URBAN LEDS
URBAN LOW EMISSION DEVELOPMENT STRATEGIES

THANE
Smart City Ltd.

CLIMATE RESILIENT CITY ACTION PLAN

THANE MAHARASHTRA, INDIA

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01
BACKGROUND

1.1 Introduction

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

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

Local governments are central to efforts of tackling the issue of climate change, which has been acknowledged by major agendas such as SDGs, the Action Agenda, and Paris Agreement. Cities can lead climate action by framing strategies and programmes, integrating such actions into ongoing urban development, and forging the partnerships necessary for effective climate responses.

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

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

Indian cities will soon be home to about 600 million people, nearly twice the population of the United States. This enormous social, economic and spatial transformation could create unprecedented development opportunities if city growth is proactively managed to realize the benefits. The population of India is expected to increase from 1,211 million to 1,518 million during 2011-2036 - an increase of 25 percent in 25 years at the rate of one percent annually. As a consequence, the density of population will increase from 368 to 462 persons per square kilometre. Of the projected population increase of about 310 million from 2011-2036, 170 million or nearly 50 percent of India's demographic growth is projected to take place in five states, namely Bihar, Uttar Pradesh, Maharashtra, West Bengal and Madhya Pradesh[1].

In Thane city, Maharashtra, rapid urbanization is accompanied by a number of challenges, including insufficient urban planning and management, lack of coordination among agencies, increased energy consumption and GHG emissions, insufficient solid waste and sewerage management, and resultant environmental issues such as pollution etc. With climate change, these challenges and resulting impact are most likely to be exacerbated.

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

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

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

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

The development of a climate action plan will help Thane understand and effectively respond to climate change impact. Through implementation of the actions suggested in the plan, the city will not only contribute towards national targets under Paris Agreement and SDGs but also attract international finance for a green economic recovery following the COVID-19 pandemic. Lastly, it will help distribute the benefits of climate action equitably amongst the city's citizens.

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

Thane Municipal Corporation (TMC), has over the years undertaken several initiatives to address the city's vulnerability to climate change through low carbon and climate resilient infrastructure systems and services. However, with rising population and haphazard development, providing efficient municipal services has become a challenge for TMC, further exacerbated by climate change.

1.2 Approach

The city of Thane is situated on the western banks of Thane creek with Parsik hills on the east and Yeoor hills on the west. Apart from creating a natural protection, the creek has facilitated movement of ships, providing impetus for the development of local and international trade since the ancient period. Traditionally home to tribal groups, Thane boasts of a rich cultural heritage, mythological background and archaeological significance, and has witnessed several events of historical importance.

As per the National Census, 1990, the population of Thane was 790,000, and as per the National Census, 2011, it had reached 1,841,488, exhibiting a sharp increase. Rapid development of residential spaces, expanding service and information technology sector, and significant decrease in industrial activities characterize the modern-day Thane city.

Thane Municipal Corporation (TMC), established in 1982, has over the years undertaken several initiatives to address the city's vulnerability to climate change through low carbon and climate resilient infrastructure systems and services. However, with rising population and haphazard development, providing efficient municipal services has become a challenge for TMC, further exacerbated by climate change. Thane is yet to achieve efficient solid waste management (SWM), sewerage treatment, and better public transport.

The effect of climate change is more pronounced in cities like Thane which are characterized by high urbanization and resource insecurity. This is further exacerbated by another human risk, the COVID-19 pandemic, leading to a state of dual emergency which a city like Thane can turn into an opportunity to bounce back, greener, stronger and more efficient.

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

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

The Climate Resilient City Action Plan for Thane is a step in the direction of achieving the long-term vision of integrating comprehensive and resilient approaches in the city's development objectives, planning and processes.

1.3 Methodology followed to prepare the Climate Resilience City Action Plan

Defining Climate Resilience

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

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

The process equips LGs to:

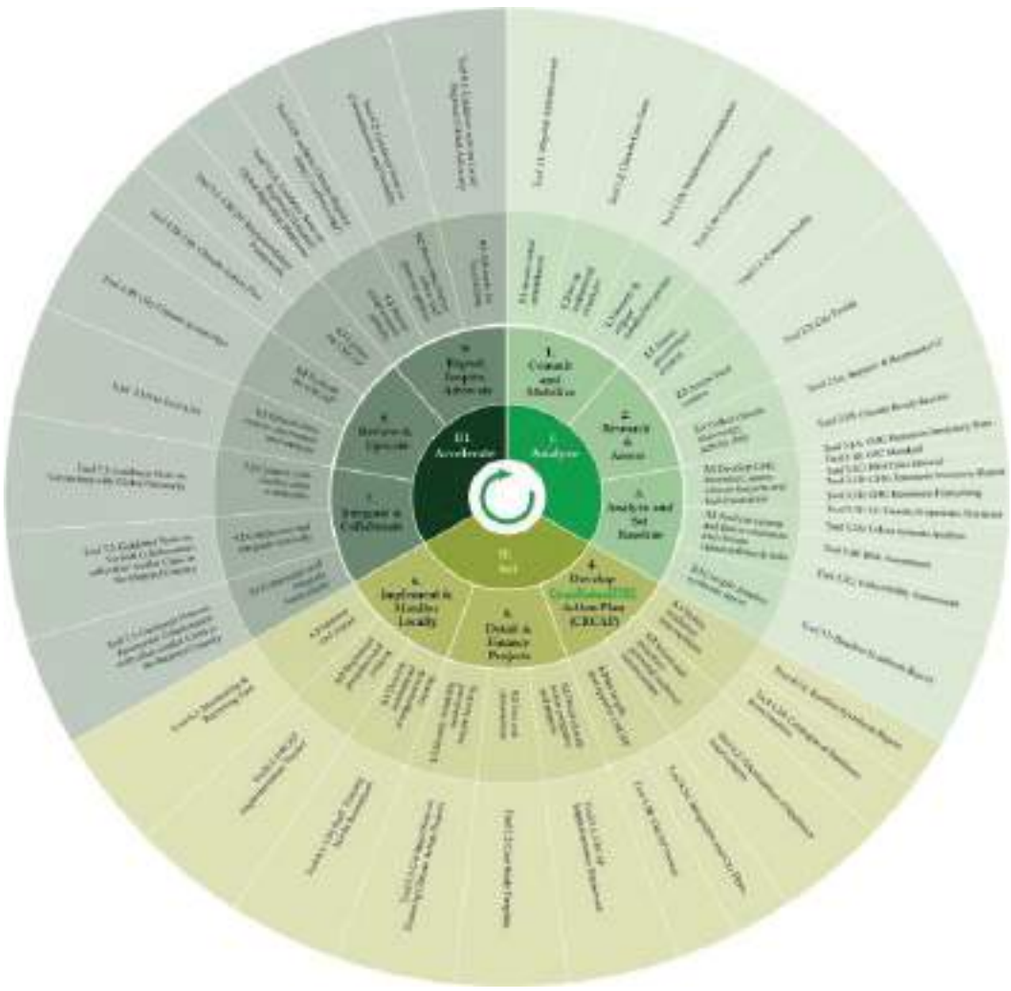
- Estimate the GHG emissions intensity of city activities;
- Assess the climate risks of various systems in the city in the context of urbanization and vulnerability;
- Identify actions to address existing and forecasted climate fragility; and
- Develop an implementation and monitoring plan which will not only help the city to adapt to existing and impending climate change impact but also steer the city's focus to climate change mitigation measures.

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

Overview of Climate Resilient Cities Methodology

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

Figure 1: ClimateResilientCities Methodology



Thane City has adapted this methodology for preparing its Climate Resilient City Action Plan. The Climate Resilient City Action Plan is the result of implementing steps 1 to 4 in Thane City. The tools provided in the tool-kit have been adapted to suit the purposes of the City.

Step: 1 – Commit and Mobilize

1.1 Secure initial commitment – It is very important to ensure senior political and local government buy-in to kick start the process for climate resilient development in the community and provide clear leadership. The presence of political, executive and administrative support required for successful planning and implementation of

climate action plans is evidence of TMC's intent to address climate change through mitigation and adaptation measures.

1.2 Set up institutional structures - A Climate Core Team was set up by TMC on 25th October, 2016 using Tool 1.2 (Climate Core Team), of nominated officials from relevant departments of TMC including the Mayor, chaired by the Municipal Commissioner. This team was involved in all the steps of preparing the CRCAP and supporting internal institutional capacity building to effectively fulfil the long-term climate resilience plan requirements by effective integration of planned initiatives into the city's developmental plans.

1.3 Identify and engage stakeholder groups - The climate action planning process should be supported by consultations with other groups in the city, such as government agencies, local NGOs, community leaders, university partners and private sector organizations, to appropriately share responsibilities and ensure ownership. TMC formed and notified the city level Stakeholder Committee using Tool 1.3A (Stakeholder Committee) composed of members chaired by the Municipal Commissioner, for a multiway process of dialogue and deliberation within the Climate Core Team, with other stakeholders, as well as among stakeholders. A Communication Plan was prepared to communicate within the core team, with other departments of the TMC, with the external Stakeholder Committee and the community at large.

Step 2 - Research and Assess

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

Step 3 - Analyze and Set Baseline

3.1 Develop GHG inventory, assess climate impact and build scenarios Base data was collected using Tool 3.1A (Energy and GHG Emissions Inventory – Data Format) for stationary fuel and electricity consumption by all community and government sectors. This necessitates relevant data collection from TMC and external agencies which have the required information (utilities), as well as determining data gaps. TMC staff members engaged through meetings and letters with a number of municipal, local and sub-national stakeholders to source the relevant energy consumption data focusing on the large carbon emitters within the municipal area. Supply and demand-side data was collected and analysed.

A GHG emissions inventory report was developed to determine sources of GHG emissions in TMC operations and the whole community using the Harmonized Emissions Analysis Tool Plus (HEAT+) sGHG emissions inventory online software tool and protocols using Tool 3.1B (Global Protocol for Community Scale GHG Emission Inventories) and Tool 3.1C (HEAT+ Manual).

The community inventory includes emissions from community/city-wide activities within the TMC jurisdiction, including emissions from TMC activities and use. This includes emissions from sources and/or activities from stationary units (residential, commercial/institutional facilities, industrial and constructions, agricultural), mobile transportation units, waste. This is a useful planning tool in developing mitigation actions for the entire community.

The LG operations inventory includes emissions from all the operations that TMC owns or controls. Sectors included in the LG operations inventory include TMC buildings, facilities such as street lighting and traffic lighting, water, waste and sewage facilities, and municipal vehicle fleet.

Energy consumption forecasting was been done for medium term and long term planning. Energy consumption from municipal services was forecasted based on population projections and municipal service delivery based on existing and future city planning. Based on the forecasting, the corresponding GHG emissions were calculated using the HEAT+ software using Tool 3.1E (GHG Emissions Forecasting).

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

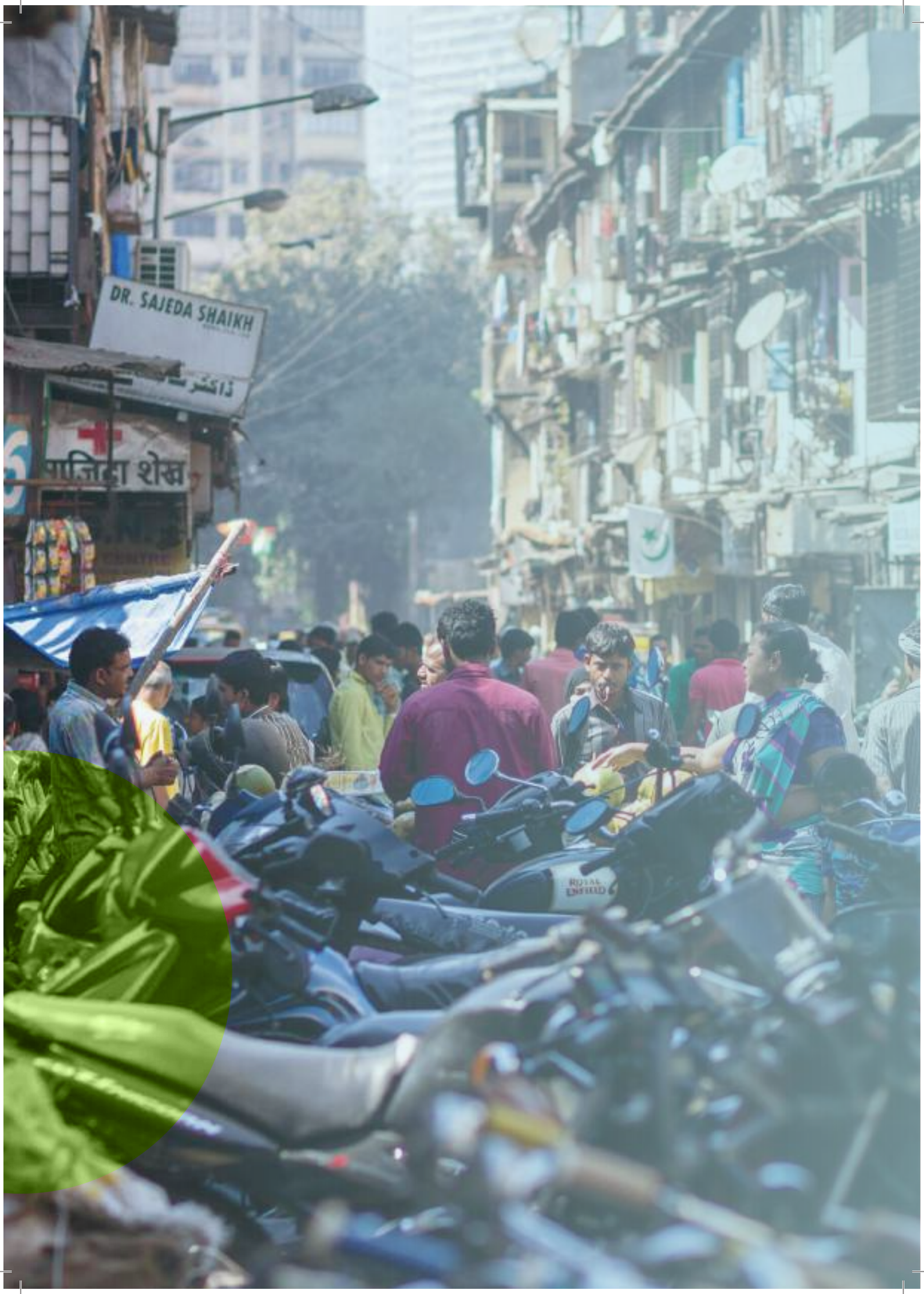
Step 4 - Develop Climate Resilient Cities Action Plan

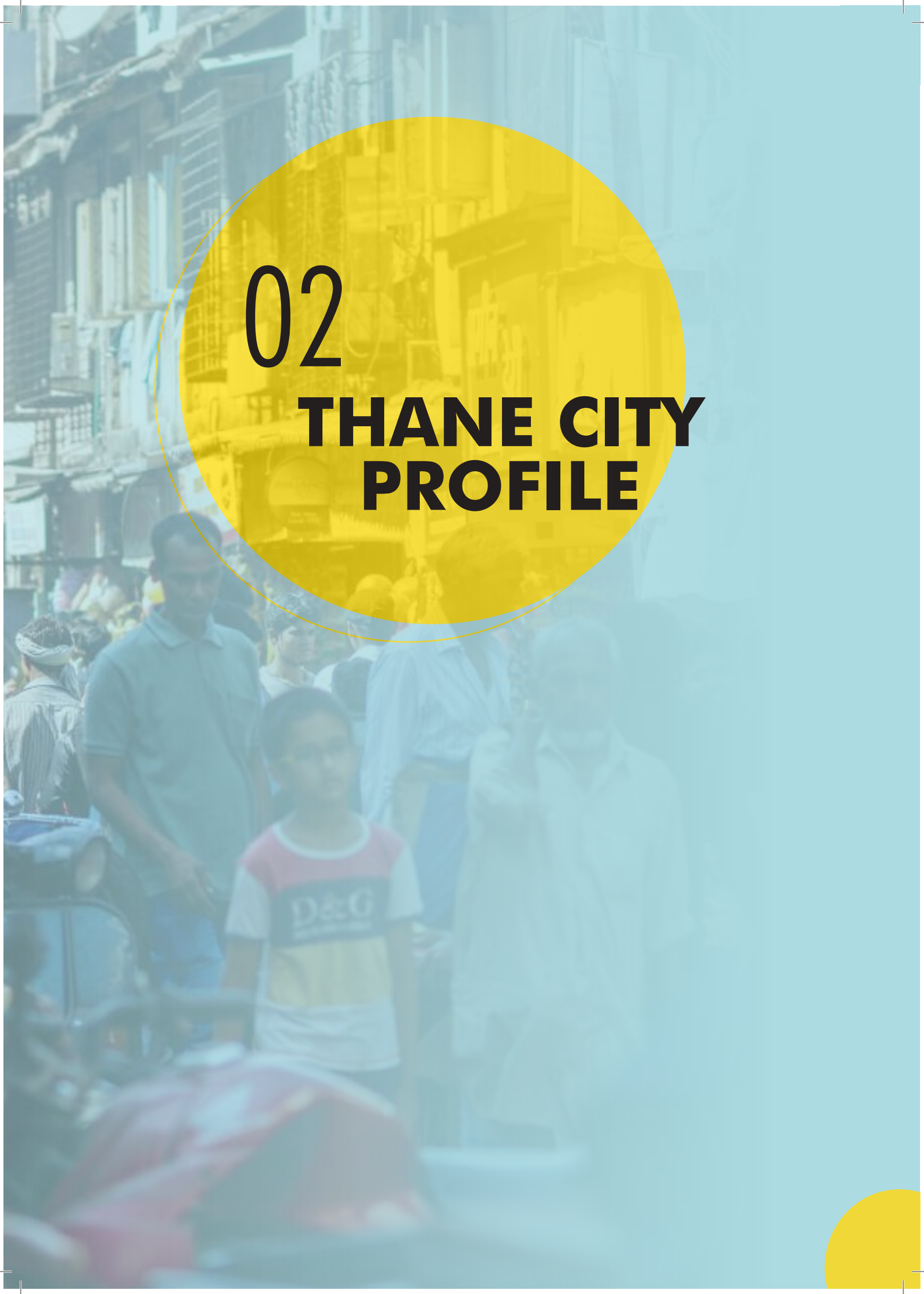
4.1 Define resilience interventions: Various mitigation and adaptation interventions were identified for Thane based on GHG emission inventory and urban system analysis in line with existing city planning. Mitigation and adaptation potential for each intervention along with financial aspect and implementation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

4.2 Screen and prioritize potential resilience interventions: Based on feasibility and impact assessment, prioritization of Resilience Interventions was done using Tool 4.2 (Prioritization of Resilience Interventions).

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

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

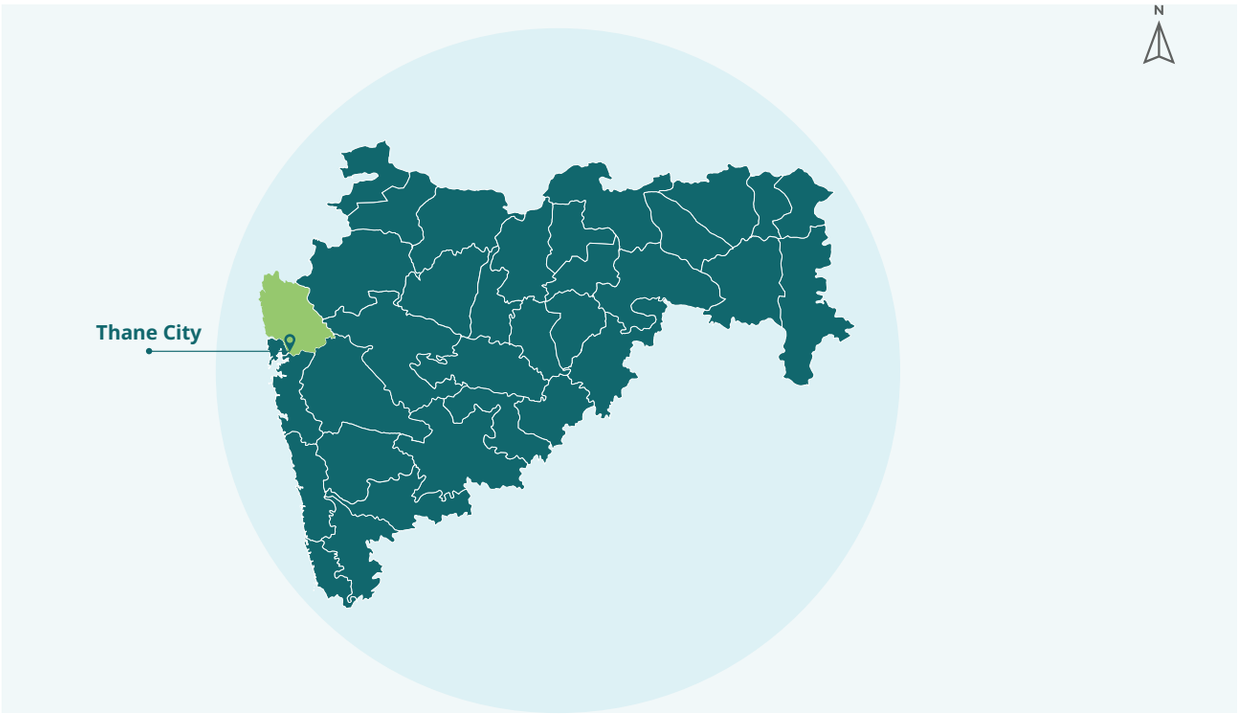

DR. SAJEDA SHAIKH



02 THANE CITY PROFILE

Thane is one of Maharashtra's major cities and the district headquarters. The National Census, 2011 pegged the population of the city at about 1.84 million. Thane is included in the Mumbai Metropolitan Region and is one of the 18 urban centres therein. Being the first urban centre on the periphery of Mumbai city, the city occupies a unique position in the region and has experienced rapid demographic growth. Owing to large scale industrial development and its proximity to the metropolis of Mumbai, Thane city has exhibited marked improvement in generating increased revenue and utilized it for economic growth, improved services and expanded infrastructure. The geographical jurisdiction of Thane spreads over an area of 128.23 sq. km. The city is located at the mean sea level on the northern part of the Konkan region and is also known as Lake City after its 35 lakes.

Figure 2: Indicative Location of Thane in Maharashtra State



2.1 Demography

Of the 1,841,488 persons in Thane as per National Census, 2011, the male and female population stands at 975,399 and 866,089 persons respectively. The city has reported an average annual population growth rate of 4.42% from 2001 to 2011. The increasing population is creating stress on urban services and on land availability. It has also led to a spurt of residential property development in the city, which provides great scope of integrating climate resilience measures in new urban development.

Thane's population is creating stress on urban services and on land availability. It has also led to a spurt of residential property development in the city, which provides great scope of integrating climate resilience measures in new urban development.

2.2 Climate

Thane has a tropical monsoon climate that borders on a tropical wet and dry climate. Overall climate is equable with high rainfall days and a few days of extreme temperatures. Thane's average temperature varies from 22°C to 36°C. Winter temperature ranges from 12°C to 20°C and summer from 36°C to 41°C. 80% of the total rainfall is usually received from June to October. The average annual rainfall is 2000-2500 mm and humidity ranges from 61% to 86%, making it a city with predominantly humid weather. The driest days are in the winter months (October – January) while the wettest are in July.

2.3 Economic Activities

Thane district is the second largest contributor to Maharashtra's economy (13.1%) after Mumbai (22.1%). Mumbai's adjoining areas of Thane-Belapur-Kalyan are emerging as a major industrial belt. Thane district's gross district domestic product stood at INR 1794.8 billion (USD 26.9 billion) in 2012-2013, increasing by over 3 times from a value of INR 540.52 billion (USD 8.1 billion) in 2004-2005.

Thane has witnessed substantial growth and increasing demand in the commercial and realty sectors due to its proximity to Mumbai. As a result, commercial and consumer-oriented services such as malls, shopping complexes, commercial hubs and hospitality services are rapidly increasing. Thane district is the second largest contributor to Maharashtra's economy (13.1%) after Mumbai (22.1%). Mumbai's adjoining areas of Thane-Belapur-Kalyan are emerging as a major industrial belt. Thane district's gross district domestic product stood at INR 1794.8 billion (USD 26.9 billion) in 2012-2013, increasing by over 3 times from a value of INR 540.52 billion (USD 8.1 billion) in 2004-2005. Thane is an emerging destination for the IT/ITES sector and associated residential and retail developments including large commercial spaces and malls. The city boundary is limited by Sanjay Gandhi National Park on the east and the Thane creek on the west; the density of the city is on the rise.

The employable population in Thane depends largely on the huge employment market in Mumbai. Industrial development in Thane has slowed down in recent times due to increased operational costs in the fast-developing urban setup of the city and industries are moving out of the city towards the newly developing industrial belt of Bhiwandi-Kalyan-Badlapur, located at a distance of 15-20 km from the city.

Economic growth in the last couple of decades has been driven by many IT industries being established in the city, and spatial and development policies pursued by the state government of Maharashtra have also contributed to economic development. The IT/ITES sector is growing rapidly in Thane, with the city being the preferred location to set up IT industries, after the cities of Pune and Mumbai. The city has emerged as a center of political power.

The economic growth is expected to continue in the city and would attract people from other areas to migrate to the city. Any climatic disruptions can have a severe negative impact on the city's growth and economy.

2.4 Thane City Local Government

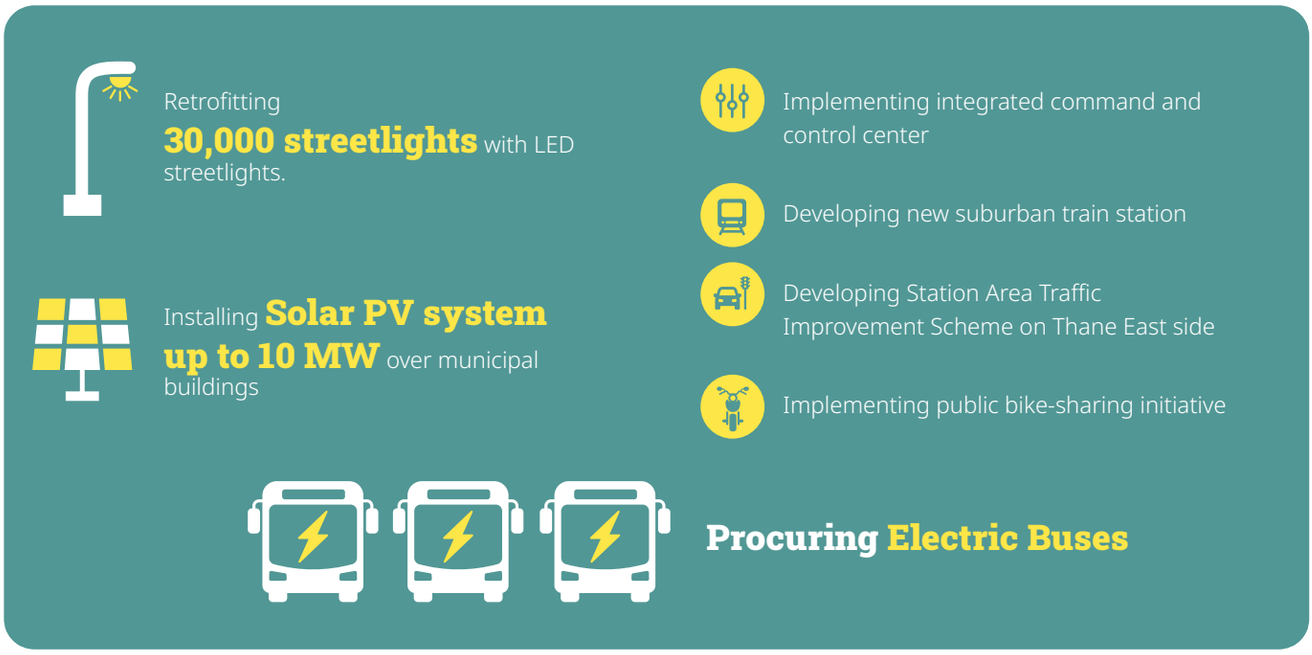
TMC has undertaken many developmental projects and schemes since 1982 for a balanced development of the city. Thane city is spread across an area of 128 sq km and is divided into 9 general wards for the purpose of maintenance of the services being provided by TMC, such as street lighting, water supply, sewerage treatment plant, waste management etc. The corporation's administrative and political wings take decisions on new developments and implement urban development projects in the city.

TMC also runs municipal markets, gardens, boating centres, pre-primary, primary and secondary schools, special schools, municipal colleges, administrative training center, nursing college, municipal hospital, health centres, fire brigade stations etc., maintained by their staff in the relevant departments in the city.

The total length of the road network in Thane is about 283 km, of which 216.81 km are major roads and 66.19 km are internal roads. The major Eastern Express Highway connecting Mumbai to the rest of Maharashtra brings heavy traffic inflow to Thane. Thane's proximity to Mumbai has made it a preferred residential hub for the service industry. Given the aggressive real estate development in recent years, the city is focusing on a number of projects addressing basic civic services.

Thane has been selected as a Smart City under the Government of India's (GoI) Smart City Mission. Under its Smart City Plan, Thane is implementing smart projects that make use of various innovative technological solutions. The key focus of the Smart City initiative in Thane is to provide a healthy, sustainable and energy efficient environment for city dwellers.

Some of the Smart City projects being undertaken are:



2.5 Major Urban Sectors

It is essential to establish the sectoral baseline and service provision, in order to enable preparation of a well-informed climate action plan development and identification of sectoral climate resilience strategies.

This overall urban profile assessment involved data collection (service level information for key urban sectors) & consultation with city authorities. The profile gives a practical snapshot of sector performance, including infrastructure and service delivery gap.

Apart from infrastructure information, the section also documents and presents sectoral policies, plans, and ongoing and planned projects or initiatives by the city. This urban infrastructure and gap analysis feeds into the GHG emission inventory forecasting and climate vulnerability assessment.

Water Supply

Present Scenario

Water Supply and Treatment

In addition to the independent water lifting scheme, TMC receives water from 3 agencies, Maharashtra Industrial Development Corporation (MIDC), Municipal Corporation of Greater Mumbai (BMC) and STEM Water Distribution & Infrastructure Co. Pvt. Ltd. TMC receives a total of about 480 MLD water from these sources located outside the city, in the proportions mentioned in the Table below.

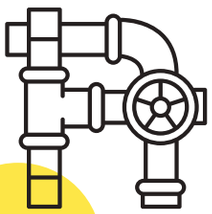
Table 1: Sources of Water Supply for Thane

Source	Quantity
TMC own source (Bhatsa dam)	200 MLD
Maharashtra Industrial Development Corporation (Ulhas River source - Barvi Dam)	110 MLD
Municipal Corporation of Greater Mumbai (Vaitarana River source - Vaitarana Dam - untreated water and treated water from Bhatsa Dam)	60 MLD
STEM Water Distribution and Infrastructure Co. Pvt. Ltd. (Ulhas River source - Barvi Dam)	110 MLD
Total	**480 MLD**

TMC's water treatment plant of 280 MLD capacity is located at Temghar and treated water is pumped to Master Balancing Reservoirs (MBR) at Mankoli. The treated water is then transmitted by gravity through transmission mains over 84 km to the Elevated Service Reservoirs (ESRs) and sumps in the city.

Water Distribution

Water available from all four sources is distributed through 54 ESRs and 17 sump and pump houses to the distribution network spanning more than 750 km. The system caters to almost 98% of the present population including in the slums. Thane's distribution system is based on both gravity and pumping, and on the division of the entire city into 44 water districts. As per service level benchmark, coverage of water supply connections in Thane is about 98% with per capita supply of about 180-200 LPCD. The extent of non-revenue water (NRW) is about 37% while efficiency in redressal of customer complaints is about 99.4%. Water is supplied for an average of 6 hours in a day.



As per service level benchmark, coverage of water supply connections in Thane is about 98% with per capita supply of about 180-200 LPCD.

Table 2: Service Level Information – Water Supply

Indicator	Status
Coverage of water supply	98%
Per capita supply	180 - 200 lpcd
Extent of NRW	37%
Efficiency in redressal of customer complaints	99.4%
Quality of water supplied	92.5%

Stipulated Projects

TMC has planned to augment its existing external sources of water as part of the SHAI dam project along with a new water treatment plant downstream of the dam. TMC has already made plans to ensure adequate availability of treated water for the population of about 4.7 million projected for 2046. Additionally, TMC has planned for the remodelling of its distribution networks in all the three water zones in the city.

Table 3: TMC's Planned Water Supply from Various Sources until 2046

Source	Water Supply Quota (MLD)	Year			
		2011	2019	2031	2046
TMC	200	190	200	200	200
STEM	257	100	110	177	257
MIDC	230	110	110	150	230
BMC	60	60	60	60	60
SHAI	100	0	0	0	100
Total	**847**	**460**	**480**	**587**	**847**

The following projects have been proposed under various government schemes:

- Remodelling of water supply network at central, south and north zones of Thane city
- **Smart Metering:** TMC has planned to undertake smart metering (fixing AMR meters) in the entire city in a step by step manner. In the first phase, consumer meters will be fixed on bulk domestic connections above 25 mm dia. and all commercial connections, followed by slum connections and connections below 25 mm dia. for apartments/buildings in the second phase. This will bring down the level of NRW in the distribution system to the desired level of 15%. The project is intended to be implemented in 3 years followed by 7 years of operation and maintenance. Through Smart Cities Mission, about 1,13,000 connections will be equipped with AMR meters. The actual execution work is underway.
- **24x7 Water Supply:** Uthalsar ward committee area covering a population of about 300,000 is chosen as a demo zone for improvement work in water supply, to be executed using TMC's own funds/AMRUT/Smart City funding at an indicative project cost of INR (500 million). The area is so selected that there is enough storage and no new tanks are required to be constructed. The project is aimed at improving technical and commercial efficiency, upgrading existing intermittent supply for continuous pressurized 24x7 water supply, and reducing NRW and gross water consumption as per norms.
- **District Metered Area (DMA)**
- **Water Audit and Water Supply Management through Supervisory Control and Data Acquisition (SCADA):** TMC has planned to undertake bulk water audit and water supply management through SCADA covering the ESRs and sump and pump houses. Under this program, TMC will fix bulk meters on the transmission mains along with flow and pressure measuring devices. Private operators will install the devices along with the SCADA system and manage the transmission system. This will help arrest leakages in the transmission system and manage pressure at all ESR nodes. It is also planned to check online water quality at ESR level.
- Network Mapping
- Leakage Mapping
- Regularization of Public Stand Posts (PSP)
- Capacity Building
- Revising Tariff Structure (50% hike is proposed in 2020-21 budget)
- Construction of ESRs and Sumps
- Energy Audit of Water Infrastructure
- Under the Smart Cities Mission, remodelling of the water supply network with 2 ESRs of 5.5 ML capacity each and 68 km distribution network is underway.

Through Smart Cities Mission, about 113,000 connections will be equipped with automatic meters

Issues Identified

Water Availability:

Due to higher per capita per day supply by TMC and easy access to ground water overall; per capita water availability is substantially high in Thane. This affects overall consumption habits of the citizens and leads to uneven distribution throughout the city.

Dependency on external agencies:

TMC depends on 3 agencies (BMC, STEM, and MIDC) with a total dependency of about 56%. However, TMC has already planned the SHAI dam project, in order to cater to its water requirement in year 2046 and achieve self-reliance in water supply.

Smart metering and NRW:

Though Thane has started implementing smart metering, the rate of installation and acceptance by citizens is comparatively low. Capacity building and awareness programs are crucial for the success of these initiatives. Once the metering is done, water audit could help identify NRW losses.

Ground water:

Thane has a good ground water level and easy access for abstraction which results in higher consumption. Despite rainwater harvesting systems being mandatory for new projects in Thane, their remaining operational after the initial few years is doubtful. For the benefits to reach residents, such systems require a strong monitoring framework.

Recyclable waste is also collected by rag pickers at dumping sites. TMC generates about 1.5-2 TPD bio medical waste from hospitals and health clinics.

Solid Waste Management

Present Scenario

Solid Waste Generation

Waste is mainly generated from households, institutions, markets and commercial establishments (viz. hotels, restaurants, shops etc.), vegetable, fruit and fish markets. On an average, for the year 2019-20, the total waste generation in Thane was approximately 1000 MT/day. About 20% waste is segregated at source/primary collection centres/ transfer stations at specific places like Hiranandani Estate, Saket area and some part of Naupada and Kalwa area. Recyclable waste is also collected by rag pickers at dumping sites. TMC generates about 1.5-2 TPD bio medical waste from hospitals and health clinics.

Solid Waste Collection

TMC has provided 97% door to door waste collection facility within its jurisdiction. Waste is collected from households using 'closed' vehicles called Ghanta Gadis with varying sizes depending on the area and population of the area they collect waste from. TMC has hired 109 large vehicles and 106 small vehicles for waste collection from different private contractors. TMC's waste collection vehicles have been fitted with RFID tags and their GPS locations are available for tracking. TMC has also procured robotic machines to clean small stormwater drains with accessibility constraints.

Figure 3: Snapshot of GPS Tracking Platform for TMC's Solid Waste Collection Vehicles

Solid Waste Treatment

About 40 TPD of solid waste is processed in Thane which includes through the waste to energy concept through 3 bio-methanation plants of 15 TPD capacity at Kalwa, 5 TPD at Hiranandani and 5 TPD at Lodha along with green waste to briquette plants. About 11 TPD of biodegradable waste is treated through composting plants of TMC with 10 TPD capacity at Kalwa and 1 TPD flower waste to manure plant. Additionally, TMC employs a biomedical waste treatment facility with incineration to treat about 1.5 TPD waste, and a thermocol waste treatment facility of 1 TPD. The remaining waste is sent directly to the dumping ground at a privately owned land. Although there is no corporation owned landfill site, TMC has proposed a landfill site at Daighar, equipped with a 600 MT capacity waste to energy project. TMC has also proposed decentralized waste treatment facilities like plastic waste-to-fuel plants, coconut shell waste treatment plants, bio-methanation plants with 100 TPD capacities and C&D waste recycling plant with 100 TPD capacity at various locations. TMC is also facilitating E-waste collection through private vendors.

Waste composition (as per 2010 analysis) in Thane was as follows:

Paper
6%

Plastic waste
8%

Coconut shell/ mango shell
9%

Cloth waste
2%

Glass
9%

Biodegradable waste
59%

Other
7%

Table 4: Service Level Information – Municipal Solid Waste Management

Indicator	Status
Coverage of solid waste collection	97%
Scientific disposal of waste through treatment plants	12%
Extent of segregation of MSW	20%
Efficiency in redressal of customer complaints	100%

The sewage network extends to 54% of the city's area with a collection efficiency of approximately 22% through underground piped networks. Other sewage is treated through septic tanks and pit latrines.

Stipulated Projects

- Animal carcass to bio CNG plant of 60 TPD capacity
- Plastic waste to oil plant of 5 TPD capacity
- Waste to energy plant of 600 TPD capacity at Daighar
- Bio-methanation plants of varying capacities (1 to 5 TPD) at various locations
- C&D waste recycling plant of 100 TPD capacity
- Scientific closure of 3 dumping areas at the Diva Khardi area through capping, and plantation through social forestry
- Mobile waste treatment plant (organic waste converter (OWC) installed on a vehicle) to treat organic waste from slums with shortage of land

Issues Identified

Waste Segregation: Various solid waste management (SWM) treatment facilities are already proposed by TMC at centralized and decentralized levels. Waste segregation has been identified as the main issue which impedes efficient waste treatment in Thane.

Waste Treatment: The proposed waste to energy plant will take a few years to operate on full load. Till then, TMC should focus on decentralized waste treatment and composting sites.

Awareness: Many citizens from urban areas and slums have been found to throw their solid waste in open nullahs and water bodies like creek, estuary and lakes in Thane. Hence, awareness to discourage dumping in open areas and water bodies should be among TMC's priorities. Scientific closure of the existing dumping site is also crucial.

Sewerage

Present Scenario

Sewer Network

TMC generates about 380 MLD sewage from its domestic water supply. The main sources of sewage generation include residential, commercial and few industrial (for domestic purpose) entities.

The sewage network extends to 54% of the city's area with a collection efficiency of approximately 22% through underground piped networks. Other sewage is treated through septic tanks and pit latrines. Out of the total 4,75,758 households, about 2,39,486 have sewer connections while 66,364 have no outlet for sewage. Other households have septic tanks and pit latrines (mostly in the slums). 100% households have toilet access in Thane which includes about 1200 public/community toilets.

Treatment Plants

TMC employs two functioning Sewage Treatment Plants (STPs of) 120 MLD (Kopri STP) and 32 MLD (Mumbra STP) capacity. Due to the lack of a sewerage network, these STPs receive about 65 MLD and 15 MLD sewage respectively, being utilized under capacity. TMC has almost completed the execution of four other STPs which will enlarge the overall treatment capacity to about 252 MLD. Thane also has about 150 private STPs treating about 22 MLD sewage and installed by various residential and commercial establishments. The cumulative sewage treatment capacity of TMC is about 27% through aerobic treatment plants. Partially treated sewage is directly discharged into the Thane creek and Ulhas river estuary.

The cumulative sewage treatment capacity of TMC is about 27% through aerobic treatment plants.

Recycle and Reuse

Easy access and availability of water supply has made reuse and recycle of treated sewage difficult in Thane. Lack of consumer acceptance leads to negligible recycling of treated sewage from the STPs of TMC. At best, about 8 MLD of treated sewage is being recycled by housing societies for flushing and gardening.

Table 5: Service Level Information - Wastewater

Indicator	Status
Coverage of sewerage collection	54%
Treatment capacity	66%
Actual treatment	27%
Efficiency in redressal of customer complaints	100 %
Quality of treated water	100%
Extent of reuse and recycle	Negligible

Stipulated Projects

- Underground sewerage scheme at various locations like Kalwa, Mumbra, Diva, and Ghodbunder areas
- Waste water treatment plant for 2 nullahs at Parsik and Kolshet on bioremediation basis on pilot scale
- Completion of the Jawaharlal Nehru National Urban Renewal Mission (JNNURM) project which includes underground gutters of 210 km, 20 sewage pumping stations and 6 STPs; execution of 4 decentralized STPs with 100 MLD total capacity at Vitawa, Kharigaon, Kolshet, and Majiwada is near completion; by 2015-16, about 62% of the work had been completed and by 2018-19, about 98%;the roads where laying sewer lines was difficult are being connected by trenchless technique
- Through Smart Cities Mission, about 37 km underground sewage lines are being laid in the Area Based Development (ABD) area of Thane, with 2,000 house connections
- Developing sewerage network at Ghodbunder road for about 1,000,000 persons is proposed under the Atal Mission for Rejuvenation and Urban Transformation (AMRUT) scheme: This includes laying of sewer lines spanning 92 km, 5 sewage pumping stations, 2 STPs of 7 MLD capacity each and 2,922 house connections. By 2018-19, about 15% work had been completed and it should be done in the next 2-3 years.
- Sewerage network proposed for Diva and Shil areas; to include sewer lines spanning 152 km, 13 sewage pumping stations and 5 STPs
- Proposed to provide rebate in property tax or water cess for the residential societies treating and reusing their sewage; feasibility study proposed to develop a policy on the same
- Individual connections to connect with main sewer line

Issues Identified

- The current STP capacity is not sufficient to treat sewage generated at the city level. Hence, decentralized STPs need to be planned in advance looking at the planned water supply capacity in the city.
- Support by reuse and recycle policy along with control over ground water abstraction will increase users' acceptance for secondary uses like construction and gardening.
- Higher per capita supply and over abstraction of ground water leads to dilution of the sewage generated and makes it difficult to operate functioning STPs with designed organic load.
- Untreated or partially treated sewage discharge increases pollution load in water bodies threatening aquatic life.
- Regular monitoring of private STPs is required to ensure they function properly.

Storm Water

Present Scenario

Thane is endowed with a natural storm water drainage system which includes 72 major nullahs and 95 sub nullahs most of which originate from either Yeoor hills of Sanjay Gandhi National Park or Parsik hills. Drains flowing from Yeoor hills pass through the city and those from Parsik hills pass through Kalwa and Mumbra. The total length of natural storm water drains in Thane city 153 km. Thane has been divided in three zones - Thane city, Kalwa and Mumbra, Diva - on the basis of catchment areas. TMC began strengthening its storm water drainage network through the Integrated Nullah Development Program (INDP) in 2006, with three of four phases completed under the INDP, as a long-term measure to control water logging in the city. The catchment area coverage under the first three phases is as shown below.

Drains flowing from Yeoor hills pass through the city and those from Parsik hills pass through Kalwa and Mumbra. The total length of natural storm water drains in Thane city 153 km

Table 6: Phase-wise Stormwater Catchment Area addressed under the INDP project

INDP	Catchment area covered in sq. km.
Phase 1	29.56
Phase 2	24.87
Phase 3	26.06
Total	**80.49**

The implementation of INDP covered 63% of thane's catchment area. Considering the existing land use, pattern of development, the tentative coefficient of runoff is 90%. The following nullah improvement projects by TMC to include the remaining catchment area are under progress since 2017:

1. Thane city – Phase I, II and Ghodbundar balance work
2. Kalwa balance work
3. Mumbra balance work
4. Holding pond, pumping station and tidal gate for Thane city and Mumbra
5. Holding pond, pumping station and tidal gate for Kalwa

Table 7: Service Level Information – Stormwater Drainage

Indicator	Status
Coverage of storm water drains	63%
Incidences of water logging	----

Designing of new stormwater drains as per the 2019 Central Public Health and Environmental Engineering Organisation (CPHEEO) manual is underway. In addition to the CPHEEO provisions, drains are being designed for 20% increased rainfall intensity as an uplift factor for climate change. The total storm water network in Thane spans more than 400 km.

Stipulated Projects

- INDP Phase 4 under the AMRUT scheme and 4.45 km length of nullah development being considered under the Smart Cities Mission
- Pumping stations and tidal gates proposed at 10 locations: 3 in core city, 3 in Ghodbunder, 3 in Mumbra and 1 in Kalwa

Issues Identified

- Land use and land cover plan of the city: More paved surface leads to less percolation and more run off generation.
- High tide impending drainage: Thane drains are tidal influenced, hindering flow from upstream area and back flow from Thane creek and Ulhas river estuary.
- Solid waste dumping in culverts: Culverts at various places are blocked due to deposition of silt and solid waste. Some of them are in the form of pipes, which are inadequate, and thereby need to be redesigned and reconstructed for increased runoff volume due to change in land use pattern.
- Siltation in drain: The problem of flooding is exacerbated by siltation in road side drains and nullahs and clogging by disposal of solid waste by citizens. Siltation has reduced the carrying capacity of drains.
- Dam overflows: Overflow of dams located on the upstream areas of Ulhas river estuary has resulted in rise in water levels, thereby flooding adjoining areas of the estuary, especially Diva and Khidkali (Riverwood area).
- Construction in flood plains, thereby obstructing flow
- Siltation and inadequate nullah cleaning
- Blockage of nullah waterways by solid waste
- Inadequate inlet arrangement for road side drains and connections from drains to nullahs

Transportation

Present Scenario

Thane being in close proximity to the Mumbai Metropolitan Region (MMR), its connectivity is crucial for the overall development of the region. The city is well connected to its suburban areas through its extensive urban rail system and road network. Although public transport makes for the highest modal share and connects the entire city, traffic congestion and long travel hours remain a major concern. Thane has a good network of roads with 93% coverage of footpaths. 74% residents use public transport (43% railways and 31% bus) but low bus frequency due to inadequate fleet capacity remains an issue in many areas. Given the absence of paid on-street parking, cars are parked on

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Over 654,000 people commute by suburban railways at Thane station every day, followed in volume by buses which acts as major feeder service to local trains

roads, worsening the traffic congestion. As per 2013 data from the Mumbai Rail Vikas Corporation Limited (MRVCL), over 654,000 people commute by suburban railways at Thane station every day, followed in volume by buses which acts as major feeder service to local trains.

Airports: Mumbai's domestic and international airports are at a distance of about 20 km from Thane. The upcoming Navi Mumbai International Airport will be about 35 km from Thane, accessible from Khandeshwar railway station located on the Thane-Panvel commuter rail corridor.

Water Ways: The important national ports of Mumbai and Navi Mumbai are at about 30 km from Thane. However, due to siltation in the Thane creek even at high tide, the city has lost its significance as a historical port for India. To reduce the burden on the road network, TMC is working on developing waterways to Vasai and Kalyan, in consultation with the Inland Waterways Authority of India (IWAI). TMC is also conducting a feasibility assessment of the second route from Thane to Mumbai and Navi Mumbai.

Rail Network: The Central Railways' main and local lines passing through Thane connect the city not only to Greater Mumbai but also to the north-eastern and south-eastern parts of India. Local suburban trains – both central and transharbor lines –connect Thane to Mumbai, Kalyan-Dombivli and Navi Mumbai. The Thane-Turbhe local line has connected the city to Navi Mumbai and Panvel node. As per Thane's revised City Development Plan (CDP), on an average day in 2000, a total of 558,000 people used the railway stations at Thane, Kalwa and Mumbra within TMC area, and this has increased rapidly since.

Metro Rail: In addition to the metro rail line no. IV being executed by Mumbai Metropolitan Region Development Authority (MMRDA) to connect Thane to Mumbai, TMC has proposed an internal metro rail project from and to the new suburban railway station in a circular pathway of 29 km.

Road Network: The Mumbai-Agra road and the old Mumbai-Bangalore road are the two important national highways passing through Thane. The Eastern Express highway also serves as an important connecting road between Thane and Greater Mumbai. As per the revised CDP (2016), the total length of road network in Thane is about 283 km out of which 216.81 km are major roads and 66.19 km are internal roads. By 2017, the total road network developed by TMC was 356 km and was expected to increase to 367.5 km in 2019-20. The forest development plan allows for total road area of 742.97 Ha. Total developable road area is 493.08 Ha, after deducting the Coastal Regulation Zone (CRZ) and forest areas. In addition to the existing 131.58 Ha, 100 Ha road area has been developed in the last 4-5 years to achieve 61.71% of developable road area.

Suburban rail is followed by bus as the predominant travel mode in Thane. Daily travel by bus as a main mode in the base year (2008) is about 0.3 million, which is 24.2% of total travel (without walk trips). Thane Municipal Transport (TMT) buses ply to all neighboring corporations such as Kalyan-Dombivli, Mumbai, Vasai-Virar, Mira Bhayander and Navi Mumbai. Moreover, buses from the fleets of Brihanmumbai Electric Supply and Transport (BEST), Navi Mumbai Municipal Transport (NMMT), Mira Bhayander Municipal Transport (MBMT), and State Transport (ST) corporations provide public bus service to Thane. TMT started its operations with a fleet of 28 buses in 1990 which has progressively grown to 323 buses in 2007. Out of a required 600 buses, TMT currently has a fleet of 343 buses. This shortage has led to increase in autos and private vehicles (64% to 74%, 1996-2007).

Intermediate Public Transport: Intermediate Public Transport (IPT) modes i.e. taxi and auto in metropolitan cities like Thane plays a vital role in meeting unstructured travel demands of users. It acts as feeder service to the main mass transport system (both rail and road based) and provides accessible movement in predefined areas. The highest growth rate is witnessed by the transportation sector with a remarkable average annual growth rate of 25.7%. Energy consumption of transportation sector is about 31% in Thane.

Non-motorized Transport (NMT): TMC has renovated 65.6 km of the 331 km of footpaths under its Harith Janpath programme (green pedestrian pathways). Footpath coverage in Thane is 93% though of poor quality. Sidewalks are uneven, lacking sufficient trees and

benches. The city center (station) area receives substantial pedestrian traffic. North Thane has extensive residential developments and good quality footpaths.

TMC runs the public bicycle sharing (PBS) system in Thane under the Smart Cities Mission to promote NMT. This facility has about 50 stations with 600 bicycles. However, long distances to work places, congestion on roads and humid climate hinder their effective use.

Stipulated Projects

- A new suburban railway station is proposed between Thane and Mulund stations, to be executed under the Smart Cities Mission in partnership with Central Railways. A land pocket of 14.83 acre has been allocated for this project near the Mental Hospital building.
- An internal metro rail network with 29 km and 22 stations is proposed with 20% capital share of TMC. The Maharashtra Metro Rail Corporation Limited (MAHA-METRO) has developed a detailed project report for the same.
- Inland waterways development with funding support by IWAI
- TMC has proposed Personalized Rapid Transit System to develop the feeder network for the metro rail system. This network will include three stages with variable lengths of 34 km, 49 km and 20 km.
- A multimodal transit hub on the east side of Thane railway station which will include elevated roads, bus terminus, separate underground parking area and separate lines for auto-rickshaw and taxis, is proposed under the Smart Cities Mission.
- A soft mobility plan has been prepared under the Smart Cities Mission to develop 12.87 km roads in the ABD area, equipped with pedestrian friendly footpaths, signage, zebra crossings, bicycle and bus stops etc. The same is proposed to be replicated on a 5 km road stretch using TMC funds.
- Proposed 50 new buses reserved for ladies named 'Tejaswini Buses'
- 100 electrical buses with charging facility to be added to reduce GHG emissions from the transport sector; 1 bus already delivered through PPP mode
- Few other projects have been proposed under the Smart Cities Mission like Intelligent Traffic System to inform about and track bus routes, coloured and attractive zebra crossings, road asset mapping and Adoptive Traffic Management System to operate traffic signals on real time and optimum time basis.
- A grade separator project at Teen Hath Naka is proposed under the Smart Cities Mission. It will include an underground two directional route with 4 lines spread across about 750 m.
- An underground parking facility is proposed under the Smart Cities Mission at Gaondevi Ground near the west side of Thane railway station. This will accommodate 130 four wheelers and 120 two wheelers at a time on pay and use basis on 4,222 sq. ft. area. Additionally, about 11,357.23 sq m area is under construction to develop a 10 storied building to park about 1,600 four wheelers and an administrative building with parking at Kashish Park. Given the traffic congestion at Gokhale road, a redevelopment project of an existing market building is proposed with parking of 450 two wheelers and 320 four wheelers, expected to be complete in 2021.
- Through the development of vibrant multi-use promenades along waterfronts, creation of no-vehicle zones in high pedestrian traffic areas, senior-citizen friendly street furniture, tactile paving, strategic interventions in urban redesigning of streets, and through TMC's unique Harith Janpath programme (green pedestrian pathways), Thane expects to achieve its target of improved walkability.

An internal metro rail network with 29 km and 22 stations is proposed with 20% capital share of TMC

100 electrical buses with charging facility to be added to reduce GHG emissions from the transport sector

Issues Identified

- Dedicated lane for walking and cycling: Cycling facilities can be improved by providing cycle tracks as well as by implementing bicycle accentuated signals.
- Lack of regulated parking: Thane's parking challenge is due to unavailability of dedicated parking areas around the station. This affects pedestrian movement; unmaintained footpaths and vehicles parked on roadsides leave pedestrians with no other option but to walk on roads.
- Air pollution: Unpaved roads and increasing automobiles result in particulate matter, SOx and NOx in Thane's air.
- Encroachments on roads by informal settlements and street vendors lead to more congestion.
- Availability of land is a major challenge for any transportation improvement project.

Buildings and Energy

At many places in Thane, buildings have different kinds of mixed uses in the same premises; such as offices, housing, and shops, clustered together. Thane exhibits compact mixed-use development in the city center areas due to relatively easy access to public transport

Present Scenario

Thane developed a strong industrial base in 1960s in the form of the Thane-Belapur-Kalyan industrial belt which housed sophisticated modern industries in its time. Being the first urban center on the periphery of Greater Mumbai, the city occupies a unique position in the region. However, gradually, dependence on tertiary sector increased, and many industries are shutting down. Due to its location and connectivity within MMR, over a period of time, Thane has developed more as a residential area rather than an industrial area. Owing to the extreme land shortage and escalating prices in Mumbai, Thane presents the best alternative for relatively affordable housing options, commercial and retail spaces.

Thane has a fair degree of mixed land use because of which citizens do not need to use transport for their food and other daily needs. Most citizens need to use public or private transport in order to reach their workplace. At many places in Thane, buildings have different kinds of mixed uses in the same premises; such as offices, housing, and shops, clustered together. The land use is divided as predominantly residential (20.8%) and industrial (9%). Generally, mixed use equipped with daily commercial needs has been developed along with residential use in the city. Due to the closure of industries, industrial areas are converted to residential or commercial. However, the land use regulation of Thane permits commercial or office development in residential neighbourhoods as well.

Thane exhibits compact mixed-use development in the city center areas due to relatively easy access to public transport. A certain degree of spread out exists towards North Thane. However, new residential developments in these areas like Ghodbunder Road are also compact in the sense that buildings are situated close together and are mostly high-rise and therefore high-density. The City Centre Rejuvenation Project includes redesigning of green spaces, retrofitting and sustainable transport to optimize mixed land use. Development of high order amenities through various schemes like the Smart City Mission, AMRUT and densification of areas along proposed the metro corridor in North Thane shall ensure endorsement of mixed use and transit-oriented development in the city.

Housing in Thane is segregated with the economically poor occupying informal settlements and the relatively well-off in gated communities. 982,000 dwellers in 252 slums are in urgent need of housing in Thane. As per the National Census 2011, Thane's slum population increased from 33% (2001) to 54% (2011) and the percentage of self-owned houses dropped from 77% (2001) to 73% (2011). Nearly 20% of the city's population lives in structurally unsafe (unauthorized dilapidated) buildings. Hence, Thane is in need of affordable housing stock which is proposed as Urban Renewal Plan (URP) or Cluster Redevelopment Policy.

The proposed URP or Cluster Redevelopment Policy is aimed at promoting well-planned development by providing better services and amenities. The scheme proposes structurally safe in-situ planned redevelopment of dilapidated structures. In addition to this, TMC's affordable housing policy permitting a Floor Space Index (FSI) of 3 is also expected to considerably improve the housing situation in the city.

In the building sector, TMC is making efforts to reduce energy consumption and shift to renewable and sustainable sources. Various policies have been developed to promote sustainable practices like rainwater harvesting, solar water heating, green buildings etc. by providing rebate in property tax. TMC has also developed a practical guide book for implementing smart and clean energy projects in existing high-rise residential apartments.

There are a total of 40,200 street lights in Thane, of which about 26,000 have been replaced with LED. In addition to replacing 7,500 street lights under an Energy Saving Contract (ESCO) project, others will be replaced as routine work.

Stipulated Projects

- URP: The total area under all the proposed URPs is 1508.93 Ha comprising of 25% of the total city area. The six priority areas finalized for cluster development are Kopri, Hajuri, Tekadi Bungalow, Lokamanyanagar, Kisannagar, and Rabodi. Out of this, a 70 acre cluster at Kisannagar will be developed under the Smart Cities Mission.
- Grid connected solar PV system at proposed various locations on the available roofs of TMC buildings with cumulative power generation of about 10 MW
- TMC has promoted energy efficiency (EE) in its buildings by installing LED tubelights, promoting star labelling programme for fans, ACs and geysers.
- Service sector development (e.g. TCS 25 lac sq. ft. area, Bair Crop Science 10 lac sq feet area)
- Holistic meditation and spirituality center proposed to be set up in cooperation with Prajapita Brahma Kumaris Ishwariya Vishwa Vidyalaya
- Modern skill development center of human excellence in health care proposed; a six storied building developed on PPP mode
- International level gymnastics center and sports complex proposed to come up at Pokharan Road no. 2
- Crematorium redevelopment planned
- 267 Kw grid connected solar PV system proposed to be installed on the roof tops of schools
- ESCO based LED street lighting to replace about 7,500 street lights, being executed by TMC
- Replacing sodium vapour street lights by LED
- 12 urban restrooms proposed under the Smart Cities mission
- Plantation of 2 lac plants, mangroves, medicinal plants, rose garden

There are a total of 40,200 street lights in Thane, of which about 26,000 have been replaced with LED.

Issues Identified

- Lack of awareness regarding green building certification among various stakeholders
- Lack of awareness of various green technologies available for buildings
- Lack of awareness regarding various government schemes and benefits like rain water harvesting, solar water heating for existing buildings
- Clearing land titles and ownership details
- Slums, unauthorized and dilapidated buildings prone to disasters and lack basic services

Enhancement of Water Bodies

Present Scenario

The two major water bodies of Thane are Thane creek and Ulhas river estuary. Thane city's catchment is divided into these two water bodies with tidal influence from the Arabian Sea. About 32 km creek length falls under TMC limits. In addition, Thane is famous for its 35 lakes. These lakes help during monsoon by holding some runoff. There are 72 major nullahs and 95 sub nullahs in the city with overall length of 153 km. TMC has undertaken restoration of lakes and INDP as a long-term measure to conserve water bodies.

Stipulated Projects

- Waterfront development: It is proposed to develop creek area for restoration, conservation, cleanliness, jogging track, promenade, water sports and tourism center. The 32 km creek area has been divided into 13 zones and TMC has chosen to work on eight prioritized zones. Of these, five (Parsik Retibundar Choupati, Nagla Bunder, Saket-Balkum, Kalwa-Shastri Nagar and Kopri) come under the Smart Cities Mission. Work on developing 9.65 km area is already underway.
- Mangrove conservation and plantation
- Lake rejuvenation plan: To enhance the water quality of the lakes and reduce pollution load, TMC is carrying out probiotic treatment, aeration system, fountains, waste management, cleaning and fencing etc. at various lakes for the last 6-7 years. For 2019-20, Rayladevi Lake and Jogila Lake are considered for rejuvenation. Under the Smart Cities Mission and through TMC funds, Masunda lakefront development is being considered.

Issues Identified

- Lack of wastewater collection and treatment facility is increasing pollution load of water bodies
- Lack of awareness among the local people: throwing solid waste in natural drains
- Encroachment on the banks of water bodies makes it difficult to take any measures of restoration
- Restoration of aquatic ecosystem should be prioritized

Health

The Health Department of TMC along with its sub departments such as the Birth and Death Registration Department, Filaria Department, Veterinary Department and Central Medical Stores Department provide health facilities including preventive, curative, specialty and super-specialty services. The Department also undertakes efforts to prevent the spread of communicable diseases.

TMC's Health Department provides public health services through 25 primary health care centres, one diagnostic center, five maternity homes, one paediatric hospital, nine diagnostic facilities and a 500 bedded Chhatrapati Shivaji Maharaj Hospital. TMC implements national health programmes such as polio vaccination, family planning and family welfare, vitamin and booster doses to children, apart from running a medical college and a nursing training institute. Other than TMC's Health Department, health infrastructure is also maintained by the government of Maharashtra, public trusts and private hospitals. The overall healthcare infrastructure in Thane includes about 238 hospitals/nursing homes, 120 maternity homes, 25 primary health centres with a total of 5,952 beds.

Biodiversity: Green Spaces

Thane has about 115 municipal gardens covering about 59.91 acre and TMC is developing several more. As per the 2011 tree census, the city has 455,070 trees with 301 different species[2]. The garden department and pollution control department in cooperation with other departments of TMC have planned various initiatives like butterfly garden, urban forest, traffic parks, and green canopies at various locations. They have initiated plantation drives at mass level and adopted the policy of planting five trees for cutting one. Thane is also working on mangrove plantations and conservation of the mangrove ecosystem.

Thane has 115 municipal gardens covering about 59.91 acre and TMC is developing several more. As per the 2011 tree census, the city has 455,070 trees with 301 different species

The approach to resilient urban development can no longer be confined to managing disaster risk and the impact of climate change but should also consider the impact of economic crises, health epidemics, and uncontrolled urbanization on a city's ability to sustain growth and provide services for its citizens[3].

Stipulated Projects

- Central park development at Balkum area covering 76,000 sq. ft. area
- Community park at Pokharan Road no. 2 covering 8,287 sq. ft. area
- Urban forestry development on 8 acre land
- Traffic and children park on 10,388 sq. ft. area
- Green canopy on footpaths, vertical gardens, garden adoption scheme; underway

Other Projects

1. Free Wi-Fi and CCTV cameras under PPP mode with 42 Cr. budget; implemented
2. Mist spray proposed using TMC funds to the tune of one crore
3. Automatic change detection and monitoring system to track development work and unauthorized development assessment proposed for 2019-20 through TMC funds worth three Cr.
4. Coastal road; work underway
5. New Thane proposed on the opposite side of Ulhas river estuary
6. Compliance to National Air Quality Index
7. Towards promoting citizens' happiness, TMC is investing funds worth about INR 40-50 million on sectors like medical, culture, tourism, skill development, capacity building, smart governance and living.
8. Upgrading firefighting services (INR 380 million budget) and strengthening Disaster Management Cell of Thane (INR 60 million budget) in 2019-20

Other Projects in the Smart Cities Mission

- Digi Thane – Digital platform to interact with citizens (INR 280 million budget)
- Enterprise resource planning – for better online services of TMC (INR 120 million budget)
- Integrated command and control room (INR 465 million. budget)
- Integration of Service Level Benchmark (SLB) with e-governance

2 Environmental Status Report 2017-18, Thane Municipal Corporation

3 World Bank. Resilient Cities. [online] Available at: https://www.worldbank.org/en/topic/urbandevelopment/brief/resilient-cities-program [Accessed 18 Mar. 2021].

Table 8: Key Projects of TMC for Urban Infrastructure Development and Service Improvement

S. No.	Project	Funding scheme	Cost (INR)	Status
		Water		
1	Augmentation of existing sources of water: The SHAI dam project	TMC and other agencies	-	Proposed and approvals being taken
2	Remodelling work of water supply network at central, south and north zones of Thane city	TMC/AMRUT	Ghodbunder road: 50 Cr.[4] Kalwa zone: 25 Cr. Mumbra Diva zone: 196 Cr.	Execution in progress and expected to be completed by 2022
3	Smart metering: About 1,13,000 connections to be equipped with AMR meters	Smart Cities Mission and TMC	121.03 Cr. (SCM: 93.19 Cr. and TMC: 27.84 Cr.)	Execution in progress
4	24x7 water supply in Uthalsar ward committee area as a demo zone	TMC	50 Cr	Proposed
5	Water audit and water supply management through SCADA	TMC	20 Cr. (for 2019-20)	In progress
6	Construction of ESRs and sumps	TMC	-	Execution in progress
7	Energy audit of water infrastructure	TMC	1 Cr. (for 2019-20)	
8	Remodelling work of water supply network with 2 ESRs of 5.5 ML capacity and 68 km distribution network in ABD area	Smart Cities Mission	35 Cr.	Execution in progress
9	Smart water management: Mapping of water infrastructure, hydraulic modelling and analysis of information provided by SCADA	TMC	5 Cr. (for 2019-20)	In progress
		Solid Waste		
1	Animal carcass to bio CNG plant of 60 TPD capacity	TMC	-	-
2	Plastic waste to oil plant of 5 TPD capacity	TMC	-	-
3	Waste to energy plant of 600 TPD (1st stage) + 600 TPD (2nd stage) capacity at Daighar to generate 14 MW energy (from 1st stage)	PPP	About 500 Cr. (TMC: 10 Cr. for 2019-20)	Execution in progress
4	Biomethanation plants of varying capacities from 1 to 5 TPD at various locations (10 plants)	TMC/Smart Cities Mission	21 Cr.	In progress
5	C &D waste plant of 100 TPD capacity	TMC	8 Cr. (for 2019-20)	Execution in progress
6	Scientific closure of 3 dumping areas at the Diva Khardi area through capping method and plantation through social forestry	TMC	15 Cr.	In progress
7	Mobile waste treatment plant to treat organic waste from the slums facing land shortage. OWC technique is proposed to be installed on a vehicle to treat the waste.	-	8 Cr. (for 2019-20)	-
8	150 containers of 1 ton capacity and 225 litterbins for collection of solid waste	Swachh Bharat Mission		Completed
9	Swachh Survekshan and complaint redressal centre	Swachh Bharat Mission and TMC	TMC: 5 Cr. (for 2019-20)	In progress

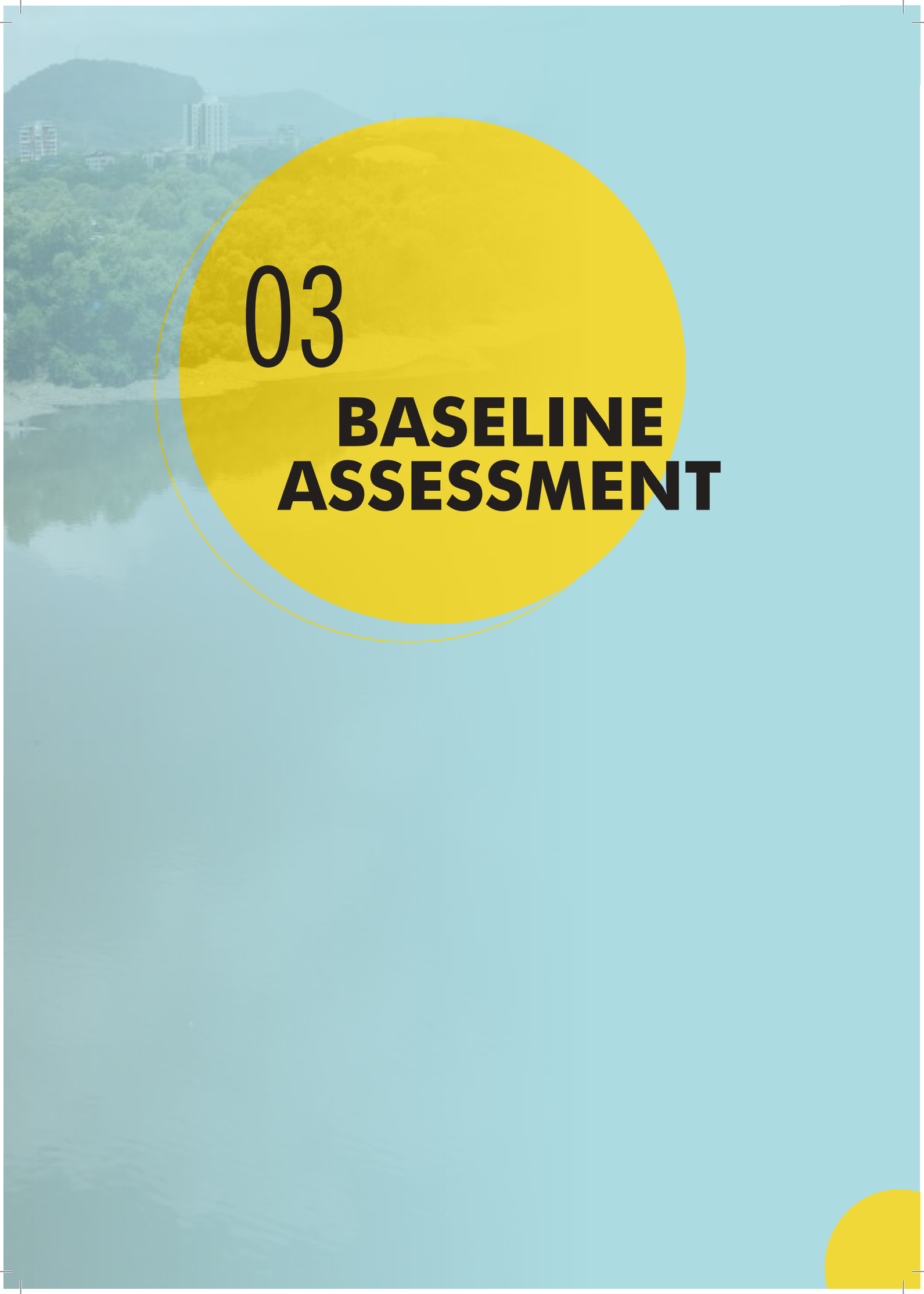
4 INR 1 Crore = INR 10 million

S. No.	Project	Funding scheme	Cost (INR)	Status
		Sewerage		
1	Developing sewerage network at Ghodbunder Road for about 10 lac population: Laying of sewer lines of 92 km, 5 sewage pumping stations, 2 STPs of 7 MLD capacity each and 2,922 house connections	AMRUT	625 Cr	Execution in progress and about 15% work completed till 2018-19
2	Underground sewerage scheme at various locations like Kalwa, Mumbra, Diva, Ghodbundar areas	-	-	In progress
3	Waste water treatment plant for 2 nullahs at Parsik and Kolshet on bioremediation basis on pilot scale	TMC	5 Cr.	-
4	Completion of JNNURM project which includes underground sewer lines of 210 km, 20 sewage pumping stations and 6 sewage treatment plants; Execution of 4 decentralized STPs with 100 MLD total capacity at Vitawa, Kharegaon, Kolshet, Majiwada	-	-	Execution in progress and about 98% work completed till 2018-19
5	About 37 km underground sewage lines being laid in ABD area with 2,000 house connections	Smart Cities Mission	25 Cr.	Execution in progress
6	Sewerage network proposed for Diva and Shil areas which include sewer lines of 152 km, 13 sewage pumping stations and 5 STPs	State Govt. and TMC	235 Cr. (TMC: 10 Cr. for 2019-20)	In progress
7	Feasibility study to provide rebate in property tax or water cess for the residential societies treating and reusing their sewage	-	-	Proposed
8	Individual connections to connect with main sewer line	TMC	110 Cr.	Execution in progress
		Stormwater		
1	INDP phase 4 and 4.45 km length of nullah development	Smart Cities Mission and TMC	160 Cr. 49 Cr (SCM)	Execution in progress
2	Pumping stations and tidal gates at 10 locations: 3 in core city, 3 in Ghodbunder, 3 in Mumbra and 1 in Kalwa	-	-	Proposed
		Transport		
1	New suburban railway station: A land pocket of 14.83 acre has been allocated for this project near the Mental Hospital building.	Smart Cities Mission in partnership with Central Railways	289 Cr. (SCM 259 Cr. and TMC 39 Cr.)	In progress
2	Internal metro rail network with 29 km and 22 stations proposed with 20% capital share of TMC	Central Govt./State Govt./MMRDA/ TMC	9,664 Cr.	Approvals are being processed, MAHA-METRO has developed a DPR
3	Inland water ways development: To purchase vessels and jetty development	IWAI and TMC	IWAI: 1st stage 661.14 Cr. 2nd stage 686 Cr. TMC: 5 Cr. (for 2019-20)	In progress
4	Personalized Rapid Transit System to develop feeder network for metro rail system; including 3 stages with lengths 34 km, 49 km and 20 km	PPP (Hybrid Annuity Model)	2500+ Cr. TMC: 30 Cr. (for 2019-20)	In progress

S. No.	Project	Funding scheme	Cost (INR)	Status
5	Multimodal transit hub at the east side of Thane railway station; including elevated roads and bus terminus, separate underground parking area and separate lines for auto-rickshaw and taxis	Smart Cities Mission	267 Cr.	In progress
6	Soft mobility plan to develop 12.87 km roads in ABD area equipped with pedestrian friendly footpaths, signage, zebra crossings, bicycle and bus stops etc; proposed to replicate this on a 5 km road stretch using TMC funds	Smart Cities Mission and TMC	23 Cr.	In progress
7	Proposed 50 new buses reserved for ladies named 'Tejaswini Buses'	-	-	In progress
8	100 electrical buses with charging facility to reduce GHG emissions from transport sector	-	-	Only one received; no progress thereafter
9	Intelligent Traffic System to inform about and track bus routes, coloured and attractive zebra crossings, road asset mapping and Adoptive Traffic Management System to operate traffic signals on real time and optimum time basis	Smart Cities Mission and TMC	SCM: Pedestrian improvement 23 Cr. SCM: Intelligent Transport System 4 Cr. TMC: Adoptive traffic management 32 Cr.	-
10	Grade separator project at Teen Hath Naka proposed; including underground two directional route with 4 lines across about 750 m	Smart Cities Mission through MoRTH and TMC	239 Cr. by MoRTH	Proposed/In progress for approvals
11	An underground parking facility is proposed under the Smart Cities Mission at Gaondevi Ground near the west side of Thane railway station. This will accommodate 130 four wheelers and 120 two wheelers at a time on pay and use basis on 4,222 sq. ft. area. Additionally, about 11,357.23 sq m area is under construction to develop a 10 storied building to park about 1,600 four wheelers and an administrative building with parking at Kashish Park. Given the traffic congestion at Gokhale road, a redevelopment project of an existing market building is proposed with parking of 450 two wheelers and 320 four wheelers, expected to be complete in 2021.	Smart Cities Mission and TMC	27 Cr. (SCM)	In progress
12	Development of vibrant multi-use promenades along waterfronts, creation of no-vehicle zones in high pedestrian traffic areas, senior-citizen friendly street furniture, tactile paving, strategic interventions in urban redesigning of streets, TMC's unique Harith Janpath programme (green pedestrian pathways)	TMC	Road assets mapping 2 Cr. for 2019-20	In progress

S. No.	Project	Funding scheme	Cost (INR)	Status
	Buildings, Energy and Green Spaces			
1	Urban Redevelopment Plan (URP): 70 acre cluster at Kisannagar	PPP (Smart Cities Mission)	3974 Cr.	In progress
2	Grid connected solar PV system at various locations on the available roofs of TMC buildings with cumulative power generation of about 10 MW	PPP (Smart Cities Mission)	70 Cr.	In progress
3	TMC has promoted EE in its buildings by installing LED tube lights, promoting star labelling programme for fans, ACs and geysers	-	-	Routine work – Execution in progress
4	Service sector development (e.g. TCS 25 lac sq. ft. area, Bair Crop Science 10 lac sq feet area)	-	-	In progress, MoU signed
5	Holistic meditation and spirituality center to be set up in cooperation with Prajapita Brahma Kumaris Ishwariya Vishwa Vidyalaya	-	-	MoU signed
6	Modern skill development center of human excellence in health care – 6 storied building developed on PPP mode	-	-	In progress
7	Plantation of 2 lac plants, mangroves, medicinal plants, rose garden	TMC	7 Cr. (for 2019-20) (2+1+2+2 Cr.)	In progress
8	Central park development at Balkum area over 76,000 sq. ft. area	-	-	In progress
9	Community park at Pokharan Road no. 2 over 8,287 sq. ft. area	-	-	In progress
10	Urban forestry development on 8 acre land	-	-	In progress
11	Traffic and children park over 10,388 sq. ft. area	-	-	In progress
12	International level gymnastics enter and sports complex at Pokharan Road no. 2	-	-	MoU signed
13	Crematorium redevelopment plan	TMC	8 Cr. (for 2019-20)	
14	267 Kw grid connected solar PV system on the rooftops of schools	TMC	2.25 Cr.	In progress
15	ESCO based LED street lighting to replace about 7,500 street lights being executed by TMC	PPP	27 Cr.	Execution in progress
16	Replacing sodium vapour street lights with LED	TMC	20 Cr. (for 2019-20)	Execution in progress
17	12 urban restrooms proposed	Smart Cities Mission	5 Cr.	Execution in progress
18	Continuous Ambient Air Monitoring equipment Systems (CAAQMS) under National Clean Air Action Plan	TMC	4.50 Cr. (for 2019-20)	Execution in progress

S. No.	Project	Funding scheme	Cost (INR)	Status
	Enhancement of water bodies			
	Waterfront development: It is proposed to develop creek area for restoration, conservation, cleanliness, jogging track, promenade, water sports and tourism center. The 32 km creek area has been divided into 13 zones and TMC has chosen to work on eight prioritized zones. Of these, five (Parsik Retibundar Choupati, Nagla Bunder, Saket-Balkum, Kalwa-Shastri Nagar and Kopri) come under the Smart Cities Mission. Work on developing 9.65 km area is already underway.	Smart Cities Mission and TMC	SCM: Waterfront development along creek line 221.5 Cr TMC: Gaymukh Ulhas river estuary 38.80 Cr.	Execution in progress
	Mangrove conservation and plantation	-	-	Execution in progress
	Lake rejuvenation plan: To enhance the water quality of the lakes and reduce pollution load, TMC is carrying out probiotic treatment, aeration system, fountains, waste management, cleaning and fencing etc. at various lakes for the last 6-7 years. For 2019-20, Rayladevi Lake and Jogila Lake are considered for rejuvenation. Under the Smart Cities Mission and through TMC funds, Masunda lakefront development is being considered.	Smart Cities Mission and TMC	SCM: Masunda lake beatification and glass cantilever 12 Cr. Kamal lakefront 2 Cr. Hariyali lakefront 2 Cr. TMC: 8 Cr. (For 2019-20)	Execution in progress



03 BASELINE ASSESSMENT

3.1 GHG Emissions Inventory Methodology

Thane's baseline inventory has been prepared based on energy consumption and municipal operation data for the period 2013-14 to 2017-18. The GHG emissions inventory has been prepared following the Global Protocol for Community Scale GHG Emissions (GPC) created collaboratively by World Resources Institute (WRI), C40 Cities Climate Leadership Group and ICLEI - Local Governments for Sustainability. In particular, it complies with the BASIC level reporting which covers Scope 1 and Scope 2 emissions from stationary and transportation energy sources, as well as Scope 1 and Scope 3 emissions from waste (Refer Annexure 5).

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

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

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

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

A city's GHG inventory is not the sum of GHG emissions from its community level activities and operations carried out by the LG body to provide basic urban services. Usually, a major part of the emissions due to the LG operations is a subset of the community level emissions. Often the community inventory data already accounts for the data pertaining to municipal government operations. Due care should be taken to avoid double accounting of emissions. For example, the electricity consumption in municipal facilities for water supply, sewage treatment, and street lighting may already be accounted in the communitywide electricity consumption data based on relevant customer/end-user categories as prescribed under the electricity distribution and tariff arrangements. Adding the electricity consumption data from such facilities, obtained from the respective departments within the LG, to the communitywide data again will result in double accounting of the emissions. Such overlaps can be prevented by careful handling of data.

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

3.1.1 Methodology for GHG Emissions Inventory

The GHGs considered in the GHG emission inventory are carbon dioxide (CO_2), methane (CH4) and nitrous oxide (N2O), gases which account for nearly 99% of global GHG emissions.

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

Table 9: 100 Year GWPs of GHGs with respect to CO_2

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

Emissions Factors

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

The GHG emissions inventory has been prepared following the Global Protocol for Community Scale GHG Emissions (GPC)

$GHG_A = EF_A \times D_A$

Where,

GHG_A = GHG emissions resulting from activity A

EFA = emission factor for activity A

DA = data for activity A

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

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

3.1.2 Harmonized Emission Analysis Tool plus (HEAT+)

ICLEI's Harmonized Emission Analysis Tool plus (HEAT+) is an online emissions accounting software package that helps LGs to account for GHG emissions and develop a comprehensive energy and carbon inventory of their respective cities. The tool helps them in making informed climate action decisions and was used to assist with the accounting of Thane's level of GHG emissions during the 5 year period of the inventory. The HEAT+ tool incorporates the latest technical findings (IPCC, 2006) and is based on the International Local Government GHG Emissions Analysis Protocol (IEAP). It also incorporates the new international reporting requirements and standards outlined in the GPC. Although HEAT+ is now GPC compliant, the government module is retained from the differentiation that was brought in with IEAP.

HEAT+ helps LGs:

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

While ICLEI designed HEAT+ as a GHG planning tool for its LG members to use while undertaking the five mile stone process of the Cities for Climate Protection (CCP) Campaign, this tool has been substantially updated to support cities in the implementation of ICLEI's latest Climate Action methodology, the Green Climate Cities. Decision makers from other levels of governments as well as from the private sector and NGOs will also find the tool useful. With an easy to navigate interface, numerous built-in reports, extensive IPCC and country-specific emissions coefficient data sets, HEAT+ provides an unparalleled software environment for everything right from preparing city specific GHG emissions inventories to evaluating the benefits of individual policies and measures for developing comprehensive action plans.

3.1.3 Data Sources and Collection

The baseline year for GHG emissions inventory is considered as financial year 2017-18. The data is collected for the last 5 years up to 2013-14 from the baseline year. A full inventory includes GHG emissions from energy, waste, forestry and land use change. However, due to limited resources and data constraints, the direct emissions from agriculture, land use change and forestry sectors were not included.

ICLEI South Asia and TMC staff members engaged through meetings and letters with a number of municipal, local and sub-national stakeholders to source the relevant energy consumption data focusing on the large carbon emitters within the municipal area. Supply and demand side data were collected and analyzed. The various sources of energy and other relevant data used in the report are elaborated in the table below:

Table 10: Sources of Data Used for GHG Emissions Estimation

Fuel Type	Sector	Data Source
Electricity	Residential	Maharashtra State Electricity Distribution Company Limited (MSEDCL)
	Commercial/Institutional	MSEDCL
	Manufacturing industry and construction	MSEDCL
	Municipal buildings, water supply (treatment and pumping), sewage (treatment and pumping), street lights	Electrical department, TMC
Diesel	Community transport	Hindustan Petroleum Corporation Ltd. (HPCL), Indian Oil Corporation Ltd. (IOCL), Bharat Petroleum Corporation Ltd. (BPCL) (Thane)
	Manufacturing industry and construction	HPCL, IOCL, BPCL (Thane)
	Municipal vehicles	Workshop Department, TMC
Petrol	Community transport	HPCL, IOCL, BPCL (Thane)
	Manufacturing industry and construction	HPCL, IOCL, BPCL (Thane)
	Municipal vehicles	Workshop Department, TMC

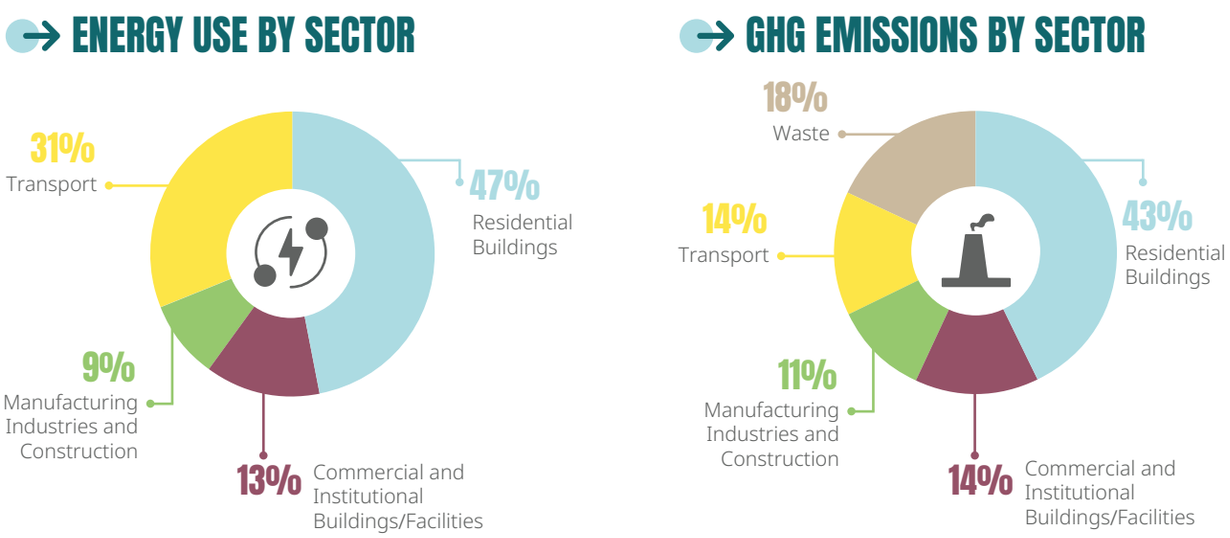
Fuel Type	Sector	Data Source
LPG	Residential	HPCL, IOCL, BPCL (Thane)
	Commercial/Institutional	HPCL, IOCL, BPCL (Thane)
	Auto LPG – Transportation	HPCL, IOCL, BPCL (Thane)
Kerosene	Residential	District Supply Office, Thane District
PNG and CNG	Residential, commercial, industrial	Mahanagar Gas Limited
Furnace Oil	Manufacturing industry and construction	HPCL, IOCL, BPCL (Thane)
Light Diesel Oil	Manufacturing industry and construction	HPCL, IOCL, BPCL (Thane)
Transport Sector		Regional Transport Office (RTO) –Thane
Solid Waste Management		SWM Department, TMC
Municipal Water Supply		Water Supply Department, TMC
Municipal Waste Water treatment		Sewerage Management Department, TMC
Municipal Street Lighting		Electrical Department, TMC

3.2 GHG Emissions Inventory of Thane

Table 11: Thane City Energy Consumption and GHG Emissions (2017-18)

Total Energy Use[5]	13,063,503 Giga Joules (GJ)
Total GHG Emissions	2,291,294 tonnes of CO_2e (tCO_2e)
Per Capita Energy Use	5.83 GJ
Per Capita GHG Emissions	1.02 tCO_2e

Figure 4: Community Scale Energy Consumption and GHG Emissions



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

Table 12: Sector wise Energy Consumption and GHG Emissions in 2017-18

Sector	Energy Use (GJ)	GHG emissions (tCO_2e)
Residential buildings	6,146,579	989,820
Commercial and institutional buildings/ facilities	1,694,386	325,851
Manufacturing industries and construction	1,205,759	250,145
Transport	4,016,778	326,057
Waste	--	399,421
Total	13,063,503	2,291,294

Figure 5: Energy Consumption Trend from 2013-14 to 2017-18

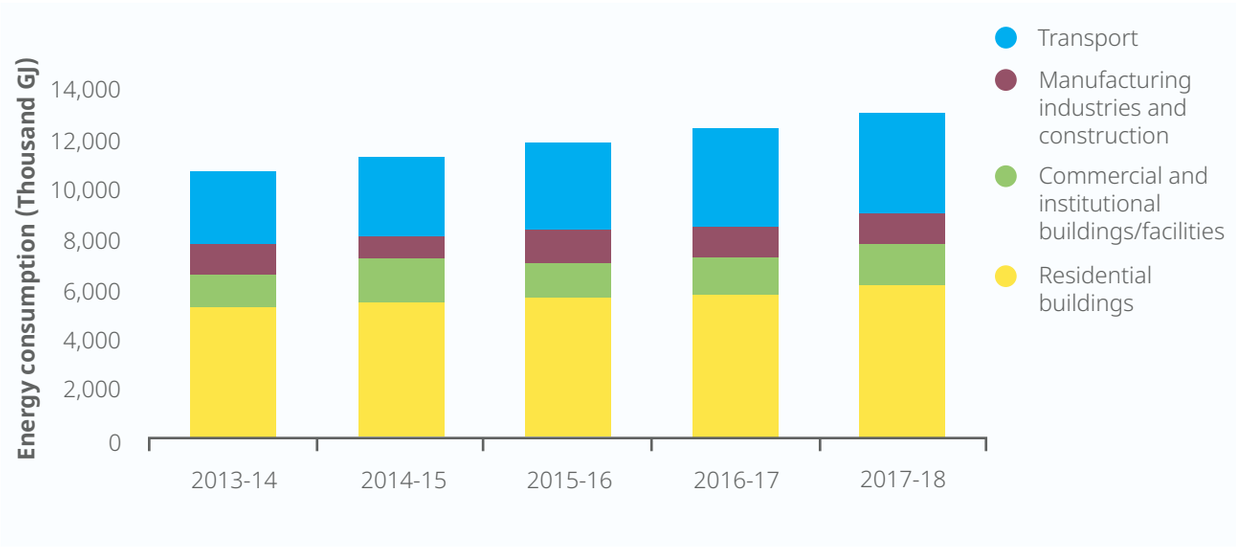
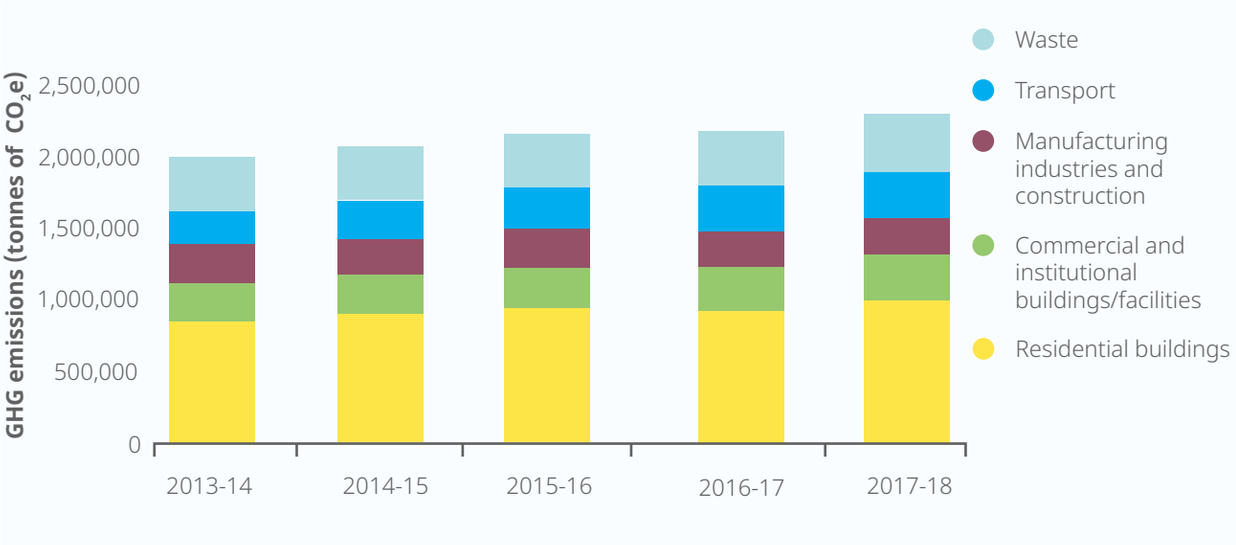


Figure 6: GHG Emissions Trend from 2013-14 to 2017-18



Largest energy consumers:

- Residential buildings **47%**
- Transportation **31%**
- Commercial and institutional buildings/facilities **13%**
- Manufacturing industries and construction **9%**
- Energy use trend Rise of **22.22%** since 2013-14 (at a CAGR of 4.1%)

Largest GHG emitters

- Residential buildings **43%**
- Waste **18%**
- Transportation **14%**
- Commercial and institutional buildings/facilities **14%**
- Manufacturing industries and construction **11%**
- GHG Emissions trend Rise of **15.3%** since 2013-14 (at a CAGR of 2.9%)

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

Figure 7: Energy Use and GHG Emissions by Energy Source/Fuel

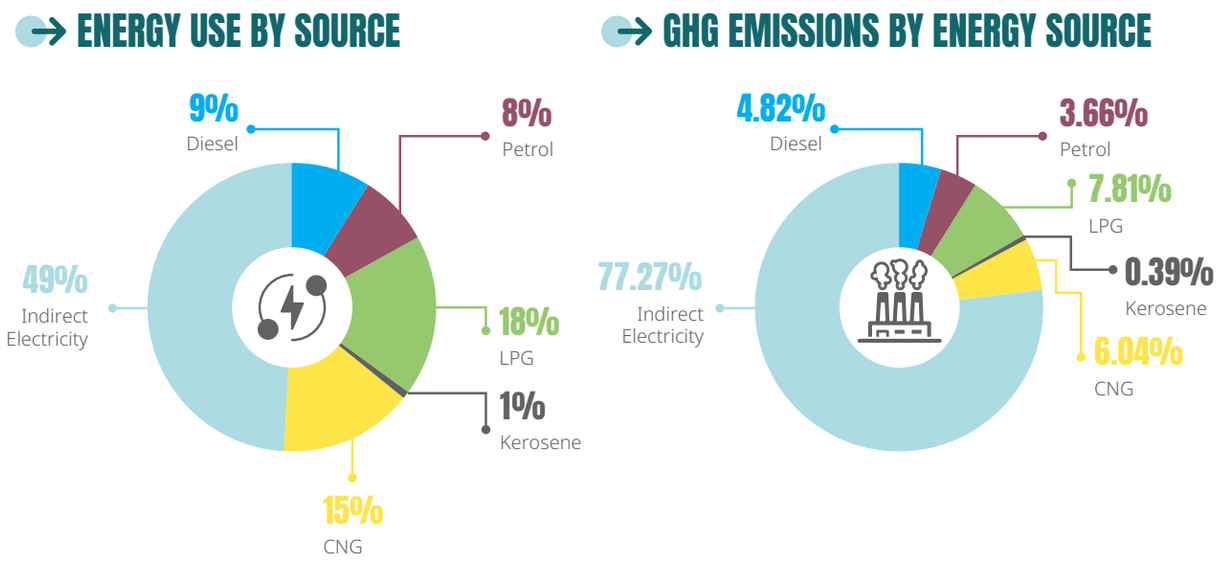


Table 13: Energy Consumption and GHG Emissions by Energy Source

Fuel/Energy Source	Energy Use (GJ)	GHG emission (tCO_2e)
Diesel	11,57,922	86,096
Petrol	9,39,968	65,378
PNG	7,04,061	39,536
LPG	22,09,440	139,537
Kerosene	95,994	6,926
CNG	19,18,889	107,931
Indirect Electricity	60,37,229	1,379,816
Total	**13,063,503**	**1,825,221**

Total community scale GHG emissions by energy source in 2017 -18:

1,825,221

tCO_2e

Prominently used Energy sources:

Electricity **48.85%**

LPG **17.88%**

CNG **15.53%**

Total community scale GHG emissions by energy source in 2017 -18: **1,825,221 t CO_2e**

Largest GHG emitting energy sources:

Electricity **26%**

LPG **7.81%**

Diesel **4.82%**

3.2.2 Sectoral Electricity Consumption and Resultant Indirect Emissions

Figure 8: Sector-wise Electricity Consumption and GHG Emissions in 2017-18

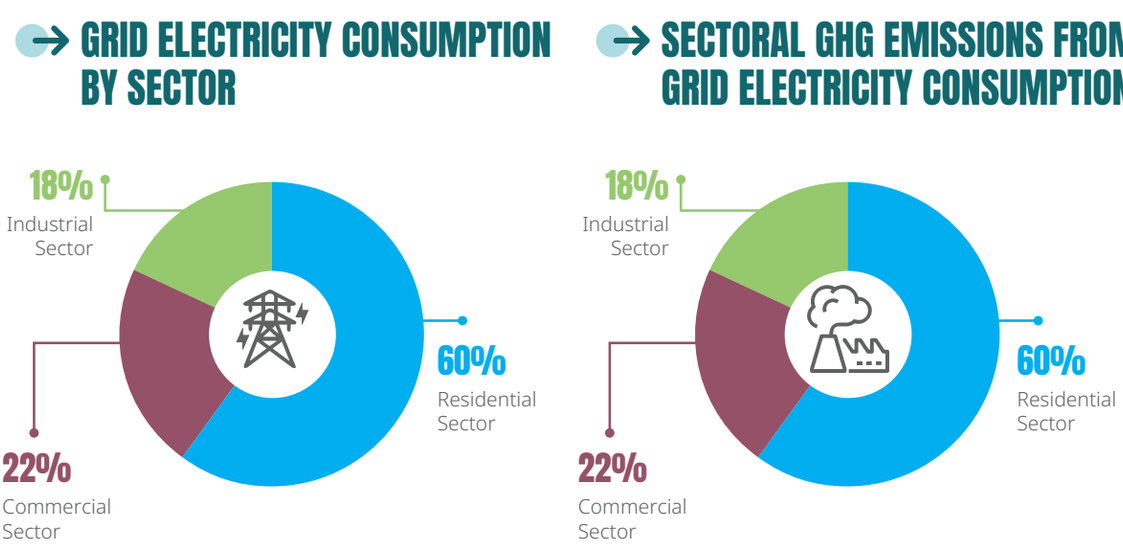
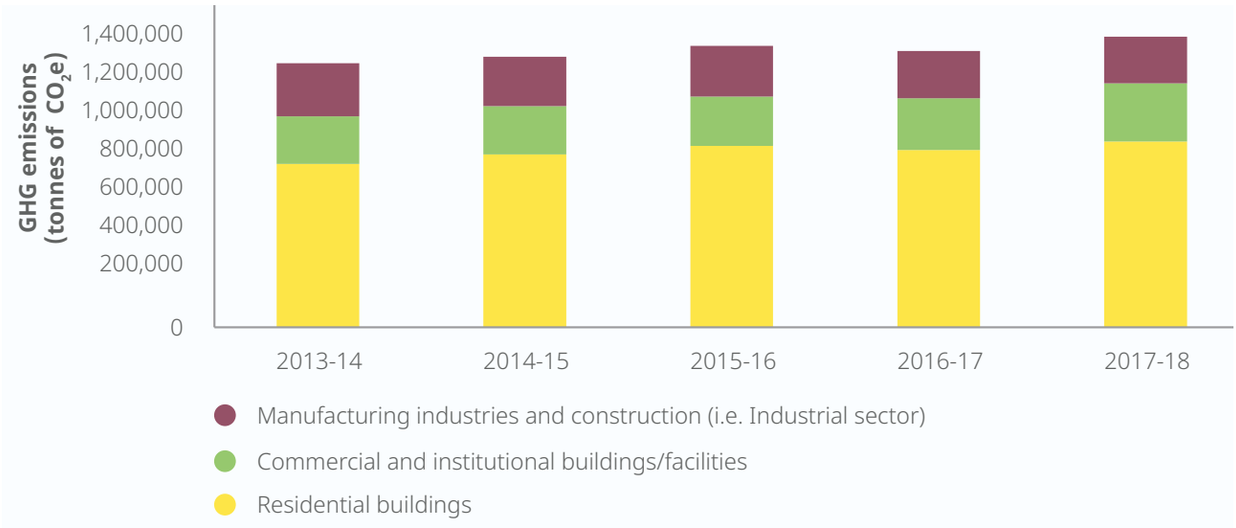


Figure 9: Trend of GHG Emissions from Grid Electricity Consumption



Total electricity consumption in 2017-18:
1,677 million kWh

Electricity consumption per capita:
722.78 kWh

Largest electricity consumers and GHG emitters:

Residential buildings
60%

Commercial and institutional buildings/facilities
22%

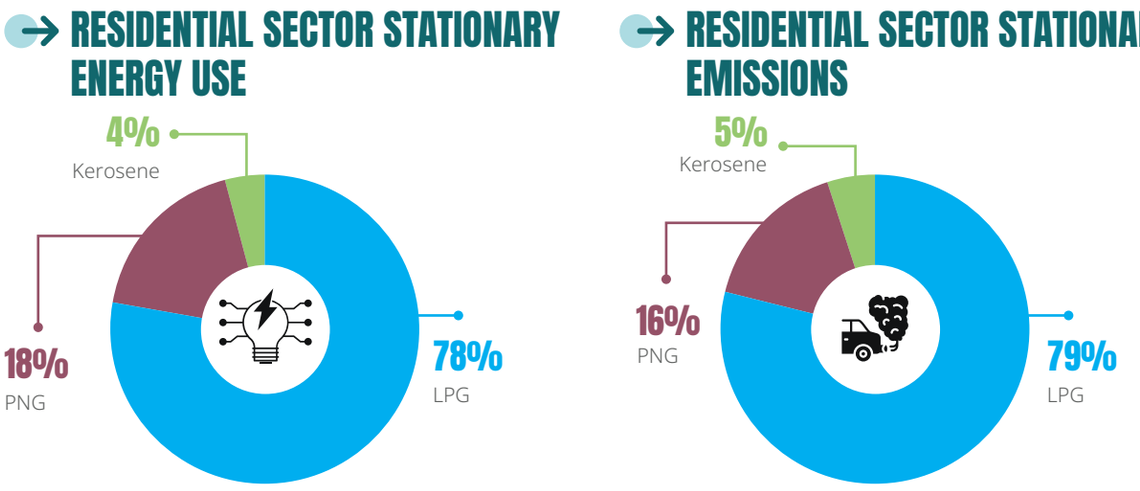
Manufacturing industries and construction
18%

Total GHG emissions from electricity consumption in 2017-18:
1,379,816 tCO_2e

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

Residential Building Sector

Figure 10: Energy Use and Resultant GHG Emissions in Residential Buildings



Total Energy Use from stationary fuel consumption in the sector:
2,495,255 GJ

Energy Use Trend:
Rise of
16.73%
(at a CAGR of 3.1%)

Trend of Kerosene Consumption:
decrease of
62.37%
(at a CAGR of - 17.8%)

Trend of LPG Consumption:
rise of
26.18%
(at a CAGR of 4.8%)

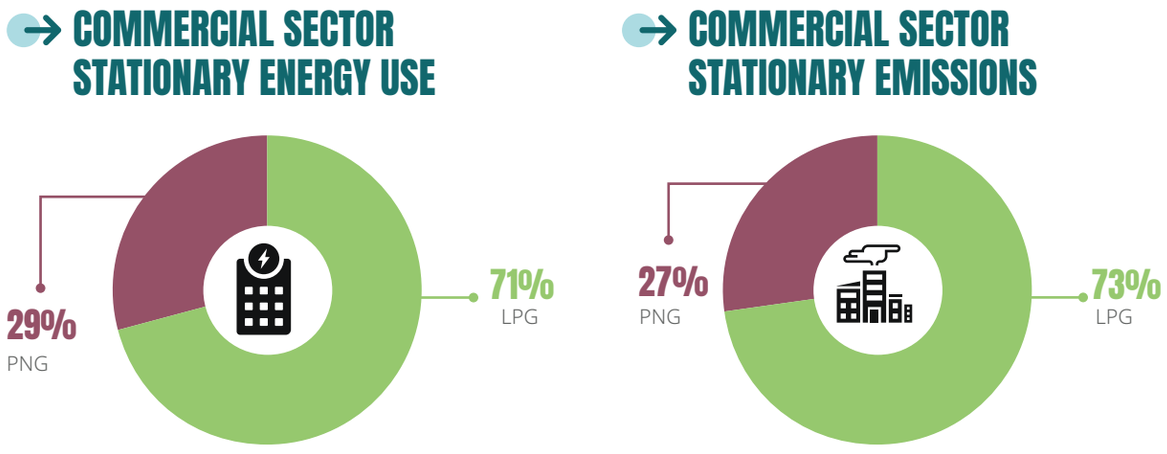
Trend of Kerosene Consumption:
LPG
79%

Trend of PNG consumption:
rise of
33.22%
(at a CAGR of 5.9%)

Trend of GHG Emissions:
CO2
rise of
15.09%
(at a CAGR of 2.9%)

Commercial and Institutional Buildings/Facilities

Figure 11: Energy Use and Resultant GHG Emissions in Commercial Sector



Total Energy Use from stationary fuel consumption in the sector:
366,713 GJ

Energy Use Trend:
Rise of
66.96% (at a CAGR of 10.8%)

Trend of LPG Consumption:
rise of
49.16% (at a CAGR of 8.13)

Trend of PNG consumption:
rise of
134.90% (at a CAGR of 18.6%)

Total GHG emissions from stationary fuel consumption in the sector:
22,410 tonnes of CO_2e

Trend of GHG Emissions:
rise of
65.36% (at a CAGR of 10.6%)

Largest GHG emitting Fuel:
LPG
73%

Manufacturing Industries and Construction Sector

Figure 12: Trend of Energy Use from Stationary Fuel Consumption in Industrial Sector

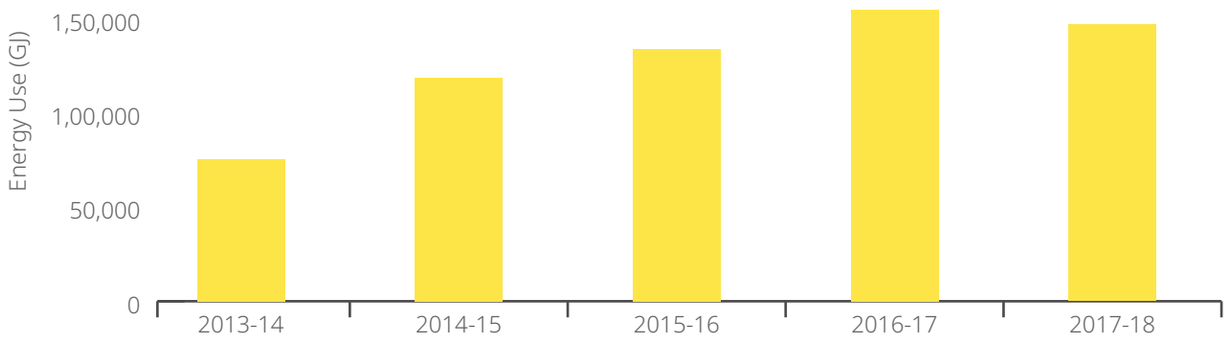
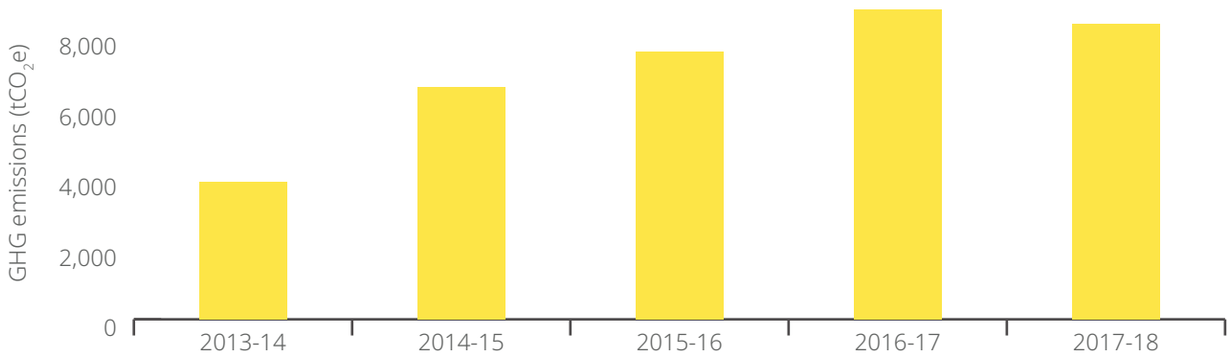


Figure 13: Trend of GHG Emissions from Stationary Fuel Consumption in Industrial Sector



Total Energy Use from stationary fuel consumption in the sector:
147,526 GJ

Energy use trend:
Rise of **110.54%** (at a CAGR of 16.1%)

Total GHG emissions from stationary fuel consumption in the sector:
8,284 tonnes of CO_2e

Trend of GHG Emissions:
rise of **110.54%** (at a CAGR of 16.1%)

3.2.4 Fuel Use in Transport Sector and Resultant Direct Emissions

On-road Transport

Figure 14: Share of Energy Consumption and GHG Emissions by Fuel in by On- road Transport in 2017-18

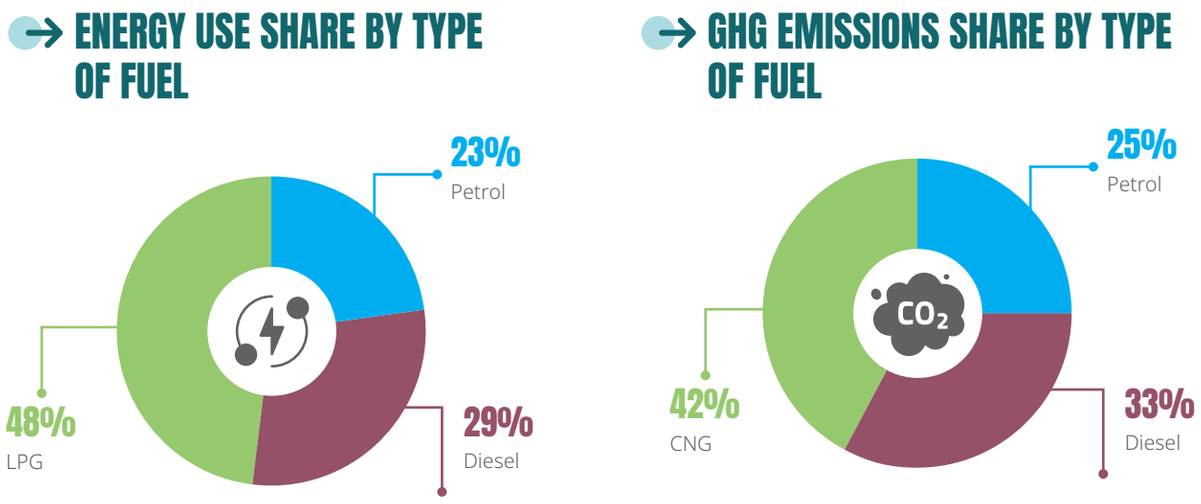
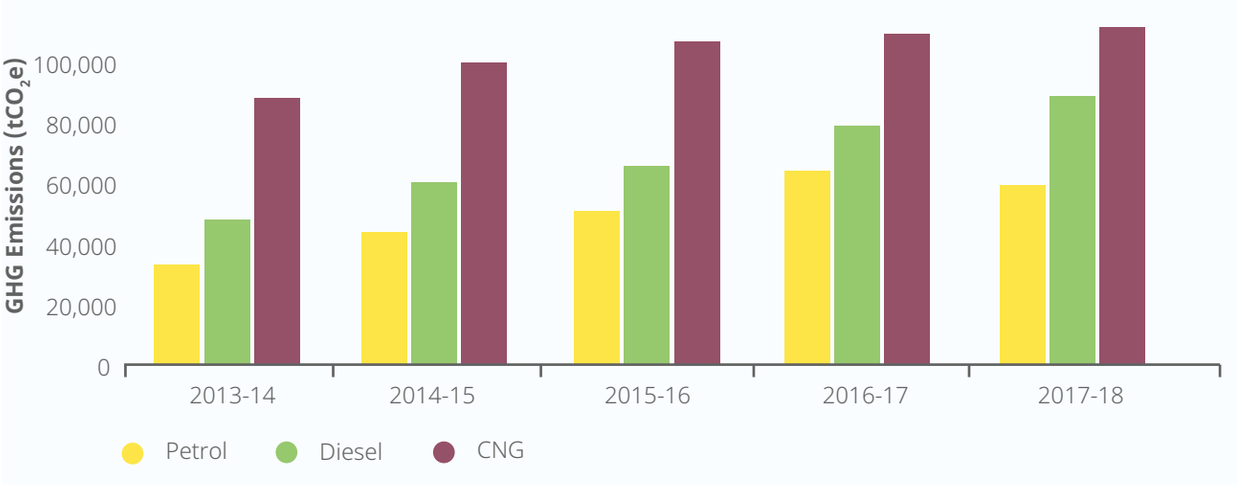


Figure 15: Trend of GHG Emissions from On-road Transport



Total energy consumption in on-road transportation in 2017-18:
4,016,778 GJ

Total GHG emissions from mobile combustion in transportation in 2017-18:
259,405 t CO_2e

Emissions from petrol consumption trend:

Rise of **85.9%** since 2013-14

Emissions from diesel consumption trend:

Rise of **66.8%** since 2013-14

Emissions from CNG consumption trend:

Rise of **17.9%** since 2013-14

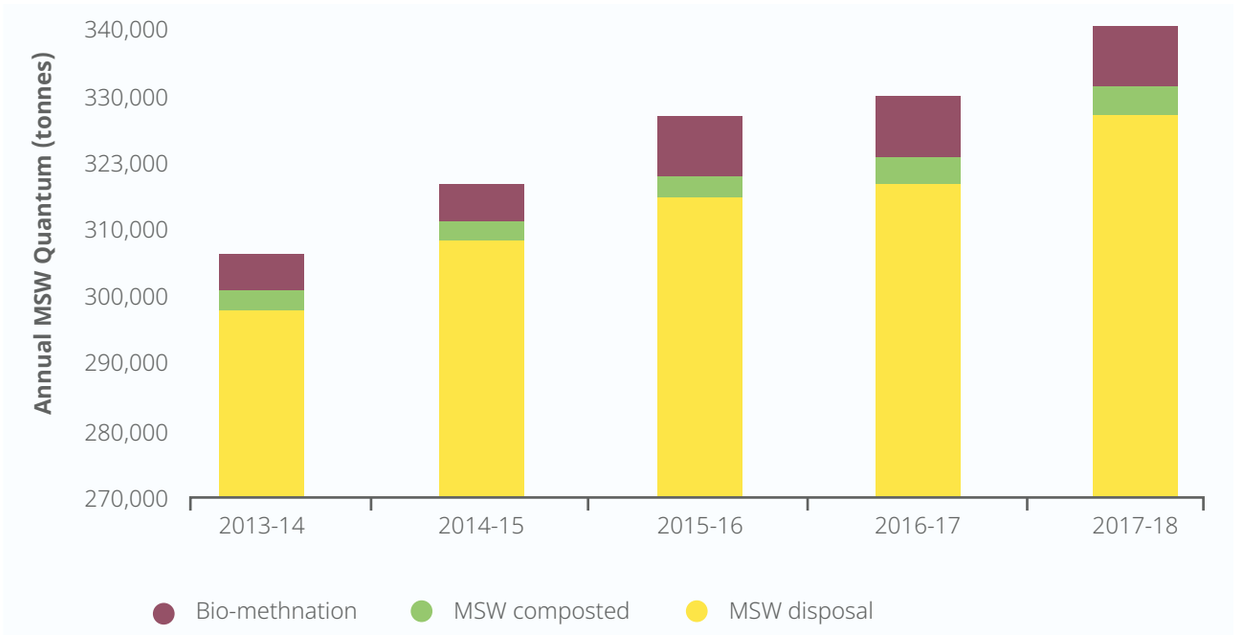
Rail Transport

Table 14: GHG Emissions from Rail Transport

Year	2013-14	2014-15	2015-16	2016-17	2017-18
Total Rail Emissions (tCO_2e)	55,963	58,460	61,067	63,791	66,636

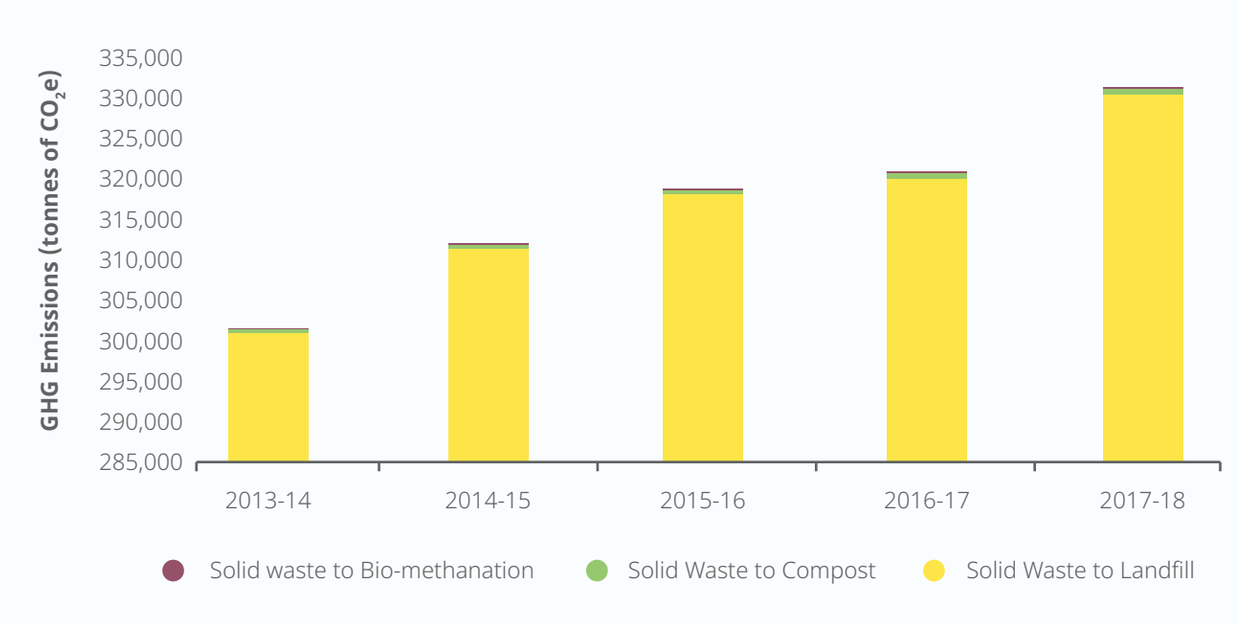
3.2.4 Waste Emissions

Figure 16: Trend of Annual Solid Waste Processing and Disposal



Emissions from MSW in the City

Figure 17: Trend of GHG Emissions from Solid Waste Disposal and Processing



Annual waste generation in 2017-18:
340,531 tonnes

Total GHG emissions from solid waste to landfill in 2017-18:
330,392 tCO_2e

Total GHG emissions from waste going to compost in 2017-18:
12,521 tCO_2e

Total GHG emissions from waste going to bio-methanation in 2017-18:
183 tCO_2e

Annual waste generation trend:
Rise of **11.07%** since 2013-14

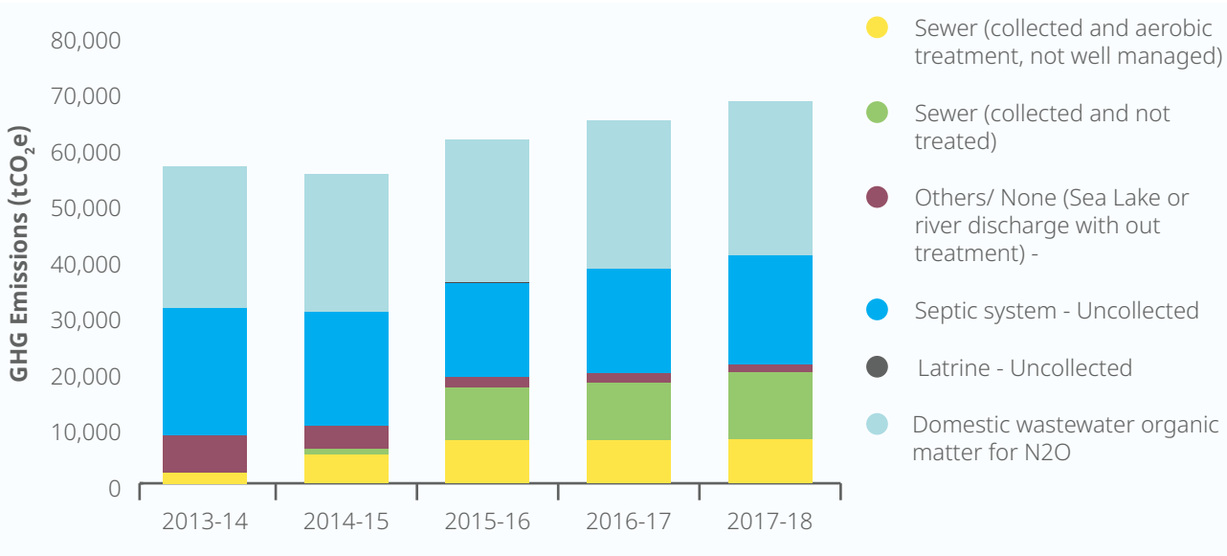
Emissions from solid waste to landfill trend:
Rise of **9.79%** since 2013-14

Emissions from waste going to compost trend:
Rise of **37.5%** since 2013-14

Table 15: GHG Emissions from Domestic Wastewater Discharge and Treatment

Treatment/ discharge pathway or system	GHG Emissions (tCO_2e)				
	2013-14	2014-15	2015-16	2016-17	2017-18
Sewer (collected and aerobic treatment, not well managed)	1,885	5,051	7,576	7,576	7,744
Sewer (collected and not treated)	-	1,065	9,505	10,332	11,979
Others/None (Sea, lake or river discharge without treatment)	6,525	4,099	1,836	1,680	1,529
Septic system - uncollected	22,817	20,345	16,901	18,661	19,411
Latrine - uncollected	106	92	74	75	76
Domestic wastewater N2O emissions	25,272	24,580	25,523	26,469	27,418
Total	**56,606**	**55,232**	**61,415**	**64,793**	**68,158**

Figure 18: Trend of GHG Emissions from Domestic Wastewater



Emissions from sewer (collected and treated) trend:

CO2 Rise of **310.89%** since 2013-14

Emissions from septic system trend:

Decrease of **14.93%** since 2013-14

3.2.5 Thane City Local Government: Energy Consumption and GHG Emissions (2017-18)

Table 16: Energy Use and GHG Emissions in Municipal Operations

Total Energy Use[6]	976,138 GJ
Total GHG Emissions	151,916 tCO_2e

Figure 19: Snapshot of Energy Use and GHG Emissions by Municipal End-Use in 2017-18

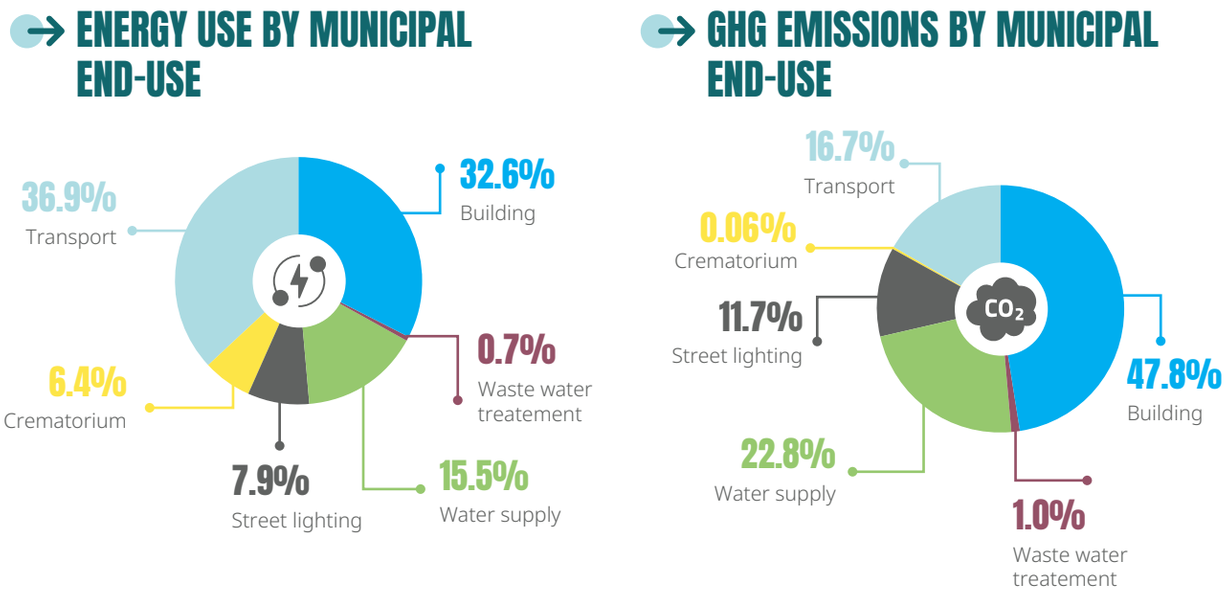


Table 17: Breakup of Energy Use and GHG Emissions in Municipal Operations

Sector	Energy Use (GJ)	GHG Emissions (Tonnes of CO_2e)
LG buildings (electricity)	3,18,479	72,646
Facilities (waste water treatment, water supply, street lighting, crematorium)	2,97,350	53,836
Transport	3,60,308	25,433

Largest energy consumers:

- Transport **36.9%**
- Buildings **32.6%**
- Facilities, water supply **15.5%**

Largest GHG emitting sector:

- Buildings **47.82%**
- Facilities, water supply **22.76%**
- Transport **16.74%**

6 Includes direct energy use due to grid electricity consumption for wastewater treatment, street lighting, water supply and lighting in government buildings; and fuel consumption by government vehicles for transportation

3.3 Energy and GHG Emissions Projection

Though the CRCAP is prepared for a period of 5 years, the energy and GHG emissions are projected with a long-term vision of 30 years that is till 2052-53. Thane's business-as-usual (BAU) energy consumption and GHG emissions are projected using Tool 3.1E (GHG Emissions Forecasting) for medium term (yearly from 2018-19 to 2027-28) and long term scenario (every 5 years from 2028-29 to 2052-53).

Consumption of fuel and electricity has been projected by applying the geometric mean method for historic data of 5 years (2013-14 to 2017-18) for the community level inventory sectors. Energy consumption from facilities (i.e. water supply, sewerage, SWM, crematorium, street lighting) has been projected based on population growth (by considering Thane's revised CDP 2016) and factoring in TMC's future planning. Based on a forecast of the energy consumption, the corresponding GHG emissions are calculated using the HEAT+ software.

A stark increase is projected in the long-term, with GHG emissions rising by over 95% of the baseline value by 2052-53. GHG emissions for residential sector are projected to rise by over 26% of that in 2017-18 in the medium term (2025-26) (Table 19). The projected trajectory for energy and GHG emissions reinforces the need to prepare a CRCAP for Thane.

Energy use in commercial, institutional and residential buildings, particularly electricity consumption, is envisaged to be a key driver for rapid rise in future GHG emissions. PNG consumption in households and commercial and institutional buildings are also projected to increase significantly under BAU scenario. GHG emissions in the transport sector are projected to rise sharply as well, with baseline energy consumption in the sector more than threefold by 2052-53. Appropriate strategies need to be designed and implemented in the short and long term to mitigate emissions from these sectors.

Figure 20: Trend of Sectoral Energy Consumption from Projections

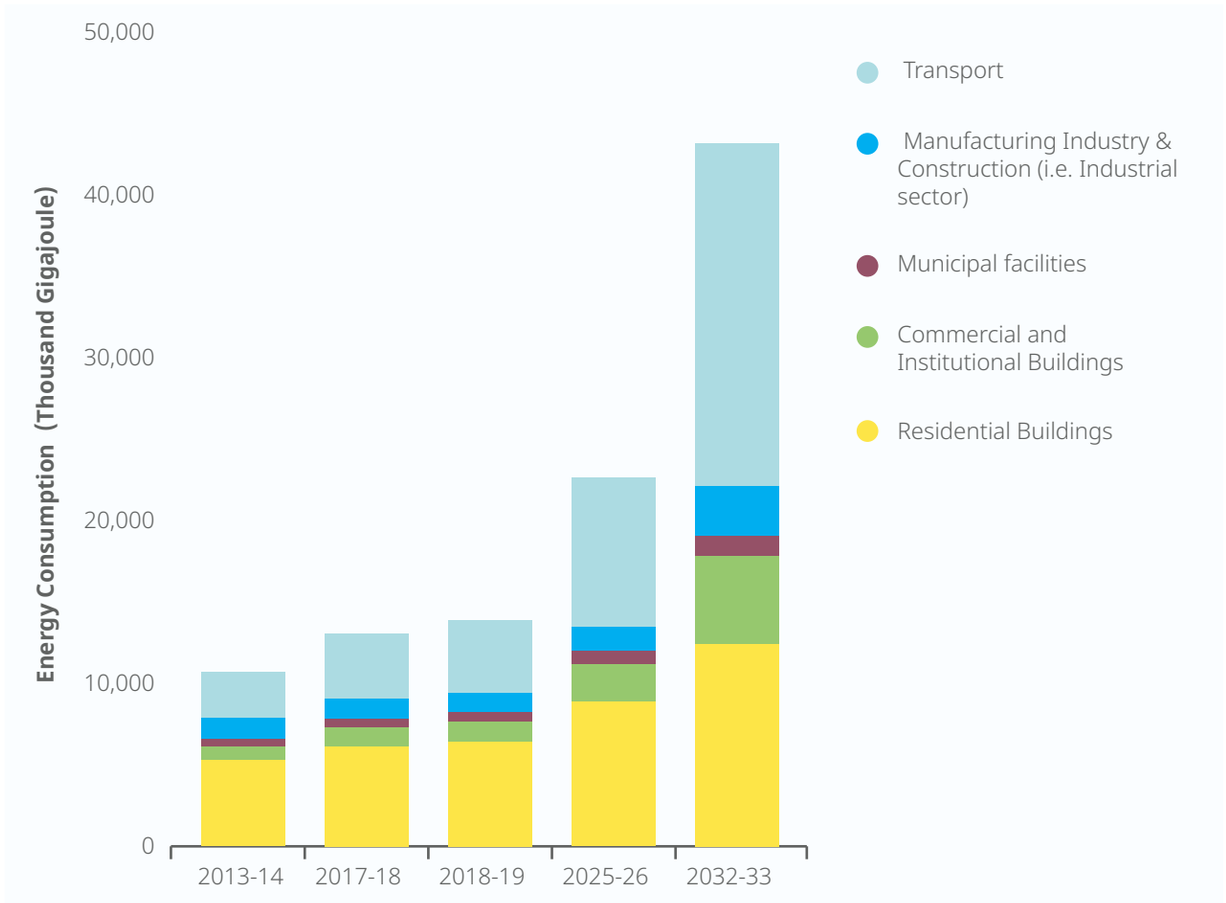


Figure 21: Trend of Sectoral GHG Emissions from Projections

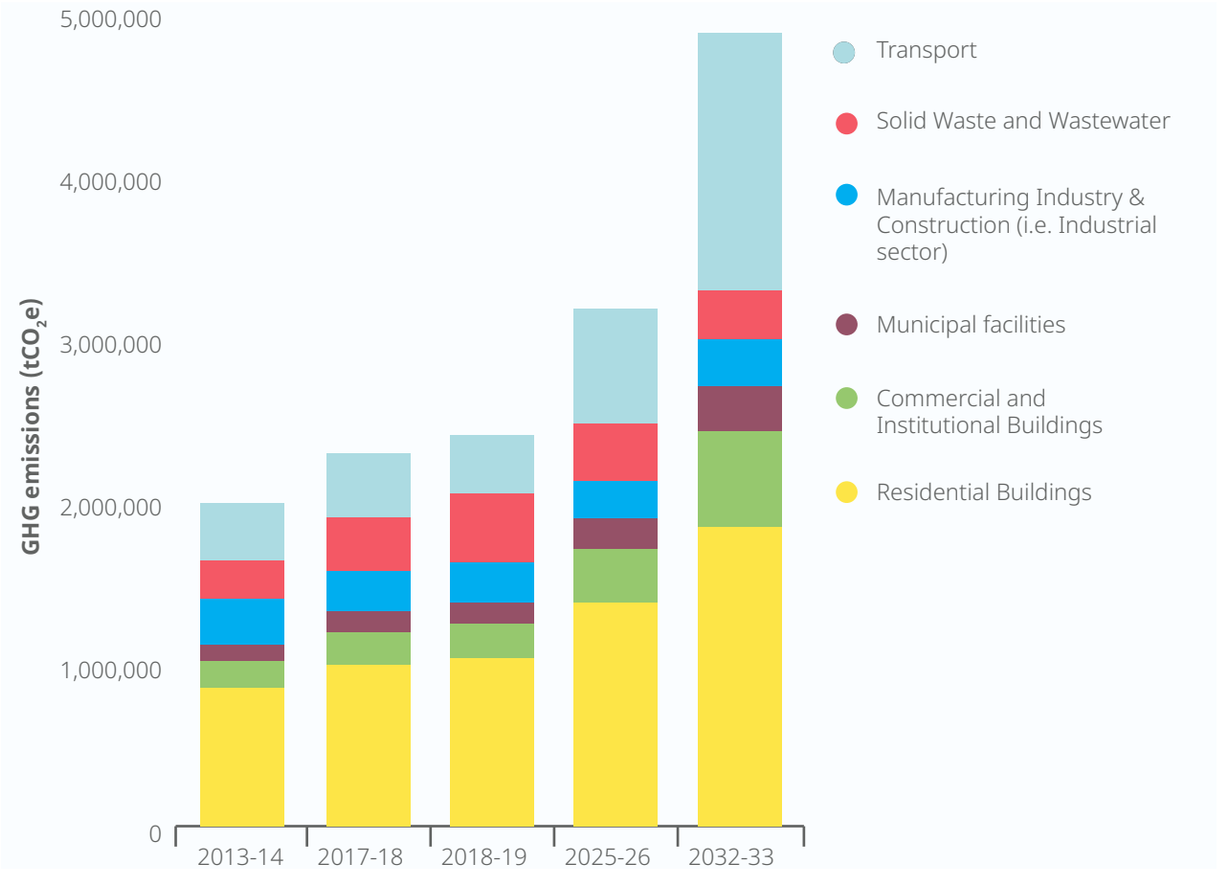
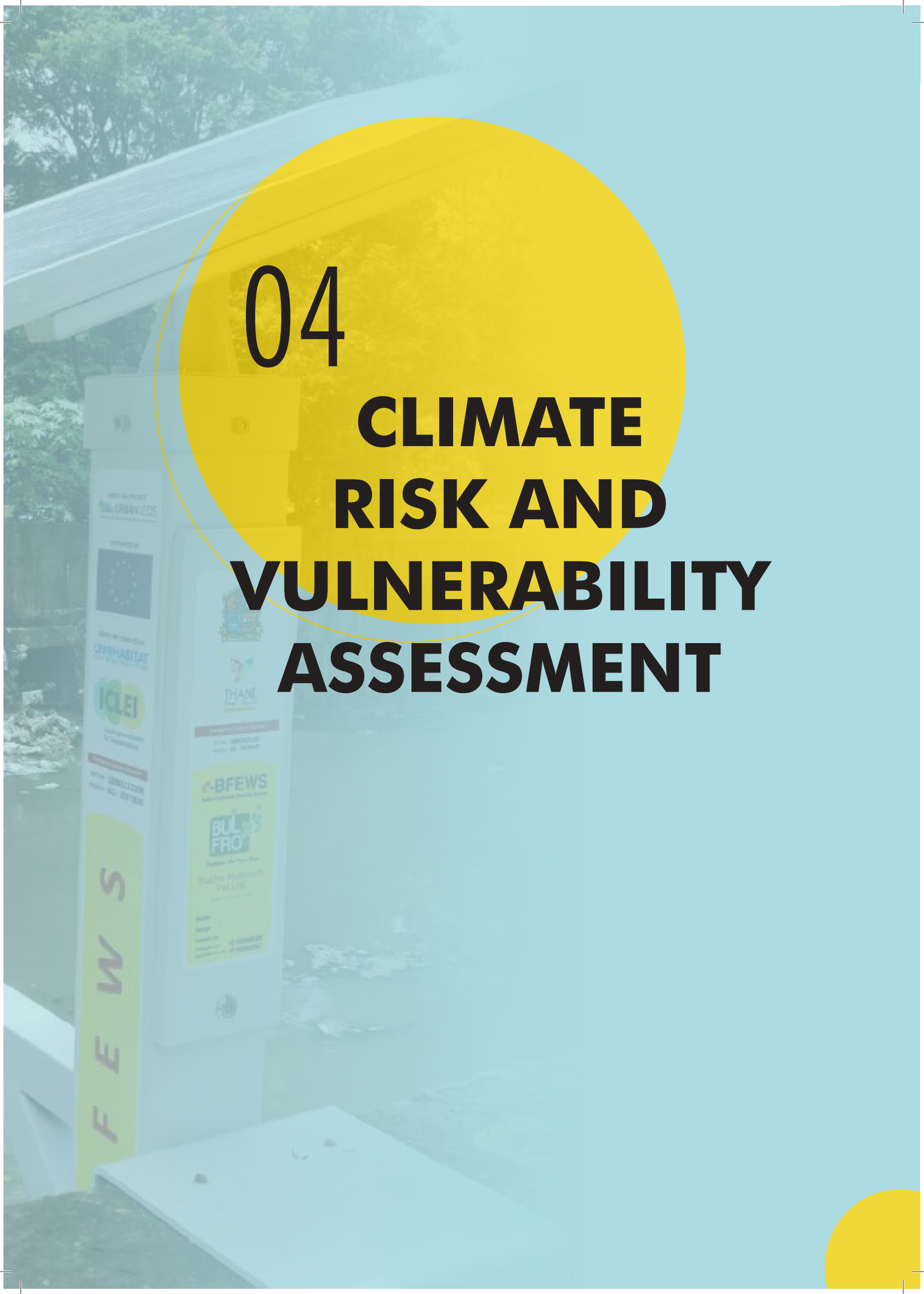


Table 18: Projected Medium and Long Term BAU Energy Consumption

Sectors	Energy Source/ Activity	Baseline Energy Consumption (GJ)		Projected Energy Consumption (GJ) (Medium Term Scenario)		Projected Energy Consumption (GJ) (Long Term Scenario)	
		2013-14	2017-18	2018-19	2025-26	2032-33	2052-53
Residential buildings	Electricity	3,139,415	3,651,324	3,791,847	4,939,165	6,433,634	13,691,919
	Kerosene	255,126	95,994	75,183	13,590	2,457	19
	LPG	1,545,219	1,949,822	2,066,551	3,104,591	4,664,045	14,920,606
	PNG	337,356	449,440	482,856	797,696	1,317,826	5,530,618
Commercial and institutional buildings	Electricity	640,459	774,983	812,816	1,134,731	1,584,141	4,109,571
	LPG	172,334	258,100	285,524	578,928	1,173,833	8,844,991
	PNG	45,591	107,095	132,585	590,955	2,633,999	188,398,000
Facilities	Electricity	449,564	552,690	581,975	835,336	1,198,997	3,367,181
	Diesel	326	923	1,198	7,394	45,645	8,280,040
	LPG	1,723	1,518	1,471	1,179	945	502
Industry and construction	Electricity	1,203,978	1,058,233	1,024,641	817,535	652,290	342,180
	PNG	70,070	147,526	177,707	653,953	2,406,520	99,559,499
Transport	Petrol	505,557	939,968	1,097,611	3,249,363	9,619,399	213,727,929
	Diesel	693,869	1,156,998	1,314,760	3,216,937	7,871,162	101,464,414
	CNG	1,627,595	1,918,889	1,999,520	2,667,207	3,557,851	8,104,103
Total	-	**10,688,184**	**13,063,503**	**13,846,242**	**22,608,561**	**43,162,743**	**670,341,569**

Table 19: Projected Medium and Long Term BAU GHG Emissions Scenario

Sectors	Energy Source/ Activity	Baseline GHG Emissions (tCO_2e)		Projected GHG Emissions (tCO_2e) (Medium Term Scenario)		Projected GHG Emissions (tCO_2e) (Long Term Scenario)	
		2013-14	2017-18	2018-19	2025-26	2032-33	2052-53
Residential buildings	Electricity	717,517	834,515	866,631	1,128,852	1,470,415	3,129,305
	Kerosene	18,452	6,943	5,438	983	178	1
	LPG	97,743	123,336	130,719	196,380	295,023	943,800
	PNG	18,978	25,283	27,163	44,874	74,134	311,124
Commercial and institutional buildings	Electricity	146,378	177,123	185,770	259,344	362,057	939,247
	LPG	10,901	16,326	18,061	36,620	74,251	559,488
	PNG	2,565	6,025	7,459	33,244	148,175	10,598,292
Facilities	Electricity	102,748	126,318	133,011	190,917	274,032	769,573
	Diesel	24	69	89	550	3,393	615,445
	LPG	109	96	93	75	60	32
Industry and construction	Electricity	275,171	241,860	234,183	186,849	149,082	78,206
	PNG	3,942	8,299	9,997	36,788	135,378	5,600,700
Waste	Waste to landfill	300,929	330,392	345,435	226,767	116,338	653,639
	Waste to energy	110	183	-	23,572	47,182	47,182
	Waste to compost and bio methanation	610	871	871	1,466	2,311	3,563
	Sewerage	56,606	68,158	79,356	102,416	139,233	246,075
Transport	Petrol	35,151	65,355	76,316	225,924	668,825	14,860,246
	Diesel	51,574	85,998	97,725	239,111	585,054	7,541,728
	CNG	91,547	107,931	112,466	150,022	200,117	455,829
	Rail	55,963	66,636	69,482	93,108	124,768	276,141
Total	-	**1,987,017**	**2,291,716**	**2,330,782**	**3,084,752**	**4,745,239**	**47,353,475**



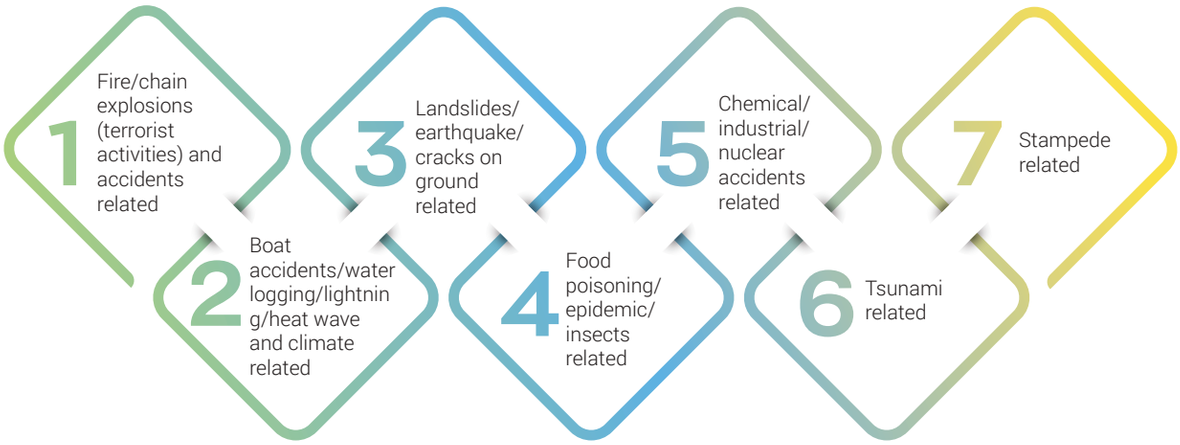
04

CLIMATE RISK AND VULNERABILITY ASSESSMENT

4.1 Disaster Management and Response Plan of Thane Municipal Corporation

TMC is aware of the disasters facing Thane due to the city's geographical position in the region. However, in the city's Disaster Management and Response Plan, climate change is considered only to a small extent. Other disasters are identified and studied in detail to formulate response plans for the same. The Plan does not identify exact climate risks and impact of climate change on various urban services.

Thane being a headquarter of regional Disaster Management Cell, has prepared disaster management reports including Standard Operating Procedures (SOPs) of Disaster Management – 2018, Risk Assessment and Response Plan 2005, and Disaster Management Plan 2018-19. A disaster management committee headed by the Municipal Commissioner has been formed at the city level to deal with emergency situations. The regional Disaster Management Cell at TMC remains in operation 24X7, receives complaints/information and diverts them to respective zonal offices for resolution. At each zone, zonal committees have been formed to tackle the risks. Key information collected by various reports and discussions with TMC officials are contained in subsequent sections. Different disaster categories identified by TMC are as below:



4.2 Brief of Disaster Management Reports in Thane

The regional Disaster Management Cell maintains records of complaints and past disasters in Thane, and prepares guidelines for response teams and disaster mitigation plans. The information from each disaster management report is summarized below to highlight the need for climate sensitive vulnerability assessment in the city.

- **Risk Assessment and Response Plan 2005:** The report includes risk assessment and vulnerability analysis for Thane with limited focus on mitigation strategy and measures. The report details the need for coordination mechanisms, institutional arrangements, and functions of control room and dissemination activities. The report fails to address climate vulnerabilities and its impact on urban systems.
- **Disaster Management Plan 2018-19:** This report describes disaster management and preparations - before, during and after the disaster. The plan focuses on identification of various disasters, vulnerabilities and links them to the importance of preparedness, prevention, mitigation, development and institutional framework. Disaster Management Act 2005 has also been discussed briefly. Various key departments have been identified and their tasks defined before, during and after

A disaster management committee headed by the Municipal Commissioner has been formed at the city level to deal with emergency situations

disasters. City level and zone level contact details of key officials/services are also provided in the report.

- **SoPs of Disaster Management Plan - 2018:** The report is comprehensive and focuses on preparedness and responses to disasters in Thane. It provides central and zone wise flow charts of response teams, and contact details and responsibilities of key departments/offices like police, fire brigade, transport, medical and health, Disaster Management Cell, information officer, education, collector, electricity, engineering, public works, and industrial health and safety. It also provides a list of tasks to be undertaken before, during and after the event and responsibilities of each department along with a list of available equipment and identified temporary shelters, for each disaster category. Further it provides data of high tide days, rainfall analysis, a summary of Disaster Management Act 2005, zone wise list of dilapidated buildings, and zone level maps of identified water logging and land slide prone sites in the city.

The table below displays information related to climate change related disasters identified by TMC and considerations of the key urban services, vulnerable areas, interventions and highlighted issues for respective disaster categories.

Table 20: Information Related to Climate Change and Natural Disasters – Considerations in TMC's Disaster Management Plan

<table>
<tr><th>Disaster categories (Based on reports available with TMC)</th><th>List of the urban systems impacted (Based on reports available with TMC)</th><th>Areas and population (number and type) impacted (Based on discussions with TMC officials)</th><th>Interventions listed as per sector (Based on discussions with TMC officials and reports shared by them)</th><th>Issues identified (Based on discussions with TMC officials)</th></tr>
<tr><td>Boat accidents/ water logging/ lightning/ heat wave and climate related</td><td>Systems are identified in general and not disaster wise
1. Health
2. Public Transport
3. Water supply
4. Storm water and sewerage
5. Education
SOPs have been prepared for all the above departments including Fire brigade and Disaster Management Cell. This includes alternative systems to be developed like water supply – 4 sources and agencies (MCGM, STEM, MIDC and TMC), contact numbers of tankers etc.
Multiple means of public transport like local trains, railways, Metro (work in progress), municipal buses, private & public transport, state transport buses, taxis and private cars</td><td>Population numbers not available disaster category wise; Areas are identified for landslides, water logging and industrial areas and also marked the same on zonal maps; Declared slums (31) have been marked on map with their population, infrastructure (water, sewerage, storm water, sanitation), access roads etc.</td><td>• Mock drills, regular meetings of disaster management committee, involvement of community and NGOs, nullah cleaning, INDP, water pumps for low lying areas
• Automatic weather monitoring stations (data available on website and android app: https://pcctmc.com/weather)
• Online pollution monitoring for SOx, NOx, RSPM and AQI (https://www.pcctmc.com/pollution_updates)
• Levels and watershed areas (catchments) marked on map; ground levels calculated, storm water drainage improvement
• Unsafe trees identification and cutting as a routine process
• Procedure to remove unauthorized hoarding/ posters etc. – Complaints (https://thanecity.gov.in/uploadpdf/MS/doc01482320170401190922.pdf)
• Practical Guidebook for Implementing Smart Technologies and Clean Energy Projects in existing high rise residential apartments 2017-18. This includes: List of organizations and their responsibilities, measures to improve water pumping efficiency which will be helpful during disasters when electricity is interruptedhttps://thanecity.gov.in/uploadpdf/MS/guide%20book.pdf
• Declaration of dangerous building - List of Dangerous & Most Dangerous buildings in the TMC Sector Ward Committees for year 2019-20 https://thanecity.gov.in/index.php

The categories of dilapidated buildings in TMC are:
• C1: Most unsafe and need immediate evacuation
• C2A: Structural maintenance after evacuation/ rehabilitation
• C2B: Structural maintenance without evacuation/ rehabilitation
• C3: General maintenance

Total dilapidated buildings in Thane identified in the 2015 are as follows:
<table><tr><th>Category</th><th>Buildings</th><th>Population</th></tr><tr><td>Authorized</td><td>442</td><td>18239</td></tr><tr><td>Unauthorized</td><td>2182</td><td>342667</td></tr></table>
For the same purpose, a cluster redevelopment has been proposed and Urban Renewal Scheme has been prepared by TMC.
• Declaration of high tide days at various public locations
• Maintaining good communication with Regional Disaster Management Cell, NDRF, IMD and state govt.
• Proposed: wet wells to store water during floods, gates on nullahs entering creek, flood pumps, retaining walls, storm water drainage improvement</td><td>Overlapping of high intensity rainfall and high tide</td></tr>
</table>

Disaster categories (Based on reports available with TMC)	List of the urban systems impacted (Based on reports available with TMC)	Areas and population (number and type) impacted (Based on discussions with TMC officials)	Interventions listed as per sector (Based on discussions with TMC officials and reports shared by them)	Issues identified (Based on discussions with TMC officials)
Landslides/ earthquakes/ cracks on ground related			Training to construction workers for earthquake resistant structures, permission for high rise buildings, rehabilitation and demolition of dilapidated buildings	Encroachments, dilapidated buildings
Food poisoning/ epidemic/ insects related			No major description is available except SOPs for before, during and post disaster	Strengthening health system
Tsunami related			Not well documented; the creek side area is prone to Tsunami	Mangrove cutting and encroachments

To plan all pre-monsoon works in Thane, mandatory procedures and responsibility to hold review meetings before monsoon, have been put in place. This includes review of all works like road construction, nullah (natural drains) cleaning, removing blockages in storm water drains and emergency preparedness under the Commissioner and Mayor's leadership.

4.3 Vulnerable Locations Identified by Disaster Management Reports in Thane

To plan all pre-monsoon works in Thane, mandatory procedures and responsibility to hold review meetings before monsoon, have been put in place.

The specific vulnerable locations identified by TMC through its Disaster Management Plan 2018-19 are showed in the following list and maps.

Common water logging areas:

- Kalwa Mumbra Zone: Banks of creek and creek adjacent areas
- Naupada Zone: Dr. Almeda Road, Deboner Society near TMC head office, Lal Bahadur Shastri road, Vandana Theatre area, Ram Maruti Road (Gajanan Maharaj Temple, Gadkari Chowk), Gokhale Road (Devdhar Hospital area), Shivaji Road (Jijamata market area, Masunda lake), M.G. Road (Pumping station, Chikhalwadi, Chavan society)
- Uthalsar Zone – Vrindavan Society, Srirang Society
- Majiwada-Manpada Zone - Ghodbunder Road (Reliance fresh, Panchamrut Society)
- Kalwa Zone – Belapur road, Vitava railway under bridge area
- Mumbra Zone- Divagaon

Common landslide prone areas:

- Atkoneshwar Nagar, Kalwa area (2 were killed in landslide in 2019)
- Parsik hills near Rehmania Hospital Mumbra Bypass Road (2 landslides in 2017, no casualty)
- Ghodbunder Road (Kasarwadavali 2016)
- Industrial areas: Kolshet Road (chemical industries), Wagale Industrial Area, No major accidents reported in last few years
- Though the city is not coastal, the adjoining creek and Ulhas river estuary may get affected by Tsunami. No ward is identified specifically for Tsunami but the entire creek line is vulnerable.

Figure 22: Zone wise Maps of Vulnerable Areas in Thane

Naupada – Kopri zone

Uthalsar zone

Wagale Estate zone

Lokmanya – Sawarkar Nagar Zone

Vartaknagar zone

Majiwada - Manpada zone

Kalwa zone

Mumbra zone

Diva zone

There are 210 slums in Thane out of which 31 are notified. Rapid slum infrastructure mapping and frameset development has been carried out for 28 slums in 2017. This assessment includes infrastructure map and location, general information, toilets, waste management information, water infrastructure, roads and access information, drainage and gutter information.

Thane's rapid slum mapping and development assessment includes infrastructure map and location, toilets, waste management, water infrastructure, road and access information, drainage and gutter information

Figure 23: Slums in Thane and Infrastructure Mapping

4.4 Vulnerability, Past Hazards and Climate Events

Multi hazard vulnerability poses a great challenge before national, state and city governments to mitigate and prevent the impact of disasters through an integrated approach. The link between climate variability, disasters and capacity to deal with its adverse impact is well established by many studies including IPCC[7]. This section documents vulnerabilities, past hazards and extreme climate events in Thane.

4.4.1 Vulnerability

Thane is located in western Maharashtra. Given the state's location in western India and as it is also spread across the central part as well, the state frequently faces climate induced disasters, majorly floods, droughts, cyclones and landslides.

Table 21: Vulnerable Areas in the State for Various Disasters[8]

Disasters	Vulnerable area
Floods	All districts (e.g. Mumbai 2005 flood)
Cyclones	Districts in Konkan region, Pune division (e.g. Cyclone Phyan in 2009)
Hailstorms	Some parts in the state, specially Marathwada and Vidarbha
Drought	Marathwada and parts of Vidarbha
Heat wave	Marathwada, Vidarbha and Nashik divisions
Landslides	Ratnagiri, Raigad, Satara, Thane, Nashik, Mumbai, Sindhudurg, Pune
Sea erosion	Districts in Konkan region

7 Field, C., Barros, V., Stocker, T., Dahe, Q., Dokken, D., Ebi, K., Mastrandrea, M., Mach, K., Plattner, G., Allen, S., Tignor, M. and Midgley, P., 2012. Managing the risks of extreme events and disasters to advance climate change adaptation - Special Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, p.582.

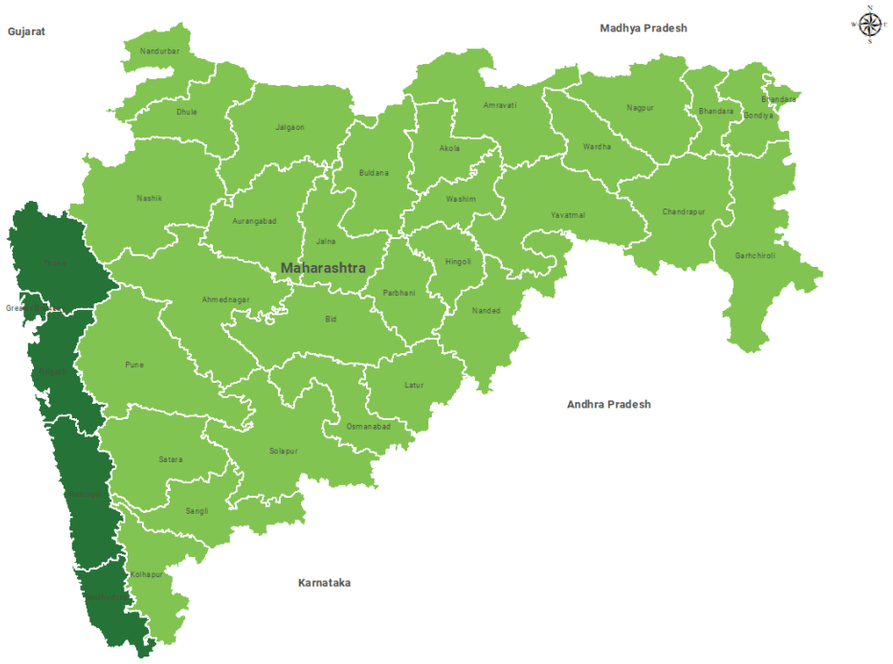
8 Singh D., Chopde S. K., Raghuvanshi S. S., Gupta A. K., Guleria S. (2018). Climate resilient disaster risk management: Best practices compendium. Department of Relief and Rehabilitation, Govt of Maharashtra and Climate Change Innovation Programme-Action on Climate Today (ACT). P 62.

Konkan is one of the six revenue divisions of Maharashtra and occupies the western region of the state which is a part of the Western Ghats. Konkan possesses unique features including Sahyadri – a hilly range, Arabian Sea, estuaries, forests and rivers, and is inhabited by large population in cities like Mumbai and Thane. The details of this region are as follows:

Table 22: Profile of the Konkan Region

Region	Konkan (Part of Western Ghats in Maharashtra State)
Districts	Mumbai city, Mumbai suburban, Thane, Palghar, Raigad, Ratnagiri, Sindhudurg
Total area	30.746 sq. Km.
Geographical extent	1506'N to 20022'N Latitude and 72039'E to 73048'E Longitude
Rainfall	2,500 mm to 4,500 mm
Temperature	Annual average maximum 370C and minimum 150C
Population	28.6 million
General profile	• Administrative division in the coastal region of Maharashtra • Immense potential in terms of industries, tourism, horticulture, minerals, fisheries etc. • Vast western coastline making it a strategic location for global trade • The economy stands fourth amongst all states and accounts for 41% of Maharashtra's GDP. • Mumbai – home to India's financial, banking and entertainment industries

Figure 24: Map of Konkan Region in Maharashtra



Based on the report published by Maharashtra state government, Konkan division including Thane is prone to high precipitation, cloud bursts and its impact like flash floods, landslides, building collapse, urban flooding

Hazards and vulnerability profile of the Konkan region: Based on the report published by Maharashtra state government, Climate resilient disaster risk management: Best practices compendium, Konkan division including Thane is prone to high precipitation, cloud bursts and its impact like flash floods, landslides, building collapse, urban flooding etc. The report also mentions that Mumbai and the neighbouring areas will be flooded even at an augmented drainage capacity of 50 mm/hour. Thane district is also vulnerable to cyclones or heavy wind. The Building Materials and Technology Promotion

Thane is prone to flooding. There are a number of flooding points which result in disruption of traffic and flooding of settlements.

Council (BMTPC) indicate that the Thane region falls in the high intensity risk zone for earthquake hazard.

The following table shows the climate change challenges and its impact on the various districts of Konkan region.

Table 23: Climate Change Challenges and Impact on the Districts of Konkan Division

Climate change Challenges	Impact	Districts affected
Change in rainfall pattern	• It has been projected that extreme rainfall will range between 10-14% more by 2030. • Increase in extreme weather events like floods • Crop damage and reduce agriculture production. • Increase in food insecurity at household level • Increase in vector borne diseases	Thane, Mumbai, Ratnagiri and Sindhudurg
Change in temperature	• Increase in minimum temperature ranging between 68-78% by 2030. • Crops sensitive to high night temperatures in the reproductive phase will be impacted more • Aggravate heat waves, deadly health consequences, including heat stress and heat stroke • Increase the energy demand for cooling in urban areas which will greatly impact the Urban Heat Island (UHI) effect • Increase in number of dry days, impacting the crop productivity	Sindhudurg, Raigad, Ratnagiri, Thane, Mumbai
Sea level rise	• Sea level rise analysis for Maharashtra coastline shows a sea level rise of 0.13-2 cm • Salt water intrusion into ground water aquifers especially near the coast.	All districts

4.4.2 Past Hazards and Climate Events

While studying climate change and its impact on Thane's development, it is essential to consider past events of disasters in the city. TMC has identified slums and few other areas as vulnerable settlements due to their location and access to infrastructure. These locations include hilltops, slopes, open streams (nullahs), low-lying areas (with tendency to flood during high tides and high intensity rainfall), coastal settlements, areas under high tension wires, areas along highways, along railway lines, within industrial zones, along water mains and open drainage etc.

Floods

Thane is prone to flooding and witnesses severe disruptions almost annually. Storm water discharges to Arabian Sea/Thane Creek through road side drains, minor nullahs (drains) and major nullahs face obstructions because of solid waste and high tides. Underground sections passing through Central Railways line get submerged during heavy rains. Thane, Kalwa and Mumbra railway stations have been identified as potentially vulnerable areas by TMC in its Disaster Management Plan. There are a number of flooding points which result in disruption of traffic and flooding of settlements. Most of the flooding points have been listed in the ward level plans and have a localized impact. However, some of these have a tendency to disrupt traffic and paralyze city life[9]. Mumbai and Thane city faced high intensity rainfall on 26-27 July 2005 and received annual average rainfall of about 3,562 mm in the same year.

July 2005 event: The 2005 monsoon proved to be extremely unpredictable for the entire state of Maharashtra, particularly Mumbai. On July 26, 2005, suburban Mumbai and Thane experienced one of the worst floods in their history and received the highest ever rainfall recorded in the last 100 years in India. According to Gupta (2007) the rainfall was the eighth heaviest ever recorded 24 hour rainfall (944 mm) in India and started in Mumbai

9 Disaster Management SOP, 2018, Thane Municipal Corporation

at around 8:30 AM on 26th July and continued intermittently over the next day[10]. About 644 mm rainfall was recorded between 8 AM and 8 PM at the Santa Cruz Meteorological Centre, Mumbai, and a total of 944 mm (nearly half of the annual average rainfall in Mumbai i.e. 2,363 mm) in 24 hours, much higher than the previous record of 575 mm in 1974. Continuous rainfall resulted in urban flash flooding. Water levels rose rapidly within 3-4 hours, thereby submerging roads and railway tracks. Traffic was completely immobilized and all low-lying areas in the city were heavily flooded. Poor households living in slums in these areas were the worst hit. All the ground floor flats were under water, and peoples' possessions like electronic goods, furniture, clothes, utensils and other household assets severely damaged. Flooding also crippled basic services and lifelines in the city for several days (GoM, 2005).[11]

The following were some of the major losses due to the event[12]:

- Most arterial roads and highways in the suburbs were severely affected due to water logging and traffic jams resulting from vehicle breakdown in deep waters
- Commercial establishments damaged: 40,000 units
- Vehicles damaged: 30,000 units
- Submergence of railway tracks and consequent stoppage of services on Central (main and harbour lines) and Western Railways around 4:30 pm on the 26th July
- Electricity supply was stopped in most parts of Mumbai's western suburbs in the night of 26 July, 2005
- Heavy rains led to the closure of the airport

The 2005 monsoon proved to be extremely unpredictable for the entire state of Maharashtra, particularly Mumbai. On July 26, 2005, suburban Mumbai and Thane experienced one of the worst floods in their history and received the highest ever rainfall recorded in the last 100 years in India

Landslides

Thane faces the risk of landslides during monsoon rains. With the pressure on land, many vacant sites on hill slopes or bottoms of hills have turned into inhabited area and thereby become vulnerable to landslides. Most cases of landslides occur during heavy rain associated with high velocity winds. It sometimes results in loss of human lives and damages to structures.

Cyclones

Due to the close proximity to the sea and presence of hilly region on one side, the coastal wards of Thane (facing the Arabian Sea) are prone to gusty winds and cyclonic impacts.

Earthquakes

Though earthquakes are not considered as climate event but Thane must prepare for them. Earthquakes in Maharashtra are showing major alignment along the west coast and Western Ghats region. Seismic activity can be seen near Ratnagiri, along the western coast, Koyna Nagar, Bhatasa and Surya areas of Thane district[13]. As per the Vulnerability Atlas of India – 2nd Edition, BMTPC, Thane district lies in earthquake hazard zone III.[14] In the years 1983, 1984 and 1985, Khardi taluka in Thane district received earthquake shocks.

10 Gupta, K., 2007. Urban flood resilience planning and management and lessons for the future: a case study of Mumbai, India. Urban Water Journal, 4(3), pp.183-194.

11 Maharashtra, Government. (2006). Maharashtra Floods 2005, Relief and Rehabilitation.

12 Hallegatte, S. et al. (2010), "Flood Risks, Climate Change Impacts and Adaptation Benefits in Mumbai: An Initial Assessment of Socio-Economic Consequences of Present and Climate Change Induced Flood Risks and of Possible Adaptation Options", OECD Environment Working Papers, No. 27, OECD Publishing. doi: 10.1787/5km4hv6wb434-e

13 State Disaster Management Authority Mantralaya, Mumbai, 2016. Maharashtra State Disaster Management Plan. Mumbai: Government of Maharashtra.

14 BMTPC, 2006. Vulnerability Atlas of India - 2nd Edition. New Delhi: MoHUA.

4.5 Climate Scenario in Thane

To appreciate climate vulnerability and suggest appropriate resilience strategies, it becomes imperative to understand the climate scenario of the city. Such an assessment will inform many important factors like energy demand, water supply, waste treatment and impact of climate change.

4.5.1 Past Weather Trends

Thane's climate is typically coastal, sultry and not very hot. It is characterized by high humidity all around the year. The area receives average rainfall of 2,500 mm to 3,000 mm in the rainy season. As per Kothawale et. al., the frequency of occurrence of hot days and hot nights shows widespread increasing trend, while that of cold days and cold nights shows widespread decreasing trend. The frequency of the occurrence of hot days is found to have significantly increased over the west coast, while that of cold days shows significant decreasing trend. The west coast region showed significant increasing trend in the frequency of hot nights[15].

Summary of precipitation and temperature trends over India (1901–2009): Based on IPCC's Fifth Assessment report, mean annual temperature has increased in India during the 20th century. However, there is no discernible change in the trend in annual precipitation for India. This could be due to lack of sufficient observational records to draw conclusive trends[16]. The Indian monsoon is, however, known to have undergone abrupt shifts in the past millennium, giving rise to prolonged and intense droughts. The study also mentioned an observed increase in heavy rain events and associated decrease in light rain events. The recent weakening in seasonal rainfall and the regional redistribution has been partially attributed to factors such as changes in black carbon and/or sulphate aerosols, land use and sea surface temperatures. The confidence in precipitation changes over the Indian land area from 1901 until 2009 remains low, with long-term positive or negative trends seen with different datasets.[17]

According to The Climate Change and India: A 4x4 Assessment report, all-India monsoon rainfall based on 1871-2009 data indicates a mean rainfall of 848 mm with standard deviation of 83 mm. It does not show any significant trend. When averaged over this period, a slight negative trend of -0.4mm/year was observed. The all-India maximum temperature is increasing by 0.71°C per 100 year. The trend of daily maximum temperature in India is observed to be increasing from January, attaining a peak in May. All-India mean annual minimum temperature has significantly increased by 0.27°C per 100 years during the period 1901-2007. In the last three and half decades, it shows a significant warming trend of 0.20°C/10 years[18].

In order to understand the climate vulnerabilities of Thane, past weather data from various sources was observed. Precipitation data for Thane district for last 21 years was obtained through Maharashtra state government's weather portal[19]. In absence of city specific temperature data, Colaba Meteorological Center in Mumbai was considered as a base to study past temperature trends and data has been collected through The National Aeronautics and Space Administration of the United States (NASA)[20]. The graphs below provide an analysis of the weather trends in terms of average annual rainfall and average annual temperature.

15 Kothawale, D.R., Revadekar, J.V. and Rupa Kumar, K., 2010, Recent trends in premonsoon daily temperature extremes over India, Journal of Earth System Science, 119(1), 51-65.

16 2013: Climate Phenomena and their Relevance for Future Regional Climate Change. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [

17 IIHS, ATREE, WOTR, IITM, 2015, Vulnerability and Adaptation to Climate Change in the Semi-Arid Regions of India.

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

19 District Administration, Thane. https://www.maharain.org/

20 GISS Surface Temperature Analysis. https://data.giss.nasa.gov/cgi-bin/gistemp/stdata_show_v3.cgi?id=207430570000&dt=1&ds=5

Figure 25: **Past Climate Trends in Thane (Rainfall Data)**

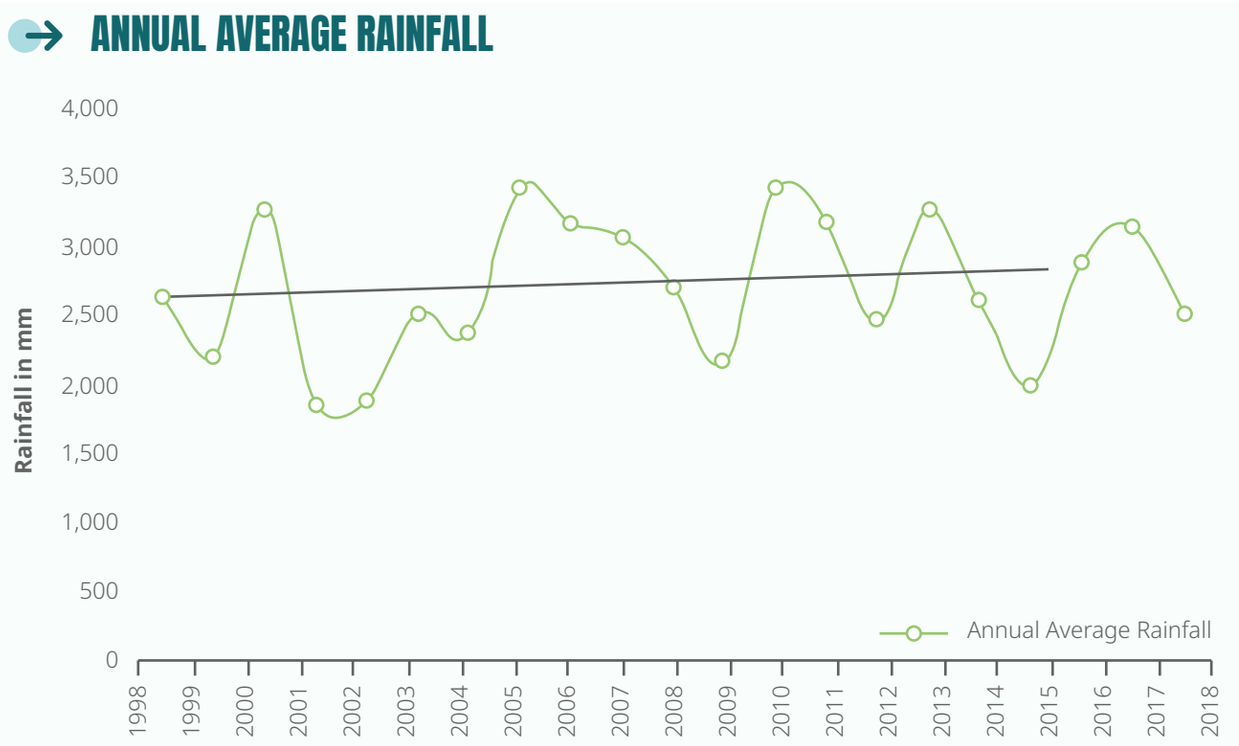
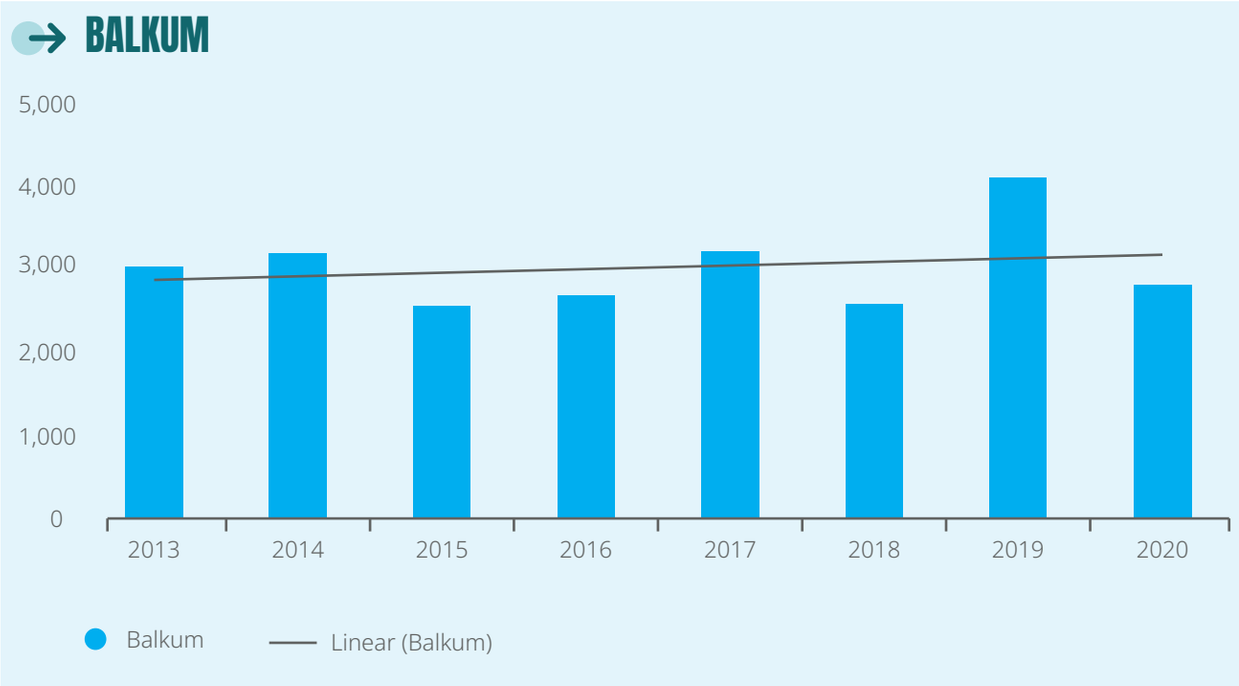
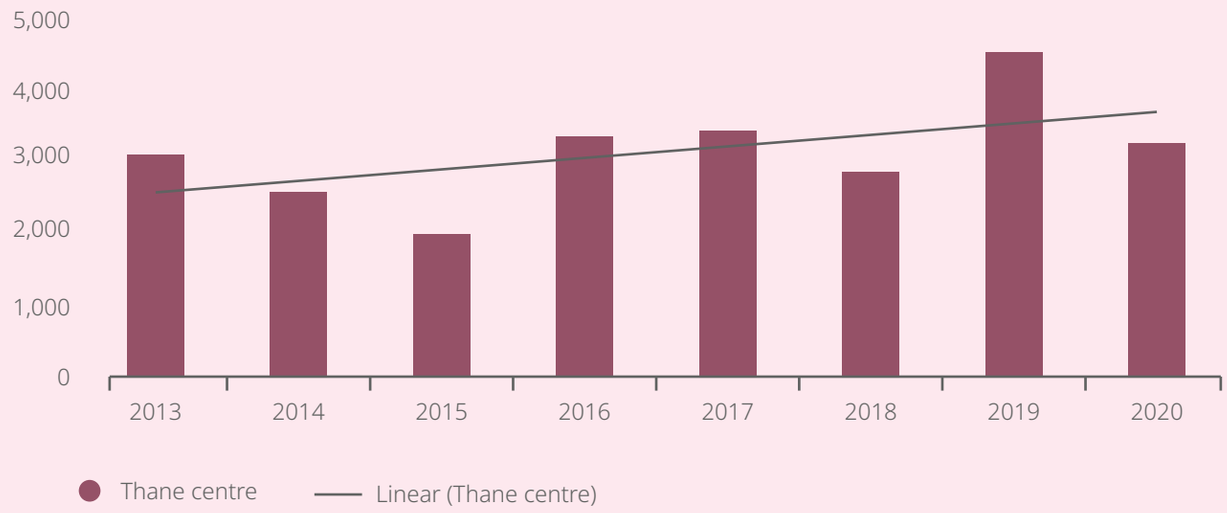


Figure 26: **Station wise Short Term Past Climate Trends in Thane (Rainfall Data)**[21]



21 Station wise short term past rainfall data sourced from TMC and Maharashtra State web-based weather data portal

THANE CENTRE



MUMBRA

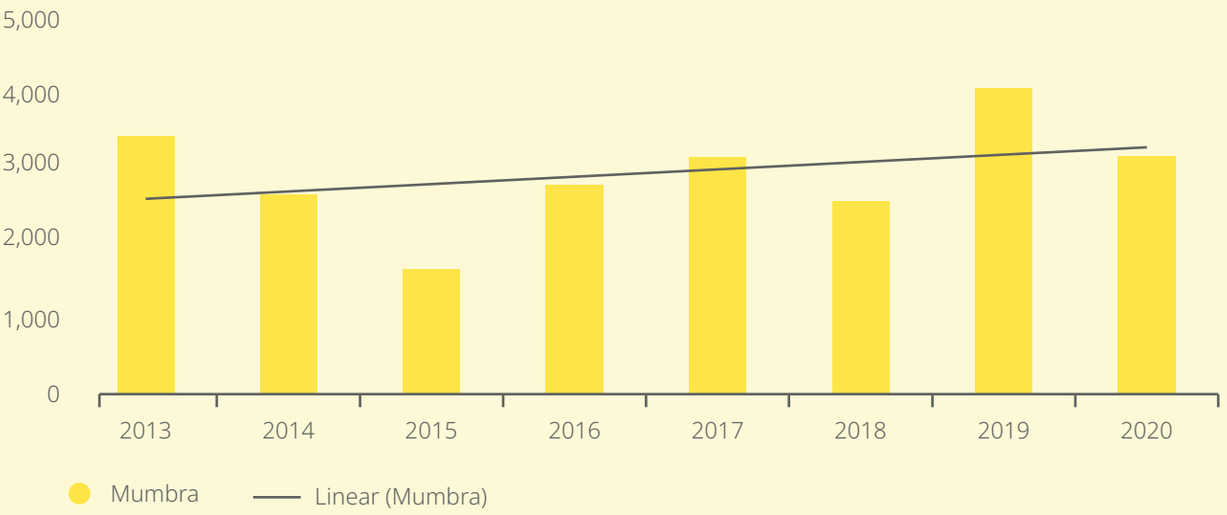
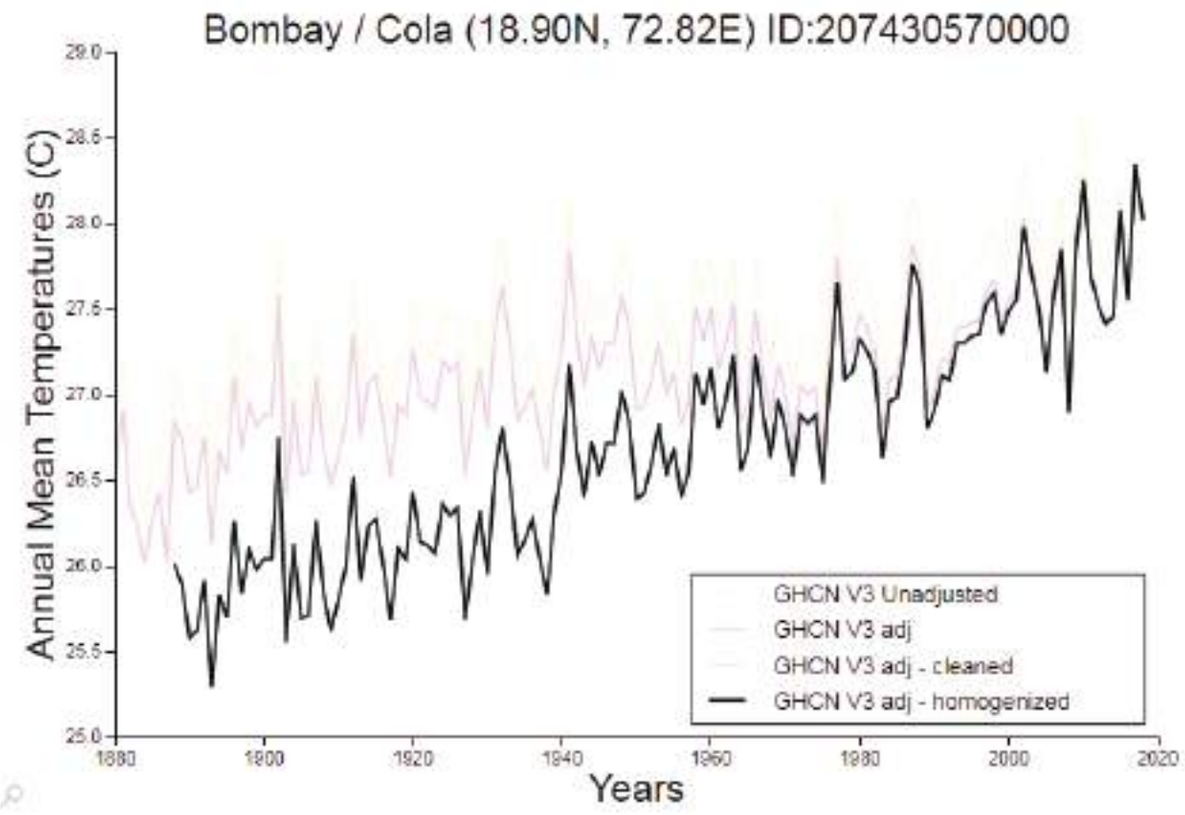


Figure 25 shows an increasing trend of rainfall for a period of 20 years in Thane. Figure 26 shows short term trend for a period of seven years at three stations in Thane namely Thane centre, Balkum and Mumbra areas. Both the figures indicate that there seems to be a varying trend in the average annual rainfall between 1,900 mm to 3,400 mm.

Figure 27: **Past Climate Trends in Thane (Temperature Data from Colaba Station in Mumbai), 1998 to 2018**

Figure 28: **Long-term Historic Climate Trend in Thane (Temperature Data from Colaba Station in Mumbai), 1880 to 2020**



Figures 27 and 28 show average temperature variations from the nearest weather monitoring station – Colaba in Mumbai. The figures indicate that the annual mean temperature shows an increasing trend.

4.6 Climate Change Projections

Due to proximity to the Arabian Sea, Thane will face issues due to sea level rise which is one of the significant impacts of climate change. The IPCC estimates that sea level is expected to rise at the rate of 2.4 mm per year in India

There is overwhelming global consensus that climate change hampers social well being and causes economic damage. However, there is still some doubt about how successful efforts to reduce emissions will prove to be, especially because of the uncertainty around quantifying how a given amount of climate change will affect a city's economy through disasters in future[22]. Due to proximity to the Arabian Sea, Thane will face issues due to sea level rise which is one of the significant impacts of climate change. The IPCC estimates that sea level is expected to rise at the rate of 2.4 mm per year in India, and will have risen by 38 cm by the middle of the century[23].

In order to assess the future vulnerabilities of a city, it is important to understand the projected climate trends for the area in which it is located. As city level projections were not available, two reports were referred to understand the future climate projections for Thane. The Climate Change and India: A 4x4 Assessment report[24] prepared by GoI was referred to understand projections for the west coast where Thane is located. According to this report, the following climate trends have been projected for the coastal region for the period 2030:

Increased temperature: In the west coast, the annual temperatures are set to increase from a minimum of 26.8°C to a maximum of 27.5°C in the 2030s. The rise in temperature with respect to the 1970s correspondingly ranges between 1.7°C to 1.8°C. Temperatures are also projected to rise for all seasons for all the three simulations from 1.5°C to 2.2°C, with the rainfall period of June, July, August and September showing the minimum rise amongst all seasons.

Increased rainfall: The west coast projections indicate that in 2030s, the annual rainfall will vary from 935±185.33 mm to 1,794±247.1 mm. The trend of rainfall in 2030s is showing an increase with respect to the 1970s. The increase in rainfall is by 6% to 8%, ranging from 69 to 109 mm. Though June, July and August show an average increase of 8 mm rainfall in 2030s with respect to 1970s, winter rainfall is projected to decrease on an average by 19 mm during January and February. The period March, April and May also show a decrease in rainfall with respect to 1970s.

In the west coast, the annual temperatures are set to increase from a minimum of 26.8°C to a maximum of 27.5°C in the 2030s. The rise in temperature with respect to the 1970s correspondingly ranges between 1.7°C to 1.8°C

The report 'Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC)', was referred to for climate projections for Konkan division. The climate projections are as follows[25]:

- Increased temperature: Increase in temperature over the entire Konkan division will be in the range of 1.1°C to 1.28°C for 2030, 1.5°C to 1.8°C for 2050 and 2.18°C to 2.6°C for 2070 based on the India Meteorological Department (IMD) climate normal: annual mean temperature 26.99°C.
- Increased monsoon rainfall: Increase in rainfall over the entire Konkan division will be in the range of 10 mm to 30 mm for 2030, 10 mm to 30 mm for year 2050 and 10 mm to 32.5 mm for 2070 based on the IMD climate normal: annual mean rainfall 2,578.2 mm.
- The projection for the 2030s is the average of projections for the period 2021-2040. Similarly, the projection for the 2050s in the average of projections for 2041-2060 and that for the 2070s is the average of projections for 2061-2080.
- The changes will be characterized by more frequent days of extremely high temperatures and intense rainfall events.

22 Policy Brief, March 2019, CLIMATE CHANGE & GROWTH How will climate change affects South Asia's economic future?

23 Kumar, Rakesh & Jawale, Parag & Tandon, Shalini. (2008). Economic impact of climate change on Mumbai, India. 12.

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

25 TERI. (2014). Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC). Project Report No. 2010GW01, The Energy and Resources Institute, New Delhi. p.302.

MSAAPC provides climate projection maps for the state considering years 2030, 2050 and 2070 for the changes in precipitation and temperature for 25X25 grids[26].

Figure 29: Projected Changes in Precipitation over Maharashtra in (a) 2030s (b) 2050s (c) 2070s Relative to the Baseline (in percent terms)

A B C

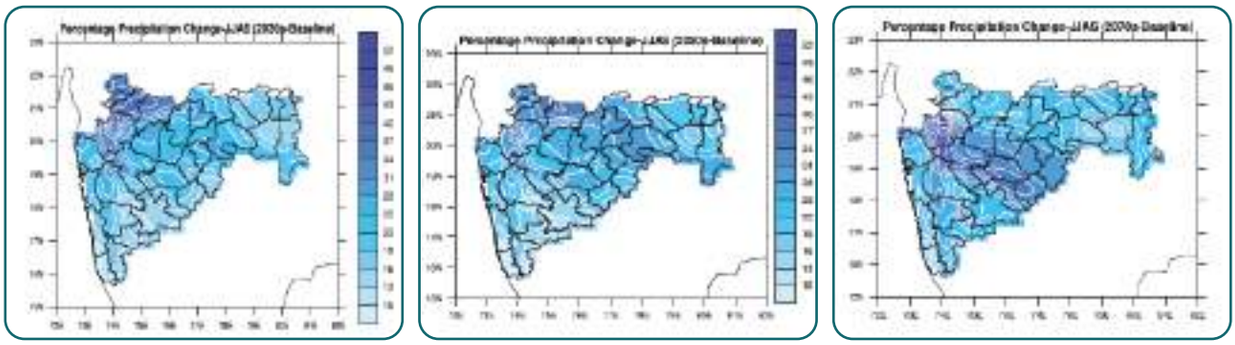
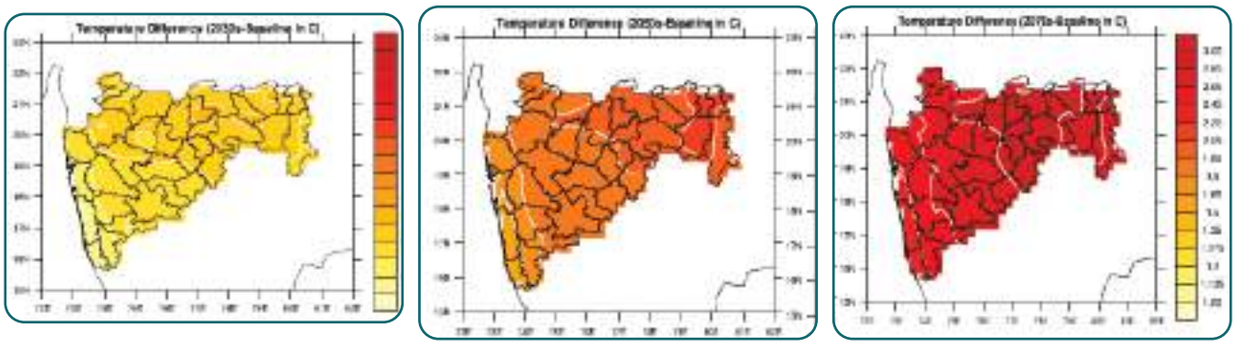


Figure 30: Projected Increase in Temperature in Maharashtra in (a) 2030s (b) 2050s (c) 2070s Relative to the Baseline (in °C)

A B C



The same report provides district level climate change projections as well. Downscaling the geographical area and impact of climate change for Thane district, following projections can be seen in future, for 25X25 km grid size and indicative for the districts:

- **Increased monsoon rainfall:** Increase in rainfall over the entire Thane district will be in the range of 20 mm to 30 mm for 2030, 20 mm to 30 mm for 2050 and 20 mm to 32.5 mm for 2070 based on the IMD climate normal: annual mean rainfall 2,578.2 mm.

District wise ranks for macro level vulnerability index and contributing factors for Thane district as mentioned in this report show that Thane is one of the districts with lowest exposure and sensitivity to vulnerability compared to other districts.

All three studies show a varying trend of rainfall and distinct increase in the maximum and minimum temperatures. It can be estimated that both regionally and locally, precipitation and temperatures are expected to rise in future. A compilation of the different climate scenario assessment statements are provided in the table below.

26 Ibid.

Table 24: Climate Scenario Statements

Changing Climate Conditions	Assessments	Climate Scenario Summary Statements
Precipitation change	Climate Change and India: A 4x4 Assessment prepared by the GoI	The west coast projections indicate that in 2030s, the annual rainfall will vary from 935±185.33 mm to 1794±247.1 mm. The trend of rainfall in 2030s is showing an increase with respect to 1970s. The increase in rainfall is by 6% to 8%, ranging from 69 to 109 mm.
	Regional assessments (Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: MSAAPC)	Increase in rainfall over the entire Thane district will be in the range of 20 mm to 30 mm for 2030.
	City level assessments	Climate projections show increased number of short duration and high intensity rainfall events in the city with no major change in average annual precipitation.
Temperature change	Climate Change and India: A 4x4 Assessment, a report prepared by the GoI	In the west coast, annual temperatures are set to increase from a minimum of 26.8°C to a maximum of 27.5°C in the 2030s. The rise in temperature with respect to 1970s correspondingly ranges between 1.7°C to 1.8°C. Temperatures are also projected to rise for all seasons for all the three simulations from 1.5°C to 2.2°C.
	Regional assessments (Assessing Climate Change Vulnerability and Adaptation Strategies for Maharashtra: MSAAPC)	Increase in temperature over the entire Konkan division will be in the range of 1.1°C to 1.28°C for 2030
	City level assessments	Climate projections indicate significant increase in temperature in the city.

Based on the above assessments, it is evident that Thane faces two major climate risks.

In subsequent sections, the major urban systems of Thane have been assessed for their climate fragility and adaptive capacities.

4.7 Risk Assessment

The risks associated with the fragilities of the urban systems were calculated through a risk assessment exercise conducted by ICLEI South Asia based on one-to-one discussions with the key officials of TMC. The fragile urban systems identified as having the highest risks were investigated further. The following table shows the fragile urban systems, their criticality, existing and anticipated problems caused by fragility and their fragility statements

Table 25: Fragile Urban Systems and Associated Problems Caused by their Fragility

S. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement
1	Water supply	Due to increasing population, commonly shared and limited sources of water in Thane, deficit in rainfall for one year will affect large population. Unaccounted higher percentage of urban poor in slums (especially unauthorized slums and migrants), illegal water supply connections and overall NRW put stress on water supply. Hilly terrain at some places, with water bodies, demands technically sound network of distribution.	• **Availability of water:** Due to higher per capita per day supply by TMC and easy access to ground water, overall per capita water availability is higher in Thane. It affects overall consumption habits of the citizens and leads to uneven distribution throughout the city. • Dependency on external agencies: TMC depends on 3 agencies: BMC, STEM and MIDC. The total dependency is about 56%. TMC has planned a SHAI dam project for 2046 requirements and self reliance in water supply. • Smart metering and NRW: Though Thane has started implementing smart metering, the rate of installation and acceptance by citizens is comparatively low. Following metering, water audit could be the next step for estimating NRW. • Ground water: Thane has easy and affordable access to ground water which resulted in higher abstraction. Despite rainwater harvesting systems for new projects in Thane being mandatory, whether they will remain operational in the long run is a question.	Water Supply Department of TMC	Water supply in the city is abundant, which encourages residents to consume more. Additionally, the supply system faces high NRW losses due to old network and use of shared resources, and is dependent on external agencies.
2	Sewage treatment	Contaminated local water bodies as well as large water bodies such as Thane creek and Ulhas river estuary are the most affected areas due to insufficient treatment facilities. During monsoon, water logging occurs at few places. Blocked drains due to solid waste and tidal situations along with overflowing septic tanks discharge sewage in storm water, affecting citizens' health .	• Current STP capacity is not sufficient to treat sewage generated at city level. Decentralized STPs need to be planned in advance looking at the planned capacity of water supply in the city. • Support by reuse and recycle policy along with control over ground water abstraction will increase citizens' acceptance for secondary uses especially construction and gardening activities. • Higher per capita supply and over abstraction of ground water leads to dilution of the sewage generated and makes the overall biological treatment/functioning of STPs with designed organic load difficult. • Untreated or partially treated sewage discharge increases pollution load in water bodies threatening aquatic life. • Regular monitoring of the private STPs is required to ensure they are functioning properly. • Reduced productivity of contaminated water bodies and land parcels; Affected ecosystem services of key areas like mangroves	Sewage Management Department of TMC	The sewerage system has insufficient treatment capacity, insufficient collection, unregulated operation of private STPs and blockage of drains due to solid waste.

S. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement
3	Storm water management	Due to its unique geographical location, Thane receives higher runoff from hilly terrain and causes water logging during short duration, high intensity rainfall during high tide. About 72 locations, identified by the Stormwater Management Department, face water logging frequently. Water logging affects transportation facilities and disrupts connectivity with other areas/cities resulting in high economic losses.	• Climate change: High intensity, short duration rainfall events • Land use and land cover plan of the city: More paved surface leads to less percolation and more runoff generation. • High tide impending drainage: Thane drains are tidal influenced, hindering flow from upstream area and back flow from Thane creek and Ulhas river estuary. • Solid waste dumping: Culverts, drains and nullahs at various places are blocked due to deposition of silt and solid waste. • Some of the culverts are in the form of pipes, of inadequate size, and need to be redesigned and reconstructed for increased runoff volume due to change in land use pattern. • Siltation in drain: The problem of flooding is exacerbated by siltation in road side drains and nullahs and clogging by disposal of solid waste by citizens. Siltation has reduced the carrying capacity of drains and disposal of solid waste has resulted in blocking of road culverts. • Dam overflows: Overflow of dams located on the upstream areas of Ulhas River estuary has resulted rise in water levels, thereby causing flooding in adjoining areas of the estuary especially Diva, Khidkali (Riverwood area). • Construction in flood plain and thereby obstructing flows • Inadequate nullah cleaning in few areas • Inadequate inlet arrangement for road side drains and connections from drain to nullah[27]	Stormwater Management Department, Disaster Management Cell of TMC	Changes in land use and land cover pattern, increasing concrete surfaces, encroachments for development on natural drains (nullahs), blockages due to solid waste, engineering designs of stormwater drains limits the efficacy of existing stormwater drains in case of extreme climate events and tidal influence, leading to water logging in certain areas.
4	Solid waste management	Thane being a metro city and very densely populated, it is very difficult to get land parcel for treatment facilities. Centralized facility puts strain on available infrastructure. Insufficient collection system as well as negligence of citizens in few places, especially on the banks of nullahs, cause blockages and reduce runoff potential of the stream.	Waste Segregation: Various SWM treatment facilities are already proposed by TMC at centralized and decentralized levels. Waste segregation is identified as the biggest issue in Thane, which impedes efficient waste treatment. Waste treatment: Though a waste to energy plant is being set up, it will take few years to operate on full load. Till then, TMC should focus on decentralized waste treatment and composting sites. Awareness: Many citizens in urban areas and slums dump solid waste in open nullahs, water bodies like creek, estuary and lakes in Thane. Awareness about not dumping garbage in open areas and water bodies must be prioritized. Scientific closure of existing dumping sites is crucial.	Solid Waste Management Department of TMC	SWM in the city is inadequate due to poor awareness among residents regarding segregation and littering, ineffective collection system, and lack of space for treatment facility. Centralized and decentralized systems for solid waste are required.

27 Feasibility assessment for early warning system on flood management under Urban LEDS II – Thane, 2020

S. no.	System	Why is it critical or fragile?	Existing and anticipated problems caused by the fragility of this system	Responsibility	Fragility statement
5	Transportation	High population density, growth of service sector and close proximity to Mumbai (state capital) demands various modes of transportation. Any delay or problem impacts a large population as well as has an economic impact.	• Dedicated lane for walking and cycling - Cycling facilities can be improved by providing cycle tracks and implementing bicycle accentuated signals. • Lack of regulated parking – Thane faces parking concerns due to unavailability of dedicated parking areas around station area. This affects pedestrian movement. Unmaintained footpaths and vehicles parked on roadsides leave pedestrians with no other option but to walk on roads. • Air pollution – Unpaved roads and increasing automobiles cause particulate matter, SOx and NOx pollution. • Encroachments on roads by informal settlements and street vendors lead to more congestion. • Availability of land is a major issue for any transportation improvement project.	Public Works Department, Roads and Projects Department, Town Planning Department, Thane Municipal Transport of TMC, Western Railways, MMR Development Authority (MMRDA), Maharashtra State Road Transport Corporation, NHAI, IWAI	Thane's transportation system is heavily dependent on public transport, yet the sheer volume of people moving to Mumbai and back daily creates congestion, impacting productivity. Thane needs affordable, safe, pleasant and less time consuming transport facilities.
6	Health	Dense population, increasing land rates and higher number of urban poor in slums and dilapidated buildings put stress on health infrastructure.	• Seasonal influence on health issues is common: Viral fever, malaria, gastro issues during monsoon; cough and cold, bronchitis, and breathing problems during winter; skin itching, dehydration and heat stroke during summer • Air pollution has been identified as a major health concern. Many offices and luxury houses are equipped with indoor air purifiers in Thane. • A major concern is rising particulate matter from development activities, open restaurants, street food (mainly tandoor - use of coal) and vehicular pollution • Contaminated and unhygienic vegetables and food also affect health.	Health Department of TMC, Health Department of Maharashtra State and private hospitals	Public health care infrastructure is limited and cannot serve the present dense population in case of epidemic or increasing air pollution.
7	Biodiversity: Green spaces and water bodies	Increasing population and residential townships require recreational spaces. Restoration and conservation of local ecosystem and development of additional green spaces will improve health of citizens.	• Lack of wastewater collection and treatment facility is increasing pollution load on water bodies. • Lack of awareness among local people – throwing solid waste in natural drains • Encroachment on the banks of water bodies makes restoration measures difficult • Restoration of aquatic ecosystem is critical • Monoculture or foreign species in fisheries of natural lakes and mangroves will affect local ecosystem. • Survival of the planted trees and conservation of heritage trees must be considered. • Landslides or collapsing dilapidated/illegal buildings is common in monsoon. • Encroachments on green spaces, nullahs and mangroves for development projects are a major concern.	Public Works Department, Garden Department, Pollution Control Department, Town Planning Department, Disaster Management Cell of TMC, Forest Department of Yeoor Hills range, Mangrove cell	Local biodiversity and ecosystems are stressed due to water pollution, dumping of waste and indiscriminate encroachment and needs restoration and conservation.

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

Table 26: Risk Assessment for the Identified Fragile Urban Systems

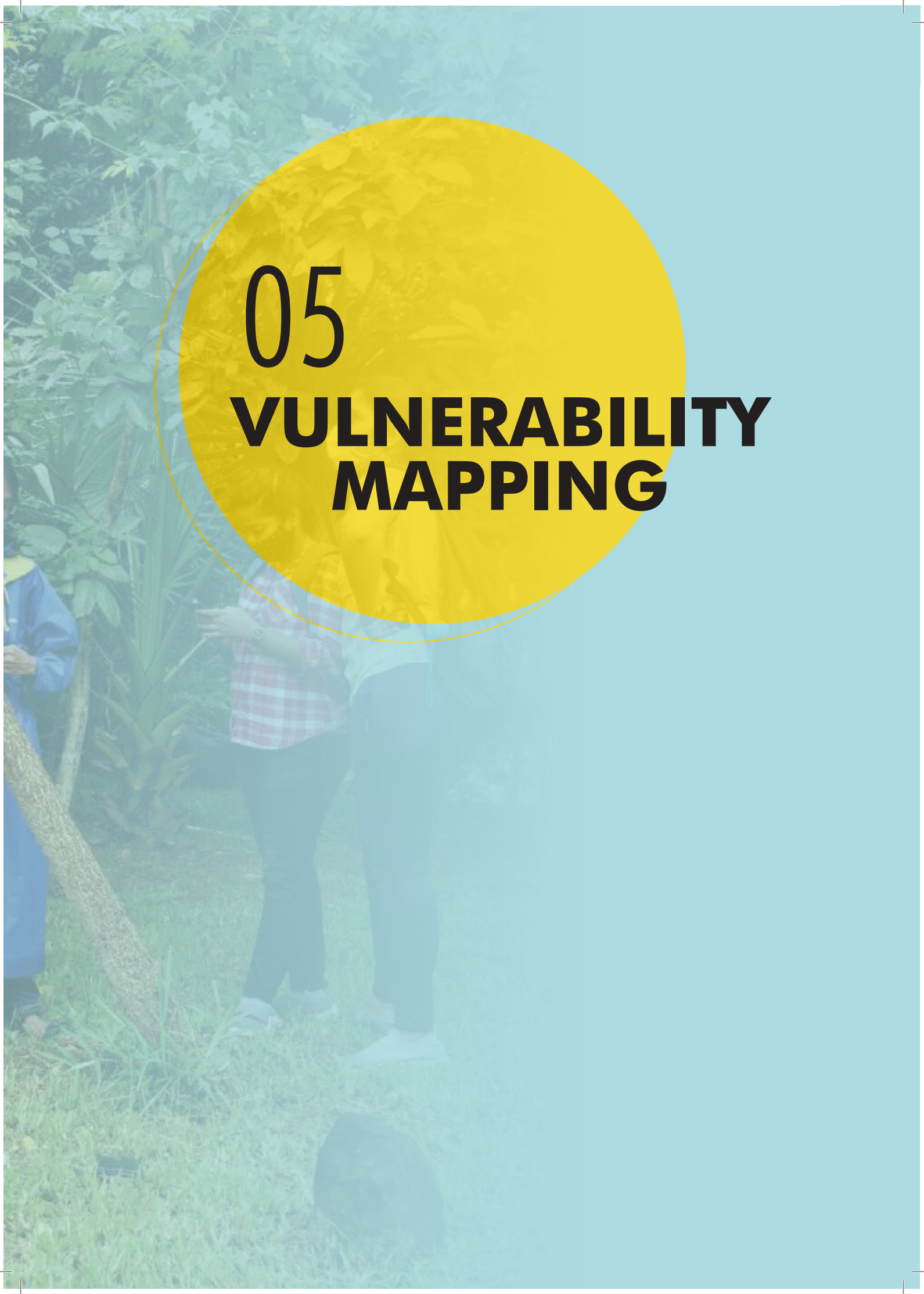
Urban Systems	Climate fragility statement	Likelihood	Consequence	Risk Score	Risk Status
Water supply	Events of short duration and high intensity rainfall, prolonged rains, delays in monsoon arrival and insufficient rainfall will put stress on water supply affecting large population.	4	2	8	Medium
	Increase in temperature will increase evapo-transpiration rate reducing available water quantity, degrading quality and increasing water demand, putting stress on ground water.	4	2	8	Medium
Sewage treatment	Heavy rains with tidal influence affects discharge of sewage and results in overflow of septic tanks or backflow of the sewage in drains.	5	3	15	High
	High temperature aids septic condition in nullahs and drains emitting odour, foul and toxic gases as well as affecting biological treatment of sewage.	3	2	6	Low
Stormwater management	Extreme climate events generate excessive runoff affecting existing capacity of drains, and causing soil erosion, landslides and water logging during high tide.	5	3	15	High
Solid waste management	Heavy rains increase moisture content and weight of the solid waste, affecting overall treatment and transportation expense. Very heavy rains and subsequent runoff can wash away solid waste from drains into natural water bodies causing pollution.	3	2	6	Low
	Higher temperatures cause fires at open dumping sites, create septic conditions to release toxic gases and contribute to GHG emissions. It will reduce the productivity of manual operations as well.	4	4	16	High
Transportation	Heavy rains and subsequent water logging will affect vehicular and public transport movement resulting in economic losses and productivity.	4	3	12	Medium
	High temperature demands more cooling in public transport especially metros, AC buses and private cabs leading to increased use of energy.	4	2	8	Medium
Health	Heavy rains promote spread of epidemics in direct and indirect ways, but help reduce air pollution especially particulate matter.	3	2	6	Low
	High temperatures will affect health of citizens causing problems like dehydration, heat stroke etc. especially for construction workers and elderly people.	3	2	6	Low
Biodiversity: Green spaces and water bodies	Short duration, high intensity rainfall results in flash floods/runoff, washing out native biodiversity (especially fish) and affecting green spaces through falling of trees, soil erosion, landslides etc.	3	3	9	Medium
	High temperatures demand more water for survival of biodiversity and affect health causing dehydration, heat stroke (especially for migratory birds) as well as conflicts between wild life and humans due to shortage of resources in natural habitat.	3	2	6	Low

Through the Disaster Management Plan, TMC has identified vulnerable areas prone to identified disasters such as water logging, landslides, explosion due to industrial activities etc. The vulnerable population located at such places has been taken into account, especially in slums. Vulnerable areas have been identified based on the climate risk to a particular urban system. The vulnerable population exposed to the impacted urban system and responsible departments/organizations are identified. TMC has already initiated several interventions and proposed projects under various missions and funding sources. These projects are listed in the following table along with other information.

Table 27: Identification of Actors for Fragile Urban Systems

S. No.	Urban Systems	Climate fragility statement	Vulnerable Areas	Actors
1	Water supply	Events of short duration, high intensity rainfall, prolonged rains, delays in monsoon arrival and insufficient rainfall will put stress on water supply affecting large population.	Entire city	Urban poor, women, street food vendors, labour camps, Water Supply Department of TMC, STEM Water Authority, BMC, MIDC
		Increase in temperature will increase evapo-transpiration rate reducing available water quantity, degrading quality and increasing water demand, putting stress on ground water.	Entire city	
2	Sewage treatment	Heavy rains with tidal influence affect discharge of sewage and result in overflow of septic tanks or backflow of the sewage in drains.	Low lying areas and banks of water bodies	Urban poor, citizens of low lying areas, shop keepers, Sewage Management Department and Public Works Department of TMC
		High temperatures aid septic conditions in nullahs and drains emitting odour, foul and toxic gases as well as affect biological treatment of sewage.	Low lying areas and city's outskirts	
3	Stormwater management	Extreme climate events generate excessive runoff affecting existing capacity of drains, and causing soil erosion, landslides and water logging during high tide.	Low lying areas as identified in Disaster Management Report 2018-19.	Citizens from low lying areas, urban poor, slums, residents of dilapidated buildings, Storm Water Management Department and Disaster Management Cell of TMC, Dam authorities
4	Solid waste management	Heavy rains increase moisture content and weight of the solid waste, affecting overall treatment and transportation expense. Very heavy rains and subsequent runoff can wash away solid waste from drains into natural water bodies causing pollution.	Entire city especially community bins in slums, markets, public places	Citizens especially urban poor residing near public/ community bins, transfer stations and dumping sites, SWM Department of TMC
		Higher temperatures cause fires at open dumping sites, create septic conditions to release toxic gases and contribute to GHG emissions. It will reduce the productivity of manual operations as well.	Open solid waste dumping sites of TMC	
5	Transportation	Heavy rains and subsequent water logging will affect vehicular and public transport movement resulting in economic losses and productivity.	Low lying areas as identified in Disaster Management Report 2018-19	Citizens especially urban poor from low lying areas, all commuters travelling through such locations, women, children, employees, Public Works Department, Roads and Projects Department, Town Planning Department, Thane Municipal Transport of TMC, Western Railways, MMRDA, MSRTC, NHAI , IWAI
		High temperature demands more cooling in public transport especially metros, AC buses and private cabs leading to increased use of energy.	Entire city	

S. No.	Urban Systems	Climate fragility statement	Vulnerable Areas	Actors
6	Health	Heavy rains promote spread of epidemics in direct and indirect ways, but help reduce air pollution especially particulate matter.	Slums and encroachment areas	Urban poor, children, elderly people, women, Health Department of TMC, Health Department of Maharashtra State and private hospitals
		High temperatures will affect health of citizens causing problems like dehydration, heat stroke etc. especially for construction workers and elderly people.	Entire area	
7	Biodiversity: Green spaces and water bodies	Short duration, high intensity rainfall results in flash floods/runoff, washing out native biodiversity (especially fish) and affecting green spaces through falling of trees, soil erosion, landslides etc.	Entire city especially steep slopes of hilly areas	All the citizens especially fishermen, tribes in forest areas of Yeoor hills, Public Works Department, Garden Department, Pollution Control Department, Town Planning Department, Disaster Management Cell of TMC, Forest Department of Yeoor Hills range, Mangrove cell
		High temperatures demand more water for survival of biodiversity and affect health causing dehydration, heat stroke (especially for migratory birds) as well as conflicts between wild life and humans due to shortage of resources in natural habitat.	Entire city especially newly planted areas	



05 VULNERABILITY MAPPING

In addition to vulnerable population, vulnerability assessment includes identification of vulnerable areas for all the prioritized fragile urban systems. Highly vulnerable areas in the context of identified climate risks and fragile urban systems of the city are mapped to arrive at vulnerable hotspots affected by maximum number of climate issues. The coverage of basic services like water supply, storm water drains, sewage collection, solid waste collection, and transport are adequate but need improvement in terms of quality especially treatment plants. Hence, city officials perceived that the fragile urban systems will get affected due to climate risks at particular locations in the city which are already under stress due to socio-economic or location disadvantages. The basic services to vulnerable population especially urban poor residing in slums will get hampered in future due to climate risks. In this context, instead of mapping fragile urban systems and relevant vulnerable locations, the areas prone to climate risks were mapped assuming vulnerable hotspots were expected to face inadequate basic services.

In this exercise, looking at the interest of TMC in air pollution mitigation, the same has been considered for mapping. Air pollution, one of the major health hazards is indirectly linked to urban infrastructure, land use, economic activities and climate change impact in the city. Further, other issues like land use and land cover, green cover, surface temperature, low lying and frequently water-logged areas and major slums in the city were considered for vulnerability assessment and mapped for Thane city.

The Vulnerability assessment includes identification of vulnerable areas and vulnerable population for all the prioritized fragile urban systems

5.1 Air Pollution

In Thane, air pollution has been identified as a major concern for health. Increasing vehicular traffic, presence of the highway within city limits which connects various cities in the state and carries cargo, other development activities, unpaved road surfaces, and restaurants that use coal for tandoor operations are the major sources for particulate matter, Sulphur Di Oxides (SO_2) and Nitrogen Oxides (NO_x). The Pollution Control Cell of TMC and Maharashtra State Pollution Control Board (MPCB) are monitoring the pollutants in Thane at various locations under the National Air Monitoring Program (NAMP). Though air pollution is not directly linked to climate change, it affects the health of citizens and urban resilience.

Air quality monitoring data for the parameters of Respirable Suspended Particulate Matter (RSPM), Sulphur Di Oxide (SO_2), Nitrogen Oxides (NO_x) and overall Air Quality Index (AQI) are provided by the MPCB for Thane and adjoining cities. The data was analyzed for the period from September 2019 to March 2020 and considered for preparing air quality maps of Thane. These maps are presented below.

Figure 31: Map of RSPM Concentration in Thane

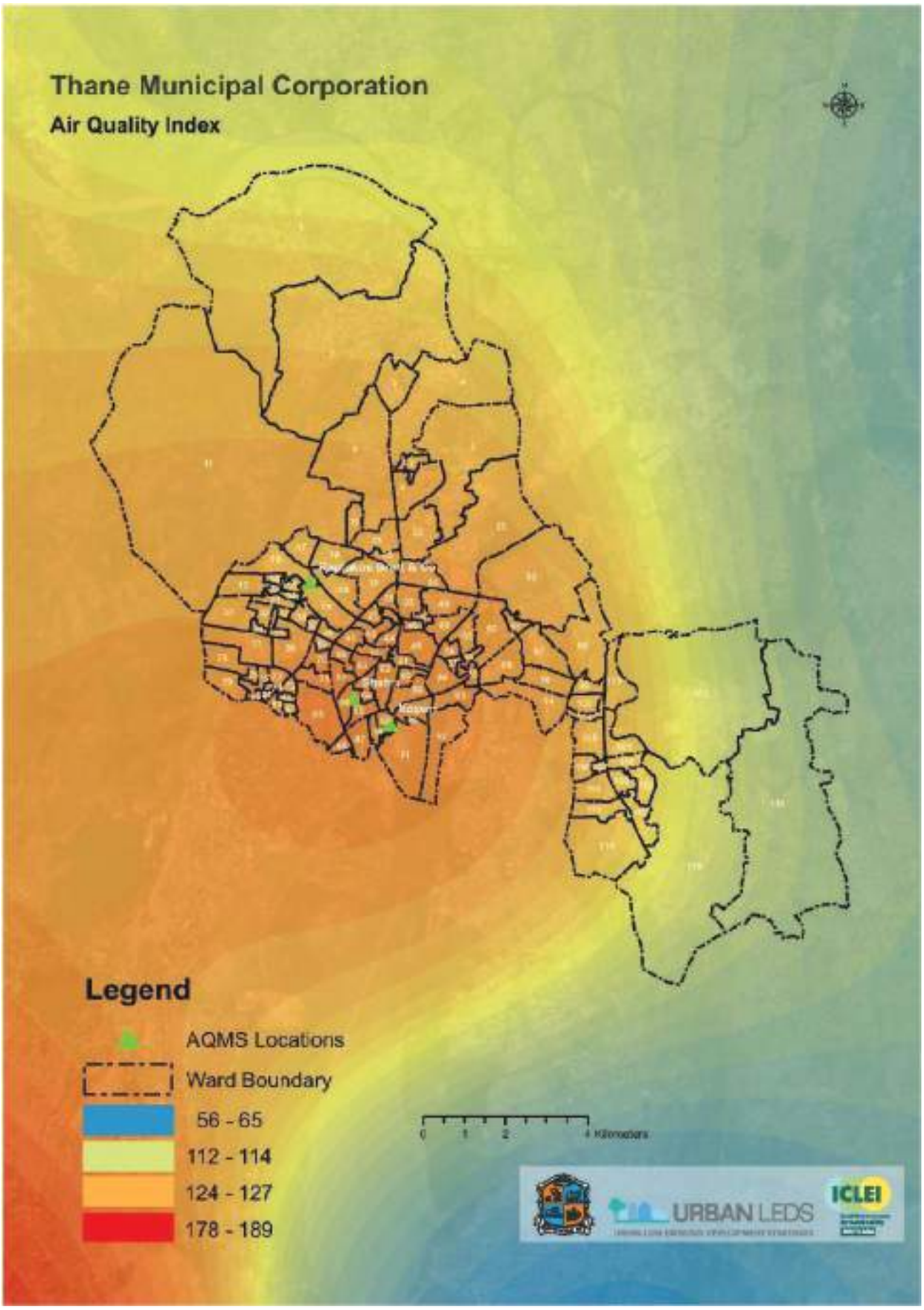


Figure 32: Map of SO_2 Concentration in Thane

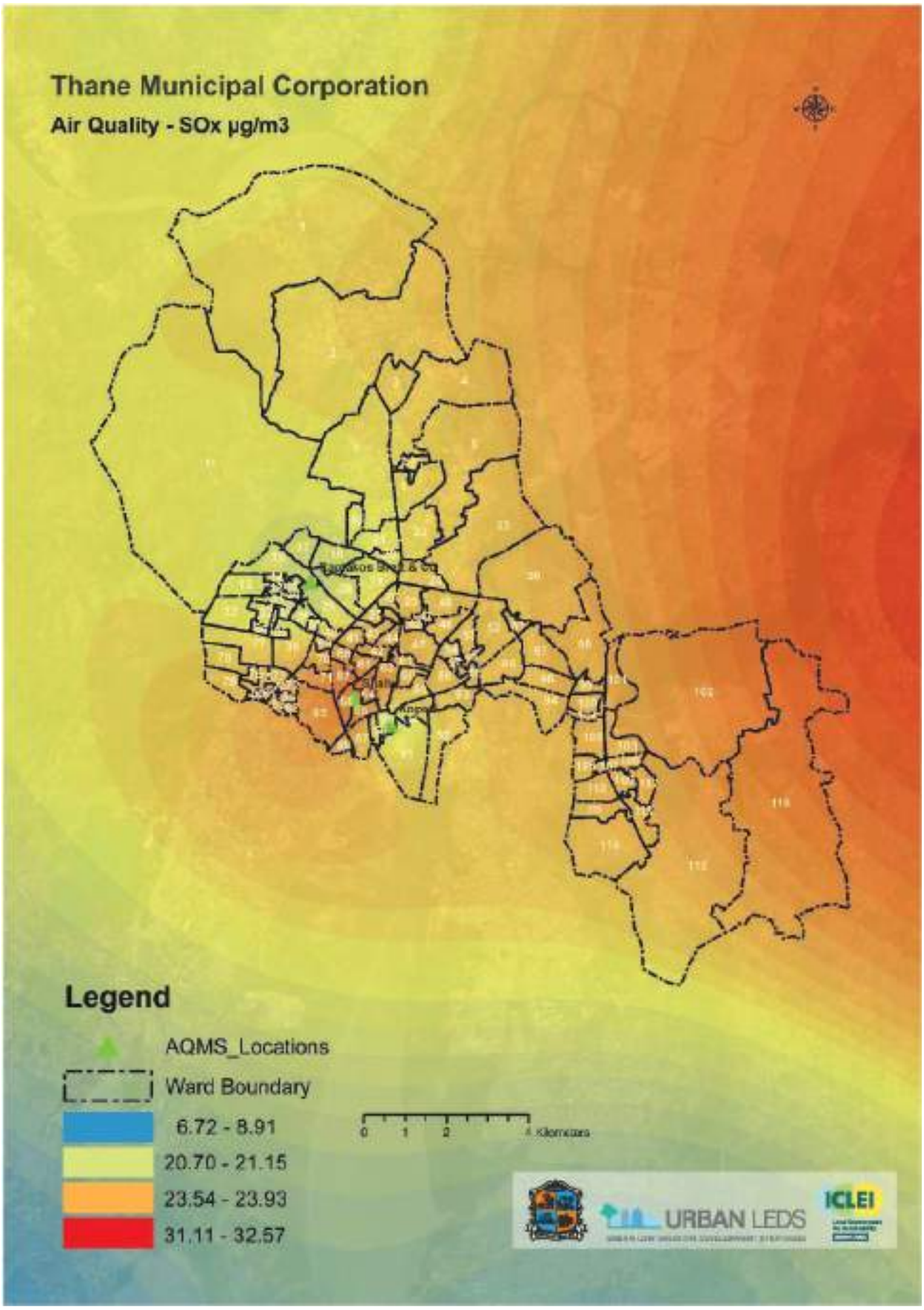


Figure 33: Map of NO_x Concentration in Thane

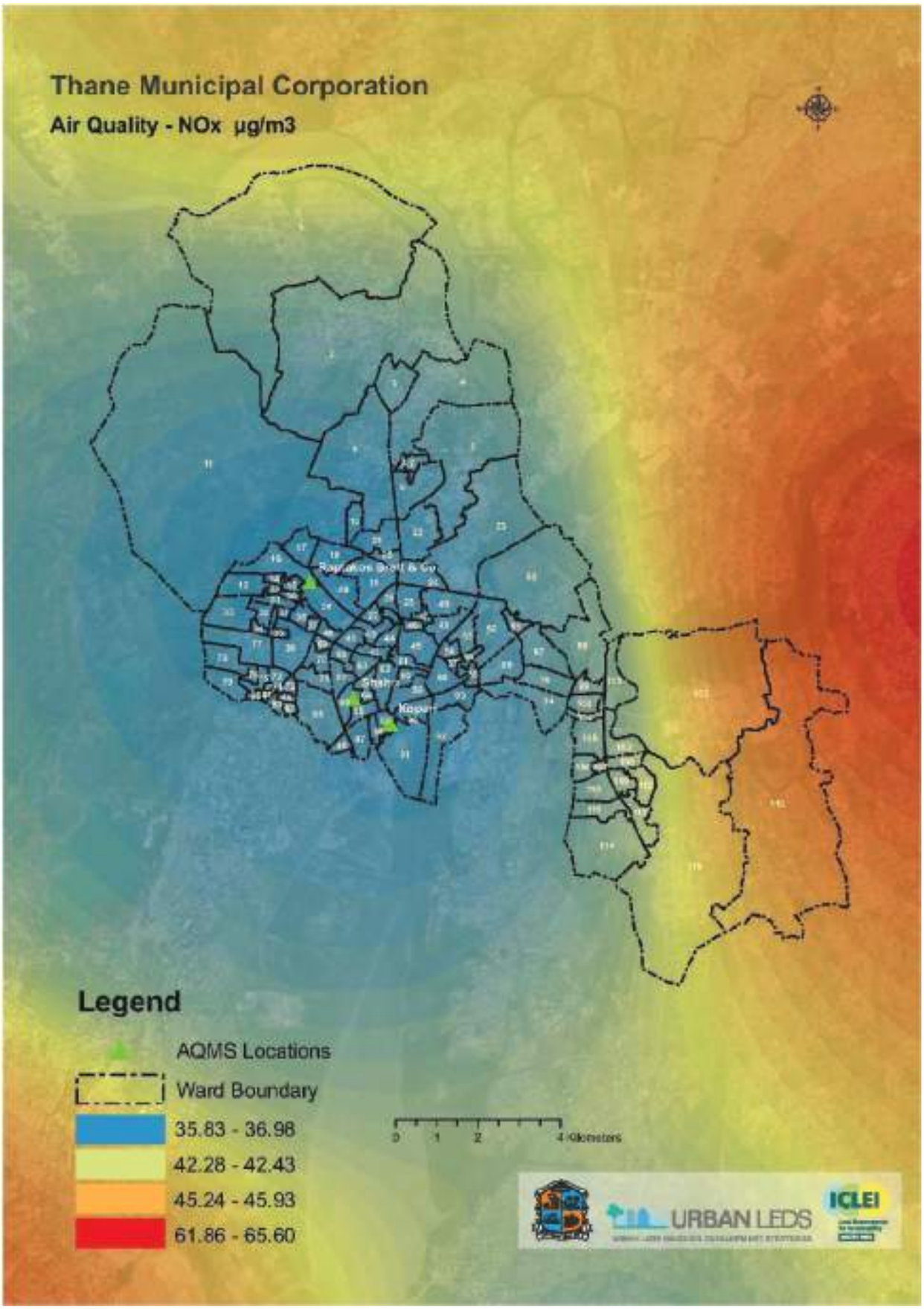
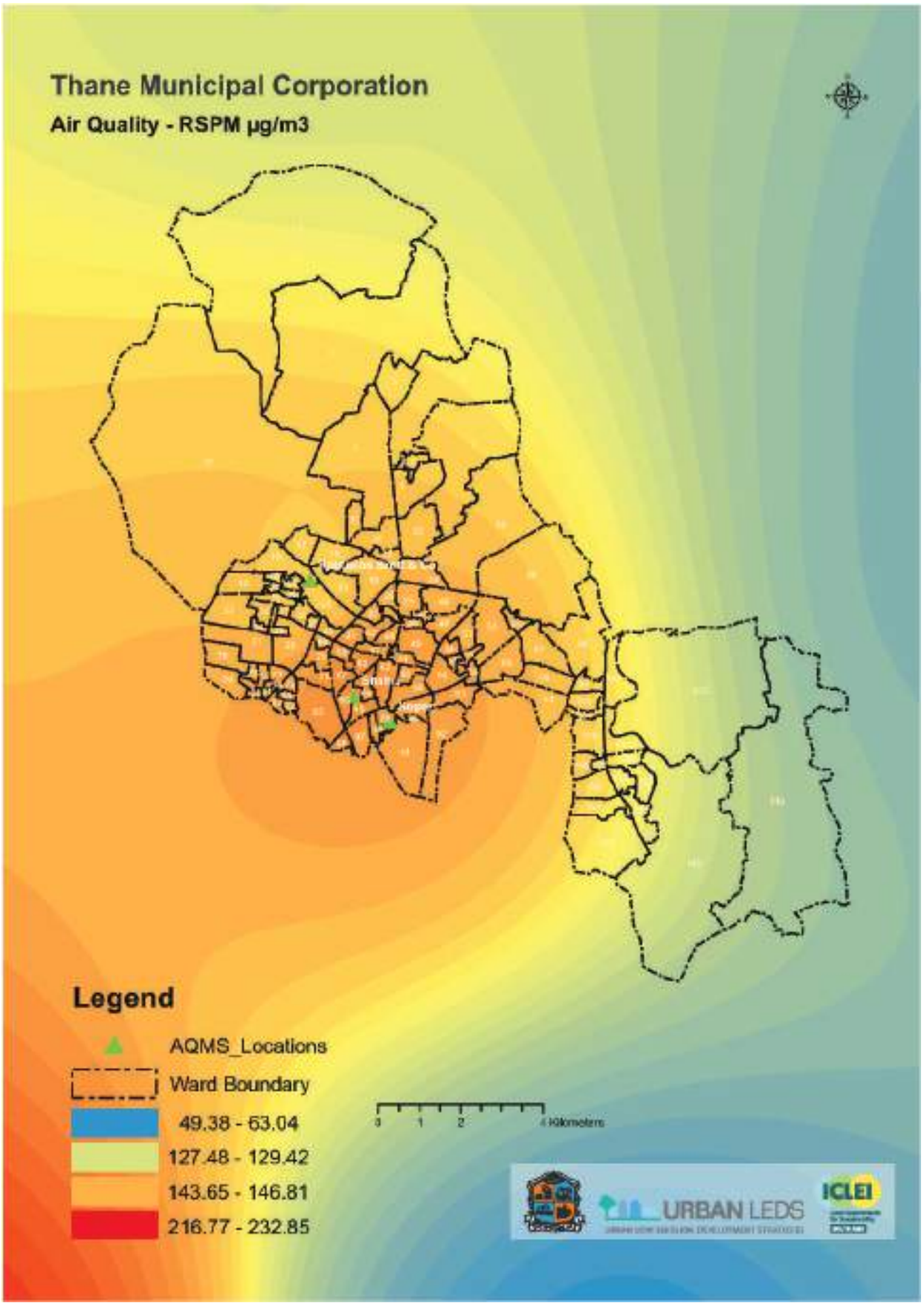


Figure 34: Map of Air Quality Index (AQI) in Thane

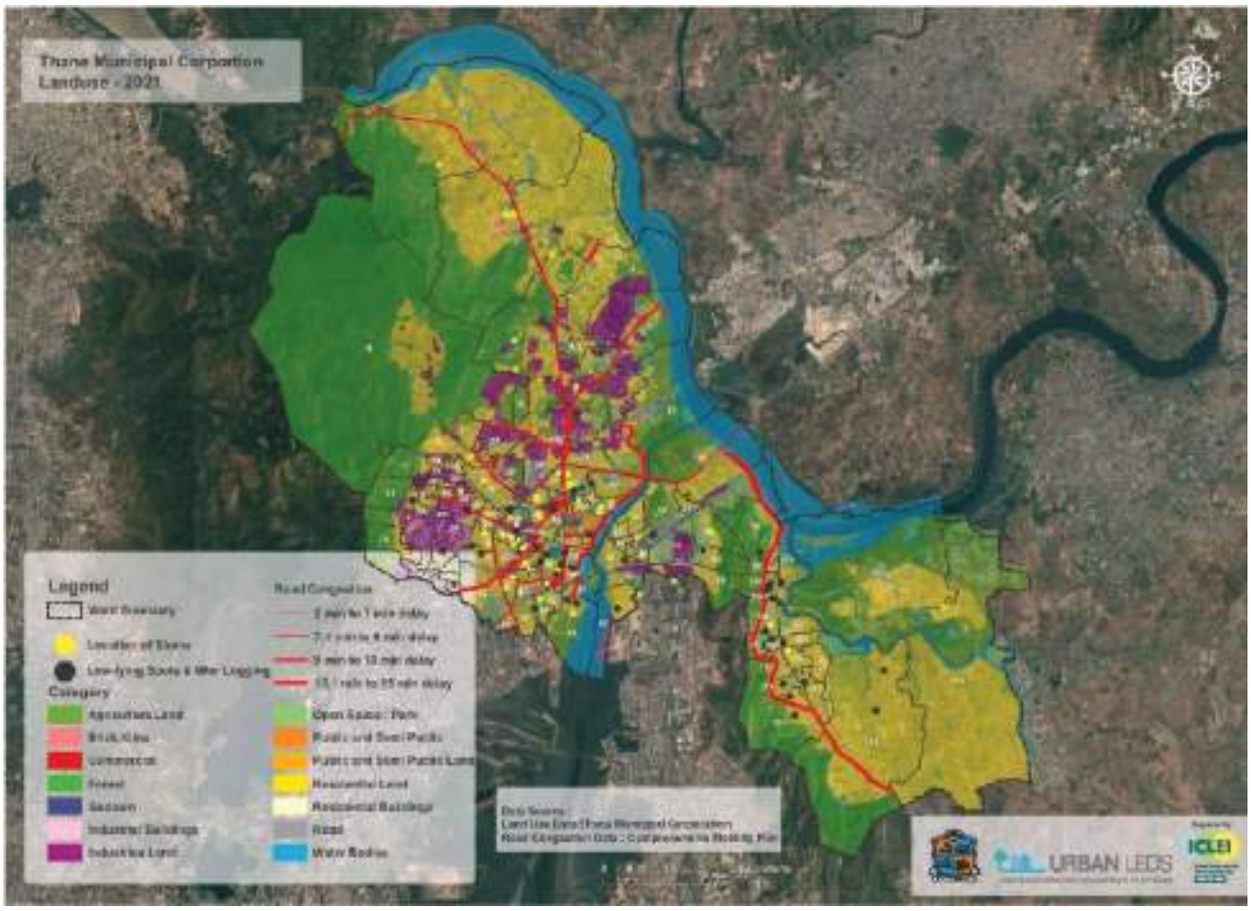


5.2 Land Use and Land Cover

The land use and land cover map the Thane has been prepared using satellite imagery data. Though the satellite images provide extensive geographic coverage, they do not portray finer details. The map shows mixed land use pattern in Thane especially for residential and commercial areas. The few dedicated industrial areas are now surrounded by residential projects. The Ulhas river estuary on the north and Yeoor hills - national park on the west are natural obstacles limiting the city's horizontal growth city while other sides are occupied by other urban local bodies.

Except Mumbra hills, Yeoor hills and CRZ areas, the developable land and concrete/paved surface in Thane contributes to vulnerability such as urban heat island effect, excess runoff generation by reducing natural percolation capacity, water logging in low lying areas, concentrated air pollutants and frequent traffic congestion/delays etc. The following map shows land use and land cover of Thane.

Figure 35: Land Use and Land Cover Map of Thane with Low Lying and Water Logging Locations



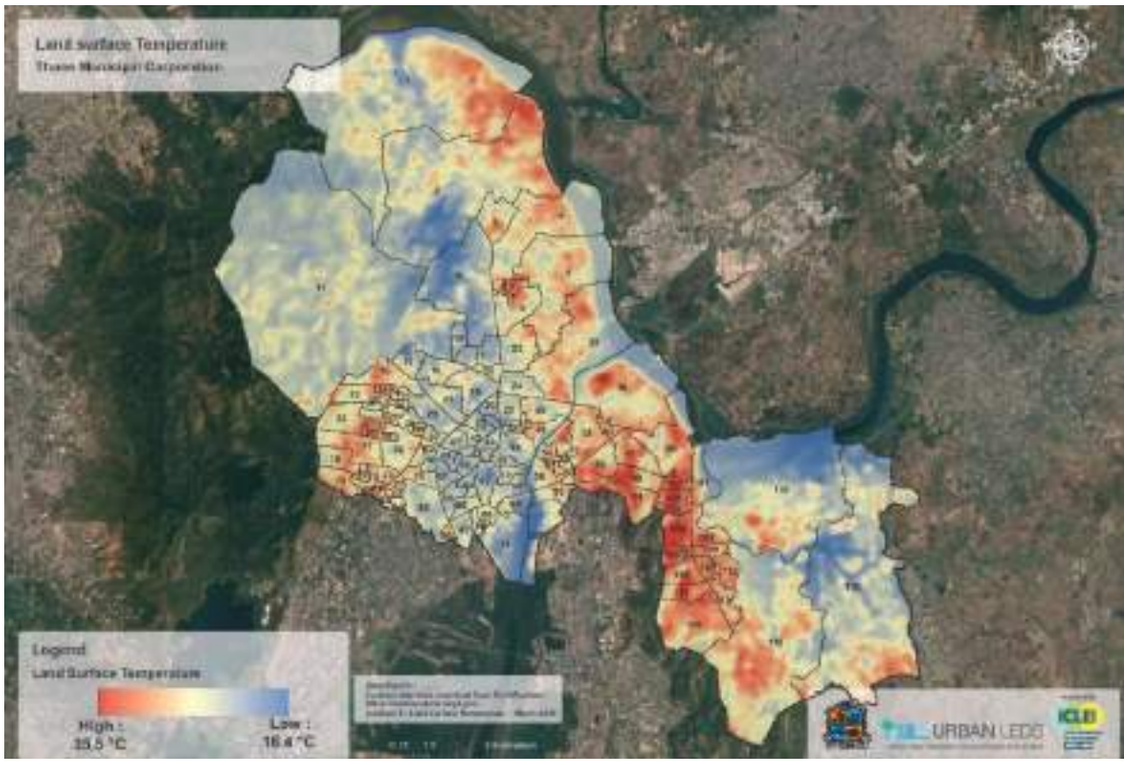
5.3 Green Cover and Land Surface Temperature

Thane's green cover has substantial potential to reduce the impact of climate change related vulnerabilities such as excess heat and excess runoff if planned properly. The green cover map of Thane shows significant cover at west side (Yeoor hills – national park) and in pockets (Mumbra hills/Parsik hills, Diva) to the south-east side. The green cover helps reduce soil erosion from hills especially Yeoor and Parsik hills and increases runoff percolation during rainfall.

Figure 36: Green Cover Map of Thane

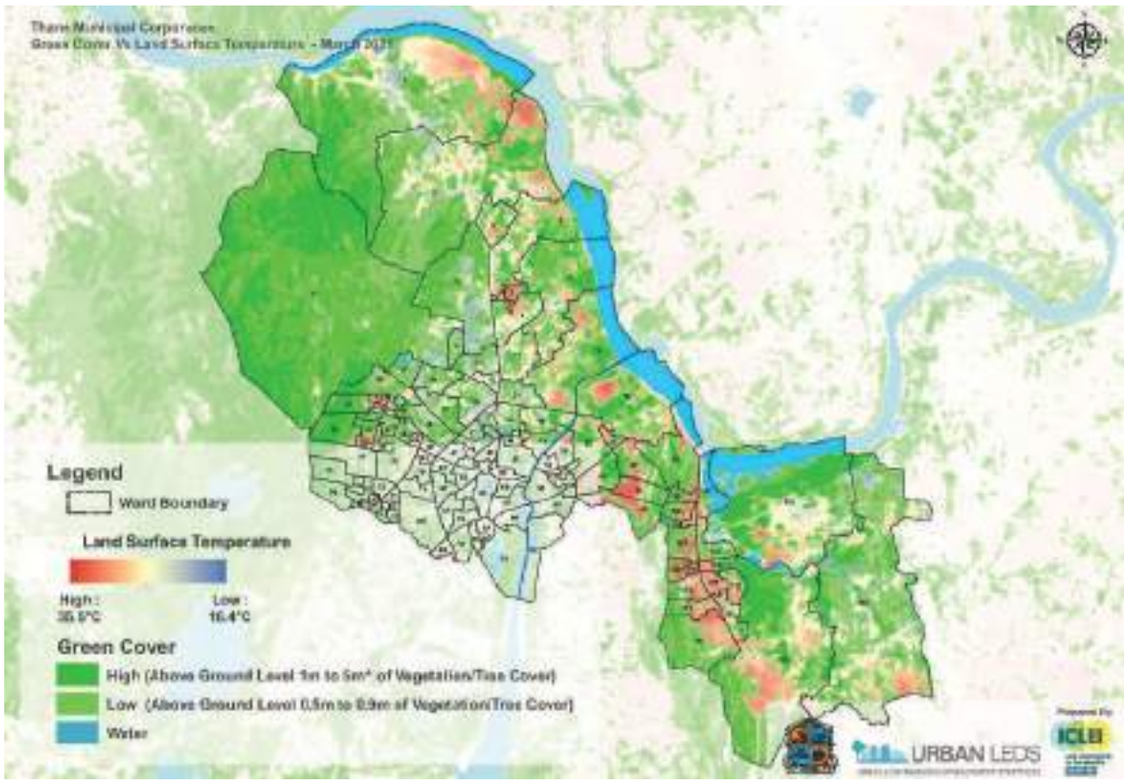
The surface temperature map of Thane (below), prepared based on satellite imagery, shows that surface temperature is higher on the north eastern side throughout Ghodbunder Road, city core area, and the southern part comprised of parts of Mumbra and Diva. This is attributable to prominent developmental activities such as roads, residential and commercial buildings and to some extent barren land or exposed rocky patches of hills.

Figure 37: Land Surface Temperature in Thane



Higher the green cover, lower the surface temperature due to its refraction and heat absorption capacity. Hence, development activities in future like a proposed road near Ulhas river estuary parallel to Ghodbunder Road and other construction activities of residential, commercial and transport projects could increase the surface temperature. Overlapping green cover with surface temperature shows areas having higher temperature where increasing green cover may mitigate heat related impact. TMC's initiatives to develop urban forests and gardens need to be strengthened. The following map shows the overlapped sectors of green cover and surface temperature.

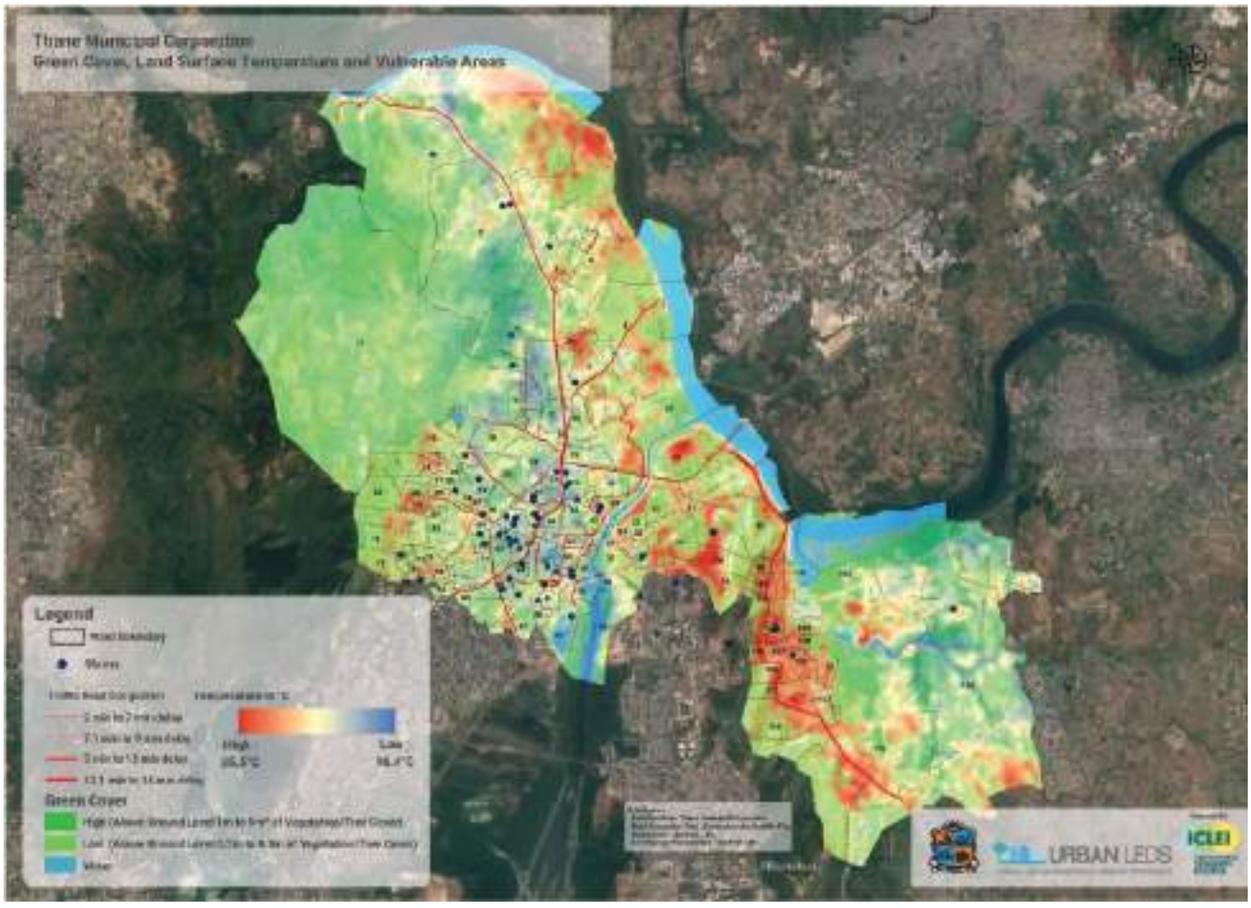
Figure 38: Correlation Between Green Cover and Land Surface Temperature in Thane



5.4 Water Logging Spots, Low Lying Areas and Traffic Congestion Roads

The discussions with stakeholders in Thane highlighted that due to short duration and high intensity rainfall will become critical risks to deal with. Low lying areas, frequently water-logged spots and major roads in the city are the vulnerable locations for change in precipitation. Due to the increase in average temperature in the city, developed areas and roads facing traffic delays have become vulnerable. The following map shows frequently water-logged spots, low lying areas and roads facing traffic delays in the city.

Figure 39: Vulnerability Issues of Thane



5.5 Climate Vulnerable Wards in Thane

Short term and high intensity rainfall and increasing temperature pose the key climate risk to Thane, along with sea level rise. Vulnerable areas will be the first to be impacted by exposure to such risks due to various features like geographical location, unauthorized settlements, encroachments, inadequate urban infrastructure, access to basic municipal services, economic condition, transportation facilities etc. This study identifies slums (urban poor), settlements on the slopes of hilly terrain, low lying areas, and traffic congestion points/roads as the vulnerable areas. Such areas and people living in these areas especially women and children are prone to higher health risks and may face shortage of basic services during disasters.

Wards are the basic administrative units of a city where planning and implementation is initiated. All the three climate risks mentioned above along with associated issues are analyzed for their ward level occurrence. Ward level analysis will help city administration to prioritize the areas of focus for adaptation and mitigation efforts. In this section, five maps were prepared based on information and data collected and available at the city level. As some data and information were not readily available, the vulnerable wards have been decided on the basis of certain assumptions and inputs from city officials. The following table displays the climate issues, basis of the mapping and the criteria adopted while defining vulnerability.

Table 28: Basis and Criterion for Vulnerable Ward Mapping

S. No.	Climate issues	Basis of the mapping	Criterion of vulnerability and number of vulnerable wards
1	Precipitation – increase in rainfall (short duration, high intensity events)	Low lying and frequently water-logged areas in the city	Occurrence of such locations in a ward (Total wards 36)
2	Temperature – increase in mean maximum temperature	Summer surface temperature data from satellite imagery	Wards with average maximum temperature exceeding 32°C (Total wards 16)
3	Sea level rise	Increase in sea level and intrusion in city	Sea level rise up to 3 m above ground level (Total wards 40)
4	Traffic delays due to road congestion	Traffic delays sourced from Comprehensive Mobility Report, Thane	Wards with traffic delay time 10 min and more (Total wards 11)
5	Most vulnerable population	Major slums in a ward	Occurrence of major slums in a ward (Total wards 32)
6	Vulnerability hotspots	Combined map of above 5 issues	Occurrence of 4 and more vulnerability issues in a ward (Highly vulnerable wards 23)

Based on the above criteria, wards are identified for their vulnerabilities. The following maps show the vulnerable wards for each of the identified climate risks and issues.

Figure 40: Precipitation Risk – Wards Affected by Water Logging

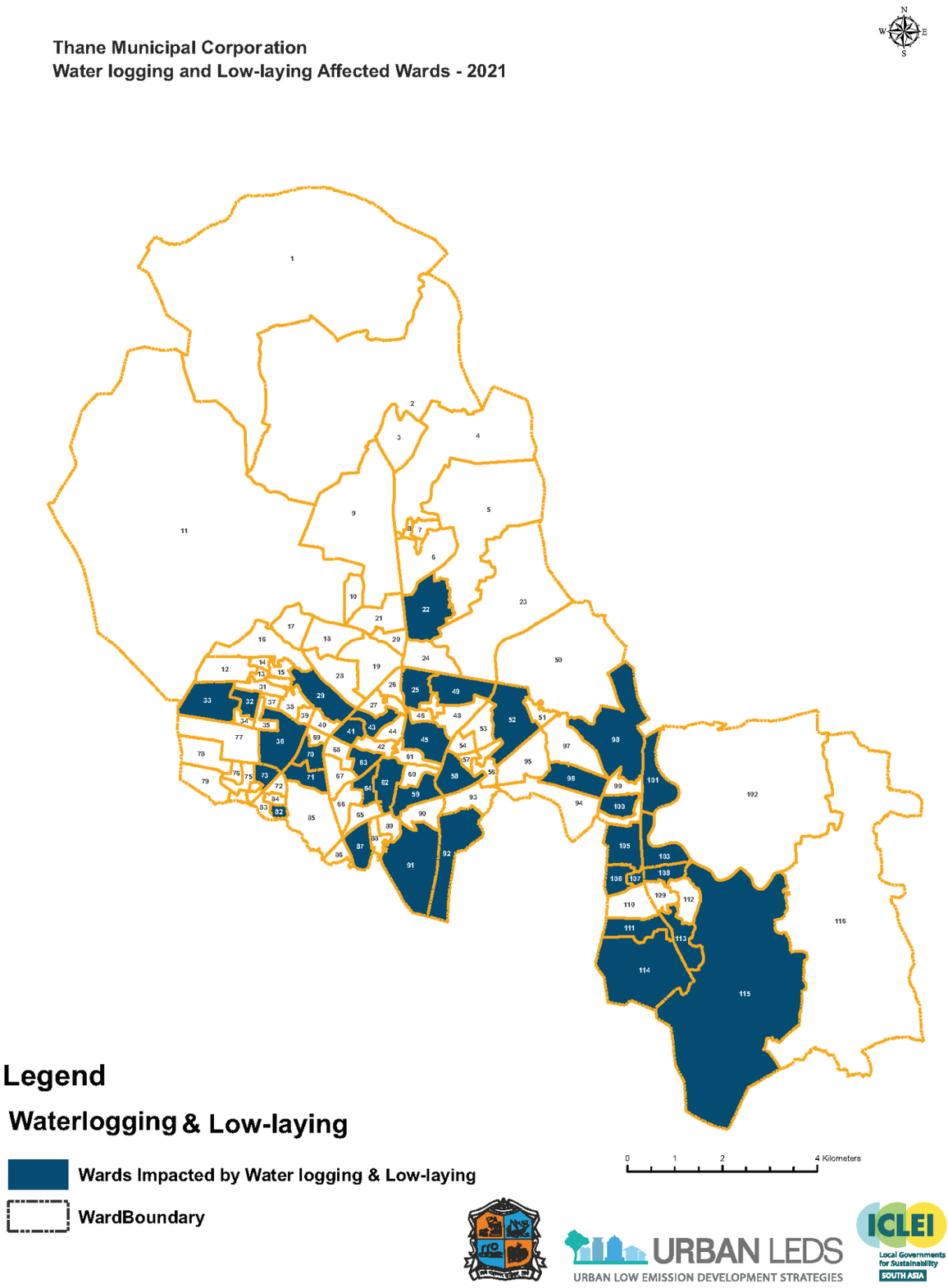


Table 29: Wards Affected by Water Logging Issues

S. no	Climate issues	Wards
1	Wards impacted by water logging	22, 25, 29, 32, 33, 36, 41, 43, 45, 49, 52, 58, 59, 62, 63, 64, 70, 71, 73, 82, 87, 91, 92, 96, 98, 100, 101, 103, 105, 106, 107, 108, 111, 113, 114, 115

Figure 41: Temperature Risk – Wards Affected by Higher Surface Temperature

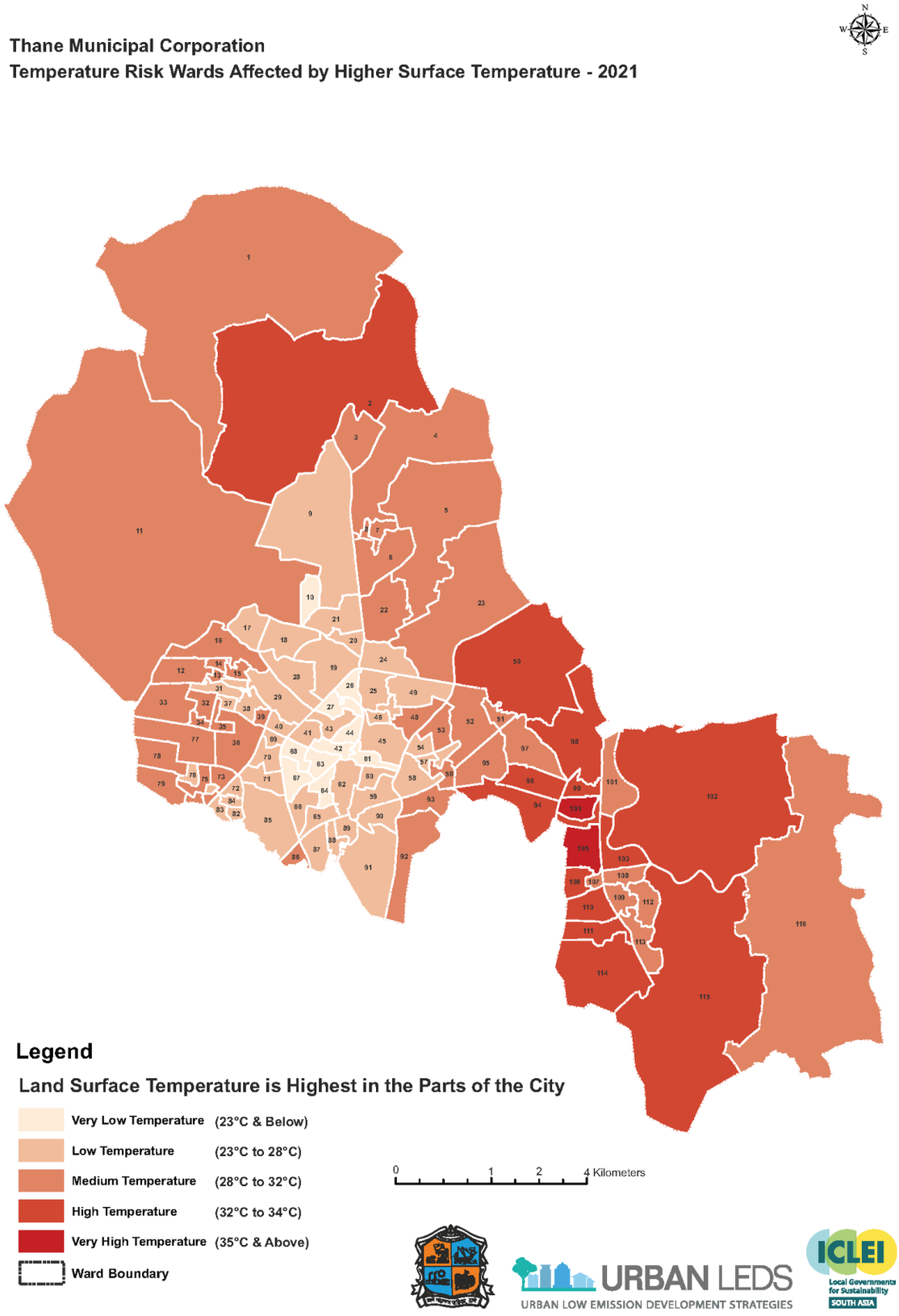


Table 30: Wards Affected by Increase in Mean Maximum Temperature

S. no	Climate issues	Wards
1	Wards impacted by increase in maximum temperature more than 320C	2, 50, 94, 96, 98, 99, 100, 102,103, 104, 105, 106, 110, 111, 114, 115

Figure 42: Sea Level Rise – Wards Affected near Ulhas River Estuary and Thane Creek

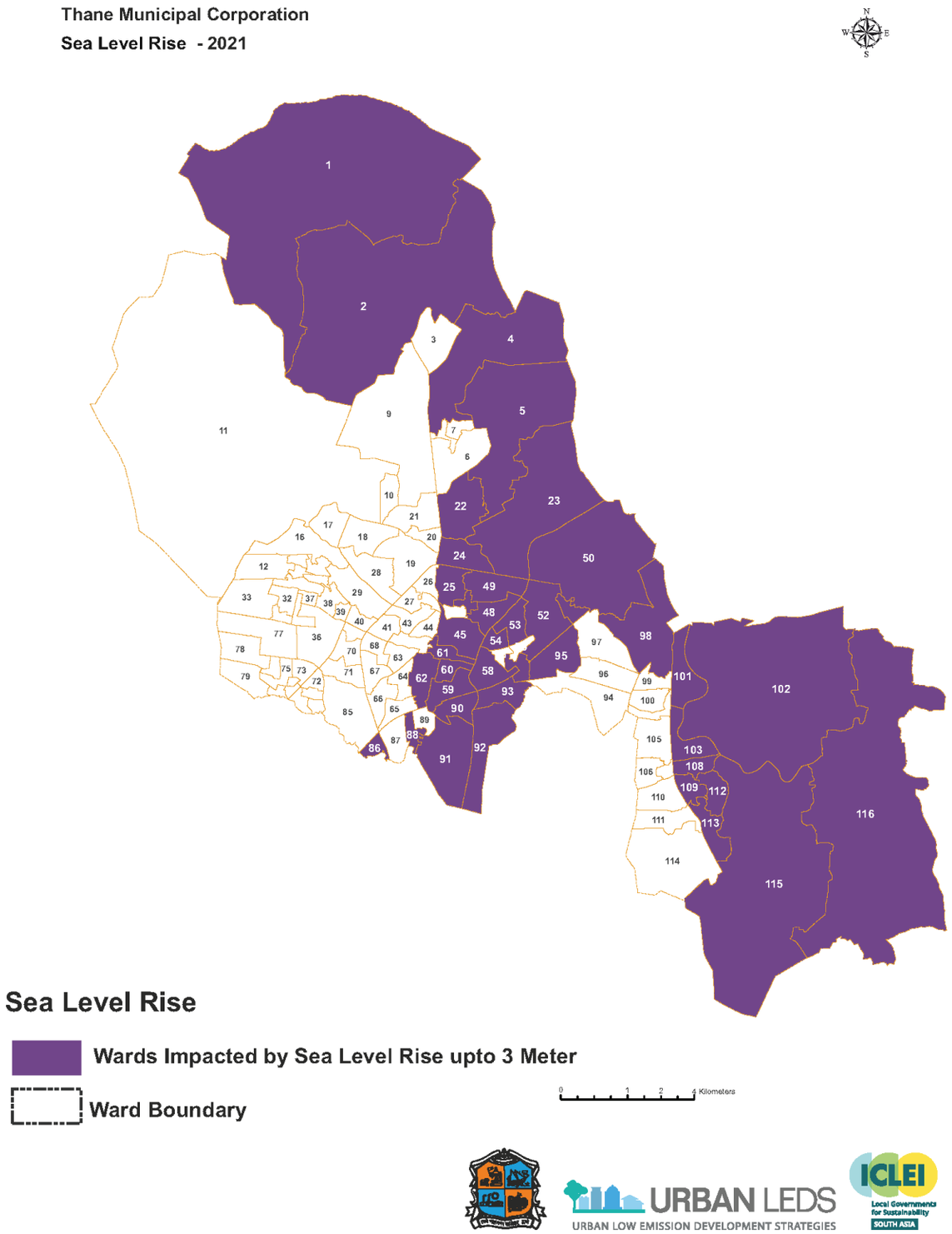


Table 31: Wards Affected by Sea Level Rise

S. no	Climate issues	Wards
1	Wards impacted by sea level rise up to 3 m	1, 2, 4, 5, 22, 23, 24, 25, 45, 47, 48, 49, 50, 51, 52, 53, 54, 56, 58, 59, 60, 61, 62, 86, 88, 90, 91, 92, 93, 95, 98, 101, 102, 103, 108, 109, 112, 113, 115, 116

Figure 43: Vulnerable Population - Urban Poor in Major Slums

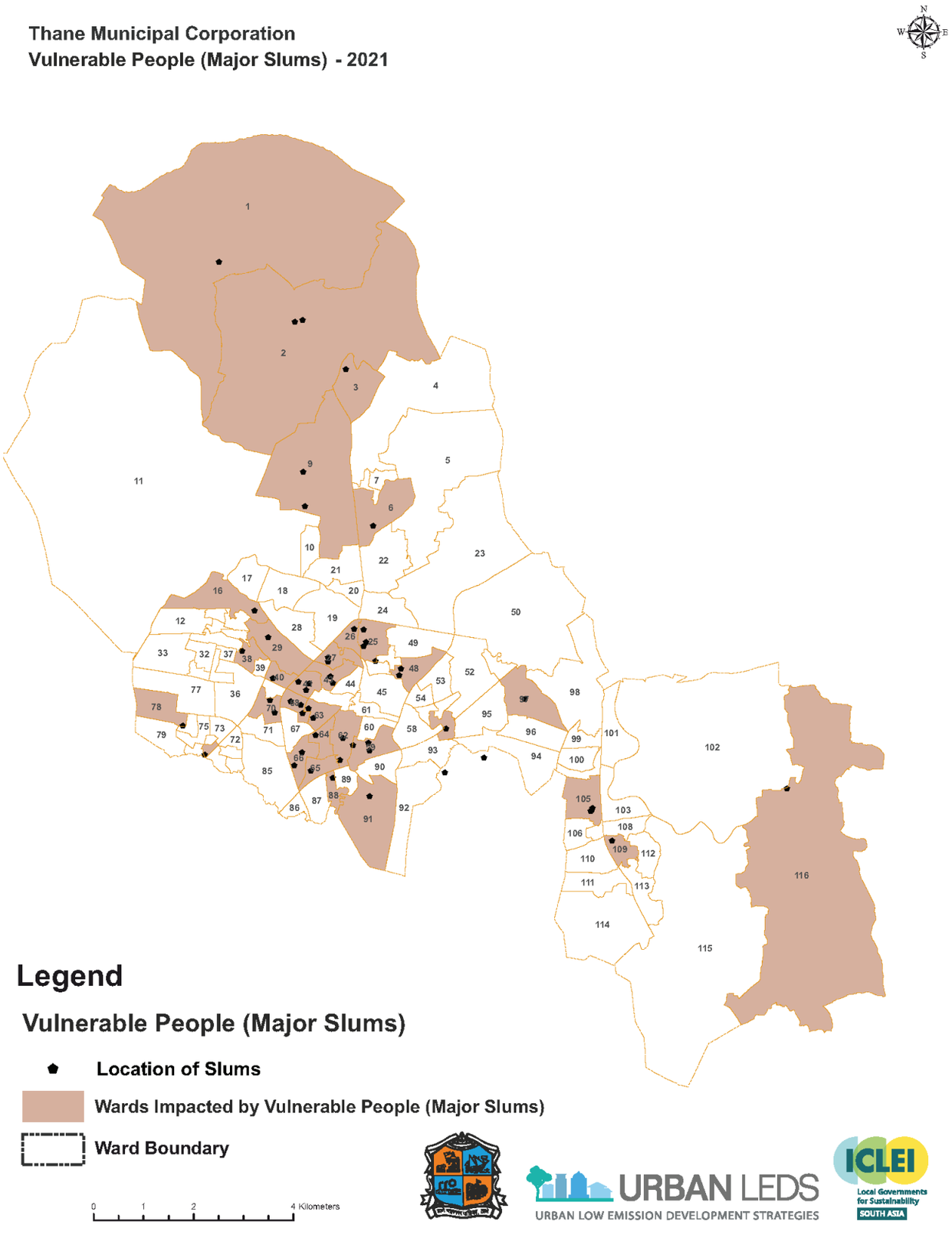


Table 32: Wards Housing Vulnerable Population (Slums)

S. no	Climate issues	Wards
1	Wards with vulnerable population – occurrence of a number of slums	1, 2, 3, 6, 9, 16, 25, 26, 27, 29, 38, 40, 41, 43, 48, 56, 59, 62, 63, 64, 65, 66, 68, 70, 78, 81, 88, 91, 97, 105, 109, 116

Figure 44: Delays due to Traffic Congestion

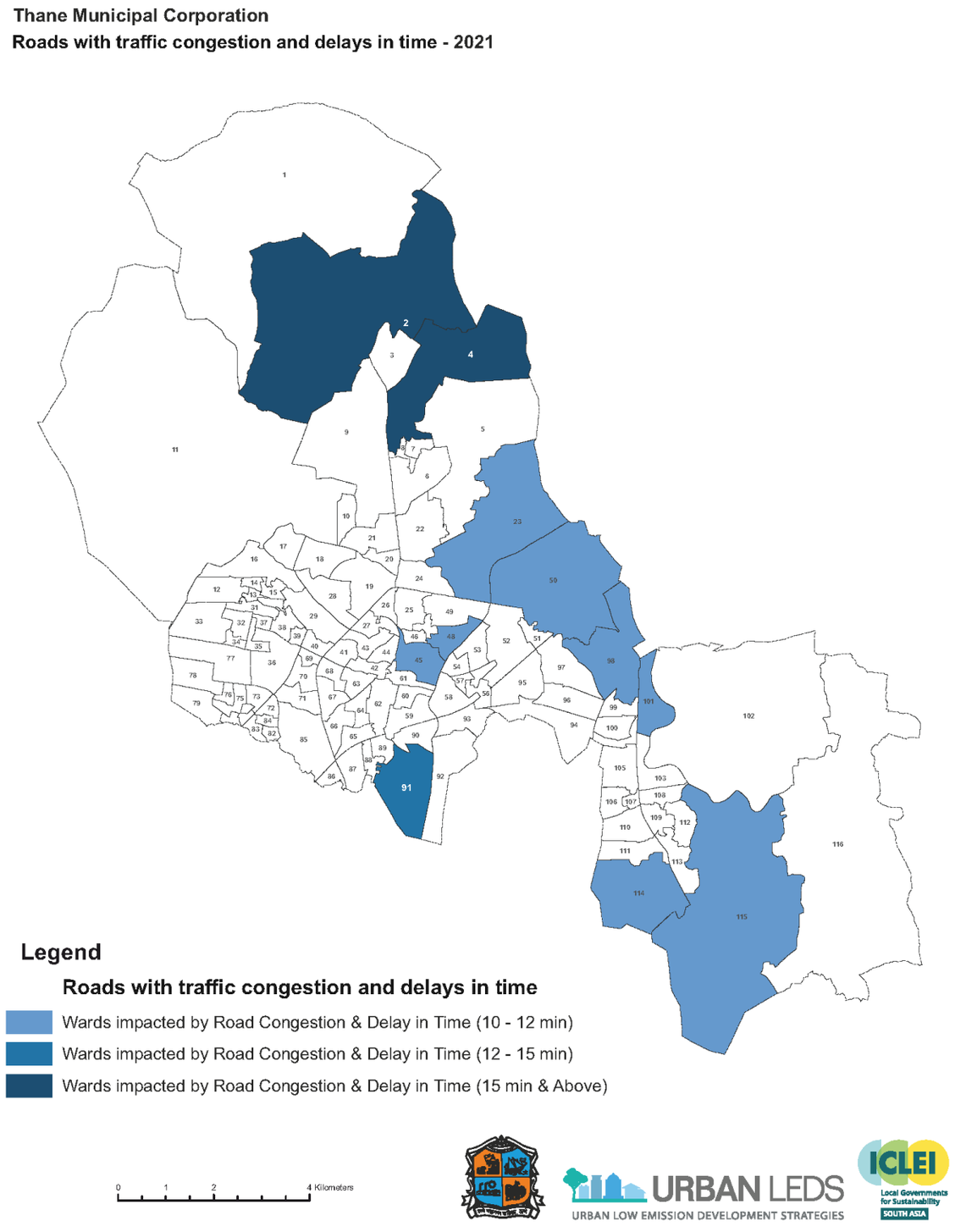


Table 33: Wards Affected by Traffic Congestion and Delays

S. no	Climate issues	Wards
1	Wards impacted by road congestion and delays by more than 10 min	2, 4, 23, 45, 48, 50, 91, 98, 101, 114, 115

Figure 45: **Vulnerable Hotspots in Thane factoring all Climate Risks**

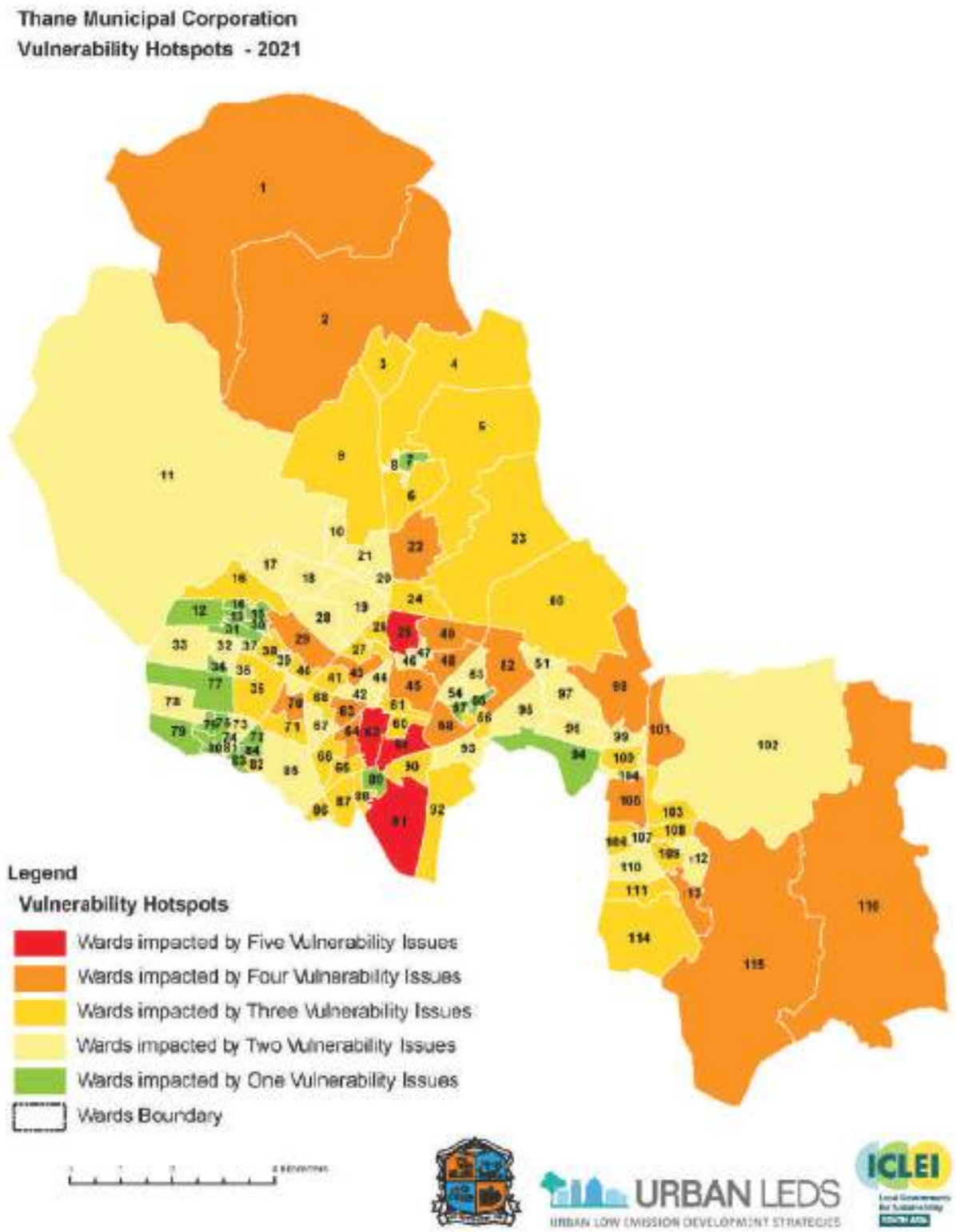


Table 34: **Wards Affected by Climate Risks and Issues**

S. no	Climate issues	Wards
1	Wards impacted by 5 vulnerability issues	25, 59, 62, 91
2	Wards impacted by 4 vulnerability issues	1, 2, 22, 29, 43, 45, 48, 49, 52, 58, 63, 64, 70, 98, 101, 105, 113, 115, 116

5.6 Climate Issues and Potential Strategies

These maps can be improved and revised in future based on detailed information and finer data availability (e.g. area and population of slums, rehabilitated slums, data from the city level weather monitoring stations, reduction in number of water logging areas, improved transport infrastructure, improved green cover etc.). Based on this revision, ward level impact of the climate risks and issues may vary. It is recommended to conduct Climate Vulnerability Assessment at city level periodically, ideally every 2 years to enhance resilience, reduce adverse impact of climate risks and factor in the changes that may occur following climate actions or new research on climate risks. The following table shows the identified climate issues and potential strategies to reduce the impact of such issues.

Table 35: Potential Strategies Identified to Address Climate Risks and Vulnerability

Climate Risks	Potential strategic/policy level interventions
Precipitation - increase in rainfall (short duration, high intensity events)	• Early warning system to enable city authority and citizens to respond quickly • Root cause analysis of localized or city wide flooding, like type of cause (engineering/manual/encroachment/geographical etc.) and respective solutions
Temperature – increase in mean maximum temperature	• Detailed study by preparing Cooling Action Plan/Heat Action Plan to mitigate urban heat island effect and heat related health disorders • Promoting green buildings especially in vulnerable areas, vertical and roof top gardens, road side plantation, land reservations for the development of parks, gardens, urban forests, increasing overall per capita green space etc. • Green belt/plantation as part of building approvals/development control regulations
Sea level rise	• Strictly following city level CRZ plans • Rehabilitation of urban poor from such areas • Demarking and considering such areas in development plans and development control regulations
Traffic delays due to road congestion	• Improving transport infrastructure by implementing various interventions especially identified in the Comprehensive Mobility Plan • Improved public transport services and awareness for maximizing usage
Most vulnerable population	• Rehabilitation of urban poor and restricting further settlement of slums on government and private land especially in vulnerable hotspots • Policy and action plan to improve economic condition, health, access to basic services for urban poor
Vulnerability hotspots	• Demarking vulnerable hotspots in the city and considering them while implementing any project related to fragile urban systems • Action plan to improve climate resilience of the city • Prioritization of the wards for improving fragile urban systems and other interventions based on their climate vulnerability

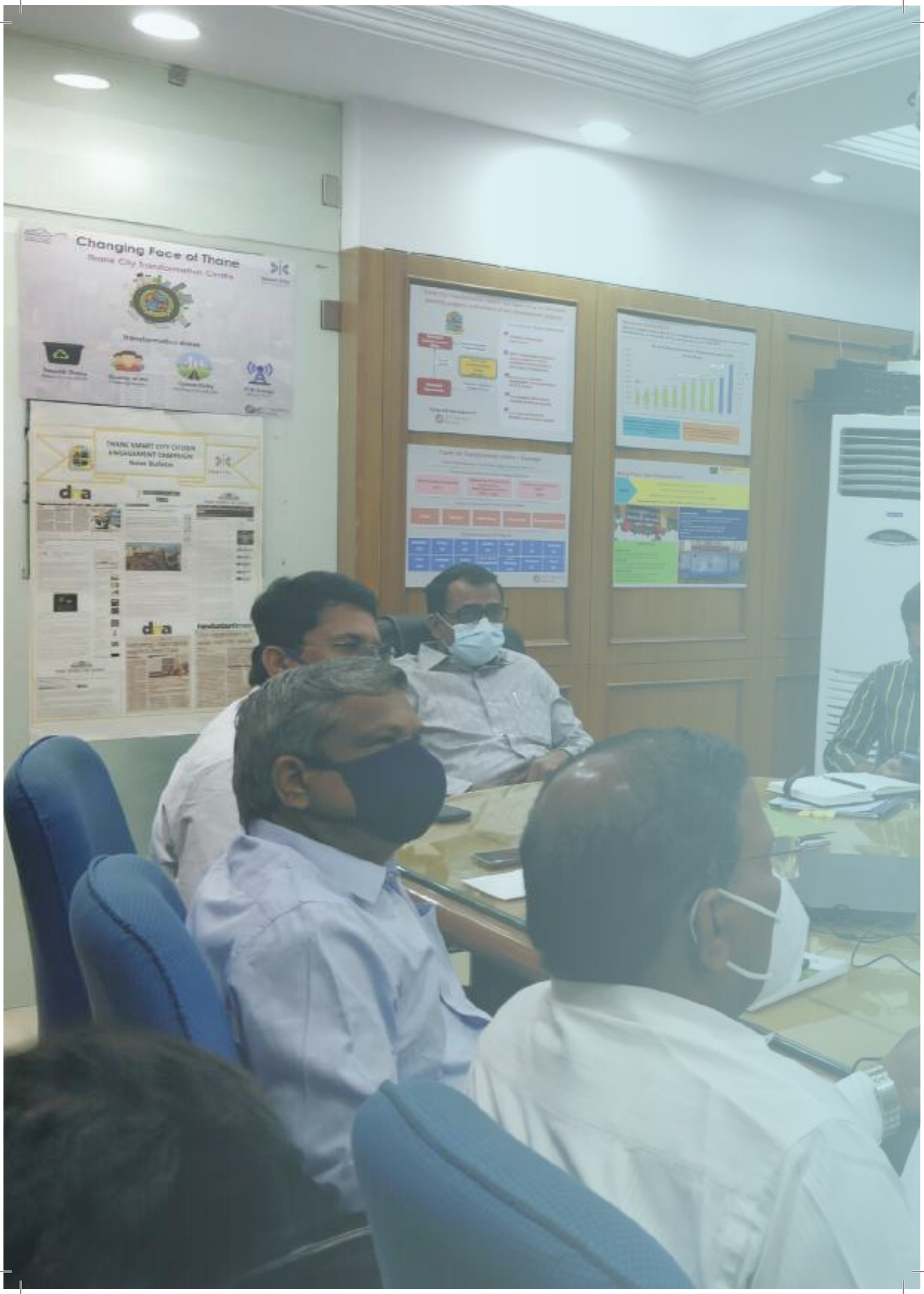
5.7 Adaptive Capacities of the Fragile Urban Systems

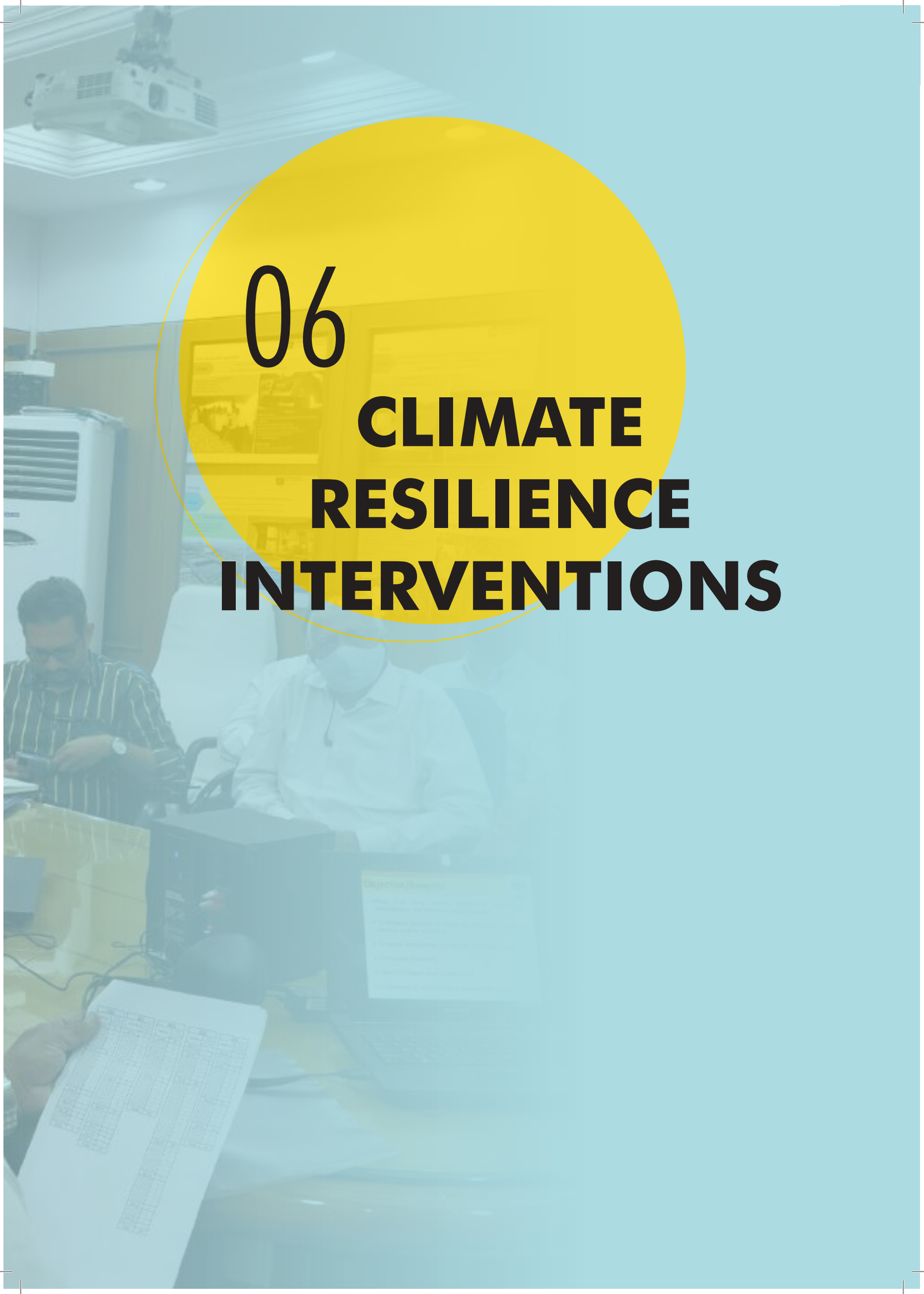
The fragile urban systems identified in this study are linked with their respective climate issues and checked for their adaptive capacities in terms of available technology for taking action, available finances, and systems of governance. An overall adaptive capacity is arrived at considering the levels in all three criteria. The analysis is qualitative, based on the perception after analyzing the existing situation and projects in the pipeline.

The following table shows the adaptive capacities of the fragile urban systems.

Table 36: Analysis of Adaptive Capacities of the Fragile Urban Systems

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


Changing Face of Thane
Thane City Transformation Centre



06 CLIMATE RESILIENCE INTERVENTIONS

The CRCAP of Thane includes climate resilience interventions in the residential, commercial, institutional, industrial and municipal service sectors. Municipal services and facilities such as water supply, sewerage, storm water, SWM, transport, street lighting, municipal buildings, disaster management, biodiversity, pollution control and health are addressed in the action plan. Additional cross-cutting services such as town planning and finance are also considered. The resilience interventions included in the CRCAP are informed by the baseline sectoral GHG emissions and identified climate vulnerabilities. Identified sectoral interventions are prioritized based on their resilience capacity, which is assessed in terms of their propensity to increase the redundancy, flexibility, and responsiveness of the relevant systems as well as GHG emissions reduction potential. The interventions are then assessed for feasibility (technical, financial and political) and their impact (short, medium or long term). As far as possible, the prioritized interventions are linked to existing city plans and schemes so as to ensure that the required interventions are integrated, with little or no additional resources, into existing departmental programs or projects. The interventions were discussed and approved by the climate core committee of the city.

Section 6.2 lists the selected climate resilience interventions that make up the CRCAP of Thane. Sector specific information, including energy consumption and GHG emissions for the baseline as well as the projected BAU scenario, along with overall GHG emissions mitigation potential and possible energy savings from all interventions in the sector, are also indicated in the table. The SDGs addressed by the proposed interventions for the sector are included to reflect overall contribution to sustainability.

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

The Climate Resilient City Action Plan (2021-25) proposes actions with an annual GHG emissions mitigation potential of 22% by 2025-26 over the 2017-2018 baseline.

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

Mitigation Target:

The Climate Resilient City Action Plan (2021-25) proposes actions with an annual GHG emissions mitigation potential of 22% by 2025-26 over the 2017-2018 baseline.

Adaptation Goal:

Thane city aims to become a climate resilient city with a socially inclusive community by addressing socio-economic impacts of climate change, mitigating flood risks, enhancing its green cover, and abating air pollution with focus on multi-sectoral and inclusive urban development.

6.1 Summary of Key Strategies and Measures for Climate Resilience

While 44 identified structural actions have immediate, direct GHG emissions reduction impacts the CRCAP also recommends several additional 'enabling strategies and actions' that have indirect impacts by enabling or building capacity for longer-term actions

The CRCAP for Thane city comprises of 44 actions (structural) delineated across 11 thematic areas/sectors that provide a pathway for Thane to enhance climate resilience and move towards a low carbon urban development pathway. These proposed interventions can deliver significant benefits in terms of reducing GHG emissions by lowering energy consumption, as well as reducing municipal expenditure on fuel and electricity.

These identified strategies will not only help reduce GHG emission and better manage local climate risks, but will also support the city in its Sustainable Development Goal (SDG) aspirations. Solid Waste Management (52%), Residential Sector (35%),and Commercial &Institutional Sector (7%) are expected to provide the maximum GHG emissions reduction benefits.

While these 44 structural actions have immediate, direct GHG emissions reduction impacts the CRCAP also recommends several additional 'enabling strategies and actions' that have indirect impacts by enabling or building capacity for longer-term actions. For example, preparation of city-wide 'Holistic Waste Management Plan' and scaling-up GIS enabled Smart Waste Management Services for bins and vehicles and their integration with Thane's Command-and-Control Centre.

Table 37 provides a summary of the key strategies and measures for climate resilience in Thane city. Figure 46 shows the GHG emissions reduction scenario on implementation of the CRCAP as compared to the Business as Usual (BAU) emissions trajectory. Through implementation of ambitious but achievable actions under the CRCAP, the city's GHG emissions can be reduced by 22% by 2025-26, from the base year 2017-18.

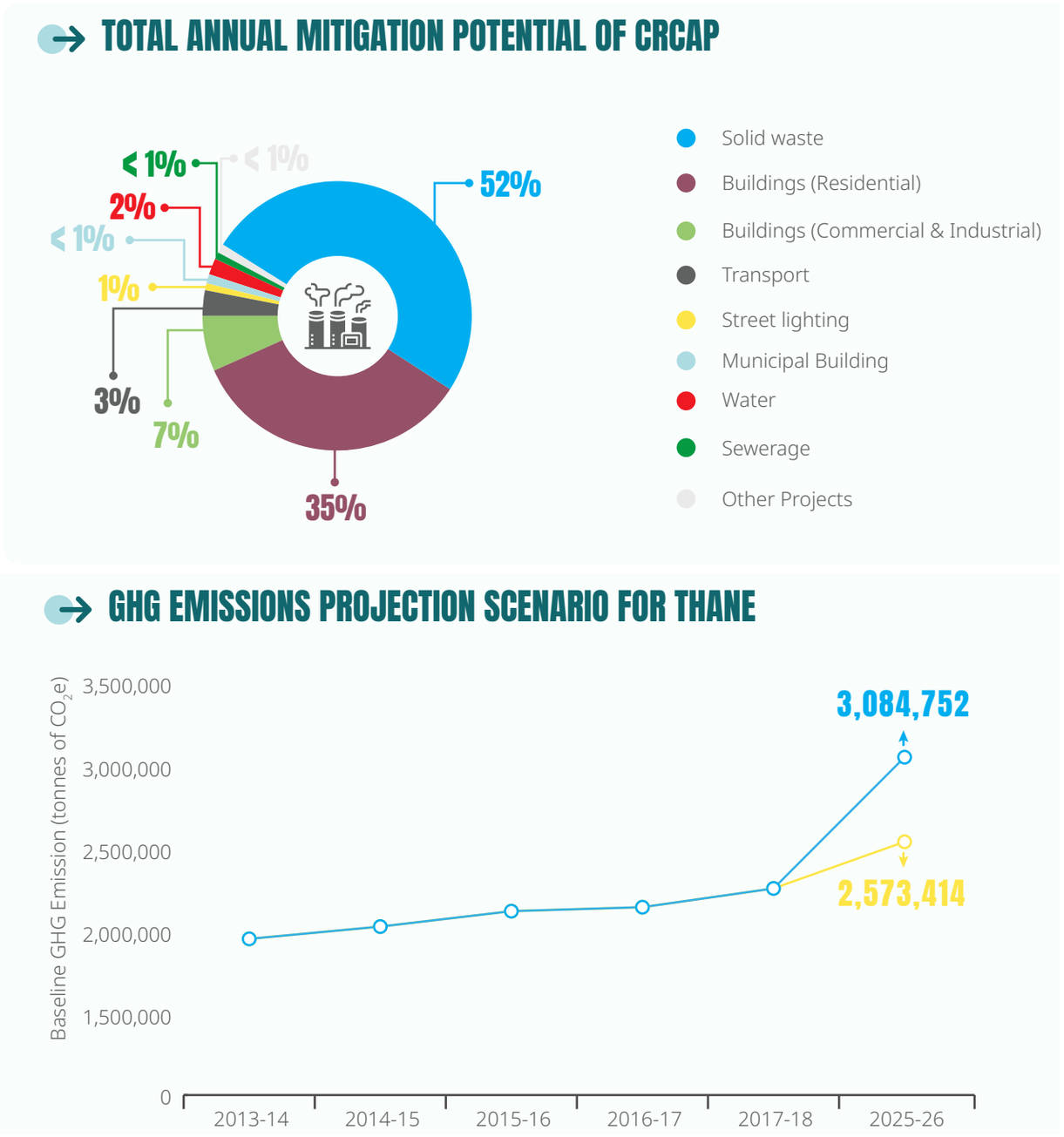
Table 37: Summary of Key Strategies and Measures for Climate Resilience

Sectors	Key Strategies	Mitigation Potential (tCO_2e)
Solid Waste	1 Waste to energy plant, Decentralized bio methanation and composting plants 2 Material recovery facility, Scientific closure and gas collection mechanism at landfill sites, Solar farm	265,604
Residential Buildings	1 Renewable Energy (RE): Solar PV, Solar water heating systems 2 EE: Lighting, fans, star rated appliances, EE in common utilities 3 Implementation of green buildings	177,258
Commercial & Industrial Buildings	1 RE: Solar PV, Solar water heating 2 EE: Lighting, fans, star rated appliances, District Cooling Systems (DCS), green buildings 3 Adoption of waste minimization, circular economy, extended manufacturer's responsibility	34,152
Transport	1 Adoption of cleaner fuel like CNG and RE (solar PV) 2 Electric cars powered by solar PV for TMC officers and as taxis for last mile connectivity 3 Electric mobility framework, NMT, Pedestrian friendly walkways	15,677
Water	1 IUWM, IWRM, CMP, Integrated GWM policy 2 Reduction in NRW, EE in pumping, Solar PV systems, Energy and water audits 3 Revising tariff structure, Water ATMs	9,611

Sectors	Key Strategies	Mitigation Potential (tCO_2e)
Street Lighting	1 EE Street Lighting, GIS mapping and online monitoring	6,443
Wastewater	1 Solar PV systems, EE pumps 2 Operating STPs on full capacity, Regular monitoring of private STPs 3 Reuse of water, duel plumbing for high rise, Faecal sludge management policy	1,866
Municipal Buildings	1 Solar PV systems 2 EE (LED lights, EE fans and ACs), Reduction of heat ingress	678
Biodiversity	1 Carbon sequestration potential of Urban Forestry, Nature based solutions, Biodiversity kiosk	49
Disaster Management, Air, Pollution and Health	1 Heat Action Plan, Clean Air Action Plan 2 Air pollution: Source apportionment study and early warning systems, Monitoring health and climate risks 3 Capacity building: Disaster Management, Pollution Control Cell to Environment and Climate Change Cell	Not applicable
Stormwater	1 RWH with regular monitoring, IoT based stormwater grid, Hydro-geological studies, Flood management plan and implementation, Early warning system and flood lines, Sustainable urban drainage systems	Not applicable

Total → 511,338 tCO_2e

Figure 46: **GHG Emissions Reduction Scenario for Thane relative to BAU**



6.2 SECTORAL CLIMATE RESILIENCE INTERVENTIONS FOR THANE

6.2.1 Residential Buildings Sector

2017-18
Energy consumption
6,146,579 GJ

2017-18
GHG emission
989,820 tCO_2e

2017-18
60% of city's electricity consumption

Baseline status

- Highest consumer of electricity and highest contributor to city's GHG emissions
- Lack of awareness on government schemes/policies/subsidies related to EE and RE
- Humid climate and increasing temperature will increase energy consumption to meet cooling demand through fans and ACs.
- Increasing population and huge residential development in the city demand more energy.

Existing and Planned Measures by TMC

1. Information, Education and Communication (IEC) activities for government schemes/Star rating/ policies/subsidies on EE and RE measures by TMC
2. Mandatory use of solar water heating systems in new buildings, Solar PV especially for Urban Renewal Scheme and property tax rebate for the existing buildings using solar water heaters (SWH)
3. EE in common utilities (such as elevators, pumps, common lighting) of high rise buildings

Potential climate impact and BAU scenario

1. 2025-26 (projected): Annual Energy consumption – 8,854,987 GJ
2. 2025-26 (projected): Annual GHG emissions – 1,371,090 tCO_2e
3. 30.3% increase in electricity consumption and 77.5% increase in PNG consumption from 2017-18 to 2025-26

Potential climate resilience impact from identified interventions

1. Annual Energy saving post implementation of all measures: 215 million kWh
2. Annual GHG emissions reduction - 177,258 tCO_2e (13% of projected BAU emissions by 2025-26)
3. Net projected GHG emissions post implementation of interventions (2025-26): 1,193,832 tCO_2e
4. Reduced grid dependency, improved self-sufficiency from decentralized RE generation, thermal comfort at lower energy use

SDGs

GOAL 3: Good Health & Well-being

GOAL 7: Affordable & Clean Energy

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Note:

Status of each intervention is defined as:- Ongoing action: Already under implementation; Planned action: Being considered and planned for; New action: Proposed for the first time in the CRCAP

Climate resilient potential of each intervention is defined as very high, high, medium or low considering the aspects of redundancy, flexibility, responsiveness, access to technology, implementation duration and GHG emissions reduction potential

Duration of implementation:- Long-term: 5 to 10 years, Mid-term: 2-4 years, Short-term: 1- 2 years

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Adoption of EE in households 1. EE star rated appliance retrofits (includes ACs, refrigerators and TVs) 2. Replacement of CFL lights with LED bulbs/ tube lights and existing conventional fans with EE fans	**Scale:** At least 20% to 30% households from high income group (HIG) and mid-income group (MIG) category will use EE appliances. **Target:** HIG and MIG to be prioritized for adoption of EE ACs, refrigerator and TVs Adoption of LED lighting, fans and electrical appliances to be targeted in households of all income categories	Energy saving: 164.69 million kWh GHG emissions reduction: 135,504 tCO_2e Very high resilience potential	492	**Implementing entities** • Citizens, TMC and MSEDCL **Implementation mode** • Investment by consumers, supported by govt. grants and mandates by TMC • Schemes like UJALA & Star rating program, awareness generation by TMC and MSEDCL on EE and potential cost savings to support adoption	Ongoing action Short term
Adoption of EE in common utilities of residential apartments (particularly high-rise buildings) 1. EE water pumping 2. Replacement of existing common area and street lights 3. EE in the elevators	**Scale:** Implementation in about 50 high-rise buildings per year. Large number of existing as well as new high-rise buildings and townships in the city that can opt for EE common utilities.	Energy saving: 2.11 million kWh Average savings from EE adoption considered to be at least 30%. GHG emissions reduction: 1,733 tCO_2e Medium resilience potential	92	**Implementing entities** • Citizens, Residential societies (especially large and medium scale), TMC and MSEDCL **Implementation mode** • Investment by consumers, supported by govt. grants and mandates by TMC. MSEDCL/TMC can facilitate subsidized energy audits and awareness generation for large and medium size societies. Audit costs can also be recovered from the energy bills.	Ongoing action Medium term
Green building adoption	**Scale:** 15 additional green buildings to be developed during action plan period, in addition to nine existing green buildings in the city Target: Private townships such as Hiranandani, Rustumji, Lodha, housing primarily high income group households. Green buildings have good potential to save energy especially in terms of lighting, ventilation and building material.	Energy saving: 0.16 million kWh GHG emissions reduction: 130 tCO_2e Low resilience potential[28]		**Implementing entities** • Building developer association and green building rating organizations, TMC Implementation mode • Investment by building developers and owners. • Promotion of Green Building Policy, increased awareness among builders and architects, supported by easier/ fast-tracked building permission approval for green buildings and mandates from TMC.	Ongoing action Medium term

28 Primarily due to limited considerations like distance between two buildings, obstacle to natural light by trees and other facility infrastructure around the buildings, building material, orientation of roads and shape of land, higher population density, space constraints etc.

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Installation of EE equipment (super-efficient fans and LED lights) in households at Urban Renewal Plan/ Cluster development at Kopri	**Scale:** Adoption in housing units under the Cluster (assumed that 25% of planned development will be completed by 2025-26) The implementation will take place in a phase-wise manner and is expected to be initiated with the Kopri scheme.	Energy saving: 3.27 million kWh GHG emissions reduction: 2689 tCO_2e Medium resilience potential	34	**Implementing entities** • TMC and private building developers **Implementation mode** • PPP model, support through municipal budget. Developing EE as an inclusive part of the URP project implementation and promoting the same.	New action Long term
Rooftop Solar PV installation at Cluster development, Kopri	**Scale:** About 52268 kWp capacity solar PV will be installed by 2025-26 Target: Residential buildings of Kopri URP	Energy saving: 7.84 Million kWh GHG emissions reduction: 6450 tCO_2e Reduced power grid dependency High resilience potential	366	**Implementing entities** • TMC, building developers & owners, DISCOM **Implementation mode** PPP mode, RESCO/PPA based model with capital investment by third-party. Ensuring Integration of renewable energy as an inclusive part of the URP project implementation (in and promoting the same.	New action Long term
Adoption of solar energy in residential buildings 1. Use of SWH in place of conventional geyser 2. Installation of Rooftop Solar PV Supporting measures: 1. Publicly available webpage with database of service providers and contacts 2. Regular monitoring of the implemented systems	**Scale:** 36 buildings will opt for rooftop Solar PV systems for electricity generation About 5,000 new households (HHs) and 500 existing HHs per year will opt for SWH Target: Individual consumers especially HIG and MIG	Energy saving: 37.38 million kWh GHG emissions reduction: 30751 tCO_2e Reduced power grid dependency Very high resilience potential	553	**Implementing entities** • Citizens, TMC and MSEDCL **Implementation mode** • TMC's policy on SWH and tax rebate, strong monitoring and promotion of the same. • Aggregation of multiple projects facilitated by TMC or external third-party to reduce costs.	Ongoing action Short term

6.2.2 Commercial and Institutional Buildings

2017-18
Energy consumption
1,140,178 GJ

2017-18
GHG emission
199,448 tCO_2e

2017-18
22% of city's electricity consumption

Baseline status

1. 68% projected increase (BAU) in electricity consumption over 2017-18
2. Lack of awareness on government schemes/ policies/ subsidies related to EE and RE
3. Considering the benefits and payback period, this sector can afford quick adoption of RE and EE
4. Due to increasing population, this sector is expected to grow significantly

Existing and Planned Measures by TMC

1. Promotion of RE and EE among all the commercial and institutional entities
2. Mandatory use of SWHs for new development and tax rebate for existing
3. District cooling

Potential climate impact and BAU scenario

1. 2025-26 (projected): Annual energy consumption – 2,140,776 GJ
2. 2025-26 (projected): Annual GHG emissions – 282,807 tCO_2e
3. About 60% increase in the GHG emissions compared to baseline of 2017-18

Potential climate resilience impact from identified interventions

1. Annual energy saving post implementation of all measures - 38.73 million kWh
2. Annual GHG emissions reduction - 31,866 tCO_2e (11% of projected BAU emissions by 2025-26)
3. 2025-26: Net projected GHG emissions post implementation of interventions: 250,941 tCO_2e
4. Reduced grid dependency, improved self-sufficiency from decentralized RE generation, thermal comfort at lower energy use

SDGs

GOAL 7: Affordable & Clean Energy

GOAL 8: Decent Work & Economic Growth

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities and Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Adoption of EE equipment in commercial and institutional buildings 1. Replacement of CFL lights with LED bulbs/tube lights and existing fans with EE fans 2. EE star rated AC retrofits	**Scale:** • About 50-60% commercial and institutional buildings shall opt for EE measures • 20% of total hot water requirement for hotels and hospitals is met by solar water heating by 2025-26	Energy saving: 32.35 million kWh GHG emissions reduction: 26,534 tCO_2e Very high resilience potential	142	**Implementing entities** • Commercial and institutional entities, TMC, DISCOM **Implementation mode –** • Investment by private businesses, supported by govt. grants and mandates by TMC. TMC's policy on solar water heating system, strong monitoring of the same and promotion of RE and EE. • IEC activities for solar PV uptake and regular monitoring of the implemented systems are also important. Solar PV systems can be installed through RESCO/PPA based model with capital investment by third-party. Aggregation of multiple projects facilitated by TMC or external third-party to reduce costs.	Ongoing action Short term
Adoption of EE in common utilities 1. EE in water pumping 2. EE in common area lighting and streetlights	**Target:** Shopping malls, centres, academic institutes, hospitals and hotels in the city	Energy saving: 0.36 million kWh GHG emissions reduction: 294.36 tCO_2e Medium resilience potential	7.5		Ongoing action Short term
Adoption of RE in common utilities 1. Use of SWH in place of conventional geyser for hotels and hospitals 2. Rooftop Solar PV in institutions and commercial units		Energy saving: 6.12 million kWh GHG emissions reduction 5037 tCO_2e Reduced share of grid dependency High resilience potential	228		Ongoing action Short term
Promotion and adoption of District cooling system (DCS) in commercial and institutional buildings, particularly at Kopri Urban Renewal Plan	Scale: Inclusion of DCS can be targeted in commercial development at Kopri URP. Assumed that 25% development takes place by 2025-26[29] High potential for district cooling adoption given the hot and humid climate, strong real estate growth (particularly in the service sector), and high cooling demand. Deep-dive feasibility studies for district cooling in Thane have concluded that the technology is commercially viable for projects with high commercial footprint and cooling demand, and can deliver significant benefits.	Energy saving: 0.16 million kWh GHG emissions reduction: 133 tCO_2e Efficient management of cooling demand to deliver improved thermal comfort Medium resilience potential	41	**Implementing entities** Commercial and institutional entities, Private building developers/owners, TMC **Implementation mode** PPP model with TMC's coordination; municipal budget to support	New action Long term

29 50% of total electricity demand assumed for air conditioning or space cooling

6.2.3 Manufacturing Industry and Construction (i.e. Industry Sector)

2017-18
Energy consumption
1,205,779 GJ

2017-18
GHG emission
250,145 tCO_2e

2017-18
18% of city's electricity consumption

Several industries are moving out of the city due to high land and operational costs, zoning and other regulations

Baseline status

1. Lack of awareness on government schemes/policies/subsidies related to EE and RE including its payback period and clean fuel
2. Due to increasing land and O&M cost, manufacturing industries are reducing but construction industry is growing with residential and commercial projects.
3. The service sector and IT industries are replacing the manufacturing industries.

Existing and Planned Measures by TMC

1. IEC activities for the benefits of RE and EE, investments needed and payback periods with potential cost savings by TMC, Industrial Association, MIDC etc.
2. Increasing share of RE with subsidies

Potential climate impact and BAU scenario

1. 2025-26 (projected): Annual Energy consumption– 1471489 GJ
2. 2025-26 (projected): Annual GHG emission – 223,637 tCO_2e

Potential climate resilience impact from identified interventions

1. Annual energy saving post implementation of all interventions - 2.62 million kWh
2. Annual GHG emissions reduction – 2,153 tCO_2e (<1% of projected BAU emissions by 2025-26)
3. 2025-26: Net projected GHG emissions post implementation of interventions: 221483 tCO_2e
4. Reduced grid dependency, improved self-sufficiency from decentralized RE generation

SDGs

GOAL 7: Affordable & Clean Energy

GOAL 8: Decent Work & Economic Growth

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities and Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Adoption of EE equipment and appliances in industries (including lighting, fans, pumps and air conditioning)	**Scale:** At least 25 industrial units will opt for EE measures having minimum 30% savings[30]. **Target:** Industrial units at the Wagale Industrial area	Energy saving: 1.87 million kWh GHG emissions reduction: 1,536 tCO_2e High resilience potential	-	**Implementing entities** – MIDC, local industries, TMC and MSEDCL **Implementation mode** –Investment by private businesses/industries supported by govt. grants and mandates by MIDC. Solar PV systems can be installed through RESCO/ PPA based model with capital investment by third-party. Aggregation of multiple projects facilitated by TMC or external third-party to reduce costs.	New action Short term
Adoption of Rooftop Solar PV in various industries	**Scale:** 100 kWp of solar PV installations per year **Target:** Industrial units, especially ones located at the Wagale Industrial area[31] and the upcoming IT industry	Energy saving: 0.75 million kWh GHG emissions reduction: 617.09 tCO_2e Medium resilience potential	35		New action Short term

30 Considering the hours of operation, opportunity for higher energy saving with reasonable payback periods
31 Roof tops, parking areas and common utility areas of the industries could be considered.

6.2.4 Water Supply

2017-18
Energy consumption
151,258 GJ

2017-18
GHG emission
34,570 tCO_2e

Availability of water: Due to high per capita per day supply by TMC and easy access to ground water, overall per capita water consumption is high in Thane.

Baseline status

1. Dependency on external agencies for water supply: TMC depends on 3 other agencies, i.e. Municipal Corporation of Greater Mumbai (MCGM), STEM water Distribution and Infrastructure company, Thane and Maharashtra Industrial Development Corporation (MIDC). The total dependency is about 56%.
2. Smart metering and NRW: Rate of installation and acceptance by citizens is comparatively low.
3. There is a mandate to construct rainwater harvesting systems in all new projects in Thane. However, their continued functioning is to be ensured.

Existing and Planned Measures by TMC

1. Augmentation of existing sources of water - the SHAI dam project
2. Remodelling of water supply network at central, south and north zones
3. Smart Metering: About 1,13,000 connections to be equipped with AMR meters
4. Smart water management: mapping of water infrastructure, hydraulic modelling and SCADA

Potential climate impact and BAU scenario

1. 2025-26 (projected): Energy consumption – 174,600 GJ
2. 2025-26 (projected): GHG emission – 38,785 tCO_2e
3. Electricity consumption will increase by 12.18% as compared to 2017-18
4. Climate Risk Status: Medium | Increased temperatures impact weather patterns, higher evapo-transpiration and may reduce available water, while also increasing water consumption
5. Flooding during high intensity rainfall events increases chances for potential contamination of surface water due to compromised water distribution and sewage collection networks

Potential climate resilience impact from identified interventions

1. Energy saving - 11.68 million kWh
2. GHG emissions reduction - 9611 tCO_2e (25% of projected BAU emissions in 2025-26)
3. Net projected GHG emissions post implementation: 29,173 tCO_2e
4. Reduced wastage of freshwater, improved EE
5. Improved ground water level through water augmentation, ground water recharge, higher degree of self-sufficiency

SDGs

GOAL 3: Good Health & Well-being

GOAL 5: Gender Equality

GOAL 6: Clean Water & Sanitation

GOAL 10: Reduced Inequalities

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

GOAL 14: Life Below Water

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Status and Duration of Implementation
Reduction of non-revenue water (NRW)	**Scale:** NRW reduction from 37% to 25% (proposed) **Target:** Entire city NRW reduction targeted through measures such as remodelling, SCADA, AMR meters, identifying illegal connections	Energy saving: 3.86 million kWh GHG emissions reduction: 3,179.90 tCO_2e Improved financial efficiency, reduced energy consumption, increased access to water High resilience potential	1,760	**Implementing entities** – Water supply and other relevant departments of TMC, MCGM, MIDC, STEM, PWD, Urban Development Department and Water Resources Department (GoM) **Implementation mode** Through state and national missions like AMRUT, Smart City and municipal budgetary provisions. For IUWM and IWRM, TMC can partner with academic institutions, international organizations, NGOs and local stakeholders along with IEC	Planned action Medium term
Reuse of treated wastewater for gardening and green cover[32]	**Scale:** Gardens and green cover , covering an area of about 10 hectares, including road side plantation and gardens, are proposed, especially near the STPs and private properties - treated wastewater can be used for this proposed green cover **Target:** 362 million litres/year treated wastewater could be reused.	Energy saving: 0.04 million kWh GHG emissions reduction: 33.83 tCO_2e Reduced fresh water consumption Low resilience potential	25		New action Short term
Solar PV installation at Temghar water treatment plant and other water pumping stations	**Scale:** About 2150 kWp capacity Target: Water treatment plants have considerable open land which can be utilized for solar PV systems. Solar PV installations targeted at three water pumping stations, to being with.	Energy saving: 3.23 million kWh GHG emissions reduction: 2,653 tCO_2e Reduced power grid dependency High resilience potential	172		Planned and New action Medium term
EE implementation based on Energy Audits	**Scale:** There is significant scope to improve EE in the water supply and distribution network and infrastructure. Conducting energy audits will help identify EE improvement measures for equipment such as pumps and motors. At least 10% reduction in energy consumption is envisaged.	Energy saving: 4.55 million kWh GHG emissions reduction: 3,744 tCO_2e High resilience potential	5		New action Medium term

32 Treated wastewater to be supplied via tankers

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Status and Duration of Implementation
Policy and planning interventions: Integrated urban water management (IUWM) plan Integrated Water Resource Management (IWRM) plan Integrated Catchment/ watershed management plan Integrated groundwater development and management plan	Key actions: Initial studies to assess existing baseline scenario, water budgeting and setting visions Assess impact of climate change on water demand and supply infrastructure Identify strategies for augmenting water resources Secure resources by integrating sustainable land-use and land-use change (LULC)/blue-green infrastructure in planning and redevelopment Conserving water resources by joining hands with rural /peri-urban areas	Enhances security of water supply in the future Equitable access to all Water efficiency High resilience potential	2		New action

6.2.5 Wastewater

2017-18
Energy consumption
6415 GJ

2017-18
GHG emission
69,624 tCO_2e

Baseline status

1. Inadequate capacity of existing STPs and protracted timeline for execution of the under construction STPs
2. Reuse and recycle policy absent; no control on groundwater extraction
3. Infiltration of rainwater runoff dilutes the sewage and makes it difficult to operate STPs with designed organic load
4. Untreated partially treated sewage increases surface water pollution, impacting aquatic life
5. Poor performance of private STPs; limited monitoring

Existing and Planned Measures by TMC

1. Extending drainage network (including pumping stations) to uncovered areas especially Ghodbunder, Mumbra and Diva
2. Construction of STPs at following locations: Vitava, Kharigaon, Kolshet, Majiwada and Diva

Potential climate impact and BAU scenario

1. 2025-26 (projected): Energy consumption – 5.13 million GJ
2. 2025-26 (projected): GHG emission – 106,633.80 tCO_2e
3. Climate Risk Status: High | Increased rainfall impacts sewage collection and treatment operations
4. 34% increase in GHG emissions as compared to base year 2017-18
5. Excess/untreated and partially treated sewage mainly from the septic tanks discharged in the Nullahs, Thane creek and Ulhas river estuary due to short duration and high intensity rainfall

Potential climate resilience impact from identified interventions

1. Energy saving - 2.27 million kWh
2. GHG emissions reduction - 1865.50 tCO_2e (2% of projected BAU emissions in 2025-26)
3. Net projected GHG emissions post implementation: 104,768.3 tCO_2e
4. Untreated discharge into water bodies or natural drains is prevented
5. Increased productivity of contaminated water bodies and land parcels and enhanced ecosystem services of key areas like mangroves.
6. Decentralized STPs help reduce Phosphorus and Nitrogen and ultimately N_2O emissions and nutrient load in water resources.

SDGs

GOAL 3: Good Health & Well-being

GOAL 5: Gender Equality

GOAL 6: Clean Water & Sanitation

GOAL 8: Decent Work & Economic Growth

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

GOAL 14: Life Below Water

GOAL 15: Life on Land

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
EE in pumping and SCADA implementation	SCADA systems for reduced manual operations and errors	Energy saving: 0.54 million kWh GHG emissions reduction: 446.20 tCO_2e Improved operational efficiency Medium resilience potential	2.5	**Implementing entities** Sewage Management Department, Pollution Control Cell, and other relevant departments of TMC, MPCB, PWD, Urban Development Department and Water Resources Department (GoM) **Implementation mode** Through state and national missions like AMRUT, Smart City and municipal budgetary provisions. For policy level interventions city can partner with academic institutions, international organizations, NGOs and local stakeholders	Planned action Short term
Solar PV for Kopri STP	**Solar PV Scale:** Kopri STP with 1,000 kWp of solar PV installation and 3 pumping stations with 50 kWp solar PV systems each	Energy saving: 1.50 million kWh GHG emissions reduction: 1,234 tCO_2e Reduced share of grid dependency High resilience potential	80		Planned action Medium term
Rooftop Solar PV for Sewage pumping stations		Energy saving: 0.23 million kWh GHG emissions reduction: 185.13 tCO_2e Medium resilience potential due to space constraint	13.5		New action Medium term
Policy and planning interventions: Action plan for decentralized sewage treatment plants Policy for waste water reuse for bulk usage like irrigation/ gardening, construction activities and dust control Policy for fecal sludge management Policy on dual plumbing and reuse of treated wastewater	Key activities: Feasibility assessment and technology selection for the decentralized treatment units[33] and provision of adequate funding Mandatory separation of grey and black water at large townships, commercial and institutional entities, to facilitate onsite treatment	Increased productivity of water bodies Reduced pollution Improved health	4		New action Short term

33 Vermifiltration, Constructed wetlands, DEWATS, Soil Bio-Technology (SBT) etc.

6.2.6 Street Lighting

2017-18
Energy consumption
77,461 GJ

2017-18
GHG emission
17,704 tCO_2e

Baseline status

1. Frequent road construction and new projects impact the efficacy of the existing street lighting
2. Partial implementation of 100% EE lighting infrastructure; slow progress
3. Street light design does not consider future development like roads and bridges

Existing and Planned Measures by TMC

1. ESCo based LED street lighting to replace about 7500 street lights is being executed by TMC
2. Sodium vapour street lights are being replaced with LED lighting

Potential climate impact and BAU scenario

1. 2025-26 (projected): Energy consumption - 57,708 GJ
2. 2025-26 (projected): GHG emission - 12,896.76 tCO_2e
3. Total 37% GHG emissions reduction as compared to base year 2017-18

Potential climate resilience impact from identified interventions

1. Energy saving - 7.83 million kWh
2. GHG emissions reduction - 6443 tCO_2e (50% of projected BAU emissions by 2025-26)
3. Net projected GHG emissions post implementation: 6453 tCO_2e
4. Improved lighting especially for traffic and pedestrian, enhanced safety and security in the city, reduced energy consumption

SDGs

GOAL 3: Good Health & Well-being

GOAL 7: Affordable & Clean Energy

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Replacement of existing street lighting with EE lights[34]	**Target:** Remaining conventional HPSV streetlights are replaced by LED street lights including ones located in slum areas, internal roads/by-lanes, new and existing roads	**Energy saving:** 7.83 million kWh GHG emissions reduction: 6,443 tCO_2e Reduced energy consumption, better visibility and security Very high resilience potential	245	**Implementing entities -** Electrical Department of TMC, Integrated Command and control centre of TMC, Private townships and road **Implementation mode** ESCo model and through municipal budget	Ongoing action Short term

34 To be undertaken through ESCo and non-ESCo modes. Other measures such as improving power factor, auto on/off are already implemented.

6.2.7 Transport

2017-18
Energy consumption
4,016,778.25 GJ

2017-18
*GHG emission
326,057 tCO_2e

Baseline status

1. Lack of dedicated pedestrian and cycling lanes
2. Lack of regulated parking – especially in the vicinity of the railway station and commercial areas
3. Air pollution due to dust from unpaved roads and increasing automobiles
4. Congestion due to road encroachments by informal hutments and vendors
5. Inadequate public transport and increasing vehicles in the city

Existing and Planned Measures by TMC

1. New sub-urban railway station: A land pocket of 14.83 acre has been allocated near the Mental Hospital
2. Metro rail project connecting Mumbai to Thane; internal metro rail network of 29 km, with 22 stations is proposed; 20% capital share of TMC
3. Inland water ways development
4. Personalized Rapid Transit System to develop feeder network for metro rail
5. Multimodal transit hub at east side of the Thane railway station which includes elevated roads as well as a bus terminus and parking area
6. Soft Mobility Plan to develop 12.87 km roads in ABD area
7. 100 electrical buses with charging facility
8. Intelligent Traffic System to inform bus routes and tracking, road asset mapping and Adaptive Traffic Management System
9. Parking facilities planned to be improved and added

Potential climate impact and BAU scenario

1. 2025-26 (projected): CNG consumption – 9,150,284 GJ
2. 2025-26 (projected): GHG emission – 708,165 tCO_2e
3. Projected BAU GHG emissions in 2025-26: 117% of 2017-18 emissions
4. Climate Risk Status: Medium | Increased temperature: increased cooling demand in public transport; increased rainfall intensity: exacerbates traffic movement issues and disrupts public transport

Potential climate resilience impact from identified interventions

6. Fuel saving - 3168.38 KL of diesel and 2.11 MU of electricity consumption
7. GHG emissions reduction[35] - 496297 tCO_2e (<1% of projected 2025-26 BAU emissions)
8. Net projected GHG emissions post implementation: 211868 tCO_2e
9. Improved public transport, NMT and reduced air pollution in the city

35 Metro emissions are not considered.

SDGs

GOAL 3: Good Health & Well-being

GOAL 7: Affordable & Clean Energy

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

*(including emissions from rail electricity consumption)

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Commercial sector: Transportation by private taxis and buses 1. CNG vehicles replace private diesel taxis and buses	**Scale:** 135 diesel taxis and buses in private offices to be replaced by CNG vehicles on priority. **Target:** Entire city	Fuel saving: 453 kilo-litres of diesel GHG emissions reduction: 735 tCO_2e High resilience potential	250	**Implementing entities:** Thane Municipal Transport, Roads and Projects Department of TMC in consultation with MMRDA, RTO, MSRDC, NHAI, Fuel companies, Transport association, Indian Railways (Local trains), Metro rail corporation, Taxi union, Auto rickshaw union	New action Medium term
2. Adoption of EVs for last mile connectivity – solar PV based charging	400 diesel taxis to be replaced by EVs. **Target:** Entire city	Energy saving: 2.11 million kWh GHG emissions reduction: 1,738 tCO_2e High resilience potential	99		New action Medium term
Public transport: 1. Electric buses in place of diesel buses, powered by solar PV	**Scale:** 60 E-buses and 55 CNG buses to replace 115 diesel buses **Target:** Thane Municipal Transport buses	Energy saving: 2,701 kilo litres (shift from diesel buses) GHG emissions reduction: 7,699 tCO_2e Very high resilience potential	1,200	**Implementation mode:** Private sector through their own investments. Government sector: The revised EV policy of Maharashtra 2021 and financial support by the state and central govt. (FAME), municipal budget/PPP modes	New action Short term
2. Rooftop SPV - RE for e-buses		Energy saving: 6.08 million kWh (solar PV charging of 60 EV buses) GHG emissions reduction: 5,000.27 tCO_2e Very high resilience potential	324		New action Short term

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
3. CNG buses in place of diesel buses for TMT		Energy saving: 732 kilo litres GHG emissions reduction: 483 tCO_2e Medium resilience potential	147		Ongoing action Short term
Introduction of electric cars in the municipal vehicle fleet, to be powered by solar PV[36]	**Scale:** 10% of the existing cars owned by TMC to be replaced until 2025-26 **Target:** TMC owned vehicles used by field officers	Energy saving: 7.81 million kWh GHG emissions reduction: 22.25 tCO_2e Medium resilience potential	—		Ongoing action Medium term
Updating Thane's Comprehensive Mobility Plan (CMP) for sustainable transport strategies and promoting pedestrian friendly walkways	**Key activities:** • Define a baseline and goals for improved public transport • Inclusion of cleaner freight and water ways • Prepare an electric mobility framework for public transport, bike delivery system and last mile connectivity	Reduced fuel consumption and GHG emission Reduced traffic congestion, improved air quality and public health, improved accessibility High resilience potential	-		New action Short term

36 Cost is not considered assuming TMC will be purchasing new vehicles to replace existing vehicles in future.

6.2.8 Solid Waste

2017-18

GHG emission

331,263 tCO_2e

Baseline status

1. **Waste Segregation:** Waste segregation is identified as the biggest issue in Thane, which impedes efficient waste treatment.
2. **Waste treatment:** Inadequate capacity of solid waste processing facilities
3. **Littering:** Rampant disposal of soli d waste in open nullahs and water bodies such as creeks, estuaries and lakes
4. **Dumpsite:** Existing dumpsite is not scientifically capped.

Existing and Planned Measures by TMC

1. A waste to energy plant is proposed.
2. Decentralized waste treatment facilities such as garden waste to manure, C&D waste recycling, Bio methanation plants, Thermocol recycling, Waste to RDF and composting sites are proposed.
3. 60 TPD Bio CNG plant for processing animal carcasses
4. A 5 TPD plastic waste to oil plant
5. A mobile Organic Waste Converter (OWC) based solid waste treatment plant to treat organic waste from the slums
6. 150 Containers of 1 ton capacity and 225 litterbins for collection of solid waste
7. Scientific closure of 3 dumping areas at the Diva Khardi area through capping method and plantation through social forestry

Potential climate impact and BAU scenario

- 2025-26 (projected): GHG emissions – 459197 tCO_2e
- 2025-26 projected emissions increase by 38.62% compared to 2017-18
- Climate Risk Status: High | Increased temperatures result in landfill fires, and disrupt treatment processes; increased rainfall results in increased moisture in the waste, rendering it difficult to handle and process

Potential climate resilience impact from identified interventions

- Energy saving - 41.88 million kWh
- GHG emissions reduction – 249,109 tCO_2e (54% of projected BAU 2025- 26 emissions)
- Net projected GHG emissions post implementation: 210,088 tCO_2e
- Energy saving - 3168 KL of diesel and 2.11 million units of electricity

SDGs

GOAL 3: Good Health & Well-being

GOAL 7: Affordable & Clean Energy

GOAL 8: Decent Work & Economic Growth

GOAL 11: Sustainable Cities & Communities

GOAL 13: Climate Action

GOAL 14: Life Below Water

GOAL 15: Life on Land

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Waste to Composting	Scale: Composting: Multiple plants with a total capacity of 32 TPD	GHG emissions reduction: 1803 tCO_2e Improved health, cleaner city, reduced emissions from landfill High resilience potential	52.5	Implementing entities: SWM department with support from Pollution Control Cell of TMC. Implementation mode: Municipal budget, schemes and financial support by state and national level like Swachh Bharat Mission. Strengthen/ promote community level composting for organic waste processing and establishing composting centres (ward level Organic Waste Converter (OWC), IEC activities for Circular Economy (3R principles) and institutionalization of citizens' participation through ward-level committees	Planned action Short term
Bio methanation	Bio methanation: Multiple plants with a total capacity of 55 TPD	GHG emissions reduction: 361 tCO_2e Improved health , cleaner city, reduced emissions from landfill, electricity and/or biogas fuel generation Medium resilience potential	75.5		Planned action Medium term
Waste to energy with generation of electricity	Waste to energy plant of 600 TPD capacity[37]. Target: Decentralized plants are planned for at large and medium townships and in commercial and institutional complexes. Waste to Energy facility at MSW management facility at Daighar	Energy saving: 41.88 million kWh (shift from conventional electricity generation) GHG emissions reduction: 7298 tCO_2e + 27141 tCO_2e (from fuel shift and additional electricity generated) Improved health, cleaner city, reduced emissions from landfill Very high resilience potential	1330		Planned action Long term
Policy and planning	Preparation of city-wide Holistic Waste Management Plan Preparation of action plan for cluster-based material recovery facilities and recycling centres Policy for waste minimization, composting, collection and segregation of domestic hazardous waste Scaling up GIS enabled Smart Waste Management Services for bins and vehicles and integration with command and control centre	Efficient waste management and appropriate treatment Very high resilience potential			New action Short term

37 Waste to energy plant will generate electricity from 50% of solid waste from 2024 and considerably reduce the land filling quantity.

6.2.9 Municipal Buildings

2017-18
Energy consumption
4,016,778.25 GJ

2017-18
GHG emission
326,057 tCO_2e

Baseline status

1. Increase in cooling demand
2. Vast development of infrastructure like parking facilities, water front development, gardens, hospitals and other amenities in the city, leading to greater energy demand
3. Rising energy demand due to increasing number of municipal buildings

Existing and Planned Measures by TMC

1. Promotion of RE and EE through various means like solar cell, awareness activities etc.
2. Mandatory implementation of EE lights, fans and ACs
3. Roof top solar PV for energy generation

Potential climate impact and BAU scenario

- 2025-26 (projected): Energy consumption – 755,517.91 GJ
- 2025-26 (projected): GHG emissions – 171,534.23 tCO_2e
- About 57% increase in 2025-26 emissions compared to baseline of 2017-18

Potential climate resilience impact from identified interventions

- Energy saving - 1.15 million kWh
- GHG emissions reduction – 946.79 tCO_2e (<1% of projected BAU emissions by 2025-26)
- Net projected GHG emissions post implementation: 170,587 tCO_2e
- Reduced grid dependency, improved self-sufficiency from decentralized RE generation, thermal comfort at lower energy use

SDGs

GOAL 7: Affordable & Clean Energy

GOAL 8: Decent Work & Economic Growth

GOAL 9: Industry, Innovation & Infrastructure

GOAL 11: Sustainable Cities & Communities

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Indicative Cost (Million INR)	Implementation Entities and Mode	Implementation Status and Duration
Adoption of EE equipment in municipal owned commercial and institutional buildings 1. Replacement of CFL lights with LED bulbs/ tube lights and existing fans with EE fans 2. EE star rated AC retrofits	Scale: EE: About 3,500 lights, 400 conventional fans and 500 ACs are considered to be replaced and retrofitted by EE measures RE: Rooftop solar PV with about 283 kWp capacity at various municipal offices	Energy saving: 0.40 Million kWh GHG emissions reduction: 328.9 tCO_2e Very high resilience potential	29	**Implementing entities:** Electrical department and other relevant departments of TMC **Implementation mode:** Allocation of municipal budget Existing policy on mandatory replacement of Star rated appliances in place of defunct appliances	Ongoing action Short term
Adoption of rooftop Solar PV systems	Target: Selected municipal offices and amenities	Energy saving: 0.42 Million kWh GHG emissions reduction: 348.8 tCO_2e Very high resilience potential	23	Strong monitoring along with IEC activities Solar PV systems can be installed through RESCO/PPA based model with capital investment by third-party. Aggregation of multiple projects facilitated by TMC or external third-party to reduce costs	Ongoing action Short term

6.2.10 Stormwater Management

The total length of natural storm water drains in Thane city is 153 km. The storm water network in the city is of length more than 400 km.

Baseline status

- Climate change: Increased rainfall with increase in high intensity, short duration rainfall events
- Land use and land cover plan of the city: More paved surface leads to less percolation and more runoff
- High tide impeding drainage: Thane drains are tidal influenced, hindering flow from upstream area into the outflow channels due to back flow from Thane Creek and Ulhas River Estuary
- Culverts are usually solid waste dumping points
- Siltation in drain: Siltation has reduced the carrying capacity of drains
- Dam overflows: Overflow of dams located on the upstream areas of Ulhas River Estuary has resulted in rise in water levels, causing flooding in adjoining areas.
- Rampant construction in flood plain of the river and creek obstructs natural flow of runoff.
- Inadequate inlet arrangement for road side drains and connections from drain to nullah

Existing and Planned Measures by TMC

- Integrated Nullah Development Program Phase 4 has been considered under the AMRUT scheme and 4.45 km length of nullah development work is considered under the Smart Cities Mission.
- Pumping stations and tidal gates at 10 locations: 3 each in core city, Ghodbundar and Mumbra areas and 1 in Kalwa area are proposed.
- Pre-monsoon cleaning of drains

Potential climate impact and BAU scenario

- Climate Risk Status: Medium | Increase in high intensity, short duration rainfall will lead to more water logging in the city.
- 63% of the city catchment area was covered after implementation of the INDP program. Drains are being designed for 20% increased rainfall intensity as an adaptation factor for climate change.

Potential climate resilience impact from identified interventions

- Proposed measures will reduce the impact of water logging and allied problems.

SDGs

GOAL 3: Good Health & Well-being

GOAL 6: Clean Water & Sanitation

GOAL 11: Industry, Innovation & Infrastructure

GOAL 12: Responsible Consumption & Production

GOAL 13: Climate Action

GOAL 14: Life Below Water

GOAL 15: Life on Land

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Cost of Interventions (Million INR)	Implementation Entities and Mode	Implementation Status, Duration
Action plan for Sustainable Urban Drainage System (SUDS)	To increase natural percolation from surfaces by using percolation pits along major roads, use of permeable surface material and training programs for architects and civil engineers for the same	To reduce the impact of water logging and flooding, especially by reducing the exposure of vulnerable groups while also improving the groundwater table in the city	20	Implementing entities Primarily stormwater (Nullah) Dept. with the help of Disaster Management Cell, Pollution Control Cell, Roads and Projects Dept., PWD, Integrated Command and Control Centre of TMC, Private townships and commercial areas Implementation mode Municipal budgetary provision, partnering with international funding and developing inclusive proposals considering state and national schemes/ missions	New action High resilience potential in short term
Stormwater Smart grid – feasibility assessment	IoT based rainfall tracking and smart use of RWH along with flood mitigation actions based on runoff generation				New action Medium resilience potential in long term
Watershed assessment and hydro-geological studies	Runoff assessment and monitoring of on ground solid waste disposal, sewage discharge and activities causing soil pollution - to be periodically assessed before onset of the monsoon				New action High resilience potential in short term
Monitoring exiting RWH systems, developing and publicizing online platform for information sharing			1		
Policy on mandatory use of roof top rain water	Captured rooftop runoff to be used for secondary purposes during monsoon, especially in large properties; regular monitoring of the same				
Rejuvenation of water bodies (lakes) in Thane	Climate risk and vulnerability assessment for Thane revealed that water logging caused during short duration, high intensity events that coincide with high tides is difficult to manage. The existing lakes can serve as holding tanks; additional holding tanks are to be proposed. Other non-infrastructural measures such as clearing inlets to drains, removing encroachments etc.				Planned action High resilience potential in medium term

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Cost of Interventions (Million INR)	Implementation Entities and Mode	Implementation Status, Duration
Scaling up - Early warning systems for water logging/ flooding[38]			15		New action Very high resilience potential in short term
Flood management planning including actions like detention tanks, tidal gates, diversions and flood pumps for overall improvement in stormwater management system					Ongoing action Very high resilience potential in medium term
Strengthening weather forecasting and monitoring system especially IoT based rain gauges to capture spatial variation of rainfall			3		New action High resilience potential in long term
Strong enforcement of flood lines in town planning					High resilience potential in medium term

38 Pilot implementation has been carried out under the European Commission funded Urban LEDS II project: Thane Urban Flood Alert Network (TUFAN)

6.2.11 Disaster Management, Biodiversity, Pollution Control and Health

Regional Disaster Management Cell: Role is limited to floods, building collapse, landslides, accidents; not inclusive of assessment of climate risks like heat waves, sea level rise etc.

Baseline status

- Slums, unauthorized and dilapidated buildings are vulnerable during disasters.
- Encroachment on the banks of water bodies makes it difficult to take restoration measures.
- Restoration of aquatic ecosystem is not given due importance.
- Need for clarifying land titles and ownership of public lands to reduce illegal encroachment on the same
- The scope for garden department and Pollution Control Cell is limited and does not include identification and implementation of climate initiatives.

Existing and Planned Measures by TMC

- Clean air action planning and implementing measures with focus on particulate matter and other gases.
- Ambient Air Quality Monitoring
- Waterfront development
- Mangrove conservation and plantation
- Lake rejuvenation plan
- Central park development at Balkum, Community park at Pokharan Road no. 2, Urban forestry development

Potential climate impact and BAU scenario

- Climate Risk Status: Medium | Increased rainfall and temperature will affect biodiversity and will adversely impact health of citizens
- Local biodiversity and ecosystems are stressed due to water pollution, dumping of waste and indiscriminate encroachment
- Biodiversity and health will get adversely impacted by climate change due to increased temperature and heavy rainfall events.
- Health of the citizens will be at risk if necessary actions are overlooked

Potential climate resilience impact from identified interventions

- This sector will enhance Thane city's resilience while developing carbon sinks. Local gardens, mangrove and conservation of lakes act as excellent carbon sinks by storing atmosphere carbon dioxide.

SDGs

GOAL 3: Good Health & Well-being

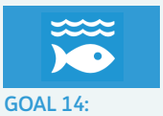
GOAL 6: Clean Water & Sanitation

GOAL 7: Affordable & Clean Energy

GOAL 8: Decent Work & Economic Growth

GOAL 11: Industry, Innovation & Infrastructure

GOAL 13: Climate Action



GOAL 14: Life Below Water

GOAL 15: Life on Land

GOAL 16: Peace and Justice Strong Institutions

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Cost of Interventions (Million INR)	Implementation Entities and Mode	Status and Duration of Implementation
Preparation of heat action plan and urban heat island maps, Geological study of landslide prone areas and suggestion of measures	Action plans are prepared to help deal with impacts of rising temperature and high intensity, short duration rainfall	High impact in terms of understanding the existing scenario and planning for mitigative actions, Increase in adaptation potential Very high resilience potential	2.5	Implementing entities: Pollution Control Cell of TMC with support from Disaster Management Cell, garden and health departments of TMC, if required	New action Short term
Capacity building of Disaster Management Cell regarding climate change and possible impacts					New action Short term
• Map and develop information base of ecosystems, their ecological attributes, benefits and valuation while highlighting Nature based solutions (NBS) • Natural Asset Mapping • Development of urban forests and regular assessment of carbon sequestration potential of green cover in Thane • Science based tree management • Nature interpretation centre and biodiversity kiosk	Green cover helps in controlling the adverse impacts of climate change, especially increase in land temperature and precipitation	Reduced surface temperature, sequestering carbon, reduced flood risk due to increase in mangrove area High resilience potential	7		New action Medium and long term
Annual Environmental Status Reporting to include SDG Monitoring and Reporting	TMC develops an Environmental Status Report annually. Its scope can be broadened to link with SDGs and national commitments like NDCs.	Better understanding, information sharing and planning especially for the vulnerable community Very high resilience potential, improved health of citizens	0.5		New action Short term

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Cost of Interventions (Million INR)	Implementation Entities and Mode	Status and Duration of Implementation
Implementation of Clean Air Action Plan and Particulate Matter Reduction Strategy, Source apportionment study of Thane, Strengthening Air Quality Monitoring network and including other gases like CO, CH_4 etc.	Thane city faces air pollution as one of the major environmental issues linked with two highways passing from the city, construction activities, industries and open areas. The city-wide plans will help limit the same and reduce the impact on health.		15		New and planned actions Short term
Early warning systems for air pollution linked with weather and source apportionment studies			5		New action Medium term
Database management by monitoring health and linking with the pollution levels, climate change and extreme weather conditions in the city			1		New action Medium term
Strengthening the Integrated Disease Surveillance Program by instituting Rapid Response Cell; addressing non-communicable diseases such as heat stress and other health impacts of climate change	Helps plan necessary precautionary actions		1		New action Long term

6.2.12 Urban Planning and Finance

Resilience Interventions	Details of Intervention	Climate Benefits and Co-benefits	Implementation Entities and Mode	Implementation Status and Duration
Institutionalizing and mandating the roles of the Climate Core Committee – an inter departmental climate resilient development taskforce	Climate Core Committee will meet regularly, plan and implement the CRCAP of Thane. Municipal Commissioner to mandate the roles and responsibilities of the Climate Core Committee The proposed Environment and Climate Change Cell coordinates among various departments for better implementation. Tapping various government schemes and inclusiveness of the projects to enhance climate adaptation and mitigation measures	Improved leadership and coordination for climate action and access to climate finance High to medium resilience potential	Implementing entities: Senior management of TMC in consultation with Pollution Control Cell and other relevant departments	New actions Short to medium term
Critical review of existing development plan and all the thematic sector specific strategies to identify the need and opportunities for integrating potential of climate resilience development				
Creation of the Thane municipal services data bank				
Piloting participatory governance at the ward level				
Improving TMC's creditworthiness and assessing TMC's credit rating regularly				
Implementing ecoBUDGET in Thane city for resource optimization				
Developing a transparent evidence base with reporting for a net-zero-carbon buildings pathway				
Issuance of green/climate bonds for funding climate resilient interventions				
Renaming Pollution Control Cell to Environment and Climate Change Cell to address a broader scope, capacity building and hiring staff from various backgrounds (like planners, architects, engineers, scientists)				

07 CONCLUSION

The CRCAP for TMC has been developed using the Climate Resilient Cities Methodology. Baseline GHG emissions have been recorded in the city through the HEAT+ tool to identify the sectors that are mainly responsible for carbon emissions within the city, both at the municipal and community levels. The sectors responsible for majority of emissions in the city, thereby providing the maximum potential to reduce emissions include the solid waste and building sector.

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

On the basis of the vulnerable urban systems, areas, and actors, and the GHG emissions information, resilience actions have been identified to help the city reduce carbon emissions and successfully adapt to potential climate change impact in the future. **The CRCAP shows an annual GHG emission mitigation potential of about 22% by 2025-26 compared to the baseline of 2017-18**.

Thane has a responsive municipal corporation and is one of the leading cities at the national level in terms of climate actions. Information, Education and Communication (IEC) and awareness generation activities can yield substantial results in changing citizens' behaviour for the better and towards a climate friendly city. An important aspect that has been highlighted during the discussions of the core team members is the need for climate cell for better coordination among different agencies. Both structural and non-structural measures are equally important to achieve adaptation as well as mitigation goals.

Annexures

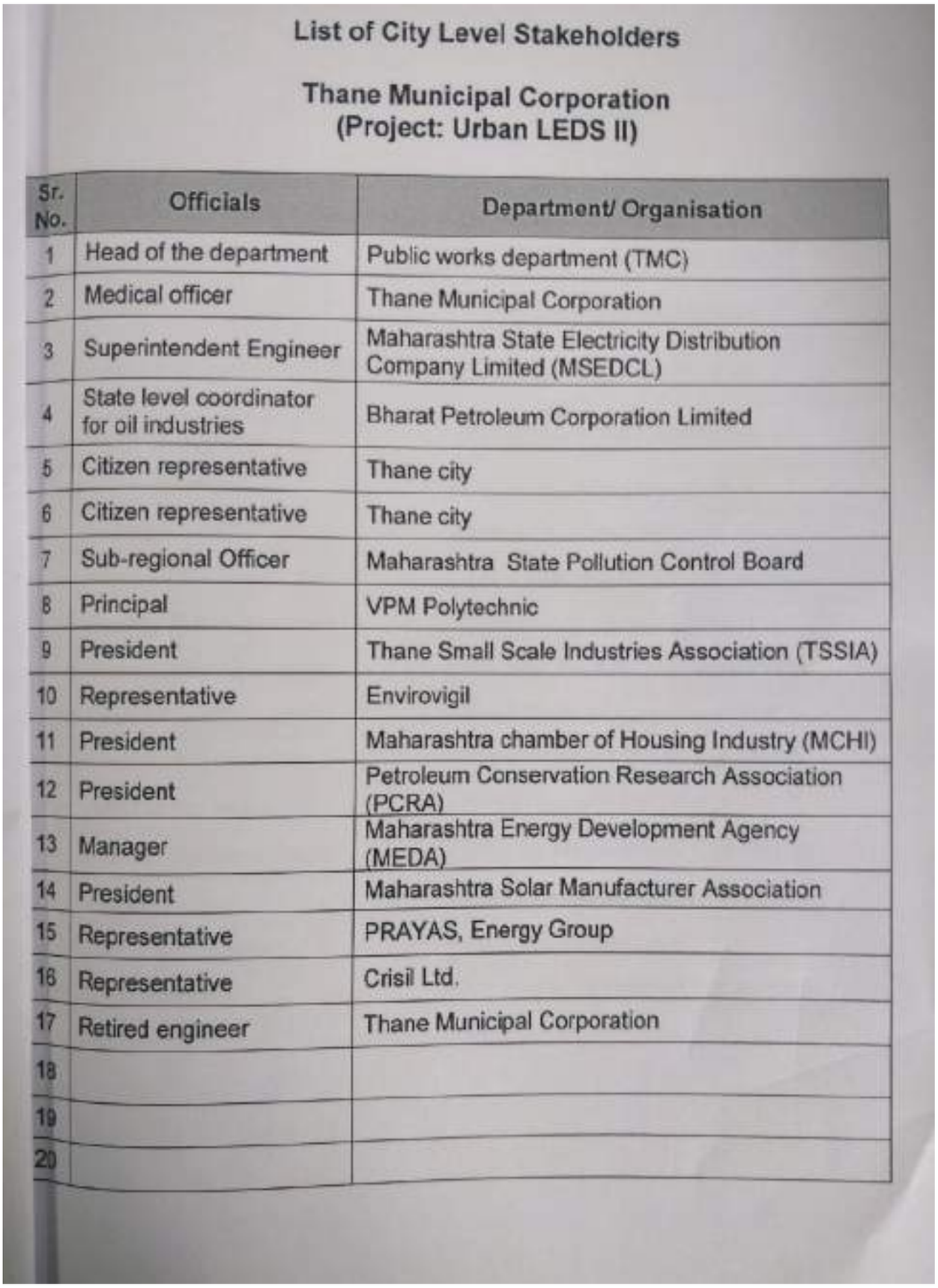
Annexure 1: Climate Core Committee in Thane

List of Core Committee Members

Thane Municipal Corporation
(Project: Urban LEDS II)

Sr. No.	Officials	Department/Organization
1	Commissioner	Thane Municipal Corporation
2	Mayor	Thane Municipal Corporation
3	Additional Commissioner (1)	Thane Municipal Corporation
4	Additional Commissioner (2) / CEO, Smart City	Thane Municipal Corporation
5	City engineer	Thane Municipal Corporation
6	Manager (Technical)	Smart City Cell (TMC)
7	Head of the department	Town Planning (TMC)
8	Head of the department	Electrical Department (TMC)
9	Head of the department	Pollution Control Department (TMC)
10	Head of the department	Solid Waste Management (TMC)
11	Head of the department	Water Supply & Sewerage (TMC)
12	Head of the department	Health Department (TMC)
13	Head of the department	Disaster Management Cell (TMC)
14	Manager	Thane Municipal Transport (TMC)
15	Executive Engineer	Electrical Department
16	CDM consultant	For Thane Municipal Corporation

Annexure 2: Stakeholder Committee in Thane



List of City Level Stakeholders

Thane Municipal Corporation
(Project: Urban LEDS II)

Sr. No.	Officials	Department/ Organisation
1	Head of the department	Public works department (TMC)
2	Medical officer	Thane Municipal Corporation
3	Superintendent Engineer	Maharashtra State Electricity Distribution Company Limited (MSEDCL)
4	State level coordinator for oil industries	Bharat Petroleum Corporation Limited
5	Citizen representative	Thane city
6	Citizen representative	Thane city
7	Sub-regional Officer	Maharashtra State Pollution Control Board
8	Principal	VPM Polytechnic
9	President	Thane Small Scale Industries Association (TSSIA)
10	Representative	Envirovigil
11	President	Maharashtra chamber of Housing Industry (MCHI)
12	President	Petroleum Conservation Research Association (PCRA)
13	Manager	Maharashtra Energy Development Agency (MEDA)
14	President	Maharashtra Solar Manufacturer Association
15	Representative	PRAYAS, Energy Group
16	Representative	Crisil Ltd.
17	Retired engineer	Thane Municipal Corporation
18		
19		
20		

Annexure 3: Prioritization of Climate Resilience Interventions for Thane

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

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

Sector	Interventions	Redundancy	Flexiblity	Responsiveness	Access to infromation	Energy saving and GHG emission mitigation potential	Overall Resilience Score
Residential Building Sector	Adoption of energy efficiency in households 1. Energy Efficient (EE) star rated appliance retrofits (includes ACs, refrigerators and TVs) 2. Replacement of CFL lights with LED bulbs/ tube lights and existing conventional fans with energy efficient fans	Yes	Yes	Yes	Yes	Yes	Very High
	Adoption of energy efficiency in common utilities of residential apartments (particularly high-rise buildings) 1. Energy efficient water pumping 2. Replacement of existing common area and street lights 3. Energy efficiency in the elevators	Intermediate	Yes	Yes	Intermediate	Yes	Medium
	Green building adoption	Yes	No	Intermediate	No	Yes	Low
	Installation of energy efficient equipment and appliances in households of Urban Renewal Plan/ Cluster development at Kopari	Yes	Intermediate	Yes	Intermediate	Yes	Medium
	Rooftop Solar PV installation at Cluster development, Kopari	Yes	Yes	Yes	Intermediate	Yes	High
	Adoption of solar energy in residential buildings 1. Use of Solar water heater (SWH) in place of conventional geyser 2. Installation of Rooftop Solar PV	Yes	Yes	Yes	Yes	Yes	Very High

Sector	Interventions	Redundancy	Flexiblity	Responsiveness	Access to infromation	Energy saving and GHG emission mitigation potential	Overall Resilience Score
Commercial and Institutional Buildings/ Facilities	Adoption of energy efficient equipments and appliances in commercial and institutional buildings 1. Replacement of CFL lights with LED bulbs/tube lights and existing fans with EE fans 2. Energy Efficient star rated Air Conditioner retrofits	Yes	Yes	Yes	Yes	Yes	Very High
	Adoption of energy efficiency in common utilities 1. Energy efficiency in water pumping 2. Energy efficiency in common area lighting and streetlights	Intermediate	Yes	Yes	Intermediate	Yes	Medium
	Adoption of renewable energy in common utilities 1. Use of Solar water heater in place of conventional geyser for hotels and hospitals 2. Rooftop Solar PV in institutions and commercial units	Yes	Yes	Yes	Yes	Yes	Very High
	Promotion and adoption of District cooling system (DCS) in commercial and institutional buildings, particularly at Kopari Urban Renewal Plan	Intermediate	Yes	Yes	Intermediate	Yes	Medium
Manufacturing Industry and Construction (i.e. Industrial sector)	Adoption of energy efficient equipments and appliances in industries (including lighting, fans, pumps and air conditioning)	Yes	Yes	Yes	Intermediate	Yes	High
	Adoption of Rooftop Solar PV in various industries	Yes	Yes	Yes	Intermediate	Intermediate	Medium
Municipal Facilities							
Water Sector	Reduction of non-revenue water (NRW)	Yes	Yes	Yes	Yes	Intermediate	High
	Reuse of water for gardening and green cover	Yes	No	Intermediate	Yes	Intermediate	Low
	Solar PV installation at Temghar water treatment plant and other water pumping stations	Yes	Intermediate	Yes	Yes	Yes	High
	EE implementation based on Energy Audits	Yes	Yes	Yes	Yes	Intermediate	High

Sector	Interventions	Redundancy	Flexiblity	Responsiveness	Access to infromation	Energy saving and GHG emission mitigation potential	Overall Resilience Score
Sewerage	Energy efficiency in pumping and SCADA implementation	Yes	Intermediate	Yes	Yes	Intermediate	Medium
	Solar PV for Kopari STP	Yes	Intermediate	Yes	Yes	Yes	High
	Rooftop Solar PV for Sewage pumping stations	Yes	Intermediate	Yes	Intermediate	Yes	Medium
Street Light	Replacement of existing street lighting with energy efficient lights	Yes	Yes	Yes	Yes	Yes	Very High
Transportation	Commercial sector: Transportation by private taxis and buses 1. CNG vehicle in place of Private taxis and buses (diesel oriented passenger vehicles)	Yes	Yes	Yes	Yes	Intermediate	High
	2. Adoption of Electric vehicles for last mile connectivity	Yes	Yes	Yes	Yes	Intermediate	High
	Public transport: 1. Electric buses in place of diesel buses	Yes	Yes	Yes	Yes	Yes	Very High
	2. Rooftop SPV - renewable energy for electric buses	Yes	Yes	Yes	Yes	Yes	Very High
	3. CNG buses in place of diesel buses for TMT	Intermediate	Yes	Yes	Yes	Intermediate	Medium
	Introduction of electric cars in the municipal vehicle fleet:	Yes	Intermediate	Yes	Intermediate	Yes	Medium
Solid waste management	Waste to Composting	Yes	Intermediate	Yes	Yes	Yes	High
	Biomethanation	Yes	Intermediate	Yes	Yes	Intermediate	Medium
	Waste to energy with generation of electricity	Yes	Yes	Yes	Yes	Yes	Very High
Municipal buildings	Adoption of energy efficient equipments and appliances in commercial and institutional buildings 1. Replacement of CFL lights with LED bulbs/tube lights and existing fans with EE fans 2. Energy Efficient star rated Air Conditioner retrofits	Yes	Yes	Yes	Yes	Yes	Very High
	Adoption of renewable energy as rooftop Solar PVs	Yes	Yes	Yes	Yes	Yes	Very High

Annexure 4: Feasibility Assessment of the Climate Resilience Interventions for Thane

Sector	Interventions	Feasibility of the intervention			Period of Impact
		Technical	Political	Financial	
Residential Building Sector	1. Publicly available webpage with database of service providers and contacts	High	High	High	Short term
	2. Regular monitoring of the implemented systems	Low	Medium	Medium	Long term
Commercial and Institutional Buildings	IEC activities for solar PV uptake and	High	High	Medium	Short term
	regular monitoring of the implemented systems	High	Low	Medium	Long term
Manufacturing Industry and Construction (i.e. Industrial sector)	Adoption of Waste minimization policy,	High	Low	Medium	Medium term
	circular economy, extended manufacturer's responsibility, climate sensitive development/business models	Medium	Low	Low	Long term
Municipal Facilities					
Water Sector	Policy and planning interventions 1. Integrated urban water management (IUWM), 2. Integrated Water Resource Management (IWRM) 3. Integrated Catchment /watershed management plan 4. Integrated groundwater development and management	Medium	Low	Medium	Medium term
	• Network Mapping; • Leakage Mapping, Regularization of Public Stand Posts (PSP) • Revising tariff Structure (50% hike is proposed in 2020-21 budget) • Water conservation at household level, usage of water efficient fixtures • Reuse of treated wastwater, incentives for reuse/recycle at society level, mandatory Dual Plumbing system for new townships, commercial and institutional properties • IoT solutions for water quality monitoring (resources as well as water supply network) • Setting up Water ATMs	High	Medium	Low	Medium term
Sewerage	Policy and planning interventions • Action plan for decentralized sewage treatment plants • Policy for waste water reuse for bulk usage like irrigation/ gardening, construction activities and dust control • Policy for temporary fecal sludge management • Policy on duel plumbing and reuse of treated wastewater	High	Medium	Medium	Medium term
	• Completion of ongoing work of decentralized STPs and sewage network • Operating existing municipal STPs on full capacity • Strong monitoring of private STPs and linking IoT based quality monitoring systems • Use of robotic systems for cleaning of sewage network	High	High	Medium	Medium term

Sector	Interventions	Feasibility of the intervention			Period of Impact
		Technical	Political	Financial	
Storm water	Action plan for Sustainable Urban drainage system (SUDS)	Low	Medium	Low	Long term
	Storm water Smart grid – feasibility assessment	Low	Low	Low	Long term
	Watershed assessment and hydro-geological studies	High	Low	Medium	Medium term
	Monitoring of exiting RWH systems, Developing and publicizing online platform for information sharing	High	Medium	High	Short term
	Policy on mandatory usage of roof top rain water	High	Low	Medium	Medium term
	Rejuvenation of water bodies (lakes) in Thane	High	Medium	Medium	Short term
	Scaling up - Early warning systems for water logging/flooding[1]	High	Medium	High	Short term
	Flood management planning including actions like detention tanks, tidal gates, diversions and flood pumps for overall improvement in Storm water management system	High	Low	Low	Medium term
	Strengthening Weather forecasting and monitoring system especially IoT based rain gauges to capture spatial variation of rainfall	Medium	Medium	Medium	Medium term
	Strong enforcement of flood lines in the town planning	Medium	Low	Low	Long term
Solid waste	Policy and planning: • Preparation of city-wide Holistic Waste Management Plan • Action Plan for setting up new cluster based material recovery facilities and recycling centres • Policy for waste minimization, composting, collection and segregation of domestic hazardous waste • Scaling up GIS enabled Smart Waste Management Services including command and control centre, collection bins, vehicles and treatment	Medium	Low	Medium	Medium term
	• Regular physical and chemical characterization of Municipal Solid Waste at ward and city level • Recycling plastic for internal roads/footpaths of a township • Identification and regularization of the informal sector in waste management services • Monitoring of mangrove areas, open plots, dark areas for illegal solid and hazardous waste dumping, deploying clean up marshals • Strong enforcement of banning single use plastic and providing alternatives like recyclable plastic, cloth bags, paper bags etc, • Extended Producer's Responsibility: promoting the businesses through tax rebate/incentives/awards for their initiatives • Scientific closure of the existing landfill sites	High	Low	Medium	Medium term
Transportation	Updating Thane's Comprehensive Mobility Plan (CMP) for sustainable transport strategies and promoting pedestrian friendly walkways	Medium	Medium	High	Medium term
	• Formation of a Transport Department within Thane Municipal Corporation (TMC) • Review of Thane Municipal Transport (TMT) Business Plan • Planning to introduce shuttle services with small capacity buses to promote shared mobility especially for local train and metros • Common/smart ticketing system (MMRDA) • Information Education and Communication (IEC) techniques for citizens and hands on training for TMT drivers on fuel saving	Medium	Low	Low	Long term

Sector	Interventions	Feasibility of the intervention			Period of Impact
		Technical	Political	Financial	
Disaster Management, Biodiversity, Pollution Control and Health	Preparation of heat action plan and urban heat island maps, Geological study of landslide prone areas and suggesting measures	High	Medium	High	Short term
	Capacity building of Disaster Management Cell regarding climate change and possible impacts	Medium	Medium	Medium	Medium term
	· Map and develop information base of ecosystems, their ecological attributes, benefits and valuation while highlighting NBS	High	Medium	Medium	Medium term
	· Natural Asset Mapping,	High	Medium	High	Short term
	· Development of Urban forests and regular assessment of carbon sequestration potential of green cover in Thane,	High	Medium	High	Short term
	· Science based tree management,	High	Medium	Medium	Medium term
	· Nature interpretation centre and biodiversity kiosk	High	Medium	High	Short term
	Annual Environmental Status Reporting to include SDG Monitoring and Reporting	Medium	Medium	Medium	Short term
	Implementation of Clean Air Action Plan and Particulate matter reduction strategy, Source apportionment study of Thane, Strengthening Air Quality Monitoring network and include other gases like CO, CH_4 etc	High	Medium	Medium	Short term
	Early warning systems for air pollution linked with weather and source apportionment studies	Medium	Low	Low	Long term
	Database management by monitoring health and linking with the pollution levels, climate change and extreme weather conditions in the city	Medium	Low	Medium	Medium term
	Strengthen the Integrated Disease Surveillance Program by Instituting Rapid Response Cell including non-communicable diseases such as heat stress and other impacts of Climate Change	Medium	Low	Low	Long term
Planning and finance	Composition of inter departmental climate resilient development taskforce to foster innovations	High	Medium	High	Short term
	Critical review of existing development plan and all of the thematic sector specific strategies to identify the need and opportunities for integrating potential of climate resilience development	Medium	Low	Medium	Medium term
	Creation of the Thane municipal service data bank	High	Medium	High	Short term
	Piloting the participatory governance	Medium	Low	Medium	Medium term
	Improving creditworthiness of Thane Municipal Corporation and conduct the credit rating regularly	High	Medium	Medium	Short term
	Implementation of ecoBUDGET in Thane city for resource optimization	Medium	Low	Low	Long term
	Developing a transparent evidence base with reporting for a net-zero-carbon buildings pathway	Medium	Low	Medium	Medium term
	Issuance of Green/climate Bond	Medium	Low	Low	Long term
	Renaming Pollution Control Cell to Environment and Climate Change Cell to look after broader scope, Capacity building and hiring staff from various backgrounds (like planners, architect, engineer, science)	High	Medium	High	Short term

Annexure 5: Sources of GHG Emissions