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Climate Risk Assessment of Navi Mumbai: Vulnerabilities, Impacts, and Economic Implications

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Abstract: *Climate change is increasingly intensifying environmental and socio-economic risks for rapidly urbanising coastal cities. This study presents a climate risk assessment of Navi Mumbai region and also focuses on identifying key climate hazards. The main objective of the study is to identify major climate risks affecting the Navi Mumbai region and it also aims to assess the vulnerability of critical infrastructure, industries, and livelihoods. The research study, also analyses the projected future climate risks under different climate scenarios. Given the region's geographic location, rapid industrial development, and proximity to coastal ecosystems it is particularly susceptible to climate-related risk such as coastal flooding, extreme rainfall, extreme heat, temperature rise and sea-level rise.*

The research identifies both the physical and transition climate risks and also studies risk impact on infrastructure, industrial operations and surrounding ecosystems. The study estimates potential financial implications arising from these risks, including impact on livelihood, disruptions to industrial operations, damage to infrastructure assets, and impacts on supply chains.

Keywords:, Climate change, Climate Risk Assessment, Urban Climate Vulnerability, Coastal Cities, Navi Mumbai, Climate Change Adaptation

I. INTRODUCTION

Climate change is having a greater impact on coastal urban areas worldwide, and this has a significant impact on infrastructure, industry, and communities. Navi Mumbai is a planned city in India, growing at a rapid pace on the western coast of Maharashtra. It is a low-lying area and is situated on the Arabian Sea. Navi Mumbai is a hub for various industries and logistics. Climate stress is already a reality in this area, and the city is already witnessing increased flooding, increased temperatures, and increased rainfall. Climate projections given by the Intergovernmental Panel on Climate Change (IPCC), indicate that the risks for coastal areas may increase under various climate scenarios, including Representative Concentration Pathway 4.5 (RCP 4.5) and Representative Concentration Pathway 8.5 (RCP-8.5).

Navi Mumbai region is a planned city in state of Maharashtra in India, and it is a growing urban and industrial hub located on a low-lying coastal area. It is a hub for various industries, including manufacturing, chemicals, and steel. Climate stress is already a reality in this area, and the city is already witnessing increased flooding, increased temperatures, and increased rainfall. Climate risks in this area may result in financial loss impact various industries.

In today's scenario, globally industries and companies are required to disclose their climate-related risks and opportunities and adhere to the ESG reporting framework. Climate risk assessment is a structured approach to assessing climate risks, and this study aims to provide a structured approach to assessing climate risks in a specific location.

Despite the growing importance for climate risk assessment, there is a lack of localised studies focusing on Navi Mumbai region, that examines various risks, including physical risks, transition risks, and their financial implications. It has been found that various assessments on climate risks have been carried out based on regional data, which does not take into consideration specific risks, such as flooding in industrial areas, impact of heat stress on operations, and

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supply chain risks. Additionally, the lack of scenario projections and analysis of supply chain risks limits the scope of assessing the full spectrum of risks, which affects the development of mitigation and adaptation strategies by industries.

II. LITERATURE REVIEW

Urban areas globally, particularly coastal cities are increasing facing risk of Climate change due to their geographic location, increasing population and rapid urbanization. Mumbai region is one of the India's largest metropolitan areas and also a major financial hub is highly susceptible to climate risks such as extreme rainfall, flooding, extreme heat and sea level rise. Various studies have examined the climate risks in Mumbai and its surrounding areas including the Navi Mumbai region, showing increased need for climate-resilient urban planning and climate risk management strategies.

In a study done by Ranger et al. (2011), the potential impacts of climate change on flood risk in Mumbai city were studies and it was highlighted that extreme flood events, like the Mumbai flood-2005, could become more regular due to increasing impact of climate change. It also estimated that climate change will also increase the probability of extreme events by two times by the end of the century and if adequate measures are not implemented, the economic losses associated will also increase significantly. The study also identified that for reducing the economic losses, improving the urban drainage system and reinforcing the infrastructure is required for building the resilience.

As per the study by Yadav et al. (2023), urban flood is identified as the most critical climate risk for the Mumbai region. It studied climate uncertainty and urban flood vulnerability using the multi-criteria analysis approach. It highlighted that flood vulnerability in coastal areas increased due to climate variability along with rapid urbanization and land-use changes.

A study published in the journal Urban Climate by Verma et al. studied flood vulnerability across Mumbai using Combined Flood Vulnerability Index (CFVI). It found that approximately 71% urban region witnessed changes in flood vulnerability, with one-third showing increased vulnerability over time. The study highlights the need for a more localized climate risk assessment for disaster management and urban planning due to the dynamic and evolving nature of climate risk in urban areas.

Geospatial technologies and machine learning techniques has improved the climate risk assessment in cities such as Mumbai. Multiple Studies on flood susceptibility modelling have been carried out using machine learning techniques such as Random Forest, Artificial Neural Networks and Gradient Boosting for mapping the flood prone areas in Mumbai Metropolitan areas and results indicate that approximately 25-30% of the region comes under high or very high flood susceptibility categories (Manna et al. 2025). Various factors such as elevation, rainfall intensity, urban density and proximity to coast also influence the flood risk. These results highlight the importance of advanced analytical techniques in urban planning and climate risk management (Manna et al. 2025).

Climate change also has an impact on rainfall patterns and temperature in Mumbai. To improve the precipitation forecasting to support early warning system and climate risk management, deep learning models such as ConvLSTM (Convolutional Neural Network-Long Short-Term Memory) architecture were used (Ghosh et al. 2025). These deep learning models analyse large climate datasets to accurately predict rainfall patterns with high precision. Thus, improved forecasting capabilities have become important for reducing the risk of disaster and decreasing the economic losses in climate sensitive urban cities (Ghosh et al. 2025).

Another factor contributing to climate vulnerability in Mumbai is Urbanization. Land use and land cover changes have led to rapid expansion of built-up areas and have changed the urban landscape. The Urban heat island effect has

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been intensified due the reduction in green spaces and wetlands and natural drainage systems (Sethi & Vinoj 2024). Rising urban temperatures and increased climate vulnerability is now linked to land use changes using the remote sensing techniques and satellite imagery.

Climate change is also affecting the socio-economic and livelihoods, according to the World Cities Report (2024), coastal communities, informal settlements and economically vulnerable populations often face high climate risk due to limited capacity to adapt. As per studies on socio-economic vulnerabilities (IPCC AR6 2022), climate hazards can affect livelihoods, damage infrastructure and also increase the economic inequality in coastal urban areas.

Thus, the overall climate risk in Mumbai region is dependent on multiple factors – climatic, environmental and socio-economic. Climate risks such as Extreme rainfall events, sea-level rise, land-use changes and rapid urbanization together contribute to the increasing vulnerability of the Mumbai region.

Multiples studies have examined the flood risk and climate variability in Mumbai region, but there remains a need for integrated climate risk assessment that will combine hazard analysis, vulnerability assessment and financial implications evaluation. Doing a comprehensive analysis will be important for informing policy decisions, improve urban resilience and support sustainable development in urbanising coastal cities such as Navi Mumbai.

III. RESEARCH GAP

Most of the existing literature studies largely focuses on physical climate risks such as flooding, rainfall variability, and sea level rise and accordingly it was found that climate variability and rapid urbanisation contribute considerably to flood susceptibility and ecological imbalance in Mumbai region.
The gaps identified in the literature are as follows:

1. **Limited integrated climate risk assessments:**
   Most studies examine individual hazards such as flooding or rainfall, rather than conducting comprehensive assessments that integrate hazard, exposure, and vulnerability frameworks

2. **Insufficient focus on economic and financial implications:**
   Existing research primarily evaluates physical vulnerability, with limited analysis of financial risks, infrastructure losses, and economic impacts on industries and urban systems.

3. **Lack of studies focusing specifically on Navi Mumbai:**
   Much of the literature concentrates on Mumbai city, while the rapidly developing urban region of Navi Mumbai, which includes industrial zones, ports, and infrastructure corridors, has received comparatively little attention.

4. **Lack of industry-focused vulnerability assessment:**
   Most studies emphasize environmental and urban infrastructure risks, while industrial assets, logistics networks, and economic supply chains remain under-explored.

IV. UNIQUENESS OF THE STUDY

The study aims to address the above gaps through a comprehensive climate risk assessment of Navi Mumbai region. The uniqueness of the study lies in the following key aspects:

1. Integrated climate risk assessment has been conducted that systematically examined climate risk across different sectors.

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2. The study incorporates climate scenarios such as RCPs, SSPs and the NGFS scenarios to project the potential climate risk for the region.

The research study also examines the potential financial impacts , such as operational disruption, infrastructure damage and supply chain impacts in addition to physical risks

V. METHODOLOGY: OBJECTIVE, STUDY AREA, DATA COLLECTION

Objective:

The main objectives of the research study are as follows:

- To identify and examine the major climate risks affecting the Navi Mumbai region.
- To evaluate climate risk under multiple future climate scenarios and time horizons
- To analyse the economic and social implications of climate hazards on key sectors in Navi Mumbai.

Study Area: Navi Mumbai, Maharashtra

The Navi Mumbai region is a coastal city and has been planned as a twin city of Mumbai situated between Thane Creek and Sahyadri Mountains on west coast in Konkan division of Maharashtra. It lies between 19°00' to 19°12'N and 72°58' to 73°03'E (Fig.1) and located 3.25 meters above the sea level. It is planned and developed by City and Industrial Development Corporation of Maharashtra (CIDCO) and situated along the Mumbai-Pune highway. The region is divided into three divisions physiologically- (i) The Upland, (ii) Plain Land, (iii) The Coastal Zone. The upland divisions cover Parsik Hills and lies in north-eastern part of the study region. The Plain area is found in the eastern, southern, and northern parts and it covers major industrial region of Thane-Belapur industrial belt. The western part of study area includes Vashi, Koperkhairne, Ghansoli, Sanpada, Nerul and Southern parts of Belapur falls under the Coastal zone surrounded by mangroves (low lying areas). The climate of the region is hot and humid, it lies in tropical climatic zone and has three seasons-summer, monsoon, and winter. The annual temperature of the city ranges from 22°C to 36°C, while in summer temperature ranges between 36°C-41°C. The predominant wind direction is southwest in monsoon and north-east during the rest of the year according to IMD's observations at Thane Belapur Industry association's premises.

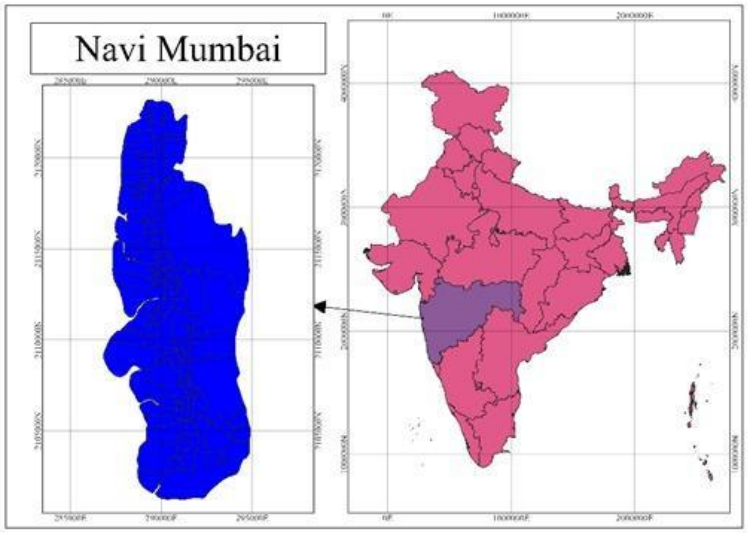

Figure 1 Study Area - Navi Mumbai

Data Collection and Analytical Tools

The study adopts a mixed-method approach, integrating both qualitative and quantitative techniques to assess the major climate hazards and its impact on livelihoods, and industrial systems. This study focuses on the assessment of climate

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risks in Navi Mumbai. The study examines the climate risk and its impact across multiple time horizons (short-term, medium-term, and long-term) using scenario-based (Medium emission scenario and high emission scenario) analysis. it also utilizes a combination of global datasets, such as IPCC climate scenarios, and region-specific data where available.

Secondary Data

For the study both primary and secondary data sources were used from published literature and globally recognised international data sources. These includes: Government reports such as the Mumbai Climate Action Plan, NDMA Reports – Review of Early Warning system for Indian Cities – Navi Mumbai and planning documents from CIDCO. Published literature on climate change, sea level rise, coastal vulnerability, climate risk for Indian and global coastal cities along with the Think Hazard tool which is free and open-source tool developed by Global Facility for Disaster Reduction and Recovery (GFDRR).Industry and infrastructure datasets related to industrial clusters, logistics networks, and urban development in Navi Mumbai region. Climate datasets for future projections and scenario analysis from the World Bank, UNDP Human Climate Horizon, Network for Greening the Financial System (NGFS) and Global Infrastructure Resilience. These sources were used to identify the major climate risk, assess exposure levels and understand the vulnerabilities across major areas in Navi Mumbai.

Primary Data and Stakeholder Inputs

To support the secondary analysis, primary data was collected to study the economic and social impacts of climate risks on key sectors, which involved targeted stakeholder consultations and interviews, including:

- Meeting with the representatives of local fishing associations in Navi Mumbai region to study the impact of climate variability on fisheries and coastal livelihoods.
- Survey of fishermen was carried out to understand the socioeconomic impact from climate change.
- Interview with the sustainability head of an industrial unit located in the TTC industrial area to understand the level of climate risks to industrial operations and supply chains in the region.

The qualitative information obtained from these sources were then used to validate secondary findings and to estimate sector-specific impacts of the climate risk. Where feasible, quantitative estimates of financial losses were calculated using available operational data and stakeholder inputs.

Scenario Analysis and Time Horizon

Time Horizon

The time horizon is an important component of any climate risk assessment as it helps assess when the potential risks and impacts may materialize in future. Climate risks across short, medium, and long-term horizons were studied to understand both immediate vulnerabilities and future exposures. For the purpose of the study, 3-time horizons/durations have been considered- Short Term (2020-2039), Medium Term (2040-2059) and Long Term (2080-2099).

Scenario Analysis

Scenario analysis is an approach for evaluating the long-term potential impacts of climate change. Climate risk scenario analysis is a structured framework used for assessing the evolution of physical risks under various global warming scenarios. for the study, various scenarios of climate conditions, including RCPs, SSPs, and NGFS , were considered to evaluate both moderate and severe impacts of climate change.

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Table 1: CLIMATE SCENARIO FOR THE STUDY

Scenarios	Description
RCP 4.5	RCP 4.5 stands for Representative Concentration Pathway 4.5. In this the radiative forcing will stabilise at 4.5 W/m^2. The emissions would peak around 2040-2050 and then will decline. The world will adopt climate policies and mov towards clean energy that will led to stabilization of greenhouse gases by mid-century. Warming is controlled but still will be significant.
RCP 8.5	RCP 8.5 stands for Representative Concentration Pathway 8.5. In this the radiative forcing will reach to 8.5 W/m^2 by 2100. The emissions under this scenario will continue to rise through the century and there heavy use of fossil fuels and very limited adoption of climate policies,
SSP2- 4.5	SSP2-4.5 stands for Socioeconomic pathway and there will be radiative forcing of 4.5 W/m2by 2100. In this scenario, there will be moderate economic growth, and the emissions would peak around mid-century and then decline slowly. There will gradual adoption of climate policies and limited shift to renewable energy. The Climate action will happen, but it will not be enough to meet 1.5°C
SSP5- 8.5	SSP5-8.5 stands for Socioeconomic pathway 8.5. in this the radiative forcing of 8.5 W/m2 by 2100. In this scenario there will be rapid economic growth which will be driven by heavy use of fossil fuels such as coal, oil and gas. The emission would continue to rise throughout the century and there will adoption of weak climate policies.
NGFS Delayed Transition	The NGFS Delayed Transition scenario means the climate actions are delayed and there is introduction of strong policies after 2030. There will be shift from fossil fuels at a faster rate in short period of time. The transition risk in this scenario will be high and there will be medium physical risk.
NGFS Fragmented World	The NGFS Fragmented World scenario means the countries will work independently with weak cooperation which will result insufficient climate action. The emissions will remain high due to lack of global cooperation. The physical risk in this scenario will be high and transition risk will be medium.

VI. RESULTS

Major climate hazards affecting Navi Mumbai regions

The climate risks for the Navi Mumbai region were identified using a hybrid method that combines both the findings from the Think Hazard tool and published literature. In the Think Hazard tool, location specific outputs for Navi Mumbai region were not directly available as it is considered as part of the Thane district. The climate risk listed for Thane region are thus considered for Navi Mumbai region. The identified climate hazards include Coastal flood, Urban flood, Landslide, Cyclone, Extreme heat, Tsunami, Water Scarcity and River Flood.

Other Climate Risks that were identified using published reports and literature include Extreme Heat, Sea level rise, Temperature rise and Extreme rainfall. According to Ranger et al. (2011) will significantly increase the flood risk in Mumbai region under high emission scenarios which will be driven by extreme rainfall, sea level rise and storm surges. Sea level rise will lead to increase in future extreme coastal water levels (1-in 100-year events) across global coastlines including India (Vousdoukas et al. - 2018) which means low-lying coastal cities like Mumbai and adjoining areas will face more regular and intense flooding. A study by Yoshida et al. (2017) finds that the number of cyclones are projected to decrease in high emission scenarios, but the frequency of category 4 and category 5 cyclones is projected to rise. Thus, it will increase the damages for the coastal areas due to stronger cyclones systems.

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Extreme Heat and Temperature rise are also high risk for the region as increase in built-up area and decrease in vegetation is leading to significant increase in land surface temperatures (Shahfahad et al. 2021). According to Varghese et al. (2025), extreme rainfall events will increase by 1.3 folds by the end of the century, thus further increasing the risk of flood.

Table 2: IDENTIFIED CLIMATE RISK

Sr. No	Climate Risk	Risk Type
1	Coastal Flood	High
2	Landslide	Medium
3	Cyclone	Medium
4	Extreme Heat	High
5	Sea Level Rise	High
6	Temperature Rise	High
7	Extreme Rainfall	High
8	Earthquake	Medium
9	Tsunami	Medium
10	Water Scarcity	Medium
11	River Flood	Low

Prioritization of risk for Scenario Analysis

The climate risks for Navi Mumbai were prioritized based on the classification of high and medium on the Think Hazard tool and published literature from studies done for Mumbai and surrounding areas. According to Vousdolkas et al. (2018) the risk of coastal floods will increase because of sea level rise and extreme sea levels thus increasing the coastal and flood related risk. Due to this, low-lying and reclaimed areas near Navi Mumbai will be affected. It is also projected that the likelihood of flood and its impact will be increased under climate change scenarios based on the studies on Indian coastal cities (Ravinder et.al, 2019).

In a study carried out by Roxy et al. (2017), it was found that there will be threefold rise in widespread extreme rain events including events such as the Mumbai floods, thus prioritizing Extreme rainfall and urban flooding becomes important. As per the research carried out – Assessment of Climate Change over the Indian Region, tropical cyclone is considered as medium-high risk and there will be increase in intensity of cyclonic storms and associated precipitation in the Arabian sea region.

Thus, climate risks such as Sea level rise, coastal flooding, urban flooding, extreme rainfall, extreme heat and cyclone are prioritized for further scenario analysis as they represent major climate risks for the coastal urban areas like Navi Mumbai.

Table 3: PRIORTISED CLIMATE RISKS FOR THE REGION

Sr. No	Climate Risks	Risk Type
1	Coastal Flood	High
2	Cyclone	Medium
3	Extreme Heat	High
4	Sea Level Rise	High
5	Temperature Rise	High
6	Extreme Rainfall	High

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B. To evaluate climate risk under multiple future climate scenarios and time horizon

The climate risks that were identified as high risk are considered for scenario analysis under different climate scenarios like SSPs, RCPs and NGFS. Different scenarios were considered because the projections for the identified climate hazards were not available for any one single scenario. For the chosen scenarios, moderate emissions scenarios and a high emissions scenario have been taken for the projections.

A. Sea Level Rise

The Sea level rise data along the coast shows a clear increasing trend, the projections under different SSP scenarios show progressive increase over time with higher emissions. Under SSP2-4.5 (which is approximately equal to RCP 4.5), the SLR is estimated to rise to 7.8 cm in 2020-2039, 16.9cm in2040-2059 and 39.4cm in 2080-2099. The SSP5-8.5 (high emission scenario similar to RCP 8.5) have SLR projections have increased 8.2cm in 2020-2039, 19.8cm in 2040-2059 and 56.4 cm in 2080-2099.

Table 4: SEA LEVEL RISE PROJECTION UNDER SSP SCENARIOS

Sea Level Rise	2020-2039	2040-2059	2080-2099	Reference
SSP2-4.5	7.8 cm	16.9 cm	39.4 cm	UNDP -Human Climate Horizon
SSP5-8.5	8.2 cm	19.8 cm	56.4 cm	UNDP -Human Climate Horizon

B. Extreme Heat (Days >35°C)

The Extreme Heat is characterized by the number of days when the temperature reaches above 35°C. For this under the RCP 4.5 moderate emissions scenario there will on average 71 hots days each year during the 2020-2039, which will increase to 81 hot days in 2040-2059 and 94 hot days in 2080-2099. In RCP 8.5 high emissions scenarios there will be 75 days where the temperature will exceed 35°C in 2020-2039, 117 days for 2040-2059 and 221 days for 2080-2099.

Table 5: EXTREME HEAT DAYS PROJECTION UNDER RCP SCNERIOS

Extreme Heat (Days >35°C)	2020-2039	2040-2059	2080-2099	Reference
RCP-4.5	71 days	99 days	125 days	UNDP -Human Climate Horizon
RCP-8.5	75 days	117 days	221 days	UNDP -Human Climate Horizon

C. Temperature Rise

The projection data for Temperature rise was taken from the NGFS Climate Impact Explorer that shows how temperature will change overtime. Under NGFS delayed transition scenario was considered for the Maharashtra state, the temperature will rise by 1.8°C for 2020-2039, 1.7°C for 2040-2059 and 1.7°C for 2080-2099. Under NGFS fragmented world scenario, the projected temperature will rise by 1.8°C in 2020-2039, 1.9°C in 2040-2059 and 2.1°C in 2080-2099 duration.

Table 6: TEMPERATURE RISE PROJECTION UNDER NGFS SCENARIOS

Temperature Rise	2020-2039	2040-2059	2080-2099	Reference
NGFS delayed transition	1.8°C	1.7°C	1.7°C	NGFS
NGFS fragmented world	1.8°C	1.9°C	2.1°C	NGFS

D. Extreme Rainfall

The extreme rainfall data show how total annual precipitation will change over time. Under the NGFS delayed transition, was considered for the Maharashtra state, it is projected to be 1307 mm/yr in 2020-2039, 1304 mm/yr in 2040-2059 and then increase to 1294 mm/yr for2080-2099 duration. Similarly, for NGFS fragmented world scenario, it is estimated to1308 mm/yr in 2020-2039, 1323 mm/yr in 2040-2059 and increase marginally to 1337 mm/yr by 2080-2099.

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Table 7: EXTREME RAINFALL PROJECTIONS UNDER NGFS SCENARIOS

Extreme Rainfall	2020-2039	2040-2059	2080-2099	Reference
NGFS delayed transition	1307 mm/yr	1304 mm/yr	1294 mm/yr	NGFS
NGFS fragmented world	1308 mm/yr	1323 mm/yr	1337 mm/yr	NGFS

E. Coastal Flood

The RCP 4.5 projections for Coastal flood show that it will be 1.45 meters in 2020-2039 and will progressively increase to 1.60 meters and 1.97 meters in the medium term (2040-2059) and long term (2080-2099) duration, respectively. Under the high emission scenarios RCP 8.5, the coastal flood data shows increasing trend and may reach 1.47 meters in 2020-2039, 1.65 meters in 2040-2059 and 2 meters in 2080-2099.

Table 8: COASTAL FLOOD PROJECTION UNDER RCP SCENARIO

Coastal Flood	2030	2050	2080	Reference
RCP-4.5	1.45m	1.60m	1.97m	Global infrastructure resilience – duration is 2030, 2050 and 2080
RCP-8.5	1.47m	1.65m	2.00m	Global infrastructure resilience – duration is 2030, 2050 and 2080

F. Cyclone

The cyclone projection data has been taken from the world bank. The projected data shows that the count of cyclones for India (landfall) for SSP2-4.5 is 5.279 during the period 2035-2064.

Table 9: CYCLONE PROJECTIONS UNDER SSP SCENAIOS

Cyclone	2020-2039	2040-2059	2080-2099	Reference
SSP2-4.5	5.279			World Bank - Cyclone

C. The economic and social implications of climate hazards on key sectors in Navi Mumbai.

Urban Coastal system is exposed to climate induced risks such as extreme precipitation, temperature variability and sea level rise. With time the risks and its impact are increasing. Being part of the Mumbai Metropolitan Region (MMR), the Navi Mumbai area have similar hydro-climatic characteristics and economic interdependencies as Mumbai, making it highly susceptible to climate risks.

Earlier studies from Mumbai region show that extreme events can generate substantial physical damage and economic loss. For instance, the 2005 Mumbai flood resulted in direct damage of approximately 2 billion USD (Ranger et al., 2011). Based on a study conducted by the United States Trade and Development Agency and KPMG, flooding in Mumbai resulted in economic losses of approximately □14,000 crore between 2005 and 2015. (USTDA and KPMG, 2019).

The Navi Mumbai region comprises of several critical economic and livelihood zones that are highly vulnerable and susceptible to climate change impacts. During the research study, the impact of climate change parameters on the following location, such as the APMC market, fishing communities, industrial clusters were studied.

A. Climate Change Impacts on APMC Market, Navi Mumbai

The APMC market located in Vashi is one of the most critical Agri-logistics nodes and pivotal wholesale distribution hub for fruits and vegetables in Maharashtra. Recent data indicates APMC market receives around 600 truckload of produce per day which not only highlights its scale but also its logistic importance.

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The climate change parameters such as extreme precipitation, extreme heat, sea level rise will have impact on market as well as the people linked to it such as farmers, workers, etc. Extreme rainfall has emerged as one of the most immediate climate risk affecting the APMC operation. In August 2025, vegetable arrival declined by 50% during heavy rain events, this resulted from transport disruption and flooded agriculture fields. Over 200 transport vehicles couldn't reach that which leads to spoilage of perishable goods and impact on the traders as well as on farmers.

B. Climate Change Impacts on Fishing Livelihoods in Navi Mumbai

In Navi Mumbai, fishing is a vital livelihood activity, especially for the Koli people who have been doing it traditionally. They live around places like Vashi, Thane Creek and Uran, along the coast too. The whole sector supports directly to the fishermen and indirectly to other informal economic networks such as processing and transport sector.

To understand ground level impact of climate change on coastal livelihood an interview with chairman of Mariaai Association Mumbai (Local fisherman Association) was conducted. The key finding from interaction was that the Navi Mumbai region supports approximate 2800-3000 fishermen. The fishermen are critically impacted from climate change parameter which leads to rough sea conditions.

During the study, structured survey was conducted to understand the ground level impact from climate change on fishermen. The survey was shared and response from 60 fisherman was collected. During the Survey, among 7 the climate change parameter, 53 fisherman rated extreme rainfall and Prolonged Monsoon period as most critical climate stressor, followed by temperature rise and sea level rise. During the heavy rainfall and red alert condition fishing activities are suspended due to rough sea conditions and safety risks. Also, this event not only leads to loss of daily income but also cause physical damage to the assets of the fishermen. Survey response indicates heavy rain and rainfall leads to reduction of 10-20% in fish catch during such period. Survey response also indicated that during the last year's heavy rainfall day fisherman had losses from □ 5000 to □ 60,000 depending upon the scale of operation. These losses are due to damage to boats, engines, nets due to heavy rainfall, strong wind current during red alert day. However, the evidences suggest that number of extreme rainfall events will go up which will result in more loss of daily income and increase in expenses due to damage from extreme rainfall events.

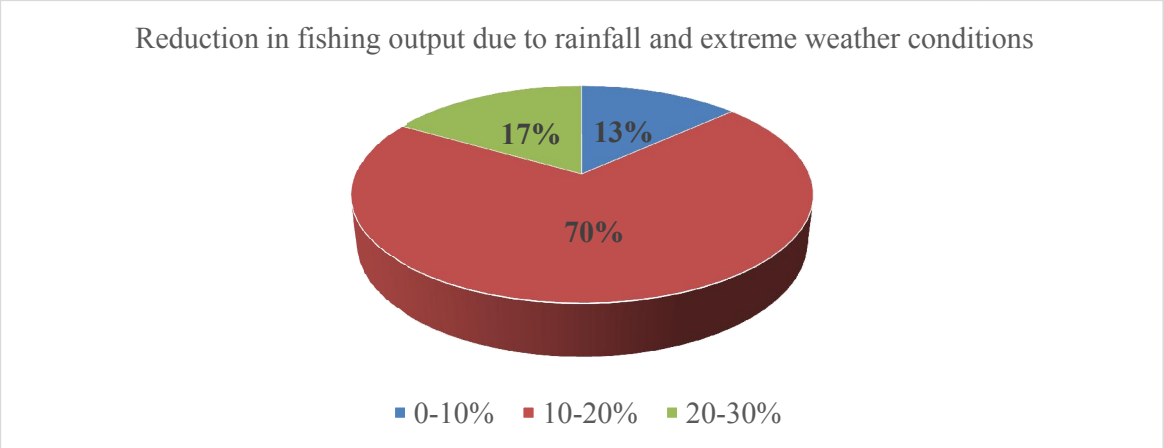

Figure 2: REDUCTION IN FISHINGOUTPUT DUE TO RAINFALL AND EXTERME WEATHER CONDITIONS

Temperature rise was observed as second most important climate stressor as it affects the fish behavior and availability. Respondents reported that rise in water temperature results in fishes moving to deeper water. Species such as sardines, Indian Mackerel are sensitive to sea surface temperature. This makes them harder to catch and require more fuel as

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Impact Factor: 8.2

fishermen need to go in more deeper sea. Based on the responses received the temperature rise in last year increased the cost of fuel to fisher man by 5-10%.

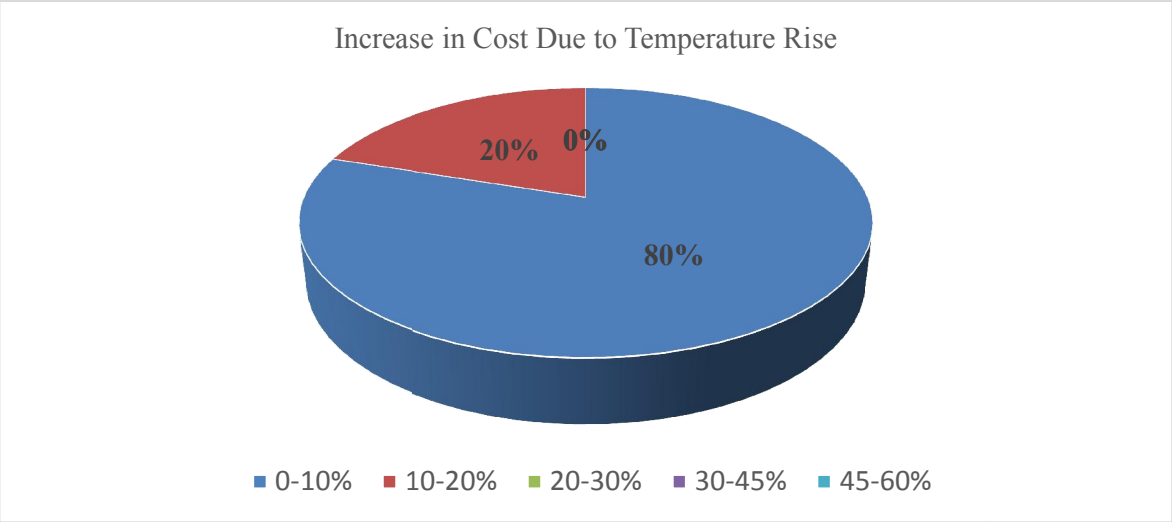

Figure 3: INCREASE IN COST DUE TO TEMPERATURE RISE

Sea level rise has a long term but concerning threats. Sea level rise leads to degradation of shallow water habitats which serves as a breeding and feeding ground for several species including juvenile pomfret, sardines, prawns. This loss of habitat result in reduction of availability of fish over time which have severe impact on habitat on fisherman community.

C. Climate Change Impact on Industrial and Economic System

Navi Mumbai's Industrial cluster is one of the largest planned industrial hub in India. The area includes key industrial clusters like the Taloja MIDC, TTC Industrial Area (Trans Thane Creek Industrial Area : Mahape, Rabale, Turbhe, Pawane). The TTC industrial hub have more than 4000 industries and generate RS 10,000 crore by the way of state and central exchequer. Also, this industrial hub provides over 5 lakh direct and 5 lakh indirect jobs.

The Navi Mumbai industrial hubs have majorly manufacturing sector industries such Chemical, Pharmaceutical, Engineering and Logistics. The impact from climate change on this industrial hub will not only impact production activities but also impact other indirect economies. To better understand the impacts, we have interviewed the sustainability head of a chemical company located in TTC industrial area. And to study the exposure and vulnerabilities of climate risks, a detailed climate change impact analysis was conducted for the company.

Based on the assessment, the climate risks that were identified and prioritised for the company includes extreme rainfall, temperature rise, cyclone, extreme heat, coastal flood and sea level rise.

1) Extreme Rainfall

Extreme Rainfall data has been collected from the District Level Changes in Climate: Historical Climate and Climate Change Projections for the Western State of India - Center for Study of Science, Technology & Policy (CSTEP). In the analysis, extreme rainfalls have been considered as very high-intensity rainfalls, which occur above 100 mm/day. For the time period 2021-2050, the projection states extreme rainfalls occur two times a year under the RCP 4.5 scenario, and three times a year under the RCP 8.5 scenario. During the discussion it has been concluded that extreme rainfall can cause 5% operational efficiency loss due to extreme rainfalls. This can result on estimated financial loss of 1.37 Crore per year under RCP 4.5 and can lead to 2.05 crore per year under RCP 8.5.

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Impact Factor: 8.2

Table 10: ESTIMATED FINANCIAL LOSS FROM EXTREME RAINFALL EVENTS

Scenario	Duration	Extreme Rainfall events (Per Year)	Estimated Financial loss (in Cr per Year)
RCP 4.5	2021-2050	2	1.37
RCP 8.5	2021-2050	3	2.05

2) Temperature Rise

Data for temperature rise used for analysis has been obtained from Climate Changeover India – an Interim Report by Centre of Climate change Research. According to the finding of the research paper by Somanathan et al., an increase of 1°C in average daily maximum temperature results in an estimated loss of 2.1% in annual manufacturing production in India. The damage is attributed to reduced labor productivity and increased labor absenteeism. The damage rate is used to calculate the loss by applying it to the rise in temperature as per the RCP 4.5 and RCP 8.5 scenario.

Table 11: ESTIMATED FINANCIAL LOSS FROM TEMPERATURE RISE

Scenario	Time Period	Temp Rise (°C)	Damage rate	Base Max Temp	Absolute Loss (MT)	Estimated Financial Loss (Crore)
RCP 4.5	2020–2039	1.26	2.10	33.33 °C(Maharashtra)	5.55	132.08
	2040–2059	1.81			7.98	189.74
	2080–2099	2.29			10.09	240.06
RCP 8.5	2020–2039	1.36			5.996	142.57
	2040–2059	2.3			10.14	241.11
	2080–2099	3.94			17.37	413.03

3) Cyclone

Asset damage and the amount of sales loss have been obtained from the research paper, which states that a manufacturing company experiences a 4-6% decrease in sales and a 2-3% decrease in total assets due to a cyclonic event. These figures have been used to calculate the damages. To calculate the indirect damages, it has been assumed that the company would have 3 days of downtime.

Table 12: ESTIMATED FINANCIAL LOSS FROM CYCLONE

Scenario	Asset Damage Percentage	Direct Damage	Downtime Days	Downtime Sales Loss	Total Estimated Loss (Crore)
RCP 4.5	3	66	3	1.965	67.965
RCP 8.5	3	66	3	1.965	84.95

4) Extreme Heat

Projections of extreme heat days (T max >35°C) were obtained from the World Bank Climate Knowledge Portal. The data on electricity consumption for FY 2024-2025 reveals a peak season increase of 12,000 kWh/month, which is due to increased heat load and demand for cool temperatures. This rise in electricity will result in rise in cost of production by approximately by 1 lakh rupees per year. This increase in consumption has been utilized for determining the incremental financial impact.

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Table 13: ESTIMATED FINANCIAL LOSS FROM EXTREME HEAT

Scenario	Time Period	Extreme Heat (no days)	Average Energy Consumed	Total consumption (in kwh)	Per unit cost (in rupee)	Total Cost (in Rupees)
RCP 4.5	2020–2039	90	387	34,830.00	8.36	2,29,707.72
	2040–2059	99		38,313.00		3,20,296.68
	2080–2099	107		41,409.00		3,46,179.24
RCP 8.5	2020–2039	91		35,217.00		2,94,414.12
	2040–2059	107		41,409.00		3,46,179.24
	2080–2099	127		49,149.00		4,10,885.64

VII. CONCLUSION

In the study, the climate risk for Navi Mumbai city was studied and it was found that area is prone to rising temperatures, extreme heat, extreme rainfall and coastal flood. The projections for identified risks were also studied under medium emission and high emission scenarios such as RCP, SSP and NGFS scenarios. The projection data for Sea level rise, Extreme heat (Days >35°C) show increasing trend in both medium emissions ad high emissions scenarios. In Temperature rise and extreme rainfall, the projection data in medium emissions scenarios – NGFS delayed transition show same value for 2040-2059 (1.7°C) and 2080-2099 (1.7°C) for temperature rise and lower value for 2040-2059 (1304 mm/yr) and 2080-2099 (1294 mm/yr) compared to 1307 mm/yr in 2020-2039. For cyclone, only projection data for SSP2 -4.5 shows that there will be 5.279 counts of all categories in India.

The research analysis shows that the identified climate risks are not isolated but systemic in nature, which have cascading impacts on critical economic sectors and livelihood systems in the region.
The study of key sectors —namely the APMC Market, fishing communities, and industrial clusters—shows that climate change is already posing a measurable economic and social impacts, which are expected to intensify in future under various climate scenarios.

At the sectoral level, the APMC market shows high level of exposure and sensitivity due to its dependence on steady logistics and the perishability of goods. Extreme rainfall events have already resulted in up to 50% reduction in arrivals which result in significant financial losses due to spoilage and price volatility. Similarly, the fishing communities also show high vulnerability and limited adaptive capacity, with climate risks such as extreme rainfall and temperature rise leading to reduced fish catch (15–30%), increased operational costs, and income losses ranging from □5,000 to □60,000 per event. Long-term risks such as sea-level rise will further affect the coastal ecosystems and fish breeding habitats which will directly impact livelihood sustainability.

Industrial areas , such as the MIDC clusters, show high economic exposure and vulnerability, with climate risks directly affecting the production efficiency, supply chains, and infrastructure. Scenario-based analysis show that extreme rainfall alone can lead to measurable operational losses, while temperature rise and extreme heat contribute to productivity decline and increased energy costs. Given the level of industrial activity and employment in the region, such disruptions have broader involvement in regional economic stability.

Overall, the study establishes that Navi Mumbai represents a high-risk urban coastal system, where climate risk can translate into both direct financial losses and indirect socio-economic impacts. The results present an urgent need for integrated, climate-resilient planning strategies, which should include infrastructure adaptation, livelihood

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diversification, and risk-informed urban development.. For building the long-term resilience of the region, adaption and mitigation measures should be taken to reduce the frequency and intensity of climate risks.

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