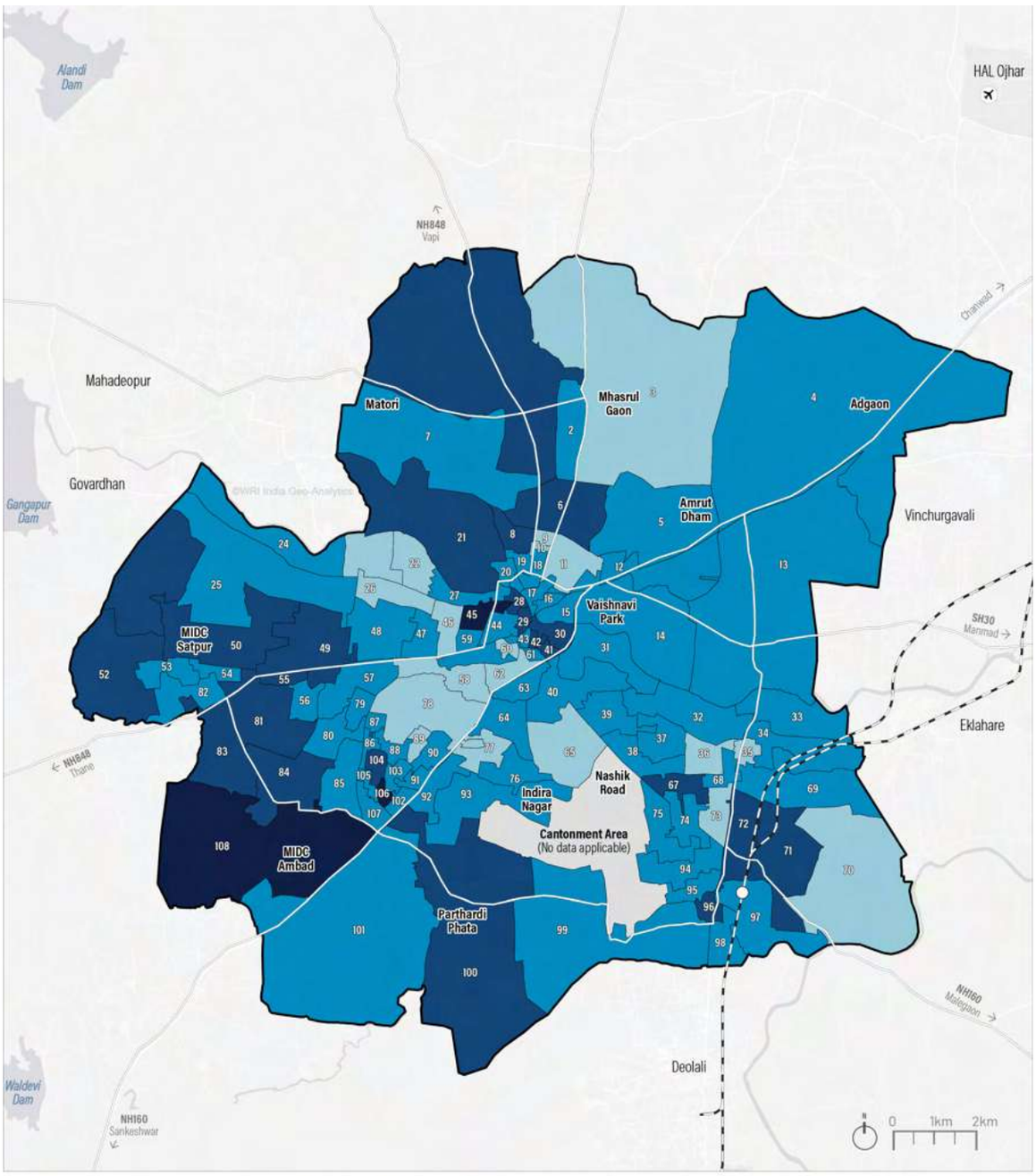
Source: *WRI India using Census 2011*

Annexure 2-17: Access to Information based on asset Ownership-information access via Broadcast Media



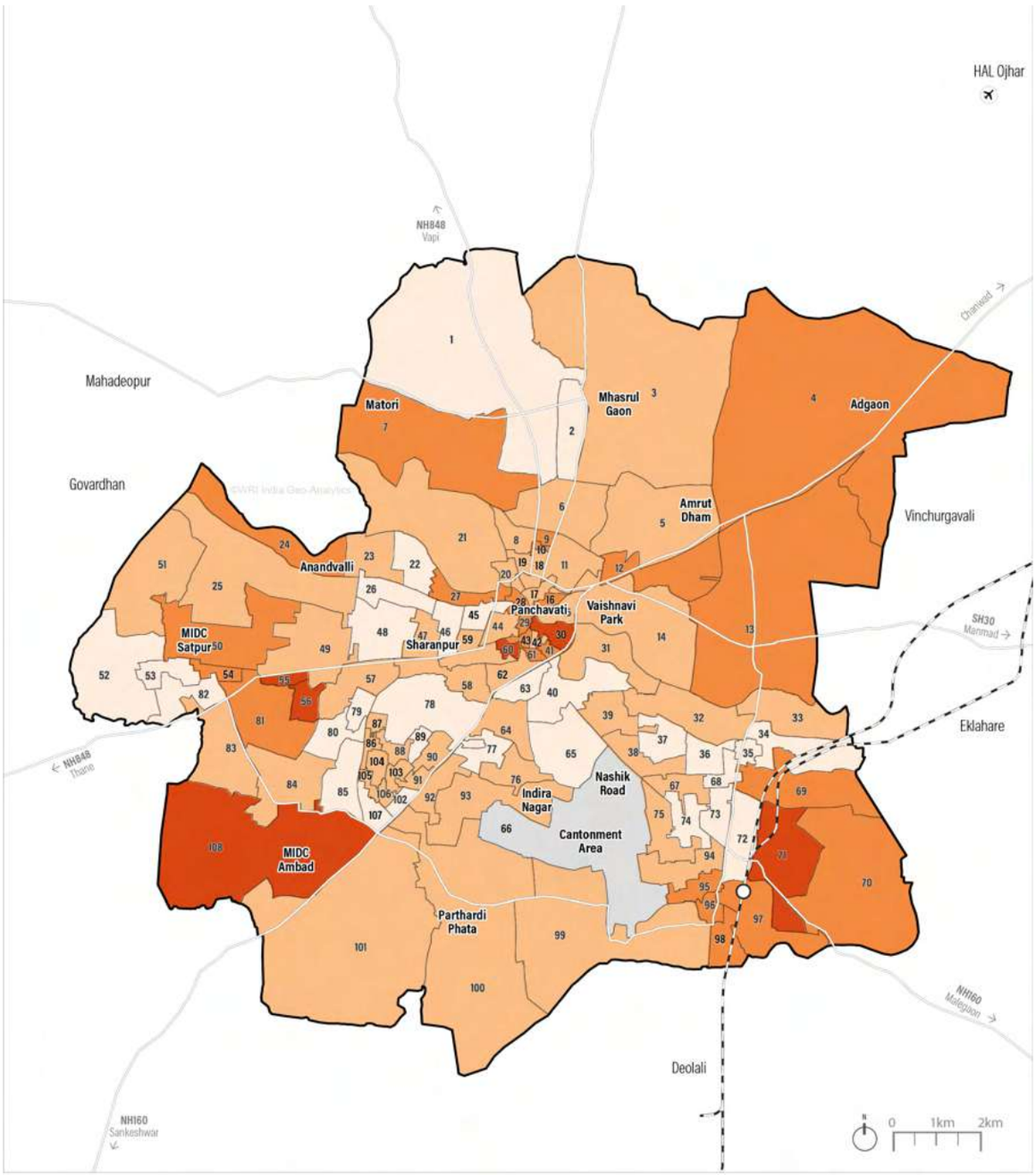
Source: *WRI India using Census 2011*

Annexure 2-18: House Ownership



Source: Census 2011; WRI India 2022

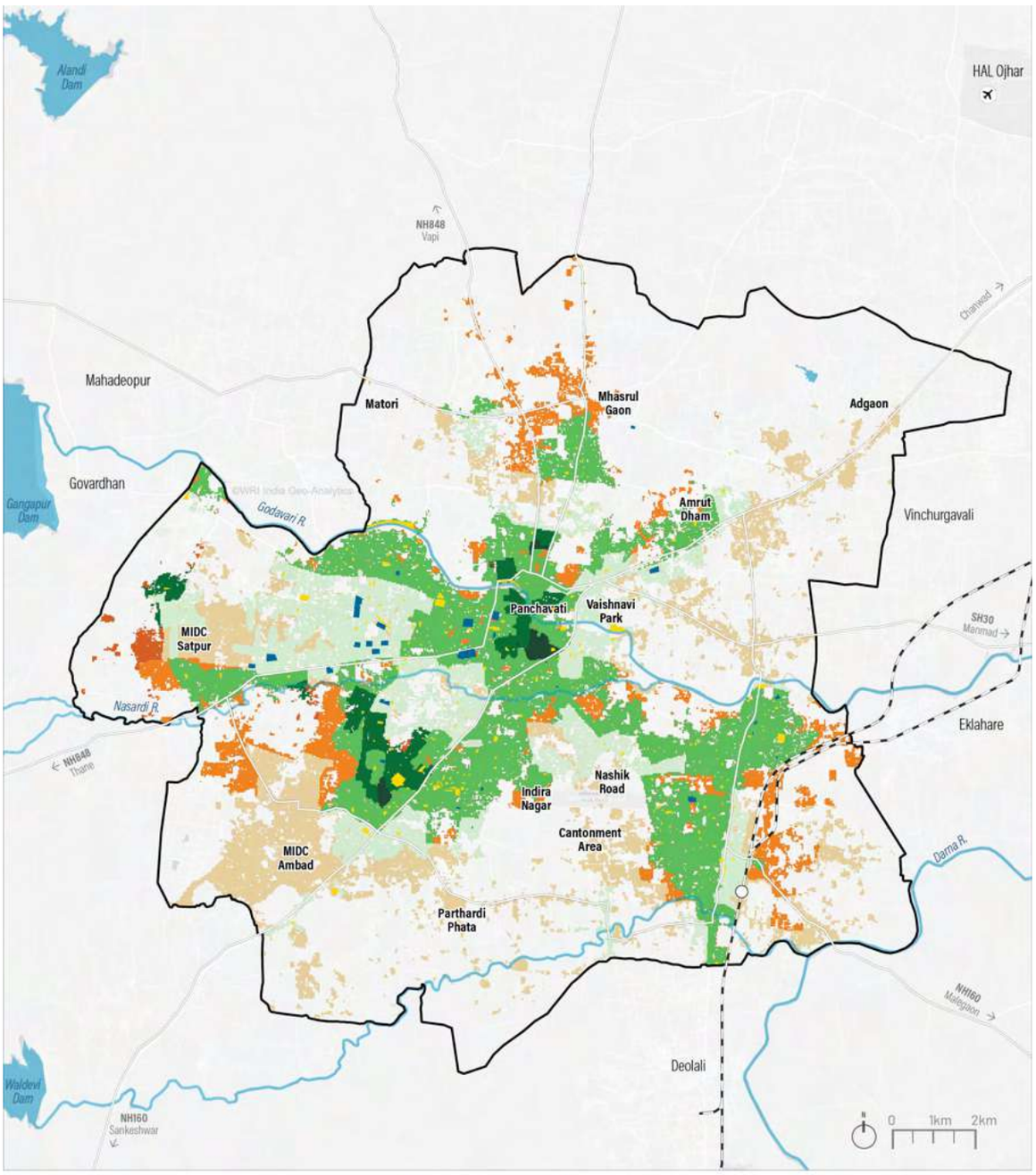
Annexure 2-19: House Condition



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

Note: Temporary roofing materials include Grass/ Thatch/Bamboo/ Mud/ Wood etc, Plastic/ Polythene, Stones/Slate and Galvenized Iron/ Metal/ Asbestos sheets.

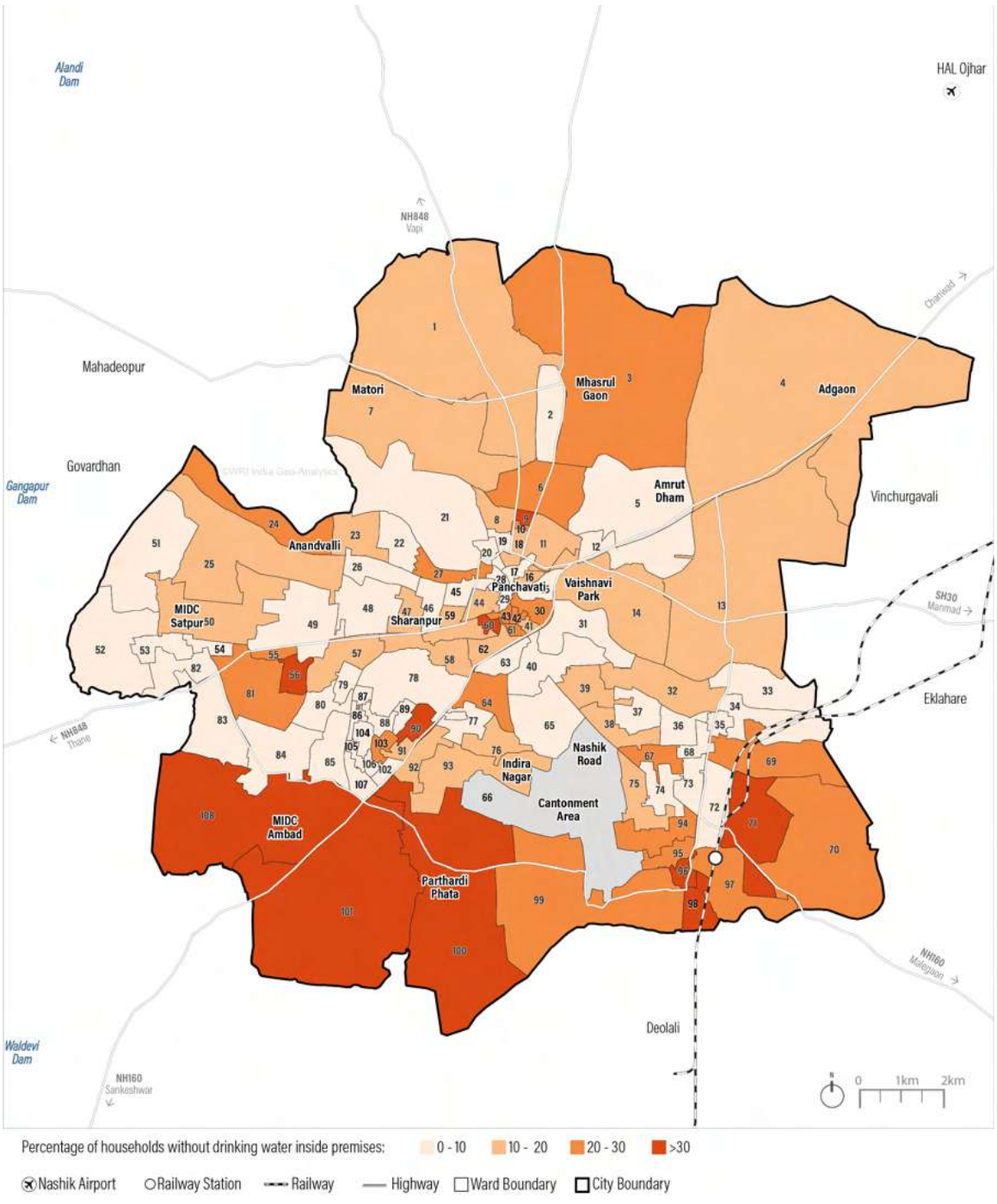
Annexure 2-20: Access to Public Recreational Spaces



Source: Census 2011, World Settlement Footprint Evolution; NMC; WRI India 2022

Note: Average distance covered in 10 minutes in Indian condition is 800 - 1,000 meters for an adult (Benvard van Leer Foundation, 2018)

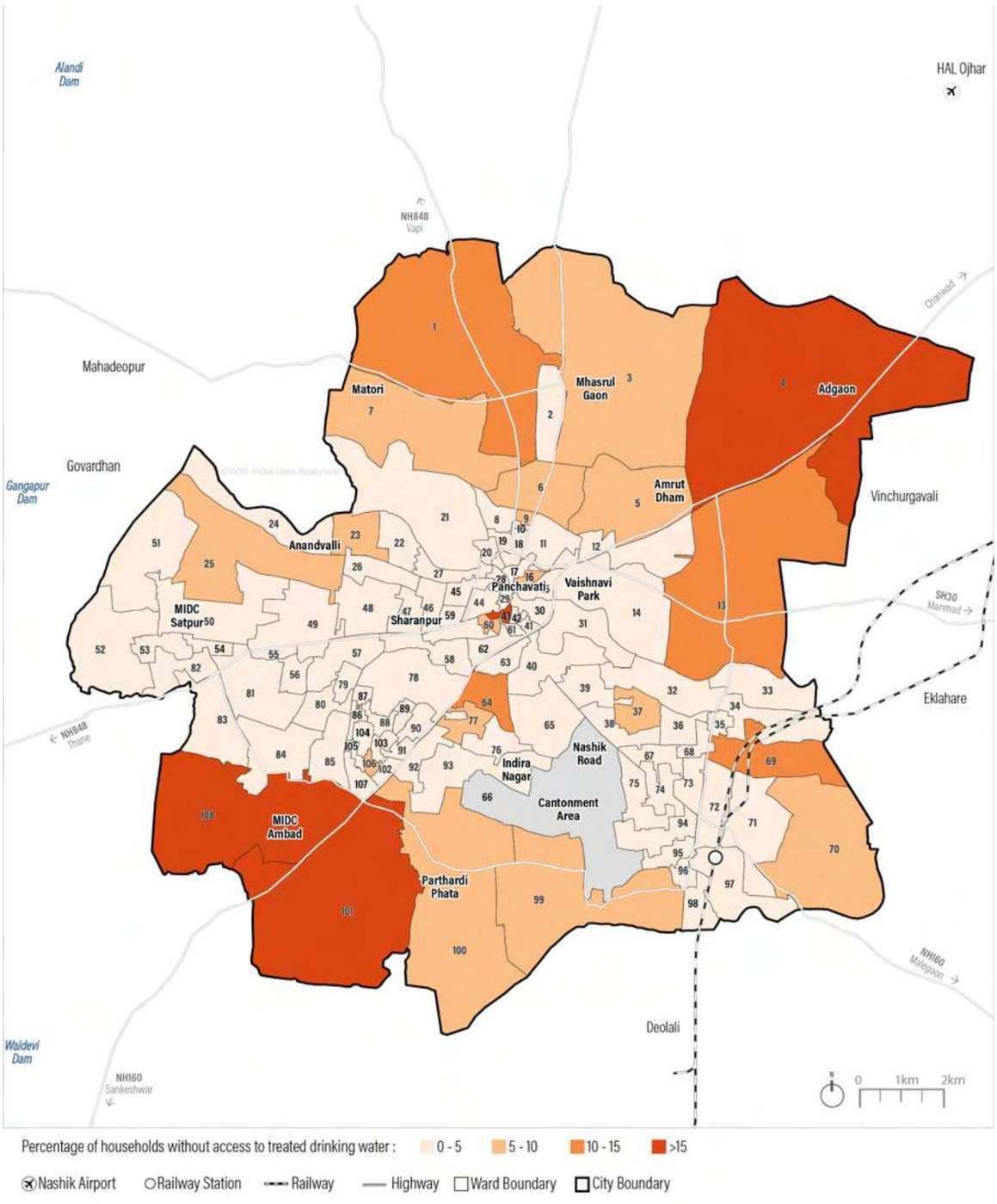
Annexure 2-21: Limited ease of access to drinking water (outside premises)



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

Note: Households without drinking water inside premises includes households with drinking water near premises and away from premises.

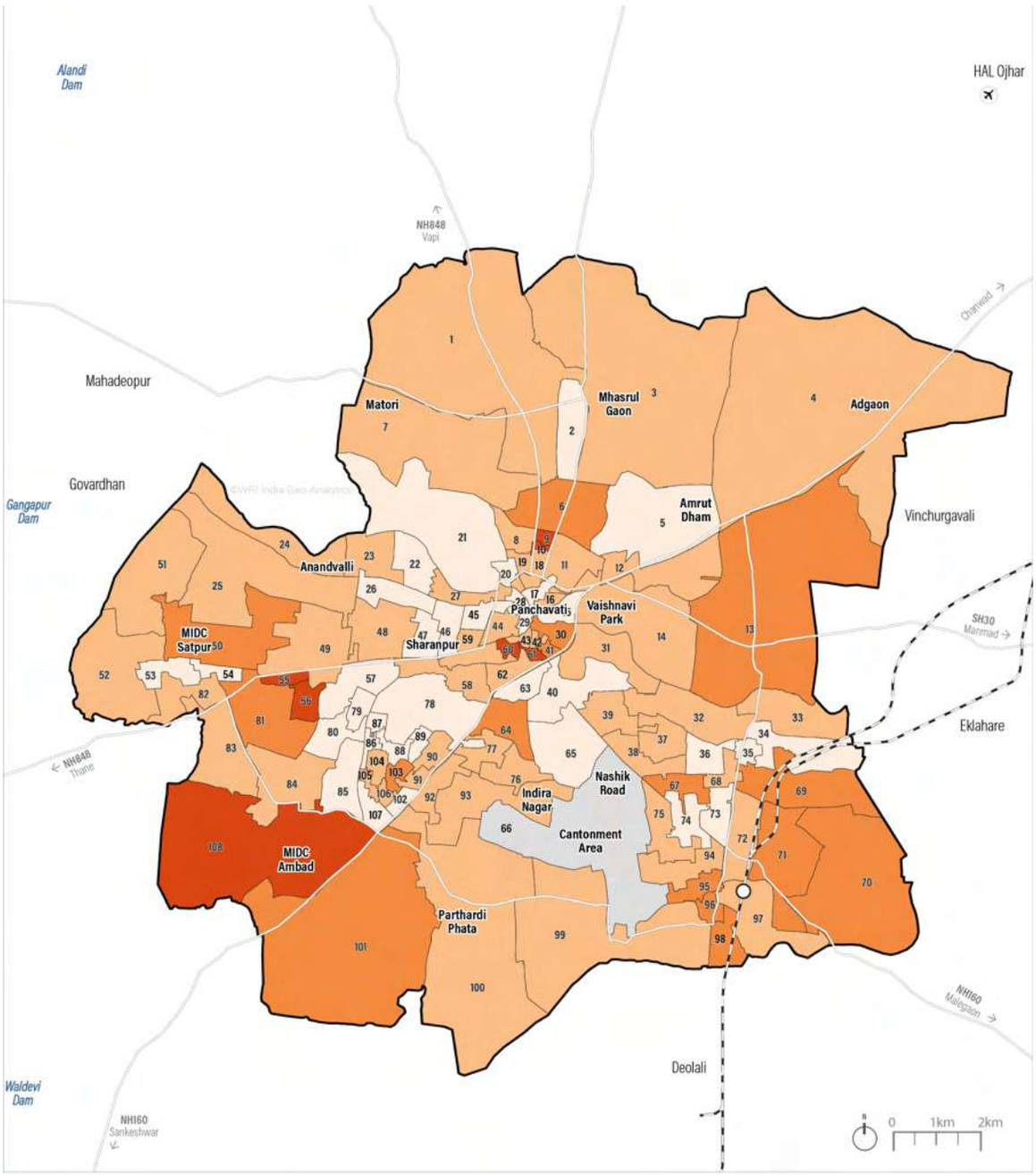
Annexure 2-22: Lack of access to treated drinking water



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

Note: Households without access to treated drinking water includes household with drinking water sources from untreated tap water, covered wells, uncovered wells, handpump, tubewell/borewell, springs, river/canal, tanks/ponds/lakes and other sources

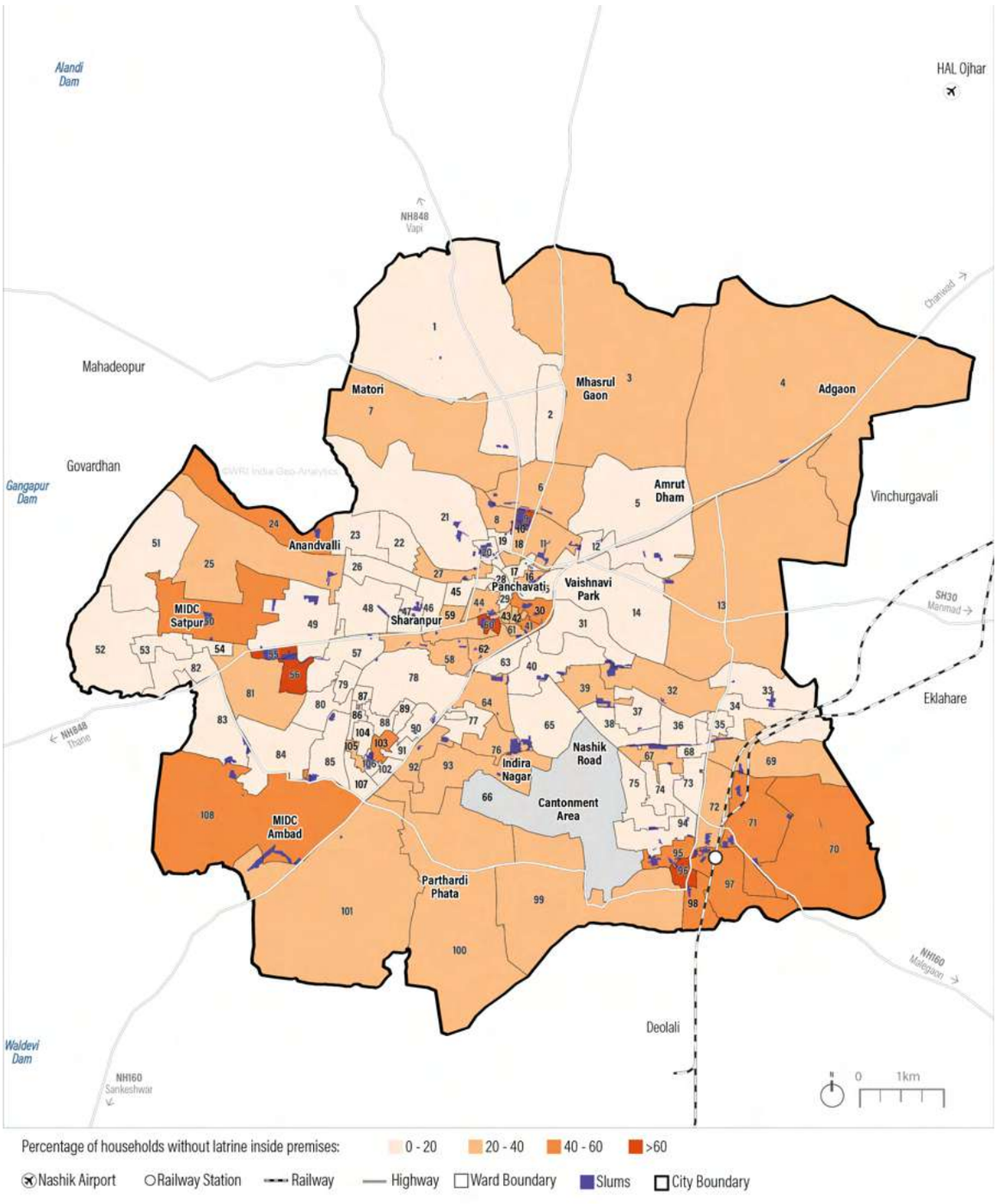
Annexure 2-23: Lack of Access of Clean Cooking Fuel



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

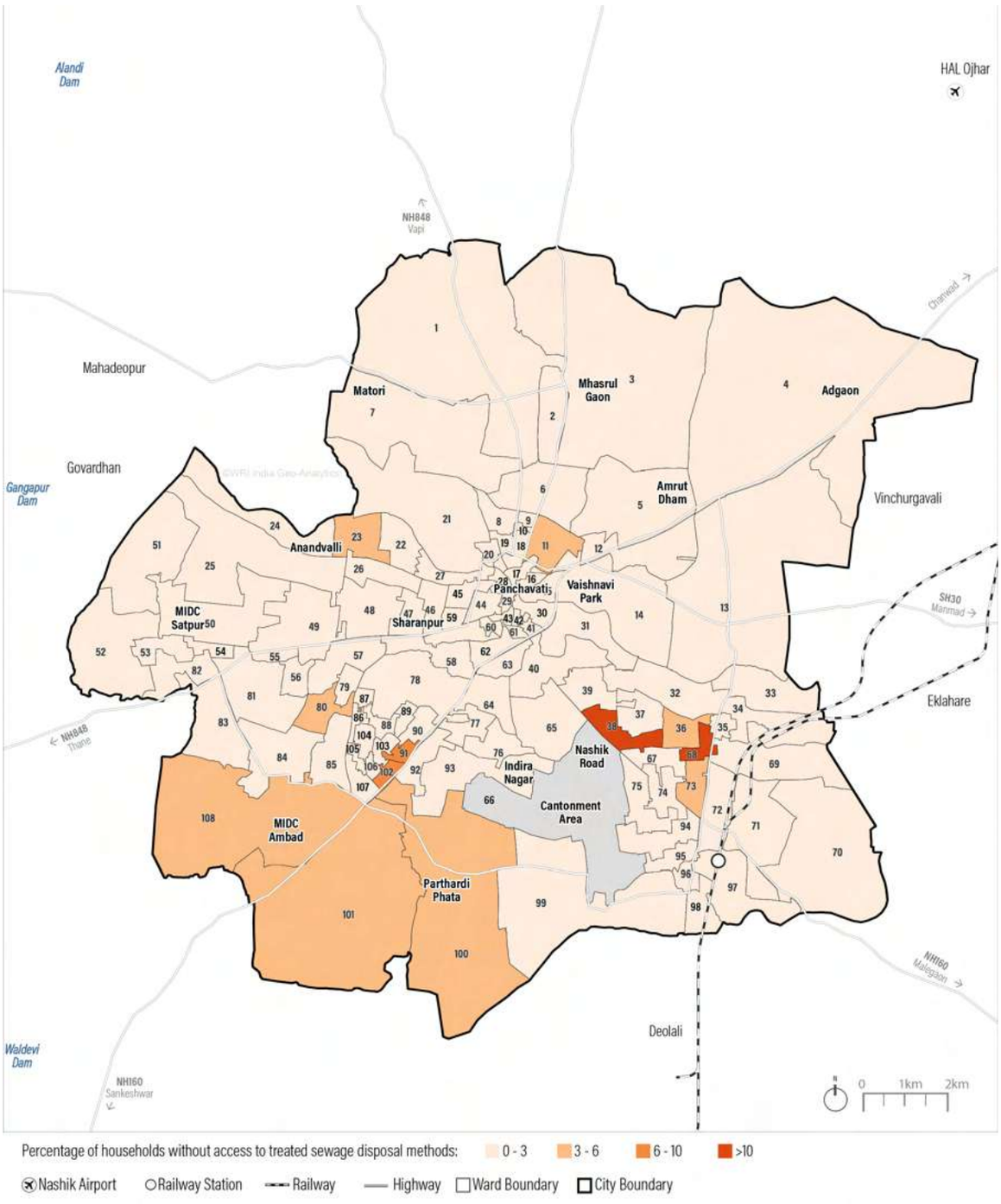
Note: 1. Clean cooking fuel includes LPG/PNG, Biogas and Electricity.
2. Households without access to clean cooking fuel includes households using firewood, crop residue, cowdung cake, coal/lignite/ charcoal, kersone, others as their fuel for cooking.

Annexure 2-24: Limited ease of access to latrine



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

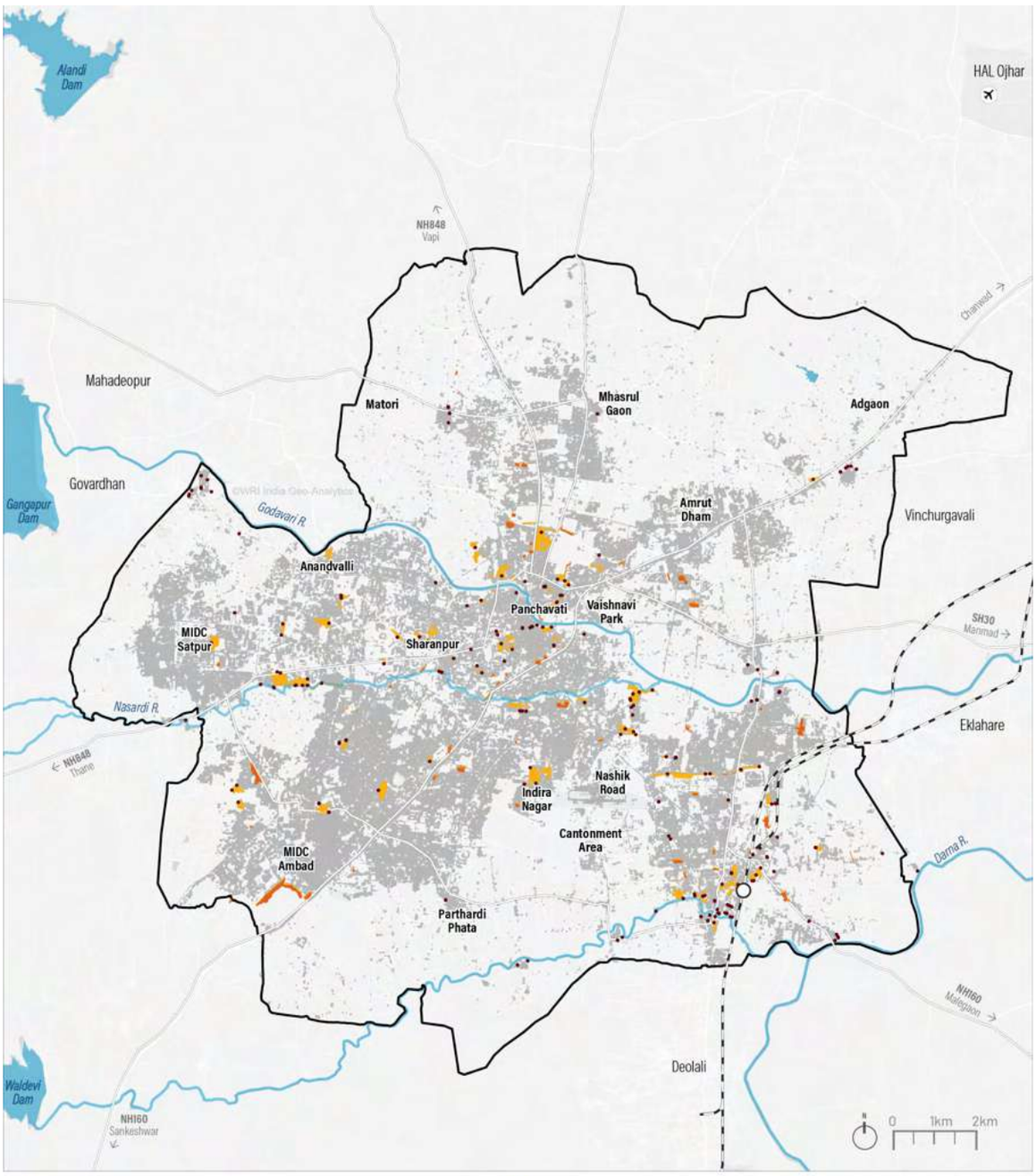
Annexure 2-25: Lack of access to treated sewage disposal methods



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

Note: Households without access to treated sewage disposal methods includes households with Flush/pour flush latrines connected to systems other than septic and piped water sewer system, pit latrine without slab/ open pit, service latrine with night soil disposed into open drain, service latrine with night soil removed by humans and service latrine with night soil serviced by animals.

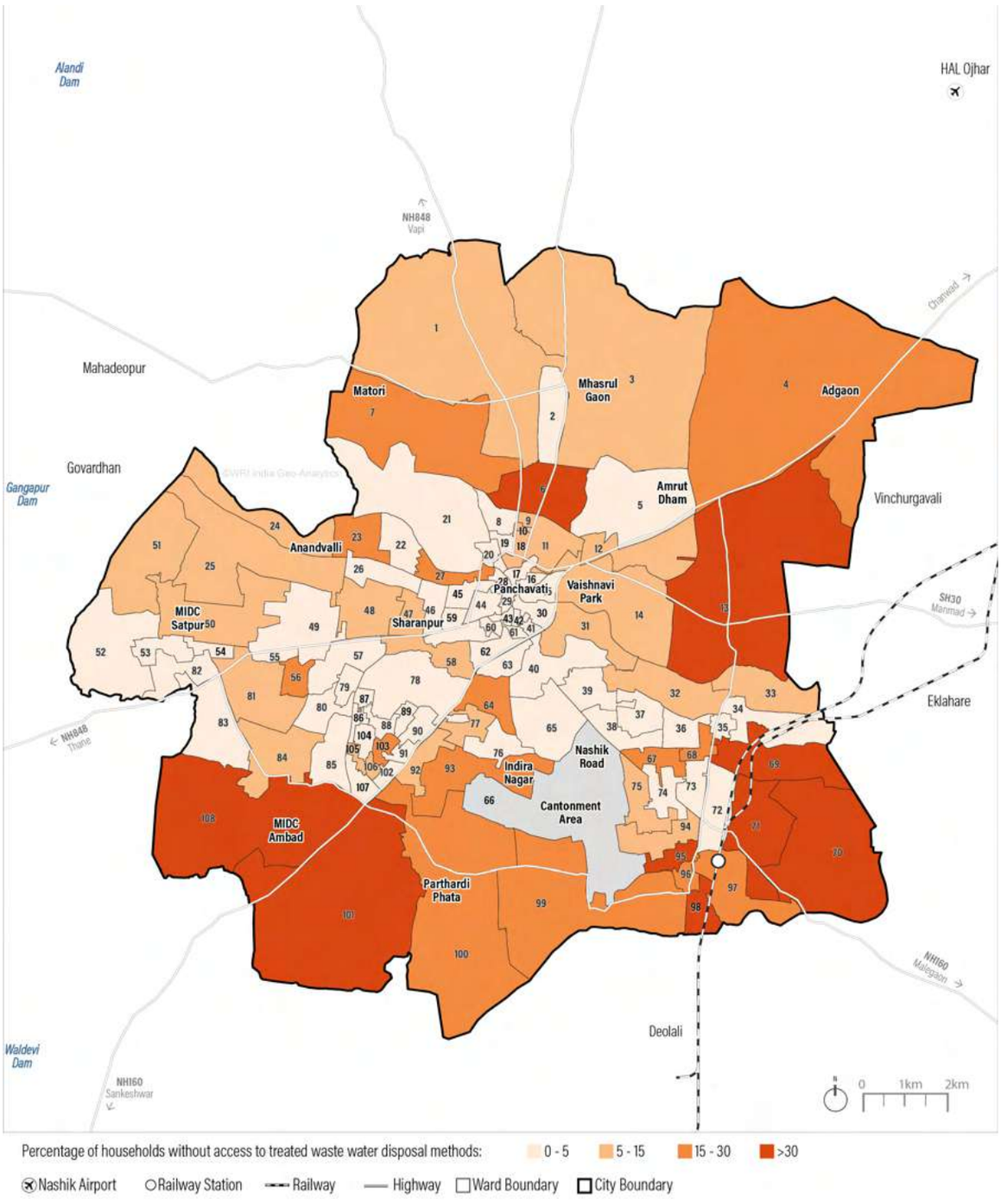
Annexure 2-26: Access to public toilets with respect to informal settlements



Source: Nashik Municipal Corporation, WRI India 2022

Note: Note: Average distance covered in 5 minutes in Indian condition is 400-500 metres for an adult (Bernard van Leer Foundation, 2018)

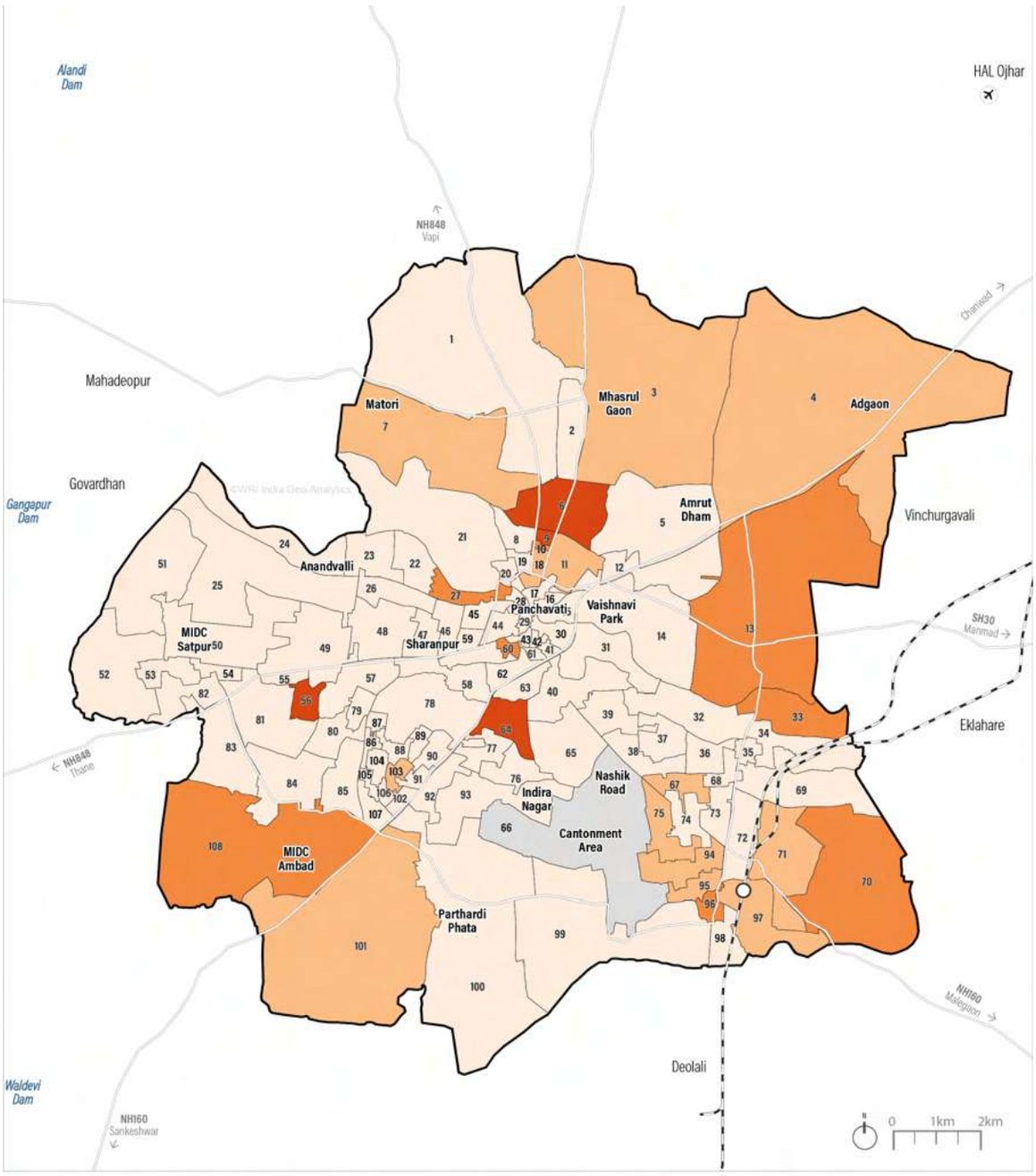
Annexure 2-27: Lack of treated wastewater disposal methods



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

Note: Households without access to treated waste water disposal methodss includes households with waste waster outlet connected with open drains and having no drainage.

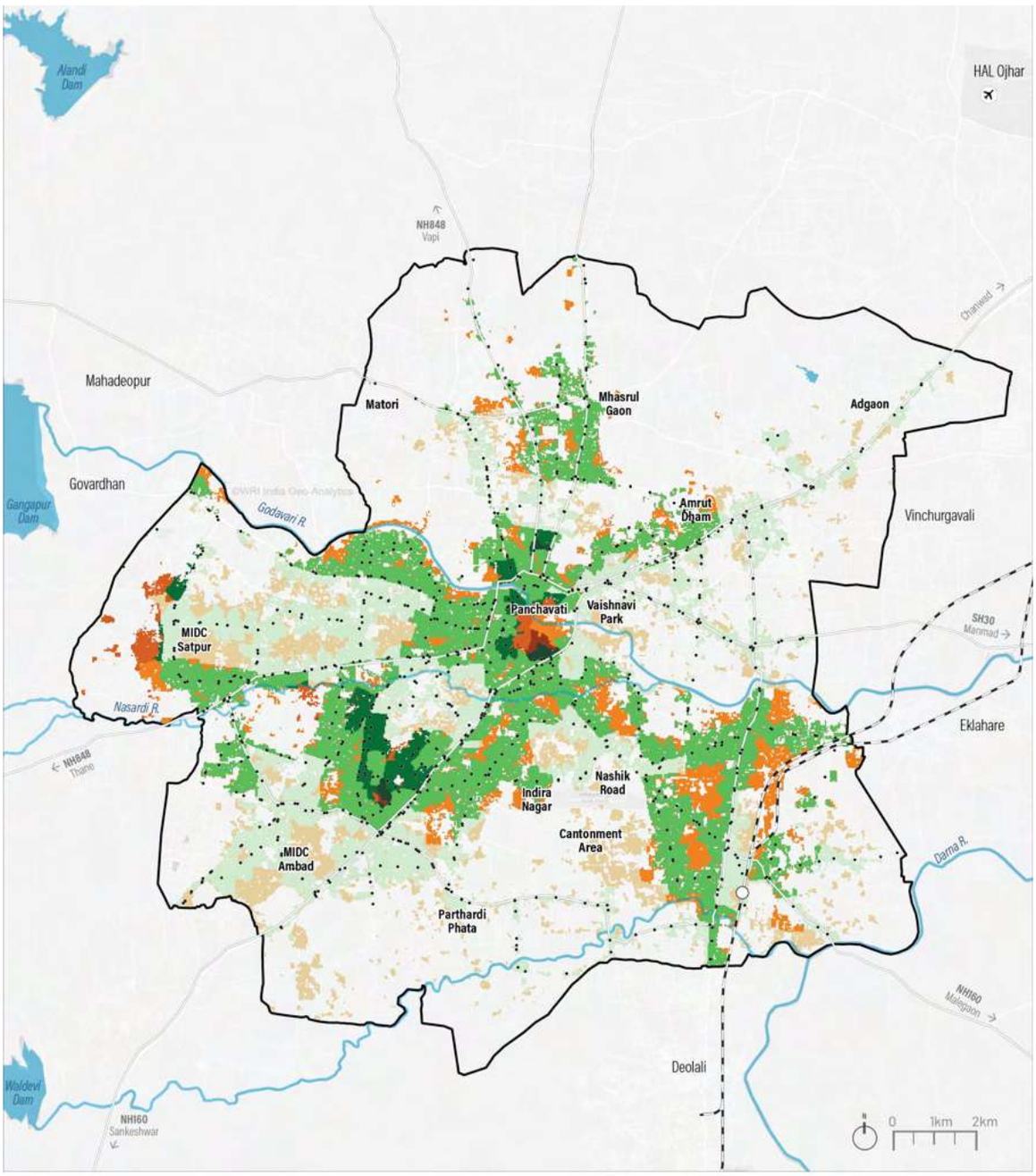
Annexure 2-28: Lack of Access to Electricity Grid



Source: Nashik Municipal Corporation, Census 2011, WRI India 2022

Note: Households without access to electricity includes households using Kerosene, other oil, any other material as their main source of lighting and households with no lighting.

Annexure 2-29: Access to Bus Stops



Population within 5 minutes walkable distance (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

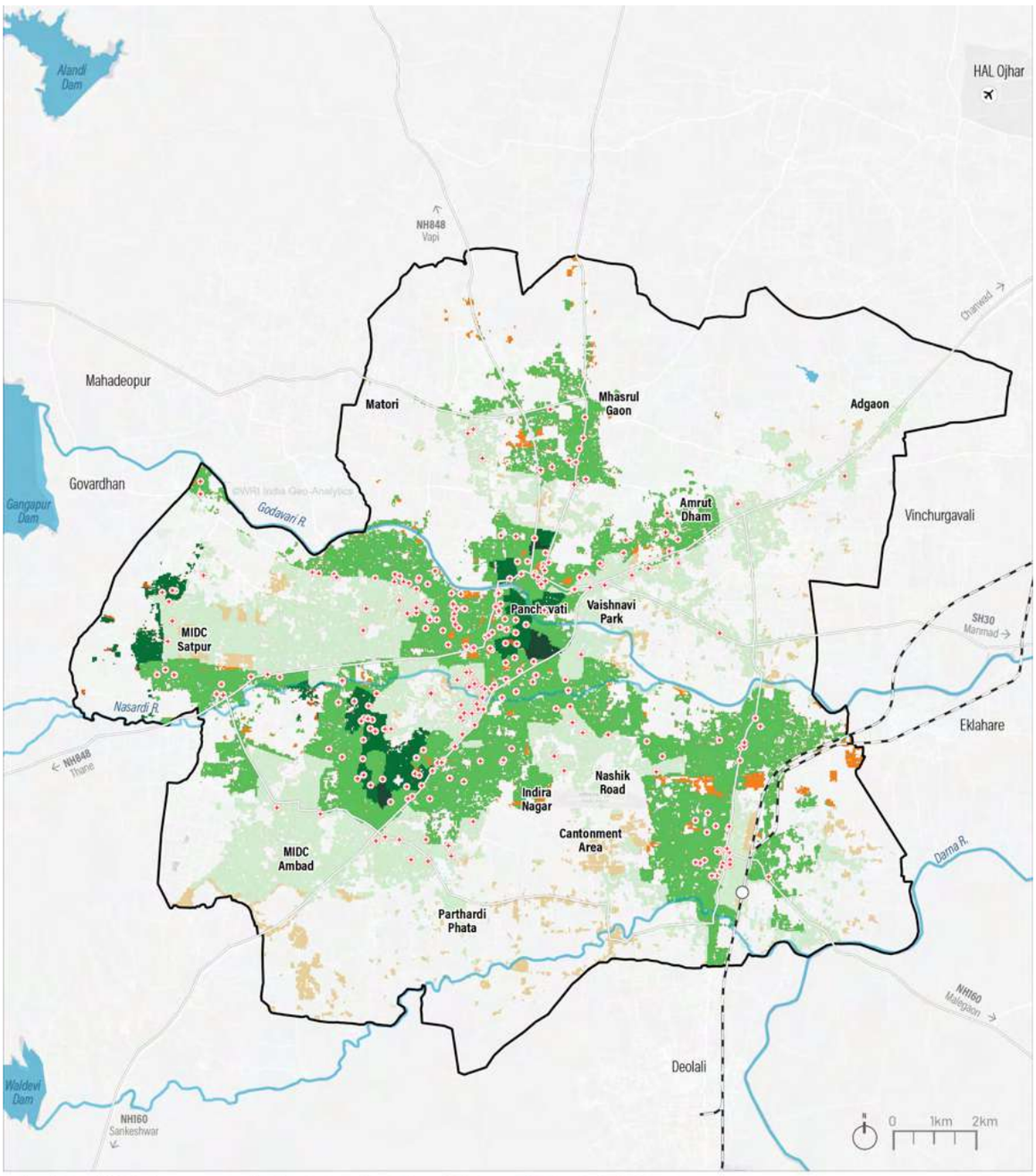
Population outside 5 minutes walkable distance (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

● Bus Stop | ⊗ Nashik Airport | ○ Railway Station | Railway Line | Highway | Waterbodies | City Boundary

Source: Census 2011, World Settlement Footprint Evolution; NMC; Nashik CITILINC 2021; WRI India 2022

Note: Average distance covered in 5 minutes in Indian condition is 400 - 500 meters for an adult (Benvard van Leer Foundation, 2018)

Annexure 2-30: Access to Hospitals



Population within 10 minutes response time (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

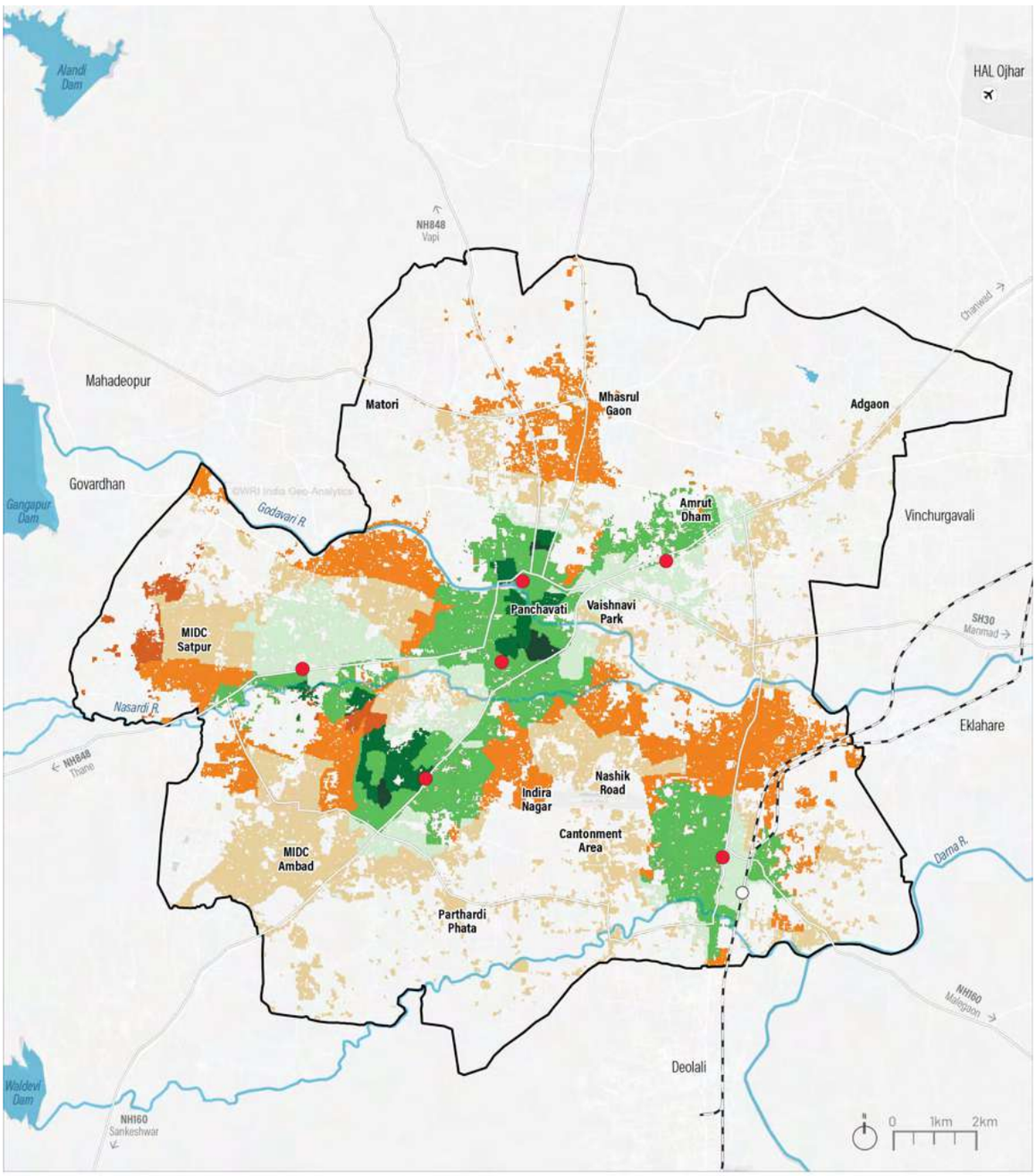
Population outside 10 minutes response time (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

Hospital | Nashik Airport | Railway Station | Railway Line | Highway | Waterbodies | City Boundary

Source: Census 2011, World Settlement Footprint Evolution; NMC; NIC 2018; WRI India 2022

Note: 1. As per the Working Group on Emergency Care in India- Ministry of Road Transport & Highways, the Emergency Medical Care network should have an average primary response time of 8 to 10 mins.
2. As per Comprehensive Traffic and Transportation Plan for Nashik 2017, speeds on the city road network are mostly around 30 kmph. Based on 8 minutes response time and average vehicular speeds throughout the city, 4 kilometre is observed as the service distance.

Annexure 2-31: Access to fire stations



Population within standard response time (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

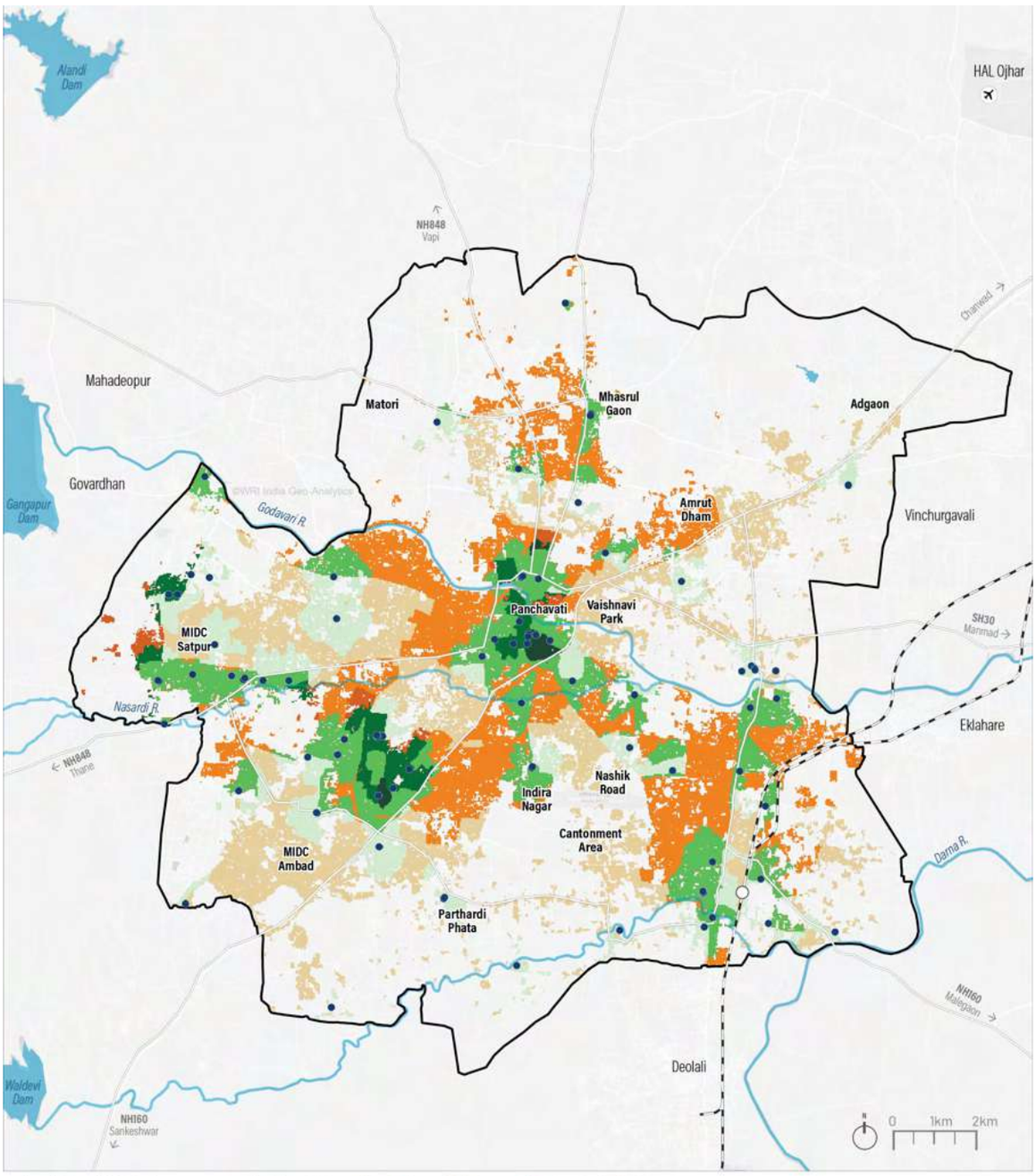
Population outside standard response time (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

Fire Station | Nashik Airport | Railway Station | Railway Line | Highway | Waterbodies | City Boundary

Source: Census 2011, World Settlement Footprint Evolution; NMC; WRI India 2022

Note: 1. As per the Standing Fire Advisory Committee (SFAC) under Ministry of Home Affairs, 5 to 7 minutes response time is considered ideal for fire stations in urban areas (ARDC, 2012).
2. As per Comprehensive Traffic and Transportation Plan for Nashik 2017, speeds on the city road network are mostly around 30 kmph. Based on 5 minutes response time and average vehicular speeds throughout the city, 2.5 kilometre is observed as the service distance.

Annexure 2-32: Access to Relief Shelters



Population within 10 minutes response time (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

Population outside 10 minutes response time (per 1,000 sq.m): ≤10 | 10 - 30 | 30 - 60 | >60

● Relief Shelter ⊗ Nashik Airport ○ Railway Station ⊶ Railway Line — Highway ■ Waterbodies □ City Boundary

Source: Census 2011, World Settlement Footprint Evolution; NMC, NIC 2018; WRI India 2022

Note: Average distance covered in 10 minutes in Indian condition is 800 - 1,000 meters for an adult (Benard van Leer Foundation, 2018)

3. Annexure 3: Vulnerability Assessment (VA) Process - Data Requirement

Annexure 3-1: Type of data required

What is city exposed to?	Who's sensitive to the risk?		Who needs to adjust to the potential risk?	
CLIMATE HAZARD **RISK** **Urban heat** **Air Pollution** **Rainfall & Lightning** **Droughts** Satellite Imagery IMD Disaster Management Dept. Fire Dept. MPCB & CPCB Town Planning Dept	DEMOGRAPHY AND SOCIO-ECONOMY City/wards/Prabhag boundary slum locations and area existing landuse **Demographic Context** • Literacy • Gender imbalance • Social composition **Socio-economic Aspects** **Physical Envirnoment Aspects** • House condition map • Access to daily urban recreation spaces **Infrastructure and service Aspects** • Access to drinking water • Access to Sanitation • Access to cooking fuel • Access to electricity • Access to public transit (bus) • Access to health care • Access to fire service	**Census dept.** **Town planning Dept.** **Electrical Dept.** **Water supply Dept.** **Sewage /Drainage Dept.** **Tax/GIS Mapping Dept.** **Public Health Dept.** **Education Dept.**	IMPACT ASSESSMENT **Impact on lives** • Population at risk due to flood • Population at risk due to heat • Social composition **Impact on livelihood** • Potential impactr on employment hubs • Migrant workforce due to flood and heat **Impact on Services** • Infrastructure exposed to hazard risks • Public transport stations with limited access • Infrastructure and property losses	**Town planning Dept.** **Water supply Dept.** **Sewage /Drainage Dept.** **Tax/GIS Mapping Dept.** **Disaster Dept.** **Waste Dept.**

Annexure 3-2: Source of required data

What is city exposed to?

CLIMATE HAZARD

RISK

Urban heat
- Landsat
- NCEI
- IMD

Air Pollution
- MPCB/CPCB
- Source Apportionment study
- Fire Dept
- NSSO?

Rainfall & Lightning
- IMD
- District Disaster Management
- Waterlogging Hotspots

Droughts
- District Disaster Management
- GSDA
- Public and Private Borewells

Who's sensitive to the risk?

DEMOGRAPHY AND SOCIO-ECONOMY

City administrative Limits
- Census Ward boundaries(98)
- Prabhag boundaries(26)

Slum/ Vulnerable Communities
- PMAY Slum Dept

LandUse/ Builtuse and Built-up
- TP Dept
- Satellite
- GIS Dept

Demographic Context
- Polpulation density

Socio-economic Aspects
- Literacy
  - **Location of schools**
  - **Effective literacy**
- Gender Imbalance
  - **Sex Ratio**
- Social Composition
  - **SC/ST Population**

Physical Environment Aspects
- Household Condition Map
- Access to urban recreational spaces

Infrastructure and service Aspects
- Access to drinking water
  - Tap water connections
- Access to sanitation
  - HH toilet access
  - Public toilets
- Access to cooking fuel
  - HH fuel
  - Quantity of wood/ Kerosene
- Access to electricity
  - Meter connections
- Access to public transit(bus)
  - Bus routes/ frequency
  - Locations bus stops
- Access to health care
  - Other data?
  - Public health dept
- Access to fire services
  - Fire dept

Who needs to adjust to the potential risk?

Impact on lives
- Population at risk due to flood
  - Waterlogging hotspots
- Population at risk due to heat
  - Satelite
  - Built-up GS dept

Impact on livelihood
- Potential impactr on employment hubs
  - Economic Census
  - ELU
- Migrant workforce due to flood and heat

Impact on Services
- Infrastructure exposed to hazard risks
- Public transport stations with limited access
- Infrastructure and property losses
  - Water supply Dept
  - Sewage/ Drainage Dept
  - Waste Dept
  - Transport Dept

- City Municipal Data
- Census 2011
- Primary / Secondary
- Satellite imagery
- Trendlines Agencies

4. Annexure 4: GHG Emissions Inventory - Data Requirement

Annexure 4-1: GHG inventory – sectors to be analysed

Stationary Energy*

- Residential buildings
- Commercial buildings and institutional buildings
- Manufacturing industries and construction
- Utility and streetlights

Transportation

- Road Transport: 4W, 3W, 2W Buses

Waste

- Municipal Solid Waste Management
- Waastewater treatment

Note: ***Excluded:** coal and fuelwood consumption, emissions from industries outside city boundary*

Annexure 4-2: Stationary Energy Sector Emissions - Type of data required

Data required	Stakeholders involved	Data format (FY 2010-2021)
LPG consumption and electricity consumption (HT and LT) with solar generation for • Residential Buildings • Commercial and institutional buildings • Public utilities: Streetlights, STPs, WTPs • Manufacturing and construction industries • Other sources	• State Electricity utility company (MAHAGENCO and MSEDCL) • Fuel agencies • Electric Department Municipal Corporation	• LPG sales in MT • HT and LT consumption (kWh) • HT and LT consumers • RE generation (kWh) Category wise

Annexure 4-3: Transport Sector Emissions- Type of data required

Data required	Stakeholders involved	Data format (FY 2010-2021)
• City-level fuel sales (petrol, diesel, Auto LPG, CNG)	• Fuel agencies BPCL, HPCL, IOCL, Go gas, Essar, Reliance	• Fuel sales (petrol, diesel in KL, Auto LPG in tonnes)

Annexure 4-4: Waste and Wastewater Sector Emissions- Type of data required

Data required	Stakeholders involved	Data format (FY 2010-2021)
• Annual waste generated • Annual waste composted/digested • Waste composition • Annual waste recycled • % of waste water treated and % that is directly discharged • Landfill in city	• Solid waste department • Sanitation department • Consultant managing waste water STPs	• Waste quantities in tonnes per day • Waste Composition as percentage • Amount of methane collected in tonnes/year from STP

5. Annexure 5: GHG Emissions - Scenario Analysis

Approach and methodology

The following steps provide the details of the planning of climate action in 5 steps using the CURB tool:

1. City Information and setup: In this step, the user must input basic information about the city, including the climate, area, base year and target years, and population. This is followed by sectoral information, which comprises the bulk of data requirements for the tool. The complete data requirements template can be found on the World Bank website.

2. GHG Inventory: This step involves entering a GHG inventory for the city in alignment with the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) framework. The GHG inventory is pivotal and informs the Business-as-Usual scenario for the city, estimating the emissions increase if no climate action is taken.

3. Context: This tab helps the user understand the main drivers for emissions and energy across each sector. It also allows users to benchmark the city's emissions performance with other cities compared by region, development index or climate.

4. Actions: This module is the crux of the tool and allows users to enter targets for different sectors and subsectors and develop scenarios by customizing and bundling multiple interventions into a comprehensive plan. The targets should be based on the city's authority to intervene in the sector and should ideally be verified with stakeholders. Along with emission and energy reductions, this module also provides the associated investment and payback period for each action. It also provides a general understanding of co-benefits associated with each action category.

5. Results: Finally, this module provides the combined impact of selected interventions as well as sectoral targets achieved. It also allows users to compare the impacts of different scenarios.

6. Annexure 6: Stakeholder Consultations

Annexure 6-1: List of important consultations

Date	Objective	Key agencies consulted and other details
14 Jan, 2022	Launch event	The launch event to propose the Nashik Climate Action Plan took place virtually, with various attendees across the state. This event was headed by the Ministry for Environment and Climate Change, Maharashtra, associated bodies, WRI India, and C40 cities, among others.
27 Jan, 2022	Singing of LoI	The Letter of Intent (LoI) for the Nashik Climate Action Plan was signed by the then Municipal Commissioner of Nashik, Shri Kailash Jadhav (IAS).
8 Feb 2022	Kick-off meeting	Commissioner, Public Health Engineering Dept (PHED), City engineer, fuel agency, zonal representatives
9 – 11 Feb 2022	Stakeholder Consultations - Data collection, validation, and discussion	Meeting with Solid Waste Management Dept (SWMD), Veterinary Dept, Gardens Dept, TATA Power, Nashik Smart city
20 Feb 2022	Stakeholder Consultations - Data collection, validation, and discussion	Meeting with MSEDCL, Regional Transport Office (RTO), Town Planning Dept (TPD)
13-18 March 2022	Stakeholder Consultations - Data collection, validation, and discussion	NMC's internal departments like water supply, SWM, transport, roads etc. and with fuel agencies
10-12 May 2022	Meeting with Government stakeholders, apprising them of CAP development process and hotspot mapping Data collection and field visit	Data collection and validation, site visit Public Works Dept (PWD), Water Supply Dept, Drainage Dept, Fire Dept, TPD
31 May- 2 Jun 2022	Validation of data collected from government stakeholders	Data validation and site visit Water Supply Dept, Drainage Dept, Transport Dept, CITILINC, TPD, IT Dept.
10 Aug 2022	Capacity building workshop on VA and GHG emissions inventory	Approximately 30 participants from NMC, Nashik Smart City Dev Corp, Nashik Waste Management Pvt. Ltd., MSEDCL fuel agency, etc.
9 Aug 2023	Presentation of draft Climate Action Plan	Approximately 20 participants from various departments of NMC and Nashik Smart City Dev Corp chaired by Hon'ble Municipal Commissioner of NMC.

A Capacity Building Workshop at NMC

Source: *WRI India*

7. Annexure 7: Notes on Climate Projections using RCP Scenarios

1. Background: The historical data (precipitation, minimum air temperature, maximum air temperature) has been obtained from the fifth generation European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis (ERA5) of the global climate at the spatial resolution of 0.25 degrees. The climatic projections are obtained through the process of running the GCMs under the Coupled Model Intercomparison Project Phase 5 (CMIP5) (Taylor, Stouffer, & Meehl, 2012) at a daily temporal scale for daily average maximum air temperature, daily average minimum air temperature and daily average precipitation. These modelled results are available for the four RCPs at a resolution of 0.125° x 0.125° to 5° x 5° varying based on the model simulations.

For RCP 4.5, the pre-downscaled projections dataset from NASA NASA Earth Exchange (NEX) - Global Daily Downscaled Projections (GDDP) - at a spatial resolution of 0.25 degrees x 0.25 degrees, have been utilized to decipher granular spatial variations. This dataset has been processed directly in Google Earth Engine at various study area domains for a comprehensive understanding of the climatic behaviour in terms of precipitation and air temperature for the future until the year 2100 for the defined epochs and entire study timeline.

For RCP 6, CMIP5 direct outputs have been obtained from the Program for Climate Model Diagnosis and Intercomparison (PCMDI) established at the Lawrence Livermore National Laboratory (LLNL), California. The data comprises of 13 model simulation outputs at varying resolutions up to 5° x 5°. The spatial analysis for RCP 6 has not been included due to the coarse resolution and unavailability of the downscaled product viable to understand the study area/ domain-wise spatial variations in the climate variables as considered for analysing RCP 4.5.

Caveat: The analysis is limited to consistently available data available from ERA5 and CMIP5 products for RCP scenarios 4.5 and 6. While the learnings from IPCC AR6 have been thoroughly nested in the Climate Change Resilience and Vulnerability Assessment of the city, the climate projections have not been revised with the Shared Socio-economic Pathways as updated in AR6, anchored extensively by the latest CMIP6 simulations, due to limited spatial products (all 21 GCM) available for the city at the desired (down) scale (PCMDI, 2022).

GCMs run using relatively coarse resolution grids (for Example, a few degrees or 10 KM2), which limits their ability to capture the spatial details in climate patterns that are often required or desired at regional or local analyses. Second, even the most advanced GCMs may produce projections that are globally accurate but locally biased in their statistical characteristics (i.e., mean, intensities, variance, etc.) when compared with real-time observations.

2. List of 21 models considered in the assessment (ESGF-LLNL, 2021): ACCESS1-0, CSIRO-MK3-6-0, MIROC-ESM, BCC-CSM1-1, GFDL-CM3, MIROC-ESM-CHEM, BNU-ESM, GFDL-ESM2G, MIROC5,

CanESM2, GFDL-ESM2M, MPI-ESM-LR, CCSM4, INMCM4, MPI-ESM-MR, CESM1-BGC, IPSL-CM5A-LR, MRI-CGCM3, CNRM-CM5, IPSL-CM5A-MR, NorESM1-M.

3. List of 13 models considered in the assessment: CCSM4, CSIRO-Mk3, GFDL-CM3, GFDL-ESM2G, GFDL-ESM2M, IPSL-CM5A-LR, IPSL-CM5A-MR, MIROC-ESM, MIROC-ESM-CHEM, MIROC5, MRI-CGCM3, NorESM1-M, bcc-csm1-1.

4. **Background:** For precipitation - Each day of the annual or desired epoch is temporally aggregated using the daily average precipitation values for each pixel (the smallest spatial unit). For comparisons between the study area/ domain, the temporal aggregates of the annual or the desired epoch are represented as spatial summation of each pixel within the defined study area/ domain.
For Temperature - Each day of the annual or desired epoch is temporally aggregated using the daily maximum and minimum average temperature values for each pixel (the smallest spatial unit). For comparisons between the study area/ domain, the temporal aggregates of the annual or the desired epoch are represented as spatial mean across all the pixels within the defined study area/ domain.

5. List of 4 models used for spatial illustration in Precipitation change: GFDL-ESM2M, IPSL-CM5A-LR, MIROC-ESM-CHEM, NorESM1-M. These have been used within the analysis to keep consistency with the WRI Aqueduct floods methodology (WRI, 2015).

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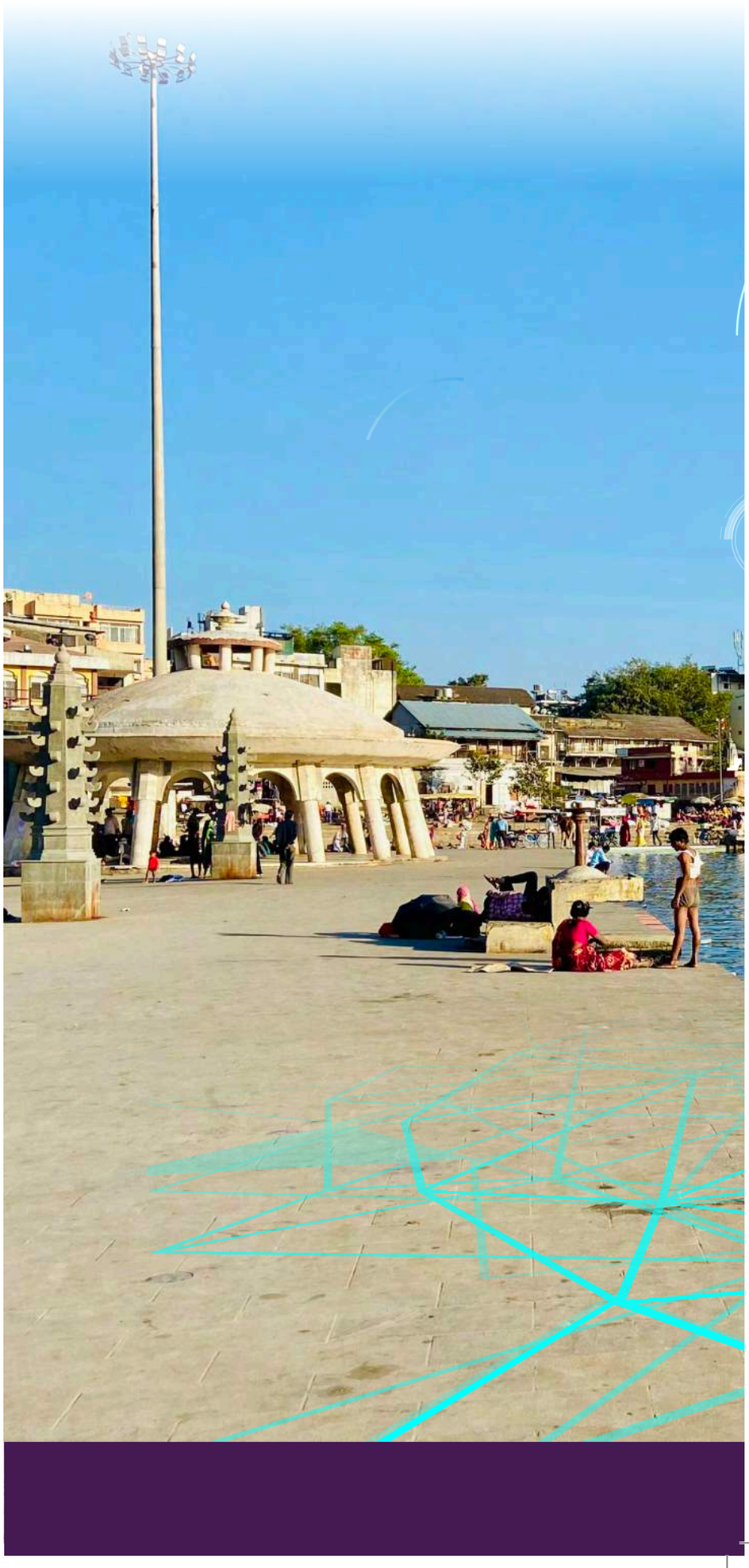

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