मिरा-भाईंदर महानगरपालिका
पर्यावरण विभाग

स्व. इंदिरा गांधी भवन, छत्रपती शिवाजी महाराज मार्ग, भाईंदर (प.) ता.जि.ठाणे - ४०१ १०१
ई-मेल : save.environs@mbmc.gov.in

जा.क्र.मनपा/पर्यावरण/ ११ /२०२५-२६ दि.१६/०४/२०२५

प्रति,
सिस्टीम मॅनेजर
माहिती व तंत्रज्ञान विभाग
मिरा भाईंदर महानगरपालिका

विषय :- मिरा भाईंदर महानगरपालिका क्षेत्राकरिताचा हवामान कृती आराखडा संकेतस्थळावर प्रसिद्ध करणेबाबत.

मिरा भाईंदर महानगरपालिका क्षेत्राकरिताचा हवामान कृती आराखडा मे. Aga Khan Agency for Habitat (AKAH) यांचेकडून प्राप्त झालेला आहे.

तरी सदर हवामान कृती आराखडा मिरा-भाईंदर महानगरपालिकेच्या संकेतस्थळावर प्रसिध्द करण्यात यावा.

(कल्पिता पिंपळे)
उप-आयुक्त (पर्यावरण)
मिरा भाईंदर महानगरपालिका

सोबत :-
१) मा. आयुक्त महोदयांचे स्विकृतीपत्र.
२) हवामान कृती आराखडा (PDF Format)

मिरा भाईंदर महानगरपालिका
MIRA-BHAINDAR MUNICIPAL CORPORATION

कार्यालय : स्व. इंदिरा गांधी भवन, छत्रपती शिवाजी महाराज मार्ग, भाईंदर (प.), ता. जि. ठाणे - ४०१ १०१.
दूरध्वनी: 022-28192828 / 28193028 / 28181183 / 28181353 / 28145985
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मुख्य कार्यालय

स्वातंत्र्याचा अमृत महोत्सव

जा. क्र. मिभा / मनपा /पर्यावरण/१८०/2024-25 दिनांक: 24/01/2025.

To,
Aga Khan Agency for Habitat (AKAH)
405A/407, Jolly Bhavan No.1,
New Marine Lines, Mumbai-400020

Sub. : Acceptance of Climate Action Plan (CAP) 2024-2050

Ref. : 1. Appointment of AKAH for Integrated Climate Action Plan, Flood Resilience, and Other Projects for Mira-Bhayandar Municipal Corporation Dt.06/06/24. (OW/MBMC/ADMC(1)/ 47/2024-25, Dt.06/06/2024)

2. Submission of draft Climate Action Plan for Mira-Bhayandar Municipal Corporation through an email Dt.19/12/2024.
3. A letter from AKAH Seeking Approval on Recommendations of Climate Action Plan Dt.10/01/2025.

Dear AKAH team,

I am pleased to inform you that the Mira-Bhayandar Municipal Corporation (MBMC) has formally received and accepted the Climate Action Plan, prepared by your team.

The Climate Action Plan outlines a comprehensive strategy that directly supports the vision of **Vikashit Mira-Bhayandar @2047** by tackling critical challenges such as the urban heat island effect and air quality. It aligns with Maharashtra's ambitious goals of achieving net-zero targets under the National Action Plan on Climate Change (NAPCC), focusing on key areas; Urban Flooding and Water Management, Urban Biodiversity and Greening, Energy and Buildings, Waste Management, Mobility, and Air Quality. This approach also reaffirms our shared commitment to sustainability and environmental stewardship.

मिरा भाईंदर महानगरपालिका
MIRA-BHAINDAR MUNICIPAL CORPORATION

कार्यालय : स्व. इंदिरा गांधी भवन, छत्रपती शिवाजी महाराज मार्ग, भाईंदर (प.), ता. जि. ठाणे - ४०१ १०१.
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मुख्य कार्यालय

स्वातंत्र्याचा अमृत महोत्सव

जा. क्र. मिभा / मनपा / /

दिनांक: _____

I commend your team for their diligent efforts and forward-thinking approach in crafting this visionary document. This initiative reflects the shared commitment between MBMC and AKAH to ensure a resilient and sustainable future for Mira-Bhayandar.

Thank you for your continued dedication to this critical initiative.

Warm regards,

(Sanjay Shripatrao Katkar, I.A.S.)
Commissioner & Administrator,
Mira Bhayandar Municipal Corporation

o/c

Cover Page

Mira Bhayandar
Climate Action Plan
2024 -2050

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List of Abbreviations

AEML	Adani Electricity Mumbai Limited
AMRUT	Atal Mission for Rejuvenation and Urban Transformation
BEE	Bureau of Energy Efficiency
BRTS	Bus Rapid Transit System
CAC	Climate Action Cell
CAP	Climate Action Plan
GHG	Greenhouse Gas
GIS	Geographic Information System
Ha	hectare
IGBC	Indian Green Building Council
IMD	Indian Meteorological Department
KW	Kilowatt
NCAP	National Clean Air Programme
NGO	Non-Governmental Organization
NZEB	Net Zero Energy Buildings
RWH	Rainwater Harvesting
JJM	Jal Jeevan Mission (Urban)
SCM	Smart Cities Mission
NMSH	National Mission on Sustainable Habitat
MSNA	Maharashtra Sujal and Nirmal Abhiyan
MSAPCC	Maharashtra State Action plan for Climate Change,
NCMP	National Cyclone Mitigation Project (NDMA),
NHP	National Hydrology Project
MoJS	
MoHUA	Ministry of Housing and Urban Affairs
EDGE	Excellence in Design for Greater Efficiencies
ICAP	India Cooling Action Plan
NMSH	National mission on sustainable

NEMMP	National Electric Mobility Mission plan
NUTP	National Urban Transport Plan
AMRUT	Atal mission for Rejuvenation and urban transformation
NBP	National Biodiversity Plan
NGC	National Green Corps
NAP	National Afforestation program
NCRMP	The National Cyclone Risk Mitigation Project
CSR	Corporate social responsibility
JJM (U)	Jal Jeevan Mission (Urban)
MSNA	Maharashtra Sujal and Nirmal Abhiyan
NCAP	National Clean Air Program

Acknowledgements

This section is to be added

Vision – **Resilient & Sustainable Urban Environment** by implementing comprehensive **Climate Action strategies**

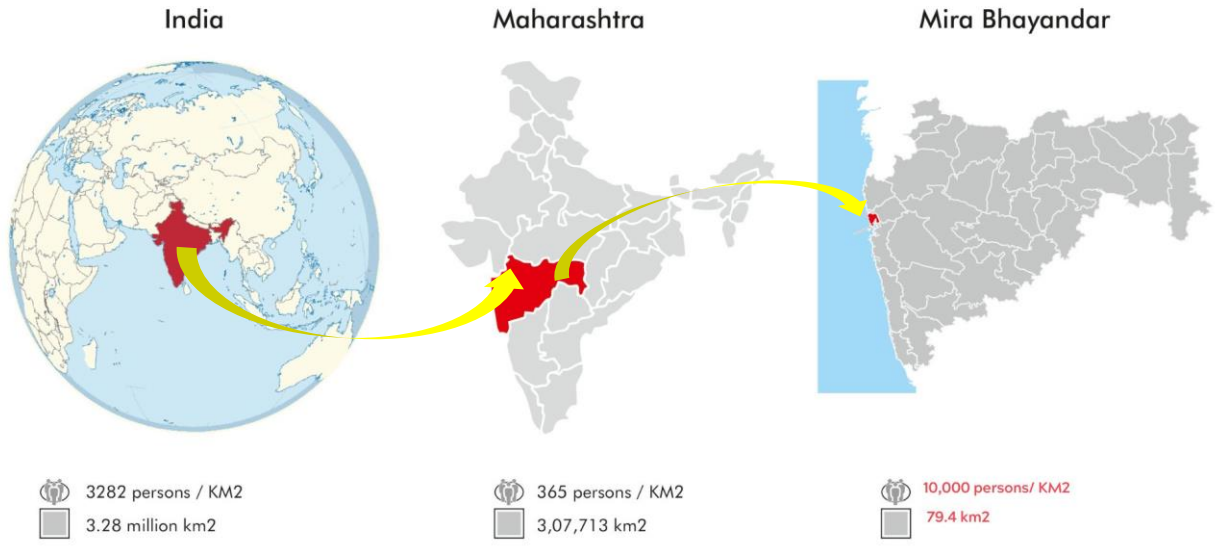
Chapter 1: City Profile of Mira Bhayandar

Mira-Bhayandar is an emerging city located in the north of Greater Mumbai.

Mira-Bhayandar is one of the major cities in the Mumbai Metropolitan Region (MMR) and is identified as a satellite city due to its proximity to Greater Mumbai and comparatively lower cost of living.

1.1 City Context

The rapidly developing city is an important growth center around Mumbai which is situated on the southern part of the Vasai Creek, with Sanjay Gandhi National Park on the east and the Arabian Sea on the west. It is at the mean sea level in the northern part of Konkan region. The city is connected with Mumbai by the Western Railway stations of Mira and Bhayandar which is accessed by 1 million[1] population daily to commute for job and other activities. It is also connected with the Dahisar area of Greater Mumbai by Western Expressway from Mumbai to Ahmedabad[2].



Mira Bhayandar spans over an area of **79.40 sq km** and has a population of **8.09 lakhs** as per the 2011 Census. The city is divided into East and West by the Mumbai Suburban Railway Line and governed by Mira Bhayandar Municipal Corporation.

[1] Comprehensive Mobility Plan, 2014

[2] Draft Revised Development Plan Mira Bhayandar (1997-2037)

The Western part of the city is mainly residential area while the eastern part is heavily dominated by small-scale industries. The city has a vibrant economy because of its small-scale industries, agricultural lands, fishing, sand and salt farming activities.

1.2 Ecological Landscape of Mira Bhayandar

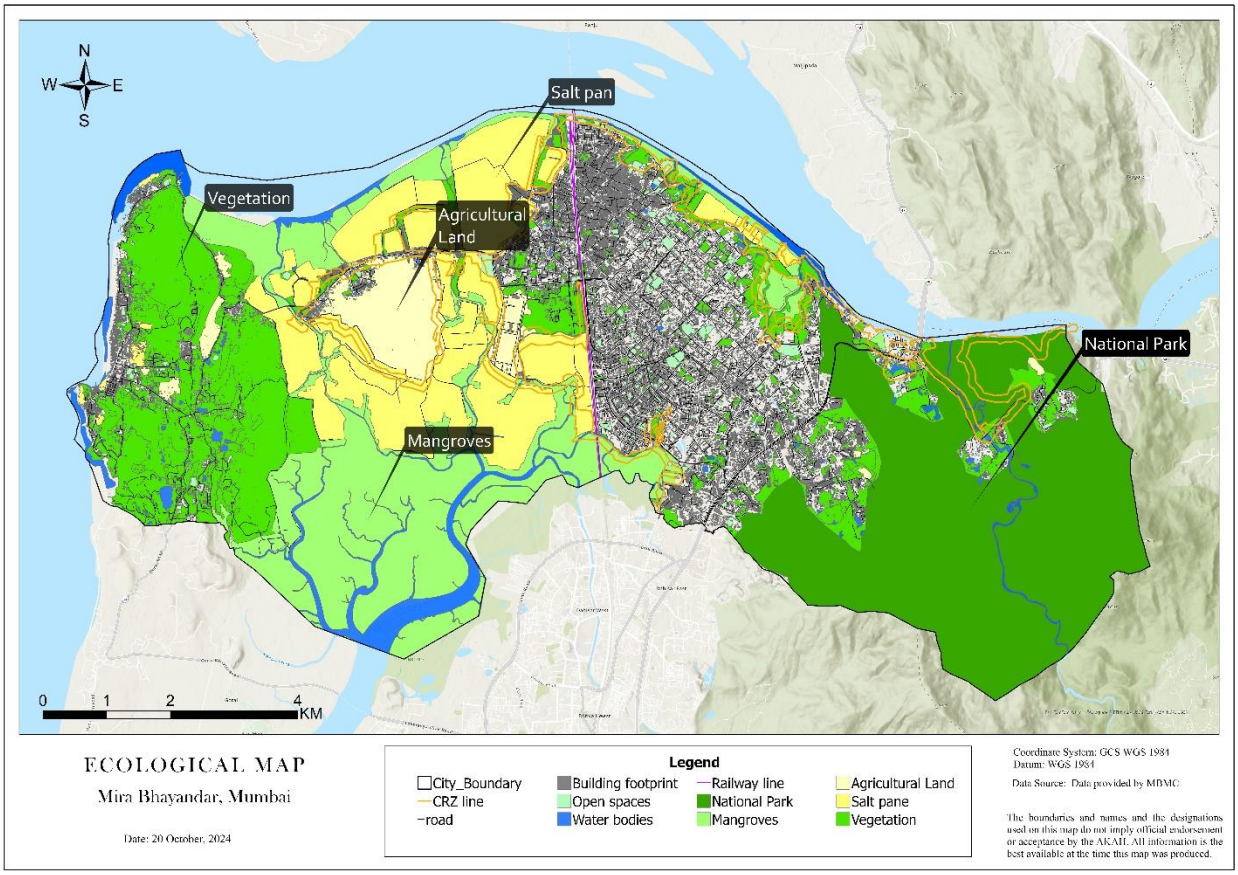


Figure 1: LULC Map for Mira Bhayandar (2000-2022)

Mira Bhayandar is located between 18 42'N – 20 20'N latitude and 0 25'E – 73 44' E longitude to the north of Mumbai. The Annual Mean Sea Level of the city is 3 meters. It is bounded by Sanjay Gandhi national Park to the east and Vasai Virar City to the north, Mumbai city to the south and engulfed by the Arabian Sea to the west. Geographically, the city is on plain-level land and situated in the northern part of Konkan region to the west of the Sahyadri hill ranges. The city falls in the Deccan lava terrain and Uttan, Ghodbunder and its eastern region are some of the hilly areas. The plain topography of the city gives to the marshy land on the west of Mira Road. The city has a well-functioning coastal ecosystem and natural drainage system including rivers, streams and forest areas and wetlands contributing to the overall flora and fauna and biodiversity. The rich mangrove forests occupying 396.82 hectares (6.12%) stands as a natural barrier to tidal surges on the eastern part of the city, controlling urban flooding and act as productive carbon sinks. Sanjay Gandhi National Park (SGNP) located on the east spread across 2566.71 Hectares (39.62% of the total area) is home to several endangered species and harbors around 1300

species of flowering plants, 43 species of reptiles, 45 species of mammals, including 38 species of snakes, 12 species of amphibians, 300 species of birds, and 150 species of butterflies[2]. The area extending from 100 meters to 4 km from the boundary of SGNP is notified as Eco-Sensitive Zone and few of the villages of Mira Bhayandar falls into the zone including Kashi, Mira, Chene, Ghodbunder and Versave.

A Coastal Zone Management Plan is underway for the city as dated in the notification released on 18th January 2019 by the Ministry of Environment & Forest Department of Government of India, No. G.S.R. 37 (E). Starting from the Vasai Creek to the Versave Village in the east, the area is proposed to be in the CRZ-I except for the existing development which will be included in CRZ – II along with the villages lining the coastline[3].

1.3 Urban landscape

In the Draft Revised Development Plan of Mira Bhayandar 2017-2037, the Existing Land Use reveals that the total developed area is 1736 Ha (26.80%), around 896 Ha (13.84%) developable area and 3845 Ha (59.35%) non-developable. Out of the developed area, the 647.62 Ha (10%) comes under Residential, 67.99 Ha (1.05%) under Commercial, 120.02 Ha (1.85%) under Industrial use, and 310.07 Ha (4.79%) under Mixed[2]. The public-semi-public areas consisting of land uses like Educational, Health services, Central and State Government properties, etc. is approximately 130.85 Ha (2.02%). Recreational land use such as Garden, park, playground, and swimming Pool is 63.78 Ha (0.98%)[2]. Transport and communication facilities consisting of the area under transportation, traffic-related land use, and communication constitute around 63.83 Ha (0.99%). The total roads are 304.17 Ha (4.69%) of the total Mira Bhayandar Municipal Corporation. Out of developable area, the agricultural land is 227.68 (3.51%) and 669.14 Ha (10.33%) vacant land of the total area. Out of the non-developable area, Wetlands covers 396.82 Ha (6.12%), Eco sensitive area which includes the area under mangrove and Sanjay Gandhi National Park covers 2568.66 Ha (39.65%) and the forest area is 0.311 Ha (0.005%)[2].

Mira Bhayandar is growing linearly because it has no scope for expansion on its south, west and East side for being surrounded by authorities like Thane Municipal Corporation, Vasai-Virar City Municipal Corporation, MCGM and Sanjay Gandhi national Park on the west and the sea on the east. The city is mostly developed along the railway line that runs through the heart of the city and connects Greater Mumbai with Mira and Bhayandar stations. National Highway 48 connects the city with MMR region and to all parts of Maharashtra and India. Apart from the road and railway network, the city has Mira Bhayandar Municipal Transport (MBMT) services operating across 20 routes and catering as a feeder system to people going to Mumbai and coming back to Mira Bhayandar. Majority of the travelers are dependent on two-wheelers (38%) in the city followed by auto-rickshaws (34%)[1].

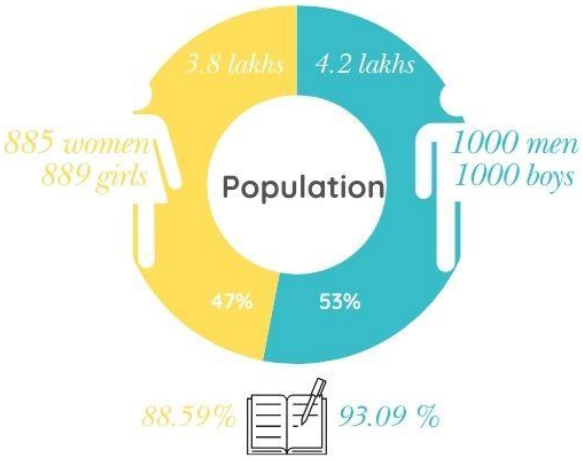
MBMC CAP has been developed for Mira Bhayandar. Write about its administrative

[3] Mira Bhayandar Environment Status Report 2022-2023

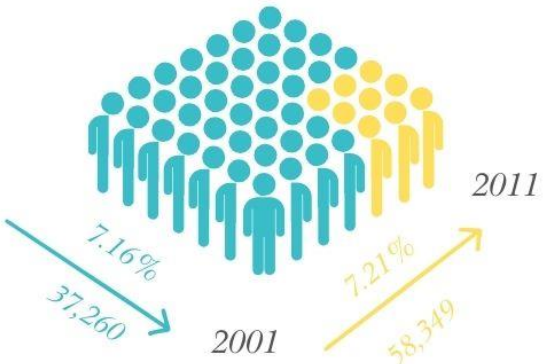
boundaries – zones and wards and municipal commissioner.

1.4 Social and Economic Context

1.4.1 Demographic Data



Total Population 8.09 lakhs



Slum Population

The city population is unevenly distributed with the majority clustered around the west of Bhayandar station and Gaothan where the gross density is 1131 persons per hectare.

The literacy rate of the city is 81.01% which is higher than Greater Mumbai (81%) and is close to the State average (82.34%) and higher than the National average (74%). The female literacy rate is 45.69% and for males 54.31%. As compared to Census 2001, the numbers indicate a slight increase in the female literacy and a drop-in male literacy rate in over a decade[2].

The sex ratio of Mira Bhayandar city is 885, which is higher than Mumbai (858) but lower than that of the State average (925) and National average (940) as per the Census

2011. However, the child sex ratio for the population below 6 years has marginally reduced from 900 to 898 from 2001 to 2011[2].

The area around Khari Gaothan situated on the east of Bhayandar station is also well-developed residential area that shows a gross density of 1129 persons per hectare. On the other hand, the areas along the west side of the coastline and the adjoining areas to the forest show the lowest gross density in the entire city.

Mostly the slum pockets are located in privately owned lands followed by Government owned lands and are majorly found in Bhayandar and Mira. These socio-economically vulnerable populations live in the extremes of the city such as along the railway track, peripheries of the forest, near water creeks and in low-lying areas prone to tidal flooding

1.4.2 Occupational Structure

According to 2011 Census data, there are 3,16,363 workers i.e., 39.09% of the total population while the remaining 4,93,015 are classified as non-workers. The percentage of the total working population increased from 1981 to 2011, i.e., 30.10% to 39.09%[2].

Workers are classified into main and marginal workers. 89.04% of the total workers are main workers while 10.96% are marginal workers as per the 2011 Census. The % of main workers have reduced from 96.26% to 89.04% in the last decade i.e., from 2001 to 2011 implying reduction in the long-term employment opportunities in the city.

Mira Bhayandar (2011 Census):

- Total Population: 814,655
- Total Workforce (Workers): 310,086 (approx. 38% of the total population)
    - Male Workers: 240,027[4]
    - Female Workers: 70,059

Types of Workers:

- Main Workers: People engaged in regular work for at least 6 months.
    - Total: 272,831 (around 33.5% of the population)
- Marginal Workers: People engaged in work for less than 6 months.
    - Total: 37,255 (around 4.5% of the population)[4]

The city is the hub of small scale-industries with the manufacturing and machine spare parts industries dotting the areas namely Saraswati, Mansarovar Complex, Kashimira and Bhayandar East. Most of the industries had come up in an unauthorized manner, developing haphazardly into an industrial slum and mainly catering to the big industries in Greater Mumbai.

Although there has been a steady decline in industrial activity with the introduction of industrial location policy and a paradigmatic shift has been noticed from agriculture to industries to the service sector in the city. However, the city has able to retain some of its traditional occupations such as agriculture, sand and salt farming, fishing and small-scale ancillary industries.

[4] Mira Bhayandar Population Census 2011-2024

1.5 Climatology

The city experiences an equable coastal climate, characterized by hot and humid summers (March to May) with maximum temperatures around 37°C and minimum around 22°C[3]. The monsoon season extends from July to late September, bringing light to moderate rainfall primarily from the southwest monsoon, though occasional precipitation occurs during the winter and pre-monsoon periods. Winters are mild, with maximum temperatures reaching 33°C and minimums dropping to 16°C. The overall temperature variation throughout the year is relatively narrow, averaging a difference of 6.8°C[3].

The dense urbanization in the center of the city coupled with reduced vegetation and water surfaces and anthropogenic activities has contributed to Urban Heat Island phenomena. The increased ambient temperature in the city during day and night times, particularly during summer months have profound effect on the socio-economic and health well-being of the population especially the outdoor workers, slum dwellers, women, children and elderly.

1.6 Administrative Structure

The administrative evolution of Mira Bhayandar has transformed it from a Gram Panchayat system to a Municipal Corporation (MBMC). Mira Bhayandar Municipal Council was formed on 12th June **1985** by the merging of five Gram Panchayats namely Bhayandar, Navghar, Kashimira, Ghodbunder, Khari, Mahajanwadi, Penkarpada and Goddeo. The city expanded rapidly from 32 sq km from **1981** to 79.40 sq km in **2011** and extending its limits to adjacent 10 Gram Panchayats namely Chene, Rai-Murdhe, Morwa, Uttan, Dongri, Pali, Tarodi, Chowk, Versave and Murde. In **2002**, the urban local body transformed into Municipal Corporation to cater to the needs of its burgeoning population[2].

The Municipal Corporation comprises 24 electoral wards, each represented by elected members, with provisions for women's representation. MBMC oversees essential services such as water supply, sewage, road maintenance, solid waste management.

Chapter 2: Mira Bhayandar's Baseline Assessment - GHG Inventory

2.1 Methodology for GHG Emissions Inventory

GHG methodology - BASIC approach

2.2 Critical Sources and Sinks

In 2023, Mira GHG emissions were 1.34 million tonnes of Co2e or 1.12 tonnes of Co2e per person, an increase from 0.89 million tonnes of Co2e in 2020. The GHG emissions inventory is developed in compliance with the Global Protocol for Communities (GPC) BASIC standards. The city's GHG emissions inventory mainly includes three GHGs – Carbon Dioxide (Co2), Methane (CH4) and Nitrous Oxide (N2o), SF6, NF3 and F-Gases. The inventory was calculated for the entire city spanning across 79.4 sq km.

For the Mira Bhayandar Municipal Corporation, emissions are taken from three critical source.

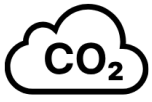
i) Stationery Energy ii) Transport iii) Waste

Around 62 % of the city's total emissions are from stationery energy, followed by 22% from the transportation sector and 16% from the waste sector.

2.2 Stationery Energy

The stationery energy sector contributes to 0.83 million tonnes of CO2e and accounts for 62% of the total emissions in the city. This sector covers the following

i) Residential Buildings
ii) Commercial and Institutional Buildings
iii) Construction and Manufacturing Industries



8,26,777 Tonnes CO2e

Emissions (2023)

4% CAGR Increase

Population Growth

21% increase in emissions

2021 to 2023

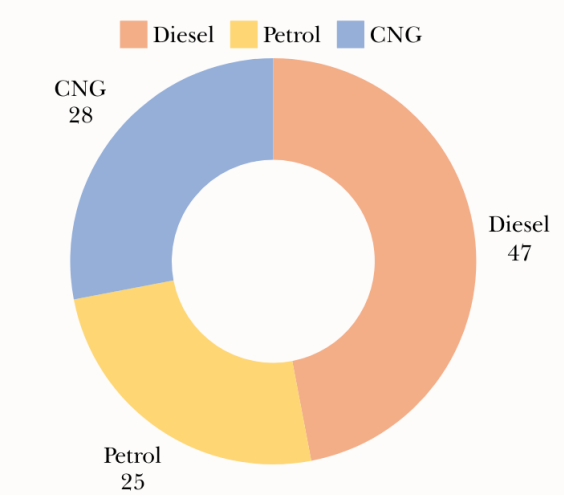
96%

Electricity's share

Energy Sector

CAGR - Compound Annual Growth Rate

Electricity falls under Scope 2 of emissions covering grid-supplied energy in the city. Out of the 62% of the emissions from stationary energy, 96% are from electricity consumption at the city level. The rest 4 % are from 'Other Sources' such as PNG, LPG, coal and kerosene. The residential buildings account for 0.54 million tonnes of CO2e which is 65% of the total stationery energy. The commercial and institutional buildings account for 0.17 million tonnes of CO2e which is 20 % of the total stationery energy.



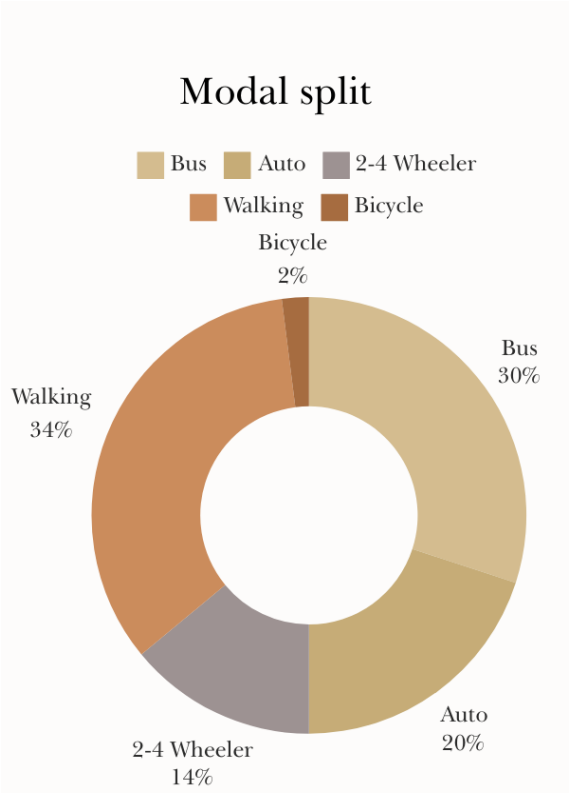
Total Emmisions in 2023

5 % increase in emissions from 2015 to 2023

2.3 Transportation

The transport sector contributes to 0.27 million tonnes of CO_2e and accounts for 22 % of the total emissions in the city. Road transportation is calculated in the GHG emissions inventory.

Transport falls under Scope 1 of the emissions covering stationary fuel combustion and in-boundary transportation for Mira Bhayandar city. The emissions from the transportation sector have been mainly from fuels such as CNG, Petrol and diesel. The on-road transport includes two-wheelers, autorickshaws, cars/taxis. Buses, trucks and others that are heavily dependent on diesel contribute 46.67% of the total emissions from the transportation sector. The number of Electric Vehicles is minimal at this stage in the city and there is a need to transition to low-carbon based eco-friendly vehicles. The vehicles dependent on CNG fuel are Intermediate Public Transport (IPT) namely three-wheelers and taxis contributing to 26.68% of the total emissions from the transportation sector.



Under NCAP 20 EV Buses are already procured, 58 more are proposed for the upcoming year

2.4 Waste

Waste sector contributes to 0.22 million tonnes of Co2e which accounts for 16 % of the total emissions in the city. The emissions are calculated from two sectors – solid waste disposal and wastewater. The Solid waste disposal contributes to 1.12 million tonnes Co2e million tonnes of Co2e (52% of the total emissions from waste) and the wastewater contributes to 1.06 million tonnes of Co2e (48% of the total emissions from waste).

Chapter 3: Mira Bhayandar's Baseline Assessment

3.1 Urban Heat

An analysis of the LULC in Mira-Bhayandar city was conducted to evaluate the spatial distribution and temporal changes in land use patterns associated with diverse socio-economic activities. The city has developed exponentially with a rapid increase in built up area from 5.52% in 2005 to 11.28% in 2022, indicating a 50.05% increase in 17 years as shown in figure 2. The Urban Heat Island Effect is prominently experienced in the city due to the high concentration of population, densely packed buildings made of low albedo materials such as concrete and asphalt, loss of natural surface as well as the loss of green cover, greenhouse gases emissions from the anthropogenic activities which traps heat in the atmosphere.

The vegetation within the main built-up area has drastically reduced to 13.6% in 2022 even though the vegetation cover at the city level has increased to 25% owing to the presence of Sanjay National Gandhi Park, mangroves and creeks which act as major carbon sinks for the city. The Land Surface Temperature map as shown in figure 6 indicates the major heat islands in the city. The barren lands/salt pans which spans across 12.3 sq km in the city in the west and the main built-up area recorded a temperature in the 37 – 47-degree Celsius range, releases a substantial amount of heat leading to higher temperatures during the day and night. On the other hand, the areas lying outside namely the dense forest cover of Sanjay Gandhi National Park in the east and mangroves and creeks adjoining the Arabian sea in the west have a comparatively cooler temperature between 35 – 30 degrees Celsius.

Major Headlines

Owing to the 50.05% increase in the built area and 13.6% decrease in the vegetation cover, two of the major contributing factors UHI, there has an observable temperature increase of 0.46 degrees Celsius between 2005 and 2022. (Figure 2)

According to the LULC data, there has been a 50.05% increase in built up area and 13.6% decrease in the vegetation cover contributing to an observable temperature increase of 0.46 degrees Celsius between 2005 and 2022.

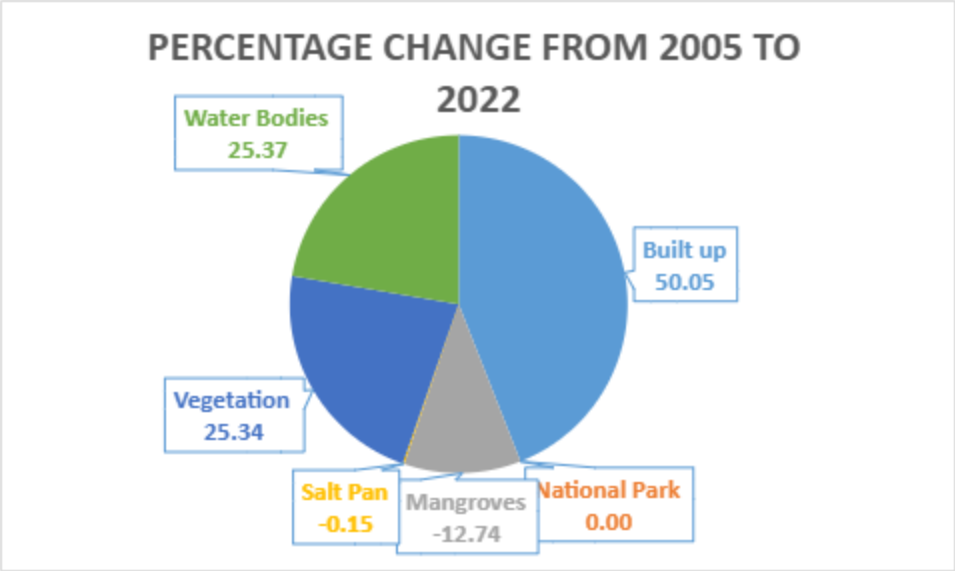


Figure 2: Percentage change in LULC Categorization between 2000-2022

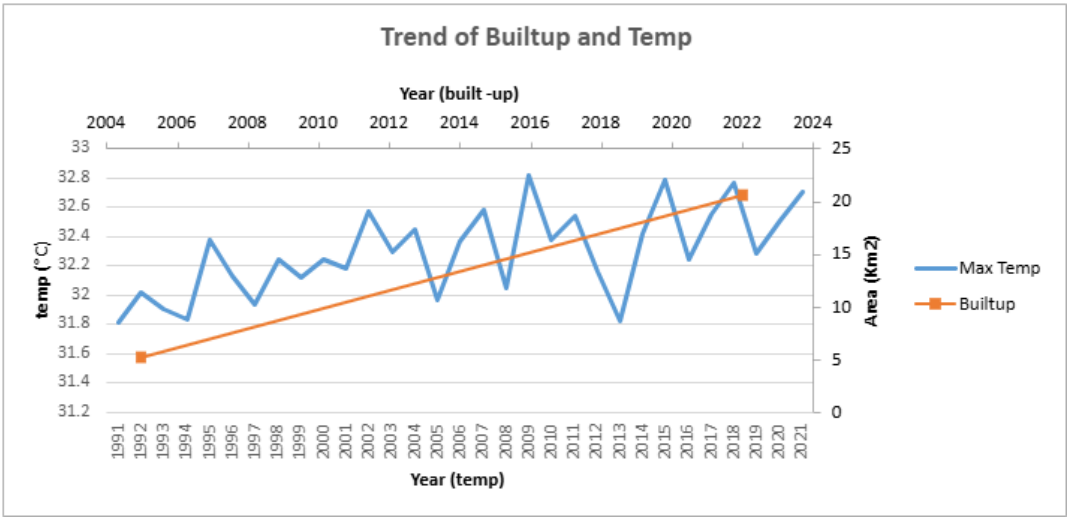


Figure 3: Trend of Built-Up Area and Temperature in Mira Bhayandar between 1991 and 2021

The Figure indicates the increase in a built-up area and the excessive use of building construction or roofing materials which has low albedo (*Low reflectivity capacity*) trapping more heat in the area. The Albedo data was analyzed by computing different band of Landsat 7 ETM+ over the years 2000 to 2023 and it was found to be reduced to 0.1 whereas the annual temperature increased by 0.46 degree Celsius. This indicates that Albedo has an inverse correlation with LST concerning roofing materials. Changes in the roofing material to higher albedo materials can play an important role / is one of the game changers in tackling/mitigating UHI in heat stressed zones.

The housing typology in Mira Bhayandar contributes significantly to the Urban Heat

Island effect. Across the city, 69% of roofs are made of heat-retaining materials like asbestos or corrugated metal sheets, 29% are concrete, and only 2% are clay, which offers better thermal regulation. In high-density wards namely 3, 4, 5, 6, 7, 20, and 22, buildings are packed closely together, further trapping heat. Slum settlements within these areas are highly cluttered with minimal space for ventilation, limited access to open, green spaces and waterbodies, exacerbating heat stress. The heat-absorbing asbestos sheets further height indoor temperature which negatively impacts the health of the household members, forcing them to make out-of-pocket expenditure for installing cooling solutions or visiting hospitals. It also affects their productivity during working hours.

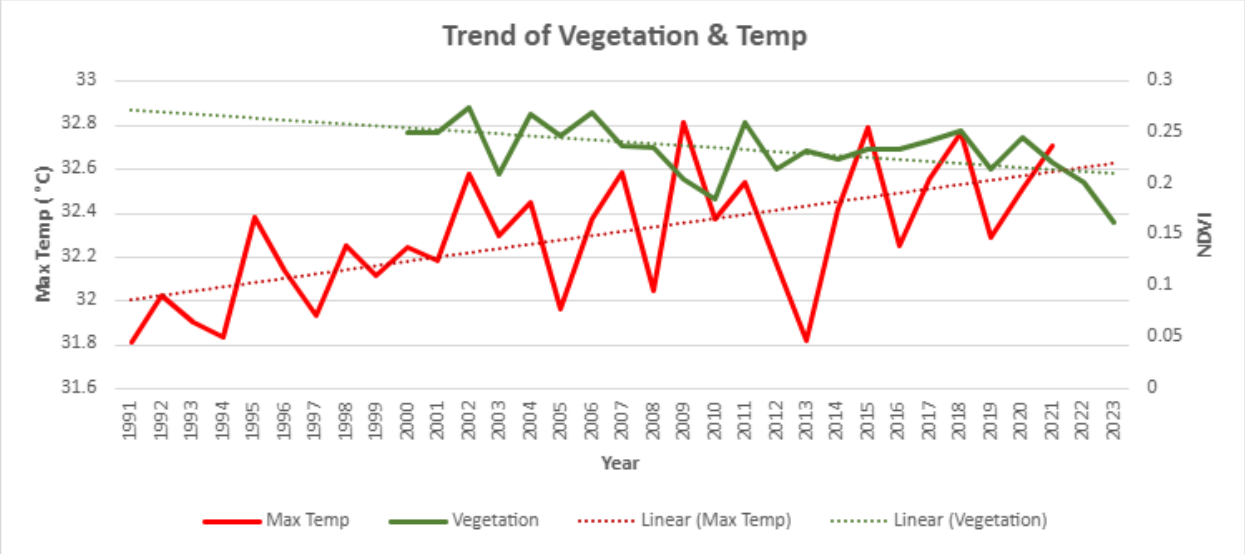


Figure 4: Trend of Vegetation and Temperature in Mira Bhayandar between 1991 and 2023

The Figure 4: show the inverse relation between LST and NDVI (vegetation cover within the built-up area) and the findings can be further understood with the help of UTFVI analysis as shown in figure 7 indicates that the areas with highest temperatures have the poorest ecological conditions (green cover and water surfaces) resulting in higher UHI and vice versa.

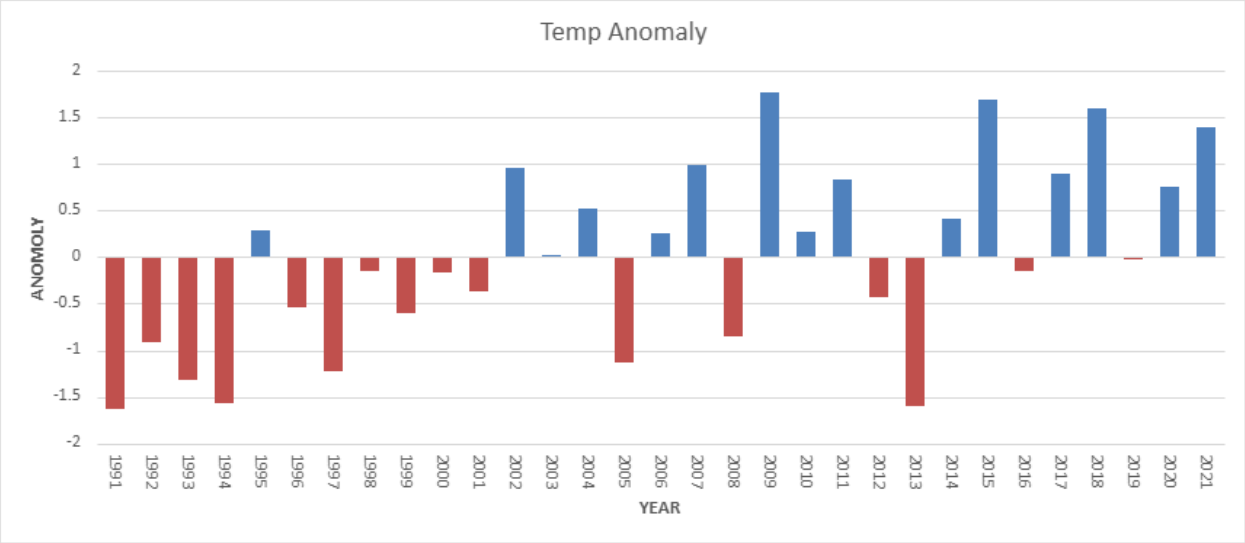


Figure 5: Temperature Anomaly calculated between 1991 and 2021 for Mira Bhayandar

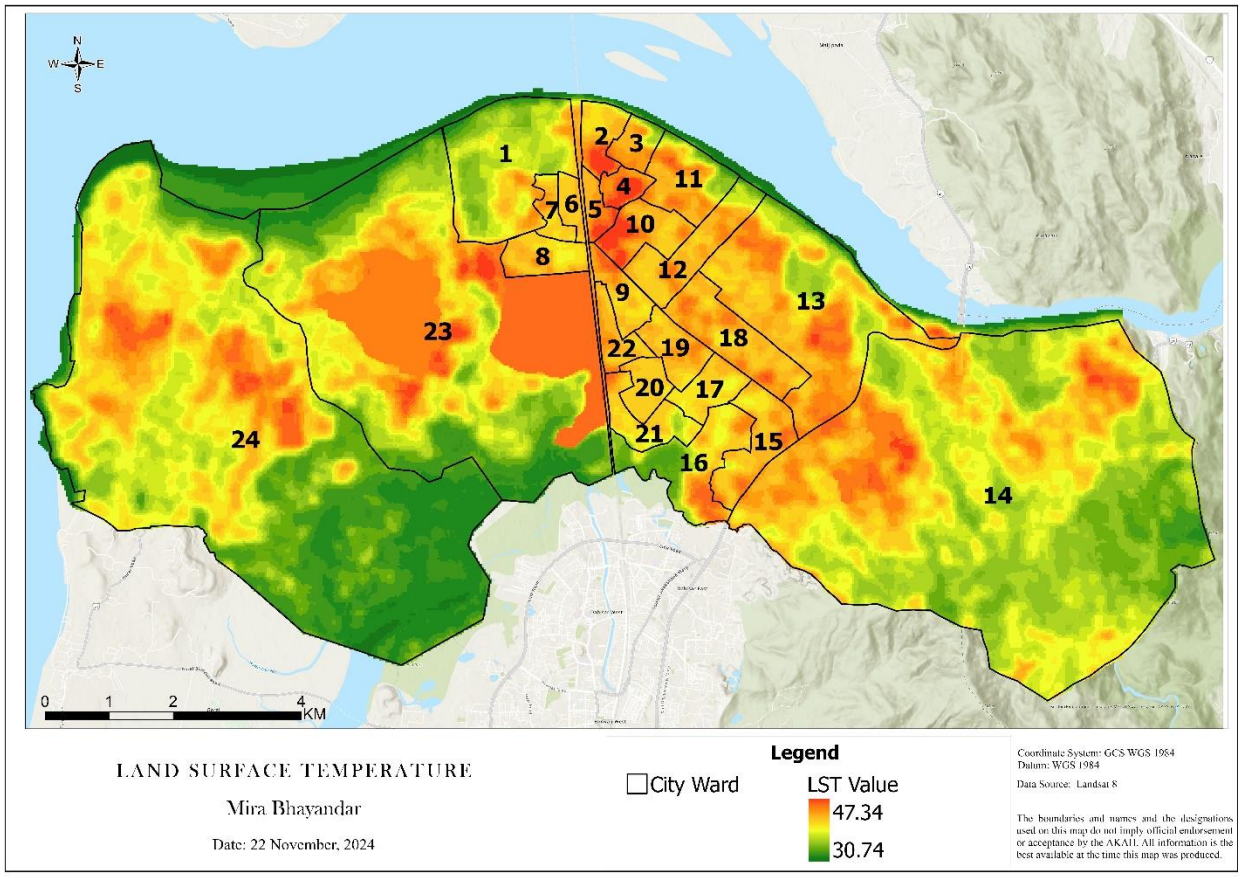


Figure 6: Land Surface Temperature for Mira Bhayandar City

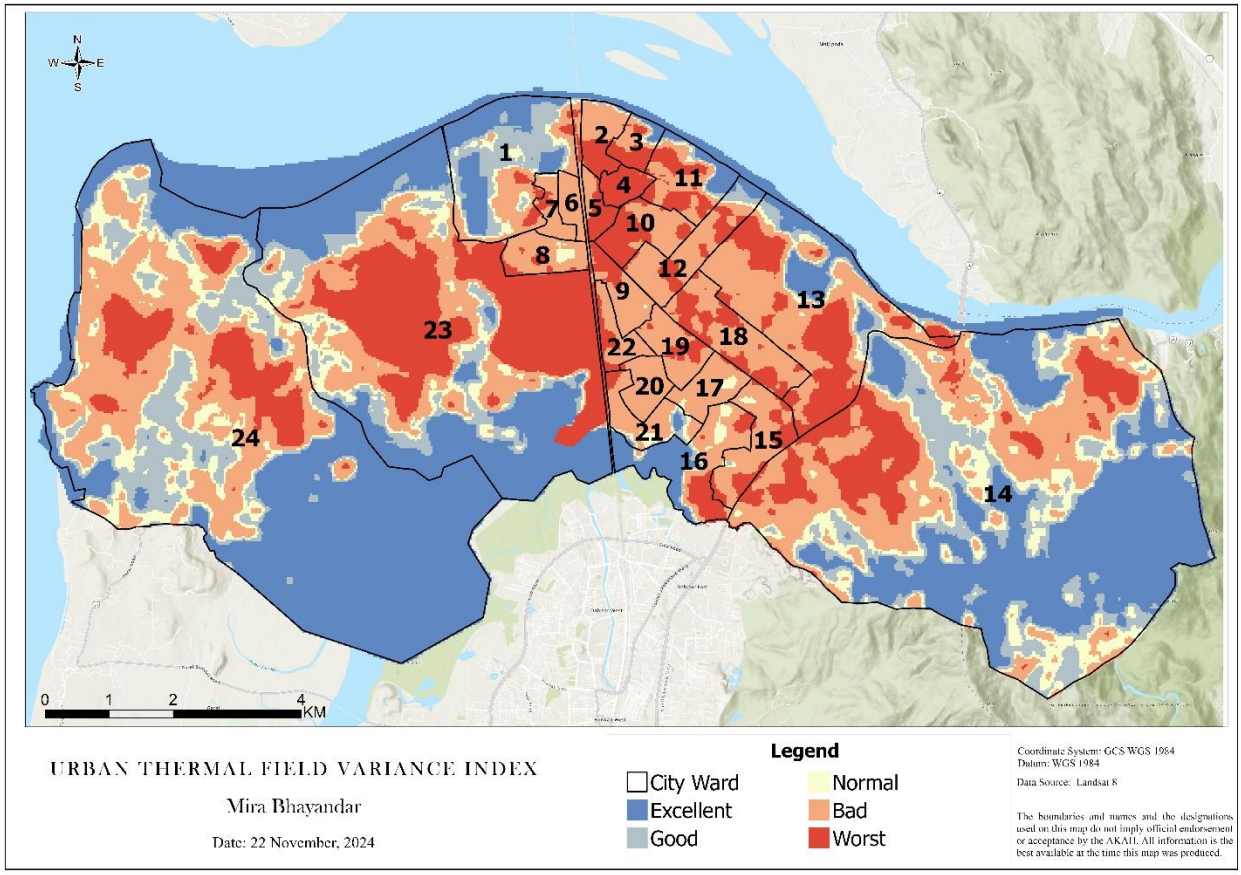


Figure 7: Urban Thermal Field Variance Index for Mira Bhayandar City

3.2 Urban Flood

The city mainly experiences light to moderate rainfall as observed in the decadal data where the frequency of rainfall events between 1991-2021 was analysed. On an average, Mira Bhayandar has experienced 3 very heavy events, 7 heavy events, 26 moderate events and 40 light events. The years 2005, 2010 and 2019 have received the peak rainfall as shown in the figure 23. Although the city not face flooding challenges caused due to heavy rainfall, storm surges, overflow from dams or riverine flooding. It majorly faces waterlogging issues caused due to undulated and clogged drainage system, poor discharging capacity of accumulated water during peak rainfall time. These are the main causes of urban flooding in the city.

The map above illustrates the flood risk distribution across Mira Bhayandar city, providing a clear indication of areas that are more physically exposed and susceptible to flooding. The analysis shows that 25% (20 sq km) of the total city area falls under the "very high risk" category, while 40% (31.8 sq km) is classified as "high risk." Additionally, 22% of the city area falls under "moderate risk," 21% under "low risk," and 6.4% under "very low risk." This data highlights that a substantial portion of the city's area is at "high" to "very high risk of flooding" as shown in the figure 23. These areas are characterized of low-lying topography, which naturally makes them more prone to

water accumulation during heavy rainfall. Furthermore, these regions often lack sufficient vegetation cover, which is critical for absorbing rainwater and reducing surface runoff. The dense urban development in form of buildings and concretization of roads in these zones significantly limits water infiltration into the ground and causes waterlogging. There are in total 72 waterlogging points in the city with ward no. 13, 20, 23, 10, 4 at higher risk of urban flooding than the rest.

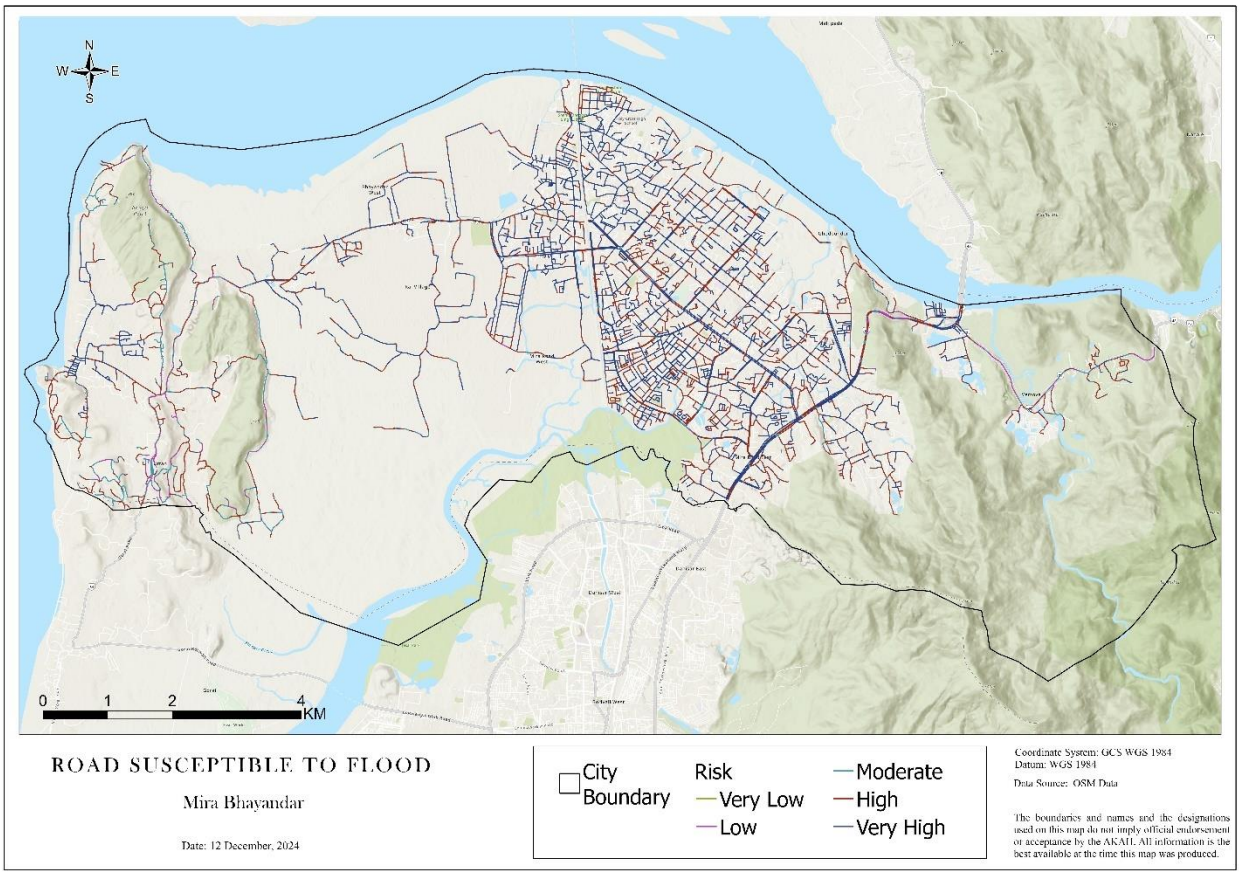


Figure 8: Flood Risk Profile of Roads in Mira Bhayandar

The city has no stormwater drainage system and the rainfall accumulated water is discharged into the creeks majorly located in the north through the existing drainage lines. The drainage network in Mira Bhayandar covers 50.24% of the total road network as shown in figure 8, and many parts of the drainage system have lower discharge capacity which hinders efficient handling of the runoff during peak rainfall. As a result, excess water accumulates on the roads causing water stagnation which in turn disrupts daily life and results in damages and losses to businesses, properties and livelihoods. This disruption negatively affects the local economy, impede transportation of goods and services due to submerged roads. Moreover, stagnant water

often seeps into houses, damaging property, posing health risks due to the spread of waterborne diseases and causing inconvenience to the residents.

Furthermore, the flowing runoff bring debris clogs the drainage lines. This creates a cyclical issue where clogged drains reduce their capacity even more, making the lines increasingly ineffective over time. Such conditions also contribute to the weakening of the road surface, necessitating frequent repairs and increasing maintenance costs.

3.3 Coastal Risk

The coastline of Mira Bhayandar has eroded by 0.5 km in the past 15 years (2008 to 2023) as shown in the figure 9. The decretion of the coastline is attributed to soil erosion and other natural processes at the mouth of the Vasai Creek in the north. On the western side, the coastline has experienced both accretion and decretion, influenced by natural and anthropogenic processes.

The decrease in the coastline has profound socio-economic ramifications on the fisherfolk community who have to now venture far out into the sea to catch fish in the riparian zone. Approximately, 30,000-40,0000 fishermen reside near the western coastline dependent on the sea for their livelihood. These climate-induced coastal risks not only threaten the livelihoods and food security of the vulnerable communities but also displaces them, leading to social instability.

Mira Bhayandar city is strategically placed in the center where it is well protected by mangroves in the upper north and south. The mangroves act as natural barricade to storm surges and does not allow sea water to enter in city, hence mitigating the effects of storm surges. The mangroves lining the upper northern and south-western coast of the city has found to be increased by 2.82 sq km on the southern part of the city as compared to the northern area along the Vasai Creek where there has been decrease by decreased by 1.66 sq km between 2000-2022 as shown in the figure 10. The area is totally untouched by urbanization due to which the density of the mangrove has increased and also the efforts of city administration in carrying out the extensive mangrove plantation activities with over 15 varieties of species.

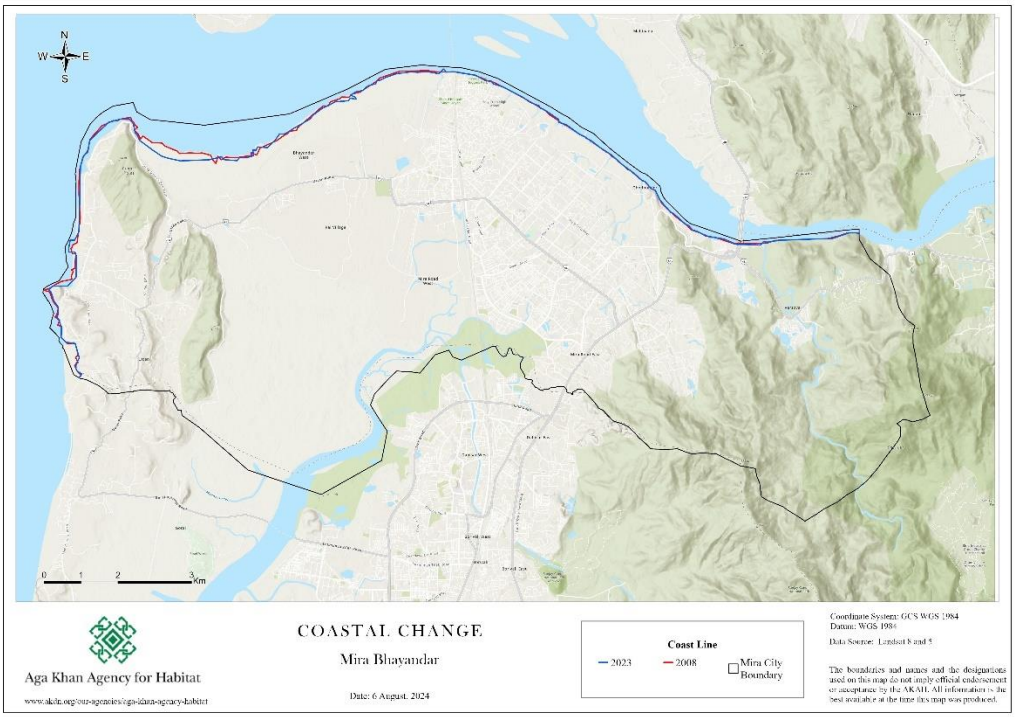


Figure 9: Coastal Change in Mira Bhayandar observed from 2008 to 2023

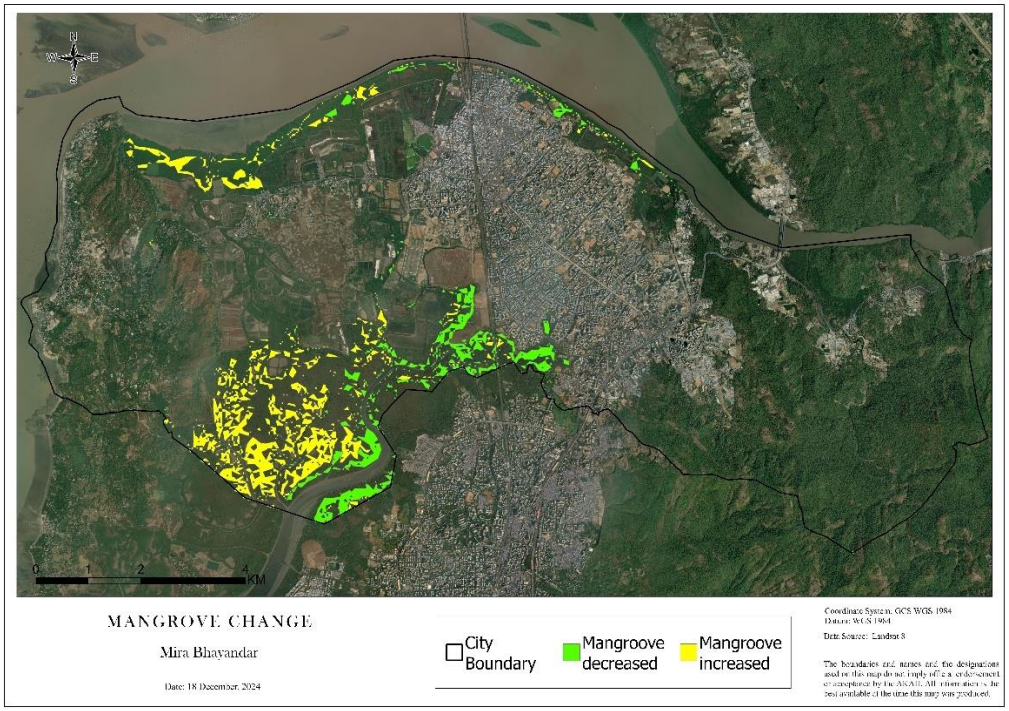


Figure 10: Change in mangrove density in Mira Bhayandar between 2000-2022

3.4 Air Pollution Risks

Mira Bhayandar is a non-attainment city in Maharashtra and has already a City Clean Air Action Plan into force. At present, it has only one Ambient Air Quality Monitoring Station installed under the National Air Quality Monitoring Programme. The air pollution data was collected from Maharashtra Pollution Control Board from 2022 to 2024 which covers the major air pollutants such as PM2.5, PM 10, SOx, NOx, Ozone. The data reveals that the average PM 2.5 and PM 10 in the city exceeds the threshold levels, amounting to 70.12 µg/m3 and 140.71 µg/m3respectively. The PM2.5 in the city is 14 times and PM 10 is 9 times more than the WHO air quality standards. The major sources of air pollution in the city are dust pollution which is caused by unpaved roads, construction activities and vehicular exhausts [5] . Another major factor of air pollution is NH 48 that passes through the center of the city carrying 37% of the daily trips in the city. Long-term exposure to air pollution can cause severe health issues such as respiratory and cardiovascular diseases, lung damage, and increased risk of cancer. It severely affects children, women, and the elderly, making them more vulnerable to respiratory problems and chronic diseases.

There are evident data gaps and a need to monitor air quality over a substantial period of time to gain a clear understanding of the sources and contributing factors to air pollution based on which the city administration can strategize to mitigate air pollution.

Pollutants	City's Average Annual Emissions	WHO Standards
Particulate Matter (PM) 2.5	70.12 µg/m3	5 µg/m3
Particulate Matter (PM) 10	140.71 µg/m3	15 µg/m3
Nitrogen Dioxide (NO2)	25.81 µg/m3	10 µg/m3
Carbon Monoxide (CO)	0.62 µg/m3	4 µg/m3 (24-hour mean)
Sulphur Dioxide (SO2)	6.8 µg/m3	40 µg/m3 (24-hour mean)

[5] City Air Action Plan for Control of Air Pollution in Mira-Bhaindar: One of the Non-Attainment Cities of Maharashtra

3.5 Exposure Analysis

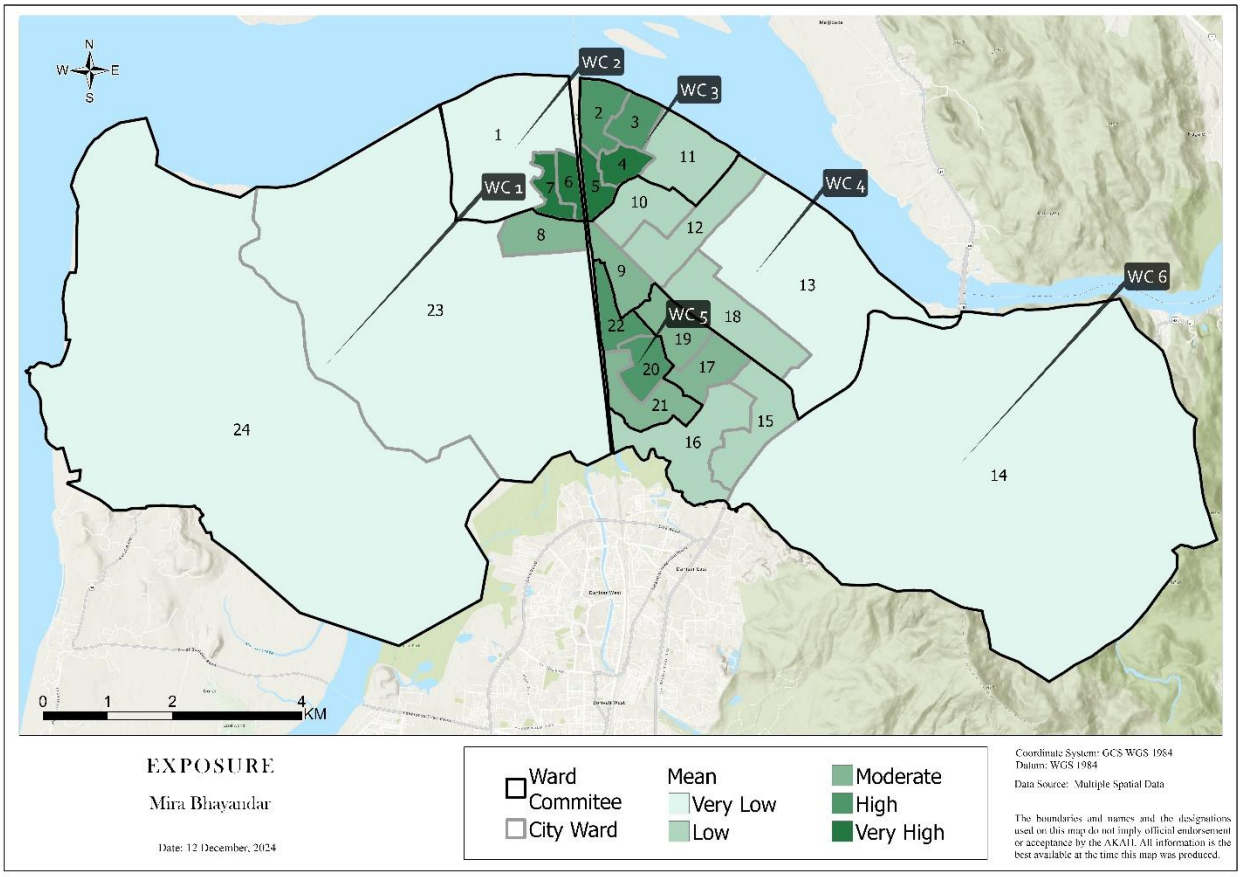


Figure 11: Ward exposure analysis for Mira Bhayandar

Indicator	Rationale	Analysis
Population Density	Population density often reflects socio-economic disparities, influencing communities' ability to cope with challenges. These differences affect access to resources, infrastructure, and essential health services, shaping resilience and overall well-being.	The interplay between population density and vulnerability is complex and multifaceted. High population density often correlates with increased risk due to greater exposure to hazards and underlying socioeconomic inequalities. **Exposed Wards: 3,4,5, 6, 7, 20, 22** are densely populated and thus highly susceptible and exposed to climatic risks.
Building Density	High building density often correlates with inadequate infrastructure and slower response management, making it difficult to meet the needs of residents. This can lead to delays in emergency response, increased pressure on	The city has 430 dangerous buildings across the city. In dense environments, the proximity of structures is often coupled with inadequate infrastructure and limited emergency response capabilities exposing the population to

	resources, and greater vulnerability to risks and disruptions.	hazards such as earthquakes, floods, and fires. The situation is exacerbated in informal settlements, where evacuation routes are congested and insufficient, building codes are poorly enforced, resulting in structures that are more vulnerable to collapse or damage. Exposed wards: **2,3,4,5,6 and 7** have the higher building density making the residing population more susceptible to climatic risks.
Informal Settlements	High population density in informal settlements is closely linked to limited economic capacity and resources, which makes it difficult to address hazards effectively. With fewer resources and lower economic means, these communities are more vulnerable, making it harder to manage risks and strengthen resilience in the face of challenges.	Approximately, 7.2% of the population resides in 36 slums in Mira Bhayandar which are mostly located in geographically vulnerable and risky locations such as near waterbodies, adjoining forest lands and low-lying flood prone areas. Their spatial location within the city exposes them to hazards and their own adaptive capacity is very limited, which makes them more marginalized vulnerable Exposed Wards: **1,2,11,13,15,16** have highest slum population than rest of the city.

3.6 Vulnerability Analysis

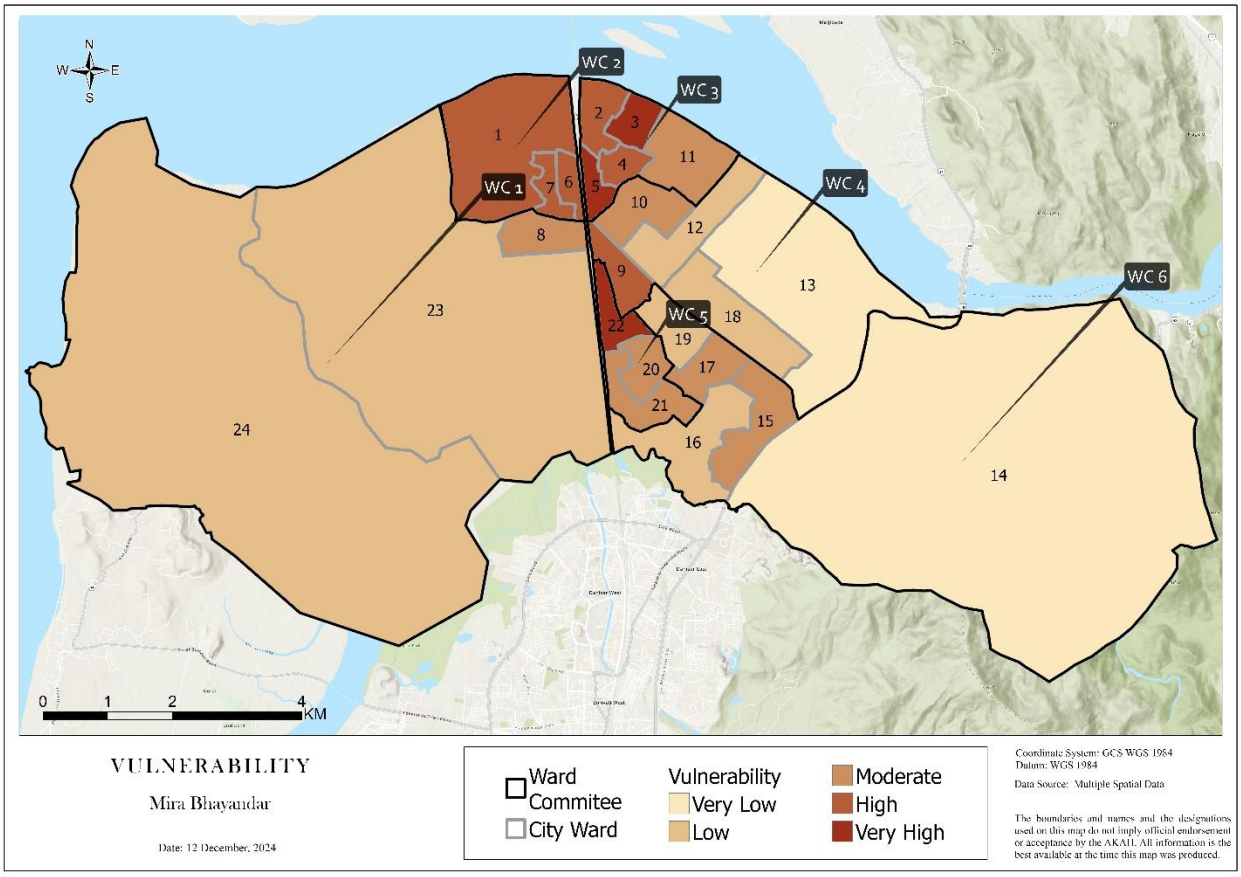


Figure 12: Ward Vulnerability Analysis for Mira Bhayandar

Indicator	Rationale	Analysis
Access to Public Transport **Metro line**: 33.1 Km (Proposed) **Bus Stations**: 93 **Routes**: 29 **Train Stations**: 2 **Road Network**: 112 Km	Access to public transport enhances resilience by improving mobility and enabling quicker responses to emergencies, ultimately decreasing vulnerability in times of crisis.	Around 60% of the population in Mira Bhayandar lives within 500 meters walking distance of bus routes catering to around 6,32,685 populations. The majority of the population in the city is dependent on public transport such as buses and railways bounding for Mumbai for jobs. The bus route networks are extensive covering the entire length and breadth of the city, but the challenges such as last mile connectivity, poor route optimization and buses catering to one-way traffic in few off-site areas are still an issue that needs to be addressed.

		Ward No: 6,24,4,21,113
Access to Education	Access to education directly relates to the ability of people to receive information and make informed decisions, strengthening their capacity to respond effectively to challenges and risks	Around 70% of the population in Mira Bhayandar have access to educational institutes within walking distance of 750 meters catering to around 1,70,140 in the city. The physical access to educational institutes in the city has a positive relation to the vulnerability indicating that youth and citizens are in a better position to perceive the hazards build their adaptive capacities and deal with the climate hazards. **Ward No: 22,10**
Access to Healthcare **Hospitals**: 177 **Beds**: 3366 **Beds/1000 Population ratio**: 4.15 **Coverage**: 50.5% of total area	Access to healthcare is an inverse indicator: *the greater the access, the lower the vulnerability*, as it enables people to receive timely treatment and preventive care, reducing the impact of health risks	More than 60% of the population in Mira Bhayandar lives within 1.25 km walking distance. According to the WHO standards the bed to population ratio should be 2.9 and in Mira Bhayandar it is 4.15 which is higher. This shows the access to healthcare services is high in the city, lowering the vulnerability of the population during any hazardous event. **Ward No: 23**
Access to Green Public Spaces	Access to green public spaces is an inverse indicator: *the greater the access, the lower the vulnerability*, as these spaces provide opportunities for physical activity, mental well-being, and a buffer against environmental stresses.	There are 79 Gardens and Public Parks in the city. With a buffer of 400 meters, almost 28% of the population have physical access to these green public spaces. The areas where the slum population resides have very few open or green public spaces limiting their access and making them more vulnerable to hazards. These spaces are not only important from a recreational point of view but also acts as an important safe and temporary shelter during disasters where communities gather after evacuation, response and recovery initiatives are carried out. The green cover absorbs extra surface runoff during heavy rainfall.

		Ward No: 4,12,5,2,11,9
Access to Disasters Shelters	Access to disaster shelters is an inverse indicator: *the greater the access, the lower the vulnerability,* as it ensures safer refuge during emergencies and helps protect communities from the impacts of disasters.	The physical access to disaster shelter has an inverse relation to vulnerability. The proximity to disaster shelters in case of climatic hazards helps reduce vulnerability and draw vulnerable populations to safe locations. Currently there are 66 disaster shelters within the city limits. In the event of disasters, the administration converts schools into disaster shelters and rents out hotels and private flats as per the need of the situation. **Ward No: 6,22,5,20,3,9**

3.7 Summary of Risk Analysis for Mira Bhayandar

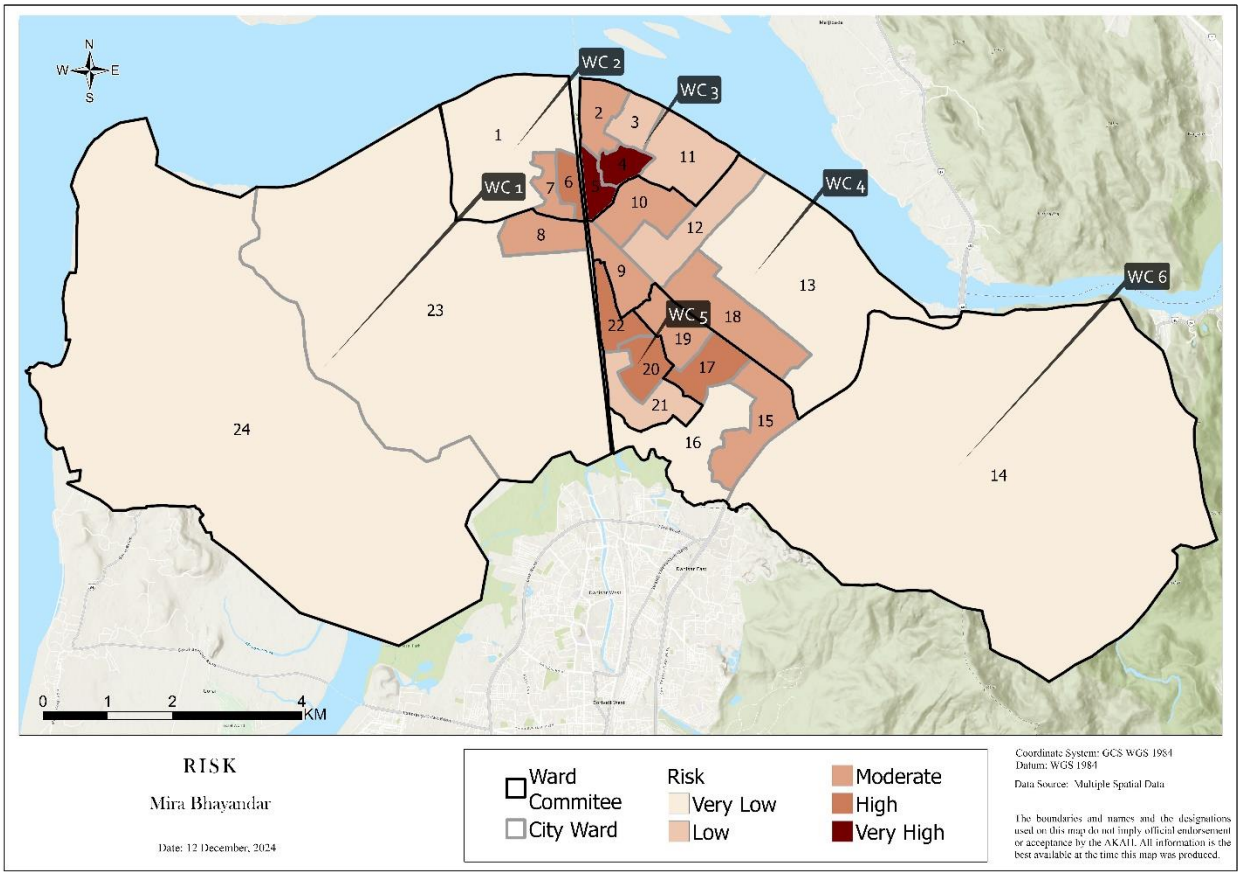


Figure 13: Ward Risk Analysis for Mira Bhayandar

According to the IPCC Sixth Assessment Report, risk is defined as "the potential for adverse effects or harm to occur as a result of the interaction between hazards, exposure, and vulnerability. It is a measure

of the likelihood and impact of an event causing damage to people, property, or the environment[6]." The risk framework for any city can be calculated as follows:

Risk = (Hazard × Exposure × Vulnerability)/Capacity[7]

Mira Bhayandar city, due to its unique geography, is physically susceptible to coastal risks. The hot and humid climate has contributed to the urban heat island effect, urban flooding, and air pollution. These hazards are exacerbated by the proliferation of anthropogenic activities, including unplanned development, high building density, poor drainage systems, and inadequate green spaces, which contribute to higher temperatures and increased urban flooding risks during the monsoon.

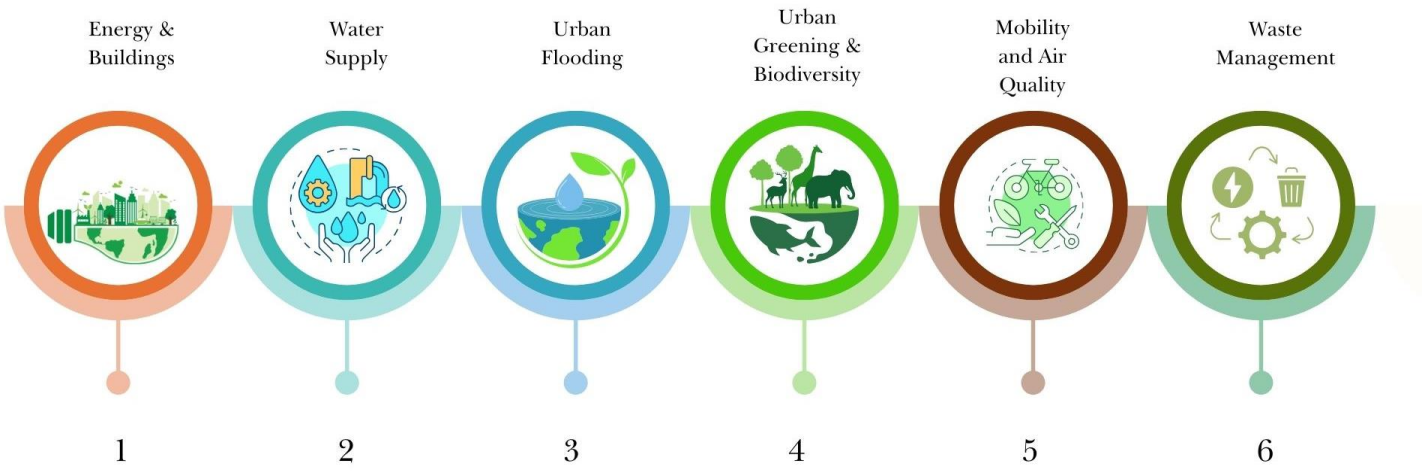
The exposure analysis for Mira Bhayandar was calculated at the ward level using three indicators: building density, population density, and informal settlements. The greater the presence of people, livelihoods, services, infrastructure, and socio-cultural-economic assets, the more vulnerable they are to damage, losses, or harm. As shown in figure 11, Ward No. 3, 4, 5, 6, 7, 20, and 22 are densely populated, and figure 12, Ward No. 2, 3, 4, 5, 6, and 7 have higher building densities, making the residing population more susceptible to climatic risks. Ward Nos. 1, 2, 11, 13, 15, and 16 have the highest slum populations, making them more exposed to hazards and more susceptible to harm due to limited capacity to cope or respond to the hazard.

The vulnerability assessment highlights gaps in access to essential services such as schools, hospitals, gardens, and public transport across the 24 wards in the city. Hazards are perceived differently by different segments of the population depending on their physical location, housing structure, access to basic services and public infrastructure, and socio-economic factors such as gender, age, class, caste, and livelihoods. These factors determine individuals' or communities' predisposition to be adversely affected or their internal capacity to cope and adapt to any hazard[8]. Individuals or communities with limited access to these services or infrastructure are less resilient to climate hazards.

Thus, by combining the potential hazards, exposure, and vulnerability, the risk analysis as shown in figure 13 reveals that Ward No. 4 and 5 are at "very high risk," followed by Ward No. 6, 17, 20, and 22, which fall under the "high risk" category. Ward No. 2, 7, 8, 10, 9, 19, 18, and 15 are in the "moderate risk" category, while other wards fall into the "low" and "very low" risk categories.

[6] IPCC Sixth Report
[7] Disaster Risk Equation
[8] Thane Heat Action Plan

Chapter 4: Sectoral Analysis and Recommendations



Chapter 4.1

Energy and Building Sector Overview

4.1.1 Electricity consumption Profile of the city

Mira Bhayandar city consumed approximately 1075 GWH of electricity in 2023 and this consumption is fueled by rapid urbanization, population growth and expansion of economic activities in the city. A steady rise in energy requirements has been seen over the years across residential, commercial, industrial and public sectors. In the city, electricity is mainly provided by TATA, ADANI followed by MSEDCL.

Mira Bhayandar is a satellite city where the majority of the population resides and travel daily to Greater Mumbai for jobs and other basic needs. The total built-up area in the city is 11.28% (LULC 2022) out of which the residential sector dominates the electricity usage with 62% of the total Electricity consumption as shown in figure 14. There are currently 0.34 million residential metered connections, and the consumer base is increasing by 4% on a yearly basis (2% increase in per capita consumption annually). The annual consumption per household is 1967 kWh, and the monthly consumption per household is 164 kWh which indicates that a major share of the households is upon the fans and electrical appliances. The total contribution of the residential sector to the emissions is 0.51 million CO2, accounting for 41% of the total emissions, and the demand is expected to grow further.

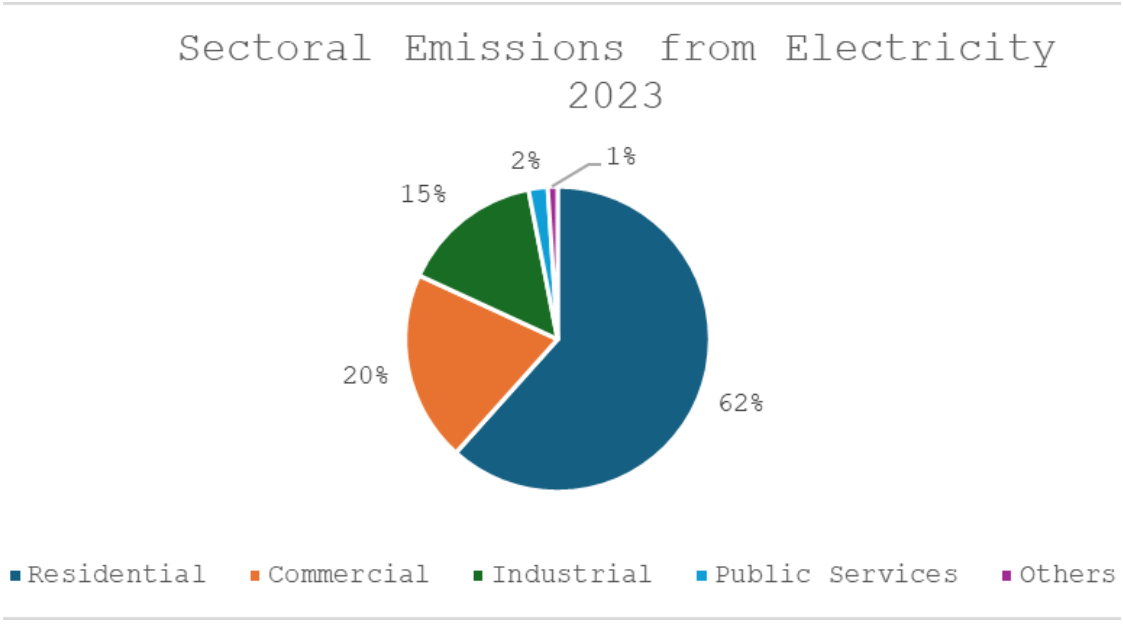


Figure 14: Sectoral Emissions from Electricity in Mira Bhayandar

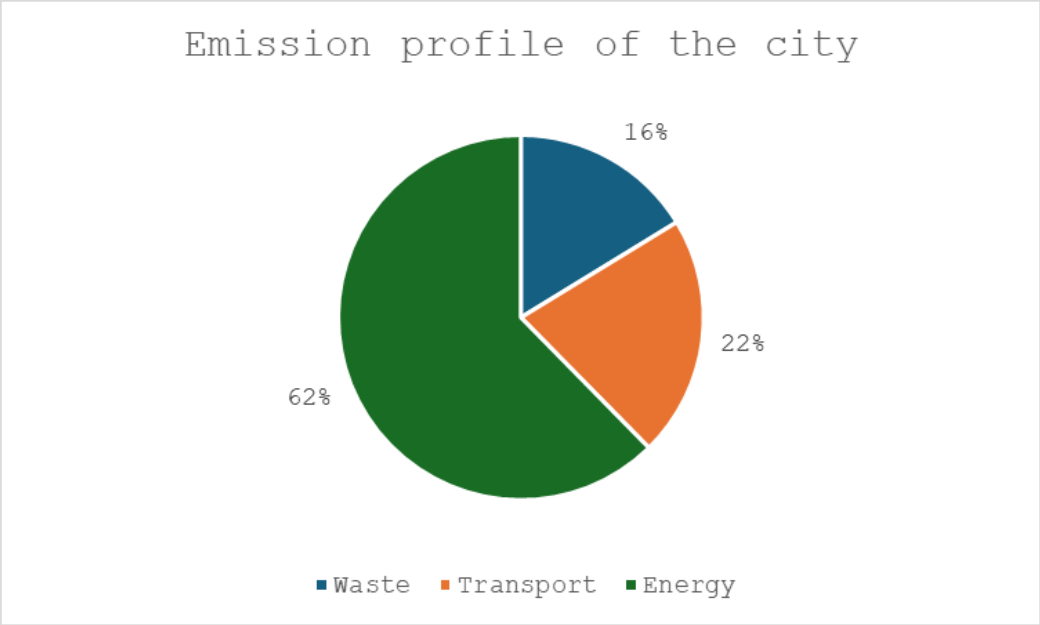


Figure 15: Emission Profile of Mira Bhayandar

The commercial sector consumes 20% of the total electricity and has shown the highest growth rate among all sectors as shown in figure 14, with electricity consumption increasing sharply from 127.85 GWh in 2021 to 217.85 GWh in 2023. There are currently 51,000 metered connections in the city and the economy has transitioned from industrial to commercial and service-based which places a significant burden on the city's energy resources. The city is dotted with 6896 small-scale industries, which accounts for 15% of the total electricity consumption as shown in figure 14, a steady rise from 113.05 GWh in 2021 to 162.30 GWh in 2023. Among the public services, government buildings and municipality consume 2% of the total electricity and street lighting consumes 1% of the total electricity. In agriculture, electricity consumption is minimal with the usage increasing slightly from 2.13 GWh in 2021 to 2.6 GWh in 2023.

4.1.2 Renewable Energy

The adoption of rooftop solar (RTS) systems in Mira Bhayandar city is significantly low. The figure 16 reveals that only 2% of the city's electricity consumption is being supplied by solar panels. The monthly average of solar energy generation is only between 76-168 kWh. However, there is immense potential for renewable energy generation in the city given its geographical and climatic conditions. Approximately 43% of the city's electricity demand can be met through renewable energy sources such as solar as shown in figure 16. This could go a long way in reducing GHG emissions and bringing down the energy sector's contribution to the city's total emissions from the current 62% to 32.86%.

In Mira Bhayandar, residents can avail the benefits of the PM Surya Ghar Yojana, a government scheme. Under this scheme, households will receive a subsidy of up to 40% of the cost to install solar panels on their rooftops, ensuring free electricity and promoting renewable energy adoption in the city. However, MBMC offers a 5% property tax rebate which acts as an incentive to societies using rooftop solar panels,

solar water heaters, and other renewable energy measures.

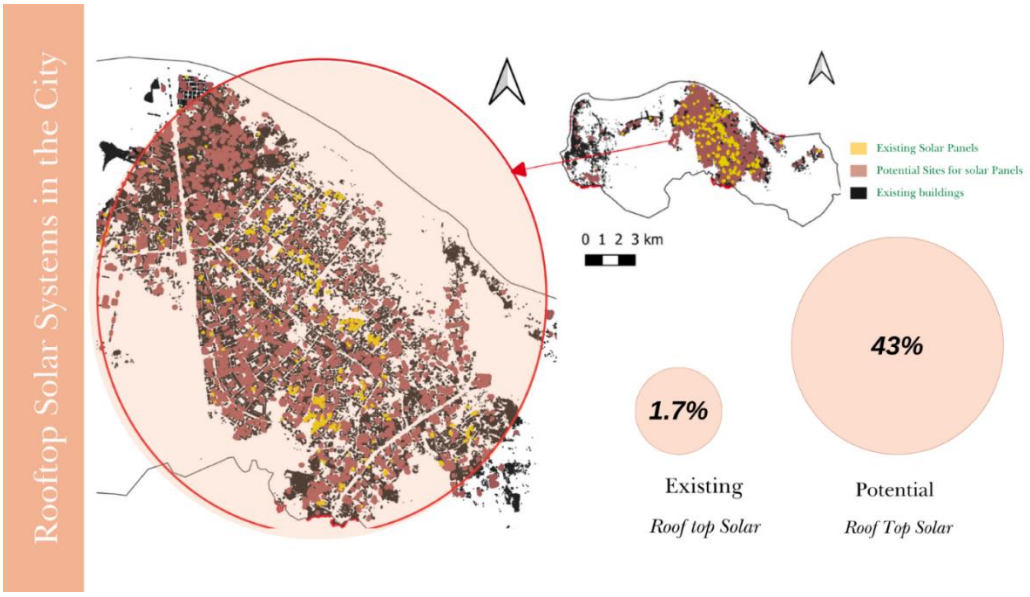


Figure 16: Extent of existing RTS in the city and the potential for scaling

Mira Bhayandar Municipal Corporation has already installed 600 solar streetlights in remote wards, with another 30-40 installations underway. The corporation is planning to solarize all schools in the city to promote renewable energy adoption at the institutional level. MBMC has a total installed solar capacity of 115 kW across its institutional buildings.

The solar photovoltaic (SPV) panels in Mira Bhayandar have the potential to generate approximately 1600 kWh/kWp annually. This highlights the opportunity for Mira Bhayandar to leverage its abundant solar energy potential to meet its growing energy demands and reduce its carbon footprint.

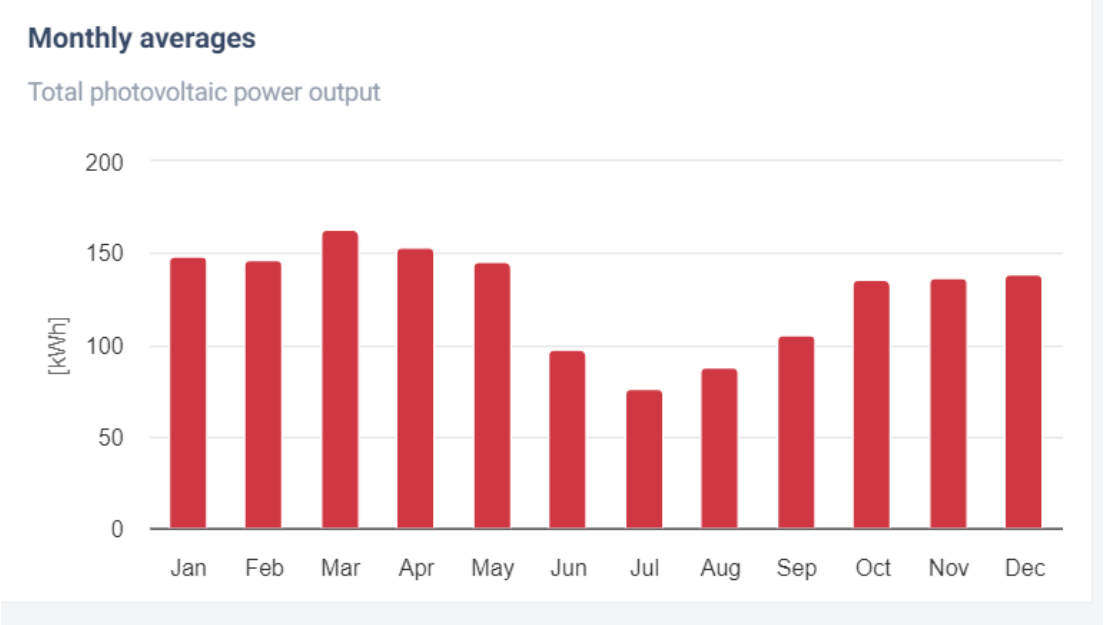


Figure 17: Monthly average output of photovoltaic power

Source: Global Solar Atlas

Average hourly profiles

Direct normal irradiation [Wh/m²]

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0 - 1												
1 - 2												
2 - 3												
3 - 4												
4 - 5												
5 - 6					1							
6 - 7		3	20	65	97	36	7	5	19	28	10	1
7 - 8	172	215	245	277	240	99	30	44	110	194	218	178
8 - 9	406	454	438	424	357	166	63	81	180	321	402	394
9 - 10	537	588	565	546	481	217	96	121	230	412	517	514
10 - 11	623	674	655	630	569	266	118	161	278	478	590	592
11 - 12	672	729	701	665	607	288	134	189	313	513	624	632
12 - 13	687	751	715	670	613	295	133	190	335	523	617	632
13 - 14	661	727	698	649	593	291	122	179	313	490	571	599
14 - 15	599	663	636	591	534	243	92	144	256	406	497	529
15 - 16	498	567	539	493	437	185	67	104	189	301	381	418
16 - 17	320	423	396	361	318	122	38	63	119	149	178	209
17 - 18	37	87	136	154	147	55	17	25	23	4	1	2
18 - 19				1	3	1	1					
19 - 20												
20 - 21												
21 - 22												
22 - 23												
23 - 24												
Sum	5,211	5,881	5,743	5,525	4,997	2,264	918	1,305	2,367	3,819	4,606	4,699

Figure 18: Average Hourly Profiles of DNI

Source: Global Solar Atlas

4.1.3 Fossil fuel consumption

In 2022-23, the distribution of greenhouse gas (GHG) emissions in Mira Bhayandar from different fossil fuels was as follows: Diesel, CNG and Petrol. Diesel fuel is the largest contributor, accounting for 41% of the total GHG emissions. Petrol contributes 22% of the emissions, compressed natural gas (CNG) contributes 26%, while piped natural gas (PNG) was responsible for 11 % of the total GHG emissions.

The emissions from different fossil fuel consumption are most likely to increase as per the needs of the growing population in the city. By 2050, GHG emissions from diesel are anticipated to grow by nearly 3 times and petrol are expected to rise by approximately 2.3 times as compared to the base year 2023. CNG in Mira Bhayandar are projected to increase over tenfold compared to the base year 2023. This substantial increase in fuel consumption and their emissions underscores the urgent need for investment in zero tailpipe emission vehicles. MBMC has procured 42 EV buses under the National Clean Air Programme (NCAP) which shows the commitment of the MBMC towards sustainability.

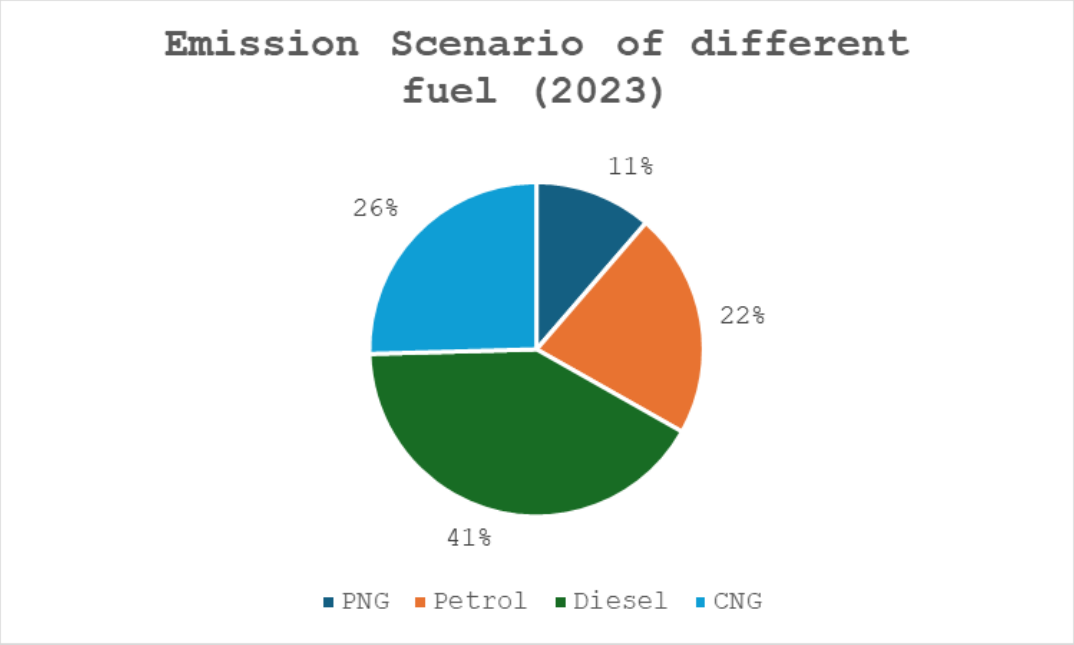


Figure 19: Emission Scenario of PNG, Petrol, Diesel and CNG in Mira Bhayandar

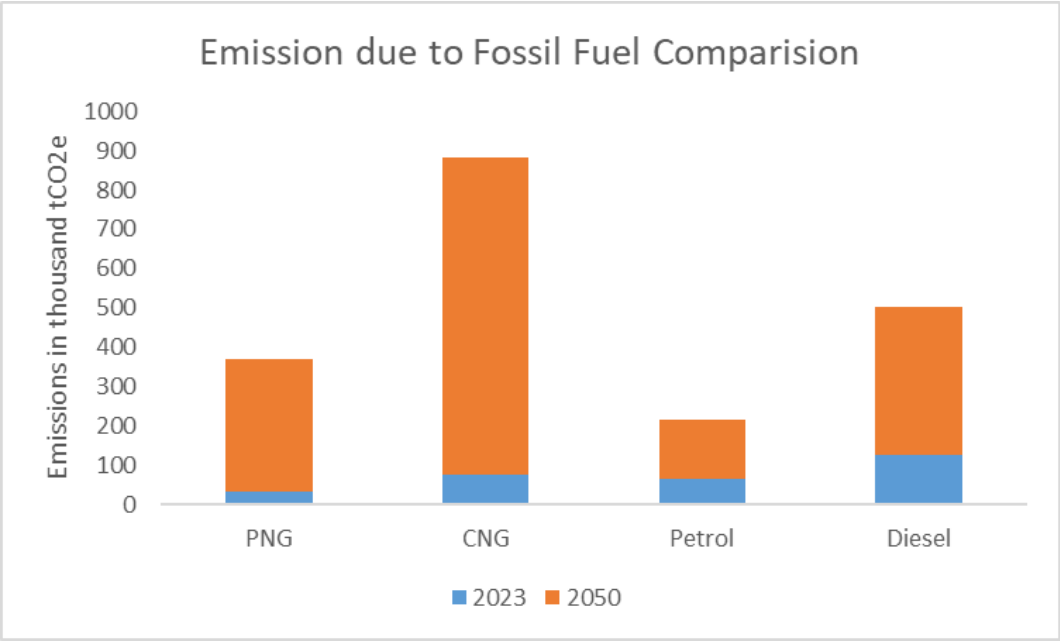


Figure 20: Projections of emissions by different fossil fuels in 2050

4.1.4 Energy Efficient Street lighting

Mira Bhayandar has made significant strides in modernizing its street lighting system. As of 2022-2023, the city has installed a mix of energy-efficient streetlights, including **7036 LED (90W)** units and **301 LED (135W)** units. However, traditional lighting systems such as High-Pressure Sodium Vapor (HPSV) lamps (4320 units) and other older technologies like Metal Halide (MH) and High-Pressure Mercury Vapor (HPMV) are mainly used for the city's lighting infrastructure. MBMC has taken a commendable step by introducing **solar streetlights** in **27 settlements**. Out of the planned **630 solar streetlights**, around **600 units** have already been installed. The city is planning to have 100% LED streetlights in the near future.

4.1.5 Key Priority Actions

4.1.5.1 Installation of Solar Trees in public parks and open spaces for increasing Renewable Energy

Description: The city has limited space to expand its energy capacity through traditional solar farms because only 25% of the area is developed, while the rest is occupied by salt pans, mangroves, and forests. This makes it difficult to install large-scale solar farms. As a solution, solar trees can be a great option for increasing the city's renewable energy capacity. Solar trees are also an example of **biomimicry**, as they draw inspiration from nature.

- **Actionable Step:** The corporation can expand its renewable energy capacity by the uptake of solar trees, which are innovative and self-sustaining structures that can be placed in public parks, alongside roads or in open spaces. These solar trees generate clean energy without taking up much land, making them ideal for cities with limited space.
- **Co-benefits**: Emission reductions, Space efficiency, Awareness and education, Economic saving
- **Concerned agencies**: PWD, Electrical department, Revenue department, Garden department
- **Aligned Schemes**: National Clean Air Plan
- **Target SDG**: 7,11,13,17
- **CSCAF Theme** – Renewable Energy
- **Time-scale**: Short to midterm (2030-2040)

Case study 1: Solar Trees in National Salt Satyagraha Memorial in Dandi

The National Salt Satyagraha Memorial in Dandi, Gujarat, has around 41 solar trees installed, each comprising 12 solar panels. These solar trees have a capacity to generate 182 kWp and can meet the energy demands of the entire memorial. The excess energy generated is sold to the Gujarat government, generating a revenue of Rs. 1,50,000 per month for the memorial[9].

4.1.5.2 Green Retrofitting

- **Actionable Step:** Achieve energy and water efficiency in existing non-residential buildings by mandating retrofitting. This process typically includes upgrading HVAC systems, installing energy-efficient lights such as LEDs, BLDC fans, motion sensors for common toilets and common areas improving insulation and incorporating water saving technologies like low-flow fixtures and water-efficient irrigation systems.
- **Co-Benefits**: Energy savings, GHG reduction
- **Agencies Concerned**: Revenue department, PWD, Electrical department, Energy rating agencies.
- **Aligned Schemes**: Save Energy Programmes, Walk Through Energy Audit, State Level EC Award Scheme for Excellence in Energy Efficiency, Conservation and Management, Empanelment of Energy Auditing Firms in Class A and Class B category.
- **CSCAF Indicator**: Promotion of Green Buildings
- **SDG:** 7,11,13
- **Timeline:** Mid-term (2040)

Case Study 2: Green Retrofitting of Nav Yuwan Society in Mira Bhayandar

[9] Solar trees to power Dandi Salt Memorial

The residential sector accounts for the highest share of electricity consumption in the city, at 62%, and contributes 41% of the total GHG emissions. AKAH has undertaken and implemented green retrofitting measures across 280 households and 10 buildings in the Nav Yuwan Housing Society in Mira Bhayandar. This demonstration serves as a significant breakthrough case to enhance the water and energy efficiency of buildings at both the household and society levels, significantly reducing electricity consumption and the building's carbon footprint. At the household level, 1,000 energy-efficient BLDC fans have been installed. At the society level, 174 motion-sensor lights have been implemented in common areas (staircases, lift lobbies, and parking lots), and a 44-kWh rooftop solar system has been installed to help the society adopt renewable energy sources for electricity consumption. It is projected that the electricity bills will reduce by 65% with the installation of BLDC fans yielding major savings to household members. Furthermore, the RTS is projected to generate 8-10% energy savings and cover 100% electricity needs of the common area. This will be the first existing housing society to be EDGE certified by the International Finance Corporation (IFC), a member of the World Bank Group.

4.1.5.3 Cooling Solutions in Informal Settlements

Description: The slum population in Mira Bhayandar constituted 7.2% of the total population in 2011, with 33,269 households residing in slums. These areas are highly vulnerable to urban heat risks due to poor infrastructure, inadequate ventilation, and limited resources for thermal comfort. To address these challenges, implementing cooling solutions such as cool roofs can be highly effective. Cool roofs, made with reflective materials or coatings, help reduce indoor temperatures, improve occupant comfort, and lower energy consumption. Additionally, integrating advanced materials like Alu foil for thermal insulation or using woodwool panels can further enhance heat resistance in slum households.

Natural ventilation solutions, such as installing ventilators strategically to optimize airflow, are also critical in mitigating heat risks. These methods, proven effective in Urban Heat Risk Reduction (UHRR) strategies, can significantly improve living conditions in slums by making them more resilient to extreme heat while ensuring energy-efficient solutions. Combining these approaches can create a comprehensive framework for improving thermal comfort and enhancing the overall quality of life for vulnerable populations.

- **Actionable Steps:**
    - Collaborate with CSRs and NGOs and relevant organizations to implement cool roofs and other sustainability measures in informal settlements.
    - Facilitate skill development by training locals in cool roof installations and maintenance.
    - Actively involve community members in decision-making and project implementation to ensure acceptance and long-term success.
    - Conduct workshops and awareness drives to educate residents about the benefits of cool roofs in reducing heat stress and energy costs.
- **Co-Benefits:** Reduced urban heat island, Lower energy consumption, livelihood opportunities Reduces cooling costs, Improves living conditions and comfort levels for vulnerable populations
- **Timeline:** Short term (2030)

- **Target SDGs:** 3,11, 13

Case Study 3: Green Building in Mira Bhayandar

The meditation center in the Ramdev Park area is the only existing green building built by MBMC. The Green Building certificate is sanctioned by the Indian Green Building Council for incorporating energy-efficient appliances, renewable sources of energy such as solar, water conservation measures like RWH, waste reduction measures and other aspects of material sustainability[10].

MBMC Meditation Centre,

Ramdev Park area of Mira Road

BUILT UP AREA - 1,000 SQM.
LANDSCAPED AREA - 2,830 SQM.

Indian Green Building Council (IGBC)

Source:https://www.freepressjournal.in/mumbai/mira-bhayandar-mbmcs-meditation-centre-bags-green-building-tag

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Figure 21: MBMC Meditation Center, first Green Building in Mira Bhayandar

4.1.6 Recommendations for Energy and Buildings

Recommendations	Responsible Agency	Aligned Schemes/Policies	Period

[10] MBMC's meditation center bags 'green building' tag

Development and Implementation of PPP Model for solar energy Adoption of PPP model of Rooftop Solar (RTS) to reduce the upfront cost of the corporation. Under this model, the corporation will provide support in form of which offers incentives (land access subsidies, tax breaks) to encourage private companies to install, operate, and maintain rooftop solar systems. At present, there is no subsidy is being given by MBMC for RTS. Steps to implement the PPP model of RTS – • Initiate with the public buildings like schools, hospitals, and government offices, and later expand to private residential and commercial buildings based on success metrics. • Use pilot projects to evaluate performance and gather insights for larger-scale implementations. • Educate residents and building owners about financial benefits and environmental impact to encourage participation. ***Co-Benefits:*** *reduced emissions, Energy efficiency, Job creation, Investment attraction*	Electrical Department, Revenue Department	-	Mid term

Development of a city level solar policy The city currently meets only 1.7% of its energy demands from RTS. However, the potential for renewable energy is 43%. The city needs a city level solar policy will mandate the uptake of rooftop solar provisions for buildings and introduce subsidy and incentive programs in collaboration with MSEDCL. Various steps can be undertaken by MBMC - • Educate households about the benefits of RTS such as subsidies on instalment to the general public. For instances, MH Solar policy provides 40% subsidy on installing RTS up to 3KW and 20% on 3KW- 10 KW. • Promote the concept of Solar cooperatives. • Promote the use of solar system by providing subsidy for hybrid inverters under Ministry of New and Renewable Energy's PM Surya Ghar scheme. • Explore the possibility of implementation of Pay-As-You-Go (PAYG) schemes to increase accessibility for residents. ***Co-Benefits:*** *cost saving, emission reduction, green Job generation, increase climate resilience, improve energy literacy*	Public works/Electrical works, MBMC, Adani electricity, Tata power, MSEDCL, NSEFI	Pradhan Mantri Surya Ghar Yojana, Maharashtra solar policy 2020, NCAP Phase-II of Grid Connected Rooftop Solar Programme	Mid term

Energy Audit in Industrial/Commercial Buildings Mandate industrial and commercial energy audits to identify inefficiencies in electricity, water, and fossil fuel usage. Use audit results to define priority areas for upgrades. • Integrate PACE into Mira Bhayandar's property tax framework. It will enable property owners to repay over 10–20 years via property taxes. • Provide incentives like interest rate subsidies for early adopters. • Offer higher benefits for industries implementing solar or water conservation projects. • Train stakeholders (industries, businesses, municipal staff) on PACE processes, benefits, and procedures. ***Co-Benefits****: energy savings, GHG reduction*	Revenue Department, PWD, Electrical Department, Energy Rating Agencies.	Energy Audit Program by Tata power, MEDA's "Save Energy Programme"	Mid term

Installation of Smart Meters The traditional meters can be replaced by the smart meters which enable both utilities and consumers to track electricity consumption, identify high-usage periods and adjust their consumption accordingly. **Installation of smart meters** • Collaborate with DISCOMS to subsidize initial installation costs. • Pilot smart meter installation in high-energy consumption areas or sectors to showcase their advantages. • Conduct awareness campaigns to educate consumers on the benefits of smart meters. ***Co-benefits****: Real-time Monitoring, Energy Efficiency, Accurate Billing, Demand Forecasting, Consumer Awareness*	Electrical works, DISCOMS	National smart meter mission	Mid term

Embodied Carbon Reduction Measures Sustainable procurement of construction materials can reduce embodied carbon from the extraction, production, and transportation of materials. Approximately, 50% of emissions come from the cement and concrete. By using alternatives like low carbon cement, recycled steel, and reclaimed wood, the carbon footprint of construction projects can be significantly reduced. • Enforce the use of sustainable materials in the construction of all new corporation projects through policies and procurement guidelines. • Financial or non-financial incentives can be given to constructors and suppliers who prioritize sustainable materials in their projects. • Introduce a carbon pricing mechanism that imposes additional costs on the use of carbon-intensive construction materials in order to discourage their adoption. • Mandate for large construction firms to conduct and report the Life Cycle Assessments that quantify the upfront carbon emissions (embodied carbon) of materials used in their projects. ***Co-benefit****: carbon reduction, waste reduction, economic savings, local job creation*	PWD, Town Planning, Revenue Department		Mid term

District Cooling in Commercial Buildings **Recommendations** • Ideal to include District Cooling Systems at the planning stage for cities to cater to urban dense neighborhoods and to avoid costly retrofitting and design mismatches at a later stage. For example, District Cooling Systems in Singapore. • Update the building regulations to prioritize district cooling aligns construction with sustainable cooling solutions. This ensures buildings are designed to connect seamlessly with future DCS infrastructure. For example, The UAE mandates provisions for DCS in high-rise developments through adjusted bye-laws. [LG1] • Mandate to establish DCS in high-density areas will maximize efficiency and cost-effectiveness due to the consistent cooling demand. ***Co-benefits****: GHG reduction, energy savings*	Urban Planning, PWD, Electrical Department	**ICAP** (up to 30%capital subsidies for installation, tax exemptions or reduced GST rates)	Mid - term

Cool Roofs in Informal Settlement Informal settlements are often highly vulnerable to urban heat risks due to poor infrastructure and inadequate ventilation. To address these challenges, implementing cooling solutions such as cool roofs, Alu foil for thermal insulation, woodwool panels, and ventilators for natural ventilation—proven strategies in Urban Heat Risk Reduction (UHRR)—can significantly reduce indoor temperatures, improve comfort, and enhance energy efficiency. By partnering with CSRs and NGOs, such initiatives can be undertaken: • Facilitate skill development by training locals in cool roof installations and maintenance. • Actively involve community members in decision-making and project implementation to ensure acceptance and long-term success. • Before the implementation, conduct workshops and awareness drives to educate residents about the benefits of cool roofs in reducing heat stress and energy costs. ***Co-benefits****: reduced urban heat island, lower energy consumption, livelihood opportunities Reduces cooling costs, improves living conditions and comfort levels for vulnerable populations.*	CSRs and NGOs	-	Short term

Installation of Energy Consumption Dashboard • Install interactive energy consumption Dashboards in public buildings such as schools, hospitals, and government offices. • Equip residents with tools such as mobile apps and web portals that provide real-time insights into household energy usage. • Highlight individual and community-level energy usage patterns on energy bills. ***Co-Benefits:*** ***l****ower energy bills, reduction in energy consumption, decrease in greenhouse gas emissions, increased awareness among residents about their energy habits.*	-	-	Short term
Phase-wise retrofitting of buildings in Mira Bhayandar To improve energy efficiency and reduce GHG emissions, a detailed technical plan focusing on retrofitting interventions by building size [small (< 500 sq km), medium (500-2000 sq km) and large (>2000 sq km)] and operational characteristics. Public buildings, starting with municipal buildings, will be used as demonstration projects. ***Co-benefits*** *energy savings, reduced carbon footprint, improved air quality, resilient urban environment, low energy consumption.*	PWD, Electrical Department, Educational Department	-	Short-Mid-Long Term *(It is a continued process)*

Promotion of BLDC Fans The city is heavily dependent on the fans for cooling mechanism. Therefore, to enhance energy efficiency and reduce electricity consumption, the adoption of BLDC (Brushless DC) fans can be promoted consuming about 28-35W at top speed, compared to 75W for conventional fans (CEEW report). • Partner with Energy Efficiency Services Limited (EESL) to provide subsidies or rebates for BLDC fans. • Explore bulk procurement to lower retail prices, as demonstrated by the LED lamp program under UJALA. • Install BLDC fans in municipal buildings, schools, and public spaces to showcase their benefits and set an example for adoption. • ·Offer financing options like on-bill financing to make these fans more accessible to low-income households. **Co-Benefits:** energy-efficiency of buildings, savings in electricity bills, reduced carbon footprint of buildings	Electrical department, PWD	-	Short-mid term

Promotion of Green Buildings There is only one Green Building in Mira Bhayandar indicating the need to scale sustainable building practices within the urban residential sector. • Incentivize housing societies to undertake green retrofitting under Edge Green Building certification system. • Promote green buildings by offering additional FSI and reduced taxes for certified green projects under EDGE, IGBC, etc. • Participate in green rating program as a city to benchmark environmental performance and sustainable practices like Pune city won Green City Award (IGBC) • Conduct targeted training and awareness programs for real estate developers, architects, engineers, RWAs, citizens and construction firms. **Co-benefits:** Energy savings, reduced carbon footprint, improved air quality, resilient urban environment, low energy consumption	PWD, Town planning department, Revenue department, Local body tax department,	Maharashtra Green Building Policy	Short Term

Passive Cooling Strategies Passive cooling techniques are critical to Mira Bhayandar because of its warm and humid climate which in turn increases the indoor temperatures of buildings. Recommendations applicable to all building types - • Position buildings to minimize solar heat gain (east-west axis orientation), design layouts to enhance cross-ventilation, install ventilators or louvered vents at higher levels to expel hot air and use of landscaping or adjacent structures to create shade. • Apply high solar reflectance index paints/light - colored exterior paints or tiles to roofs. • Use external shading devices like overhangs, fins, and pergolas. ***Co-Benefits:*** *mitigate UHI effect, reduced indoor temperature*		-	Mid Term

Replacement of Asbestos Sheet In Mira Bhayandar, informal settlements commonly use asbestos sheets (majorly black which has higher carcinogenic properties). Besides, housing societies use asbestos on their rooftop to prevent leakages of rain inside the buildings. • Establish strict regulations to phase out asbestos in new constructions and renovations while ensuring compliance with building codes. • Provide direct financial support to cover some part of the cost of replacing asbestos roofs with eco-friendly materials. • Develop a system for the safe collection, transportation, safe handling and disposal of asbestos waste according to UNEP guidelines or Asbestos in Emergencies. • Conduct public awareness drives to educate residents, builders, and suppliers about the health risks of asbestos. ***Co-benefits****: improve health well-being, job creation, improved indoor air quality, particularly beneficial for children and elderly, decreased healthcare costs.*			Mid-Long Term

Chapter 4.2

Water Supply Management

4.2.1 Existing Water Supply Network

Mira Bhayandar water supply network depends on 125 MLD from **Maharashtra Industrial Development Corporation** and 86 MLD from **Shahad-Temghar (STEM)** water supply scheme to meet its daily water needs, receiving approximately **221 MLD**[11]. Although, the city requirement is **235 MLD** and often receives daily water supply to less than **190 MLD** due to infrastructural limitations. There exists a gap of **45 MLD** which is being compensated by private tankers, borewells and even inadequate supply of water to the population.

The water distribution system in Mira-Bhayandar operates through **30 Elevated Storage Reservoirs** which rely on gravity-fed pipelines and struggle with pressure consistency due to aging pipelines. The city's **Non-Revenue Water (NRW)** is estimated at **21%**[11], primarily due to lack of metering and pricing systems, leakages, theft, and inefficiencies in the aging water supply distribution network. It is imperative to conduct a detailed NRW audit to identify and quantify losses to better manage the water supply system in the city.

4.2.2 Equitable water distribution

The water distribution network in the city is facing challenges with respect to its aging pipelines, cross-connections in the system causing pressure fluctuations, inconsistent water pressure, and an inefficient distribution network.

The water supply in Mira-Bhayandar varies widely across neighborhoods, ranging from **90 to 125 LPCD** which is below the WHO benchmark of **135 LPCD**[12]. About **75% of households** are connected to the water supply, which is below the ideal benchmark of universal coverage. To resolve the issue of accessibility and inconsistent supply, the **Mira Bhayandar Municipal Corporation (MBMC)** has stopped issuing new connections to buildings above four floors.

Only **74% of water connections are metered,** which leaves a large portion of the distribution unmonitored, undermining the city's efforts of equitable distribution. The city aspires to upgrade the existing water supply system to ensure 24*7 water provision, but it is facing challenges in terms of water shortages that necessitates periodic 24-hour shutdowns every two or three weeks to stabilize resources. Seasonal fluctuations and the outdated water supply network within the city further exacerbate the situation, leading to unreliable and erratic delivery times, which typically range from 2 to 4 hours per day in most wards.

In order to address the inequities, MBMC operates water tankers sourced from **borewells** and **baawdis**

[11] Surya Detailed Project Report
[12] CPHEEO Manual on Water Supply and Treatmentv

to supplement the city's water supply coming from MIDC and STEM. The supplementary sources provide about **1 MLD** of additional water to the city. These tankers are priced at approximately **₹1000 per 10,000 liters**[13]. The slums neighborhoods have poor access to water supply systems with only few slum households connected to the formal water supply network and fulfill their water needs through tankers.

4.2.3 Used Water Recycling and Reuse

The wastewater management system includes decentralized treatment plants with a total capacity of **115 MLD**, but limited space, poor coverage and connectivity challenges limit their efficiency. The water from the **tertiary treatment plant (TTP)** is sold at a subsidized rate of **₹700** per **10,000 liters**, typically for use in construction sites, gardens, and other non-potable purposes. To augment the existing capacity, **MBMC** has planned to install an addition of **9 secondary treatment plants** and **1 tertiary treatment plant** with a capacity of **5 MLD** to enhance the city's wastewater treatment capacity, though space constraints in the city still pose a challenge[22].

Water quality is examined on a daily basis but there are cases of reverse siphoning, contamination and turbidity in the water which the city is trying to address.

4.2.4 Augmentation of infrastructure and modernization initiatives

MBMC has initiated modernization programmes such as exploring digital metering solutions and implementing Integrated Water Resource Management to reduce leakage, better manage the resources, upgrade and expand the existing infrastructure. The city can reduce both operational cost and carbon footprint by adopting Integrated water Resource management (IWRM) principles and integrating renewable energy for pumping systems.

The city has undertaken various water conservation efforts in the recent past including mandating **rainwater harvesting** for new Residential Welfare Associations, offering **5% tax rebates** as incentives. However, post-installation monitoring of these new infrastructure is often lacking, which affects the long-term sustainability of the initiatives. Additionally, active community participation and monitoring measures can be incorporated into the ongoing **tree plantation drives** and **water conservation programmes** to make it more engaging, collaborative and sustainable.

4.2.5 Key Priority Actions

4.2.5.1 Eco Sewage Treatment Plants

- **Description**: The city is planning to construct 8 STP and 2 TTP to meet the current gap of 17.5 MLD. The traditional sewage treatment plants (STPs) often face challenges such as high energy costs, maintenance difficulties, and environmental impacts highlight the need to adopt a sustainable alternative.
- **Actionable Steps:** To enhance sustainable urban water management, the city can construct Eco STPs, which will utilize natural, low-energy biological processes for treat the wastewater, particularly for informal settlements or areas lacking robust infrastructure.

[13] Mira-Bhayandar: MBMC To Link Water Tanker Bills With GPS Records

- **Concerned Agencies**: Sewerage Department
- **Aligned schemes/policies**: National Water Policy, Swachh Bharat Mission, National mission on Sustainable Habitat
- **Co-Benefits**: Reduced Water Contamination; Enhanced Regulatory Compliance; Optimized Resource Management
- **CSCAF Indicator**: Energy-efficient wastewater management system
- **Timeline**: Short Term (2030)
- **Target SDGs:** 6,14

CASE STUDY 1: GWALIOR ECO STP

The eco-sewage treatment plant in Gwalior, Madhya Pradesh, first of its kind, role model for sustainable wastewater management in India. This plant was established in 2020 to address the severe water crisis the city faced due to rapid urbanization, which led to increased demand for freshwater and the discharge of untreated wastewater into local water bodies. The successful operation of this STP helped in reducing the discharge of wastewater into the Chambal River. The Gwalior STP utilizes Sequencing Batch Reactor technology, which is known for its efficiency in treating large volumes of wastewater. The plant has a treatment capacity of 145 million liters per day, far above from the previous STP of 52 MLD capacity. The SBR technology implemented at this facility allows for a batch-wise treatment process that includes filling, aeration, settling, and decanting stages. This method has achieved over 95% removal efficiency for organic matter and suspended solids, making the treated water suitable for agricultural use and contributing significantly to the conservation of freshwater resources[14].

4.2.5.2 Establish zonal distribution systems equipped with bulk water meters to isolate zones for maintenance and monitor consumption patterns, enabling efficient water management and tracking.

Description: City is currently not classified in distribution zones limiting its capacity of addressing the maintenance and building its own resilience with respect to the thefts, leakages and identifying consumption patterns of the commercial as well as the household units.

- **Actionable Step:** Zonal distribution and bulk metering systems ensure targeted interventions by isolating zones for efficient maintenance and consumption tracking. This approach directly addresses water loss and supports equitable water supply.
- **Concerned Agencies**: Water Supply Department; Revenue Department; PWD
- **Co-Benefits**: Reduced Water Consumption; Optimized Resource Management
- **Aligned schemes/policies**: JJM, SCM, NMSH
- **CSCAF Indicators:** Water Resource Management, Energy Efficient Water Supply Management
- **Target SDGs:** 6,14, 11

[14] Case Study on 145MLD Sewage Treatment Plant (STP) (SBR Technology) in Gwalior

- **Timeline**: Short Term

4.2.5.3 Develop & Implement a comprehensive Non-Revenue Water Reduction Strategy

Description: There lies a data gap of quantifying the Non-Revenue Water Quantum and is being currently projected around 21%. This figure is expected to be increasing with the city's aging water supply network.

- **Actionable Step:** Develop and implement a comprehensive NRW Reduction Strategy through a PPP model to address the current 21% NRW. This will help to maximize resource utilization and enhance service reliability.
- **Concerned Agencies**: Water Supply Department, Revenue/Tax Department
- **Co-Benefits**: Community Trust and Engagement; Informed Decision-Making; Financial Benefits
- **Aligned schemes/policies**: AMRUT, JJM (Urban), SCM, MSNA, NMSH
- **CSCAF Indicators:** (Extent of Non-Revenue Water
- **Target SDGs:** 6
- **Timeline**: Mid Term (2040)

Case Study 3: Implementation of Zonal Distribution System to reduce NRW in Puri

Puri district, Odisha has implemented the zonal distribution system aimed at reducing NRW which was estimated around 54%. The city has adopted a 24x7 Water Supply Project under the "Drink from Tap Mission," that involved creating 19 District Metered Areas (DMAs). Each DMA is equipped with bulk water meters that allow for precise monitoring of water consumption and effective management of the supply network. This zonal approach facilitates the identification of leaks and unauthorized connections, enabling targeted maintenance and operational efficiency. Moreover, each DMA is served by dedicated service tanks that ensures decentralized control over water distribution and improving accountability and service delivery. The transition to a continuous water supply system has enabled the city to reduce its NRW from 54% to approximately 15%[15].

4.2.6 Recommendations for Urban Water Supply Management

Recommendations	Responsible Agency	Aligned Schemes/Policies	Period
Metering Systems and Tariffs • Prioritize high-consumption zones and commercial areas to ensure they are fully metered, offering subsidies or rebates to capture significant portions of unmetered water usage by	Water Supply Department, Sewerage Department, Garden Department, Revenue/Tax Department	AMRUT, JJM (Urban), SBM, NMSH, MSNA	Short Term

[15] DRINK FROM TAP MISSION IN PURI CITY

simplifying and expediting the procedures for new meter installations. • Implement a phased roll out of Ultrasonic metering system as pilot covering 10-15 % of the target household which allows for testing the ultrasonic metering technology and addressing any operational challenges before scaling up. • Implement usage-based water tariffs in areas consuming over the standard supply of 135 lpcd to effectively recover O&M and CAPEX costs. • Expand Water Supply Infrastructure and Community Outreach Programs to increase household coverage to 100%. • Provision of 24*7 water supply to the citizens by upgrading the current distribution system. ***Co-Benefits:*** *reduced water loss, improved water security and quality of water, reduced wastages*			

Case Study 3: Adoption of volumetric tariff structure by Hyderabad Metropolitan Water Supply and Sewerage Board

The Hyderabad Metropolitan Water Supply and Sewerage Board (HMWSSB) has adopted a volumetric tariff structure aimed at promoting efficient water use and ensuring cost recovery for the board. This traffic structure charges consumers based on their actual water consumption, measured through meters and the price per kiloliter (kl) increases with higher consumption levels, thereby encouraging consumers to save water. The tariff is structured into several slabs: for domestic users, the rates start at ₹6.00 per kl for the first 15 kl and rise to ₹35.00 per kl for consumption above 200 kl. This approach also incorporates cross-

subsidization, where higher-income households help subsidize lower-income users, promoting equity in access to water resources[16].

Recommendations	Responsible Agency	Aligned Schemes/Policies	Period
Sustainable Water Management • Develop a water balance plan for the city. • Mandate the reuse of at least 20% that is 23 MLD of inline treated water for gardens, flushing, industries, etc. (NMSH guidelines). ***Co-Benefits:*** ***r****educed water Contamination, enhanced regulatory compliance, optimized resource management, sustainable water management, reduced water loss, improved water security*	Sewage Department, Water Supply Department, Revenue Department, PWD, Garden Department	National Water Policy, SBM, NMSH, MSNA	Short Term
Groundwater Dependence • Deploy an IoT-enabled metering and GPS tracking system for water tankers and borewells to enhance monitoring, prevent unauthorized extraction, and improve the efficiency of water distribution. • Initiate rainwater harvesting projects after conducting detailed hydrogeological surveys to map shallow aquifers and identify recharge zones. • Integrate the findings into urban planning to maximize groundwater replenishment and mitigate water scarcity. ***Co-Benefits:*** ***r****educed water contamination; enhanced regulatory compliance; optimized resource*	Water Supply Department; Revenue Department	JJM(Urban), Smart Cities Mission, NMSH	Short Term

[16] Cost Recovery and Tariff Practices for Urban Water Supply and Sanitation in India

management, minimizing saltwater intrusion.			
Efficiency Measures • Mandate the installation of low-flow fixtures like aerators in residential complexes to reduce per capita water consumption and sensitize people on water usage. • Optimize water pump operations by incorporating advanced energy-efficient technologies and transition to solar or wind (renewable sources), to reduce energy consumption and operational costs. • Limit cross-connections in the water supply network by strategic zoning, installation of isolation valves, and use of supervisory technologies like SCADA for real-time monitoring and control. ***Co-Benefits:*** *reduced water contamination; enhanced regulatory compliance; optimized resource management*	Water Supply Department, Revenue Department, Electricity Department, PWD	JJM(Urban), Smart Cities Mission, NMSH, AMRUT	

Chapter 4.3.

Urban Flooding

4.3.1 Introduction

Mira Bhayandar, a rapidly growing urban area within the Mumbai Metropolitan Region (MMR) under the Thane district of Maharashtra, faces significant challenges concerning urban flooding and water logging. The increasing frequency of extreme rainfall events, coupled with inadequacies in existing stormwater infrastructure, has exacerbated the city's vulnerability to floods. The Mira Bhayandar Climate Action Plan emphasizes the need for developing climate-resilient infrastructure and adopt nature-based solutions to mitigate risks associated with urban floods. This section provides an in-depth analysis of Mira Bhayandar's flood risks using rainfall trends, infrastructure assessments, and relevant data. It further presents clear strategies and recommendations to improve urban Flood Risk Management in the city.

4.3.2 Climatic Trends and Rainfall Patterns

4.3.2.1 Rising Rainfall Trends (1991–2021)

The rainfall data from 1991 to 2021 as shown in figure 22, highlights a significant upward trend in cumulative annual rainfall, signalling the increasing likelihood of intense and heavy rainfall events.

Observations:

- Annual rainfall totals have shown consistent growth over the Last Three Decades.
- Flooding events in 2010, 2018, and 2019 are clear indicators of how extreme rainfall can Over whelm the city's infrastructure.

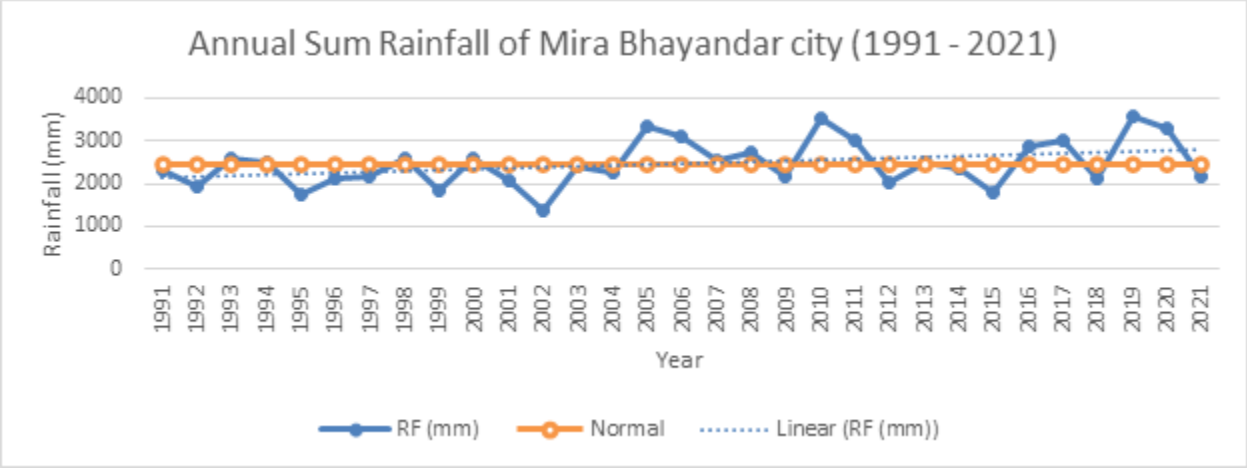

Figure 22: Cumulative Annual Rainfall Trend in Mira Bhayandar (1991–2021)

[Graph: Annual rainfall trend based on provided data]

The above graph depicts the trend in annual rainfall totals from 1991 to 2021. The data shows a consistent upward trend, indicating that the region is experiencing more rainfall year after year. This trend is significant for understanding the increasing likelihood of intense and heavy rainfall events. Such events pose a heightened risk of urban flooding, a situation already observed in the city during the

years 2010, 2018, and 2019, where extreme rainfall led to significant flooding incidents.

The rising intensity of rainfall aligns with global and regional climate change predictions, which forecast an increase in extreme weather events. These climatic trends underscore the urgency of addressing the city's infrastructure vulnerabilities to mitigate urban flood risks.

4.3.2.2 Distribution of Rainfall Intensity

Rainfall events in Mira Bhayandar are categorized into light, moderate, heavy, and very heavy rainfall. Analysis reveals the following trends:

- Light and Moderate Rainfall: These events have historically dominated, contributing to the city's average annual precipitation.
- Heavy and Very Heavy Rainfall: In recent years, there has been a rising trend in heavy rainfall events, contributing disproportionately to urban flooding.

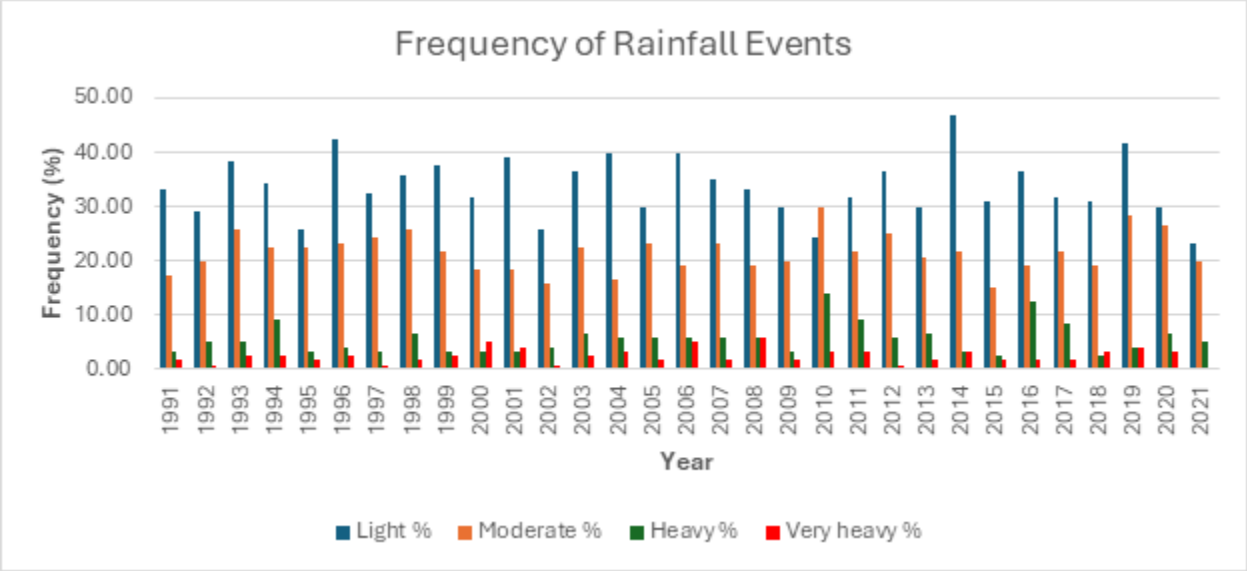

Figure 23: Rainfall Intensity distribution over time

[Graph: Frequency distribution of light, moderate, heavy, and very heavy rainfall events]

The figure 23 illustrates the frequency distribution of rainfall events in Mira Bhayandar from 1991 to 2021, categorized into four intensity levels: light, moderate, heavy, and very heavy rainfall. Over the years, a consistent pattern emerges, showing a persistent occurrence of light and moderate rainfall events. However, the data also highlights a notable increase in the proportion of heavy and very heavy rainfall events, particularly in recent years.

This shift in rainfall intensity reflects a growing pattern of extreme weather events in the region. Heavy and very heavy rainfall events, while less frequent overall, have shown an increasing trend in both frequency and impact. These intense rainfall events are likely contributing to the city's vulnerability to urban flooding, as evidenced by significant flooding incidents in 2010, 2018, and 2019.

Such extreme rainfall events overwhelm the city's drainage systems, leading to flash floods and prolonged waterlogging in vulnerable areas. This trend underscores the need for enhanced flood risk management and infrastructure improvements to

mitigate the impacts of these extreme weather events.

4.3.2.3 Intensity-Duration-Frequency (IDF) Analysis

The IDF curve demonstrates the relationship between rainfall intensity, duration, and return periods. Key observations include:

- High-Intensity Rainfall Events: Intensities increase sharply for durations such as 12 and 24 hours.
- Infrastructure Vulnerability: The city's existing drainage systems are not equipped to handle rainfall intensities predicted for higher return periods.

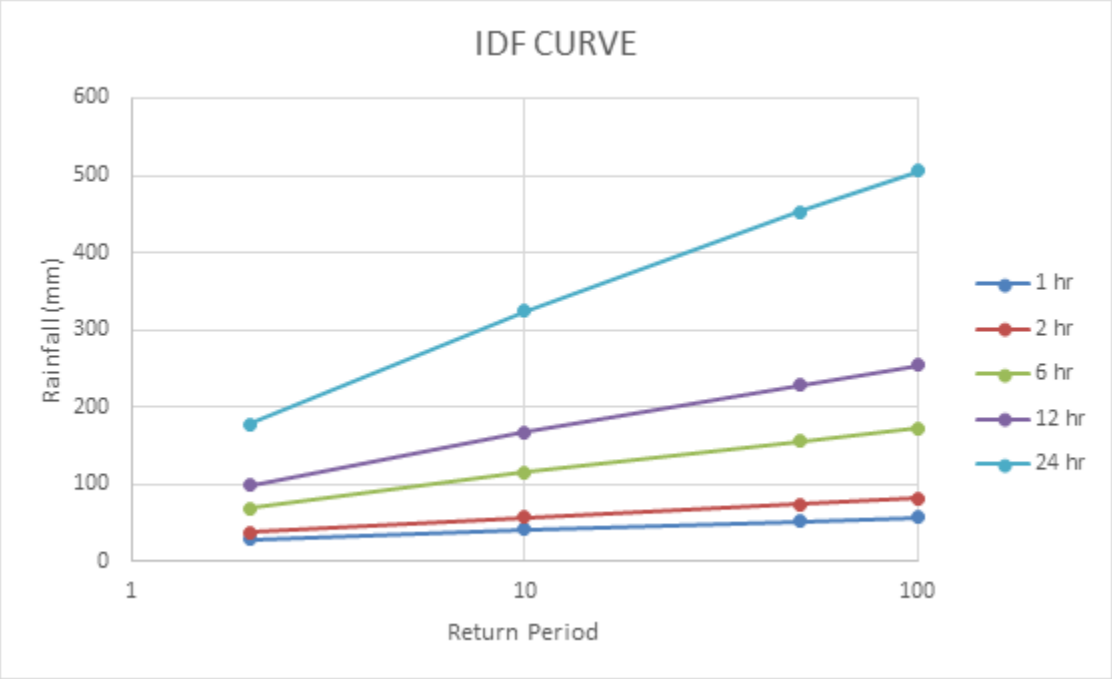

Figure 24: IDF Curve for Mira Bhayandar

[Graph: IDF curve showcasing the rainfall intensities over various Durations and return periods]

The IDF (Intensity-Duration-Frequency) curve presented above highlights the relationship between rainfall intensity, duration, and return period, providing critical insights into extreme rainfall events. The curve shows that as the return period increases, rainfall intensity also rises significantly, with a particularly steep escalation for longer durations such as 12 and 24 hours.

The IDF curve further demonstrates that while extreme rainfall events are less frequent, they can have devastating impacts if the infrastructure is not designed to handle peak intensities. Mira Bhayandar's existing drainage system must be upgraded to accommodate the rainfall intensities associated with higher return periods, especially for durations like 12 and 24 hours, where the risk of flooding is more pronounced. Prolonged heavy rainfall can overwhelm the low-capacity drainage systems, leading to water stagnation and increasing the city's vulnerability to flash floods.

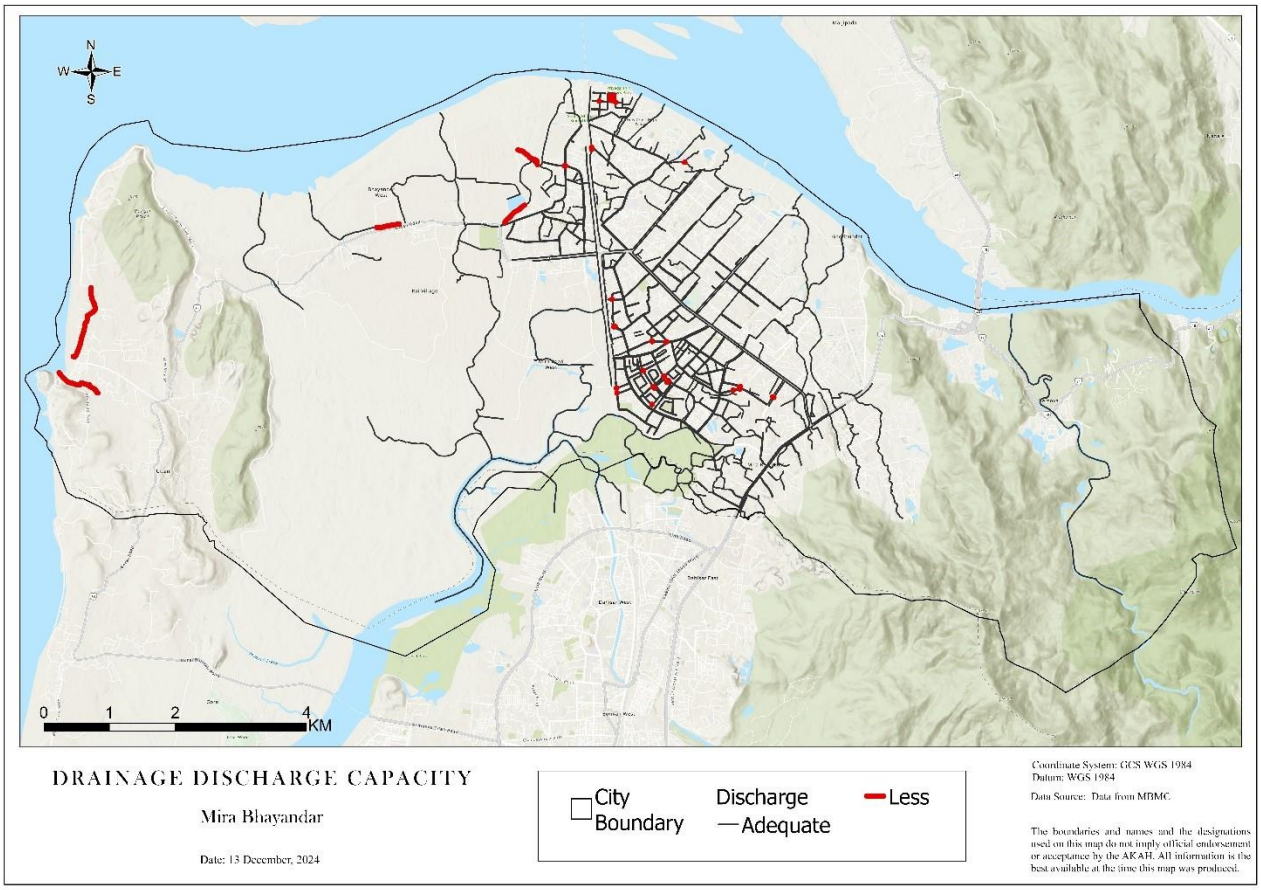

Figure 25: Drainage Discharge Capacity in Mira Bhayandar

The figure 25 illustrates the drainage discharge capacity in Mira Bhayandar, highlighting areas of concern where drainage lines marked in red indicate low discharge capacity. These drainage systems struggle to effectively handle accumulated rainwater during periods of peak rainfall. As a result, excess rainwater cannot drain out efficiently, leading to waterlogging and flooding issues in these areas.

This inadequate drainage performance is particularly problematic during intense and heavy rainfall events, which have become more frequent in recent years. When the drainage infrastructure fails to cope with the volume of rainwater, it disrupts normal urban activities, damages property, and poses significant risks to public safety. Low-capacity drainage systems often exacerbate the impact of flash floods, making certain areas more vulnerable to prolonged water stagnation.

The IDF analysis highlights the urgent need needs for urgent flood immediate flood immediate storm drainage systems and reduce the city's drainage systems to withstand peak rainfall intensities and durations.

4.3.3 Challenges of Existing Drainage Infrastructure

4.3.3.1 Drainage System Capacity Constraints

The Drainage discharge capacity map identifies critical areas where low-capacity stormwater lines are unable to efficiently manage accumulated rainwater.

Areas of Concern:

- Low-Capacity Drainage lines: Marked in red indicate high-risk zones prone to flooding.
- overburdened drainage network often leads to water stagnation, especially in low-lying regions. This situation worsens when rainfall intensity surpasses the system's discharge capacity.

Landmark	Length	Width	Req Breadth
Sagar Complex	7.54	0.76	4.85
Old Raviraj Complex	48.82	0.74	0.75
Old Raviraj Complex	48.78	0.74	0.75
Old Raviraj Complex	47.89	0.74	0.76
Old Raviraj Complex	48.07	0.74	0.76
Old Raviraj Complex	6.86	0.67	5.33
Kheteshwar Chowk	13.11	1.26	2.79
Kheteshwar Chowk	13.20	1.26	2.77
Bhayandar Imaging Centre	39.30	0.73	0.93
Navghar Shamshan Road	6.39	0.66	5.73
Orchid Multispeciality Hospital	30.41	1.26	1.20
Orchid Multispeciality Hospital	5.66	0.56	6.46
Orchid Multispeciality Hospital	50.84	0.72	0.72
Your V Care Multispeciality Hospital	24.81	1.30	1.47
N H English Academy	11.45	1.57	3.19
LBS Marg	16.31	1.61	2.24
Silver Crown Apartment	24.85	1.28	1.47
Om Shanti Chowk	44.11	0.74	0.83
Om Shanti Chowk	16.84	1.12	2.17
Om Shanti Chowk	12.14	1.17	3.01
Jain Mnadir	9.63	1.13	3.80
Jain Mnadir	11.17	1.33	3.28
BAPS Shri Swaminarayan Mandir Mira Bhayandar	33.26	0.73	1.10
BAPS Shri Swaminarayan Mandir Mira Bhayandar	7.36	0.86	4.97
BAPS Shri Swaminarayan Mandir Mira Bhayandar	28.81	0.73	1.27
BAPS Shri Swaminarayan Mandir Mira Bhayandar	29.04	0.73	1.26
BAPS Shri Swaminarayan Mandir Mira Bhayandar	6.26	0.64	5.85
Mira Road Railway Station	8.08	0.99	4.53
Manav Kalyan Kendra	7.84	0.89	4.67
Sector 4 ground	9.58	1.07	3.82

Figure 26: Drainage Discharge Capacity Map for Mira Bhayandar

[Map: Highlighting low-capacity Drainage lines and flood-prone zones]

Overburdened drainage network often leads to water stagnation, especially in low-lying regions. This situation worsens when rainfall intensity surpasses the system's discharge capacity.

4.3.3.2 Aging Infrastructure and Maintenance Issues

- Under-Designed Systems: Much of Mira Bhayandar's stormwater infrastructure was built for historical rainfall patterns and lacks

the capacity to handle the current and projected intensities.

- Blockages and Siltation: Poor maintenance, including irregular cleaning of drains, results in blockages that reduce the effective capacity of the drainage network.
- Urbanization Impact: Rapid urbanization and construction have increased impermeable surfaces, reducing groundwater recharge and amplifying surface runoff.

4.3.3.3 Urban Flood Risk and Vulnerable Areas

Urban flooding in Mira Bhayandar primarily occurs rainfall events, topographic challenges, and unplanned development.

- Extreme Rainfall Events: Intense and prolonged rainfall overwhelm the city's drainage systems.
- Topographic Challenges: Low-lying zones act as natural water stagnation hotspots.
- Unplanned Development: Construction in natural drainage paths and wetlands reduces flood-Buffering capacities.

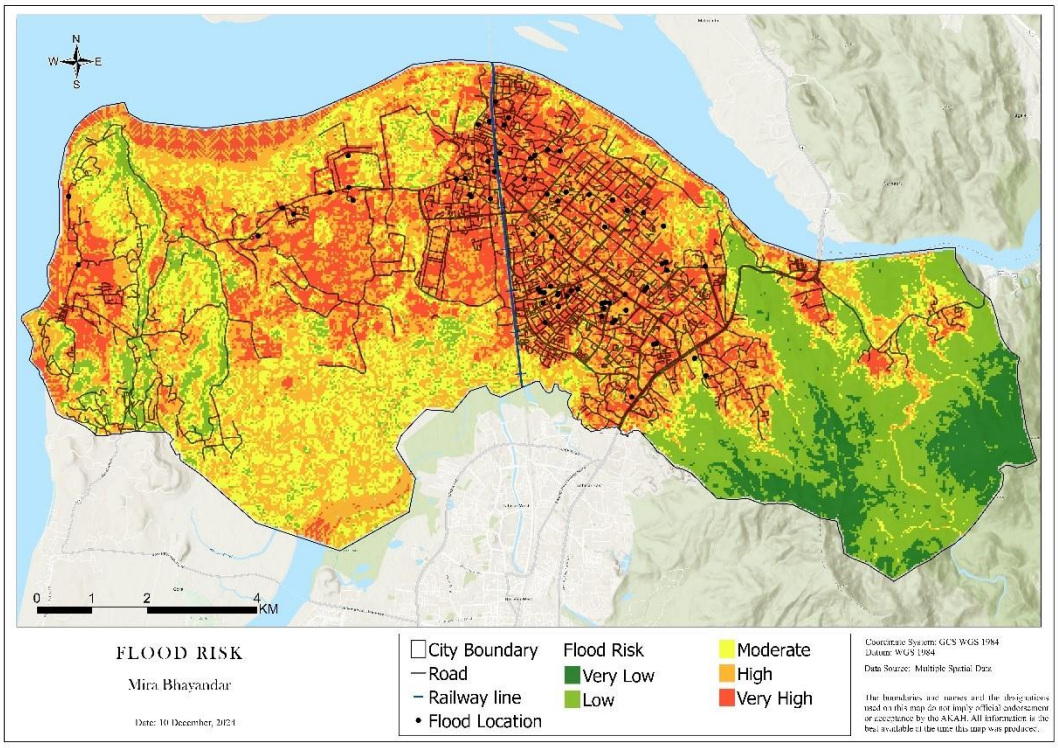

Figure 27: Map of Vulnerable Flood Zones in Mira Bhayandar

[Map: Identifying chronic waterlogging zones and high-risk areas]

4.3.4 Strategies for Risk Management

Sr. No.	Strategies	Description

1	**Infrastructure Upgrades**	• Redesign and expand the drainage network to meet rainfall intensities projected for higher return periods (12–24 hours). • Install sensor-based monitoring systems to detect blockages and optimize discharge performance. • Installation of floodgates at identified 9 priority drainage locations to avoid the storm surge.
2	**Nature-Based Solutions**	• Protect and rehabilitate natural lakes, wetlands, and ponds to serve as flood buffers. • Develop urban green spaces and retention ponds to absorb excess rainwater. • Promote the use of pervious pavements to enhance groundwater recharge and reduce surface runoff.
3	**Urban Planning and Zoning**	• Restrict construction in vulnerable low-lying areas. • Require rainwater harvesting systems in residential and commercial buildings. • Ensure climate-resilient urban growth by integrating flood risk assessments into development control plans.
4	**Early Warning and Flood Forecasting Systems**	• Real-time rainfall monitoring systems with early warning alerts for extreme weather events. • Employ flood forecasting models to prepare for impending rainfall and flooding.
5	**Community Participation**	• Educate citizens on flood preparedness and proper waste disposal to prevent drain blockages. • Involve community stakeholders in disaster response plans and local flood action plans.

Mira Bhayandar's increasing vulnerability to urban floods necessitates immediate and sustained action. The city, situated in a rapidly urbanizing region, faces significant challenges due to inadequate infrastructure, changing rainfall patterns, and the lack of comprehensive urban planning. However, by implementing a multi-faceted approach that includes upgrading infrastructure, adopting nature-based solutions, and enforcing robust urban planning measures, Mira Bhayandar can significantly mitigate flood risks and enhance its resilience to climate extremes.

4.3.5 Key Priority Actions

4.3.5.1 Upgrading the Drainage Infrastructure and implementing Nature-based Solutions

- **Actionable Steps:**
    - Investing in the expansion and modernization of the city's drainage systems is crucial especially in the “high” and “very high” risk wards – 13,20,23,10 and 4. This includes increasing the capacity of existing drains, constructing new drainage channels, and ensuring regular maintenance to prevent blockages.
    - Restore and protect natural water bodies to serve as flood buffers.
    - Stormwater Management - Implementing advanced stormwater management systems, such as green roofs, permeable pavements, and rain gardens, can help in reducing surface runoff and recharging groundwater levels.
    - Install floodgates at 9 key drainage points to block high-tide creek water and address waterlogging in vulnerable areas.
- **Aligned Policies:** Swachh Bharat Mission (Urban), National Water Policy (2012), AMRUT, National Flood Management Programme
- **Concerned Agencies:** Town planning and city Engineer, Disaster Management, Garden Department, Storm Water Drainage Department, Solid Waste Management Department
- **Co-Benefits:** Improved forecasting accuracy, Enhanced Public safety, Reduce waterlogging, Improved drainage lines
- **CSCAF Indicator:** Flood/Water stagnation risk management
- **Target SDGs:** 11, 13, 3, 9
- **Timeline:** Mid Term (2040)

Case Study 1*: Role of EWS during Cyclone Fani in Odisha*

Guwahati, a flood prone city in Assam has successfully implemented a Flood Early Warning System (FEWS) designed to predict and manage urban flooding. This system was launched in August 2020 by the Energy and Resources Institute in collaboration with the National Disaster Management Authority and other local agencies. It aims to provide timely alerts about flash floods and heavy rainfall, which are common occurrences in the region due to its geographical and climatic conditions. The system is equipped with an integrated urban drainage module, enabling street-level flood predictions. The flood levels and hotspots can be visualized on Google Maps, facilitating the identification of flood-affected zones and help authorities to better prepare for disasters.

4.3.5.2 Enforce Urban Planning Regulations

- **Actionable Steps:**
    - Enforcing strict zoning regulations to prevent development in flood-prone areas can help in reducing the risk of property damage and loss of life.

  - Implement strict zoning rules to restrict construction in low-lying areas.
  - Integrating SUDS into urban planning can ensure that new developments are designed to manage water sustainably.
  - Mandate rainwater harvesting systems in all new and existing buildings.
- **Aligned policies*:*** MSAPCC, NPDM, ICZM
- **Concerned Agencies:** Town Planning department and City Engineer Office
- **Co-Benefits:** zoning of areas to identify low-lying areas and controlling development to reduce urban flooding
- **CSCAF Indicator:** Disaster Resilience
- **Target SDGs:** 6,11
- **Timeline:** Short-term (2030)

Case Study 2: Chennai Drainage System

Chennai improved its drainage system through integrated waterway management approach, involving its rivers, canals, and estuaries. Due to the inefficient drainage system, sandbar formation at river mouths, inadequate tidal flushing, and stagnant waterways became a common occurrence. To address the issues, a network was created connecting the Cooum and Adyar Rivers and the Buckingham Canal to the sea, enabling tidal flow for continuous flushing. Modifications to channel dimensions and river mouths were made to optimize water movement, simulations and engineering interventions ensured residual flow for water quality improvement. Furthermore, regular maintenance, such as dredging and sand bypassing, was given priority to sustain the system's effective functioning.

4.3.5.3 Establish Early Warning Systems

- **Actionable Steps:**
  - Introduce real-time flood monitoring and early alert mechanisms to provide timely warnings to residents.
  - Employ flood forecasting models to prepare for impending rainfall and flooding.
- **Co-Benefits:** *reduce the risk during peak rainfall time.*
- **Concerned Agency:** Disaster Management Department
- **Aligned Policies:** MSAPCC, National Flood Management Programme, NPDM
- **CSCAF Indicator:** Flood and Stagnation risk management
- **Target SDGs:** 6,11,14
- **Timeline:** Short Term (2030)

4.3.6 Key Recommendations for Urban Flooding

Recommendations	Responsible Agency	Aligned Schemes/Policies	Timeline
Engage Communities • Foster local participation in flood mitigation and preparedness activities through awareness programs and community-based action plans. • Engaging the community in flood risk management through education and awareness programs can foster a culture of preparedness and resilience ***Co-Benefits:*** *resilient communities by educating them about hazards and ways to prepare and respond*	All MBMC in-line departments	NPDM, NMSH	Continued process
Integrate past and future climate risks, trends and projections in planning for and implementing climate-proofing infrastructure – public and private, (e.g., SWD outfalls, residential / housing projects) • Climate criteria as part of EIA & internal approval process • Dedicated data, norms and guidelines included in the feasibility, DPR, implementation plans - o Of assets protected in storm surge flooding o % of heavy rainfall leading to landslides/ erosion/ flooding o Number of deaths from natural disasters per 100,000 population o Percentage of population vulnerable to natural hazards (e.g., excessive heat, droughts, flooding, landslides, earthquakes, cyclones)	Disaster Management and Solid Waste Management Department, Storm Water Drainage Department	Smart Cities Mission, MSAPCC, National Flood Management Programme, National Hydrology Project	Continued process

Co-Benefits: *future projections about climatic events, establishment of climate-proofing infrastructure*			
Integrate a nature-, ecosystem- and community-based approach in the overall disaster risk management of the city • Reduced disasters and communities affected • Percentage of population vulnerable to natural hazards (e.g., excessive heat, droughts, flooding, landslides, earthquakes, cyclones) • Reduced losses (physical, financial and human) to infrastructure ***Co-Benefits:*** *community awareness and involvement, reduced damages and losses to property and lives*	Disaster management, City Engineer Office, Town Planning Department	NPDM, NMSH	Continued Process

Chapter 4.4

Urban Greening and Biodiversity

4.4.1 Existing Green Cover and Biodiversity

Mira Bhayandar is uniquely situated, bordered by the Sanjay Gandhi National Park (SGNP) to the east, the Sahyadri foothills to the west, Ulhas Creek to the north, and expansive mangroves along the Arabian Sea to the south[2]. The region is further characterized by two Uttan and Gorai beaches and the center of the city is dominated by salt pan lands. These surrounding geographical features significantly limit the scope of horizontal urban expansion in the area.

The city's proximity to SGNP, one of the world's largest urban national parks which spans across 18.16 sq km (39.62% of the total area) is home to several endangered species and harbors around 1300 species of flowering plants, 43 species of reptiles, 45 species of mammals, including 38 species of snakes, 12 species of amphibians, 300 species of birds, and 150 species of butterflies[2].This rich biodiversity hotspot supports vital ecosystem services and acts as critical carbon sinks benefiting the city's environmental health.

Mira Bhayandar's coastline stretches for 23.6 km featuring dense mangrove forests that serve as natural barriers against coastal erosion and storm surges. The inter-tidal zones serve as important habitats for various marine and bird species, including flamingos who stay for a long period of time during winters. The wetlands on the east, namely Ghodbunder Road, are critical stopover points for migratory birds namely stonechat, rose finch and black tailed godwit, making it an important region for avian biodiversity.

Currently, the city has 79 public parks and gardens along with approximately 120 water bodies including lakes, ponds and wetlands. Within the main built-up area, the city has 77 Hectare of area under Green Cover with 0.7 square meters of green space per person which is much lower than 10 square meter per person according to URDPFI guidelines, 2014. The city has 6,47, 963 trees implying city has only 0.8 trees per person excluding the area of mangroves and Sanjay Gandhi National Park which are not in direct control of city administration (Tree census Report 2017-2018). Based on the tree census, the city has a capacity to sequestrate approximately 9720 mtCO2 per year based on the tropical estimates.

4.4.2 Nature-Based Practices

The western part of Mira Bhayandar, particularly **Dongri** and **Uttan**, is home to many indigenous agricultural and fishing communities. These communities have historically upheld the practice of protecting **sacred groves (**small patches of forest dedicated to local deities or ancestral spirits), along with the lush mangroves and salt pans, which serve as vital biodiversity reservoirs/hotspots.

Dongri's historical significance as a center for salt production and **Uttan's Catholic heritage**, evident in its ancient churches like the **Our Lady of Vailankanni Shrine**, highlight the diverse layers of human and natural history interwoven into the region. In **Dongri**, the Agri, Koli and Christian fishing communities are protecting the sacred groves who maintain a strong connection with the nature and

gather to celebrate different rituals and festivals all-round the year. These traditions not only reinforce the cultural identity of the region but also play a critical role in conserving biodiversity.

Similarly, **Uttan**, another coastal village, is rich in cultural heritage, with its traditional fishing festivals, local cuisine centered around fresh seafood, ancient temples, and vibrant festivals like the **Narali Purnima** (coconut festival), which is celebrated by the Koli fisherfolk to honor the sea god. The sacred groves in this area which are also revered as a community protected groves act as natural water recharge pits as they absorb the rainfall acting as bio swales, helping to recharge and store the groundwater and in turn protect against soil erosion because of the water runoff. These areas were also seen as non-developable areas untouched by urbanization for a long time were cutting and chopping activities were banned by the dwelling communities. However, there has been observable habitat loss over the years and the native species of trees, birds and insects are becoming endangered due to anthropogenic activities and pollution.

4.4.3 Citizen Awareness and Accessibility

There are 79 gardens and public parks in Mira Bhayandar as shown in figure 28, most of them are only open during specific hours between 6–9 AM and 4–7 PM. The spaces are inaccessible in the afternoons when especially women, children and senior citizens, visit to play or for leisure activities. Outdoor workers like street vendors, street sweepers, laborers also take a respite from the scorching heat in the shaded areas during the afternoons. The absence or limited access at intervals during the day, combined with a lack or poor provision of essential amenities like shaded areas, drinking water, universal design and seating, makes these parks less inviting, particularly during the city's hot summers. Most of the slums located in ward 13 and 14 have few gardens and public parks which restrict their physical access and makes them even more vulnerable.

The city is undergoing various greening initiatives but most of them are beautification projects where the focus is on ornamental trees to enhance the aesthetics of the city. These initiatives could become ecologically more valuable by promoting native plantation of fruit-bearing trees, like jamun, neem, and banyan, that can provide better shade, support the local biodiversity, and encourage participation from the community in maintaining these spaces. There are few ongoing local initiatives where the environmentally conscious residents and communities are taking the lead to conserve the biodiversity and nature in the city. Green clubs and resident welfare associations have started tree plantation drives and programs like "Adopt a Tree' and advocate for keeping parks open for longer durations, installing or improving facilities for thermal comfort.

4.4.4 City-wide conservation Initiatives

At present, the city has approximately 120+ waterbodies such as lakes, ponds, wetlands and Ulhas Creek at the far south end of the city. The city has undertaken various initiatives in rejuvenating water bodies in Mira Bhayandar but most of them are addressing short-term, project-based intervention improving aesthetics and recreation value. However, linkages with ecological restoration, community involvement and safeguarding of dependent livelihoods on waterbodies would be some of the long-term sustainable measures. In few locations, most of beautification interventions such as use of concrete has disrupted the natural recharge and ecological functions of few water bodies. The focus should be on regular de-siltation, restoring natural recharge zones, using constructed wetlands for wastewater treatment, and enforcing heavy fines on polluters and other pollution control measures to protect these ecosystems.

It is also imperative to seek participation from local residents in regular checks and monitoring and maintenance of water bodies. The **Mira Bhayandar Municipal Corporation (MBMC)** has taken steps in this direction, launching initiatives like plantation drives and beach cleanups that actively engage volunteers and NGOs. While these programs raise awareness to some extent succeed in imbibing a sense of shared responsibility among the residents, but these initiatives need to be linked with long term sustainable and integrated approaches such as a) plans for safe discharge of untreated wastewater b) runoff of pesticides and fertilizers from agricultural lands and c) unchecked pollution that continue to destroy the ecology.

It is commendable that MBMC has conducted two tree censuses, with a third underway, to document its green assets. These surveys serve as critical documents for future urban planning and to strategize conservation efforts but it is not available in the public domain. It is recommended to make these documents available in public domain. These findings will be extremely useful to merge into the **People's Biodiversity Register.**

The city's **Biodiversity Management Committee (BMC)** was established to oversee conservation efforts and ensure sustainable use of local biodiversity. This committee needs to be reactivated with adequate resources and build strong inter-departmental interlinkages.

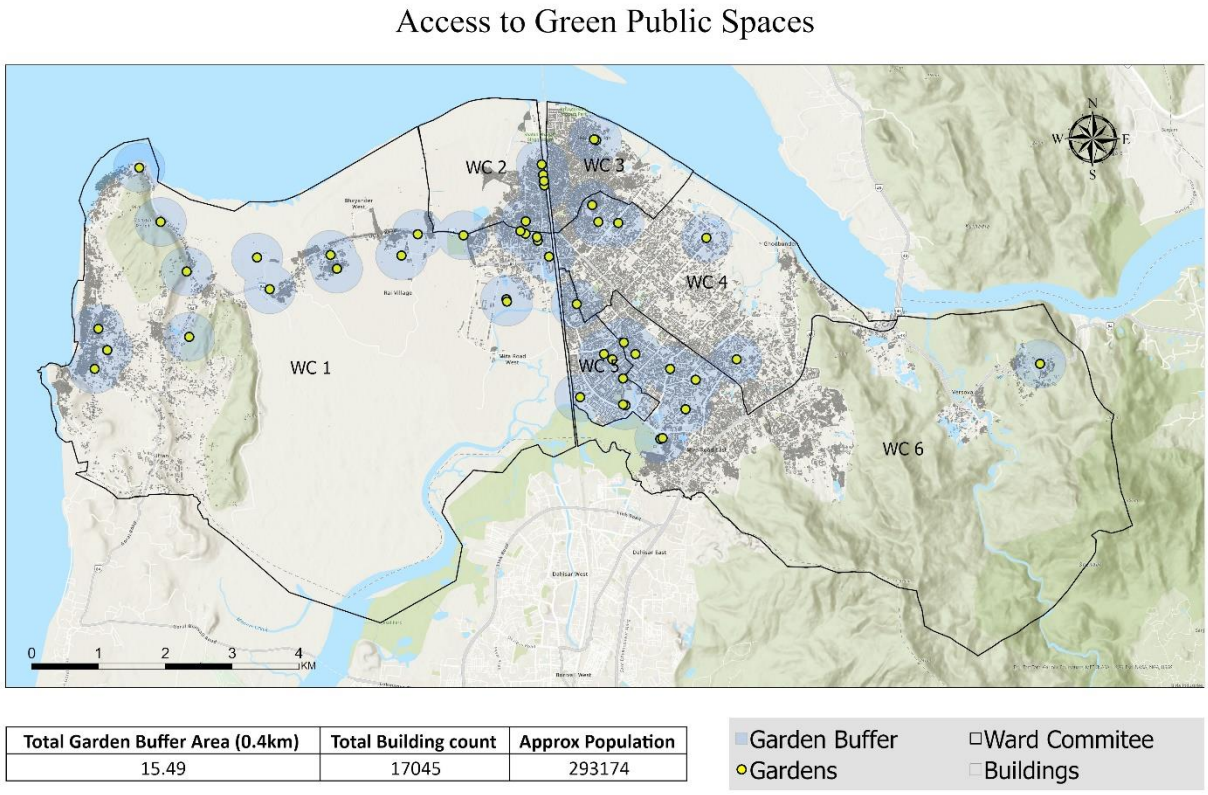

Figure 28: Access to Garden and Public Parks in Mira Bhayandar

4.4.5 Key Priority Actions

4.4.5.1 Establishment and effective functioning of ward-level Biodiversity Management Committees (BMCs)

- **Actionable Steps:**
    - Mandate to involve the local stakeholders such as wildlife conservationists and rescuers in the BMC who can bring in valuable insights on species-specific needs, habitat conservation, and rescue efforts, particularly for marine and urban wildlife. Their involvement can also link the committee's work with ground-level expertise in species protection and ecosystem preservation.
    - A standing committee member should serve as the chairman of the central BMC to ensure alignment with municipal priorities and effective governance.
- **Concerned Agencies**: Garden Department; Environment Department
- **Co-benefits**: Enhanced Conservation Strategies; Reduced Impact of Invasive Species
- **Aligned policies/Schemes:** National Biodiversity Action Plan (NBAP), AMRUT, National Green Mission
- **CSCAF Indicators:** Rejuvenation & Conservation of Water Bodies and Open Spaces, Urban Biodiversity
- **Target SDGs:** 11,15,17
- **Timeline**: Short Term (2030)

4.4.5.2 Promote nature-based bio repellents to avoid pesticides.

- **Actionable Steps:** Promoting fruit bearing trees supports the flora and fauna using natural repellants to control pests instead of harmful fertilizers which breaks the food system.
- **Concerned Authorities**: Environment Department; Garden Department
- **Co-benefits:** Enhanced ecosystem resilience through improved species interactions.
- **Aligned policies/Schemes:** National Mission on Sustainable Habitat, AMRUT 2.0, National Biodiversity Action Plan (NBAP)
- **CSCAF Indicators:** Urban Biodiversity
- **Target SDGs:** 11,15
- **Timeline**: Short Term (2030)

Case Study 1: Bio repellants in Public Gardens, Bangalore

Bangalore city promotes the use of nature-based repellents in public gardens under the community-led urban greening projects. With rapid urbanization leading to diminished greenery and increased mosquito populations, the middle-class community have turned to traditional knowledge and natural solutions to manage pests without relying on chemical pesticides. In this initiative, various plants recognized for their repellent properties, such as Citronella (Cymbopogon nardus), Tulsi (Ocimum sanctum), and Neem (Azadirachta indica), have been cultivated in community gardens and public parks. These plants not only enhance biodiversity but also serve as effective natural repellents against mosquitoes and

other pests. The project has shown favourable outcomes, with significant reductions in mosquito populations reported in areas where these plants are grown[17].

4.4.5.3 Promote and Conserve Green spaces in the city

- **Actionable Steps:** Promote community-led development of greenery in the spaces between road dividers, upcoming metro lines, and any new construction to mitigate Urban Heat Island Effect. Furthermore, it is imperative to acknowledge the importance of sacred groves and conserve them in peri-urban villages to protect both cultural and ecological heritage.
- **Concerned Authorities**: Environment Department, Garden Department
- **Co-benefits**: Urban Cooling, Air Quality Improvement
- **Aligned policies/Schemes**: Maharashtra Harit Sena Initiative, Sacred Grove Protection Initiative by Maharashtra Forest Department, National Afforestation Programme (NAP)
- **CSCAF Indicators:** 3 (Urban Biodiversity)
- **Target SDGs:** 11,15
- **Timeline**: Mid Term (2040)

Case Study 2: Urban Space Management, Bhubaneshwar

The case study on urban green space management in Bhubaneswar, India, highlights the city's efforts to address challenges related to the distribution, accessibility, and quality of green spaces. Currently, Bhubaneswar has a total of 495.1 hectares of urban green space, which is below the recommended standards for recreational use. Key issues identified include unequal distribution of green areas, lack of maintenance, and encroachment on public spaces. The study emphasizes the need for a comprehensive urban green space management plan that incorporates public participation and sustainable landscaping practices. Additionally, it points out that government-developed neighborhoods tend to have more usable open space compared to private land holdings, while certain areas, particularly in the Old Town, suffer from inadequate green space due to land constraints. The research advocates for better integration of green spaces into urban planning to enhance air quality, reduce heat island effects, and improve overall quality of life for residents. Effective management and expansion of these spaces are deemed crucial for fostering ecological health and community well-being in the rapidly urbanizing environment of Bhubaneswar[18].

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[17] Motivations behind gardening in a rapidly urbanizing landscape - A case study of urban gardening in Bangalore, India

[18] Urban Green Space Management and Planning: A Case Study of Bhubaneswar

4.4.6 Recommendations for Urban Greening and Biodiversity

Recommendations	Responsible Agency	Aligned schemes/policies	Period
Maintain a People's Biodiversity Register at a city level • Engage the community in maintaining a People's Biodiversity Register (PBR) to record and monitor the city's biodiversity along with the migratory variations of the species. • Identify biodiversity hotspots across urban and peri-urban areas and assess the presence of invasive species in order to protect and sustain its flora and fauna. • Involvement of the local communities, NGOs, and volunteers will be critical. • Assess the soil quality and the impact of invasive species to ensure the plantation efforts are ecologically compatible and not leading to environmental degradation. • Position the city as a wildlife-friendly corridor by creating interconnected green corridors, incorporating native vegetation, water bowls, and feeding spots to support avian and terrestrial species, and most importantly by involving local communities to safeguard biodiversity and urban ecosystem. ***Co-Benefits:*** ***e****nhanced biodiversity; improved air quality, water management and reduced impact of invasive species*	Garden Department; Environment Department Garden Department; Environment Department	NBAP, AMRUT, National Green Mission	Short Term

Nature Based Solutions • Promote Butterfly Gardens and Nana-Nani Parks by planting a mix of native ornamental and fruit-bearing species. • Promote nature-based bio repellents to avoid pesticides. ***Co-benefits:*** ***e****nhanced ecosystem resilience through improved species interactions.*	Environment Department; Garden Department	NMSH, AMRUT 2.0, NBAP	Short Term
Community led Conservation Initiatives • Strengthen aquatic ecosystems in Mira Bhayandar by collaborating with local communities for wetland restoration, pollution control, and sustainable fishing practices. • Promote community-led development of green spaces, including open spaces, road dividers, and urban parks, while conserving sacred grove practices in peri-urban villages to protect cultural and ecological heritage. • Adopt nature-based conservation techniques in the rejuvenation and beautification of lakes and wells. • In partnership with local communities and NGOs, explore in-situ bioremediation methods for Mangrove and Wetland Safeguard Program. ***Co-benefits****: biodiversity conservation, livelihood enhancement*, Urban Cooling; air quality improvement, carbon sequestration	Environment Department; Garden Department	Maharashtra Wetland Conservation Strategy, Maharashtra Harit Sena Initiative, Sacred Grove Protection Initiative by Maharashtra Forest Department, NAP, AMRUT 2.0, NBAP	Short Term
Citizen Awareness and Accessibility • Develop an informative booklet based on the findings of the People's Biodiversity	Environment Department; Garden Department, Education Department	National Mission on Sustainable Habitat, AMRUT 2.0, NBAP, Urban	Short Term

Register (PBR) and distribute it in both MBMC and private school libraries. The register can act as a guide to Local Biodiversity Action Plan (LBSAP). • Install informative display boards in parks and green spaces to help citizens identify and learn about the native species in the area, ecological roles, and conservation status developing a deeper connection between the community and the natural environment. • The parks can be kept open to provide respite from heat and kept open during the noon hours for the citizens and gig workers/laborers. • Broaden the scope of Environmental Status Reports (ESRs) in Mira Bhayandar to align with Sustainable Development Goals (SDGs) 14,15,16 and 17. ***Co-benefits:*** *Eenvironmental awareness, knowledge of local biodiversity, awareness and knowledge about local ecosystems, sense of protection of native species and equitable access to vulnerable population.*		Green Guidelines by MoHUA, NEP, National Green Mission, NGC	

Chapter 4.5

Mobility and Air Quality

4.5.1 Private Transport

Mira Bhayandar, a vital urban hub falls under the Thane district and the vehicle registrations for the region are processed at the Thane RTO. The city has recently established RTO in Ghodbunder. The analysis of vehicle registrations across categories between 2015 and 2023 provides valuable insights into fuel usage patterns, showcasing both dominance of conventional fuels and steady transition and adoption of low-emission, renewable energy options and future mobility trends in Mira Bhayandar.

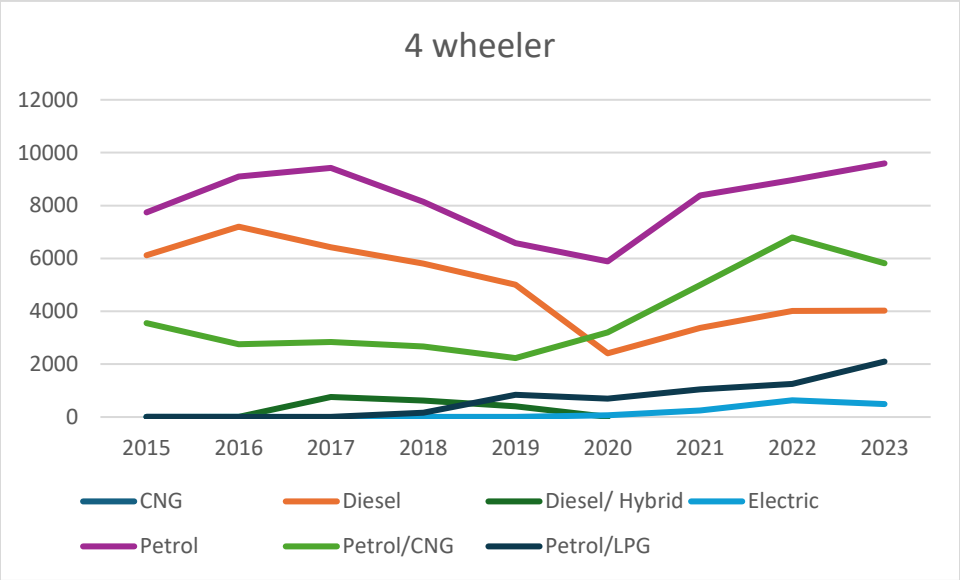

Figure 29: Trend analysis of different fuel consumption by 4 wheelers between 2015-2023

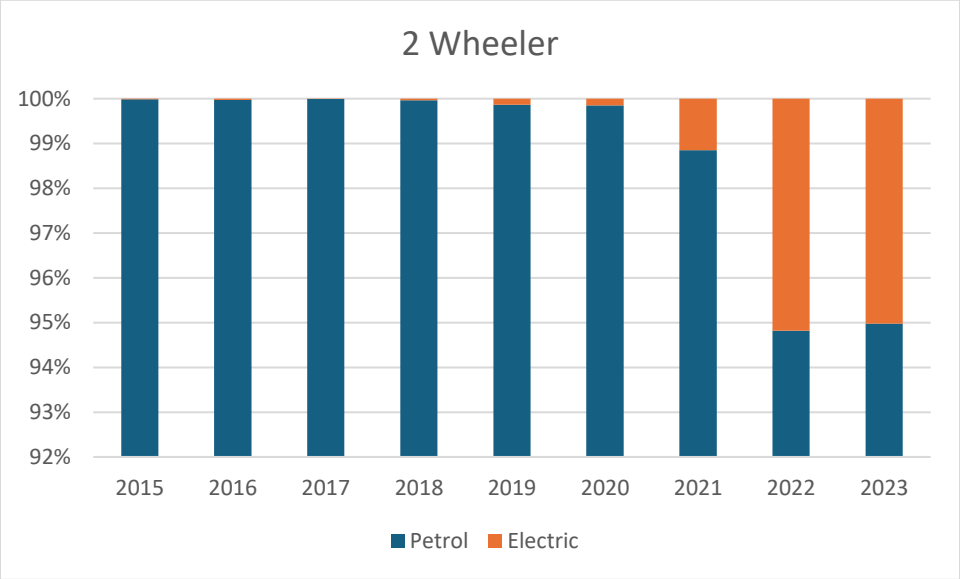

Figure 30: Trend analysis of different fuel consumption by 2 wheelers between 2015-2023

Private vehicles constitute only 21% of the total fleet and the pressure on the public transport systems is mounting with the growing population and city expansion. The city is actively working towards increasing the share of eco-friendly public transportation, such as electric and hybrid buses that will be critical to reduce congestion and emissions.

Diesel vehicles are steadily losing their market share, with a cumulative drop of over 34% for 4-wheelers since 2015 as shown in figure 29, highlighting the impact of stricter emission norms, and incentives to switch to cleaner alternatives[1]. Electric vehicles across both 3- and 4-wheeler categories demonstrate the highest growth rates. For instance, EV registrations in the 4-wheeler category surged by over 48,700% in just 8 years (2015-2023) as shown in figure 29. This is attributed to favorable government policies/schemes, acknowledging the cost-saving benefits, and growing environmental awareness among the people.

4.5.2 Non-Motorized Transport

The city has a significant percentage of population, approximately 20% making daily trips by foot and 5% are made by bicycle[1]. The average walking distance for commuters is 1.5 km while cyclist cover around 2 km per trip. However, the total length of footpaths in the city is currently inadequate, with nearly 60% of the roads having no dedicated footpaths for pedestrians, particularly in densely populated neighborhoods[1]. At present, there are no dedicated cycling lanes in the city which deters residents to use cycling, a sustainable eco-friendly, cost-effective mode of transportation. Moreover, dedicated and safe bike parking stations are available at only 3 locations near major transit hubs, with a total capacity for 50 bicycles.

The integration of NMT such as footpaths, cycling parking stations and infrastructure with the public transport systems such as the Mira Bhayandar Municipal Transport is crucial. Currently, only 30% of bus stops are accessible by footpaths limiting the ease of commuters to transition between walking/cycling and public transport. There are only 15 marked crosswalks across major intersections which is insufficient and can lead to unsafe crossing.

The city requires an estimated 12,672 Equivalent Car Spaces (ECS) for on-street parking in the MBMC area, indicating a high demand for parking solutions.

4.5.3 Public Transportation in Mira-Bhayandar

Mira-Bhayandar, a bustling suburban region in the Mumbai Metropolitan Region (MMR), boasts a growing and diverse public transportation network designed to cater to the city's increasing population and mobility needs. The city's public transport ecosystem is a combination of municipal buses, auto-rickshaws, and an upcoming metro line, which together aim to provide seamless connectivity to residents and visitors.

4.5.3.1 Mira-Bhayandar Municipal Transport (MBMT)

The Mira-Bhayandar Municipal Transport (MBMT) was established in 2006 and a key public transport provider in the region. MBMT operates 29 bus routes and serves 93 bus stops across the city. The routes extend from Ambedkar Nagar to Ghodbunder Gaon and from Bhayandar Railway Station (W) to Manori Tar, offering reliable intra-city and inter-city connections. The city is served by two primary bus stations located in **Mira Road** and **Bhayandar**. MBMT's fleet predominantly consists of diesel and CNG buses, with plans to integrate 42 electric buses into the system by 2030 as part of a Green Mobility Initiative.

The total daily movement of passengers across the network is around 15 lakhs demonstrating the substantial mobility demands of the region (MBMC Mobility Plan 2023-2053). The Origin-Destination (OD) matrix informs that internal trips account for 25% of the daily trips facilitated by MBMT and IPT while trips originating from MBMC to external locations and vice-versa comprise 19%. A major highway, NH-48 passes through the center of the city accounts for 37% of the daily trips and a major contributor to dust pollution in the city.

4.5.4 Intermediate Public Transport (IPT)

The road network in Mira Bhayandar is **112 kilometers which carries both** public and private transport vehicles. **CNG-powered auto-rickshaws** offer affordable fares ranging between INR 10 to 20 and last-mile connectivity to commuters.

Metro Connectivity

*The upcoming **Metro-9** project is a game-changer for Mira-Bhayandar's public transportation. The metro corridor is elevated and spans **10.41 kms**, connecting **Dahisar** to **Bhayandar (West)**, with 8 stations. It is being developed in two phases:*

*1. Phase 1: **Dahisar to Kashigaon** (expected to be completed by December 2024).*

*2.Phase 2: **Kashigaon to Subhash Chandra Bose Maidan (Bhayandar, West)** (expected to be completed by December 2025).*

The upcoming metro will reduce the on-road traffic congestion and offer faster, eco-friendly alternatives to existing transport modes. The project includes constructing 3 flyovers beneath the metro line to further ease vehicular movement.

4.5.5 Key Priority Actions

4.5.5.1 Complete Street Concept for Mira Bhayandar for Dust Control

Description: Complete Streets integrate all modes of transportation, including walking, cycling, and public transport, with a focus on safety, efficiency, and environmental health.

- **Actionable Steps:**
  - Ensure streets are well-lit, seating arrangements at frequent intervals, active usage of street-level spaces (e.g., shops, cafes) to increase foot traffic and reduce isolation.
  - Design streets with features like ramps, tactile paving, and wide pathways to accommodate wheelchairs, strollers, and individuals with mobility challenges.
  - Use of clear and universal signage, including maps with safe routes highlighted, play areas or interactive elements for children, safe, clean, and well-maintained gender-inclusive restrooms at regular intervals.
  - Involve women, non-binary individuals, and other underrepresented groups in the planning process to reflect diverse needs.
- **Co-Benefits:** - Improved Air Quality, Enhanced Public Health, Increased Safety and Social Inclusion and Equity
- **Concerned Agencies: Town Planning, PWD, Electrical**
- **Aligned Schemes/ Policies:** *National Clean Air Programme (NCAP)* and seek grants or loans under state/national urban renewal schemes.
- **SDGs: 3,5,7,9,11,13**
- **CSCAF Indicator:** Level of Ai Pollution, Percentage of coverage of NMT network (pedestrian and bicycle in the city)
- **Timeline:** Long-term (2050)

Case Study 1: Pune's "Reclaiming Streets, 1 Kilometer at a time"

Pune city was ranked as one of the most congested cities globally in 2020, highlighting the urgent need for improved mobility and public spaces. In response, the city implemented initiatives by empaneling architectural firms to enhance walkability and reclaim public spaces through "Complete Street Designs'. In total 9 streets of Pune with more or less kilometer each was transformed, including two major commercial streets, Jangali Maharaj Road and Ferguson Road. A major share of these streets was occupied by four-wheelers and unauthorized activities, leaving little space for pedestrians. The streetscaping transformed the utility of these roads by including the widening of footpaths parallel parking spaces to reduce vehicular congestion, and adding seating areas with public gym areas and designated space for street vendors[19].

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[19] Pune's "Reclaiming Streets, 1 Kilometer at a time"

4.5.5.2 Enhancing Walkability and Heat Mitigation in High Pedestrian Traffic Areas

Description: To improve walkability and mitigate urban heat island effects in Mira Bhayandar, strategic interventions should focus on incorporating shading and greening in areas with high pedestrian activity, such as market streets, transit hubs, and public parks. These measures will enhance thermal comfort and encourage walking.

- **Actionable Steps:**
  - Deploy durable and retractable awnings over sidewalks and shopfronts in commercial areas
  - Replace asphalt with natural paving stones or tiles that absorb less heat, traditional impervious concrete pavements with **permeable paving materials** to reduce heat absorption and improve rainwater infiltration.
  - Set up small, shaded "cooling stations" in busy zones for pedestrians with water fountains, shaded benches, and cooling features power.
  - Install heat-resistant benches, bollards, and garbage bins made from materials that absorb less heat and remain cool to touch.
- **Concerned Agencies:** Transport department, Vehicle department
- **Target SDGs**: 3,7,9,11, 13
- **Co benefit:** Enhanced Urban Liveability, Public Health Benefits, Energy Efficiency and Climate Action
- **CSCAF:** Percentage of coverage of NMT network (pedestrian and bicycle in the city)
- **Timeline:** Long term (2050)

Case Study 1: Non-Motorized Transport Network Plan for Coimbatore

Coimbatore, the second-largest city in Tamil Nadu, spread across 257 sq km had an absence of robust NMT which has raised concerns about the safety of pedestrians and cyclists. Walking and public transport account for 57% of the total trips in the city and nearly 1 lakh population is dependent on cycles for daily commute. For around 70%, walking and cycling are preferred modes for first-mile and last-mile connectivity.

In response, the Coimbatore City Municipal Corporation (CCMC) has developed an NMT Network Plan aimed at enhancing the safety and convenience of NMT users. The plan promoted walking and cycling at 26 pedestrian hotspots and proposed a 290-kilometer network of safe, accessible roads for pedestrians and cyclists. The primary objective of this initiative was to create a comprehensive framework that supports safe and convenient walking and cycling infrastructure, enabling Coimbatore to adopt a sustainable, low-carbon mobility future by 2035[20].

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[20] A Sustainable Asset Valuation of Non-Motorized Transport in Coimbatore, India

4.5.5.3 Need of having emission inventory for air quality

Description: At present, the city does not have an emission inventory. This makes it hard to identify the main sources of air pollution and take effective action. By creating an inventory, the city can measure emissions from different areas, such as transportation, industries, and waste management. This step will help the city decide mitigation strategies, set clear air quality goals and track progress over time.

- **Actionable Steps:** Develop an air pollution emission inventory for the city to identify major pollution sources, establish a baseline for air quality management, and support the development of targeted mitigation strategies.
- Regular updates help monitor progress and refine policies to achieve cleaner air.
- **Concerned Agencies:** Environment Department, Town Planning Department
- **Co-benefits:** Health benefits, Climate action support, Improving air quality
- **Aligned schemes:** National clean air program
- **CSCAF Indicators:** Level of Air Pollution, Clean Air Action Plan (Planning and Implementation)
- **Target SDG**: 3, 11,13
- **Timeline:** Short-Term (2030)

4.5.6 Recommendation for Mobility and Air Quality

Recommendations	Responsible Agency	Aligned Schemes/Policies	Period
Electrical Vehicles • Develop public EV charging stations on government land under a revenue-sharing model in partnership with private entities. • This initiative will increase accessibility to EV infrastructure, accelerate EV adoption, and generate revenue for the government. ***Co-Benefits: e****mission reduction, improved air quality, revenue generation, job creation, traffic decentralization, enhanced transportation sustainability.*	Transport Department, MBMC, MAHAPREIT, Electrical works	FAME India Scheme, NEMMP, Smart Cities Mission	Mid Term
Air Quality Monitoring Station Install more Air Quality Monitoring SNational clean air program stations (currently only 1)	Environment Department, Town Planning Department, Traffic Department	NCAP	Short Term

at different locations focusing on high-traffic areas, industrial zones, and residential neighborhoods.in the city to make a comprehensive database. ***Co-benefits:*** *health benefits, climate action support, improving air quality.*			
Variable Parking Mechanism Implementation of time-based Variable Parking Mechanism / Zonal parking pricing on the different parking zones identified based on traffic density, land use and availability of public transport. High-density areas will have higher parking charges whereas peripheral zones would have lower rates. ***Co-Benefits:*** *Reduced Traffic Congestion, Improved Air Quality, Revenue Generation, Behavioural Shift*	-	Smart Cities Mission, NUTP	Short Term
Hawking Zones in Mira Bhayandar • Conduct surveys to map areas with the highest vendor density, such as markets in Bhayandar West, Mira Road stations, and commercial zones like Shanti Nagar and Kanakia Road. • Prioritize zones where street vending obstructs pedestrian movement and creates traffic bottlenecks. • Allocate designated vending zones with clear boundaries near market hubs, malls, and railway stations.	National Association of Street Vendors of India, Local Police and Traffic Management Authorities.	Street Vendors (Protection of Livelihood and Regulation of Street Vending) Act, 2014, Smart Cities Mission, AMRUT.	

• Ensure these zones are strategically located to attract customers without disrupting traffic or pedestrian flow. • Include essential facilities like shaded areas, drinking water, waste bins, and public restrooms to support vendors and customers. • Install signage to guide pedestrians to these designated vending areas. • Collaborate with street vendor associations to ensure fair allocation of spaces and adherence to vending rules. • Implement a token or permit system to regulate the number of vendors in each zone. • Designate specific entry and exit points for vending areas to minimize disruptions to traffic. • Create adjacent walking paths and cycle lanes to ensure pedestrian safety. • Sanction permits for vendors operating in designated zones to prevent overcrowding and illegal vending.			
Promotion of Public Transport • Introduce regulations where vehicle ownership requires proof of adequate parking space to discourage unnecessary vehicle purchases. • Designate certain roads as car-free zones on specific days to promote walking,	Transport department	NUTP, FAME India Scheme, Smart Cities Mission	Mid Term

cycling, and public transport usage. • Allow parking only in designated areas, eliminating illegal parking that often contributes to congestion and environmental degradation. ***Co-Benefits:*** ***r****educed air pollution, less congestion, encouragement for public transport, improved urban aesthetics*			
Augmentation of EV charging infrastructure • Provide **dedicated parking spaces** with integrated charging facilities at high-traffic and accessible locations such as ▪ Commercial hubs ▪ Public parking lots ▪ Airports and railway stations ▪ Residential neighbourhoods • Offer **subsidized parking rates** to incentivize EV ownership and usage. • Power charging stations with renewable energy sources, like solar panels can be established to reduce dependence on non-renewable energy. ***Co-Benefits:*** ***r****eduction in air pollution and greenhouse gas emissions, promote green job, supports a seamless transition to EVs by addressing range anxiety.*	Town Planning Department, Revenue Department	-	Mid Term
Non-Motorized Transport • Implement continuous and well-marked cycle lanes to	Transport department, Town planning department, PWD	NUTP, AMRUT Scheme Smart Cities Mission	Mid Term

encourage cycling as a viable commuting option. • Develop and maintain well-lit, clean, and safe pathways for pedestrians and cyclists. • Remove encroachments on footpaths and cycle tracks to ensure safe usage. • Engage local experts and community members to ensure inclusive planning and consistent maintenance. ***Co-Benefits:*** *Reduced Traffic Congestion, Health Benefits, Air Quality Improvement, Increased Accessibility*			
Freight Transport Conducting a comprehensive freight movement study is crucial to understanding the logistics landscape in Mira Bhayandar. Th study should map out: Freight movement patterns across different zones. Types of vehicles (e.g., light, medium, heavy-duty). Fuel usage trends and associated greenhouse gas emissions. Routes with high freight activity or congestion hotspots. Launch pilot projects focused on electrifying municipal service fleets Accelerate the transition to EVs in the freight sector by offering a comprehensive incentive package	Transport department, Revenue department	-	Mid Term
Promote Electric three-wheeler auto Rickshaw • Offer upfront purchase subsidies, battery-swapping station	-	FAME India, (NEMMP), Urban Transport Initiatives under AMRUT, (NCAP)	Mid term

subsidies, or interest-free loans to the customers. • Establish fast-charging technology hubs near high-traffic areas such as public transport nodes, markets, and residential zone to minimize downtime for drivers. connectivity. • Incentivize private players to develop battery-swapping networks, reducing operational delays for e-auto drivers. • Develop an integrated fare system allowing passengers to seamlessly transfer between e-autos and public transport, potentially leveraging QR codes or mobility cards. ***Co-benefits:*** *reduce tailpipe emissions, lower operating costs, improve driver income, enhanced accessibility*			

Chapter 4.6

Waste Management

4.6.1 Waste collection and generation

Mira Bhayandar generates approximately 650 tonnes of waste daily, amounting to 569 grams per capita per day for residents and 284.50 grams per capita per day for the floating population[21]. The major sources of solid waste include households, fresh produce markets, meat and chicken shops, hotels, commercial establishments, schools, colleges, and other institutions. Residential areas, colonies, and apartment complexes contribute 82% of the total waste generated, while commercial and market areas contribute 16% and 2%, respectively.

The city has nearly an efficient waste management system and ODF ++ (**Swachh Survekshan, 2021).** The city's generated waste predominantly Wet consisting of food and organic waste, which accounts for 55.42% of the total waste. Plastics, including plastic bags, accounts for 10.69%, while miscellaneous inert materials such as ash, soil, and silt constitute 11.42% of the total waste. Paper waste contributes 8.68%, and horticulture waste and wood make up 5.76%, which could be composted or reused by recovering the resources. Glass and metals (1.62%), leather, rubber, and synthetics (0.69%), tetra packs and laminated plastics (2.52%), and clothes and rags (3.20%) hold minor shares in the total waste generation[21]. The waste composition of the city emphasizes the need for targeted strategies to effectively manage their wet waste (food and organic content) and undertake measures to reduce plastic waste, and recycle or repurpose other materials.

The waste collection system in Mira Bhayandar is primary door-to-door, and the city is bin-free. However, occasional dump points were found near markets, railway station, transit points and other areas where there is heavy footfall. The waste is being collected by MBMC in two main categories – wet and dry using a QR-based system, although this system does not cover the slum areas and few other pockets in the city. All waste-related data is stored in an online database to assist in solid waste management planning. Street sweeping is conducted in two shifts: from 7:00 AM to 10:30 AM and from 2:30 PM to 6:30 PM.

4.6.2 Wet Waste

The city generates a significant proportion of biodegradable wet waste, including food and garden waste, which constitutes 55.42% of the total waste generated. The management and processing of this wet waste have been entrusted to M/s. Saurashtra Enviro Projects Pvt. Ltd. on a Design, Build, Finance, Operate, and Transfer (DBFOT) basis. However, only 10% of the total waste is composted, the city has the potential to scale up composting operations,

[21] Solid Waste Management Detailed Project Report for Mira Bhayandar

given the immense amount of wet waste generated daily.

MBMC has operationalized four of its planned seven biogas plants till now by leveraging bio-methanation technology developed by the BARC. The energy produced at plants is later used to operate the facility making it self-sustainable. These plants collectively recycle 50 tonnes of wet garbage daily, generating 275 kVA of electricity. The city administration plans to expand the capacity to 100 TPD and 575 kVA across all seven plants. The decentralized model helps in reducing the waste transportation costs and also in operating the facility with the generated electricity. The compost is utilized as manure by the municipality and also made available to citizens through women's self-help groups. MBMC aims to transmit surplus energy to the grid, promoting use of renewable energy, energy-efficiency and cost savings.

The city has also deployed innovative strategies such as the "On-the-Go Composting" wherein mobile Tow-Go vans are deployed to process wet waste into compost while collecting garbage across the city. These vans are CNG and solar powered with a carrying capacity of 1.5 tonnes of waste daily. Other initiatives include collecting the waste oil from the restaurant and discharging the liquid waste into the nallah after treatment. At present, there is no mechanism to manage the 5 tonnes of poultry waste produced per day but MBMC is keen at tackling the challenge.

4.6.3 Dry Waste

The non-biodegradable dry waste accounts for 27.40% of the total, consisting of materials like paper, plastic, cloth, and other recyclables. A substantial portion of dry waste is informally recycled by unorganized sectors, with limited data available on these activities. To address this, the city has also entrusted dry waste processing to M/s. Saurashtra Enviro Projects Pvt. Ltd. The primary processing facility in Uttan receives 150 tonnes of segregated waste daily and a portion of it is converted into refuse-derived fuel for Ultratech Cement Company.

4.6.4 Hazardous Waste

The city also collects and treats hazardous and mixed waste though a plasma technology-based plant which has installed capacity of 8 tonnes. With an investment of ₹8.27 crore, the project aims to process 8 tonnes of waste daily at a facility in Dhaavgi village, Uttan. This innovative thermal treatment technology generates less harmful by-products and converts waste into 7% ash, which can be used in construction materials such as cement and pavement blocks. This initiative will not only help the city in managing hazardous and mixed waste but also address the challenge of limited space and harmful emissions into the air.

4.6.5 Waste transportation and disposal

Municipal solid waste is collected using diesel-operated vehicles, but the city lacks transfer stations which increases their transportation costs and reduces efficiency in waste handling. The waste is later directly transported to the dumping site at Uttan.

The majority of the waste ends up in the landfill, but the city administration can explore alternatives like composting and recycling to achieve Zero Waste to Landfill. The city faces challenges in managing leachate from garbage hills, which impacts local farms and pollutes nearby water bodies in Uttan. Additionally, the absence of a comprehensive construction and demolition waste management strategy has led to illegal dumping near wetlands and public spaces.

4.6.6 Wastewater

The city has 10 STPs which treat 110.5 MLD and 1 tertiary treatment plant with 5 MLD capacity stationed at different parts of the 107 km drainage network. Although, the total installed capacity of STPs is 128 MLD and there exists a gap 17.5 MLD in the existing treatment capacity[21]. The city administration has budgeted for installing STP with a loading capacity of 48 MLD and it is currently under construction. At present there are 10 STPs out of which 8 are working. Moreover, the city uses SCADA technology to optimize the sewage treatment infrastructure, achieving a 42% cost reduction and saving ₹4.61 crore annually to the administration[22]. This technology enables real-time monitoring which supports efficiency in operations and water reuse through a tertiary treatment plant for non-potable applications, conserving resources and improving sustainability.

4.6.7 Key Priority Actions

4.6.7.1 Construction and Demolition waste

Description: C&D waste accounts for nearly half of the solid waste generated globally each year. This type of waste includes materials such as concrete, wood, metals, glass, and plastics, which are produced during the construction, renovation, and demolition of buildings and infrastructure. The city lacks a comprehensive strategy to manage C&D waste.

- **Actionable Steps:**
    - Include clauses in municipal and government contracts mandating a minimum percentage of recycled C&D materials for construction projects.
    - Offer financial incentives or tax rebates for contractors and developers using recycled C&D materials.
    - Implement QR codes on C&D waste trollies to track the source, quantity, and destination of waste.
    - Conduct workshops with builders, contractors, and government officials to promote awareness of C&D waste reuse and traceability systems.
- **Indicators to track the progress -**
    - Quantity of Recycled C&D Waste:
    - Volume of C&D waste reused or recycled annually.
    - Recycling Rate of C&D Waste
    - Number of Projects Using Recycled C&D Materials:
    - Reduction in C&D Waste at Dumping Sites
- **Concerned Agencies:** Solid waste department, Maharashtra Pollution Control Board, Public Works Department

[22] Mira- Bhayandar: MBMC Aims To Save More Than ₹ 4.61 Crore Annually With SCADA System Implementation In Sewage Treatment

- **Co-Benefits:** Landfill Diversion, Resource Conservation, Cost Efficiency for Projects.
- **Aligned Schemes/Policies:** Construction and Demolition Waste Management Rules, 2016, National Resource Efficiency Policy, 2019, Swachh Bharat Mission 2.0
- **Target SDGs:**9,11,12,13 15
- **CSCAF Indicator:** C&D waste management
- **Timeline:** Mid-Term (2040)

4.6.7.2 Management of Furniture and Poultry Waste

Description The management of bulky furniture waste in Mira Bhayandar is a pressing issue for the city administration.

- **Actionable Steps:**
  - Establish specific monthly collection days for registered bulky furniture waste, ensuring items are segregated for reuse, recycling, or processing into biochar and compost to decrease landfill pressure.
  - By implementing scheduled collection days, residents can plan ahead, and ensure that bulky items are disposed of responsibly rather than being left on sidewalks or in yards.
- **Indicators to track the progress:**
  - **Monthly Collection Rate**: Percentage of households participating in bulky furniture waste collection days.
  - **Waste Diversion**: Amount of furniture waste diverted from landfills and processed
- **Concerned Agencies:** Solid waste department
- **Co-Benefits:** Landfill Pressure Reduction**,** Resource Recovery**,** Environmental Improvement**,** Community Awareness**,** Employment Opportunities
- **Aligned Schemes/Policies:** Swachh Bharat Mission**, Smart** Cities Mission
- **SDGs:** 11,12,13,15
- **CSCAF Indicator:** Extent of dry waste recovered and recycled
- **Timeline:** Short-Term (2030)

Poultry Waste

Description The management of poultry waste in Mira Bhayandar is currently inadequate, with no established mechanism to treat it. Poultry markets and shops generate significant amounts of organic waste which if not properly managed, can lead to public nuisance, environmental pollution, and health hazards.

- **Actionable Step:** Establish designated collection points at poultry markets and shops with a daily collection schedule using specialized vehicles to process collected waste through composting for organic fertilizer and anaerobic digestion for biogas production.
- **Indicators:**
  - Percentage of collected poultry waste processed through composting or anaerobic digestion.
- **Concerned Agencies**: Solid Waste Department
- **Co-Benefits**: Reduced Environmental Pollution, Improved Public Health
- **Aligned Schemes/Policies**: Solid Waste Management Rules, 2016, National Biogas and Manure Management Programme (NBMMP), Swachh Bharat Mission 2.0

- **Target SDGs**: 3,6,7,11,13
- **CSCAF Indicator:** Extent of Wet Waste Processes
- **Timeline:** Short Term (2030)

Case Study 1: Coconut waste

The Mira Bhayandar Municipal Corporation MBMC established a mini processing unit in Bhayandar to recycle leftover tender coconut shells. This unit converts the shells into organic manure and coir ropes, adhering to sustainable waste management practices. With a capacity to process 40 tonnes of coconut shells, the initiative aims to reduce the burden on dumping grounds while producing valuable by-products for societal benefit. Recognizing the project's impact, MBMC has provided space and infrastructure to enhance recycling operations, aligning with the principles of "Reduce, Reuse, and Recycle."

4.6.7.3 Use of Biogas in Municipal Waste Collection Vehicles

Description: Currently the city has biogas plants of 50 tonnes and utilizes the generated electricity to run the facility operations. There is a scope for the city administration to use the generated electricity to run waste collection vehicles and earn revenues.

- **Actionable Steps:**
  - Install purification systems to upgrade raw biogas to biomethane by removing impurities such as carbon dioxide and hydrogen sulfide, making it suitable for vehicle use.
  - Retrofit existing waste collection vehicles to run on compressed biogas (CBG) instead of diesel.
- **TargetSDG:7,11,12,13**
- **Aligned schemes/Policies:** SATAT (Sustainable Alternative Towards Affordable Transportation) Initiative, Swachh Bharat Mission
- **Target SDGs:** 7
- **Timeline:** Mid-Term (2040)

Case Study 2: RRR Initiative

MBMC has launched the Reduce, Reuse, and Recycle (RRR) initiative, setting up 24 centers across the city to encourage sustainable waste management. These centers collect items such as old clothes, books, toys, and e-waste for refurbishment or recycling, and later distributed to those in need. A mobile RRR van complements the effort, promoting community participation and environmental conservation. This initiative, part of the Swachh Bharat Mission-Urban 2.0, aligns with fostering sustainable living habits and reducing waste generation.

4.6.8 Key Recommendations for Waste Management

Recommendations	Responsible Agency	Aligned Schemes / Policies	Period
Strategies for dust management Effective dust management in Mira Bhayandar is essential to address air quality concerns caused by particulate matter (PM10 and PM2.5) emissions. 1. Construction Dust Control • Enforce covering of construction and demolition sites with tarpaulin or similar materials. • Use water sprinklers and fog cannons to suppress dust at construction sites. • Mandate daily water sprinkling during active construction phases and temporary storage for C&D waste to avoid scattering. • Use GPS-enabled vehicles for proper transportation of C&D waste to designated site. 2. Road Dust Management • Prioritize paving all unpaved roads to minimize dust from vehicular movement. • Deploy mechanized sweepers with HEPA filters for regular cleaning of major roads and intersections. • Use tanker trucks with spray nozzles for daily water sprinkling on major dust-generating roads. 3. Green Barriers and Landscaping • Prioritize planting dust-tolerant native species like neem, focus, and cassia.	Solid Waste Department	(NCAP) (C & D) Waste Management Rules 2016, (NBC) of India	Short term

• Convert vacant plots into temporary green spaces to prevent loose soil from becoming airborne. 4. Policy and Enforcement • Introduce penalties for non-compliance, such as failure to cover materials or improper waste disposal. • Install additional dust monitoring stations to track PM10 and PM2.5 levels. ***Co-benefits****: Reduced incidence of respiratory, Improved visibility and reduction of urban heat island effect, Conservation of biodiversity in affected areas, Enhanced liveability and comfort.*			
Extended producer responsibility for wastewater • For New and Existing Societies - ▪ Mandate to install and operate on-site decentralized wastewater treatment for new societies with high water consumption (>5,000 litres/day) and introduce a minimum wastewater reuse target. ▪ Existing Societies should be encouraging to obtain treated water from centralized facilities and procure EPR certificates. • Mandate for Industries – ▪ To meet reuse targets based on their total water consumption ▪ To report freshwater usage, wastewater treatment, and reuse annually. • Create a dedicated monitoring platform to monitor and ensure compliance with water consumption, wastewater	Solid Waste Department	NCAP, C & D Waste Management Rules 2016, NBC of India	Short term

generation, treatment, and reuse data. Provide incentives or subsidies for treated wastewater adoption, such as reduced water tariffs or EPR certification benefits. Plan and establish satellite STPs for zones with high residential or industrial densities. Implement penalties for non-compliance or delay in achieving reuse targets. Treated water must meet Central Pollution Control Board and State Pollution Control Board standards. ***Co-benefits**: reduced incidence of respiratory, improved visibility and reduction of urban heat island effect, conservation of biodiversity in affected areas, enhanced liveability and comfort.*			
Management of sanitary waste • Install red coloured bins in public areas, residential societies, and commercial complexes specifically for sanitary waste collection (Solid Waste Management Rules, 2016) and separate compartments to prevent mixing with wet and dry waste. • Set up incinerators at key locations, such as hospitals and waste transfer stations, for safe and environmentally friendly disposal of sanitary waste. Promote the use of decentralized treatment technologies like sanitary napkin incinerators in public toilets, schools, and colleges.	Solid Waste Department	SBM (Urban), Solid Waste Management Rules, 2016	Short Term

• Explore autoclaving and shredding technologies as an alternative to incineration. • Co-benefits: Reduced incidence of respiratory, Improved visibility and reduction of urban heat island effect, Conservation of biodiversity in affected areas, Enhanced liveability and comfort			
Alternative of MRF in the city Set up small MRF units and waste collection centres in designated wards of Mira Bhayandar establishing a local buyer network for recyclable materials such as glass and paper. These centres will be powered by solar energy to reduce carbon emissions and a mobile MRF facility should be considered to offer flexible, decentralized waste management solutions. ***Co-Benefits****: landfill diversion, increased recycling rates, economic growth and job creation, community empowerment*	Solid waste department, Town Planning	SBM-Urban 2.0	Mid Term
Bulk waste generator • BWGs should segregate waste at the source into categories such as wet, dry, e-waste, and hazardous waste. • Encourage BWGs to set up composting units or biogas plants for wet waste and partner with authorized recyclers for dry and e-waste. • Revise municipal waste management by-laws to redefine BWGs as entities generating 50 kg or more waste per day.	Solid Waste Department	SBM-2.0	Short Term

E-Waste Management Policy • Develop city-wide e-waste collection centres to accept batteries, EV components, and other electronic waste. • Partner with certified recyclers to process and safely extract materials such as lithium, cobalt, and nickel from EV batteries. • Mandate Extended Producer Responsibility (EPR) for EV manufacturers to ensure safe disposal and recycling of their products. • Regularly track e-waste volumes, collection rates, and recycling efficiencies especially from the commercial buildings. Action Plans: 1. **Short Term** (0–3 years): • Set up pilot collection centres and recycling units. • Partner with EV manufacturers for EPR compliance. • **Medium Term** (3–7 years): • Expand infrastructure to ensure city-wide coverage. • Develop policies for sustainable sourcing and recycling incentives. • **Long Term** (7+years) • Integrate e-waste management into city planning and smart city frameworks.	Solid waste department	-	Mid Term
Comprehensive Wastewater Management and Sustainable Sludge Treatment Strategy	Environmental Dept.	AMRUT, SBM 2.0, National Policy on	Mid Term

• Ensuring 100% coverage within the city limits with a fully closed and underground sewer collection network. • Transitioning all domestic wastewater treatment plants to aerobic systems either by constructing new or upgrading existing anaerobic STPs. • Maintaining and regularly operating sludge removal systems in all STPs, with the collected sludge repurposed for bio-methanation or compost production. • Ensure proper and safe disposal of sludge to reduce environmental impact (National Policy on Faecal Sludge and Septage Management, 2017).		Fecal Sludge and Septage Management 2017, National Urban Sanitation Policy	

Chapter 5: Conclusion

The Mira Bhayandar Climate Action Plan is a significant initiative aimed at creating a resilient and sustainable urban environment by addressing the multifaceted challenges posed by climate change. The plan outlines actionable solutions to mitigate and adapt to climate impacts effectively by analyzing greenhouse gas (GHG) emissions, climate hazards, vulnerabilities, risks, exposures, and sector-specific scenarios. The GHG inventory highlights the primary sources of emissions, with stationary energy accounting for 62%, largely from residential electricity consumption. Transportation contributes 22%, reflecting a dependency on fossil fuels, while waste management adds 16%. These emissions involve adopting renewable energy, enhancing energy efficiency, and improving waste management practices.

Mira Bhayandar faces multiple climate hazards, including urban heat islands (UHIs), flooding, and coastal risks. Rapid urbanization and vegetation loss have exacerbated the UHI effect, with densely built-up areas experiencing elevated temperatures. The city also faces issues of waterlogging every year caused due to the aging drainage system with structural inefficiencies. The socially and geographically marginalized populations, especially those in informal settlements near water bodies and forest peripheries, are most at risk due to inadequate infrastructure and limited adaptive capacity. The Rapi Risk Assessment reveal that densely populated wards and regions with high building density face heightened vulnerabilities due to inadequate public infrastructure such as access to public transportation, educational institutes, open spaces, healthcare and socio-economic disparities. These systemic inequalities can be addressed through inclusive urban planning and community-focused interventions which is critical for building their resilience.

The energy sector's reliance on traditional sources necessitates an urgent transition to renewable energy. The recommendations include developing a city-level solar policy, adopting public-private partnership models for rooftop solar, and retrofitting buildings with energy-efficient technologies. Promoting low-carbon construction practices and implementing district cooling systems can further reduce emissions. Equitable water management strategies, such as increased wastewater recycling, modernized infrastructure, and rainwater harvesting, aim to conserve resources and mitigate urban flooding.

To address the year-on-year basis urban flooding in the city, it requires upgrading stormwater drainage systems, enhancing green cover to absorb runoff, and adopting nature-based solutions like mangrove restoration. These measures can mitigate waterlogging, reduce associated economic losses, and bolster ecological resilience. Enhancing urban green cover and conserving biodiversity are integral to reducing UHI effects and improving ecological health. Nature-based solutions, such as rejuvenating lakes, creating biodiversity parks, and enforcing eco-sensitive zone regulations, are prioritized to enhance environmental sustainability.

Sustainable mobility solutions are crucial for improving air quality and reducing transport emissions. The city should expand their public transportation, promote non-motorized transit options, and introduce electric vehicles that can help alleviate air pollution. Strengthening regulatory frameworks and establishing robust air quality monitoring systems will guide effective mitigation strategies. Waste management improvements, including better segregation, increased recycling rates, and scientific disposal of hazardous waste, are essential for reducing environmental impacts. It is imperative to

acknowledge and integrate waste workers into the formal economy and provide training opportunities that will foster a circular economy and enhance social equity.

The successful implementation of the MBCAP relies on cross-cutting strategies. Community engagement and awareness campaigns can drive behavioral changes, while capacity-building initiatives equip local governments and communities with essential skills to tackle climate challenges. Establishing a governance framework aligned with state and national policies ensures coherence and accountability across actions.

The vision of the MBCAP is to transform Mira Bhayandar into a climate-resilient city by 2050, aligning with India's broader net-zero goals. This entails reducing emissions, fostering equitable urban development, and enhancing adaptive capacities to withstand climatic stresses and uncertainties. To achieve this vision, it requires coordinated efforts across sectors, sustained investments in innovative solutions, and active participation from government bodies, private entities, and local communities. By implementing these strategies, Mira Bhayandar can serve as a model for urban centers, demonstrating that resilience and sustainability are attainable through proactive and inclusive planning.

Annexure

References